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Australian VANADIUM LIMITED

TENINDEWA VANADIUM PROCESSING FACILITY

Section 38 EPA Referral Supporting Document

FINAL

April 2022

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Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Australian Vanadium Limited

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Report No. 6183/R28
Date: April 2022

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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
V1	Georgina Davies	3 March 2022	Emma Molloy	14 March 2022
V2	Trevor Smith	11 April 2022	Emma Molloy	12 April 2022

Executive Summary

Australian Vanadium Limited (AVL) intends to establish an integrated vanadium production operation in WA. This aligns with Australian and Western Australian government strategies to increase development of the critical and battery minerals sector, including downstream processing within Australia.

The subject of this referral is the Tenindewa Vanadium Processing Facility (the Proposal). The processing facility will produce a high purity vanadium pentoxide and an iron-titanium co-product.

The Proposal is not expected to have a significant impact on the environment. This Referral has been submitted as several project stakeholders have expressed the expectation that the project should be referred to the EPA. The environmental impacts of the proposal can be effectively managed through the native vegetation clearing permit process and environmental licensing under Part V of the EP Act.

The Proposal location is approximately 80 km east of Geraldton and 27 km west of Mullewa on the Geraldton-Mount Magnet Road in the City of Greater Geraldton. The proposed site is directly adjacent to the Geraldton-Mount Magnet Road and is identified as Lot 40 and Lot 41 on Plan 28736. AVL has selected the location to optimise the environmental, social and economic sustainability of the Proposal and proceeded with the preferred site only after receiving in-principal support from all neighbouring landowners.

The primary components of the Tenindewa Processing Facility will be a vanadium concentrate processing plant and lined evaporation ponds for storage and evaporation of residual liquid from the process. Additional support facilities will include heavy and light vehicle access roads, water production bores that access the deep Irwin River High Cliff aquifer, a reverse osmosis plant, and ancillary office and other support facilities. Water will be sourced from the deep Irwin River High Cliff aquifer, over 200 m below ground level. The processing facility is expected to operate for at least 50 years, which could be increased with maintenance and refurbishment.

The processing plant includes innovations to increase energy efficiency and extract maximum value from the vanadium concentrate with minimal residual waste. The only waste will be a barren solution, which will be stored in lined evaporation ponds and evaporate over time to leave a salt residue.

The land is currently zoned Rural. AVL has submitted a Development Application to the State Development and Assessment Unit under Part 17 of the *Planning and Development Act 2005* to seek planning approval for the Proposal. Liaison has also been undertaken, and is ongoing, with the City of Greater Geraldton regarding amending the Local Planning Scheme to permit the development. Works approvals and licenses will also be required from the Department of Water and Environmental Regulation (DWER) under Part V of the *Environmental Protection Act 1986* (EP Act)**.**

The Proposal location is on private land currently used for agricultural purposes. The nearest residence to the processing location is Wyalong homestead (3.2 km northeast). AVL has consulted with all nearby landowners who have expressed support for the facility. AVL has an agreement with the current landowners which includes an option to purchase the land.

There will be minimal native vegetation clearing for the facility. The land is largely cleared and currently used for agriculture. Less than 7 ha of native vegetation clearing is required. A flora survey will be undertaken prior to any native vegetation clearing to identify any protected flora that may be present. The disturbance area will be adjusted where possible to avoid impacts to protected flora. Appropriate environmental approvals will be obtained prior to undertaking any native vegetation clearing.

Emissions to air will be assessed and managed via the DWER assessment under Part V of the EP Act. Air emissions from the processing plant will be mitigated via bag filters and scrubbers and other typical industrial processes to meet emissions limits and ensure there is no adverse impact to sensitive receptors and landowners.

The Proposal is not expected to trigger EPA assessment for greenhouse gas emissions. Direct (Scope 1) greenhouse gas emissions from the processing facility are predicted to remain below 100,000 tpa CO_2-e. Primary sources of greenhouse gas emissions are natural gas use and transformation of sodium carbonate to carbon dioxide in the kiln. Natural gas is used in the roasting kiln as well as for power generation. A proportion of power generation will be from other fuel sources such as green hydrogen and solar power with batteries. The proportion of renewable power sources will be increased as technologies become viable.

There are not expected to be any significant impacts to any other environmental factors from the processing facility. The proposal is unlikely to impact the surrounding environment on a local, regional and state scale.

Overall, the potential environmental impacts of the proposal are expected to be low and can be adequately assessed and regulated by other decision-making authorities.

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1.0 Introduction

1.1 Background

Australian Vanadium Limited (AVL) (The Proponent) is an emerging vanadium producer in Western Australia (WA). Vanadium is mainly used to strengthen steel, with growing demand from the battery market. Vanadium's use in master alloys for defence and aerospace applications makes it a critical mineral.

AVL is developing three projects to bring onshore mining, vanadium concentrate processing and production of battery electrotype to Western Australia. The three projects are at different stages and comprise:

- The Australian Vanadium Project – Mining and Beneficiation Operations, located near Meekatharra, which is under assessment by the EPA (CMS17549). Currently pending proponent response to a request for additional information.
- The Tenindewa Vanadium Processing Facility (the Proposal), located near Mullewa, which is the subject of this Referral.
- A further downstream plant, situated in Kwinana, that would take vanadium pentoxide and produce electrolyte for use in batteries.

AVL intends to establish an integrated vanadium production operation in WA to process vanadium ore through to the vanadium products required for battery and steel applications. An Australian invention, the Vanadium Redox Flow Battery (VRFB) is set to play a vital role in the battery revolution. AVL's vision is to supply its high-grade product to battery makers worldwide, a market expected to grow significantly on the back of increased renewable energy generation. Through its 100% owned subsidiary, VSUN Energy, AVL is developing the VRFB market in Australia.

AVL has completed a pre-feasibility study (PFS) for the mining and beneficiation operations and downstream processing facility and is close to completing a bankable feasibility study (BFS). The Company's PFS results highlight AVL's potential to become a new, low-cost vanadium producer.

AVL and their subsidiary VSUN Energy are both members of the Future Battery Industries Cooperative Research Centre and are engaged with the WA Government Future Battery Industry Strategy and the Federal Government's Critical Minerals Facilitation Office. The mining and beneficiation operations and downstream processing facility were awarded Major Project Status by the Federal Government in September 2019 and Lead Agency Status by the State Government in April 2020. Most recently AVL has been awarded a $49 million Federal Government co-operation grant intended to progress the Project into the execution phase.

The following section provides an overview of the types of activities that would be undertaken at the Tenindewa Vanadium Processing Facility, which is the subject of this Referral. This information is provided for context and does not form part of the Proposal Content Document.

1.2 Processing Facility

The Tenindewa Vanadium Processing Facility will be comprised primarily of a vanadium concentrate processing plant and lined evaporation ponds for storage and evaporation of residual liquid from the process. Additional support facilities include heavy and light vehicle access roads, a water production bore, reverse osmosis plant, and ancillary office and other support facilities.

The processing facility will produce a high purity vanadium pentoxide and an iron-titanium co-product. The processing plant is designed to consistently generate above 11,000 tonnes of V_2O_5 flake (98.5% w/w) per annum and approximately 1,050,000 tonnes of iron-titanium co-product. The vanadium pentoxide will be packaged for transport to Fremantle Port for export, and the iron-titanium co-product will be bulk transported and exported via Geraldton Port.

The primary input to the processing facility is an iron-titanium-vanadium concentrate, which can be sourced from the AVL Mining and Beneficiation Operations, other vanadium mines within Western Australia, or other sources such as slag from steel manufacturers overseas. The source of concentrate may vary depending on market conditions. The vanadium concentrate arriving at the processing site will either be directly tipped into the concentrate feed bins or into the concentrate stockpile which will be a designed facility for temporary storage until it is fed into the feed bins via a front-end loader. Handling of the concentrate will occur in the concentrate handling area and subsequent processing will involve the following activities:

- mixing & pelletising
- roasting
- leaching (generation of the washed iron-titanium co-product)
- desilication
- precipitation and filtration
- barren solution treatment
- vanadium pentoxide production (generation of vanadium pentoxide solid flakes).

Raw inputs during processing are expected to include sodium carbonate, organic binder, flocculant, sulphuric acid, aluminium sulphate, ammonium sulphate, sodium metabisulphite and sodium hydroxide. All reagents will be stored in designated and suitably designed hydrocarbon and chemical storage areas. The process will also use raw water, and natural gas for direct combustion in the kiln and power generation. Renewable and hydrogen energy sources are expected to be included and increased as they become available and viable.

There will be air emissions from the processing plant, which will be mitigated via filters and scrubbers and other typical industrial processes to meet emissions limits and ensure there is no adverse impact to sensitive receptors and landowners. The only other waste from the process is barren solution, which will be treated to neutralise the pH and stored in lined ponds for evaporation. The residue will comprise salts, which may be a future product if a suitable market can be found.

A haulage road capable of accommodating quad road trains will also be constructed to connect the Geraldton-Mt Magnet Road to the processing facility. There will be a separate entrance road for light vehicles and other deliveries off the Erangy Springs Road.

Figure 1.1 below provides a summarised representation of the processes involved.

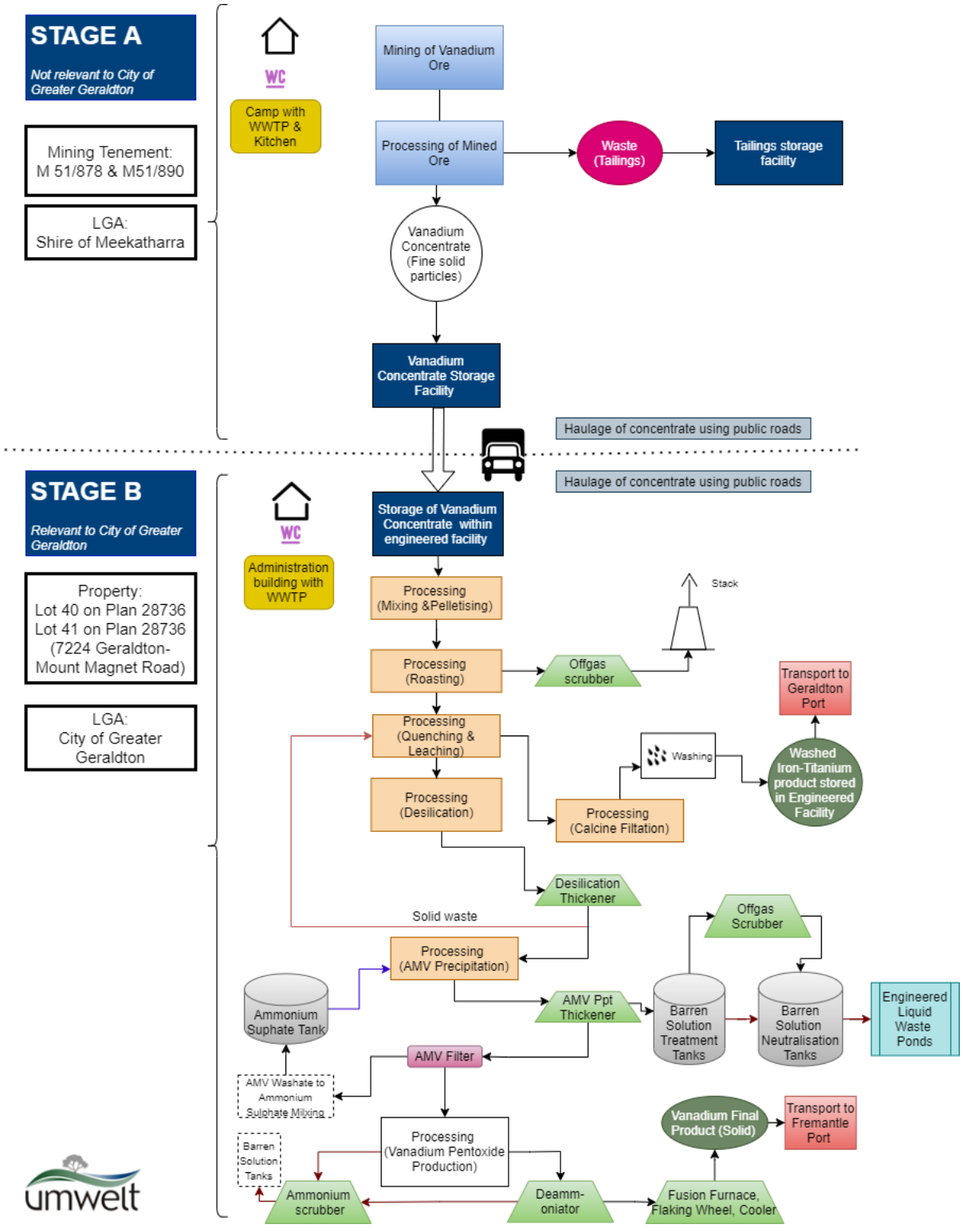


Figure 1.1 Process Plant Facility Operational Summary

2.0 Proposal

2.1 Proposal Content

Refer to Proposal Content Attachment.

2.2 Local and Regional Context

2.2.1 Site Location

The processing facility is near Tenindewa, a small rural locality of agricultural properties. The Tenindewa locality is approximately 80 km east of Geraldton and 27 km west of Mullewa on the Geraldton-Mount Magnet Road and lies within the City of Greater Geraldton.

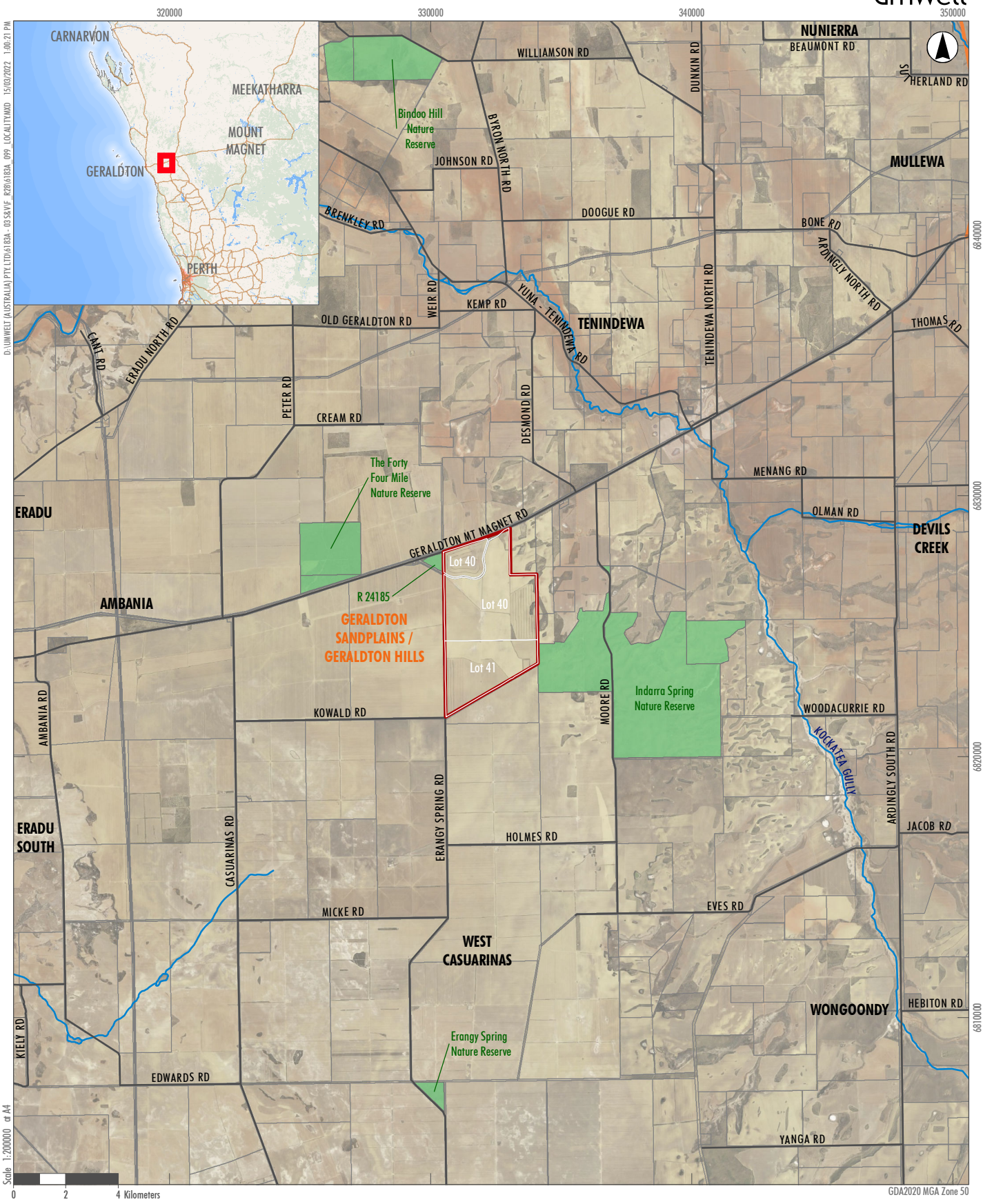
The City of Greater Geraldton is also the regional service centre for the Mid-West region of Western Australia. It contains varied environments including fertile farmland, forests, rivers and coastal areas and is rich in indigenous and pioneering history. The region's economy is based on tourism, mining and agriculture as well as the Port of Geraldton, a major west coast port.

The processing location is on private land currently used for agricultural purposes. It is directly adjacent to Geraldton-Mount Magnet Road and is identified as Lot 40 and Lot 41 on Plan 28736. The Tenindewa railway siding is located at 1.5 km from the site's northern boundary and the nearest residence to the processing location is Wyalong homestead (3.2 km northeast of Lot 40 boundary). No natural, historic, visual or recreational amenity values have been identified within the surrounding area.

A search for any surrounding reserves within 3 km of the project area was undertaken using the DBCA – 011 (DBCA - Legislated Lands and Waters) dataset (DataWA, 2021). Three natural reserves were identified as shown below. No direct impacts to the nature reserves are expected. Location of the reserves are presented in **Figure 6.1** and are:

- Indarra Spring Nature Reserve (R 41885) is located immediately east of Lot 41. The reserve has been classified as a Class A reserve under Section 5(1)(d) of *Calm Act 1984*. The nature reserve is protected for the purpose of conservation of flora and fauna.
- Reserve R 24185 is located immediately west of Lot 40. R 24185. It is a Class A reserve under Section 5(1)(d) of *Calm Act 1984* and is protected for the purpose of conservation of flora and fauna.
- The Forty-Four Mile nature reserve (R 1017) is located 3.2 km west of the proposal. It is a Class A reserve under Section 5(1)(d) of *Calm Act 1984* and is protected for the purpose of conservation of flora and fauna.

AVL has an Option Agreement with the landowners which includes conditions relating to future purchase of the land for use by AVL. Access to the premises is via the Geraldton–Mount Magnet Road. The Proposal area is in a relatively remote part of the Mid-West region of Western Australia, where the land use is predominantly agricultural.



Legend

- Project Area
- Property Boundaries
- IBRA Regions / Sub-regions
- Nature Reserves
- Roads
- Watercourses

FIGURE 2.1

Processing Facility Location

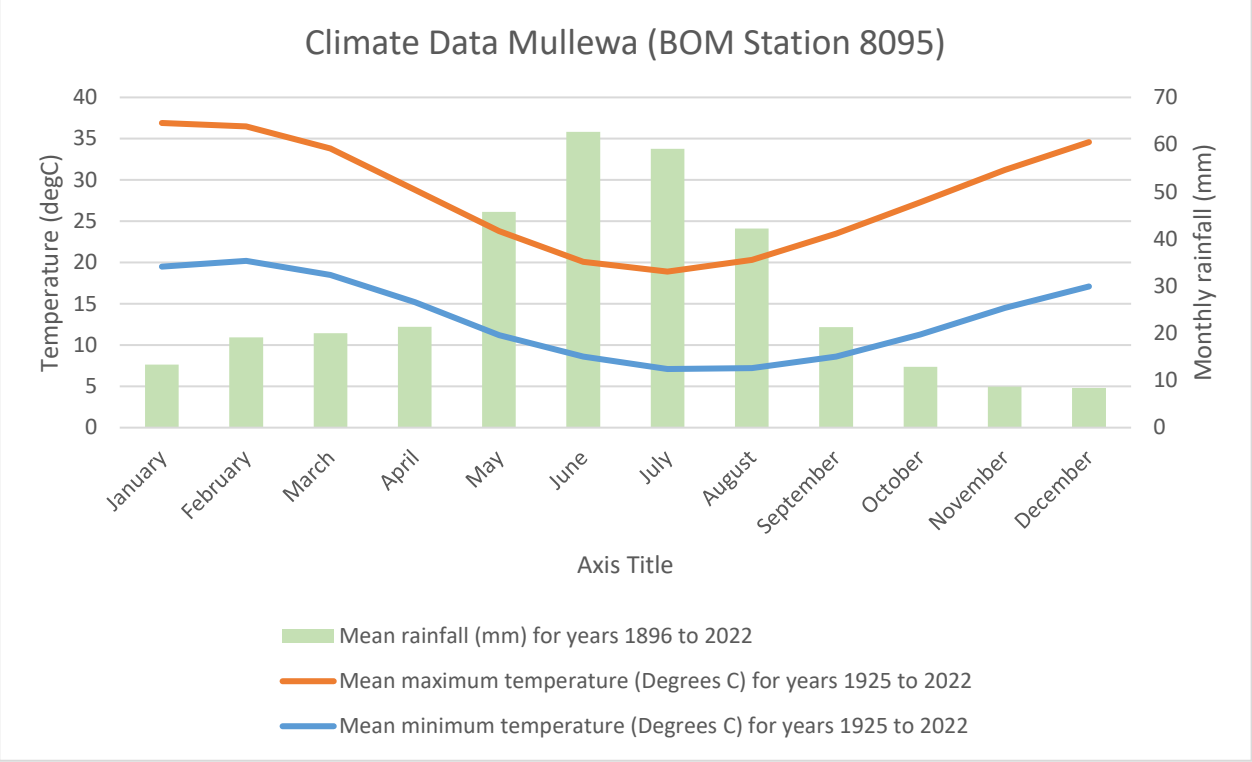
Image Source: WA SLIP Imagery (2021) Data source: WA SLIP (2020)

2.2.2 Climate

An understanding of the regional climate is important to provide context about the receiving environment and identify potential environmental impacts. Key aspects of climate are temperature, rainfall, evaporation and wind conditions.

The current climate of Mullewa is described as hot dry summer and cold winter with summer drought (Bureau of Meteorology, 2022a). Weather reading has been taken from the Mullewa BOM weather station (site number 008095) (Bureau of Meteorology, 2022b). Mean annual rainfall and temperature data from this site are presented in **Graph 2.1.**

Graph 2.1 Monthly Climate Statistics – Mullewa



Mean annual rainfall at Mullewa is 332 mm with the highest rainfall occurring during winter (May to August).

Mean maximum temperatures range from 36.9°C in January to 18.9°C in July. Mean minimum temperatures range from 20.2°C in February to 7.1°C in July.

Climate records for Mullewa indicate the regional prevailing wind direction in the morning is from the east-southeast with afternoon winds coming from the southeast to southwest (Bureau of Meteorology, 2022b). This pattern is strongest in summer, and the wind direction is more variable in winter.

Future climate change projections have been sourced from the Climate Change in Australia website (CSIRO, 2022) for the Southern and South-Western Flatlands West sub-cluster. Future climate for the region is projected with high confidence to include the following changes:

- Decreases in winter rainfall by up to 15% by 2030 and 30-45% by 2090, leading to a significant decline in annual rainfall. Time spent in drought is expected to increase.

- Increases in mean, maximum, and minimum temperatures, as well as more frequent hot days, longer warm spells, and hotter maximum temperatures during warm spells. Frost risk days are expected to decrease.
- There will be a harsher fire-weather climate.
- Evaporation will increase in all seasons, and humidity will decrease in winter and spring. Winter solar radiation will increase related to the decline in winter rainfall.
- Associated with the use of Geraldton and Fremantle Ports for shipping, sea level will rise, and the height of extreme sea-level events will increase.

The predicted significant decline in winter rainfall will decrease the viability of this area for agricultural use. Availability of surface water is also expected to decrease, and evaporation potential will increase. The Tenindewa processing facility will source water from deep aquifers, which are not expected to be impacted by the project climate changes. The increase in evaporation will support faster evaporation from the barren solution ponds.

Current and projected future climate will be considered in planning for the construction and operations of the processing site.

2.3 Proposal Alternatives

Several potential locations within WA were assessed to determine the preferred location for the processing facility. The alternatives were assessed on factors including current and surrounding land use, significant environmental values, Aboriginal heritage considerations, possible social/community concerns, access to infrastructure such as gas and water, and distance from ports and the mine site.

Based on these assessments, the Tenindewa site was chosen as the preferred site given that:

- It is located near the Port of Geraldton which makes it economically viable to ship the co-product Iron-Titanium to overseas market.
- It is located near a gas pipeline and major highway.
- Surrounding land users are supportive of the proposal based on initial and ongoing consultation.
- Preliminary risk assessment conducted during the site selection process concluded that the environmental sensitivity surrounding the Tenindewa site is low.
- Potential for adverse social impacts was considered low.
- Implementation of the proposal would bring a lot of economic benefits to the City of Greater Geraldton and the town of Mullewa, including creation of job opportunities as well as supporting local businesses.

Based on the abovementioned points, Tenindewa site was considered the best site for this proposal over the alternative sites assessed during the early stage of the project.

3.0 Legislative Context

The Proposal is referred to the WA EPA under section 38 of the EP Act as several project stakeholders have already expressed the expectation that the project should be referred to the EPA. The Proposal is not expected to have a significant impact on the environment.

This proposal was prepared in accordance with the following guidelines:

- *Referral of a proposal under section 38 of the Environmental Protection Act 1986* (EPA, 2021a)
- *Instruction and template on how to identify the Content of a Proposal* (EPA, 2021b)
- *Instructions on how to prepare an Environmental Review Document* (EPA, 2021c)
- *Statement of environmental principles, factors, objectives and aims of EIA* (EPA, 2021d).

The Proposal has not been referred to the Federal Department of Agriculture, Water and the Environment (DAWE) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as it is not considered likely to have a significant impact on any Matters of National Environmental Significance. Preliminary discussions have been held with DAWE and the Proposal will be referred under the EPBC Act if it is identified to trigger a Matter of National Environmental Significance.

The Proposal is located on private land, which AVL would purchase to facilitate development of the Proposal. AVL has an Option Agreement with the current landowner, and support from all nearby landowners for development of the Proposal.

The Proposal is in the City of Greater Geraldton, and the land is currently zoned as Rural. The proposed industrial development would not be permitted in the current land zoning. AVL has submitted a Development Application to the State Development and Assessment Unit under Part 17 of the *Planning and Development Act 2005* to seek planning approval for the Proposal. Liaison has also been undertaken, and is ongoing, with the City of Greater Geraldton regarding amending the Local Planning Scheme to permit the development.

The environmental impacts of the proposal can be effectively managed through the native vegetation clearing permit process and environmental licensing under Part V of the EP Act.

The identified environmental decision-making authorities and approvals processes, and their ability to mitigate environmental impacts, are described in **Table 3.1**.

Table 3.1 Environmental Decision-Making Authorities

Decision-making authority	Legislation and guidelines regulating the activity	Approval required	Environmental Factor and Proposal Activity	Can the statutory decision-making process mitigate impacts on the environment? If yes, summary of reasons.
DWER - Environment	*Environmental Protection Act 1986* Part V Environmental Protection Regulations 1987 Industry Regulation Guide to Licensing (DWER, 2019a) Guidance Statement – Environmental Siting (DWER, 2016) Guideline – Risk Assessments (DWER, 2017) Guidance Statement – Regulatory Principles (DWER, 2015)	Works Approval	Terrestrial environmental quality, air quality Construction of processing facility, evaporation ponds, power plant and wastewater treatment plant.	Yes, this process upholds EPA's objective to maintain the quality and land and soils to protect their environmental values. Works Approval application and DWER assessment will consider risks from emissions and discharges to the environment and management of wastes. This will include risk assessment and controls relating to point and non-point sources of emissions and handling and storage of environmentally hazardous materials. The risk assessment will consider DWER listed Environmental Sensitive receptors including nearby human receptors, the groundwater management area, surface water catchment area, noise impacts, dust impacts and nearby reserves. Applications for Works Approvals are publicly advertised, and DWER seeks direct comment from relevant public authorities and direct landowners. Granted Works Approvals are also published and open to public appeal.
		Critical Containment Infrastructure Report assessment	Terrestrial environmental quality Commissioning of waste storage facilities (evaporation ponds)	Yes, this process upholds EPA's objective to maintain the quality and land and soils to protect their environmental values. DWER will assess the Critical Containment Infrastructure Report to ensure that waste containment infrastructure is properly constructed with no material defects and all requirements have been met before being approved for use.
DWER – Environment	*Environmental Protection Act 1986* Part V Environmental Protection Regulations 1987	Environmental Commissioning Report and Licence Application	Terrestrial environmental quality, air quality	Yes, this process upholds EPA's objective to maintain the quality and land and soils to protect their environmental values. The Environmental Commissioning Report is required to demonstrate that environmental commissioning activities have been completed, the premises can operate to the specification detailed in the Works Approval

Decision-making authority	Legislation and guidelines regulating the activity	Approval required	Environmental Factor and Proposal Activity	Can the statutory decision-making process mitigate impacts on the environment? If yes, summary of reasons.
	Industry Regulation Guide to Licensing (DWER, 2019a) Guidance Statement – Environmental Siting (DWER, 2016) Guideline – Risk Assessments (DWER, 2017) Guidance Statement – Regulatory Principles (DWER, 2015)		Operation of processing facility and wastewater treatment plant.	application, and emissions and discharges from the premises meet the required standard. The operational licence will include conditions for monitoring and annual reporting of environmental emissions and discharges and quality of the surrounding environment during operations, to verify compliance with required standards. Environmental factors that are expected to be subject to monitoring and reporting include air emissions and surrounding groundwater quality. The annual reporting process also includes an audit for compliance with licence conditions. Applications for Licences are publicly advertised, and DWER seeks direct comment from relevant public authorities and direct landowners. Granted Licences are also published and open to public appeal.
DWER – Environment	*Environmental Protection Act 1986* Part V Environmental Protection (Clearing of Native Vegetation) Regulations 2004	Native vegetation clearing permit	Flora and vegetation Clearing of native vegetation	Yes, this process upholds EPA's objective to protect flora and vegetation to maintain biological diversity and ecological integrity. The DWER assessment considers the likely environmental impacts of an application in accordance with the requirements of the EP Act and bilateral agreement (where relevant). The DWER guidelines and information sources are used by assessors in gathering the information required for objective assessment under each clearing principle. Applications and determinations for clearing permits are published on the DWER website. Decisions can be appealed in writing within 21 days of the applicant being notified of the decision. A vegetation clearing permit will include conditions to manage and monitor any potential impacts to flora.

Decision-making authority	Legislation and guidelines regulating the activity	Approval required	Environmental Factor and Proposal Activity	Can the statutory decision-making process mitigate impacts on the environment? If yes, summary of reasons.
DWER – Water	*Rights in Water and Irrigation Act 1914* (RIWI Act) Operational Policy 5.12 Hydrogeological reporting for a groundwater licence (Department of Water, 2009)	Groundwater Licence Application	Inland waters Groundwater Abstraction	Yes, this process upholds EPA's objective to maintain hydrological regimes and quality of groundwater to protect environmental values. A hydrogeological study is required to support the application to take water. The level of detail in the application is commensurate with the potential impact to other groundwater users, groundwater-dependent ecosystems and the level of existing use in the groundwater region. The hydrogeological study will include an assessment of the impacts of the proposed abstraction. A groundwater licence operating strategy is also typically required, which will detail monitoring and reporting of groundwater during operations to check for any adverse impacts.
SDAU	*Planning and Development Act 2005*	Development Application	Social surroundings Construction of processing facility including supporting infrastructure	Yes. Traffic and bushfire impact and mitigation measures are expected to be assessed as part of the Development Application.
City of Greater Geraldton / Dept of Health	Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974	Application to construct or install an apparatus for the treatment of sewage.	Terrestrial environmental quality Installation of a Sewage Treatment Plant	Yes, this process upholds EPA's objectives to protect terrestrial environmental quality. Impacts to soil are expected to be managed under the Permit.

4.0 Stakeholder Engagement

4.1 Key Stakeholders and Engagement Strategy

AVL has identified key stakeholders and means of engagement for both the mine site and processing site projects in the attached *Stakeholder Engagement Plan* (Australian Vanadium Limited, 2021) (**Appendix A**).

Primary stakeholders are the current landowner for Lots 40 and 41, as well as adjacent landowners. AVL undertook consultation with all local landowners in 2019 prior to signing the Option Agreement for Lots 40 and 41. The current landowner required all neighbouring landowners to endorse the proposal prior to signing the Option Agreement. AVL continues to focus on providing updates to the current and neighbouring landowners.

AVL has also been proactive in engaging with local and regional agencies including the City of Greater Geraldton (local government authority) and Mid-West Development Commission.

A Development Application was submitted under Part 17 of the *Planning and Development Act 2005* to the State Development Assessment Unit (SDAU) in December 2021, to meet the cut-off date of January 2022 for submissions to SDAU. A Development Assessment Forum was facilitated by SDAU with AVL, consultant representatives, and numerous interested stakeholders on 17 February 2022.

Records of key stakeholder engagement are provided in the following section.

4.2 Stakeholder Consultation Outcomes

AVL is undertaking on-going consultation with a range of stakeholders and interested parties. AVL strives to keep stakeholders informed of developments in the Proposal planning and will continue to proactively consult stakeholders as the Proposal progresses.

A range of stakeholders have been engaged thus far. **Table 4.1** summarises the engagement outcomes for key external stakeholders regarding the proposal.

Table 4.1 Engagement Strategy for Key External Stakeholders

Category (date)	Stakeholder	Areas of Interest	Engagement Strategy and Outcomes	Issues/topics raised	Proponent Response/Action
Landowners **(2019 and ongoing)**	Critch Family	Owners of the land where the processing plant would be located.	The family is very supportive of the processing plant and the economic benefits it will bring to the region. Contact is frequent and ongoing.	No issues raised	N.A.
	Brad and Betty Smith	Adjacent landowners	A meeting was held, and the landowners expressed an interested in upgrades to the airstrip, and additional water. They raised the issue of traffic management and expressed that they would want to ensure that truck movement didn't affect harvest grain truck movement. No objections to proceeding with studies.	Traffic impacts from trucks on Erangy Road, dust emissions, water sources. Prevailing easterly wind in summer.	Traffic impact assessment has been conducted. Erangy Springs Road would be used for light vehicles, the main haul truck access would be off Geraldton-Mt Magnet Road. Water source has been identified as is supported by hydrogeology study. Dust emissions will be estimated, and prevailing wind direction considered. Typical dust control measures will be used.
	Rod and Andrew Messina	Adjacent land	This stakeholder has been involved in general discussion about the proposal. No objections or issues have been raised.	No issues raised	N.A.
	Geoff and Ofellia Koward	Adjacent land	Meetings have been held with this stakeholder. They are interested in additional water and overall are supportive of proposal.	Waste generation	No wastes will be discharged to the environment, all solid and liquid wastes from the processing plant will be contained.
	Brendan Weir	Adjacent land	Meeting has been held, and the stakeholder has indicated that he is comfortable with plan. Landowner	Dust and traffic impacts.	Traffic Impact assessment has been conducted.

Category (date)	Stakeholder	Areas of Interest	Engagement Strategy and Outcomes	Issues/topics raised	Proponent Response/Action
			advised that he wanted to ensure his workers' houses wouldn't be affected by dust and traffic at school start and finish. He also identified that he is keen on improvements to power and water in the region.		Dust emissions will be estimated and prevailing wind direction considered. Typical dust control measures will be used.
	Glenn and Eliza Thomas	Adjacent land	Meeting has been held, landowners are generally supportive of the proposal for the region, but want to ensure that dust and noise doesn't affect them and their workers.	Dust and noise impacts	Controls will be in place to prevent noise and dust impacts. Screening assessment of dust and noise emissions will be undertaken to support Works Approval application.
Local and regional agencies **(2019 and ongoing)**	Mid-West Chamber of Commerce and Industry (MWCCI)	Socio-economic benefits to the region.	AVL is a member of the MWCCI and is engaged with them on an ongoing basis.	No issues raised	N.A.
	Mid-West Development Commission	The Proposal's prospective socio-economic benefits to the mid-west region. Interest in the location of the processing plant.	Meetings have been held regarding Proposal planning and progress for three years. MWDC has facilitated collaboration with relevant stakeholders. Consultation will occur as required.	No issues raised	N.A.
	City of Greater Geraldton	Socio-economic benefit to the region.	Multiple meetings have been held and are ongoing. The primary topic is planning approvals for the processing plant.	Processing plant is "general industry" which is not permitted in land zoned "rural". Waste management plan required.	AVL has submitted an application through SDAU and is engaging with City of Greater Geraldton regarding application for re-zoning or specified additional use.

Category (date)	Stakeholder	Areas of Interest	Engagement Strategy and Outcomes	Issues/topics raised	Proponent Response/Action
				Potential for residual contamination at the end of the facility life.	A waste management plan will be prepared and submitted to the City of Greater Geraldton. All wastes will be contained. As an industrial facility it has an indefinite life, so detailed closure planning is not completed at this stage. AVL will need to comply with all environmental regulations at the time of closure, properly decommission the site and clean up any residual contamination.
State government agency **(2021 and ongoing)**	State Development Assessment Unit (SDAU)	State-significant proposal	Briefing note and preliminary meetings prior to submission of Development Application. Development Application submitted 12 December 2021 under Part 17 of the *Planning and Development Act 2005*.	Will the proposal be referred to the EPA? SDAU assessment process will cease if EPA decide to assess the proposal. Visual impact, bushfire management Elevation plan, site contour plan, site feature survey	Yes, it will be referred by the proponent to the EPA, although we don't necessarily expect the EPA will need to assess the proposal. Visual impact assessment and bushfire assessment were submitted as part of Development Application. Additional plans will be sourced and provided to SDAU.
	Main Roads WA	Highway intersections and road maintenance	Attended engagement meeting facilitated by SDAU, 17 February 2022	Will require maintenance agreement for public highways due to volume of transport (>300,000 tpa).	AVL will engage directly with MRWA regarding maintenance agreement, as well as the Traffic Impact Assessment and design of turning and merging

Category (date)	Stakeholder	Areas of Interest	Engagement Strategy and Outcomes	Issues/topics raised	Proponent Response/Action
					lanes at the two intersections with Geraldton-Mt Magnet Road.
	Department of Mines, Industry Regulation and Safety	Proving advice on development of private land regarding possible underlying mineral or hydrocarbon resources.	Attended engagement meeting facilitated by SDAU, 17 February 2022	No mining or exploration tenement in the area, no indication that it might be prospective for oil and gas or other minerals. Non-contentious.	N.A.
	Department of Primary Industries and Regional Development	Agricultural productivity	Attended engagement meeting facilitated by SDAU, 17 February 2022	What will be the emissions, will there be brine disposal? Will there be buffers, how will it sit in the landscape?	There will be air emissions, treated through filtration and scrubbing systems to meet environmental regulations. There will be no effluent or liquid emissions, all will be contained in lined evaporation ponds. There will be buffers and tree plantings around the processing plant.
	Department of Biodiversity, Conservation and Attractions	Nearby nature reserves	Attended engagement meeting facilitated by SDAU, 17 February 2022	Will there be any direct or indirect impacts to Indarra Nature Reserve?	No expecting any direct impacts, indirect impacts will be assessed and expected to be minor.
	Department of Planning, Lands and Heritage	Regional land use, heritage	Attended engagement meeting facilitated by SDAU, 17 February 2022	Why not use other industrial-zoned land in Geraldton?	Narngulu lots are not big enough, and visual impact would be greater due to proximity to town. Oakagee was

Category (date)	Stakeholder	Areas of Interest	Engagement Strategy and Outcomes	Issues/topics raised	Proponent Response/Action
				Any plans for expansion in the long term? Has there been engagement with Traditional Owners?	considered but there is no existing infrastructure. No plans for expansion, the size of the facility is defined by the roaster which is the most expensive item. There is the potential to use other feed stocks e.g. import slag from New Zealand. The land is freehold, and there are no known heritage sites.
	Environmental Protection Authority	Greenhouse gas emissions	Correspondence (meetings, phone discussions, emails and letters) Oct 2021 – Jan 2022.	How will cumulative greenhouse gas emissions from both facilities (mine site and processing site) be assessed?	The two sites are separate proposals in separate regions and can operate independently. The only environmental factor with a region that encompasses both sites is greenhouse gas emissions, due to global region. The two proposals are referred to the EPA as separate proposals. This Proposal discusses cumulative greenhouse gas emissions.
Federal agencies **(Feb 2022)**	Department of Water and Environment (DAWE)	Matters of National Environmental Significance under the EPBC Act	Meeting held 23 February 2022. DAWE will review information provided and liaise with AVL for any additional information needed to understand if the Proposal may trigger the need for assessment under the EPBC Act.	DAWE officers were primarily concerned whether the Proposal would require assessment due to nuclear activities.	The EPA Referral and Tenindewa Preliminary Environmental Risk Assessment were provided for background information.

5.0 Environmental Principles and Factors

5.1 Objects and Principles of the EP Act

The five environmental principles as defined under the EPA Statement of Environmental Principles, Factors, Objectives and Aims of EIA **(EPA, 2021d)** have been considered while assessing the impacts of the project as summarised in **Table 5.1**.

Table 5.1 Objects and Principles

Principle	Consideration
1. The precautionary principle ***Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.***	A desktop environmental review was undertaken to determine whether any significant environmental values were present within and nearby to the proposed development. The desktop review identified the possible presence of *Styphelia marginata* immediately outside the northern side of the proposal boundary. This species is listed as Threatened (Endangered) under the *Biodiversity Conservation Act 2016* (BC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The proposed haul road is expected to cross a small area of native vegetation area. Due to the risk of impact to a significant environmental value, a targeted flora survey will be undertaken to determine whether any protect flora species are present in the proposed area of native vegetation clearing. No land clearing will be undertaken without approval. If the survey confirms the presence of *Styphelia marginata* or any other listed species the proponent will prioritise actions and control measures that avoid disturbance. If this is not possible and clearing of this species is required, then the appropriate approvals will be sought.
2. The principle of intergenerational equity ***The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.***	Implementation of the Proposal will shift the land use from agricultural to industrial. Agricultural productivity will be maintained where possible by minimising total land disturbance and allowing the previous landowner to utilise un-used portions of the land (outside of a buffer) for ongoing agricultural use. Agricultural productivity in the region is likely to decline in the medium term due to predicted reduction in winter rainfall associated with climate change. Development of this Proposal will establish a facility that can provide economic value and productivity to future generations. The Proposal is expected to bring benefit to nearby businesses and communities. Mitigation controls will be in place to prevent direct and indirect impacts to the environment arising from the construction and operations of the facility.
3. The principle of the conservation of biological diversity and ecological integrity ***Conservation of biological diversity and ecological integrity should be a***	The proposal area is of low ecological value due to its past clearing and current use as agricultural land. A flora survey will be undertaken prior to land clearing to determine whether the floristic diversity of the areas of native vegetation within the proposal development envelopes, as well as nearby remnant native vegetation. The proposal disturbance areas will be amended where possible to avoid impacts to listed flora species and protect biological diversity.

Principle	Consideration
fundamental consideration.	Existing tree lines will be retained where possible. Additional tree planting for screening will use local native species to enhance ecological integrity. Indirect impacts to the nearby reserves will be avoided through implementation of mitigation controls as further discussed in the below sections.
4. Principles relating to improved valuation, pricing, and incentive mechanisms ***This includes polluter-pays principle, goods and services should be priced based on the full lifecycle cost, and environmental goals should be pursued in the most cost-effective way.***	Discharges to the environment will be recorded and reported through mechanisms such as the National Greenhouse and Energy Reporting Scheme, National Pollutant Inventory and Prescribed Premises Licence (EP Act Part V), where applicable. Prescribed Premises Licence fees are charged based on reported discharges to the environment, which incentivises abating volumes of pollutants discharged. The Proponent will be responsible for funding the cost of environmental management measures and closing the site to a standard agreed with key stakeholders. Expectations of the financial investment market are driving projects to achieve environmental, social, and corporate governance goals. These open market forces will drive pursuit of environmental goals in the most cost-effective way.
5. The principle of waste minimisation ***All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.***	The Proposal has been designed to minimise mineral waste generation. The location of the proposal close to Geraldton Port will facilitate recouping maximum value from the processing plant inputs. Due to the location near a port, it is feasible for AVL to sell the iron-titanium co-product. Traditionally other vanadium mining and processing operations stockpile this as a waste, even though it is highly enriched in iron and titanium. The only waste will be treated barren solution. This will be stored in lined ponds which will drive evaporation of excess water, leaving behind a residual salt. AVL will seek opportunities to recoup value from this residual salt if it is financially viable. The Proposal will seek to maximise use of renewable energy and minimise greenhouse gas emissions. Management and mitigation measures specified in this document aim to reduce the risk of pollution, including ongoing management and mitigation measures for the life of the Proposal.

5.2 Identification of Key Environmental Factors

A preliminary assessment was undertaken against the EPA Key Environmental Factors and Department of Agriculture, Water and the Environment (DAWE) Matters of National Significance (MNES) to identify likely environmental impacts from implementation of the proposal.

The purpose of the assessment was to inform environmental impacts, determine areas of focus for mitigation of the impacts and verify the environmental approvals pathway. Sensitive receptors were determined by using the following guidance:

- EPA key environmental factors as defined under the *Statement of environmental principles, factors, objectives and aims of EIA* (EPA, 2021a).
- *Matters of National Environmental Significance - Significant impact guidelines 1.1* (DAWE, 2013).
- *DWER Guideline: Environmental Siting* (DWER, Guideline: Environmental siting, 2020a).

Potentially relevant industries as listed in the EPA Guidance for the Assessment of Environmental Factors No. 3 include:

- Vanadium mine – including processing of vanadium: separation distance 1500-3000 m
- Metal smelting, refining, or processing – up to 1000 tpa: 300-500 m separation distance; over 1000 tpa: case by case.

Therefore, taking a conservative approach, a separation distance of 3 km was used to identify potential sensitive environmental receptors.

Based on the preliminary environmental impact assessment, the Proposal is not expected to have a significant impact on the environment or any MNES. It is possible that there would be an impact on significant flora listed if they cannot be avoided in locating the site entry and exit roads. The potential impact will be determined after a targeted flora survey is undertaken, and the road designs are finalised.

Nevertheless, key stakeholders such as the SDAU and City of Greater Geraldton have expressed an expectation that the processing facility should be referred to the EPA under Part IV of the EP Act. Therefore, this referral has been prepared for consideration by EPA under section 38 of the EP Act.

Table 5.2 lists the environmental factors and classification relevant to this Proposal and indicates the section number in this document. Information regarding each environmental factor is provided in this Supporting Document to enable verification of the preliminary risk assessment. The level of detail relates to the factor classification, with a low level of detail for factors that were classified as "not significant".

Table 5.2 Preliminary Environmental Risk Assessment

Theme	Factor	Section	Classification	Basis of Classification
Land	Flora and Vegetation	6.0	Other decision-making authority	There is the potential for significant flora to be present in the proposed development envelope. While the Proposal will be designed to avoid impacts to significant flora, it may not be feasible to avoid all impacts. Any residual impacts can be assessed and managed through the native vegetation clearing permit process and under the *Biodiversity Conservation Act 2016*.
	Landforms	8.1	Not significant	No significant landforms identified.
	Subterranean fauna	8.2	Not significant	No direct impacts to subterranean fauna from Proposal activities. The groundwater source is the deep aquifer (>200 m below ground level) and is separated from the superficial aquifer.

Theme	Factor	Section	Classification	Basis of Classification
	Terrestrial Environmental Quality	7.0	Other decision-making authority	There is the potential for impacts to terrestrial environmental quality from accidental release of environmentally hazardous materials. The potential impacts will be managed through typical industrial controls such as effective design, construction, and management of run-off and storage facilities. The Works Approval and licensing process administered by DWER under Part V of the EP Act can effectively assess the impacts to terrestrial environmental quality and ensure EPA objectives are maintained.
	Terrestrial Fauna	8.3	Not significant	No direct impacts to conservation significant fauna or habitat are expected. The proposal is primarily located within previously cleared land. The small amount of native vegetation clearing that will be required is not expected to significantly impact on terrestrial fauna values.
Water	Inland Waters – Surface Water	8.4	Other decision-making authority	There is the potential for impacts to surface water from accidental release of environmentally hazardous materials. The potential impacts will be managed through typical industrial controls such as effective design, construction, and management of run-off and storage facilities. The Works Approval and licensing process administered by DWER under Part V of the EP Act can effectively assess the impacts to inland waters and ensure EPA objectives are maintained.
	Inland Waters - Groundwater	8.5	Not significant	Water for the Proposal will be sourced from the Irwin River-High Cliff Aquifer, over 200 m below ground level. No groundwater dependent ecosystems rely on this water source.
Air	Air Quality	8.6	Other decision-making authority	The closest sensitive human receptor is Wyalong Homestead, 3.2 km from the Proposal. Potential impacts associated with particulate and other air emissions can be managed using standard practices. The Works Approval and licensing process administered by DWER under Part V of the EP Act can effectively assess the impacts from air emissions and ensure EPA objectives are maintained.
	Greenhouse Gas Emissions	8.7	Not significant	Scope 1 greenhouse gas emissions will be less than 100,000 tonnes per annum. AVL is committed to minimizing direct greenhouse gas emissions where feasible.

Theme	Factor	Section	Classification	Basis of Classification
People	Social Surroundings	8.8	Not significant	The Proposal has been designed to minimise potential impacts to social surroundings such as visual amenity, fugitive dust emissions, loss of agricultural productivity and increase in traffic movements. The Proposal location was selected in consultation with the local community and has in-principal support from nearby landowners. The residual impact to social surroundings is low.
	Human Health	8.9	Not significant	The closest sensitive human receptor is Wyalong homestead, 3.2 km from the Proposal. No radiation exposure risk is expected from the Proposal.

6.0 Flora and Vegetation

6.1 EPA Objective

The EPA objective of the factor Flora and Vegetation: *"To protect flora and vegetation so that biological diversity and ecological integrity are maintained."*

Ecological integrity is defined by the EPA as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements.

6.2 Relevant Policy and Guidance

EPA Environmental Factor Guideline: Flora and Vegetation (EPA, 2016a) has been used to address this section. An assessment for conservation significant flora and presence of native vegetation within 3 km of the proposal area was undertaken.

Other guidelines relevant to the consideration of Flora and Vegetation includes:

- Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016b)
- Statement of Environmental Principles, Factors, Objectives and Aims of EIA (EPA, 2021d)
- Instructions for the preparation of data packages for the Index of Biodiversity Surveys for Assessments (IBSA) (EPA, 2021e).

Laws and regulations relevant to the consideration of Flora and Vegetation include:

- *Environmental Protection Act 1986* (EP Act)
- *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Biodiversity Conservation Act 2016* (BC Act)
- *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*
- *Biosecurity and Agriculture Management Act 2007* (BAM Act).

6.3 Receiving Environment

The proposal area is located within the Geraldton Sandplains IBRA Region (Code: GS) and Geraldton Hills subregion (Code: GES01) which is characterised by the following (DAWE, 2000):

- Endemic proteaceous scrub-heaths on the sandy earths
- Extensive, undulating and lateritic sandplain on a mantling Permian to Cretaceous strata
- Extensive York gum and jam woodlands occurring on outwash plains associated drainage.

The DPRID-005 Native Vegetation dataset was used to identify presence of native vegetation. The proposal area has been largely cleared due to previous agricultural and pastoral activities. However, some remnant native vegetation is present both within Lot 40 and in the road reserve.

A DBCA search for Ecological Communities did not detect any Priority and Threatened Ecological Communities within 3 km of the proposal boundary. The closest Threatened Ecological Community, Eucalypt Woodlands of the Western Australia Wheatbelt (ID: Wilroy01) is 32 km east.

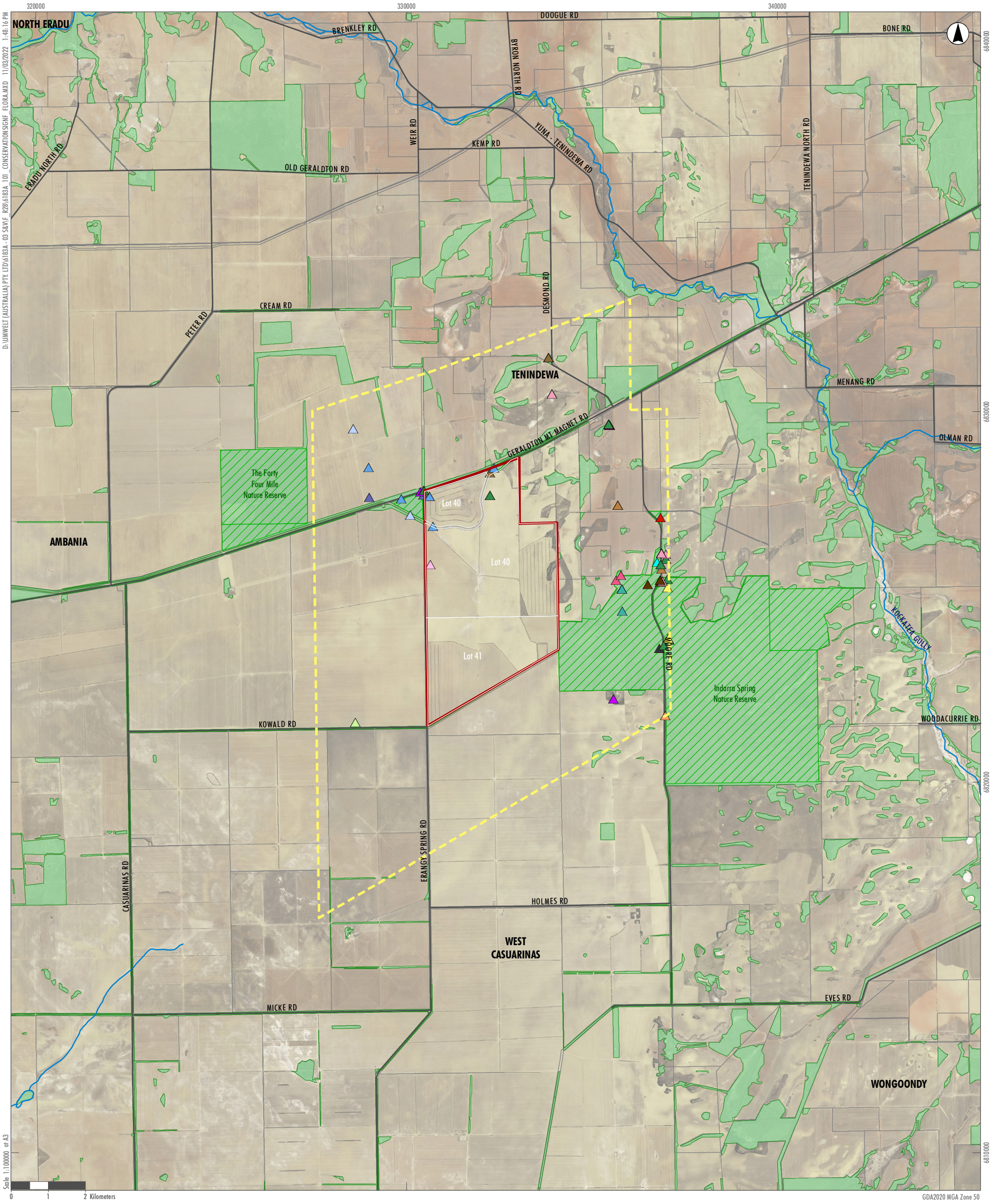
To identify presence of conservation significant species under the *Biodiversity Conservation Act 2016* (BC Act), a DBCA flora search was requested. The DAWE Protected Matters Search Tool (PMST) was also used to identify presence of any protected species as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that could trigger an EPBC referral or a joint referral. **Table 6.1** provides a summary of the findings and **Figure 6.1** shows the location of the conservation significant flora recorded within 3 km of the proposal area.

Table 6.1 Conservation Significant Flora

Species	BC Act	EPBC Act	Likelihood of presence	Distance from Project Boundary**	Source
Styphelia marginata (previously *Leucopogon marginatus*)	T (E)	T (E)	Recorded (last recorded in 1985)	15 m	DBCA flora Search
Caladenia wanosa	T (E)	T (V)	May occur	N. A	PMST Search
Conostylis dielsii subsp. *Teres*	T (V)	T (E)	Likely to occur	N. A	PMST Search
Conostylis micrantha	T (V)	T (E)	May occur	N. A	PMST Search
Eucalyptus beardiana	T (E)	T (V)	May occur	N. A	PMST Search
Chamelaucium sp. Tenindewa (F. Lullfitz L 3219)	P1		Recorded	1.9 km	DBCA flora Search
Lepidobolus eurardyensis	P1		Recorded	1.7 km	DBCA flora Search
Tricoryne sp. Geraldton (G.J. Keighery 10461)	P1		Recorded	1.6 km	DBCA flora Search
Desmocladus ferruginipes	P1		Recorded	1.7 km	DBCA flora Search
Atriplex spinulosa	P1		Recorded	2.6 km	DBCA flora Search
Petrophile pilostyla subsp. *syntoma*	P2		Recorded	0.4 km	DBCA flora Search
Lepidobolus basiflorus	P2		Recorded	2.4 km	DBCA flora Search
Dampiera krauseana	P3		Recorded	0.1 km	DBCA flora Search
Thryptomene hubbardii	P3		Recorded	1.9 km	DBCA flora Search

Species	BC Act	EPBC Act	Likelihood of presence	Distance from Project Boundary**	Source
Verticordia chrysostachys var. *pallida*	P3		Recorded	Within proposal boundary.	DBCA flora Search
Beyeria gardneri	P3		Recorded	Within proposal boundary.	DBCA flora Search
Comesperma rhadinocarpum	P3		Recorded	2.7 km	DBCA flora Search
Comesperma rhadinocarpum	P3		Recorded	2.7 km	DBCA flora Search
Scholtzia sp. Geraldton (F. Lullfitz L 3216)	P3		Recorded	2.6 km	DBCA flora Search
Acacia leptospermoides subsp. *psammophila*	P3		Recorded	2.6 km	DBCA flora Search
Anthotroche myoporoides	P3		Recorded	2.6 km	DBCA flora Search
Gnephosis cassiniana	P3		Recorded	2.6 km	DBCA flora Search
Grevillea candicans	P3		Recorded	2.6 km	DBCA flora Search
Schoenus pennisetis	P3		Recorded	2.7 km	DBCA flora Search
Thryptomene orbiculata	P3		Recorded	1.9 km	DBCA flora Search
Jacksonia velutina	P4		Recorded	Within proposal boundary.	DBCA flora Search

**Conservation status P1=Priority 1; P2=Priority 2; P3=Priority 3; T=Threatened; E=Endangered; V=Vulnerable*
***Closest species recorded from proposal boundary*



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Legend

- Project Area
- 3 km Buffer
- Remnant Native Vegetation
- Nature Reserves
- Property Boundaries
- Roads
- Watercourses

Flora Records - BC Act (P1)

- *Atriplex spinulosa*
- *Chamelaucium* sp. Tenindewa (F. Lullfitz L 3219)
- *Desmocladus ferruginipes*
- *Lepidobolus eurardyensis*
- *Tricoryne* sp. Geraldton (G.J. Keighery 10461)

Flora Records - BC Act (P2)

- *Lepidobolus basiflorus*
- *Petrophile pilostyla* subsp. syntoma

Flora Records - BC Act (P3)

- *Acacia leptospermoides* subsp. psammophila
- *Anthotroche myoporoides*
- *Beyeria gardneri*
- *Comesperma rhadinocarpum*
- *Dampiera krauseana*
- *Gnephosis cassiniana*
- *Grevillea candicans*
- *Malleostemon nephroideus*
- *Schoenus pennisetis*

- *Scholtzia* sp. Geraldton (F. Lullfitz L 3216)
- *Thryptomene hubbardii*
- *Thryptomene orbiculata*
- *Verticordia chrysostachys* var. pallida
- *Verticordia fragrans*

Flora Records - BC Act (P4)

- *Jacksonia velutina*

Flora Records - EPBC Act (T(E))

- *Styphelia marginata*

FIGURE 6.1

Conservation Significant Flora

Image Source: WA SLIP Imagery (2021) Data source: WA SLIP (2020)

Some of the listed species have been recorded within the proposal area and many have records within 3 km of the proposal area (refer to **Figure 6.1**). If these species are still present, they may occur within the remaining remnant vegetation. Most of the above species were recorded in the Indarra Spring Nature Reserve and Reserve R 24185 to the west of Lot 40. Further details on the nature reserves have been described under **Section 2.2.1** Site Location**.**

The Threatened Flora species *Styphelia marginata* was previously recorded within the Geraldton-Mount Magnet Road Reserve in front of Lot 40. The species was recorded in 1985, therefore limited information is available to determine whether the species is still present. Given that the species was previously recorded, it may be present within the native vegetation in the area given the same environment exists.

A targeted survey is planned in 2022 to check whether any listed flora occur in the remnant native vegetation in the road reserve north of Lot 40 and within Lot 40.

6.4 Potential Environmental Impacts

The processing plant will be on cleared land, which minimises the amount of native vegetation clearing required.

Establishment of site entry and exit points is expected to require small amounts of native vegetation clearing. There is residual native vegetation within the road reserves immediately north of Lot 40 alongside the highway. Native vegetation is also present on the north-east section of the proposal boundary. As Threatened Flora has been recorded in the nearby road reserve, there is the potential for clearing of Threatened Flora if it is present at locations proposed for the site entry and exit points.

Furthermore, there is a risk of accidental clearing of protected flora if land disturbance occurs outside of planned areas. This risk is highest during construction activities.

There may be minor indirect impacts to native vegetation in the adjacent reserves, such as dust deposition and increased risk of fire.

6.5 Mitigation Measures

A targeted flora survey will be undertaken in the appropriate season to check whether any listed species occur in the native vegetation remnants within and adjacent to the proposed proposal development area. Any proposed native vegetation clearing will be adjusted where possible to avoid locations of listed flora, particularly Threatened Flora. Appropriate environmental approvals, such as a native vegetation clearing permit, will be sought prior to any clearing of native vegetation.

Management measures will be in place to prevent indirect impacts to the species such as dust suppression activities and clear demarcation of approved disturbance areas to prevent unauthorised clearing and disturbance. Controls to prevent indirect impacts are expected to be managed under the DWER Part V approvals and will include the following:

- an internal clearing permitting process
- an online GIS database with location of key species
- dust suppression as required during construction and operations to prevent excessive dust emission and deposition on nearby vegetation.

6.6 Assessment and Significance of Residual Impacts

Application of the mitigation measures discussed above and regulation under Part V of the EP Act will reduce the potential impact to flora and vegetation during construction, commissioning, and operations of the processing facility to low.

6.7 Environmental Outcomes

Proposed environmental outcomes for protection of flora and vegetation are:

- No introduction of invasive weed species within the Proposal area during construction or operations.
- No unauthorised clearing of flora.
- No vegetation clearing outside of the development envelope.

7.0 Terrestrial Environmental Quality

7.1 EPA Objective

The EPA objective of the factor Terrestrial Environmental Quality is: "*To maintain the quality of land and soils so that environmental values are protected.*"

Social and economic impacts from changes of the current land use and impacts to agricultural productivity are discussed in the Social Surroundings environmental factor.

7.2 Relevant Policy and Guidance

EPA Environmental Factor Guideline: Terrestrial Environmental Quality (EPA, 2016c) has been used to address this section. Terrestrial environmental quality can be defined as the chemical, physical, biological and aesthetic characteristics of soils. Discharge of contaminants to soils can also impact on water quality (surface water or groundwater). Many of the relevant guidelines for control of environmental discharges are associated with managing impacts to water quality.

Guidelines relevant to the consideration of Terrestrial Environmental Quality include:

- Statement of Environmental Principles, Factors, Objectives and Aims of EIA (EPA, 2021d)
- Water Quality Protection Guidelines No. 4 – Sensitive water resources (Department of Water, 2016)
- Water Quality Protection Guidelines No. 6 – Mining and Mineral Processing – Minesite Stormwater (Water and Rivers Commission, 2000a)
- Water Quality Protection Guidelines No. 10 – Mining and Mineral Processing – Above-ground fuel and chemical storage (Water and Rivers Commission, 2000b)
- Water Quality Protection Note No. 26 – Liners for containing pollutants, using synthetic membranes (Department of Water, 2013)
- Water Quality Protection Note No. 61 – Tanks for ground level chemical storage (Department of Water, 2008)
- Water Quality Protection Note No. 65 – Toxic and hazardous substances – storage and use (Department of Water, 2006)
- Landfill Waste Classification and Waste Definitions 1996 (as amended 2019) (DWER, 2019b)
- Assessment and Management of Contaminated Sites (DWER, 2014)
- Australian Standard 1940 The storage and handling of flammable and combustible liquids.

Laws and regulations relevant to the consideration of Terrestrial Environmental Quality include:

- EP Act
- *Contaminated Sites Act 2003* and associated Regulations 2006
- *Environmental Protection (Controlled Waste) Regulations 2004*

- *Environmental Protection (Unauthorised Discharges) Regulations 2004*
- *National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM)*
- *Dangerous Goods Safety Act 2004* and associated regulations
- *Work Health and Safety Act 2020* and associated regulations.

7.3 Receiving Environment

The proposed site has a long history of agricultural use (crops such as wheat and canola) and the soil in the area is suitable for agriculture. No soil sampling has been undertaken to date to investigate soil characteristics in the area. To further understand the soil characteristics in the area, the following searches were undertaken:

- DWER – 059 (Contaminated Sites Database) dataset was checked for the presence of any contaminated sites within 3 km of the proposal area (DataWA, 2021). No contaminated sites were identified.
- DWER – 048 (Acid Sulphate Soil Risk Map 100K) dataset was assessed to determine the presence of any Acid Sulphate soil risks in the area (DataWA, 2021). No risk for Acid Sulphate Soils were identified.
- The Natural Resource Information (WA) online database provided the following context (dwer, 2021):
    - The area comprises the Binnu East Subsystem 4 (soil landscape map unit 227Be_4) and the Eradu 1 subsystem (soil landscape map unit 220Er_1).
    - The soil landscape mapping shows that the area is characterised by:
        - level to gently sandplains and relict hardpan wash plains on Permian and Carboniferous sedimentary rocks of the Perth Basin
        - yellow deep sands, red-brown hardpan shallow loams, yellow sandy earths, red sandy earths, deep, yellow siliceous clayey sands and pale sands over ferruginous gravel.
    - Both soil units have a high to extreme hazard potential for wind erosion.
    - Both soil units show no potential for water erosion hazards.
    - The soils show low salinity and alkalinity at surface. Soil unit 227Be_4 shows potential for acidity at surface but no potential for acidity at subsurface. Both soil units show no potential for alkalinity at subsurface.

The proposal is not located near a sensitive water resource (e.g. a public drinking water source area or a high value water-dependent ecosystem) as defined in *Water quality protect note no. 4: Sensitive water resources* (Department of Water, 2016).

7.4 Potential Environmental Impacts

Construction and operational activities may potentially impact the soil quality within the proposal area. At the end of the operations, the use of the soil within the proposal area for agricultural purposes may not be viable without mitigation measures. Social and economic impacts from changes of the current land use and impacts to agricultural productivity are discussed in the Social Surroundings environmental factor.

The feasible impacts to terrestrial environmental quality are grouped into impacts to topsoil revegetation quality, and potential discharge of contaminants.

7.4.1 Impacts to Topsoil Quality Relevant to Revegetation

Impacts to topsoil revegetation quality from proposal implementation may comprise the following:

- poor topsoil stripping and handling practices during construction phase leading to insufficient material for rehabilitating the area
- poor weed management hygiene on the site leading to introduction of invasive species
- loss of soil during windy days due to soil characteristics demonstrating high to extreme potential for wind erosion.

7.4.2 Discharge of Contaminants

Proposal activities will use, handle and store materials which, if discharged into the environment, have the potential to adversely impact terrestrial environmental quality, as well as other environmental values.

Table 7.1 lists the potential contamination sources, and the pathways by which these contaminants might impact soils. **Table 7.1** also lists the soil receptor locations and the other environmental values that might be reasonably impacted.

Table 7.1 Potential Contaminants, Contamination Pathways and Soil-Related Receptors

Contamination Source	Potential Contamination Pathway	Potential Receptor
Hydrocarbons stored in appropriately designed facilities and used in plant and vehicles	Leak, spill or failure leading to hydrocarbon discharge from storage facility, vehicle, plant or workshop	• Plant area, mining area or other cleared disturbed area – no topsoil • If not cleaned up, may impact on groundwater or surface water
Reagents stored in appropriately designed facilities and used in the processing plant	Leak, spill, overtopping or failure leading to reagent discharge from storage facility, pipeline or plant facility	• Plant area or other cleared disturbed area – no topsoil • If not cleaned up, may impact on groundwater or surface water
Concentrate stored in stockpiles	Leaching from stockpile Water erosion/runoff from stockpile Wind erosion from stockpile	• Leaching into groundwater • Transport by surface water to undisturbed areas including topsoil • Transport by wind to undisturbed areas including topsoil and adjacent land
Intermediate liquids formed as part of processing stored in appropriately designed facilities and used in the plant	Leak, spill, overtopping or failure leading to intermediate liquid discharge from storage facility, pipeline or plant facility	• Plant area or other cleared disturbed area – no topsoil • If not cleaned up, may impact on groundwater or surface water

Contamination Source	Potential Contamination Pathway	Potential Receptor
Calcine solids stored in appropriately designed facility, washed to leach out further vanadium-rich solution	Leak, spill, overtopping or failure leading to discharge of wash water or leachate from storage facility Water erosion/runoff from stockpile Wind erosion from stockpile	• Leaching into groundwater • Transport by surface water to undisturbed areas including topsoil • Transport by wind to undisturbed areas including topsoil and adjacent land
Emissions to air from processing plant	Particulate emissions from flash dryer, de-ammoniator or fusion furnace	• Transport by wind to undisturbed areas including topsoil and adjacent land
Vanadium pentoxide product	No pathways identified, solid metallic material packaged for transport.	• Not applicable
Fe-Ti product	Leak, spill or failure leading to discharge from storage facility Water erosion/runoff from stockpile Wind erosion from stockpile	• Leaching into groundwater • Transport by surface water to undisturbed areas including topsoil • Transport by wind to undisturbed areas including topsoil and adjacent land
Final waste liquids treated to reduce toxicity (neutralised barren solution), evaporated in appropriately designed facilities	Leak, spill or failure leading to discharge from plant facility, pipeline or storage facility	• Plant area or other cleared disturbed area – no topsoil • In the event of a large discharge or failure, may impact on adjacent land • If not cleaned up, may impact on groundwater or surface water
Residual salts remaining from evaporation of neutralised barren solution, stored in appropriately designed facilities	Residual salts may be permanently retained in a lined encapsulated storage facility on site after closure of the processing plant.	Future land uses would be restricted in the area immediately above and surrounding the storage facility to prevent damage to the encapsulation. This may reduce economic value of the land and ability to use it for agriculture. Alternatively, the residual salts may be removed and the entire processing area remediated.

The environmental values that may feasibly be impacted by discharge of contaminants are topsoil quality, groundwater quality and surface water quality, and associated water-dependent environmental values.

7.5 Mitigation Measures

Risks to terrestrial environmental quality and associated management controls will be assessed and managed as part of the Works Approval and Operating Licence application through DWER Industry Regulation, under Part V of the EP Act.

The following measures will be implemented during detailed design, construction and operations to minimise potential impacts to terrestrial environmental quality:

Mitigation of impacts to topsoil quality and revegetation

- Topsoil from areas proposed for disturbance will be stripped and stored for use in rehabilitation.
- Appropriate measures will be taken to maintain the viability and quantity of topsoil, these may include:
    - Stripping topsoil as soon as possible following vegetation clearing.
    - Avoiding stripping and handling of soil during windy or wet conditions.
    - Covering soil stockpiles with stripped vegetation.
    - Limiting the height of stockpiles to 2 m.
    - Using only water of acceptable salinity for dust suppression on topsoil stockpiles.
    - Considering the use of dust suppression surfactants for long-term soil stockpiles.
    - Locating stockpiles in flood-free areas which are also sheltered from wind exposure and have sufficient separation distance from unsealed roads to minimise the risk of saline water spray accumulating on stored topsoil.
- Processes for management of weeds will be determined in consultation with adjacent landowners, and may include:
    - Weed and seed checks of vehicles prior to entering site during topsoil stripping.
    - Regular weed surveys and control measures as required.

Mitigation of impacts from discharge of contaminants

- Storage, handling, reporting, monitoring and clean-up of reagents, hydrocarbons and other pollutants will be undertaken in accordance with standard safety management practices and regulatory requirements including the *Work Health and Safety Act 2020, Dangerous Goods Safety Act 2004* and EP Act Part V (Industry Regulation).
- Spills will be recorded and cleaned up as soon as practicable to mitigate ongoing pollution.
- Concentrate, intermediate products and final products will be further characterised including assessment of physical properties and risk of metalliferous drainage.
- All environmentally hazardous materials will be stored and transported through the process site in facilities designed in accordance with relevant guidelines such as *Water quality protection note no. 61 – tanks for ground level chemical storage* (Department of Water, 2008), *Water quality protection note no. 26 - Liners for containing pollutants, using synthetic membranes* (Department of Water, 2013), *Water quality protection note no. 65 – Toxic and hazardous substances storage and use* (Department of Water, 2006) or other appropriate guideline. These requirements include use of chemically-resistance containers, suitable bunding and secondary containment, and separation of clean stormwater.

- Waste containment infrastructure will be designed, constructed and operated to manage the risk of flooding or overtopping. Regular visual inspections of waste containment infrastructure will be undertaken to ensure freeboard level and structural integrity are maintained.
- Groundwater monitoring bores will be installed and regular monitoring undertaken of ambient groundwater quality in the shallow aquifer, to detect any adverse impacts on groundwater quality from unknown leaks or other sources.
- Options for final disposal of residual salts will be explored prior to closure of the processing plant, and include:
    - AVL will seek opportunities for recovery and sale of salts that may become technically or financially viable over time.
    - Excavation and removal of salts from the lined facilities and disposal to an approved off-site location.
    - Encapsulation of residual salts in an enclosed permanent storage facility on site, which would restrict possible future land uses over the area where the salts are stored to prevent damage to the encapsulation
- The method of final disposal of residual salts will be agreed with relevant stakeholders (including local landowners, local government authority and relevant regulators) prior to closure of the processing plant.
- At the time of closure, the processing plant will be decommissioning, deconstructed and removed from site for appropriate disposal or resale if possible. Any residual contamination will be remediated for a final land use agreed with relevant stakeholders prior to closure.
- Concentrate storage and processing area to be equipped with engineering controls to prevent dust emissions. Concentrate transportation to be undertaken in tarped trucks to prevent emission of concentrate to the environment and prevent soil contamination due to deposition of the concentrate on the soil.

AVL will apply for a Works Approval and Operating Licence under the EP Act Part V prior to commencement of construction of the processing plant and hazardous material storage facilities. The design, construction, commissioning and operations of the processing plant and associated facilities that may discharge or emit materials to the environment will be regulated by DWER under Part V of the EP Act.

7.6 Assessment and Significance of Residual Impacts

Application of the mitigation measures discussed above and regulation under Part V of the EP Act will reduce the potential impact to terrestrial environmental quality during construction, commissioning, and operations of the processing facility to low.

As an industrial facility, the processing plant has an indefinite life and AVL is not required to develop a formal closure plan at this stage of the proposal. Nevertheless, AVL has identified the likely activities required to be undertaken upon closure of the facility. A decommissioning and closure plan would be developed and agreed with relevant stakeholders prior to closure to ensure closure outcomes meet community and regulator expectations. There is not expected to be any residual impact to terrestrial environmental quality following decommissioning of the facility.

7.7 Environmental Outcomes

Environmental outcomes for terrestrial environmental quality comprise the following:

- No introduction of invasive weed species within the proposal area during construction or operations.
- Groundwater quality is maintained comparable to baseline groundwater or suitable for beneficial uses.
- Any leak, spill or discharge of hazardous materials or contaminants onto land not owned by AVL is cleaned up promptly and the land is returned to a condition suitable for the current use.
- A decommissioning and closure plan is developed and agreed with relevant stakeholders prior to closure to ensure closure outcomes meet community and regulator expectations.

8.0 Other Environmental Factors

8.1 Landforms

Table 8.1 Other Factor - Landforms

Item	Description
EPA objective	To maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.
Relevant policy and guidance	EPA Environmental Factor Guideline: Landforms (EPA, 2018a).
Receiving environment	The landforms at the processing site are not considered significant as the landform is typical in the region and unremarkable.
Potential environmental impacts	No major excavational works or mining activities will occur and therefore no permanent change to the physical landform is anticipated. No impacts to landforms are expected.
Application of the mitigation hierarchy	No mitigation measures are considered required.
Assessment and significance of residual impacts	No residual impacts.

8.2 Subterranean Fauna

Table 8.2 Other Factor - Subterranean Fauna

Item	Description
EPA objective	To protect subterranean fauna so that biological diversity and ecological integrity are maintained.
Relevant policy and guidance	EPA Environmental Factor Guideline: Subterranean Fauna (EPA, 2016d) Technical Guidance: Subterranean fauna surveys for environmental impact assessment (EPA, 2021f)
Receiving environment	A hydrogeological investigation was undertaken by Rockwater in 2021, which informed preparation of the *Bore Completion Report and H2 Level Hydrogeological Assessment* (Rockwater, 2022). Rockwater identified that there is a superficial low salinity aquifer hosted in the Wagina Sandstone occurring at approximately 20 m below ground level. This is expected to be used by local farmers. There may be potential habitat for stygofauna in this aquifer. The superficial aquifer is isolated from the deeper Irwin River High Cliff aquifer by a clay aquitard. The deep aquifer occurs at a depth of over 200 m below ground level (Rockwater, 2022). There is a low likelihood of stygofauna being present at such a depth. All groundwater sourced to support the operations would be from the deeper aquifer.
Potential environmental impacts	There will be no direct impacts to subterranean fauna. No major excavational works or mining activities will occur within the proposal area. Although groundwater abstraction will occur, the water source for this proposal is the deep aquifer, at a depth of over 200 m below ground level. The proposed groundwater abstraction from the deep aquifer is not expected to impact on the superficial aquifer. Therefore, any groundwater drawdown will be below a depth that could provide suitable habitat for stygofauna.
Application of the mitigation hierarchy	Water abstraction from the superficial aquifer will be avoided.
Assessment and significance of residual impacts	No residual impacts.

8.3 Terrestrial Fauna

Table 8.3 Other Factor - Terrestrial Fauna

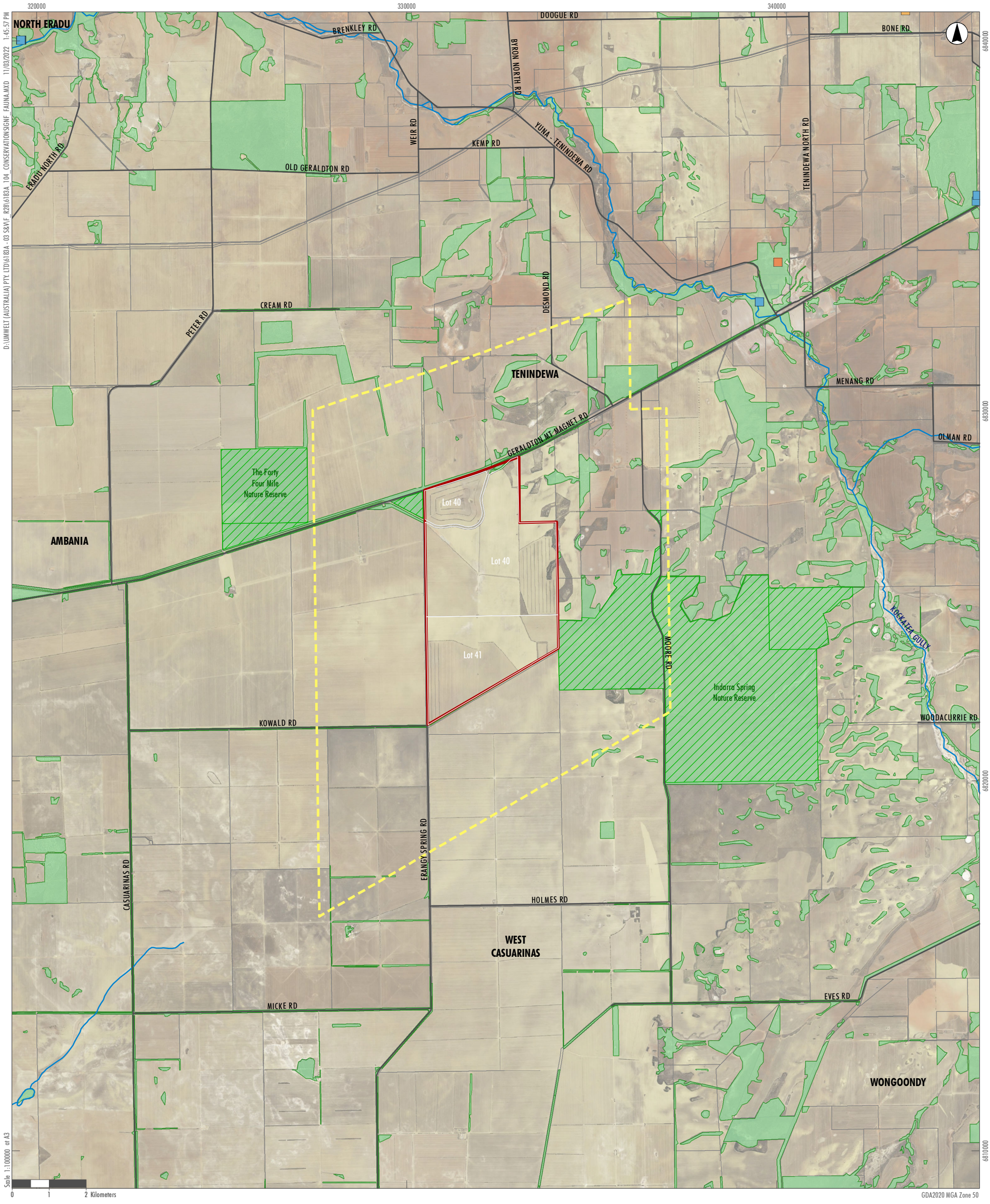
Item	Description
EPA objective	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Relevant policy and guidance	EPA Environmental Factor Guideline: Terrestrial Fauna (EPA, 2016e) has been used to address this section.
Receiving environment	To identify presence of conservation significant fauna under the BC Act, a DBCA fauna search was requested. The DAWE Protected Matters Search Tool (PMST) was also used to identify presence of any protected fauna species as listed under the EPBC Act that could trigger an EPBC referral or a joint referral. Summary of findings have been presented in **Table 8.4**. The DBCA search did not identify any conservation significant fauna species recorded with 3 km of the proposal boundary. The closest significant species recorded, Yuna broad-blazed slider (*Lerista yuna*) listed as Priority 3 under the BC Act, was 4.7 km east of the proposal. The DAWE PMST search tool identified eight species that may potentially occur within the proposal boundary. However, none of these species have been previously recorded within 3 km of the proposal boundary. Conservation significant species that could possibly occur have been listed in **Table 8.4**, and comprise six birds, one mammal and one spider.
Potential environmental impacts	No direct impacts to conservation significant fauna or habitat are expected. The proposed development footprint falls in a largely cleared area and therefore impacts to fauna are low given that limited clearing would be required to support the proposal. However, conservation significant fauna may be present in the area and may be subject to indirect impacts including: • Vehicle strikes on main roads and access roads from traffic movement. • Noise and vibration leading to fauna migration away from the proposal area into non suitable habitats and predation zones. • Fauna death by fauna entering the proposal area and possibly drowning in hazardous waste containment ponds. • Light emissions from operations impacting nocturnal fauna. • Poor waste management practices during construction and operation attracting fauna to the proposal.
Application of the mitigation hierarchy	Indirect impacts to fauna will be mitigated through assessment under Part V of the EP Act.
Assessment and significance of residual impacts	The proposal is not expected to have a direct impact to conservation significant fauna. Due to low density of fauna habitat in the area, the likelihood of an indirect impact to conservation significant fauna is low. Residual impacts are expected to be low.

Conservation-significant species that could possibly occur near the proposal are listed in **Table 8.4**. Records of conservation significant fauna previously found in the region are shown in **Figure 8.1**.

Table 8.4 Conservation Significant Fauna

Species	BC Act	EPBC Act	Likelihood of presence	Source
Curlew Sandpipe (*Calidris ferruginea*)	CR	CR	May occur	PMST Search
Carnaby's Cockatoo (*Calyptorhynchus latirostris*)	E	E	Likely to occur	PMST Search
Grey Falcon (*Falco hypoleucos*)	V	V	May occur	PMST Search
Malleefowl (*Leipoa ocellata*)	V	V	Likely to occur	PMST Search
Night Parrot (*Pezoporus occidentalis*)	CR	E	May occur	PMST Search
Australian Painted Snip (*Rostratula australis*)	EN	E	May occur	PMST Search
Chuditch (*Dasyurus geoffroii*)	V	V	May occur	PMST Search
Shield-backed Trapdoor Spider (*Idiosoma nigrum*)	E	V	May occur	PMST Search

**Conservation status P1=Priority 1; P2=Priority 2; P3=Priority 3; T=Threatened; E=Endangered; V=Vulnerable; CR =Critically Endangered*



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Legend

- Project Area
- 3 km Buffer
- Remnant Native Vegetation
- Nature Reserves
- Property Boundaries
- Roads
- Watercourses

Fauna Records - BC Act (EN or P)

- an Idiosoma trapdoor spider

Fauna Records - BC Act (P3)

- Yuna broad-blazed slider

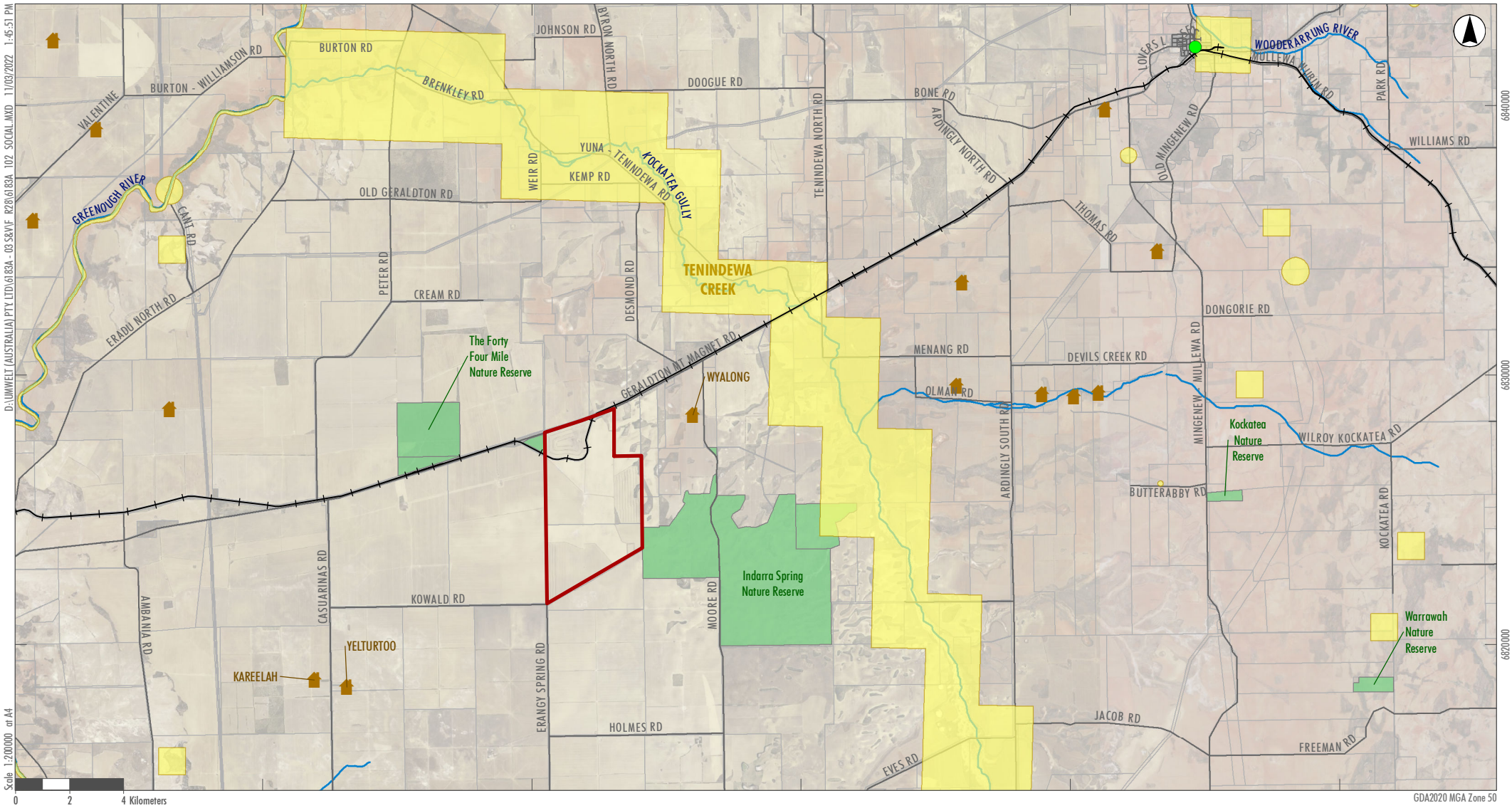
Fauna Records - BC Act / EPBC Act (EN)

- Carnaby's cockatoo

FIGURE 8.1

Conservation Significant Fauna

Image Source: WA SLIP Imagery (2021) Data source: WA SLIP (2020)



Legend

- Project Area
- Property Boundaries
- Nature Reserves
- Aboriginal Heritage
- Railway
- Roads
- Watercourses
- Homesteads
- Mullewa

FIGURE 8.2

Social Surroundings

Image Source: WA Slip (2022) Data source: Geoscience Australia (2006); WA SLIP (2022)

8.4 Inland Waters – Surface Water

Table 8.5 Other Environmental Factor - Inland Water

Item	Description
EPA Objective	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.
Relevant Policy and Guidance	EPA Environmental Factor Guideline: Inland Waters (EPA, 2018b)
Receiving Environment	A desktop assessment was undertaken to identify the surface water context of the area. The following surface water values were identified near the proposal: o Kockatea Gully which is a minor river is located at 7.8 km directly east of the proposal boundary. o Greenough river which is a mainstream is located at 16.7 km north-west of proposal boundary. o There is an unnamed minor tributary located at 8.9 km south-west of the proposal boundary. The proposal area is located within the Greenough River basin catchment area (DWER – 027 dataset) and Greenough River and Tributaries Catchment Area (DWER- 030 dataset) (DataWA, 2021). **Figure 2.1** provides the location of the nearby surface water features.
Potential environmental impacts	Impacts to the Greenough River and Tributaries Catchment Area can possibly occur if waste containment infrastructure fails or bunds are over-topped. This could occur during large rainfall and flooding events or due to poorly designed, constructed or maintained infrastructure. This potential impact is assessed in **Section 7.0 Terrestrial Environmental Quality.**
Application of the mitigation hierarchy	AVL will apply for a Works Approval and Operating Licence under the EP Act Part V prior to commencement of construction of the processing plant and hazardous material storage facilities. The design, construction, commissioning and operations of the processing plant and associated facilities that may discharge or emit materials to the environment will be regulated by DWER under Part V of the EP Act. Further mitigation measures are described in Section 7.0 Terrestrial Environmental Quality.
Assessment and significance of residual impacts	Regulation under Part V of the EP Act will reduce the residual impact to surface water to low.

8.5 Inland Waters – Groundwater

Table 8.6 Other Environmental Factor – Groundwater

Item	Description
EPA Objective	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.
Relevant Policy and Guidance	EPA Environmental Factor Guideline: Inland Waters (EPA, 2018b)
Receiving Environment	A desktop assessment was undertaken to identify the groundwater context of the area. The following groundwater values were identified near the proposal: • The proposal area is located within the Gascoyne Groundwater Area, which is a proclaimed groundwater area under the *Rights in Water and Irrigation Act 1914*. There is no groundwater allocation plan for this area. • Private bores are present within and surrounding the proposal area. DWER's Water Reporting Portal shows private bores have been installed to a maximum depth of 21.3 m below ground level (mbgl) (DWER, 2021a). The proposal is not located in or near a sensitive water resource (e.g. a public drinking water source area or a high value water-dependent ecosystem) as defined in *Water quality protect note no. 4: Sensitive water resources* (Department of Water, 2016). A hydrogeological investigation was undertaken by Rockwater in 2021, which informed preparation of the *Bore Completion Report and H2 Level Hydrogeological Assessment* (Rockwater, 2022) (**Appendix B**). Rockwater identified that the proposal location lies over the north-south trending Urella Fault. The western side of the proposal area overlies the Wicherina Terrace, and the eastern side overlies the Irwin Terrance. The most prospective aquifers are west of the Urella Fault. A hydrostratigraphic hole was drilled on the western side of the proposal boundary and Rockwater logged the geological sequence as: • 0-40 m below ground level (mbgl): Wagina Sandstone, comprised of medium to coarse grained sand with sandy clay, hosting the Wagina Aquifer. • 40-75 mbgl: Carynginia Formation aquitard comprised of clayey gravel, clay and grey silty shale • 75-220 mbgl: Irwin River Coal Measures, comprising gravelly clay, sandstone, and black carbonaceaous shale • 220- over 300 mbgl: High Cliff Formation, hosting the Irwin River-High Cliff Aquifer, comprised of sandstone The superficial low salinity aquifer hosted in the Wagina Sandstone is expected to be used by local farmers. The superficial aquifer is isolated from the deep Irwin River-High Cliff Aquifer by a clay aquitard. The deep aquifer occurs at a depth of over 200 m below ground level. The groundwater quality of the deep aquifer was sampled in

Item	Description
	September 2021 and was brackish (6,850 mg/L total dissolved solids). This is the proposed water source for AVL. No groundwater dependent ecosystems rely on the Irwin River-High Cliff Aquifer, due to the depth being more than 200 mbgl.
Potential environmental impacts	Potential impacts to groundwater include changes in groundwater quality or changes in groundwater depth (increase or decrease). Change in groundwater quality can possibly occur if waste containment infrastructure fails or bunds are over-topped. This could occur during large rainfall and flooding events or due to poorly designed, constructed or maintained infrastructure. This potential impact is assessed in **Section 7.0 Terrestrial Environmental Quality.** Increase in groundwater depth could occur from discharge to groundwater. However, the proposal does not include any discharge to groundwater. Decrease in groundwater levels could occur from groundwater abstraction. AVL intends to apply for a licence to take groundwater for 1.2-1.5 GL/annum from the deep Irwin River High Cliff aquifer. The proposed groundwater abstraction could draw down groundwater levels in the deep aquifer.
Application of the mitigation hierarchy	AVL will apply for a Works Approval and Operating Licence under the EP Act Part V prior to commencement of construction of the processing plant and hazardous material storage facilities. The design, construction, commissioning and operations of the processing plant and associated facilities that may discharge or emit materials to the environment will be regulated by DWER under Part V of the EP Act. Further measures to mitigate potential impacts to groundwater quality are described in **Section 7.0 Terrestrial Environmental Quality**. Abstraction of groundwater will be regulated under the *Rights in Water and Irrigation Act 1914* (RIWI Act). The hydrogeological assessment will be submitted as part of the application for a licence to take groundwater.
Assessment and significance of residual impacts	Regulation of the proposal under the EP Act Part V and the RIWI Act will reduce the residual impacts to groundwater to low.

8.6 Air Quality

Table 8.7 Other Environmental Factor – Air Quality

Item	Description
EPA Objective	To maintain air quality and minimize emissions so that environmental values are protected.
Relevant Policy and Guidance	EPA Environmental Factor Guideline: Air Quality (EPA, 2020b) The impact assessment for this environmental factor focuses on point source emissions to air including particulates and pollutants that can impact on human health. Fugitive emissions to air are addressed in Social Surroundings.
Receiving Environment	The closest sensitive human receptor is located 3.2 km northeast of the processing location. Climate records for Mullewa indicate the regional prevailing wind direction in the morning is from the east-southeast with afternoon winds coming from the southwest (Bureau of Meteorology, 2020). Two of the three closest homesteads are located northeast of the mine site, and are in the direction of the prevailing afternoon winds.
Potential environmental impacts	Point source air emissions will occur from stacks as part of the processing facility. Relevant substances that are applicable to the processing operations may include sulphur dioxide or sulphur trioxide, nitrogen dioxide, ammonia, vanadium containing particulates, carbon monoxide, total suspended particulates, particles less than 10 µm (PM10) and particles less than 2.5 µm (PM2.5).
Application of the mitigation hierarchy	A screening assessment for air emissions will be undertaken in accordance with the Draft DWER Guideline: Air emissions. The stack heights and gas and dust scrubbing and filtration systems at the processing plant facility will be designed to meet relevant air quality guidelines. Continuous Emission Monitoring Systems (CEMS) will be installed on relevant stacks for real time sampling and measurement of gas and particulate emissions. AVL will apply for a Works Approval and Operating Licence under the EP Act Part V prior to commencement of construction of the processing plant. The design, construction, commissioning and operations of air emissions from the processing plant will be regulated by DWER under Part V of the EP Act.
Assessment and significance of residual impacts	Regulation of the proposal under the EP Act Part V will reduce the residual impacts of air emissions to low.

8.7 Greenhouse Gas Emissions

Greenhouse gas emissions are not expected to be a key environmental factor, as Scope 1 emissions are calculated to be below 100,000 tpa CO_2-e. A Greenhouse Gas Emissions Management Plan has been prepared for the Tenindewa Processing Facility (**Appendix A**). A summary of the assessment for greenhouse gas emissions is presented in the table below.

Table 8.8 Greenhouse Gas Emission

Item	Description
EPA Objective	To reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change
Relevant Policy and Guidance	*Environmental Factor Guideline: Greenhouse Gas Emissions* (EPA, 2020a) *Western Australia Greenhouse Gas Emissions Policy for Major Projects* (Government of Western Australia, 2019a) *Western Australian Climate Policy* (Government of Western Australia, 2020) *Future Battery Industry Strategy Western Australia* (Government of Western Australia, 2019b) *Western Australian Renewable Hydrogen Strategy* (Government of Western Australia, 2021) *Resources Technology and Critical Minerals Processing – National Manufacturing Priority Road Map* (Commonwealth of Australia, 2021) *Australia's Critical Mineral Strategy* (Commonwealth of Australia, 2019) *Guideline: Defining a 'facility' for the purposes of the National Greenhouse and Energy Reporting legislation* (Clean Energy Regulator, 2021) *Supplementary Guideline: Operational control* (Clean Energy Regulator, 2021) *The Equator Principles* July 2020 *Recommendations of the Task Force on Climate-related Financial Disclosures* (TCFD) National Greenhouse and Energy Reporting Act 2007 and associated technical guidelines National Greenhouse and Energy Reporting Regulations 2008 National Greenhouse and Energy Reporting (Measurement) Determination 2008.

Item	Description
Receiving Environment	The receiving environment of greenhouse gas emissions is the global atmosphere. The emission of greenhouse gases in one location contributes to the cumulative quantity of greenhouse gases in the global atmosphere, although the scope of the EPA's obligations is the State of Western Australia. The receiving environmental context is the emissions and policies relating to greenhouse gas management at the federal and state level. The Western Australian *Greenhouse Gas Emissions Policy for Major Projects* (Government of Western Australia, 2019a) adopted an aspirational target of net zero greenhouse gas emissions by 2050 and committed to working with the Commonwealth to achieve the targeted reductions under the Paris Agreement. The *Western Australia Climate Policy* (Government of Western Australia, 2020) commits to actions to achieve the target of net zero emissions by 2050. The policy also recognises that reduction of greenhouse gas emissions must occur to mitigate potential impacts from climate change including extreme weather events, rising sea levels, changes to climate and loss of habitats. The State *Greenhouse Gas Emissions Policy for Major Projects* is intended to apply to new significant proposals that meet the criteria of a designated large facility under the Australian Government's Safeguard Mechanism. The Safeguard Mechanism applies to facilities with Scope 1 covered emissions of more than 100,000 tonnes per annum. The Tenindewa Processing Facility will not be a large facility under the Safeguard Mechanism, as Scope 1 emissions do not exceed 100,000 t CO2-e pa at the processing facility. The EPA *Environmental Factor Guideline for Greenhouse Gas Emissions* states that proposals which expect to emit more than 100,000 tpa CO2-e of Scope 1 emissions as a direct result of activities at a facility level would be assessed for this environmental factor. The processing facility site is not expected to emit more than 100,000 tpa CO2-e of Scope 1 emissions. Potential investors are focused on the longevity of the proposal which comprises financial sustainability (minimising operating costs) as well as maintaining social and environmental licenses to operate. There are global expectations of the need to reduce greenhouse gas emissions. Social licence to operate requires the proposal to demonstrate practices that recognise and mitigate climate change risks.

Item	Description
Potential environmental impacts	Peak average annual GHG emissions for the processing facility were calculated as 95,575 t CO2-e pa, which is below the threshold that would require EPA assessment. The Proposal includes innovations to enhance energy efficiency during processing. Vanadium production from the Proposal will have 50% lower carbon emissions intensity than 70% of vanadium produced globally. Scope 3 GHG emissions associated with mining and beneficiation of vanadium concentrate and transport of large inputs and products were calculated as 114,584 t CO2-e pa. The calculated transport emissions could be reduced by mitigation throughout operations, as technologies become available. Vanadium is primarily used for strengthening steel, which reduces the volume of steel that is required to be used for applications such as rebar. If the entire volume of vanadium pentoxide planned to be produced by the Proposal each year was used in high strength low alloy steel, the **net reduction** in carbon emissions from downstream use is estimated as 14,500,000 t CO2-e pa. A growing use of vanadium is in vanadium redox flow batteries, which support the transition to a lower-carbon economy. This application is expected to drive increasing demand for vanadium and demonstrates the value of vanadium as a critical mineral and a battery metal.
Application of the mitigation hierarchy	The calculated GHG emissions for the processing facility incorporate: • design improvements developed during Proposal feasibility studies to reduce GHG emissions by over 20,000 t CO2-e pa • mitigation of GHG emissions feasible to incorporate straightaway upon proposal commencement, which will further reduce emissions by 11,000 t CO2-e pa The mitigation opportunities that are expected to be feasible upon commencement of the proposal include: • incorporation of 35% renewable power generation and battery storage into the power plant • use of 100% electric or hydrogen powered light vehicles at the processing facility • incorporation of 2% of green hydrogen into the natural gas feed These mitigations are estimated to reduce the peak Scope 1 GHG emissions to 95,575 t CO2-e pa at Proposal commencement. Additional mitigation strategies (such as inclusion of green hydrogen as an increasing proportion of the natural gas feed) are expected to be implemented during operations as technologies become available. It is also believed that further opportunities to improve efficiencies and reduce emissions will be achieved during detailed design and planned early vendor involvement, including site visits to similar operations both locally and abroad.

<table>
<tr><th>Item</th><th>Description</th></tr>
<tr><td>Assessment and significance of residual impacts</td><td>
The indicative residual Scope 1 GHG emissions for the process facility per five-year period are presented in the table below. AVL will measure and report performance against these targets each year.

Table 8.9 Scope 1 GHG Emissions Targets
<table>
<tr><th>Timeframe</th><th>Peak Annual Processing Facility GHG Emissions (t CO_2-e pa)</th></tr>
<tr><td>Commissioning and commencement of full operations (nominally 2025) to Year 5</td><td>95,575</td></tr>
<tr><td>Five years after commencement of full operations (2030) to Year 10</td><td>86,477</td></tr>
<tr><td>Year 10 (2035) to Year 15</td><td>70,754</td></tr>
<tr><td>Year 15 (2040) to Year 20</td><td>63,309</td></tr>
<tr><td>Year 20 (2045) to Year 25</td><td>58,309</td></tr>
<tr><td>Year 25 (2050) and ongoing</td><td>53,309</td></tr>
</table>

It is not feasible to reduce the processing facility GHG emissions to net zero by reduction and mitigation strategies alone, as the facility uses gas for direct heating and emits carbon dioxide from sodium carbonate transformation.

Australian Vanadium Limited (AVL) is committed to mitigating GHG emissions as much as practicable to support the transition to a low-carbon economy. This will be undertaken in a way that is financially sustainable for the Proposal. AVL acknowledges the expectations of stakeholders to continually improve GHG management and transition to net zero emissions. GHG emissions and performance will be reviewed and reported each year in a publicly available report.
</td></tr>
</table>

8.8 Social Surroundings

The EPA Objective is to protect social surroundings from significant harm.

The EPA Environmental Factor Guideline: Social Surroundings (EPA, 2016f) states that social surroundings may include Aboriginal heritage, historical heritage, amenity (impacts associated with visual amenity, noise and fugitive dust emissions) and economic surroundings that may be impacted by the physical activities of the proposal.

Other relevant policy and guidance includes:

- *Guidance Statement – Environmental Siting* (DWER, 2016)
- *Guideline – Risk Assessments* (DWER, 2017)
- *Guidance for the Assessment of Environmental Factors No. 3 - Separation Distances between Industrial and Sensitive Land Uses* (EPA, 2005).

Table 8.10 lists the social values identified near the proposal, the possible impacts, mitigation measures, and assessment of residual impacts.

The residual impact to social surroundings is expected to be low.

Table 8.10 Impact Assessment for Social Surroundings

Type	Social Values	Potential Impacts	Mitigation	Assessment of Residual Impacts
Residential Area	Mullewa Town is located at approximately 25 km northeast of the proposal area.	Increase in road traffic within townsite.	A Traffic Impact Statement has been prepared and submitted with the Development Application to the State Development Assessment Unit. The road network through Mullewa is a major highway and proposed haul trucks are compliant with the existing highway classification. Main Roads WA will review the traffic impact statement and agree road use conditions with AVL.	Traffic data for the main highway near Mullewa indicates annual average daily traffic volume is 620 movements per day (322 heavy vehicle and 298 light vehicle). The increase in traffic movements associated with the proposal through Mullewa townsite would be 20 heavy vehicle movements per day and an estimated 56 light vehicle movements per day associated with personnel residing in Mullewa. This is a 6% increase in heavy vehicle movements and 19% increase in light vehicle movements.
	Public road users	Increase in traffic volume along proposed transport routes.		
Homesteads	Wyalong – 3.2 km NE of Lot 40 Yelturtoo – 5.8 km SW of Lot 41 Kareelah – 6 km SW of Lot 40	Fugitive dust emissions from: • Wind erosion of cleared areas and stockpiles • Material handling including loading and tipping • Driving on unsealed roads • Land clearing for establishment of infrastructure	A screening assessment for fugitive dust emissions will be undertaken in accordance with the Draft DWER Guideline: Dust emissions. Fugitive dust emissions will be managed through typical controls such as water trucks on any unsealed road and sprays as needed for stockpiles and material handling. The concentrate and Fe-Ti Co-product will be transported with moisture levels suitable to facilitate handling and minimize dust emissions (typically 7-8%).	AVL will apply for a Works Approval and Operating Licence under the EP Act Part V prior to commencement of construction of the processing plant. The potential noise impacts associated with construction and operations of the processing plant will be assessed and regulated by DWER under Part V of the EP Act. Refer to **Section 8.6** for details on management of point source emissions to air.

Type	Social Values	Potential Impacts	Mitigation	Assessment of Residual Impacts
		Noise emissions from construction and operation of processing facility.	A screening assessment will be undertaken as part of the DWER Works Approval application using the DWER Guideline: Assessment of environmental noise emissions. The processing facility will be designed to meet noise limits.	AVL will apply for a Works Approval and Operating Licence under the EP Act Part V prior to commencement of construction of the processing plant. The potential noise impacts associated with construction and operations of the processing plant will be assessed and regulated by DWER under Part V of the EP Act.
Other nearby land uses	Railway line immediately north of the proposal boundary	Haul vehicle and light vehicle interactions with two level crossings on Geraldton-Mt Magnet Road and one level crossing on Erangy Springs Road.	A Traffic Impact Statement has been prepared and submitted with the Development Application to the State Development Assessment Unit. The road network along Geraldton-Mt Magnet Road is a major highway and proposed haul trucks are compliant with the existing highway classification. Main Roads WA will review the traffic impact statement and agree road use conditions with AVL.	Road usage is not expected to impact on the railway line.
	Public road users	Visual amenity impacts.	A visual amenity analysis was undertaken and submitted as part of the Development Application to the State Development Assessment Unit. The processing plant will have at least 1 km setback from the Geraldton-Mt Magnet Road. There is existing vegetation along the road and the railway. Vegetation along the road corridor will be retained where possible (with the exception of the haul road) to preserve the visual screen.	An accurate 3D model of the proposed processing facility concluded that the bulk of the facility would not be visible from the Geraldton-Mt Magnet Road.

Type	Social Values	Potential Impacts	Mitigation	Assessment of Residual Impacts
Agricultural use of land	Agricultural production within Lots 40 and 41	Loss of productive agricultural land within Lots 40 and 41 when AVL take ownership and develop the processing plant.	The proposal lies in the Mullewa Agricultural Land Area. Agricultural importance is limited by availability of fresh groundwater and low rainfall, which leads to lower yields than experienced on similar soils to the south and west (Department of Agriculture and Food, 2013). AVL will purchase Lots 40 and 41 from the landowner, which will provide financial compensation for loss of the land. Parts of Lots 40 and 41 that are not part of the processing plant development envelope and are outside of appropriate buffer zones are proposed to be leased back to the previous landowner for use.	The residual impact from loss of productive agricultural land is expected to be low.
	Agricultural production within adjoining and nearby land	The proposal could impact on agricultural productivity of adjacent and nearby land if: • Dust emissions result in accumulation of environmentally deleterious materials on nearby agricultural land outside of Lots 40 and 41 • Discharges of environmentally hazardous materials result in contamination of surface or groundwater.	A screening assessment for fugitive dust emissions will be undertaken in accordance with the Draft DWER Guideline: Dust emissions. Mitigation of impacts from discharge of contaminants is described in **Section 7.0 Terrestrial Environmental Quality**.	AVL will apply for a Works Approval and Operating Licence under the EP Act Part V prior to commencement of construction of the processing plant. The potential dust emissions and discharges of hazardous materials associated with construction and operations of the processing plant will be assessed and regulated by DWER under Part V of the EP Act.

Type	Social Values	Potential Impacts	Mitigation	Assessment of Residual Impacts
Aboriginal heritage	Tenindewa Creek (Site ID 18905) located 8 km east of the proposal location	Due to the distance from the proposal, no impacts to Tenindewa Creek are expected. It is possible that excavation associated with construction could unearth Aboriginal artefacts or remains.	The design, construction, commissioning and operations of the processing plant and associated facilities that may discharge or emit materials to the environment will be regulated by DWER under Part V of the EP Act. The proposed area is largely cleared, and no evidence of Aboriginal sites has been found during a desktop search of the Aboriginal Heritage Inquiry System. Should any Aboriginal artefacts or human remains be encountered during construction or other excavations, all nearby excavation work will cease and appropriate authorities will be notified.	No residual impacts to Aboriginal heritage sites are expected.

8.9 Human Health

Table 8.11 Other Environmental Factors - Human Health

Item	Description
EPA Objective	To protect human health from significant harm
Relevant Policy and Guidance	Environmental Factor Guideline: Social Surroundings (EPA, 2016f)
Receiving Environment	Material and waste characterisation undertaken to support the proposal approvals have not identified the presence of any radioactive metals in the mine orebody and hence in the vanadium concentrate arriving at the Processing facility.
Potential environmental impacts	No likely impacts
Application of the mitigation hierarchy	No mitigation controls required
Assessment and significance of residual impacts	No residual impacts

9.0 Matters of National Significance

The DAWE Protected Matters Search Tool (PMST) was used to identify any MNES that could trigger a referral under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). A summary of the search has been presented in **Table 9.1**.

Table 9.1 Commonwealth Factors Impact Summary

Factor	Present	Description	Comments
World Heritage Properties	No	Not applicable	
National Heritage Places	No	Not applicable	
Wetlands of International Importance	No	Not applicable	
Great Barrier Reef Marine Park	Not applicable	Not applicable	
Commonwealth Marine Area	Not applicable	Not applicable	
Listed Threatened Ecological Communities	No	Not applicable	No Listed Threatened Ecological Communities present
Listed Threatened Species (flora)	Yes	Potential presence of 5 listed flora species.	Database searches identified five flora species as having some potential to occur (ranging from 'may' to 'likely'). *Styphelia marginata* was also identified as being recorded in a nearby road reserve in 1986. The presence of any listed flora species will be confirmed through a flora survey in 2022. Refer to **Section 6.0** for more information.
Listed Threatened Species (fauna)	Yes	Potential presence of 8 listed fauna species.	Database searches identified eight fauna species as having some potential to occur (ranging from 'may' to 'likely'). However, it is not expected that fauna will be directly impacted by the Proposal due to the low density of fauna habitat in the area. Any indirect impacts will be managed through DWER approvals and licences. Refer to **Section 8.3** for further detail.
Listed Migratory Species	Yes	Potential presence of 7 species comprising avifauna.	The Protected Matters Search Tool identified one migratory marine bird, five migratory wetland birds, and one migratory terrestrial species that may occur. Due to the migratory nature of these species and the likely low habitat value of the Proposal area, there is not expected to be any significant impacts to migratory species.

At this stage, it is expected that no direct impacts to any MNES will occur as part of this proposal unless targeted flora surveys identify the presence of *Styphelia marginata* or any other species classified under the EPBC Act. Any proposed native vegetation clearing will be adjusted where possible to avoid locations of listed flora. If this is not possible then the appropriate approvals will be sought.

10.0 Holistic Impact Assessment

The impact assessment presented in the above sections discusses each environmental factor individually. However, there are interactions between the environmental factors that can amplify or mitigate impacts. The holistic impact assessment presented here describes the interactions between environmental factors and impact of the proposal on the environment as a whole.

Accidental discharges to land are primarily assessed for the potential impact on terrestrial environmental quality. Other environmental factors that may be impacted by discharges to land include surface water, groundwater, and social surroundings. These impacts are described in the above sections. The potential impacts from accidental discharges and emissions to land will be regulated by DWER through the Works Approval and Licence application under Part V of the EP Act.

Emissions to air, including particulates, fugitive dust emissions, and substances hazardous to human health, may impact on air quality, terrestrial environmental quality, social surroundings, and possibly flora and vegetation. The potential impacts from air emissions will be regulated by DWER through the Works Approval and Licence application under Part V of the EP Act.

Use of the land will result in a small amount of native vegetation clearing. Due to extensive clearing in the region for agriculture, even small amounts of native vegetation clearing can be significant if they provide key habitat for protected fauna or flora. However, there are three nature reserves within 5 km of the proposal site that provide protection for flora and habitat representative of the region. Nevertheless, a flora survey will be undertaken to check for the presence of protected flora prior to undertaking any land clearing. Clearing of native vegetation will be assessed and regulated by DWER through the Native Vegetation Clearing Permit process.

Use of the land will also result in loss of productive agricultural land, which is a potential impact to social surroundings. However, substantial consultation with the landowner and nearby landowners has demonstrated support for the proposal. Locating the processing plant near rural towns provides opportunities for the workforce to be drawn from nearby residents, or for workers to live in nearby towns, boosting the economic activity of the region. The workforce is expected to reside in nearby towns, rather than the typical fly-in-fly-out (FIFO) model of remote sites. A residential workforce benefits from better work-life balance compared to FIFO workers and families.

The proposal is also expected to bring positive impacts via creation of job opportunities while supporting local businesses. The construction phase of the proposal is expected to employ a maximum of 450 people, and operations phase would employ around 125 people.

The proposal will contribute direct greenhouse gas emissions from on-site activities. However, downstream use of vanadium pentoxide as a strengthening agent in steel (primary use) was calculated to result in net offset (reduction) of global greenhouse gas emissions by approximately 14,093,000 t CO_2 pa.

Where applicable AVL has applied the mitigation hierarchy to identify measures to avoid, minimize and rehabilitate environmental impacts including:

- Minimise clearing of native vegetation by locating the processing facility in an area that has previously been cleared.
- Avoid and minimize risk of discharges of hazardous materials to the environment by appropriate design, construction and management of storage facilities.
- Design and location of the processing plant to maximise value from concentrate and minimise wastes.

- Avoid impacts to groundwater-dependent ecosystems and other groundwater users by taking water from the deep aquifer.
- Manage light, dust and noise emissions during construction and operational phase.
- Minimize generation of GHG emissions as far as practicable.

Overall, the potential environmental impacts of the proposal are expected to be low and can be adequately assessed and regulated by other decision-making authorities. The proposal is unlikely to impact the surrounding environment on a local, regional and state scale.

11.0 Cumulative Impact Assessment

Cumulative impact assessment as described in the *Statement of environmental principles, factors, objectives and aims of EIA* (EPA, 2021d) considers the incremental impacts on the environment of a proposal as well as other reasonably foreseeable future activities.

There are numerous approaches that can be taken for cumulative impact assessment, as outlined in the *Cumulative Environmental Impact Assessment Industry Guide* (Minerals Council of Australia, 2015). The cumulative impact assessment presented here considers both:

- the cumulative impact of other known proposals in the region on regional environmental factors
- the cumulative impacts of other AVL proposals where sufficient information is known to undertake an impact assessment, and where the environmental impacts from the proposals occur in the same region.

These two approaches to cumulative impact assessment are presented below.

11.1 Cumulative Impact from Known Proposals in the Region

Two proposals have been identified in the region that have recently been assessed or are under assessment by the EPA (**Table 11.1**). These proposals were reviewed to identify the risk of cumulative impacts to environmental factors relevant to the Tenindewa Processing Facility.

Table 11.1 Nearby Proposals Recently Under Assessment by the EPA

Proposal Title	Key Environmental Factors	Status of Impact Assessment
Northern Goldfields Interconnect Pipeline	Social Surroundings, Flora and Vegetation, Terrestrial Fauna	Approved, Ministerial Statement 1184 approved on 2 February 2022
Yogi Magnetite Project	Preliminary environmental factors: Air Quality, Social Surroundings, Flora and Vegetation, Subterranean Fauna, Terrestrial Environmental Quality, Terrestrial Fauna, Hydrological Processes, Inland Waters, Environmental Quality	Environmental Review published for public comment 15 April 2020. No further stages of EPA Assessment publicly available.

The publicly available information for each of these proposals was reviewed to identify any cumulative impacts or key learnings applicable to the development of the Tenindewa Processing Facility. This review focussed on flora and terrestrial fauna, which may be relevant if any significant flora or fauna values are identified during the detailed flora survey.

The flora and fauna surveys for these two regional proposals did not encompass the Tenindewa Proposal location or any area within approximately 15 km. Nevertheless, the desktop studies identified some of the same significant taxa that may be present near Tenindewa. Significant taxa that have been identified in these regional surveys will be included in the targeted search for the Tenindewa Proposal, where relevant to the environmental context.

The Ministerial Statement for the Northern Goldfields Interconnect Pipeline defined that the proposal is limited to the following extent of direct impacts relevant to flora and fauna:

- disturbance of up to 1,930 ha of native vegetation
- no more than 0.28 ha of Eucalyptus Woodlands of the Western Australian Wheatbelt community
- not more than 0.25 ha of foraging habitat for Carnaby's cockatoo
- no direct or indirect impacts to threatened flora species *Eucalyptus beardiana.*

The Tenindewa Processing Facility proposal does not anticipate any direct impacts to any of these significant environmental values. This will be confirmed following the targeted flora survey and impacts to significant environmental values will be avoided where possible.

The Yogi Magnetite Project Environmental Review Document proposes clearing of no more than 200 ha of native vegetation within the pipeline development envelope. The proposal has not yet been approved by the EPA. The Environmental Review Document Limited had limited information on the locations of significant flora and predicted impacts from the pipeline corridor. Therefore, no cumulative impacts have been identified from development of the Tenindewa Processing Facility and the Yogi Magnetite Project.

No cumulative impacts to regional significant flora and fauna values are expected due to development of the Tenindewa Processing Facility Proposal.

11.2 Cumulative Impact of AVL Proposals

AVL has two proposed facilities that are sufficiently progressed to assess the potential environmental impacts: this Tenindewa Processing Facility proposal, and the Mine and Beneficiation Operations proposal.

The only environmental region that encompasses both proposals is greenhouse gas emissions, which apply to a global region. The Mine and Beneficiation Operations would be located near Meekatharra, which is a separate environmental region to the Tenindewa Processing Plant for all other environmental factors. Therefore, the cumulative impact assessment of AVL proposals relates only to greenhouse gas emissions.

Vanadium concentrate for the Tenindewa Processing Plant may be sourced from numerous locations. The Mine and Beneficiation Operations produce vanadium concentrate, which is one source of concentrate for use in the Tenindewa Processing Plant. Alternative sources of vanadium include vanadium concentrate from other vanadium mines in Western Australia, or vanadium-rich slag which may be sourced from offshore steel manufacturers (for example in New Zealand). For this assessment, it is assumed that vanadium concentrate would be sourced from the Mine and Beneficiation Operations.

Table 11.2 below summarises the calculated greenhouse gas emissions for the Tenindewa Processing Facility and other components of upstream and downstream emissions during operations. The second part of the table sums different ways to measure "cumulative" greenhouse gas emissions, depending on where the boundary of the proposal is drawn.

Cumulative direct emissions from the Proposal are calculated as a peak of 95,575 t CO_2-e per annum. Cumulative direct and indirect emissions from the Proposal based on the global environmental region that is applicable for greenhouse gas emissions are calculated as a net negative 14.5 million t CO_2-e per annum due to reduction in emissions from steel manufacture through strengthening steel with vanadium.

Table 11.2 Calculated Cumulative Operational Greenhouse Gas Emissions for AVL Proposals

Item	Description	Calculated GHG Emissions (t CO_2-e per annum, base case scenario)
Calculated GHG Emissions		
Tenindewa Processing Facility	Scope 1 direct emissions for the proposal	95,575
Mine and Beneficiation Operations	Direct emissions calculated at the mine facility	60,717
Transport – onshore (within WA)	Indirect (Scope 3) emissions – transport for mine facility including concentrate to processing plant	103,297
	Indirect (Scope 3) emissions – transport for processing facility. Includes transport of fuel, reagents, and products (V_2O_5 and FeTi coproduct) within Western Australia.	11,287
Use of vanadium in steel	Indirect (Scope 3) net emissions associated with use of vanadium to strengthen steel, assuming all V_2O_5 produced by AVL is used for this purpose	- 14,700,000
Cumulative GHG Emission Calculations		
Cumulative Proposal	Direct (Scope 1) emissions from this proposal	95,575
Cumulative onshore	Calculated direct and indirect emissions from all associated activities within WA	210,159
Cumulative global (GHG Environmental Region)	Calculated direct and indirect emissions from all associated activities worldwide	- 14,489,841

The cumulative global impact of the Proposal is calculated to be a significant net reduction in greenhouse gas emissions.

12.0 Additional Information

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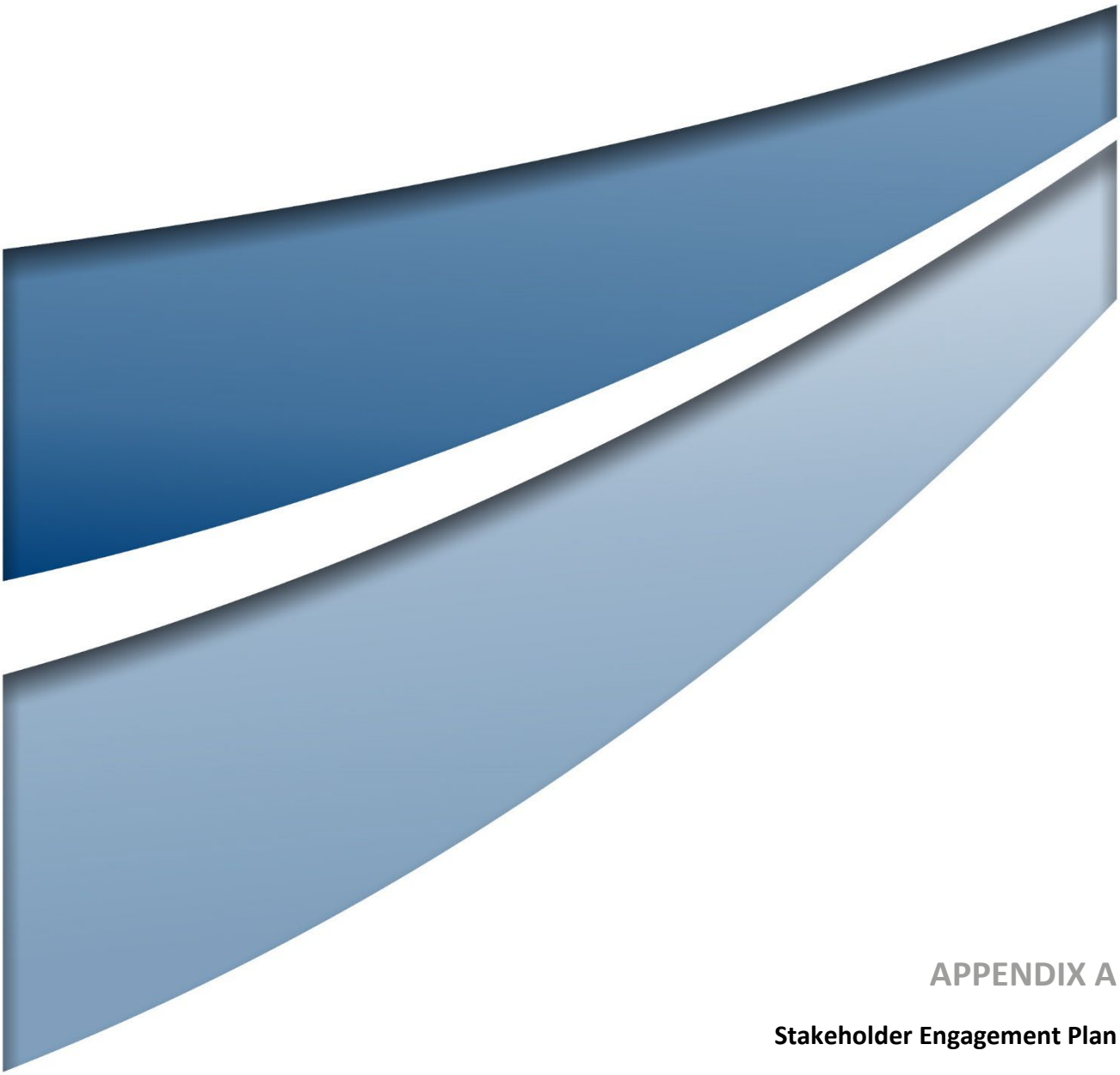


APPENDIX A

Stakeholder Engagement Plan

Creating a Green Fuelled Vanadium Battery Industry

Stakeholder Engagement Plan

Contents

Introduction

The Stakeholder Engagement Plan includes processes required to identify the people, groups and organisations that could affect or be affected by the Project, and to analyse stakeholder expectations and impact on the Project. It outlines a systematic approach to stakeholder engagement that will help AVL develop and maintain over time a constructive relationship with their stakeholders throughout the duration of the Project.

AVL is undertaking ongoing consultation with a range of stakeholders and interested parties. This stakeholder engagement plan is a dynamic document and will be regularly reviewed, updated, and expanded as needed by AVL throughout all stages of project implementation.

This Stakeholder Engagement Plan will include:

- Stakeholder Identification and Analysis: identify groups and organisations that have significant influence on project direction or who are significantly impacted by the Project.
- Stakeholder Impact Analysis: to analyse stakeholder expectations and their impact on the Project.
- Stakeholder Engagement Activities: outlines the processes and steps undertaken to implement the planned stakeholder engagement and management strategies.
- Timeline.

Resources and Responsibilities

AVL exists to create superior and sustainable returns for all stakeholders through exploration, development and operation of the world leading Australian Vanadium Project and downstream processing opportunities. AVL recognises that the success of the Project will depend on developing an open relationship with a wide range of local and regional stakeholders. AVL strives to keep stakeholders informed on the various developments in the various stages of the Project and will continue to proactively consult stakeholders as the Project progresses.

To effectively manage stakeholder engagement, AVL has a team to communicate project related information to key stakeholders in a proactive and timely manner. This will provide increased support and minimise stakeholder resistance throughout the life of the Project. Managing stakeholder engagement helps to increase the probability of project success by ensuring that stakeholders clearly understand the Project's goals, objectives, benefits, and risks.

The stakeholder management team consists of:

- Vincent Algar – AVL's Managing Director
- Samantha McGahan – AVL's Stakeholder Engagement Manager
- Amy Chadbourne – AVL's Community Relationship Advisor

Vincent Algar is AVL's Managing Director and is primarily responsible for managing and liaising with the different stakeholders. Vincent will play a lead role in building positive and mutually beneficial relationships with all stakeholders. Vincent will be managing the collaborative stakeholders for this program, ATCO and Bryah, the Federal and State Government and regulatory and industrial bodies. Vincent will provide full and timely disclosure of relevant information to stakeholders.

Samantha McGahan is AVL's Stakeholder Engagement Manager and is primarily responsible for managing and implementing the Stakeholder Engagement Plan. She will also be responsible for the liaison and communication with different stakeholders. Samantha has been appointed Chair of the Meekatharra Community Resource Centre (CRC) committee as a result of her engagement in the Meekatharra region.

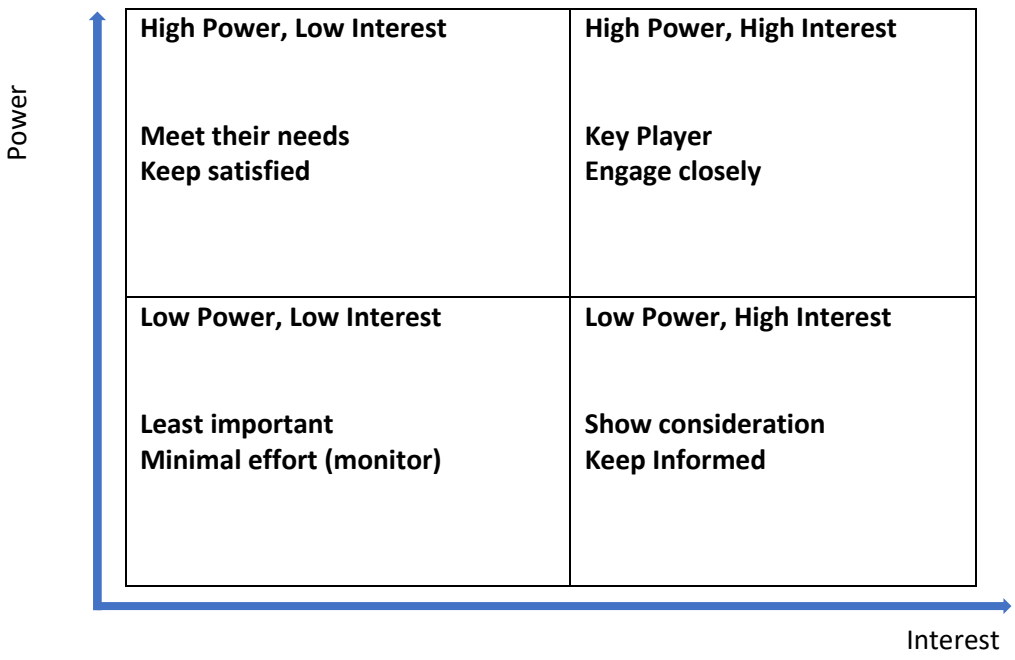
AVL has appointed Amy Chadbourne, to be based in Geraldton, as AVL's Community Relations Advisor for the Mid-West region. Amy will liaise with stakeholders across the region and communicate AVL's plans for the mine site and CMB plant in the Meekatharra region, and the processing plant near Mullewa. She has built a strong relationship with the owners of the processing plant site.

AVL believes that stakeholder engagement is the responsibility of all staff and that each person has a role to play. For example, Geologists in the team are involved in Heritage Surveys and meetings. In the Meekatharra region Tony Standish and Gemma Lee, AVL's Senior Geologists have undertaken numerous engagement activities with members of the Yugunga-Nya People Traditional Owners and Pastoralists. Chief Operating Officer, Todd Richardson maintains relationships with the company's consultants and members of government.

Stakeholder Identification and Impact Analysis

AVL has identified stakeholder groups that may be affected by and be interested in the implementation of the Project. Stakeholders will be identified by performing a stakeholder analysis in which potential stakeholders and relevant information, interests, involvement, interdependencies, influence, and potential impact on project success are identified and analysed.

A wide range of stakeholders have been engaged according to the area(s) of the Project with which they are most involved. The below table summarises the engagement strategy for key external stakeholders that have been engaged regarding the Project as a whole, encompassing both the mine site and the downstream processing plant. These stakeholders include federal and state government agencies and elected officials. Some parties, such as local and specialised stakeholders, have been engaged regarding either the mine location or the processing location. The below matrix will be used to evaluate each stakeholder's bearing on the Project by combining their impact and influence, to enable AVL to develop and implement an engagement management strategy effectively.



Please note: Impact is measured by High (H), Medium (M) or Low (L). State of change readiness is assessed using the measures from the Project Management Body of Knowledge (PMBOK) as follows:

- U – Unaware – this group has no information about the Project.
- R – Resistant – aware of project and resistant to the changes and impacts the Project may bring.
- N – Neutral – aware of the Project and neither supportive nor resistant.
- S – Supportive – aware of the Project and the potential changes and impacts and is supportive.
- L – Leading – aware of the Project and actively engaged to ensure the Project's success.

To assist with stakeholder identification and analysis AVL has created a stakeholder register categorised by stakeholder group. The register captures the following information:

- Group name.
- Description of the stakeholder.
- Level of impact on the Project.
- Level of impact on the group by the Project.
- Role of each group.
- Strategies and actions to address issues, risks, and opportunities.

Stakeholder Group	Stakeholder	Level of impact on the Project	Level of impact on the group by the Project	Role	Strategies and actions
Business to Business Collaboration	Bryah Resources Limited	L	H	Transform downstream mineral processing supply chains and capture 31.3 million tonnes of nickel-copper-cobalt minerals at the Australian Vanadium Project through a base metal concentrate collaboration	AVL and Bryah are working together to maximise the recovery of metals from this world-class Vanadium-Titanium-Magnetite (VTM) deposit, with Bryah taking the lead on further studies relating to the base metal recovery circuit. AVL holds the mineral rights to vanadium, titanium, iron and cobalt and is a major shareholder (4.44%) of Bryah.
	ATCO Australia Pty Ltd	L	L	Supply of renewable energy (renewable hydrogen) for 10 years	AVL and ATCO are working together to enable the use of green hydrogen in the natural gas supply of the Project processing plant, thereby reducing the carbon footprint and supporting the emerging hydrogen industry in Australia. AVL and ATCO have an MOU to accelerate deployment of the green hydrogen in the critical mineral processing sector.
	Westgold Resources Limited	L	L	Supply of Life-of-Mine (LOM) water requirements for the Australian Vanadium Project. This option will utilise excess water that flows into Westgold's Meekatharra Gold Operation, leading to positive outcomes for both parties and responsible management of valuable high-quality water resources.	AVL has signed a co-operation and access agreement with Westgold for access to excess water from Westgold Operations. A Letter of Agreement is expected to progress to a formal agreement within 3 years.
	Amec Foster Wheeler Australia Pty Ltd (Wood)	L	L	Project design and final engineering components of the mining concentration and processing plant facilities	Wood being AVL's engineering consultant, is assisting with the Bankable Feasibility Study and vanadium processing plant design based on the results of initial testwork undertaken.
	ALS Metallurgical	L	L	Benchscale and pilot scale testwork	ALS are performing most testwork that will provide data for the engineering design of the process plant. Work is ongoing to produce ultra-high purity vanadium as a feed stock for the vanadium electrolyte plant. This will ultimately allow the production of an Australian vanadium redox flow battery.
	Primero Group Pty Ltd	L	L	Downstream processing capabilities to collaboratively develop and construct a modular and scalable vanadium electrolyte plant.	Primero is an engineering group with capability in design, build and operation of mineral processing plants. AVL will work with Primero on the final design and construction of a vanadium electrolyte plant. Primero have additional capability in Mineral

Stakeholder Group	Stakeholder	Level of impact on the Project	Level of impact on the group by the Project	Role	Strategies and actions
					Processing relevant to the CMB (Crushing Milling and Beneficiation) plant which produces vanadium concentrate and will support AVL with knowhow and Front End Engineering Design after Financing.
	Horizon Power	S	S	VRFB Offtake	AVL have had discussions with different grid operators for enabling deployment of renewable energy to the market and which will also lead to direct emission reductions.
	Western Power	S	S		
International Business	US Vanadium Holding Company LLC	L	L	IP required for the production of electrolyte in the AVL vanadium electrolyte pilot-scale production facility will be licensed by AVL from US Vanadium.	MOUs for Vanadium offtake, high purity vanadium purchase and electrolyte technology transfer have been signed with specialty chemical producer U.S. Vanadium
	VRFB Manufacturers			Vanadium or vanadium electrolyte offtake	AVL has undertaken discussions with international VRFB manufacturers for offtake of vanadium or vanadium electrolyte manufactured by AVL in Australia. AVL has signed MOUs with various VRFB manufacturers for vanadium pentoxide and vanadium electrolyte offtake arrangements to support global VRFB sales.
	Enerox GmbH (CellCube)	S	S		
	Invinity Energy Systems	S	S		
	Sumitomo Electric	S	S		
	SCHMID	S	S		
	E22	S	S		
	CEC VRFB	S	S		
	V-Flow Tech Pte Ltd	S	S		
	WattJoule	S	S		
Research Collaboration	Curtin University	L	L	Extend and commercialise existing collaborative partnerships with research institutions to scale the Project's IP and technical proponents.	Ongoing research arrangements to improve vanadium production technologies, minimise environmental impact, and maximise the value of products and co-products.
	ANSTO	L	L		
	Newcastle University	L	L		
	FBICRC	S	S	AVL is working together with FBICRC on developing vanadium extraction and processing skills, particularly in Western Australia.	AVL has signed an agreement to offer in-kind services to the FBICRC.

Stakeholder Group	Stakeholder	Level of impact on the Project	Level of impact on the group by the Project	Role	Strategies and actions
Traditional Owners	Yugunga-Nya People	S	S	Impacts to land use and ethnographic sites, discovery of Aboriginal artefacts. Heritage protection. Employment and contracting.	Consultation and negotiation has been in progress since 2015. Four Aboriginal surveys involving Yugunga-Nya representatives have been completed ahead of submitting a referral to the EPA. Discussions have been held to address various concerns and de-risk any issues that might arise. Identify archaeological sites and prior to a commencing a program of works, AVL's geologists shall prepare a Planning Memorandum to ensure that the restricted areas are known to all. Discuss and identify employment opportunities for the Yugunga-Nya People. The Claim of the Yugunga-Nya people was dismissed in 2019 by the register of Native title claims, resulting in large areas previously claimed no longer being under Native Title. This includes the Project tenure. Members still identifying with the claim group live in Geraldton, Perth and Meekatharra and are involved with all aspects of society from Heritage to contractor business. AVL will continue to work within the requirements of the Heritage Act, as well as actively engage with members on opportunities on and around the Project.
Community Groups	Stephen Michael Foundation Mission Australia Shooting Stars Eon Foundation	S	S	Socio-economic benefits for the local area	AVL sponsors the Stephen Michael Foundation which engages the local children in education through sport and other activities. AVL has supported Mission Australia and has had discussions with Shooting Stars and Eon Foundation regarding support for their work.
Local Landholders	Farmers	S	S	People residing (or using land), and owners of businesses operating in Project areas where land has been, or will be used, as well as areas expected to be impacted by transportation.	Discussions with land owners in relation to impacts the Project will have on their land, noise, emissions etc. Regularly engage local stakeholders to capture their views and ensure they are understood by the Project team and considered in decision making where possible. AVL team met with the families in October 2019, all of them are supportive of the Project and interested in ensuring the impact of dust and noise, as well as impacts of truck movements on them would be minimal.
	Mark Canny	S	S		
	Dave Green	S	S		
	Tim Freeman	S	S		
	Nick Green	S	S		
	Peter Freeman	S	S		
	The Smith Family	S	S		
	The Critch Family	S	S		

Stakeholder Group	Stakeholder	Level of impact on the Project	Level of impact on the group by the Project	Role	Strategies and actions
	Rod Messina	S	S		The land owners and families have also expressed interest in the additional water supply to their property and expansion of the airstrip.
	Glenn and Eliza Thomas	S	S		
	Offelia and Geoff Kowald	S	S		
	Brendan Weir	S	S		
	Hill View Station	S	S	Impact on biosecurity. Carbon farming. Interaction with pastoral activities. Contracting opportunities. Post-mine rehabilitation. Transport routes. Dust and noise impacts and final land form.	Various interactions between AVL and the owners and station managers to discuss the arrangements for land access and recognise the proposal impacts to carbon farming activities. Ongoing consultation has occurred and AVL has received in principle agreement prior to submitting referral to EPA.
	Polelle Station	S	S	Groundwater drawdown, areas of disturbance, impacts to pastoral activities, post-mining rehabilitation, final landform, impacts on local roads, transport routes, dust and noise impacts. Contracting opportunities.	Multiple ongoing engagements with the owners and station managers to discuss the rehabilitation plan to be undertaken at the end of project life. Consultation with the landowners and other key stake holders to prepare the mine closure plan. AVL has received in principle agreement ahead of submitting referral to the EPA. Continuing consultation throughout operations.
	Yarabubba Station	S	S	Interaction with pastoral activities. Contracting opportunities. Post-mine rehabilitation.	Various interactions between AVL and the owners and station managers to discuss any concerns and raise any issues in relation to the Project.
Adjoining Tenement Holders	Technology Metals Australia Limited	S	S	Miscellaneous licence across AVL tenure to access its southern tenement.	Discussions between AVL and Ian Prentice, Managing Director to discuss access to TMT southern tenements. Confidentiality agreement signed relating to the Southern Mining Licence application of AVL and TMT.
	Monument Mining Limited	S	S	Possible source of good quality water. Use of haul road for access. Monument benefit by dewatering pits enabling unmined resources below the pits to be accessed and mined.	Ongoing discussions between AVL and Monument Mining CEO around potential access to water on Monument Mining tenements. Non-disclosure agreement signed concerning water, land access and gold exploration.

Stakeholder Group	Stakeholder	Level of impact on the Project	Level of impact on the group by the Project	Role	Strategies and actions
Federal Government	Major Projects Facilitation Agency	S	S	Major Project agency for the Project.	Engagement has been ongoing since February 2019 with Major Project status awarded in September 2019. Regular meetings with Ministers (Minister for Industry, Science and Technology, Minister for Resources and Northern Australia, Minister for Defence Industry) and Advisors to provide update on progress of the Project.
	Northern Australian Infrastructure Fund	S	S	Meekatharra is within the NAIF area and the Proposal meets the NAIF funding remit. Contact is to be maintained until plans are certain enough to apply for funding. The benefit to the local community is a key NAIF eligibility consideration, particularly benefits to the Indigenous community through healthcare and education facilities.	Various meetings between Directors and Associate Director to discuss and provide an update on the proposal progress and consult regarding finding applications.
	Department of Biodiversity, Conservation and Attractions (DBCA)	S	S	Conservation of significant flora and fauna, and adequacy of ecology surveys.	Meeting/correspondence associated with environmental impact assessment to conservation / significant ecological values.
	Hon Christian Porter MP – Minister for Industry, Science and Technology Hon Keith Pitt - Minister for Resources and Northern Australia Hon Melissa Price MP – Minister for Defence Industry Senator Linda Reynolds CSC – Minister for Government Services- Senator for Western Australia	S	S	AVL's Major Project Status, the Project's prospective economic benefits and supply of critical minerals.	Consult with and keep informed of project progress. Members have consistently expressed support for the Project.

Stakeholder Group	Stakeholder	Level of impact on the Project	Level of impact on the group by the Project	Role	Strategies and actions
	Department of Water and Environmental Regulation (DWER) – Office of the Environmental Protection Authority	S	S	Assessment of Project under Part IV of the *Environmental Protection Act 1986* for any potentially significant impacts on environmental factors.	Meetings have been held prior to submitting referral to the Environmental Protection Authority. Consultation will continue through the Project referral assessment process.
State Government	Department of Mines, Industry Regulation and Safety (DMIRS)	S	S	All aspects of environmental impact assessment, land disturbance and vegetation clearing, mining landforms, management of dangerous goods, Mining Proposals, Mine Closure Plan, Programs of Work Tenement conditions Closure and rehabilitation Safety.	DMIRS is the lead agency for AVL. Recurring fortnightly meeting since 15 May 2020 in providing assistance, advice and government department contacts related to environment, heritage, mining, land use and roads. Jenny Oosterhof is AVL's main point of contact at DMIRS as the responsible agency for the Project's Lead Agency Status. Consultation to continue prior to submitting Mining Proposal and Mine Closure Plan
	Department of Planning, Lands and Heritage (DPLH)	S	S	Aboriginal heritage. Crown land administration. Heritage, cultural and archaeological sites.	As Required, Planning approval, particularly the re-zoning of areas associated with the processing plant.
	Environmental Protection Authority Services	S	S	Environmental impact assessment support to the EPA	Ongoing discussions with EPA around environmental impact assessment based on possibly locating disturbance anywhere within the development envelope.
	Department of Water and Environmental Regulation (DWER)- Licensing	S	S	Assessment of works approval for development of prescribed premises under Part V of the *Environmental Protection Act 1986*, including crushing, milling and beneficiation plant, refinery, power plant, wastewater treatment plant and tailings storage facilities.	Scoping meeting will be held prior to submitting the works approval application. Consultation will continue through the works approval assessment process.
	Department of Water and Environmental Regulation (DWER) – Water	S	S	Assessment of application for licenses to install bores and abstract groundwater.	Meetings held. Further consultation will be undertaken prior to and through the water licensing assessment process.

Stakeholder Group	Stakeholder	Level of impact on the Project	Level of impact on the group by the Project	Role	Strategies and actions
	Department of Jobs, Tourism, Science and Innovation (JTSI)	S	S	Proposal for Job creation and provide expertise to facilitate major downstream projects in critical minerals and other priority commodities.	Discussions with JTSI's Deputy Director of General Strategy and International Engagement, Simone Spencer to promote the Australian Vanadium Project and attract investment in the critical and battery mineral market. Provide insights, including the opportunities presented by advanced manufacturing and remote operations for the mining industry, and financing models employed by a range of commodities. Vincent Algar is a member of the Future Battery Industry Taskforce run through JTSI and chaired by the Hon Bill Johnston MLA. Samantha McGahan is a member of the Future Battery Industry Working Group.
	Main Roads WA (MRWA)	S	S	Use of public highways ad main roads for heavy vehicle movements. Potential impacts on main roads, heavy vehicle movements, transport routes, transport of dangerous goods.	Ongoing communications between AVL and MRWA on proposed truck routes, movements and freight quantities. AVL have and will continue to consult to secure in-principle agreements prior to submitting a referral to the EPA and discussions around safety and efficiency improvements.
	Mid-West Development Corporation	S	S	The Project's prospective socioeconomic benefits to the Mid-West region. Interest in the location of the processing plant.	AVL had multiple meetings with the Chairman, CEO and Project Manager to discuss the Project proposal and associated benefits to the region. Assisted in contacting key members of the commission and several stakeholders in the Mid-West region.
	Ian Blayney MLA – Liberal Member for Geraldton Vince Catania MLA – National Member for North West Central Hon Stephen Dawson MLC – Minister for Mental Health; Aboriginal Affairs; Industrial Relations	S	S	The Project's prospective socioeconomic benefits to the state and mid-west region. Interest in the location of the processing plant. Interest in the role of vanadium supply in the renewable energy industry and the application of green hydrogen in industry.	Consult with and keep informed of project progress. Members have consistently expressed support for the Project. Several members have facilitated collaboration with relevant stakeholders.

Stakeholder Group	Stakeholder	Level of impact on the Project	Level of impact on the group by the Project	Role	Strategies and actions
	Hon Bill Johnston MLA – Minister for Mines and Petroleum; Energy; Corrective Services Ronald Shane Love MLA – National Member for Moore Hon Alannah MacTiernan MLC – Minister for Regional Development; Agriculture and Food; Hydrogen Industry Hon Darren West MLC – Member for Agriculture; Parliamentary Secretary to Minister for Regional Development				
	Royal Flying Doctors Service	S	S	Runway upgrade at Polelle.	Meeting with Ian Ruff.
Local Government	Shire of Meekatharra	S	S	Road use. Development of infrastructure corridor. Regional employment and economic growth (socio-economic benefits for the local area). Wastewater treatment plant. Regional Infrastructure (including roads and airports).	AVL has consulted with Shire staff and received verbal support. On-going engagement throughout operations.
	Shire of Cue	S	S	Road construction and use. Development of infrastructure corridor. Regional employment and economic growth.	Multiple meetings between AVL and Shire President, CEP and Community and Development Services Manager to discuss the Project and the associated employment and economic benefit it will bring to the region.

Stakeholder Group	Stakeholder	Level of impact on the Project	Level of impact on the group by the Project	Role	Strategies and actions
	City of Greater Geraldton - Shane Van Styn (Mayor)	S	S	Socio-economic benefits for the local area.	Multiple meetings held with Shane and other members of the City of Geraldton. Very supportive of the Project and have been assisting where possible.
	Greater Geraldton Council	S	S	Location for the Vanadium Processing Plant. Assist to secure close proximity transport infrastructure from the processing facility to the mine.	Option Agreement for land, to locate its processing plant near to the City of Geraldton. Frequent discussions with the local stakeholders regarding the number of opportunities for the local communities, such as: • increased Mid-West region employment opportunities; • utilises existing gas, water, road and rail infrastructure; • close to Mid-West industry services platform; • benefits to flow through to the communities of Mullewa and Geraldton.
	Geraldton Port	S	S		
	ARC Rail infrastructure	S	S		
	Water Corporation	S	S		
	Department of Water	S	S		

Stakeholder Engagement Activities

To ensure the correct level of engagement is being achieved by each stakeholder, AVL has employed a strategy of engaging early, and often with a wide range of stakeholders. Engagement to date has comprised a progressive broadening of consultation with key stakeholders. As part of this, AVL has adopted the process of regularly communicating and working with key stakeholders to meet their needs and expectations, and to address any potential issues as they occur. The stakeholder engagement process assists to systematically foster appropriate stakeholder engagement throughout the life of the Project. The key benefit of this process is that it provides a clear, actionable plan to interact with project stakeholders to support the Project's interests.

Stakeholder engagement activities have been undertaken by AVL since 2012, with the identification of and engagement with parties directly affected by the Project. Consultation with stakeholders is frequent and ongoing, and AVL is undertaking on-going discussions with a range of stakeholders and interested parties. AVL strives to keep stakeholders informed of developments in the Project planning and will continue to proactively consult stakeholders as the Project progresses. Public meetings, consultations, systems, procedures and management plans will be used to align the key stakeholders, namely the Project team, AVL's operations team, the contractors, the workforce and the community, in order to achieve the Project objectives. Feedback is provided to the Board and Senior Management after consultation with stakeholders to ensure that any concerns or recommendations are considered, and where possible, incorporated into the proposal planning and implementation. Broad stakeholder communications are maintained through a variety of channels including an emailing list, ASX announcements and social media.

Engagement with Business stakeholders

To ensure the correct level of engagement with different business stakeholders, AVL has been undertaking regular reporting on project progress, impacts and undertaken measures throughout the implementation of the Project with the different business stakeholders.

AVL is focused on completing a Bankable Feasibility Study for the Australian Vanadium Project and has frequent discussions with Bryah Resources to progress the studies of extracting value from the non-magnetic waste stream. The concept of maximising value from the resource is an important part of the AVL value proposition. AVL will assist Bryah Resources with samples from their non-magnetic tailings and also samples of drill core from its southern pit areas to progress further feasibility studies into the flotation of the Ni-Cu-Co sulphides. The strategy also strongly complements AVL and Bryah Resources' involvement in critical and battery metals as their demand increases.

As the Project progresses towards production, AVL will collaborate with ATCO for the supply of green hydrogen from the 10MW electrolyser at ATCO's Clean Energy Innovation Park to the planned processing plant near Geraldton. Hydrogen generated will be transported via truck to gas network injection points. AVL will be able to consume the initial 2 tonnes per day of green hydrogen in the processing plant and has the capability to scale up this quantity over time. This will result in a significant reduction in carbon emissions over the Project's life. It is anticipated that there will also be future opportunities for the expansion of hydrogen applications within the manufacturing process.

AVL and Westgold have signed a collaboration agreement that will see surplus water from operations at the Meekatharra asset used at the Australian Vanadium project in Western Australia. AVL's innovative collaborations with Westgold can assist both the EPA (Environmental Protection Authority) and DWER

(Department of Water and Environmental Regulation) with their water management and environmental custodianship, whilst allowing this critical project to progress.

AVL continues to engage and collaborate with various research institutions and external engineering contractors to scale the Project's IP and technical proponents. Vincent Algar, AVL's Managing Director and Todd Richardson, AVL's Chief Operating Office have regular communication with the different stakeholders during the whole process of the Project planning, design and development.

Engagement with Federal and State Government

Throughout the progression of the Project so far, AVL has maintained a close relationship with the different government agencies and holds regular meetings with Ministers (Minister for Industry, Science and Technology, Minister for Resources and Northern Australia, Minister for Defence Industry) and Advisors who have an interest in the region. The Project has been awarded 'Major Project Status' by the Australian Federal Government and 'Lead Agency Status' by the Western Australian Government in recognition of its strategic importance as a critical mineral and battery metal project.

No major concerns have been raised beyond expected queries from regulatory agencies, for example discussions with DWER regarding water sourcing.

Engagement with Local Government, Traditional Owners and Local Landholders

AVL will seek to involve the local community during the planning, construction and operation of the Project. In particular, AVL will seek to understand and address local community concerns about the environmental and social impacts of the Project's activities.

AVL has focused on public consultation around planning regulations and negotiations with local council and community members of the region which comprises the Yugunga-Nya People and pastoralists at Polelle, Hillview and Yarrabubba Stations, wider Meekatharra community, the Yulella Aboriginal Corporation, the Stephen Michael Foundation, the Meekatharra Aboriginal Reference Group, the Meekatharra Industry Group, local business owners, and individuals living and working in Meekatharra.

AVL will be actively listening and soliciting input and feedback to make sure communications are being received and understood, and to capture essential information to help adjust and to respond to problem areas.

AVL has demonstrated its commitment to the local community through sponsorship of the Stephen Michael Foundation (the Foundation). The Foundation is active across the state and runs a range of community programmes in the Murchison to engage children and young people in education through participation in sport. Sponsorship of the Foundation has enabled AVL to engage and build relationships with the community and stakeholders in the Meekatharra region.

Traditional Owner consultation

The Yugunga-Nya people identify as the traditional owners of the land where the Vanadium-Titanium-Iron (V-Ti-Fe) deposit site is located. On 7 August 2020, the Yugunga-Nya People's Native Title Claim was dismissed by the National Native Title Tribunal. Regardless of dismissal, AVL has continued to build and maintain strong relationships with these Traditional Owners, finding meaningful and positive ways of encouraging future participation at the site. AVL is committed to meeting its obligations under the Heritage Act 2018; engaging local Yugunga-Nya businesses and ensuring the most appropriate people are employed in undertaking heritage surveys and site-specific work.

This includes ensuring that Evelyn Gilla-Shay as one of the elders, is included from a consultation perspective, as she is unable to undertake the arduous survey itself. Yugunga-Nya member Marianne Shay

is a valued member of the AVL field team and is included on all relevant work in the field. The skills she has developed through her work with AVL has enabled her to secure work with neighbouring company Technology Metals Australia. Yugunga-Nya member Carl Peterson is AVL's main contact through the mining agreement negotiations and subsequent to the claim being dismissed, AVL has had discussions around potential construction roles he can provide to the Project through his business joint venture. Carl aims to provide employment to as many Yugunga-Nya People as he can and is keen to help build a brighter future for the younger members of the group. AVL has also had meetings with Joslyn Mongoo regarding joint venture projects she has set up for civil, facilities management and construction activities.

AVL has had extensive stakeholder engagement with local communities since 2012. Currently, AVL has appointed two dedicated positions to build and strengthen relationships, driving engagement across the Meekatharra, Mullewa, and Geraldton and Meekatharra areas, being:

- A Stakeholder Engagement Manager, located in Perth and responsible for all community engagement activities in the Meekatharra region, and broader stakeholder engagement of AVL; and
- A Community Liaison Officer, located in Geraldton and responsible for engagement with the community across the Mullewa and Geraldton regions.

AVL has developed a CRM system which is used to capture engagements with local communities, government agencies and businesses. The CRM collects information on discussion topics, administrative engagement activities and documented outcomes. AVL is committed to administrative governance and quality control through the CRM, with our continued focus on accountability.

AVL is committed to building a local presence and has affiliation with multiple local groups and businesses. These include:

- National Indigenous Australians Agency (NIAA);
- Meekatharra Aboriginal Reference Group (MARG);
- Meekatharra Community Resource Centre (MCRC);
- Yulella Aboriginal Corporation;
- Meekatharra Industry Group;
- Indigi Personnel Services;.
- Stephen Michael Foundation; and
- Murlpirrmarra Connection.

Currently, AVL has multiple community engagements. These include:

- A Geraldton-based community liaison officer who conducts engagements in Geraldton and Mullewa;
- A Perth-based Stakeholder Engagement Manager currently engaging with Meekatharra; and
- Relationships with the Stephen Michael Foundation, which we intend to grow and further expand, as AVL commences its operations.

AVL will concentrate future efforts on:

- Conducting stakeholder identification, communications and mapping;
- Developing engagement strategies and action plans for all sites and communities to include an understanding of potential impacts, planning for management of expectations, and subsequent articulation of sustainable development opportunities;
- Clarifying roles, responsibilities and scope for community-facing staff;
- Developing local and Indigenous strategy to include the identification of local opportunities through current goods and services procurement;

- Developing a corporate social responsibility strategic plan to align our social investment efforts with targeted needs of the community and distribution of sponsorships and donations;
- Formalising and implementing a community and stakeholder co-designed feedback process; and
- Developing an approved methodology for our stakeholder engagement process in the CRM system.

Timeline

Stakeholder	Type of communication and proposed method	Responsibility	Timing
Federal Government	Official correspondence and meetings, progress reports	AVL team	During project design, construction and implementation phases
State Government	Official correspondence and meetings, progress reports	AVL team	During project design, construction and implementation
Local Government, community representatives	Regular communication by phone or through meetings, project progress updates and reports	AVL team	All project phases
Business Stakeholders	Face-to-face presentation, official correspondence and meetings, project progress updates and reports	AVL team	Ongoing and during project design, construction and implementation phases
Research Stakeholders	Face-to-face presentation, official correspondence and meetings, project progress updates and reports	AVL team	Ongoing and during project design, construction and implementation phases
Industry Stakeholders	Official correspondence and meetings, project progress updates and reports	AVL team	Project planning and design phases
Local Landholders	Public meeting to explain the construction process and its impacts on land as well as the planned compensation measures and how they will be executed.	AVL team	All project planning, design and commissioning phases of the Project

Monitor Stakeholder Engagement

It will be critical to continually monitor and evaluate the efficiency of the stakeholder engagement plan with the different stakeholders, in order to ensure impacts are considered and acted upon where appropriate and in a timely manner.

AVL is actively adjusting strategies and plans for monitoring stakeholder engagement activities by collecting data, assessing the level of engagement, and using insights from the data collection to alter strategies and design campaigns for engaging effectively with stakeholders. AVL encourages stakeholders

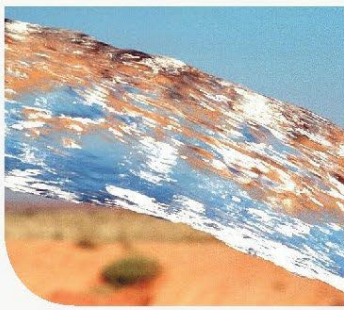
to participate and voice questions and concerns, and the most significant issues will be addressed in a formal, rigorous process through risk management processes.

Stakeholder Engagement Plan updates

The stakeholders have been identified and their information documented in the Stakeholder Analysis Register will be reviewed on a monthly basis to ensure the Project plan is meeting expectations, and to make modifications if required. The Project team has planned for, and will work to involve, engage, and listen to all key stakeholders throughout the Project lifecycle.

APPENDIX B

Bore Completion Report and H2 Level Hydrogeological Assessment



TENINDEWA VANADIUM PROCESSING PLANT

BORE COMPLETION REPORT AND H2 LEVEL HYDROGEOLOGICAL ASSESSMENT

REPORT FOR

AUSTRALIAN VANADIUM LIMITED

FEBRUARY 2022

Report No. 538.0/22/01

Rockwater
HYDROGEOLOGICAL AND ENVIRONMENTAL CONSULTANTS

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REVISION	AUTHOR	REVIEW	AUTHORISED	ISSUED
Draft	SB	GB	GB	7/2/2022
Final	SB		GB	14/2/2022

1 INTRODUCTION

Australian Vanadium Limited (AVL) is proposing to build a processing plant to process vanadium ore near Tenindewa in the Midwest Region of Western Australia (Figure 1). The processing plant will require a low-salinity water resource for processing the ore. It is estimated that 1.2 GL/year (i.e. 38.0 L/s) of brackish groundwater will be required to produce 0.8 GL of low salinity water via a reverse osmosis plant. AVL is currently seeking regulatory approvals for the processing plant and it requires surety of a reliable water supply.

AVL initially engaged Rockwater to undertake a desktop assessment to identify suitable target aquifers below its proposed processing plant at Tenindewa. The study identified that there was some uncertainty of the underlying stratigraphy at this location and that a hydrostratigraphic drilling programme was required. AVL subsequently engaged Rockwater to supervise the drilling of a hydrostratigraphic hole to assess the potential of the underlying aquifers at Tenindewa, and if successful, supervise the construction of a monitoring bore, suitable for obtaining aquifer parameters from a low flow pumping test. Rockwater was also engaged to prepare this H2 level hydrogeological assessment and bore completion report.

This H2 level hydrogeological assessment and bore completion report has been prepared to support AVL's application for a Section 5C Licence to take water for a proposed allocation of 1.2 GL / year from the Irwin River-High Cliff Aquifer, in accordance with the Department of Water (DoW) *Operational Policy No. 5.12 – Hydrogeological reporting associated with a groundwater licence* (DoW, 2009).

1.1 REGULATORY FRAMEWORK

The proposed Tenindewa processing plant is located in the Perth Groundwater Province of the Gascoyne Groundwater Area. The Department of Water and Environmental Regulation (DWER) does not have a groundwater allocation plan for this area, however management objectives are likely to be similar to the adjacent Arrowsmith Groundwater Area. The purpose of the Arrowsmith groundwater allocation plan is to guide sustainable groundwater allocation decisions, while promoting efficient use of the resources to optimise water use for regional growth (DoW, 2010).

Hydrostratigraphic drilling, bore construction, and operation in Western Australia is governed by the Rights in Water and Irrigation Act (the Act), (Rights in Water and Irrigation Act 1914, Government of Western Australia)

The requirements of the Act include licences to:

1. Construct or alter a bore (Section 26D of the Act); and
2. Take and use groundwater (Section 5C of the Act);

As the DWER does not have an allocation plan for the Gascoyne Groundwater Area, groundwater extraction is allocated based upon the data provided in Hydrogeological Assessments.

1.2 GROUNDWATER LICENCES

AVL obtained a 26D Licence to construct or alter a well (CAW) from the Department of Water and Environmental Regulation (DWER). A summary of the CAW licence is provided below and included as Appendix I:

- Licence Number: CAW205953(1)
- Description of Water Source: Gascoyne Perth – Permian Sandstone
- Activity: Construct up to two non-artesian wells for mining or public supply
- Location: Lot 40 and Lot 41 on Plan 28736 Volume/Folio 2216/19
- Validity: 28 May 2021 to 27 May 2022.

AVL does not presently have a Section 5C licence for groundwater extraction at the proposed Tenindewa Processing plant.

2 PROJECT SETTING

2.1 LOCATION

The proposed processing plant is located on Erangy Springs Road, at Tenindewa; about 63km East of Geraldton and 28 km West of Mullewa (Figure 2.) The recently completed monitoring bore, TMB 01, is located on the western boundary of the property, adjacent to Erangy Springs Road. The nearest licenced user of groundwater is the Water Corporation's Wicherina borefield located 24 km west of the proposed processing plant (Figure 2).

2.2 CLIMATE

The project area is characterised by a Mediterranean climate, with cool, wet winters and hot, dry summers. The maximum monthly mean temperature at Mullewa is 36.7°C (January); the minimum monthly mean temperature is 7.4°C (July). Annual rainfall at Mullewa BoM station (Station ID 008095) 28 km east of the project area, has averaged 333.5 mm / year since 1896 (Table 1). More recently, rainfall averaged 286 mm from 2001 to 2011 and 299mm in the 10 year period from 2011 to 2021. The annual evaporation at Geraldton BoM station (Station ID 008050), located 63 km west of the project area, was 2034 mm during 2020 and exceeded average monthly rainfall throughout the year (Table 1). Climatic data from Mullewa and Geraldton are presented as Figure 3.

Table 1 – Tenindewa area climate data

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1896-2021 Average Rainfall (mm)	13.4	19.1	20.0	21.4	45.7	62.7	59.1	42.2	21.3	12.9	8.7	8.4	333.5
2020 Evaporation Data (mm)	251	208	198	156	130	100	91	105	134	175	220	270	2034

1 Rainfall data from Mullewa (BoM Station 008050)

2 Evaporation data from Geraldton 2019 to 2020 (BoM Station 008050)

2.3 BIOREGIONS AND LANDUSE

The project area is within in the Geraldton Sandplains bioregion (SEWPAC, 2012). It consists largely of cleared agricultural land with fragmented pockets of remnant vegetation. Extensive clearing of native vegetation for agriculture has occurred since the 1960s, with land clearing rates stabilising from about 2000 to 2005, with about 73% of the area currently cleared. Non-cleared areas in the project area are primarily road reserves and nature reserves, with minor, isolated remnants of native vegetation on freehold land.

3 HYDROGEOLOGICAL SETTING

3.1 OVERVIEW

The proposed processing plant overlies the Perth (sedimentary) Basin, which in this area comprises up to 2 km of sediments overlying the Archaean basement. The western boundary of the project area overlies the northern extent of the Wicherina Terrace, near to where the terrace merges with the Bookara Shelf, and is approximately 1.0 km west of the Urella Fault which trends north-south and dissects the property. The Urella Fault forms the boundary between Wicherina Terrace and the Irwin Terrace which underlies the eastern side of the project area. (Figures 2 and 4). The most prospective aquifers are present west of the Urella fault.

The sediments of the Bookara Shelf transition from Jurassic and Permian in the south to Ordovician and Silurian in the north (DoW, 2017). At the south of the Wicherina Terrace, the stratigraphic sequence is about 200 m upthrust relative to the Bookara Shelf. However, at the north of Wicherina Terrace, near to the project area, there is likely to be negligible displacement between the two structures. At the project area, the sub-cropping formations are interpreted to be the Permian-aged Wagina Sandstone, Carynginia Formation, Irwin River Coal Measures and High Cliff Sandstone.

The stratigraphic sequence in this largely unexplored area of the Perth Basin is somewhat uncertain. Geological mapping in both the Western Australian Carbon Dioxide Geological Storage Atlas (DMP, 2013) and the DoW Northern Perth Basin: Geology, hydrogeology and groundwater resources bulletin (DoW, 2017) have mapped the sub-cropping strata at Tenindewa to be Jurassic-aged Yarragadee Formation (Figure 4). However, Palynological analyses of drill cuttings and the interpretation of gamma logs from TMB 01 demonstrate that the sub-cropping strata is of Permian age, and that Jurassic sediments (ie Yarragadee Fmn) are absent.

Significant displacement occurs across the Urella Fault. East of the Urella Fault, on the Irwin Terrace, the early Permian-aged Nangetty Formation is mapped to be the sub-cropping formation. The Nangetty Formation is stratigraphically lower than all formations intersected in Bore TMB 1.

3.2 GEOLOGICAL SEQUENCE

The geological sequence of the Wicherina Terrace beneath the project area, as intersected during the drilling of monitoring bore TMB 01 (Table 2), is based on observations, descriptive analysis of drill cuttings, wireline geophysical surveys and palynological analysis of drill cuttings. A composite log including lithological descriptions, wireline geophysical logs and interpreted stratigraphy is presented as Figure 5.

Table 2 – The stratigraphic sequence of TMB 01

Geological data					TMB 01		
Age			Geological Formation	Aquifer	Thickness	Depth	Elevation
Permian	Late 252.2 – 259.8	Kungurian	Wagina Sandstone	Wagina Aquifer	40	40	218
	Unconformity						
	Early 272.3 Ma	Artinskian	Carynginia Formation	Aquitard	35	75	183
			Irwin River Coal Measures	Irwin River-High Cliff Aquifer	146	221	37
			High Cliff Formation		>82	>303	>-37

A. Nomenclature: Thickness: Formation thickness (m); Depth: Depth to base of formation (m bgl); Elevation: Elevation of base of formation (m AHD)
B: unless otherwise specified all depths in this report m below ground level.

3.2.1 WAGINA SANDSTONE

The Late Permian Wagina Sandstone is a fluvial and deltaic deposit that forms within the same sequence as the Dongara Sandstone (delta front marine sands) and Beekeeper Formation (distal deltaic marine sequence) (Mory and Iasky, 1996). The TMB 01 drill site is underlain by the Wagina Sandstone from ground surface to 40 m depth.

At TMB 01, the Wagina Sandstone comprises:

- SAND: Yellow-grey, well sorted, medium to very coarse-grained sand, predominantly coarse, sub-angular grains. Predominantly quartz, minor feldspar, trace iron staining, unconsolidated, and;
- CLAY: Sandy, white-grey, soft puggy clay with minor, well sorted fine grained, sub-rounded quartz sand, moderately consolidated.

3.2.2 CARYNGINIA FORMATION

The Wagina Sandstone rests on the Carynginia Formation, with a low angle unconformity (Mory and Iasky, 1996). The Carynginia Formation is an Early Permian siltstone, claystone and sandstone sequence between the Irwin River Coal Measures and overlying Wagina Sandstone. A unit described as the Mingenew Formation, along the Urella Fault system, is a locally sandy, fossiliferous variation of the Carynginia Formation (Playford, 1976). The Carynginia Formation was intersected from 40 m to 75 m depth at TMB 01.

At TMB 01, the Carynginia Formation comprises:

- CLAYEY GRAVEL: Pink/grey, very poorly sorted clay to small pebbles, mostly granules sized particles, angular, predominantly quartz, and minor feldspar with about 30 % white puggy clay moderately consolidated.
- CLAY: Buff-grey/ pink massive clay, well consolidated and;
- SHALE: Light grey silty shale, well consolidated

3.2.3 IRWIN RIVER COAL MEASURES

The Carynginia Formation has a transitional and conformable contact with the underlying Irwin River Coal Measures (IRCM). The IRCM comprise alternating beds of siltstone, claystone with subordinate sandstone and minor coal (DoW, 2017). The IRCM lay conformably between the upper Carynginia Shale and the lower High Cliff sandstone. The IRCM were intersected from 75 m to 221 m depth at TMB 01.

At TMB 01, the Carynginia Formation comprises:

- GRAVEL/CLAY: Light grey /white poorly sorted clay to granules, sub-angular to sub-rounded grains. Predominantly quartz, minor feldspar, well consolidated.
- SANDSTONE: Light grey, moderately sorted medium grained sand to granules, sub-angular to angular, predominantly quartz, minor feldspar and traces of pyrite, with 10 to 25% light grey interbedded clay, moderately consolidated, and;
- SHALE: Black carbonaceous shale with about 20% very fine to fine grained silty sandstone occasional light grey siltstone beds, traces of pyrite.

3.2.4 HIGH CLIFF SANDSTONE

The High Cliff sandstone unit was deposited in a mixture of beach ridge, shallow marine and lower deltaic environments (Smith and Mory, 1995). The High Cliff Sandstone lies conformably between the upper Irwin Coal Measures and the lower Holmwood Shale. The High Cliff Sandstone was intersected from 221 m to 303 m depth at TMB 01.

At TMB 01, the High Cliff Sandstone comprises:

- SANDSTONE: Light olive grey, well-sorted coarse-grained sand to granules, mostly very coarse-grained, sub-angular, predominantly quartz, minor feldspar and traces of pyrite, weakly consolidated.

3.2.5 PALYNOLOGY ANALYSES

MG Palaeo undertook palynological analysis of a representative sample of shaley formation material from 195 to 207 m depth at TMB 01 (Appendix III). The pollen assemblage identified (*P. sinuosus* Zone) indicates that the sample from this depth is from the Carynginia Shale, however this does not correlate well with the Gamma Log which shows the IRCM to be present at this depth rather than the Carynginia Formation which is interpreted to be present from 40 to 75 m depth.

Two taxa that are more regular in the Artinskian-aged *M. trisina* Zone than in the overlying *P. sinuosus* Zone include *Columnisporites* cf. *peppersi* and *Gondisporites ewingtonensis*. Neither of these taxa were recorded in the 195-207 m depth sample.

The occurrence of *P. sinuosus* zone in the sample taken from a 195-207 m depth, which gamma data interpretation suggests is the IRCM could be the result of caved samples, or that the base of the *P. sinuosus* Zone extends into the uppermost IRCM in some parts of the basin. Sample caving, is where the drilling process continually erodes the overlying strata during drilling, resulting in overlying strata contaminating cuttings as they are circulated out of the hole. As the Carynginia Formation is present from 40 to 75 m depth, sample caving is the likely explanation.

The most distinct determination of this Palynological analysis and the gamma survey interpretation, is that the Jurassic-aged Yarragadee Formation is not present below the Tenindewa processing plant on the western side of the Urella Fault.

3.3 HYDROGEOLOGY

The Wagina Sandstone which extends to 40 m depth at TMB 01, hosts the Wagina Aquifer, where saturated. There are no details of bores constructed to less than 50 m depth proximal to the proposed processing plant, so it is unclear if an aquifer is present in the Wagina Sandstone this location, however resistivity logs from TMB 01 indicate that the water table is roughly 24 m below ground level.

The primary aquifer west of the proposed processing plant is considered to be the Lower Permian, Irwin-High Cliff Aquifer, hosted in the Irwin River Coal Measures and High Cliff Sandstone. The top of the aquifer is intersected at 110 m depth, however the most productive aquifer is present in the basal High Cliff Sandstone, from 221 m depth. At Tenindewa, the High Cliff Sandstone is a clean coarse grained sand interval with negligible interbedded shale.

The Irwin River–High Cliff Aquifer is truncated to the east by the Urella fault, about 1 km east of TMB 01. East of the Urella Fault, on the Irwin Terrace, the early Permian Nangetty Formation, is mapped to be the sub-cropping formation. The Nangetty Formation is up to 1000 m thick on the Irwin Terrace and dominated by laminated sandy siltstone and mudstone.

A basal sandstone member of the Nangetty Formation, designated the Wicherina Sandstone, comprises sandstone with minor interbedded siltstone, shale and claystone (WAP, 1964). On the western side of the Urella Fault, at the Wicherina 1 well, located 16 km south of the proposed processing plant, on the Wicherina Terrace, this member is 378 m thick. The Wongoondy 1 Bore located 23 km south-east of the proposed processing plant, on the Irwin Terrace, intersected a sandstone aquifer from 268 to 312 m depth, which is interpreted to be the Nangetty Formation.

Within 10 km of the proposed processing plant, the overlying Holmwood shale is mapped, which gives some indication that much of the 1,000 m thickness of the Nangetty Formation is present in this area. However, due to the paucity of drilling data proximal to TMB 01, it is uncertain if the aquifer intervals intersected west of the fault are in hydraulic connection with aquifer intervals of Nangetty Formation east of the Fault. It is likely that these permeable units would provide some level of pressure support to the Irwin High Cliff Aquifer where sandstone units are juxtaposed and in hydraulic connection across the fault.

The displacement of the Holmwood Shale across the Urella Fault may have also resulted in smearing of the clay dominated strata resulting in a poor hydraulic connection between sandstones on either side of the structural divide.

To the west of TMB 01, the Wicherina Shelf merges with the Bookara shelf, which extends 32 km to the west, to the Northampton Inlier which is overlain by Jurassic aged sediments including the Cattamarra Coal measures, a formation that hosts part of the Yarragadee Aquifer.

4 EVALUATION OF THE IRWIN RIVER-HIGH CLIFF AQUIFER

The Irwin River–High Cliff (IRCH) Aquifer consists of the Irwin River Coal Measures and the High Cliff Sandstone, which are hydraulically connected where both formations are present. At TMB 01, the basal High-Cliff Sandstone is the targeted zone of the aquifer. The gross thickness of the High Cliff Sandstone ranges from about 26 m at its type section on the southern bank of the Irwin River Irwin Terrace to 150 m Mt Horner 1. At TMB 01, the formation thickness is about 82 m and entirely conductive to groundwater flow based on its gamma signature. However, any cementation (if present) that cannot be estimated by analysing the gamma data alone may in practice reduce the net thickness. The net aquifer thicknesses at TMB 01 and the Wicherina 1 well located 16 km to the south are provided in Table 3.

Table 3 – Effective (net) aquifer and thickness

Bore	From	To	Gross Thickness	Net Thickness	Net to Gross Ratio
	(m)	(m)	(m)	(m)	(%)
TMB 01	221	>303	>82	82	100.0%
Wicherina 1	835	893	58	58	100.0 %

4.1 GROUNDWATER RECHARGE AND DISCHARGE

Recharge into the IRHC Aquifer is by direct rainfall infiltration where it outcrops, downward leakage through overlying Wagina Sandstone. In the Northampton Inlier in the west and north-west, and from lateral discharge from the Greenough River (Swarbrick 1964b).

Groundwater discharge from the aquifer is not documented in the available literature, however as previously discussed it is likely that there is some connection between the Yarragadee and IRHC Aquifers. The Yarragadee Aquifer is mapped to the south of TMB 01.

4.2 GROUNDWATER FLOW AND POTENTIOMETRIC SURFACE

The potentiometric surface of the Irwin River-High Cliff Aquifer at TMB 01 is 110.5 m bgl (147.9 m AHD). There are insufficient data to develop groundwater contours for the IRHC Aquifer. However, the DoW (2017) noted there is limited north–south flow in the Irwin River-High Cliff Aquifer, with hydraulic heads 12 m higher in the northern sub-province than in the south. Groundwater flow south of Wicherina is inferred to be to the south-west, while groundwater flow north of Wicherina is to the south-east (Swarbrick 1964). Groundwater flow is restricted by the Wicherina Barrier, where the underlying Holmwood Shale rises above the potentiometric surface of the aquifer (DoW, 2017).

The groundwater flow velocity is estimated from hydraulic conductivity and hydraulic gradient to be between 0.1 and 1 m/day.

4.3 HYDRAULIC PARAMETERS

The hydraulic parameters of the IRHC Aquifer are not readily available in published literature. The transmissivity derived from analysis of the TMB 01 pumping test is 622.3 m^2/day from production zone (241-271 m bgl). The hydraulic conductivity for this interval is therefore 20.7 m/day (Table 4). A storativity of 1.04×10^{-4} was assumed in the analysis of the pumping tests.

Table 4 – High Cliff Sandstone parameters from pumping tests

Parameter	Symbol	Unit	TMB 01
Transmissivity	T	m^2/d	622.3
Horizontal hydraulic conductivity	K	m/d	20.7
Aquifer thickness	h	m	30
Storativity	S	–	1.02×10^{-5}

4.4 GROUNDWATER QUALITY

Groundwater salinity within the IRHC Aquifer beneath outcrops in the Irwin River area ranges from 750 to 1,400 mg/L TDS, but can be up to 8,000 mg/L TDS where it mixes with more saline groundwater in the underlying Nangetty Formation. Groundwater salinity increases to the north-east away from the Northampton Inlier (DoW, 2017). The groundwater salinity at TMB 01 is 6,850 mg/L.

The moderate salinity of this formation demonstrates that there is some degree of flow through the aquifer. The increasing salinity from west to east away from the Northampton Inlier suggests that the aquifer is recharged from this area.

4.5 GRAIN SIZE DISTRIBUTION

Grain size distributions were assessed by the University of Western Australia (UWA) Earth and Environment Analysis Laboratory for five representative samples of formation material from the IRHC Aquifer at TMB 01 (Appendix IV; Table 5). The samples were analysed using by mechanical sieve analysis, employing 10 sieve fractions ranging from <125 µm to >2,800 µm.

TMB 01 is constructed with +0.8 to -1.6 mm graded gravel pack and 0.5 mm aperture screens. Future bores screened in this aquifer could be constructed without gravel pack and 0.5 mm aperture screens would retain 77 to 85% of the formation material

Table 5 – Sieve analysis cumulative mass

Sample depth (m)	Percentage cumulative mass; sieve size (micron)									
	2800	2000	1400	1000	500	355	250	180	125	<125
240-246	0.76	6.24	17.33	23.52	36.42	5.56	3.63	1.57	0.37	4.60
246-252	4.63	11.11	12.96	18.99	32.99	7.62	3.53	1.42	0.57	6.18
252-258	4.59	12.72	32.72	19.58	15.55	3.91	3.30	1.94	0.61	5.09
258-264	3.99	4.51	13.64	21.42	34.26	6.46	5.04	3.19	0.67	6.82
264-270	0.64	2.49	11.72	22.63	44.19	7.54	2.88	1.78	0.48	5.65

4.6 GROUNDWATER QUALITY

Groundwater salinity within the Irwin River - High Cliff Aquifer beneath the Tenindewa site had a laboratory analysed salinity of 6,850 mg/L Total Dissolved Solids (TDS) and the pH is 6.4 in-situ.

The water is dominant in sodium and chloride ions with trace concentrations of aluminium, manganese, zinc, iron and ammonia. Detailed groundwater chemistry data are discussed in section 8.2.

5 EXISTING GROUNDWATER USE

5.1 OTHER USERS

The Water Corporation is the main user of the Perth Basin Permian Aquifer and has a groundwater licence to 150,000 kL/ for drinking water supplies (Table 6). The Shire of Chapman Valley also has a small allocation from this aquifer. The nearest user of the Yarragadee Aquifer is SRV GRSF (Table 6). These licences are shown on Figure 2. At present there is no allocation plan for the Perth Basin Permian Aquifers in the Gascoyne Groundwater Area, however, 290,000 kL / year of groundwater extraction has been licenced from this aquifer.

Current active groundwater licences for the Permian aquifers nearby in the vicinity of TMB 01 (30 km radius) are presented in Table 6.

Table 6 – Permian / Yarragadee Aquifer groundwater licences nearby to the AVL Tenindewa processing plant

Licence number	Distance from AVL	Licence allocation	Owner	Expiry date	Licence address
105700 Permian Sandstone	24.2 km	150,000	Water Corporation	31-07-2026	Crown Reserve 17711 Volume/Folio Lr3025/914 Lot 7019 Geraldton Mount Magnet Rd Wicherina
166862 Permian Sandstone	30.2 km	6,000	Shire of Chapman Valley	22-10-2020	Roads within the Shire of Chapman Valley; Lot 8256 On Plan 149836 Volume/Folio 1561/466 Lot 8256 East Yuna
183807 Yarragadee North	27.1 km	35,000	SRV GRSF Pty Ltd	25-06-2028	LOT 9985 ON PLAN 206953; LOT 9985 ON PLAN 206953; LOT 3 ON DIAGRAM 66360

5.2 GROUNDWATER DEPENDENT ECOSYSTEMS

The IRHC Aquifer has a potentiometric surface of 110 m below ground level in the vicinity of the project area and therefore would not support a terrestrial vegetation groundwater dependent ecosystem proximal to the proposed processing plant. The direction of groundwater flow and discharge from the aquifer is poorly understood, however, it is most likely that the aquifer discharges into the overlying Yarragadee Aquifer and it does not directly discharge to surface, or support aquatic GDE such as mound springs or river systems.

The IRHC Aquifer is unlikely to support significant stygofauna communities, as it is a confined aquifer and is not locally connected with the surface to facilitate carbon and nutrient pathways. Water analysis for the project has supported this assumption as nitrogen and phosphorus results were very low (see section 9).

6 SCHEME DESCRIPTION

6.1 PROPOSED USE AND ESTIMATED VOLUMES

AVL has determined that it would require a water supply of 1.2 GL/year to produce 800 ML/ year of low salinity water suitable for the processing of vanadium ore.

6.2 AQUIFER INTERVALS

The proposed water supply would be sourced from the High Cliff Sandstone interval of the Irwin-High Cliff Aquifer. Future production bores would be constructed with the screens set across the entire interval of the High Cliff sandstone, which at TMB 01 extended from 221 to 303 m depth. To allow for well losses and aquifer drawdown the production casing / pump chamber would extend through the Irwin River Coal measures near to the top of the High Cliff Sandstone.

TMB 01 is constructed near to the western boundary of the proposed processing plant site. It is proposed that a duty production bore will be drilled approximately 500 m south of the monitoring bore and a stand-by bore drilled 500 m north of TMB 01, both located nearby to the western boundary of the processing plant.

7 TENINDEWA MONITORING BORE TMB 01

Monitoring Bore TMB 01 was drilled to assess the potential of the underlying aquifers at Tenindewa, and obtaining aquifer parameters from a low flow pumping test. Details of TMB 01 are summarised in Table 7. A composite log including lithological descriptions, wireline geophysical logs and interpreted stratigraphy is presented as Figure 5 and the TMB 01 bore construction diagram is presented as Figure 6.

Table 7 – TMB 01 bore details

Bore	GDA 94, Zone 50		Azimuth	Ground level*	Drill depth	Cased depth	Screened interval	Screened aquifer	Potentiometric Surface	
	mE	mN		(m AHD)	(m bgl)	(m bgl)	(m bgl)		(m bgl)	(m AHD)
TMB 01	330,532	6,825,096	Vertical	258	303	223.28	241.28 to 271.28	Irwin River-High Cliff	110.51	147.49

m AHD – meters Australian Height Datum
m bgl – meters below ground level
*Elevation from google earth

7.1 BORE DESIGN CRITERIA

The construction of TMB 01 is discussed in the following subsections, and presented in a bore completion diagram (Figure 6). The bore design meets the Minimum Construction Requirements for Water Bores in Australia, Edition 4 (National Uniform Drillers Licensing Committee, 2020) and the licence to construct or alter a well CAW205953(1).

7.2 TMB 01 BORE CONSTRUCTION

TMB 01 was drilled with mud rotary drilling techniques using a Failing 2500 drilling rig. The drilling operations were conducted by Steven Chitty who holds Class 3 Waterwell Driller's Licence (DL 039), issued by the Australian Drilling Industry Association. The bore was spudded on 12 August 2021 and bore development concluded on 10 September 2021. The TMB 01 bore construction diagram is presented as Figure 6.

7.3 SURFACE CASING

The surface casing is designed to stabilise the loose sediments encountered in the sub-surface during drilling operations, and prevent erosion of the top part of the hole by drilling fluids returning to the surface. A 311 mm diameter mud-rotary hole was drilled from ground level to 24 m depth. The hole was then lined to 23.5 m with 260.4 mm ID, 273.1 mm OD, 6.35 mm WT, ASME B36.10 carbon steel casing. The casing annulus was cement grouted to ground surface.

7.4 PILOT HOLE

The pilot hole for TMB 01 was drilled from 17 to 20 August 2021. A 216 mm pilot hole was drilled from the base of the surface casing at approximately 24 m depth to 303 m. Data from the hole identified 82 m of productive aquifer between 221–303 m depth.

7.5 GEOPHYSICAL LOGS

Wireline surveys were conducted to fully characterise the aquifer in TMB 01. These comprised Natural Gamma and Resistivity (16" and 64" Normals) surveys. Logs were run in open the 216 mm diameter drill hole. Geophysical logs (Appendix II) were run by Westlog on behalf of Western Drilling. Geophysical logs are plotted on Figure 5 and raw data from Westlog is included as appendix II.

7.5.1 NATURAL GAMMA

The Natural Gamma Ray log (Figure 5) provides a measurement of the natural radioactivity of the formations. This can be directly correlated with clay content since clays generally contain radioactive elements such as potassium, uranium and thorium. The natural gamma log confirmed that the aquifer is clean and free from clay, as it appeared in the drill cuttings and also correlated well with logs form other nearby holes, including Wicherina 1.

7.5.2 RESISTIVITY

Resistivity survey results (Figure 5) were used to assess groundwater salinities (Table 8) for the main clean sandstone beds of the Irwin-High Cliff Aquifer, as interpreted on the composite log. The (low resistivity) response of clay-rich strata was also used to correlate the depth of clay-rich intervals in the samples, as described in the composite log (Figure 5).

Table 8 – TMB 01 resistivity results

Interpreted clean sandstone units	From	To	64" resistivity	Salinity[1]
	(m)	(m)	(ohm.m)	(mg/L)
1	142.6	147.0	10.6	2,675
2	171.1	174.8	8.6	4,119
3	221.8	301.7	4.4	6,603
			Average salinity (mg/L):	4,466
			Average salinity open to screens (mg/L):	6,660

1: Calculated using Archie's law (tortuosity factor of 0.27 [very weakly consolidated sandstone], cementation exponent of 2.22 [very weakly consolidated sandstone]).

7.6 PUMP CHAMBER

The 216 mm hole was circulated clean and then back filled to 225 m depth with +0.8 - 1.6mm gravel prior to the installation of the pump chamber casing. The hole was lined with 125.74 mm ID, 139.7 mm OD API 5CT Grade L80 casing with furnished with New-Vam threaded couplings, from 0.5 m above ground surface to 223.95 m bgl; including a DN 100 AGE Developments float shoe from 223.19 to 223.95 m bgl. The casing annulus was pressure cement-grouted with 5,200 L (110 % of calculated annular volume) of SG 1.65 cement-bentonite slurry. Cement returns were observed at the surface while displacing cement from the bore casing.

7.7 AQUIFER SECTION

A 155 mm diameter hole was drilled from the base of the cement shoe at 223.95 m to 275.5 m depth through the gravel pack to accommodate the bore screens. The screen string was then telescopically installed, by lowering the string through the pump chamber on an inflatable packer. A hanger ring on the screen riser pipe was set on a landing ring placed within the pump chamber at 223.19 m depth. The screen string is comprised of 80 mm ID, 91 mm OD 304 grade stainless steel wire wound screens and 77.92 mm ID, 88.9 mm OD, dual certification 304/304L grade, schedule 40, stainless steel riser assembly. The wire wound screens have 0.50 mm apertures which provide 16.7% open area, and a capacity of 8.5 L/s per 6 m length.

The screen string depth settings are provided in Table 9.

Table 9 – TMB 01 screen depth settings

Depth (m bgl)		Length	Component
From	To	(m)	
222.68	223.28	0.60	M-packer
223.28	241.28	18.0	Stainless steel casing riser
241.28	271.28	30.0	Screened interval (0.5 mm aperture)

8 PUMPING TESTS

The test pumping of TMB 01 was conducted by Western Irrigation using a Lowara 12G55 SB 35 stage, 7.5 kw pump. Flow rates were measured via a calibrated flow meter and controlled via a variable speed drive. Groundwater levels were measured with an electric water level indicator and down-hole data loggers.

Discharged water was diverted from the bore head-works through a 100 mm diameter discharge pipeline to a nearby sump.

8.1 STEP-RATE PUMPING TEST

Test pumping of TMB 01 bore commenced on 5 October 2021 with a 4 x 1 hour step-rate pumping test, conducted at 1.5, 2.5, 3.0 and 3.25 L/s. Drawdown observations during the step rate pumping test are plotted on Figure 7 and the interpretation of the results are included in Table 10 and as Appendix VI.

The step-rate pumping test was conducted to determine initial hydraulic parameters and potential maximum sustainable yield of the bore. Analysis of the data indicates a higher skin factor (6.89) than was observed during the constant rate pumping tests (6.35), indicating the bore was still developing during the step rate pumping test.

Table 10 – Step rate pumping test summary

Bore ID	Step-rate test					
	C[1]	P[2]	B[3] (m)	S[4]	T[5] (m^2/d)	Skin Factor
TMB 01	0	2.0	12.68	1.015e-4	622.3	6.89

1. C= Nonlinear well loss coefficient
2. P = Nonlinear well loss exponent
3. B = Y-intercept of simulated step-rate drawdown
4. S = Aquifer storativity
5. T = Aquifer transmissivity

8.2 CONSTANT-RATE PUMPING TEST

Following the recovery of water levels, a 24-hour constant rate test was undertaken at 3.25 L/s (Figure 8, Appendix VI). During the 24-hour test the water level in TMB 01 drew down 2.49 m, from a standing level of 110.05 m bgl, to 112.54 m bgl. The drawdown showed continued development of the aquifer between 600 and 900 minutes where the water level recovered slightly before resuming the previous drawdown trajectory. The electrical conductivity of the water produced was relatively stable during the test, but showed a declining trend, possibly the result of removal of remnant drilling fluids.

The constant-rate pumping test was conducted to determine hydraulic parameters and maximum sustainable yield of the bore (Table 11).

Table 11 – Summary of pumping test results

Bore	Q[1]	Duration[2]	Drawdown[3]	Transmissivity	Storativity
	(L/s)	(minutes)	(m)	(m^2/day)	
TMB 01	3.25	1440	2.49	622.3	1.015e-4

1. Constant discharge rate of bore airlift
2. Duration of test
3. Drawdown at the end of the constant-rate test

Following the 24 hour pumping test the bore recovery was monitored. The bore had completely recovered within one hour of cessation of pumping. However, as the well loss drawdown was the largest component of this pumping test, it was not possible to make an accurate interpretation of aquifer parameters from the recovery data.

8.3 PUMPING CAPACITIES

The pumping water level in TMB 01 at the required flow rate of 38 L/s was estimated using Aqtesolv software (Appendix VI). The estimation incorporated aquifer parameters and bore performance data derived from test pumping, which is likely to over-estimate the well loss drawdown that would occur in a larger diameter production bore. At the average flow rate of 38 L/s it is predicted that the pumping water level would be approximately 33 m below the static water level, at about 140 m below ground level, about 60 above the depth setting of a pump the proposed borefield.

9 GROUNDWATER CHEMISTRY

Groundwater samples were collected by Rockwater during bore airlift development and upon completion of pumping development. The samples were collected in laboratory bottles containing any preservatives required, and submitted to NATA-registered ALS Laboratories for comprehensive analyses (Table 12; Figure 9; see completion report for TMB 01 in Appendices VIII).

Water sampling results show:

- The groundwater in the Irwin River – High Cliff aquifer is brackish, with a salinity of 6,850 mg/L TDS is and of circumneutral pH 6.53 to 6.4. However, pH measurements in the lab are marginally higher (6.56) due to degassing of acidic dissolved gases such as H2S and CO2 in transit and sampling.
- The chemical composition of the groundwater is dominated by sodium and chloride ions and has similar ratios of major ions to seawater, though much less saline. The water is more similar in chemical composition to the Leederville Aquifer than the Yarragadee Aquifer.
- The groundwater contains trace concentrations of aluminium, manganese, zinc, iron and ammonia.
- The airlifted sample shows elevated concentrations of nitrogen, this is likely attributed to the presence of residual drilling fluids in the bore during airlifting.

Table 12 – Chemical composition of groundwater

Analytes	Units	LOR[1]	Airlifted Sample	Pumped Sample	2000 ANZECC[2]
Field pH	pH	0.01	6.55	6.4	-
Field EC	µS/cm	1	17000	8650	-
Field Temperature	°C	0.1	26.5	27.6	-
pH	pH Unit	.01	6.56	6.56	-
Electrical Conductivity @ 25°C	µS/cm	1	10600	11000	-
Total Dissolved Solids @180°C	mg/L	10	6430	6850	4,000
Total Hardness as $CaCO_3$	mg/L	1	1200	1180	-
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	<1	<1	-
Carbonate Alkalinity as $CaCO_3$	mg/L	1	<1	<1	-
Total Alkalinity as $CaCO_3$	mg/L	1	49	67	-
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	49	67	-
Sulphate as $SO4^{2-}$	mg/L	1	607	625	1,000
Chloride	mg/L	1	3320	3480	-
Calcium	mg/L	1	146	148	1,000
Magnesium	mg/L	1	204	198	-
Sodium	mg/L	1	1700	1810	-
Potassium	mg/L	1	67	66	-
Aluminium	mg/L	0.01	0.02	<0.01	5
Arsenic (Dissolved)	mg/L	0.001	<0.001	<0.001	0.5
Cadmium (Dissolved)	mg/L	0.0001	<0.0001	<0.0001	0.01
Chromium (Dissolved)	mg/L	0.001	<0.001	<0.001	1.0
Lead (Dissolved)	mg/L	0.001	<0.001	<0.001	0.1
Manganese (Dissolved)	mg/L	0.001	1.27	1.14	0.1
Selenium (Dissolved)	mg/L	0.01	<0.01	<0.01	0.02
Zinc (Dissolved)	mg/L	0.005	0.017	0.170	20
Iron (Dissolved)	mg/L	0.05	12.6	29.4	-
Arsenic (Total)	mg/L	0.001	<0.001	<0.001	0.5
Iron (Total)	mg/L	0.05	-	34.2	0.25
Dissolved Mercury by FIMS	mg/L	0.0001	<0.001	<0.001	<0.0001
Ammonia as N	mg/L	0.01	2.23	1.84	1.89
Nitrite as N	mg/L	0.01	0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	<0.01	0.03	0.01
Nitrite + Nitrate as N	mg/L	0.01	0.01	0.03	0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	2.5	2.2	2.2
Total Nitrogen as N	mg/L	0.1	2.5	2.2	2.2
Total Phosphorus as P	mg/L	0.01	0.04	0.04	5.47
Reactive P as P	mg/L	0.01	<0.01	<0.01	1.59

1. Limit of reporting
2. ANZECC Australian and New Zealand Environment and Conservation Council Guidelines for fresh and marine quality water
A. Airlifted samples from TMB 01 on 10/09/21 and Pumped sample from TMB 01 on 06/10/21

10 ASSESSMENT OF POTENTIAL IMPACTS

An analytical assessment of drawdown was completed using AQTESOLV software, using the confined Dougherty-Babu method. Nine aquifer parameter scenarios were assessed, using the aquifer coefficients derived from test pumping as the mid case, values of ±50% of the transmissivity and storativity were also assessed.

The software produced gridded data for each scenario after one year of operation at an average discharge rate of 38 L/s (1.2 GL/year) The predicted drawdown at relevant drawdown receptors of the Irwin-River High Cliff Aquifer is presented in Table 13 and Figures 10 and 11.

This method of drawdown assessment makes the following assumptions:

- The aquifer has infinite areal extent;
- The aquifer is homogeneous and of uniform thickness;
- The potentiometric surface is initially horizontal;
- The pumping and observation wells are fully or partially penetrating;
- Flow is unsteady;
- The aquifer is confined; and
- Water is released instantaneously from storage with decline of hydraulic head.

This analytical method of drawdown impact assessments does not account for aquifer recharge and is therefore are likely to be conservative. This assessment also assumes that aquifers are present on both sides of the Urella fault and of homogenous composition, and therefore does not allow for the potential of an aquifer boundary resultant that may be present at the Urella Fault.

Table 13 – Projected drawdown in the Irwin-River High Cliff Aquifer after 10 years of groundwater extraction at the proposed Tenindewa processing plant.

	Aquifer Parameters		Drawdown at receptor (m)		
Scenario	Transmissivity (m2/day)	Storativity	GWL 105700 Water Corporation	GWL 166862 Shire of Chapman Valley	GWL 183807 SRV GRSF Pty Ltd
High T - High S	933.45	1.52e-04	1.25	1.10	1.20
High T - Mid S	933.45	1.02e-04	1.35	1.25	1.30
High T - Low S	933.45	5.08e-05	1.55	1.40	1.50
Mid T - High S	622.30	1.52e-04	1.70	1.50	1.60
Mid T - Mid S	622.30	1.02e-04	1.85	1.70	1.80
Mid T - Low S	622.30	5.08e-05	2.15	1.95	2.05
Low T - High S	311.15	1.52e-04	2.80	2.43	2.65
Low T - Mid S	311.15	1.02e-04	3.15	2.75	2.95
Low T - Low S	311.15	5.08e-05	3.70	3.35	3.55

The nearest user of the IRHC Aquifer to the Tenindewa processing plant is the Water Corporation Wicherina Borefield, located 24 km west of the proposed processing plant. The predicted drawdown at this location following 10 Years of groundwater extraction at 1.2 GL / year at the proposed processing plant borefield is estimated to range from 1.25 m to 3.70 m (Table 13). This drawdown would likely be insignificant to the operation of the existing users water supply bores.

The nearest user of the overlying Yarragadee Aquifer is SRV GRSF Pty Ltd, located 27 km south west of the processing plant. Following 10 years of the proposed extraction at the proposed processing plant borefield, it is estimated that drawdown at the SRV GRSF borefield would be 1.20 to 3.55 m (Table 13). This drawdown would likely be insignificant to the operation of the existing users water supply bores.

It is unlikely that terrestrial vegetation communities are dependent on the Irwin River High Cliff Aquifer in the area of influence due to the depth to the top of the aquifer (>100m) and its potentiometric surface. The Irwin River High Cliff Aquifer is not known to discharge to any rivers or springs, but rather discharge into overlying aquifers. The Irwin and Greenough Rivers and the associated vegetation communities are therefore unlikely to be impacted from abstraction at the proposed Tenindewa borefield.

11 GROUNDWATER MONITORING

Groundwater monitoring and long-term management of the bores will be detailed in a Groundwater Licence Operating Strategy (GLOS) to be prepared following the construction of the Tenindewa Borefield. The proposed monitoring schedule provided in Table 14 will be included in a GLOS and be undertaken from the commissioning date onwards.

Table 14 – Operational monitoring schedule

Frequency	Production Bores	Monitoring Bore
Daily	Instantaneous flow rate	None
	Check pipelines for leaks and pressure loss	
	Pump status (on or off)	
	Pumping/static water level	
Monthly	Cumulative flow readings	Water Level Measurement
Annually	Groundwater sample via a sampling tap at the headworks, Field EC, pH, Temperature	Download of EC and water Level Logger

12 SUMMARY AND RECOMMENDATIONS

Australian Vanadium Limited has drilled a hydrostratigraphic hole, TMB 01, to define the hydrostratigraphy on the western side of the Urella Fault, beneath its proposed processing plant at Tenindewa, and to identify a suitable aquifer to provide a water supply of 1.2 GL/ year for processing ore.

Drilling of the TMB 01 identified that Permian strata underlie the processing plant rather than Jurassic aged sediments as was previously understood. Drilling intersected about 80 m of the High Cliff Sandstone from 221 to 303 m depth. A partially penetrating monitoring bore was then constructed with screens set from 240 to 270 m depth across the IRHC Aquifer. A low flow pumping test was conducted to derive aquifer parameters and assess if it could supply the required 1.2 GL/ year to the processing plant.

Test pumping of the TMB 01 derived hydraulic parameters of Transmissivity - 622 m^2/ day (k=20.7 /day) and Storativity - 1.015 $x10^{-4}$. These parameters were employed to conduct analytical drawdown assessments based upon 10 years of 1.2 GL / annum groundwater extraction from the Irwin River High Cliff Aquifer. The assessment, while incorporating some uncertainty, indicates that extraction from IRHC Aquifer at the proposed processing plant would result in manageable drawdown of the potentiometric surface at the nearest other users of the aquifer. The IRHC Aquifer is not likely to support any terrestrial or aquatic GDE in the proximity of the Tenindewa processing plant.

The hydrostratigraphy east of the Urella Fault is uncertain, although it is understood that up to 1,000 m of the Nangetty Formation underlies the surface. The Nangetty Formation is predominantly laminated sandy siltstone and mudstone, however it includes some significant aquifer intervals including the basal Wicherina sandstone member which is up to 378 m thick.

Owing to the paucity of drilling data, on both sides of the Urella fault, and a lack of groundwater extraction and observation data. It would be difficult to develop or calibrate a meaningful numerical groundwater model to assess the proposed extraction at Tenindewa. It is therefore recommended that an adaptive management approach is applied to the proposed borefield, whereby suitable trigger levels are assigned in consultation with the DWER and borefield operations respond to observed drawdown.

AVL hereby submits this detailed H2 level assessment to the DWER in support of a Section 5C Groundwater Licence application 1.2 GL/annum

DATED: 14 FEBRUARY 2022

ROCKWATER PTY LTD

Matthew Vear
Hydrogeologist

Steve Bolton
Principal Hydrogeologist

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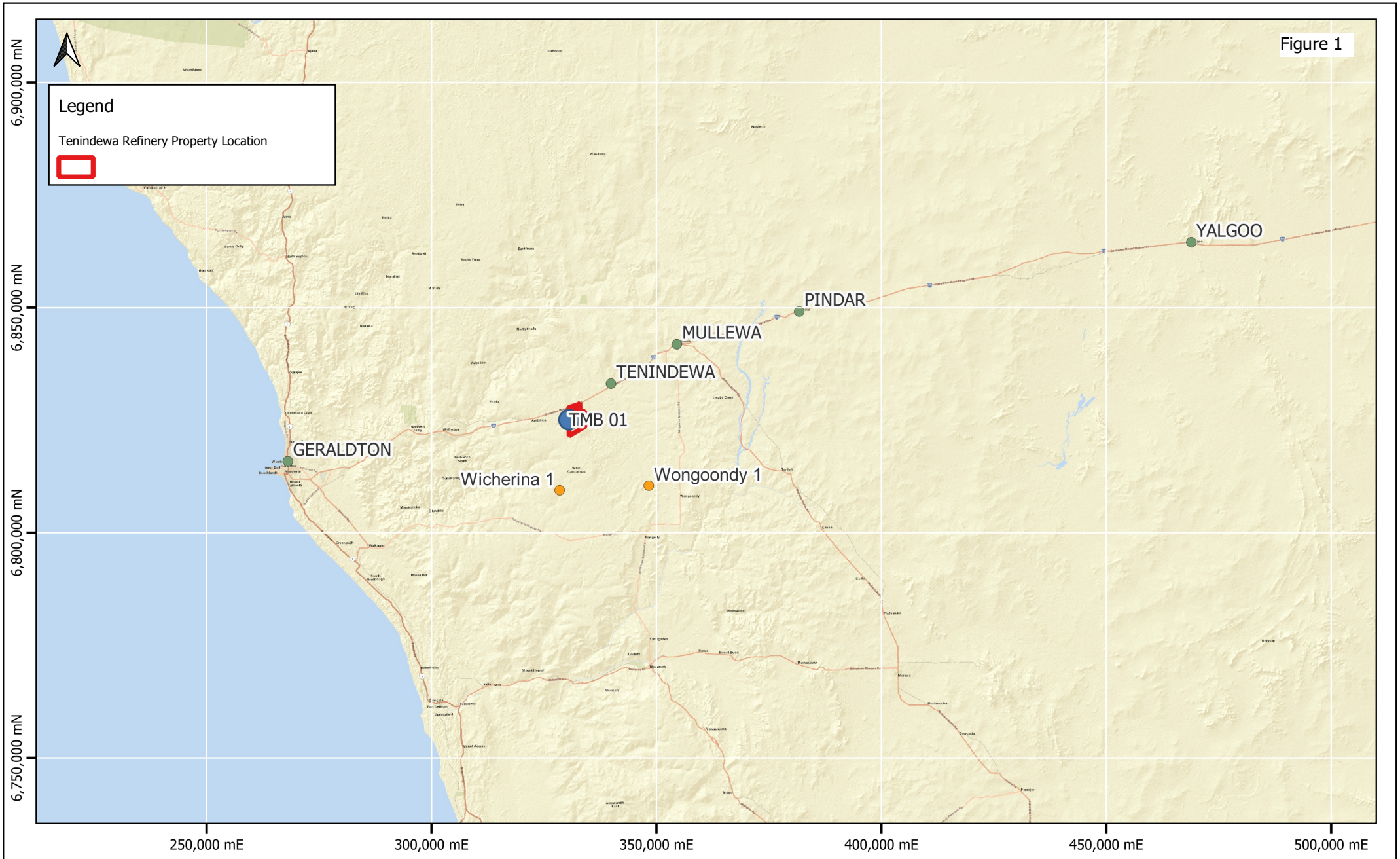
FIGURES



Rockwater HYDROGEOLOGICAL + ENVIRONMENTAL

Australian VANADIUM LIMITED

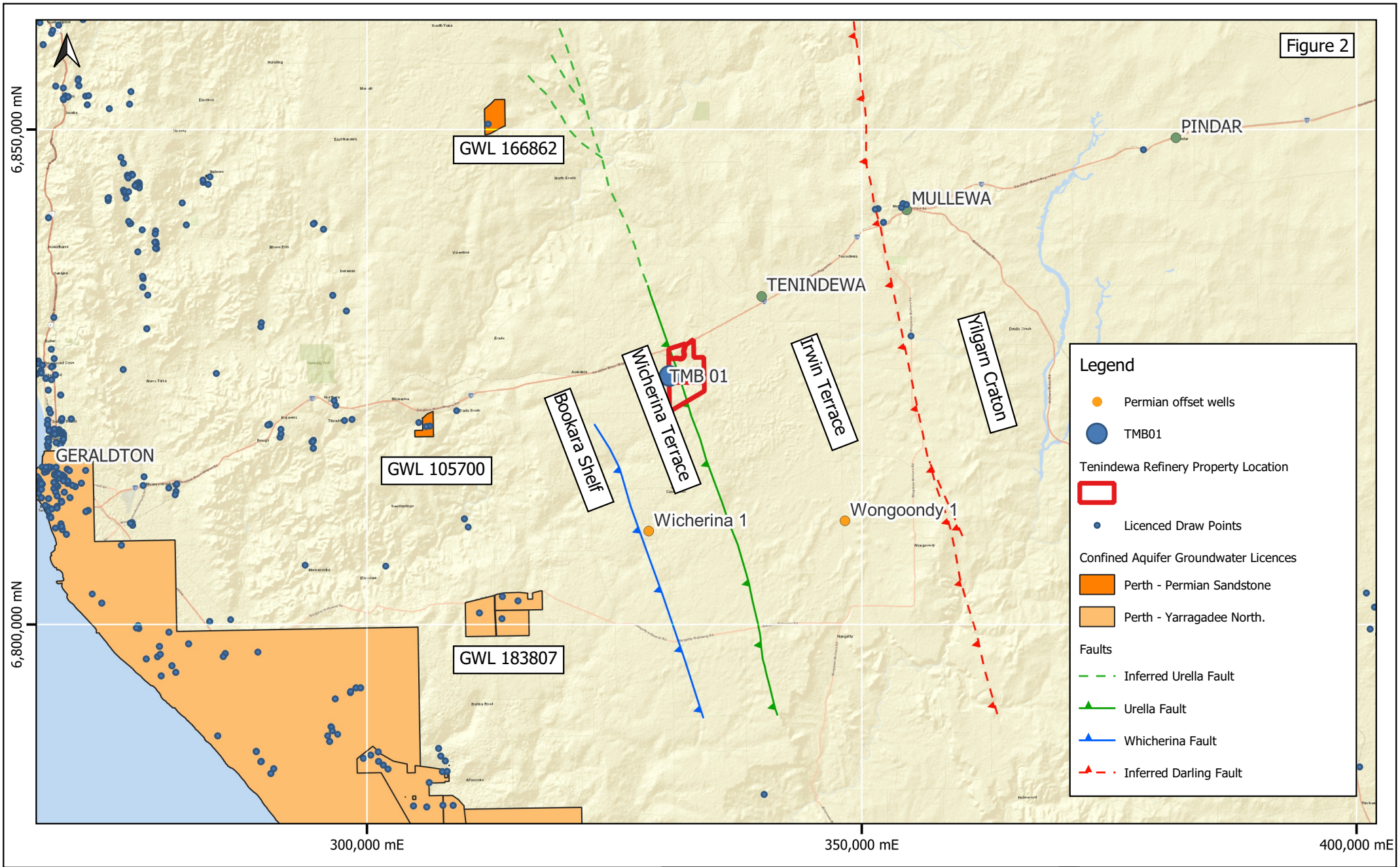
0 25 50 km

1:1,100,000

Coordinate System: GDA 2020 MGA Zone 50

Client	Australian Vanadium Limited
Project	Tenindewa Processing Plant Water Supply H2 Assessment
Date	February 2022
Figure Number	538/22/01-1

Tenindewa Processing Plant
Project Locality



Rockwater HYDROGEOLOGICAL + ENVIRONMENTAL

Australian VANADIUM LIMITED

0 10 20 km

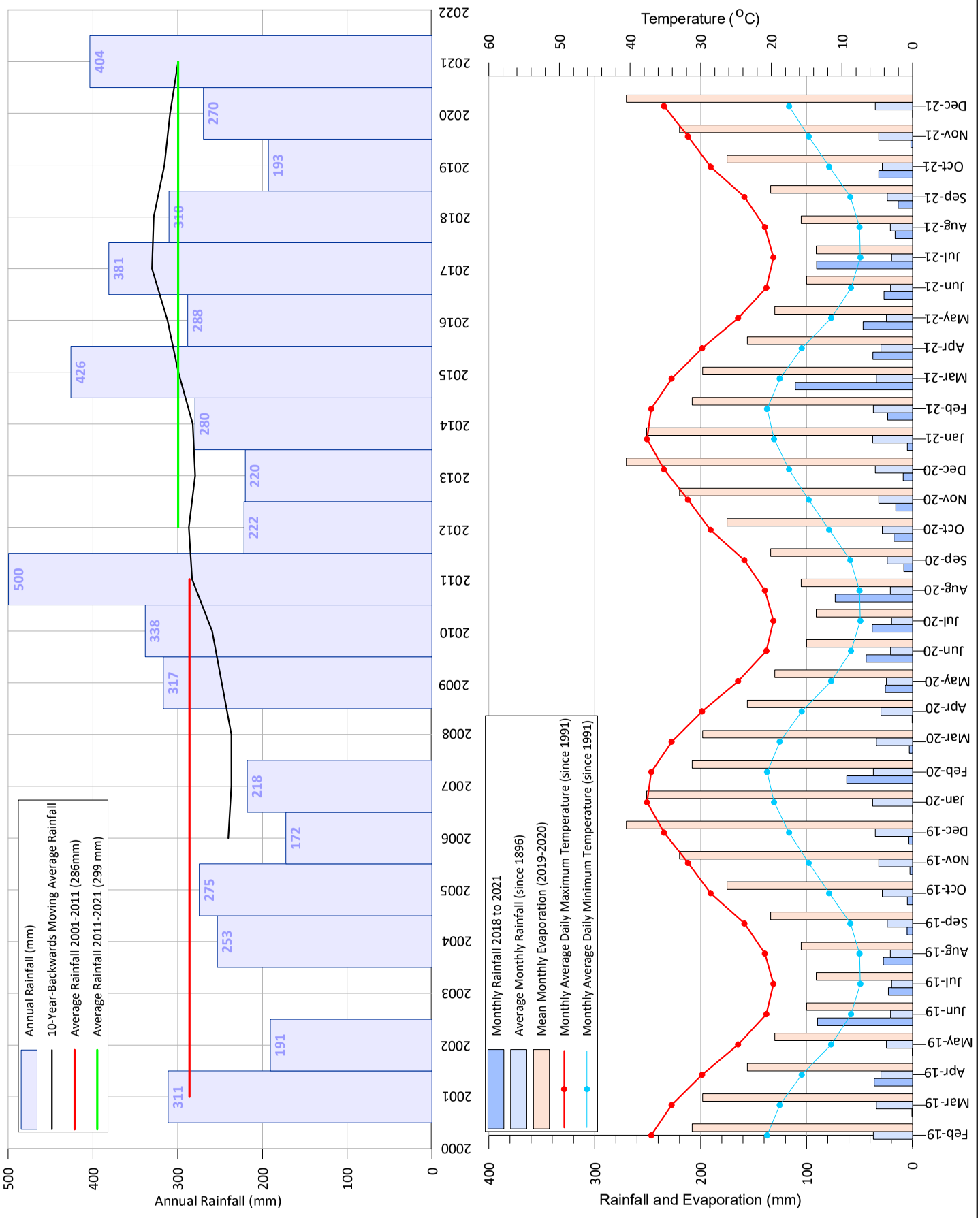
1:500,000

Coordinate System: GDA 2020 MGA Zone 50

Client	Australian Vanadium Limited
Project	Tenindewa Processing Plant Water Supply H2 Assessment
Date	February 2022
Figure Number	538/22/01-2

Tenindewa Processing Plant
Site Setting

FIGURE 3



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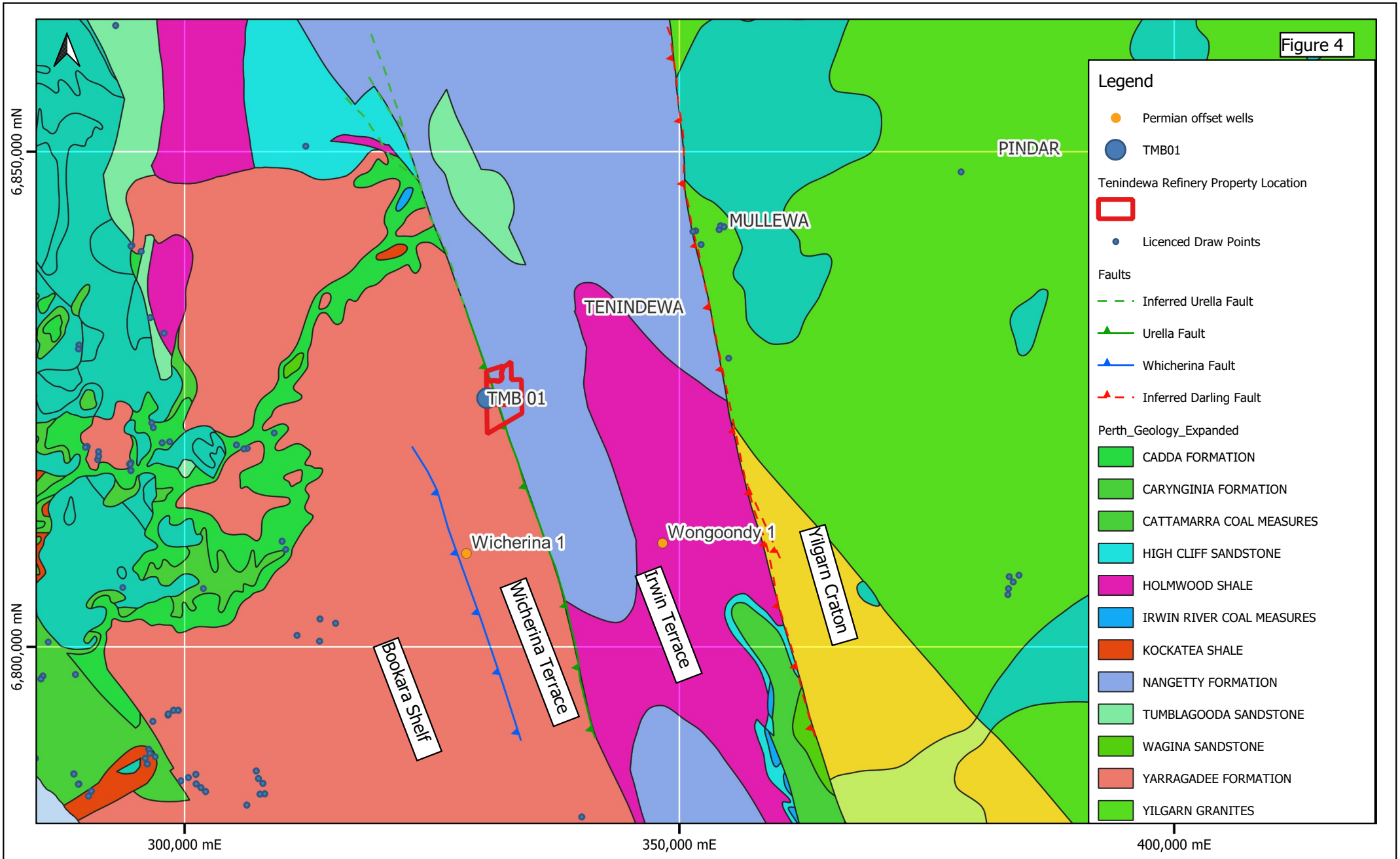
Client:	Australian Vanadium Limited
Project :	Tenindewa Processing Plant Water Supply H2 Assessment
Date:	February 2022
Dwg. No:	538-0/22/01-3

SUMMARY OF
CLIMATIC CONDITIONS AT
Mullewa and Geraldton
BoM Stations 008095 and 008050

Rockwater
PROPRIETARY LIMITED



Rockwater HYDROGEOLOGICAL + ENVIRONMENTAL

Australian VANADIUM LIMITED

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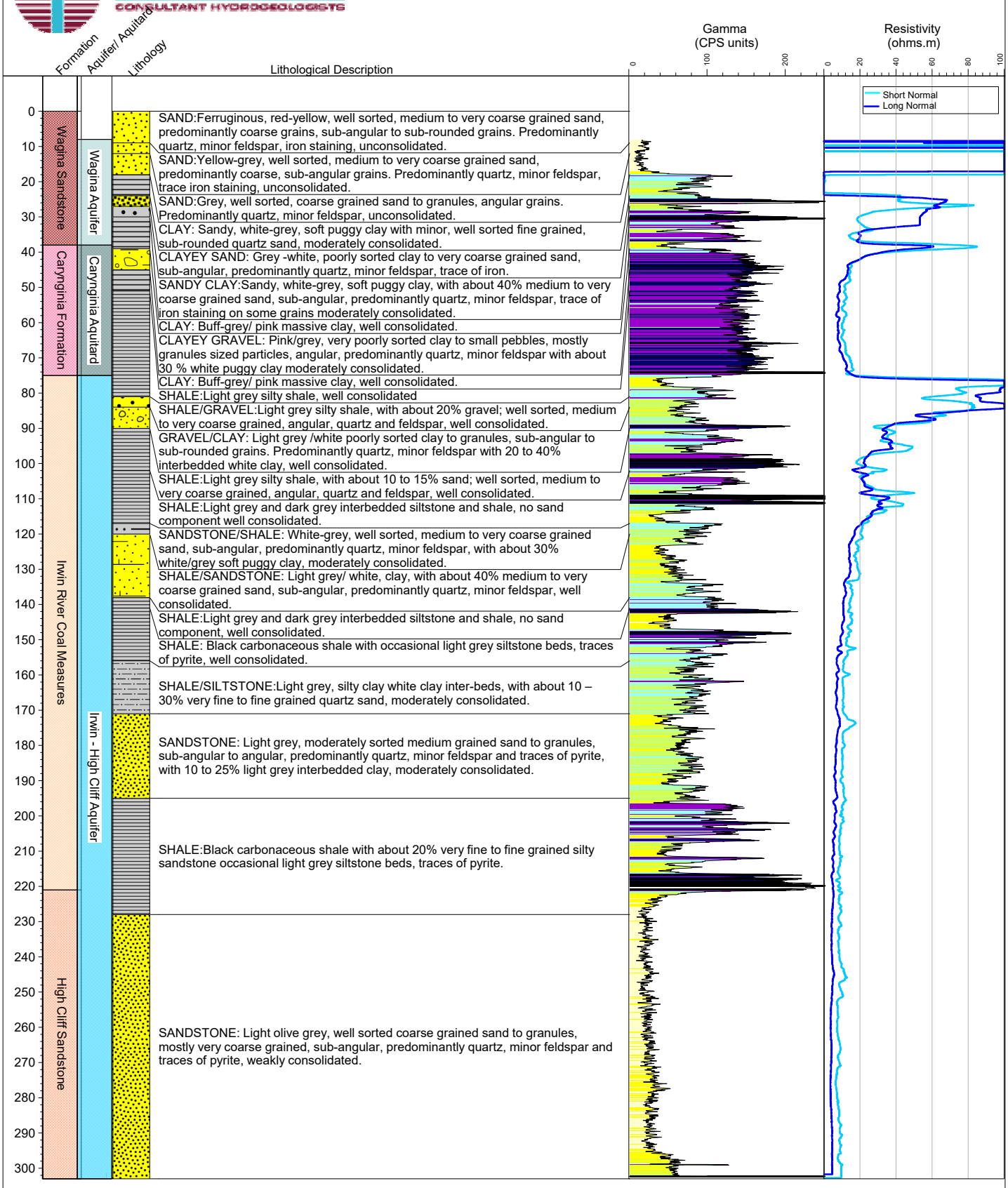
1:500,000

Coordinate System: GDA 2020 MGA Zone 50

Client	Australian Vanadium Limited
Project	Tenindewa Processing Plant Water Supply H2 Assessment
Date	February 2022
Figure Number	538/22/01-4

Tenindewa Processing Plant
Mapped Geology
(after DMP,2013)

Figure 5



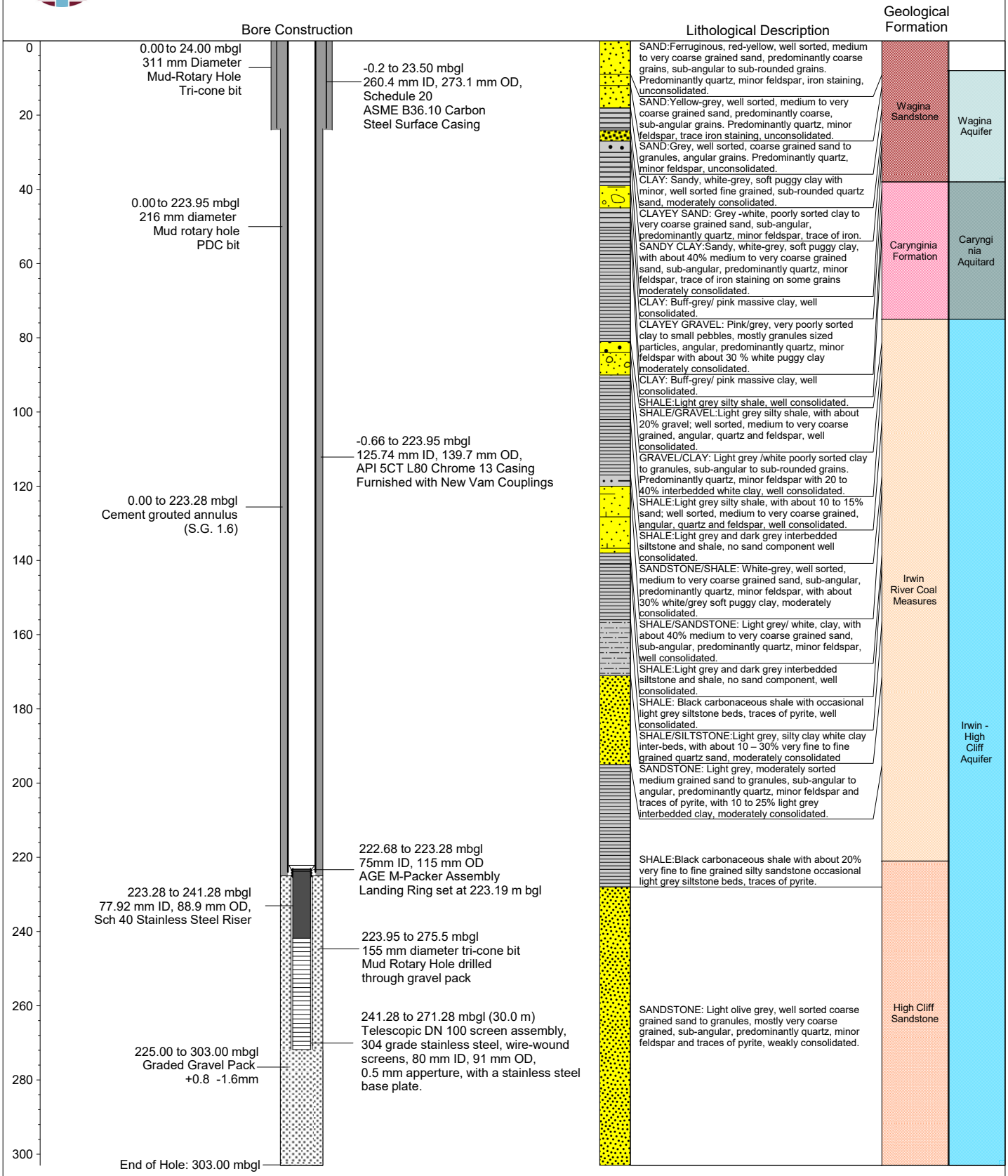
538-0/Strater/TMB01 BoreCompletionDiagram.sdg

CLIENT:	Australian Vanadium Limited
PROJECT:	Tenindewa Refinery Water Supply H2 Assessment
DATE:	February 2022
DWG. NO.:	538-0/22/01-5

Monitoring Bore TMB 01 Composite Log

Figure 6

Rockwater
CONSULTANT HYDROGEOLOGISTS



Construction Date: 12/8/2021 to 10/09/2021
Easting (m MGA): 330545
Northing (m MGA):6825096
Elevation (m AHD): 258

Depth Drilled (m bgl): 303.0
Top of Casing (m agl): 0.66
Cased Depth (m bgl): 271.28
Screened Interval (m bgl): 241.28 to 271.28

SWL (m bgl) (04 October 2021): 110.50
Water Chemistry (06 October 2021): 6850 mg/L TDS, pH 6.60
Airlift (L/s): 0.5

538-0/Strater/TMB01 BoreCompletionDiagram.sdg

CLIENT: Australian Vanadium Limited

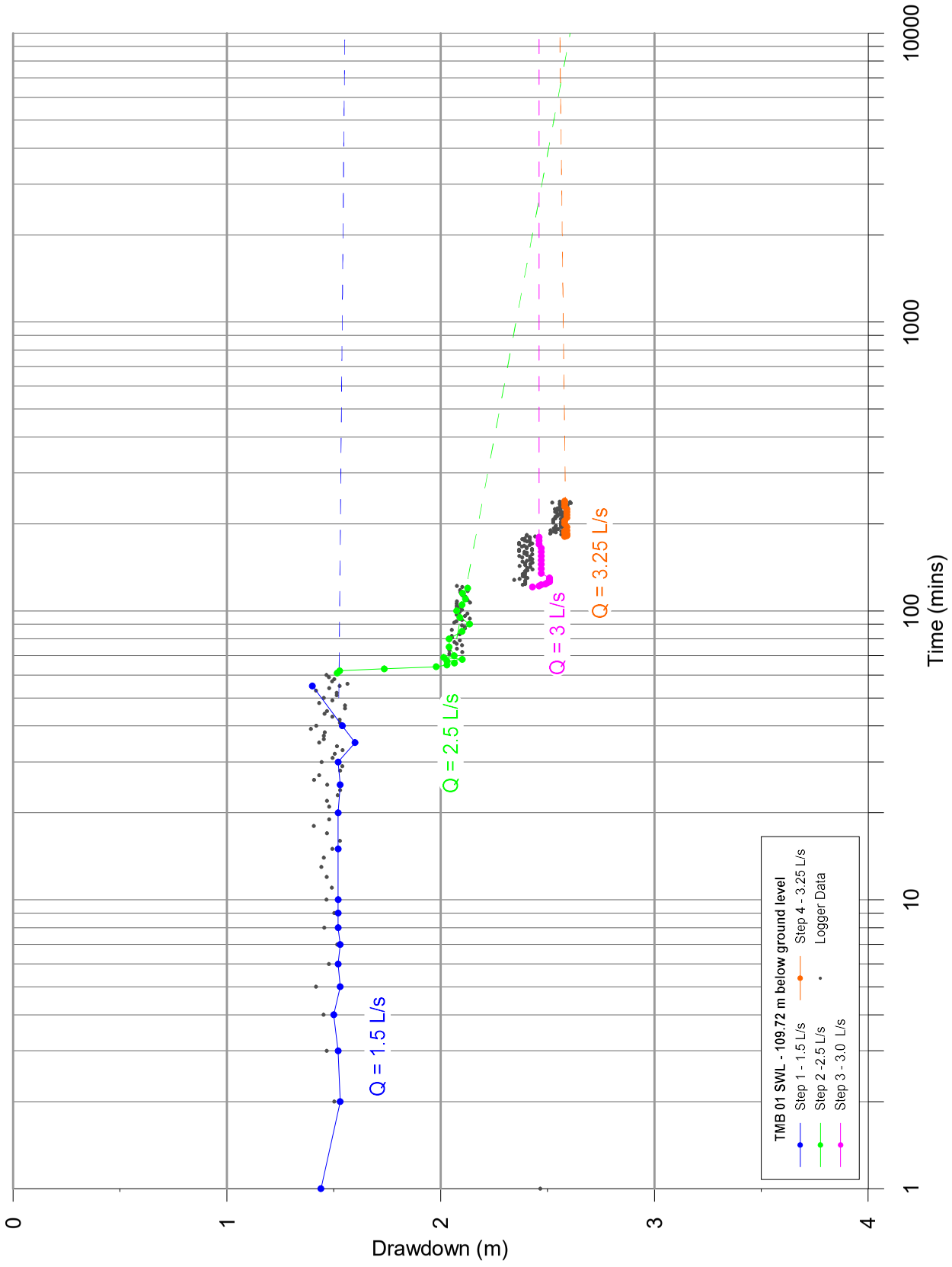
PROJECT: Tenindewa Refinery Water Supply

DATE: February 2022

DWG. NO.: 538-0/22/01-6

Monitoring Bore TMB 01 Bore Construction Diagram

Figure 7



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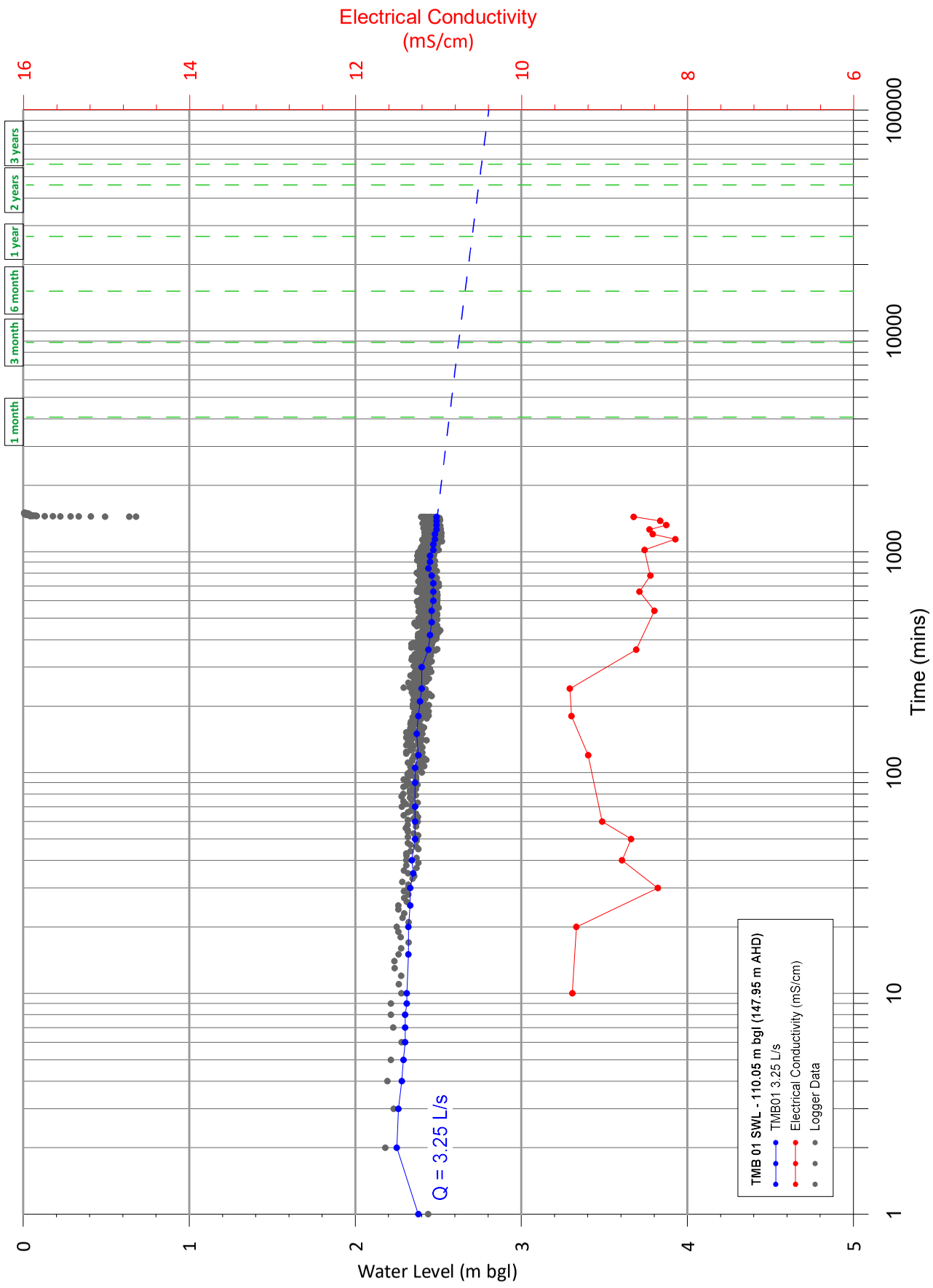
Client:	0Australian Vanadium Limited
Project :	Tenindewa Processing Plant Water Supply H2 Assessment
Date :	February 2022
Dwg. No:	538-0/22/01-7

Tenindewa Monitoring Bore TMB01
Step-Rate Pumping Test
Drawdown

Rockwater PROPRIETARY LIMITED

Figure 8



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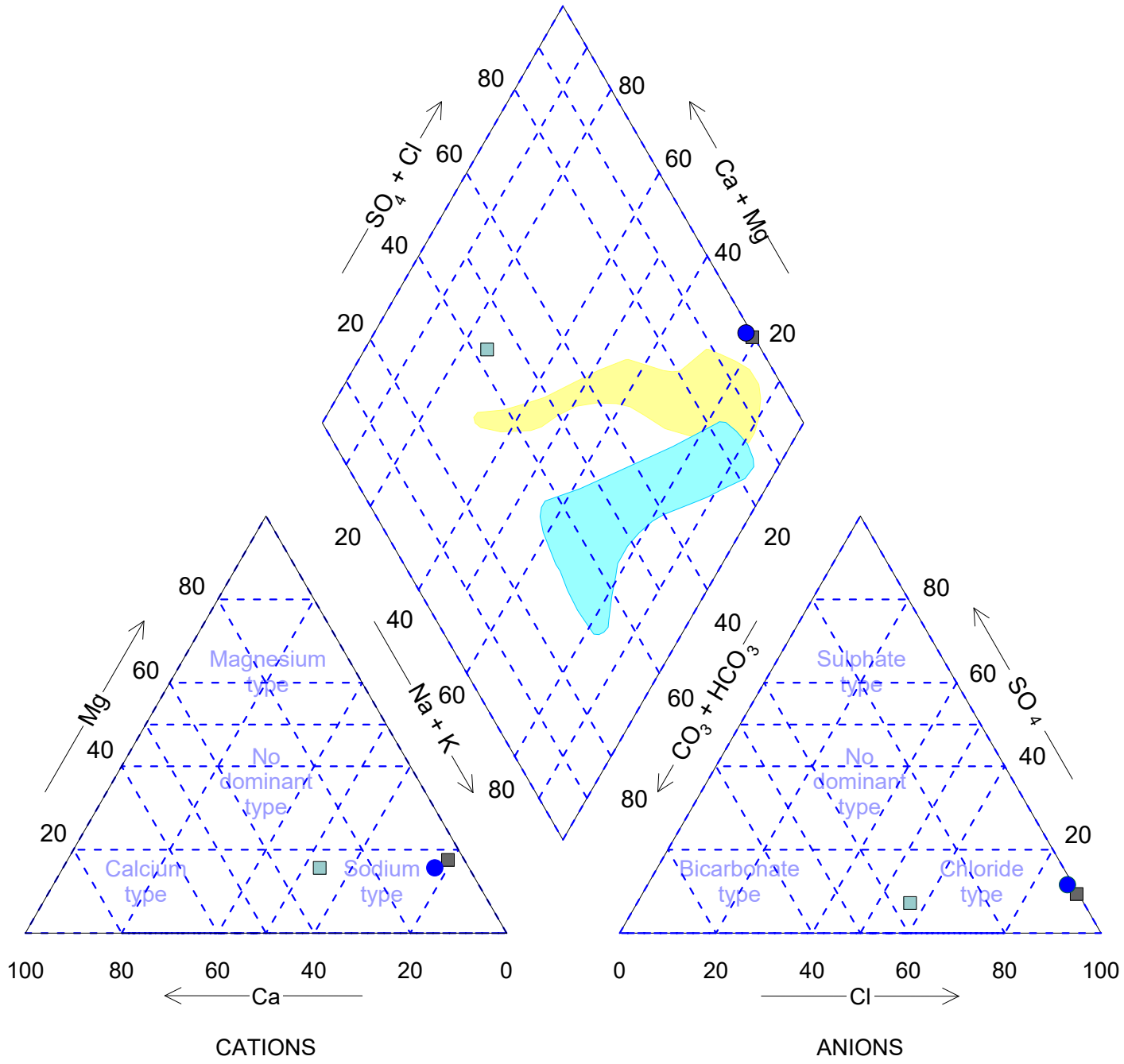
Client:	0Australian Vanadium Limited
Project :	Tenindewa Processing Plant Water Supply H2 Assessment
Date :	February 2022
Dwg. No:	538-0/22/01-7

Tenindewa Monitoring Bore TMB01
Constant-Rate Pumping Test
Drawdown and EC
(3.25 L/s - 280.8 KL/day)

Rockwater PROPRIETARY LIMITED

Figure 9



LEGEND

TMB 01 | Geraldton Rain Water | Sea Water

Typical Composition of Leederville Groundwater (Davidson, 1995)

Typical Composition of Yarragadee Groundwater (Davidson, 1995)

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Client: Australian Vanadium Limited

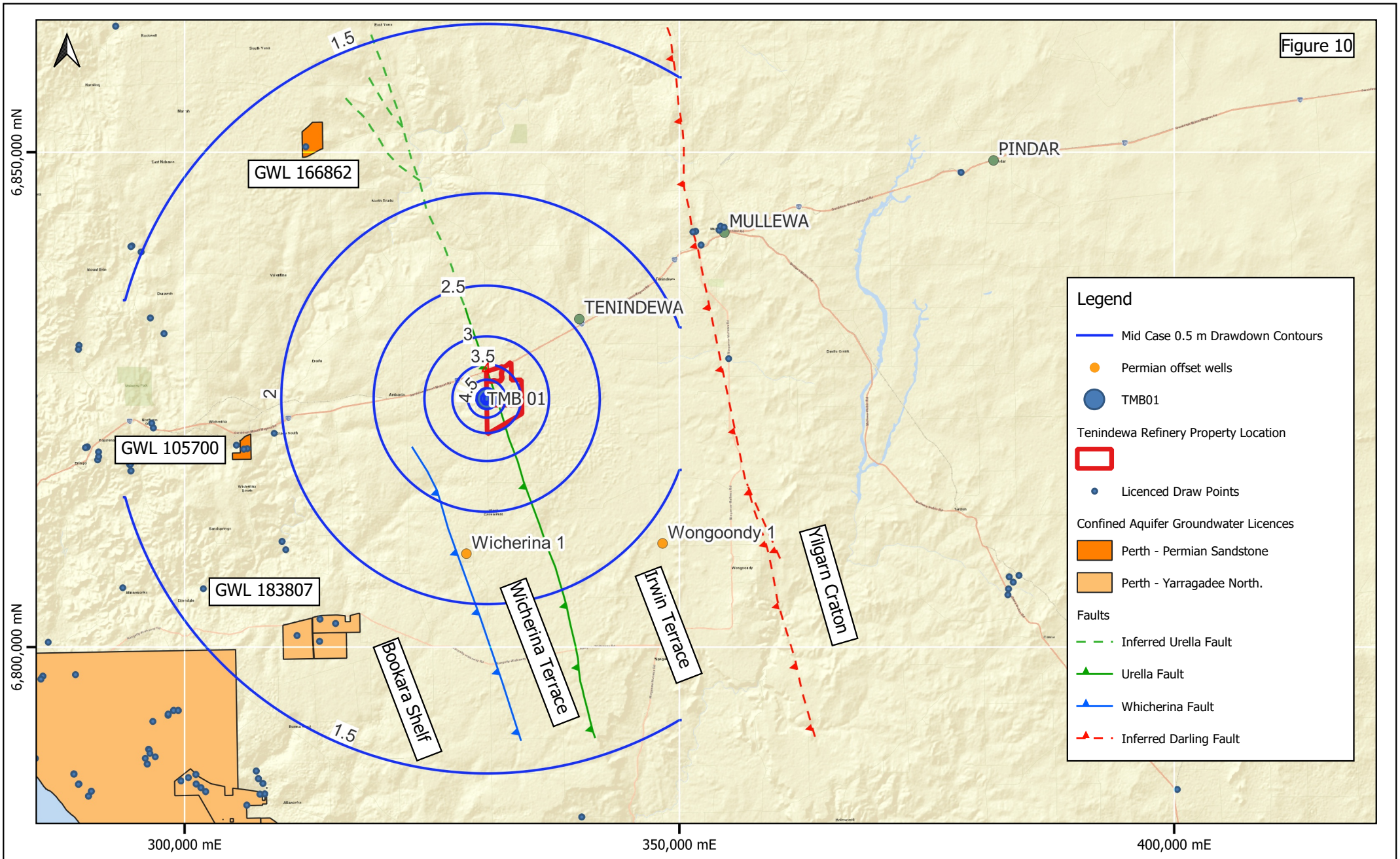
Project: Tenindewa Processing Plant Water Supply
H2 Assessment

Date: February 2022

Dwg. No: 538-0/22/01-9

Tenindewa Monitoring Bore TMB 01
Chemical composition of groundwater

Rockwater PROPRIETARY LIMITED



Rockwater HYDROGEOLOGICAL + ENVIRONMENTAL

Australian VANADIUM LIMITED

0 10 20 km

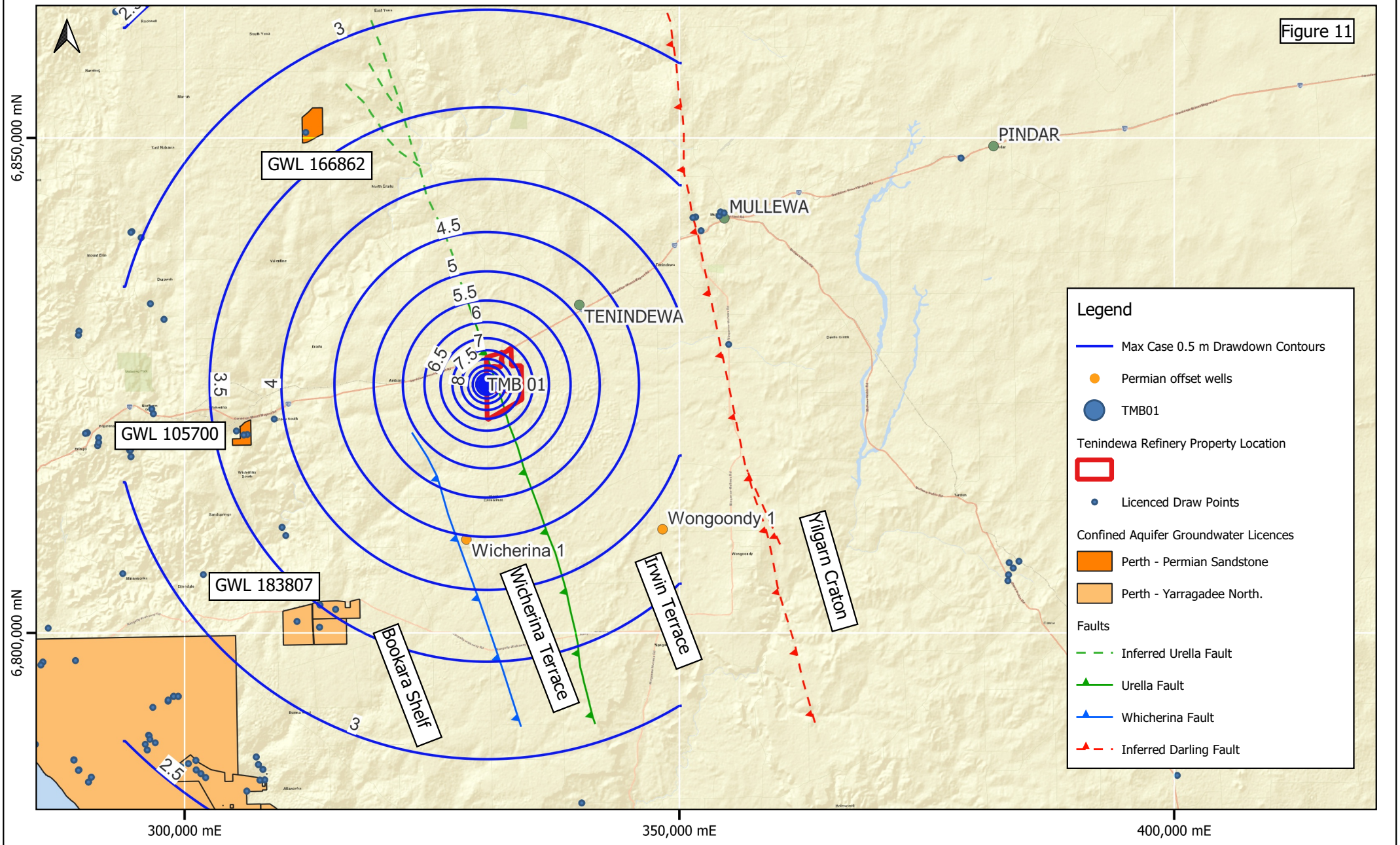
1:500,000

Coordinate System: GDA 2020 MGA Zone 50

Client	Australian Vanadium Limited
Project	Tenindewa Processing Plant Water Supply H2 Assessment
Date	February 2022
Figure Number	538/22/01-10

Mid-Case projected drawdown countours
Q – 1.2 GL/year, T-622.30, S- 1.02x10-4

Figure 11



Rockwater HYDROGEOLOGICAL + ENVIRONMENTAL

Australian VANADIUM LIMITED

0 10 20 km

1:500,000

Coordinate System: GDA 2020 MGA Zone 50

Client	Australian Vanadium Limited
Project	Tenindewa Processing Plant Water Supply H2 Assessment
Date	February 2022
Figure Number	538/22/01-11

Max-Case projected drawdown countours
Q – 1.2 GL/year, T-311.15, S- 5.08x10-5

APPENDIX I
CAW LICENCE

LICENCE TO CONSTRUCT OR ALTER WELL

Granted by the Minister under section 26D of the Rights in Water and Irrigation Act 1914

Licensee(s)	Australian Vanadium Limited
Description of Water Resource	Gascoyne Perth - Permian Sandstone
Location of Well(s)	LOT 40 ON PLAN 28736 - Volume/Folio 2216/19 - Lot 40 LOT 41 ON PLAN 28736 - Volume/Folio 2216/19 - Lot 41

Authorised Activities	**Activity**	**Location of Activity**
	Construct up to 2 non-artesian well(s) for mining or public supply.	LOT 40 ON PLAN 28736 - Volume/Folio 2216/19 - Lot 40 LOT 41 ON PLAN 28736 - Volume/Folio 2216/19 - Lot 41
Duration of Licence	From 28 May 2021 to 27 May 2022	

This Licence is subject to the following terms, conditions and restrictions:

1. The well must be constructed by a driller having a current class 2 water well drillers certificate issued by the Western Australian branch of the Australian Drilling Industry Association or equivalent certification recognised nationally by the Australian Drilling Industry Association.

2. The licensee shall construct the well(s) to the specifications provided with the application for this licence dated 15/04/2021.

3. The licensee shall provide to the Department of Water and Environmental Regulation within 30 days of drilling, the results of down-hole geophysical logging of the borehole. The results must contain gamma and normal resistivity data in the format of an electronic .LAS file.

4. Any well that is to be permanently decommissioned shall, within 30 days of being identified as not fit for purpose or no longer required, be sealed and filled to prevent the surface entry of contaminants and the vertical movement of water in the well, including water in the annular space surrounding the casing, using methods described in ‘Minimum construction requirements for water bores in Australia, Fourth Edition, 2020’

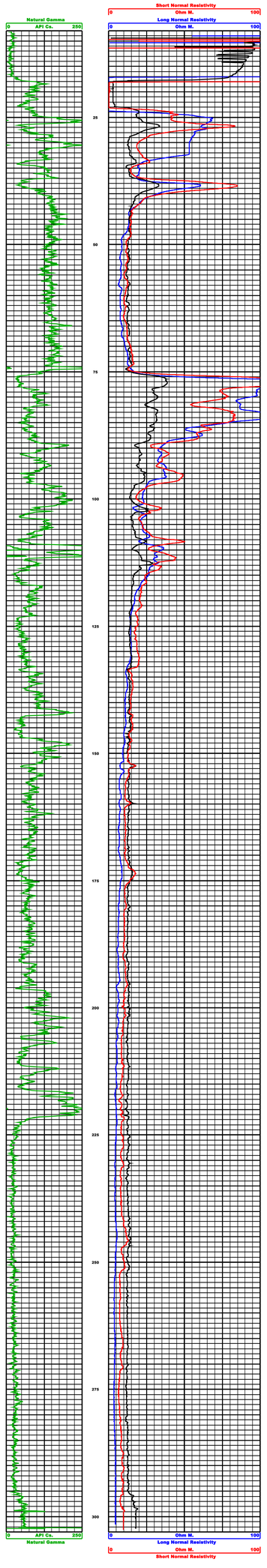
End of terms, conditions and restrictions

APPENDIX II

WIRELINE GEOPHYSICAL LOG RAW DATA

Company	WESTERN DRILLING
Hole Number	VANADIUM AUST MB #1
Area	TENIDAWA
Service Company	WESTLOG WIRELINE SERVICES
Log Type	GAMMA RES
Permanent Datum	GL — Log Measured from GL
Date	24/8/21
Depth Driller	303M
Depth Logger	303M
Hole Diameter	216MM
Casing Type	SFACE
Casing Diameter	
Casing Depth	24M
Fluid Type	GELS
Fluid Level	
Fluid Density	
Recorded by	TIM ROBERTS
Witnessed by	STEVE CHITTY

Vertical Scale: meters 1:250



APPENDIX III

MG PALAEO PALYNOLOGY REPORT

MGPALAEO
geological and stratigraphical consultants

Palynological Analyses of the TMB-1 Well, Perth Basin, Australia

By

Daniel Mantle

Prepared for: Rockwater Pty Ltd

September, 2021

MGPALAEO | Geological and Stratigraphical Consultants | Unit 1 / 5 Arvida Street, Malaga, WA 6090
info@mgpalaeo.com.au | (08) 9249 4628 | www.mgpalaeo.com.au
ACN 149 377 097 | ABN 66 149 377 097

Contents

Indemnity statement

This report is proprietary to Rockwater Ltd Pty. One copy of the report is archived by MGPalaeo, Malaga, WA.

MGPalaeo has made every effort to ensure that interpretations, conclusions and recommendations made herein are accurate and reliable in accordance with good industry practice and its own quality management procedures. MGPalaeo does not, however, guarantee the correctness of any such interpretations and shall not be liable or responsible for any loss, costs, damages or expenses incurred or sustained by anyone resulting from any interpretation or recommendation made by any of its officers, agents or employees.

1. Introduction

This report presents the interpretative palynological analysis of a single cuttings sample from the TMB-1 well. The sample was processed by MGPalaeo at their Malaga Laboratory in Perth and analysed by Dr Dan Mantle.

The sample was analysed quantitatively with the first 100 specimens counted and subsequent species simply recorded as present. Key data and interpretations are provided in summary palynological table (Table 1). Details of the palynomorph assemblage are also recorded on the StrataBugs distribution chart, with each taxon expressed as a percentage of the entire assemblage (Enclosure 1). From this information a zonal assignment is made to the key pan-Australian palynostratigraphic schemes (see Figure 1; these zonations build upon the schemes of Kemp et al., 1977, Price et al., 1985, Helby, Morgan, & Partridge, 1987, Backhouse, 1991, and Price, 1997)

The palaeoenvironmental assessment contained in the report is based on the proportions of marine microplankton (saline algae) to non-marine spores and pollen and freshwater algae, combined with an evaluation of marine microplankton diversity. This enables a broad environmental subdivision giving a general impression of proximity to shoreline.

Relative abundances of taxa in running text are discussed in the following percentage-interval terms:

Rare (R): ≤1%
Frequent (F): 2–4%
Common (C): 5–19%
Abundant (A): 20–49%
Superabundant (SA): ≥50%

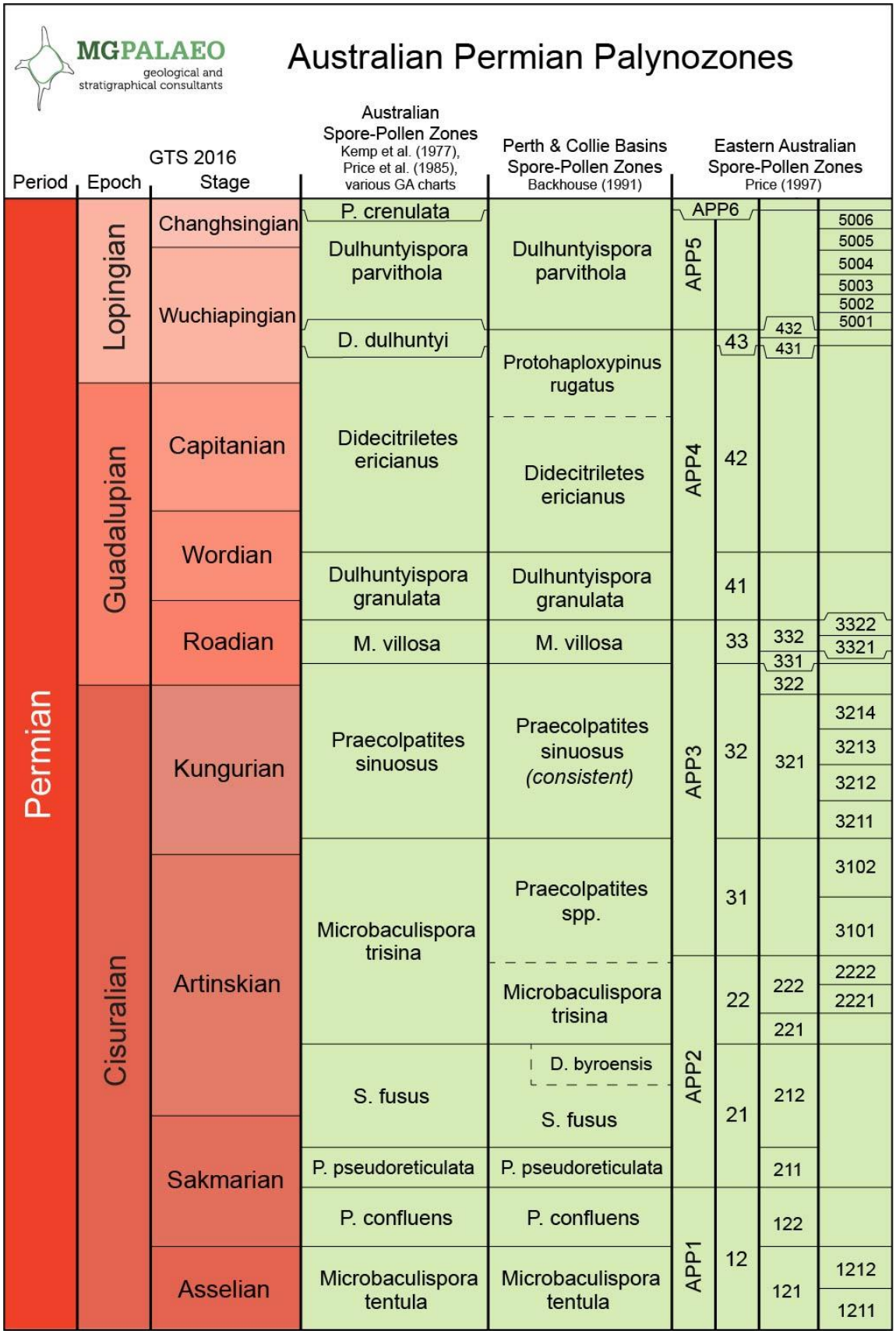


Figure 1: Permian palynological zonation schemes applicable to Perth Basin studies.

2. Results

TMB-1 well

Zonal assignment:	***Praecolpatites sinuosus* Zone [APP3.2 Zone]**
Depth interval:	195/207 m (cutts)
Stage/Age:	Kungurian to basal Roadian
Palaeoenvironment:	Non-marine to marginal marine (unless spiny acritarchs are caved)
Assignment based on:	Very rare *Praecolpatites sinuosus* and *Microbaculispora trisina*, along with the absence of younger marker taxa.
Supporting taxa:	Common *Microbaculispora tentula* and *Scheuringipollenites ovatus*, frequent *Laevigatosporites colliensis*, rare *Cycadopites cymbatus*, *Striatopodocarpites cancellatus*, and a single questionable specimen of *Granulatisporites parvus.*
Comments:	The assemblage is dominated by terrestrial spores and pollen along with frequent *Botryococcus*, thus suggesting a terrestrial depositional environment or a predominantly terrestrial source for the assemblage. However, there are also rare spiny acritarchs present (both *Micrhystridium* and *Veryhachium*), which if in-situ indicate at least a marginal marine depositional environment. These spiny acritarchs are slightly paler and brighter than the rest of the assemblage so there is a reasonable chance these are caved.

3. References

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Price, P.L., 1997. Permian to Jurassic palynostratigraphic nomenclature of the Bowen and Surat basins. In Green, P. (ed): The Surat and Bowen Basins, Southeast Queensland. Queensland Department of Mines and Energy, Brisbane. 137-178.

TABLE 1: PALYNOLOGICAL DATA SUMMARY: TMB-1 (RockWater)

TOP DEPTH [mbRT]	BASE DEPTH [mbRT]	SAMPLE TYPE	MICROFOSSIL YIELD	PRESERVATION	PERCENTAGE				DIVERSITY (*1)		SPORE-POLLEN COLOUR (*2)	ZONE	SUBZONE	ENVIRONMENT (*3)	KEY DATUMS
					MICROPLANKTON			SPORE-POLLEN	MICRO-PLANKTON	SPORE- POLLEN					
					DINOFLAG.	SPINY AC.	OTHER								
195	207	CUTTS	Very High	Fair	0	2 (?Cv)	4	94	Very low (4)	Very high (38)	Orange - Brown	P. sinuosus [APP3.2]		Marginal Marine to Non-marine	P. sinuosos (VR), M. trisina (R), M. tentula (C), L. colliensis (F), C. cymbatus (R), ?G. parvus (VR), S. ovatus (C), S. fusus (VR), S. cancellatus (R)

*1: DIVERSITY	
V. High	30+ species
High	20-29 species
Moderate	10-19 species
Low	5-9 species
Very Low	1-4 species

*2: SPORE-POLLEN COLOUR		
Colour	**HC Potential**	
Translucent to pale yellow	Pre-generation	
Yellow	Immature to Early Oil	
Orange	Main Oil	Early Wet Gas & Condensate
Orange-brown		
Light brown	Late Oil	Wet Gas and Condensate
Mid brown		
Dark brown	Dry Gas	Late Wet Gas
Black		Overmature

The spore-pollen colour is related to hydrocarbon potential assuming that regional thermal maturity has increased with depth over a similar time frame. However other factors such as volcanic intrusions or localised movements of hot fluids may also greatly affect spore-pollen colour.

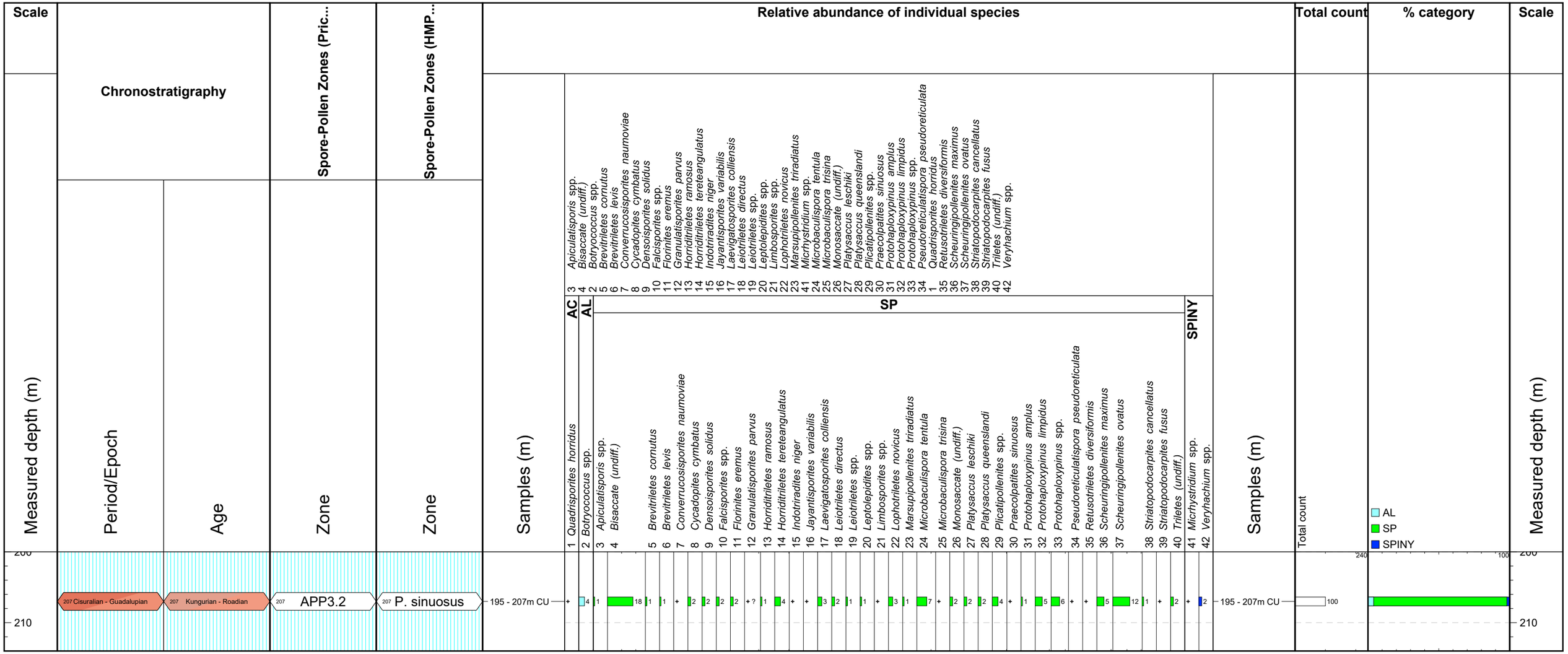
*3: ENVIRONMENT	DINOFLAGELLATE CONTENT %	DINOFLAGELLATE DIVERSITY	FRESHWATER ALGAE CONTENT %
Offshore Marine	67 to 100	Very High	Low
Shelfal Marine	34 to 66	High	"
Nearshore Marine	11 to 33	Moderate	"
Very Nearshore Marine	5 to 10	Moderate-Low	"
Marginal Marine	<1 to 4	Low-Very Low	"
Brackish	0, Spiny Acritarchs only	Extremely Low	"
Non-Marine (undiff.)	0, no Spiny Acritarchs	Nil	Low <3
Non-Marine (lacustrine)	0, no Spiny Acritarchs	Nil	Moderate 3-10+

MGPalaeo (Dan Mantle) Interval: 200m - 214m
Scale: 1:500

TMB-1

MGPALAEO
geological and stratigraphical consultants

TMB-1



APPENDIX IV
GRAIN SIZE ANALYSIS

Sieve Size (phi)	-2.5	-2	-1.5	-1	-0.5	0	1	2	3	<3
Sieve Size (micron)	5600	4000	2800	2000	1400	1000	500	250	125	<125
Sample ID	Mass (%)	Mass (%)	Mass (%)	Mass (%)	Mass (%)	Mass (%)	Mass (%)	Mass (%)	Mass (%)	Mass (%)
240-246	0.76	6.24	17.33	23.52	36.42	5.56	3.63	1.57	0.37	4.60
246-252	4.63	11.11	12.96	18.99	32.99	7.62	3.53	1.42	0.57	6.18
252-258	4.59	12.72	32.72	19.58	15.55	3.91	3.30	1.94	0.61	5.09
258-264	3.99	4.51	13.64	21.42	34.26	6.46	5.04	3.19	0.67	6.82
264-270	0.64	2.49	11.72	22.63	44.19	7.54	2.88	1.78	0.48	5.65

APPENDIX V

TMB 01 BORE COMPLETION DATA

Rockwater HYDROGEOLOGICAL + ENVIRONMENTAL CONSULTANTS	**TENINDEWA WATER SUPPLY** **TMB 01** **MONITORING BORE COMPLETION DATA**

Bore Designation:	**TMB 01**
Status:	Monitoring Bore
Coordinates (m MGA):	330,532 mE, 6,825,096 mN
Ground Elevation:	258 mAHD
Drilling Commenced:	12 August 2021
Bore Completed:	10 September 2021
Drilling Contractor:	Western Drilling
Drilling Rig:	Failing 2500
Depth Drilled:	303.0 m
Drilling Details:	0.0 to 24.0 m 311 mm mud rotary pilot hole 24.0 to 303 m reamed to 216 mm mud rotary (PDC) 223.95 to 275.0 m drilled through gravel pack 155 mm mud rotary (Tricone)
Surface Casing:	-0.2 to 24.0 m, 260.4 mm ID, 273.1 mm OD, Schedule 20, ASME B36.10 carbon steel casing, with cement grouted annulus
Intermediate Casing:	-0.66 to 223.95 m, 126 mm ID, 140 mm OD, API 5CT Grade L80 Casing with landing ring installed at 223.19 m bgl.
Production String:	222.68 to 223.28 m, M-profile packer 223.28 to 241.28 m, 77.92 mm ID, 88.9 mm OD, dual certification 304/304L, Schedule 40, stainless steel casing 241.28 to 271.28 m, 80mm ID, 91 mm OD, dual certification 304/304L, Schedule 40, stainless steel screen (0.5 mm apertures) with stainless steel base plate
Top of Casing:	0.66 m above ground level
Static Water Level (10/09/21):	110.5 m below ground level
Water Salinity (06/10/21):	6850 mg/L TDS
Water pH (06/10/21):	6.60

LITHOLOGY:

Depth From (m)	Depth To (m)	Lithology	Formation	Description
0	9	SAND	Wagina Sandstone	SAND: Ferruginous, red-yellow, well sorted, medium to very coarse-grained sand, predominantly coarse grains, sub-angular to sub-rounded grains. Predominantly quartz, minor feldspar, iron staining, unconsolidated.
9	12	SAND		SAND: Yellow-grey, well sorted, medium to very coarse-grained sand, predominantly coarse, sub-angular grains. Predominantly quartz, minor feldspar, trace iron staining, unconsolidated.
12	18	SAND		SAND: Grey, well sorted, coarse-grained sand to granules, angular grains. Predominantly quartz, minor feldspar, unconsolidated.
18	24	CLAY		CLAY: Sandy, white-grey, soft puggy clay with minor, well sorted fine grained, sub-rounded quartz sand, moderately consolidated
24	27	CLAYEY SAND		CLAYEY SAND: Grey -white, poorly sorted clay to very coarse grained sand, sub-angular, predominantly quartz, minor feldspar, trace of Iron
27	30	SANDY CLAY		SANDY CLAY: Sandy, white-grey, soft puggy clay, with about 40% medium to very coarse grained sand, sub-angular, predominantly quartz, minor feldspar, trace of iron staining on some grains moderately consolidated.
30	39	CLAY		CLAY: Buff-grey/ pink massive clay, well consolidated.
39	45	CLAYEY GRAVEL	Carynginia Formation	CLAYEY GRAVEL: Pink/grey, very poorly sorted clay to small pebbles, mostly granules sized particles, angular, predominantly quartz, and minor feldspar with about 30 % white puggy clay moderately consolidated.
45	51	CLAY		CLAY: Buff-grey/ pink massive clay, well consolidated.
51	81	SHALE		SHALE: Light grey silty shale, well consolidated
81	84	SHALE/GRAVEL	Irwin River Coal Measures	SHALE/GRAVEL: Light grey silty shale, with about 20% gravel; well-sorted, medium to very coarse grained, angular, quartz and feldspar, well consolidated.
84	90	GRAVEL/CLAY		GRAVEL/CLAY: Light grey /white poorly sorted clay to granules, sub-angular to sub-rounded grains. Predominantly quartz, minor feldspar, well consolidated.
90	102	SHALE		SHALE: Light grey silty shale, with about 10 to 15% sand; well sorted, medium to very coarse grained, angular, quartz and feldspar with 20 to 40% interbedded white clay, well consolidated.
102	117	SHALE		SHALE: Light grey and dark grey interbedded siltstone and shale, no sand component well consolidated.
117	120	SANDSTONE/SHALE		SANDSTONE/SHALE: White-grey, well sorted, medium to very coarse-grained sand, sub-angular, predominantly quartz, minor feldspar with about 30% white/grey soft puggy clay, moderately consolidated.
120	138	SHALE/SANDSTONE		SHALE/SANDSTONE: Light grey/ white, clay, with about 40% medium to very coarse-grained sand, sub-angular, predominantly quartz, minor feldspar, well consolidated.
138	141	SHALE		SHALE: Light grey and dark grey interbedded siltstone and shale, no sand component, well consolidated.
141	156	SHALE		SHALE: Black carbonaceous shale with occasional light grey siltstone beds, traces of pyrite, well consolidated.

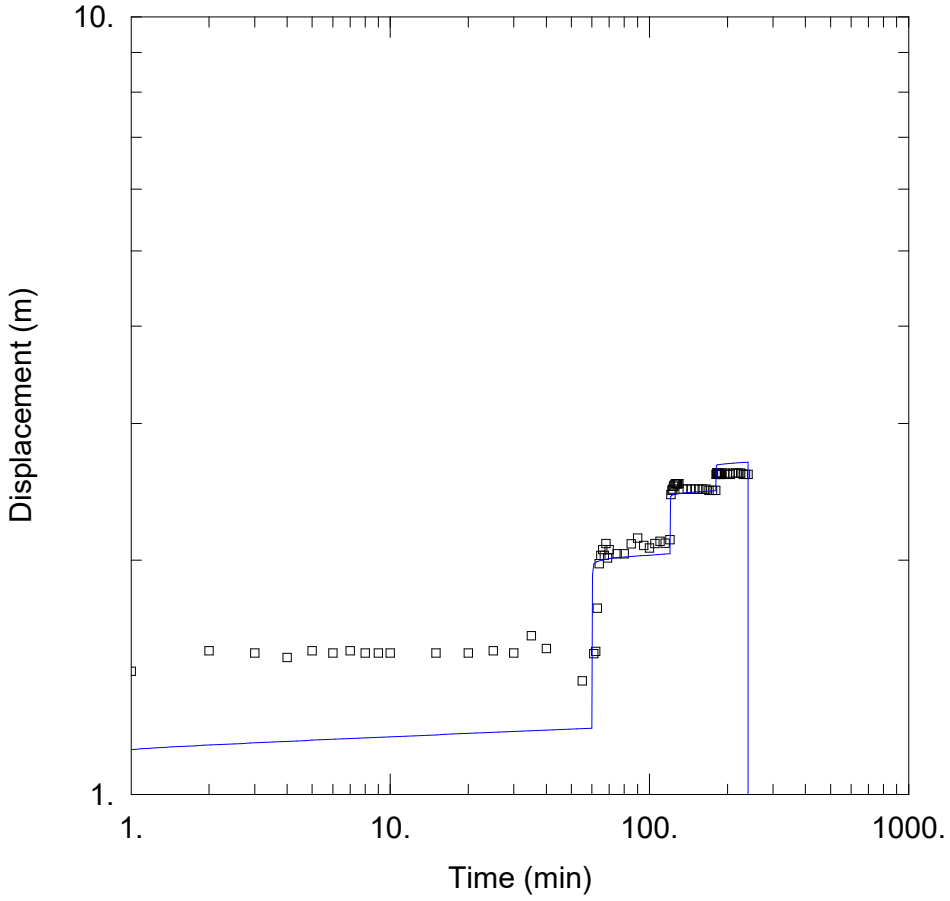
Depth From (m)	Depth To (m)	Lithology	Formation	Description
156	171	SHALE/SILTSTONE	Irwin River Coal Measures	SHALE/SILTSTONE: Light grey, silty clay white clay inter-beds, with about 10 – 30% very fine to fine grained quartz sand, moderately consolidated.
171	195	SANDSTONE		SANDSTONE: Light grey, moderately sorted medium grained sand to granules, sub-angular to angular, predominantly quartz, minor feldspar and traces of pyrite, with 10 to 25% light grey interbedded clay, moderately consolidated.
195	228	SHALE		SHALE: Black carbonaceous shale with about 20% very fine to fine grained silty sandstone occasional light grey siltstone beds, traces of pyrite.
228	303	SANDSTONE	High Cliff Sandstone	SANDSTONE: Light olive grey, well-sorted coarse-grained sand to granules, mostly very coarse-grained, sub-angular, predominantly quartz, minor feldspar and traces of pyrite, weakly consolidated.

DEVELOPMENT DATA:

Date	Time	pH	Water Temperature at surface (°C)	Airlift Rate (L/s)	Measured Conductivity (mS/cm)	Indicative Salinity (mg/L)
9/09/2021	16:25	8.68	24.0	0.8	8.32	5408
9/09/2021	16:35	8.61	24.4	0.8	7.97	5180.5
9/09/2021	17:05	8.62	23.5	0.8	8.91	5791.5
9/09/2021	17:30	8.50	24.1	0.8	8.79	5713.5
9/09/2021	17:50	7.28	24.6	0.8	11.44	7468.5
9/09/2021	18:00	7.80	24.3	0.8	11.59	7533.5
9/09/2021	18:10	7.96	24.2	1	11.86	7709
9/09/2021	18:15	7.95	23.9	1	11.73	7624.5
10/09/2021	8:15	6.40	23.4	2	11.07	7195.5
10/09/2021	8:20	7.08	23.8	1.8	10.84	7046
10/09/2021	8:25	7.13	23.5	1.8	11.40	7410
10/09/2021	8:30	7.00	23.6	1.8	11.42	7423
10/09/2021	8:35	6.78	24.2	1.8	11.47	7455.5
10/09/2021	8:55	6.68	23.8	1.8	11.63	7559.5
10/09/2021	9:10	6.67	24.6	1.8	11.52	7488
10/09/2021	9:20	6.67	23.8	1.8	11.54	7501
10/09/2021	9:40	6.65	23.5	2	11.75	7637.5
10/09/2021	9:55	6.61	22.9	1.8	11.39	7403.5
10/09/2021	10:15	6.61	23.5	1.8	11.38	7397
10/09/2021	10:30	6.59	23.6	1.8	11.30	7345
10/09/2021	10:45	6.56	23.7	1.8	11.22	7293
10/09/2021	11:00	6.55	23.5	1.8	11.20	7280
10/09/2021	11:15	6.55	23.6	1.8	11.19	7273.5
10/09/2021	11:30	6.53	23.4	1.8	11.20	7280

APPENDIX VI

ANALYSIS OF TEST PUMPING DATA



TMB01 STEP RATE PUMPING TEST

PROJECT INFORMATION

Company: Rockwater Pty Ltd
Client: Australian Vanadium Limited
Project: 538-0
Location: Tenindewa
Test Well: TMB 01
Test Date: October2021

AQUIFER DATA

Saturated Thickness: 80. m

Anisotropy Ratio (Kz/Kr): 0.09586

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
TMB 01	330532	6825096

Observation Wells

Well Name	X (m)	Y (m)
TMB 01	330532	6825096

SOLUTION

Aquifer Model: Confined

Solution Method: Dougherty-Babu

T = 622. m^2/day
Kz/Kr = 0.09586
r(w) = 0.108 m
C = 0. min^2/m^5

S = 0.0001015
Sw = 6.889
r(c) = 0.0625 m
P = 2.

Step Test Model: Jacob-Rorabaugh
Time (t) = 1. min Rate (Q) in cu. m/min

$s(t) = 12.68Q + 0.Q^{2.}$
W.E. = 79.99% (Q from last step)

Data Set: I:\538-0\Aqtesolv\TMB01 SRT.aqt
Title: TMB01 Step Rate Pumping Test
Date: 02/04/22
Time: 07:42:12

PROJECT INFORMATION

Company: Rockwater Pty Ltd
Client: Australian Vanadium Limited
Project: 538-0
Location: Tenindewa
Test Date: October2021
Test Well: TMB 01

AQUIFER DATA

Saturated Thickness: 80. m
Anisotropy Ratio (Kz/Kr): 0.09586

PUMPING WELL DATA

No. of pumping wells: 1

Pumping Well No. 1: TMB 01

X Location: 330532. m
Y Location: 6825096. m

Casing Radius: 0.0625 m
Well Radius: 0.108 m

Partially Penetrating Well
Depth to Top of Screen: 20. m
Depth to Bottom of Screen: 50. m

No. of pumping periods: 5

Pumping Period Data

Time (min)	Rate (L/sec)	Time (min)	Rate (L/sec)
0.	1.5	180.	3.25
60.	2.5	240.	0.
120.	3.		

OBSERVATION WELL DATA

No. of observation wells: 1

Observation Well No. 1: TMB 01

X Location: 330532. m
Y Location: 6825096. m

Radial distance from TMB 01: 0. m

Partially Penetrating Well
Depth to Top of Screen: 20. m
Depth to Bottom of Screen: 50. m

No. of Observations: 77

Observation Data

Time (min)	Displacement (m)	Time (min)	Displacement (m)
1.	1.44	123.	2.47
2.	1.53	124.	2.49
3.	1.52	125.	2.5
4.	1.5	126.	2.51
5.	1.53	127.	2.51
6.	1.52	128.	2.51
7.	1.53	129.	2.51
8.	1.52	130.	2.51
9.	1.52	135.	2.47
10.	1.52	140.	2.47
15.	1.52	145.	2.47
20.	1.52	150.	2.47
25.	1.53	155.	2.47
30.	1.52	160.	2.47
35.	1.6	165.	2.47
40.	1.54	170.	2.46
55.	1.4	175.	2.46
61.	1.517	180.	2.46
62.	1.527	181.	2.58
63.	1.736	182.	2.59
64.	1.98	183.	2.59
65.	2.03	184.	2.59
66.	2.065	185.	2.59
67.	2.03	186.	2.58
68.	2.101	187.	2.58
69.	2.015	188.	2.58
70.	2.064	189.	2.58
75.	2.04	190.	2.59
80.	2.04	195.	2.59
85.	2.1	200.	2.58
90.	2.136	205.	2.58
95.	2.09	210.	2.59
100.	2.075	215.	2.59
105.	2.101	220.	2.59
110.	2.116	225.	2.59
115.	2.103	230.	2.58
120.	2.126	235.	2.58
121.	2.43	240.	2.58
122.	2.46		

SOLUTION

Pumping Test
Aquifer Model: Confined
Solution Method: Dougherty-Babu

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
T	622.	m^2/day
S	0.0001015	
Kz/Kr	0.09586	

Sw	6.889	
r(w)	0.108	m
r(c)	0.0625	m
C	0.	min^2/m^5
P	2.	

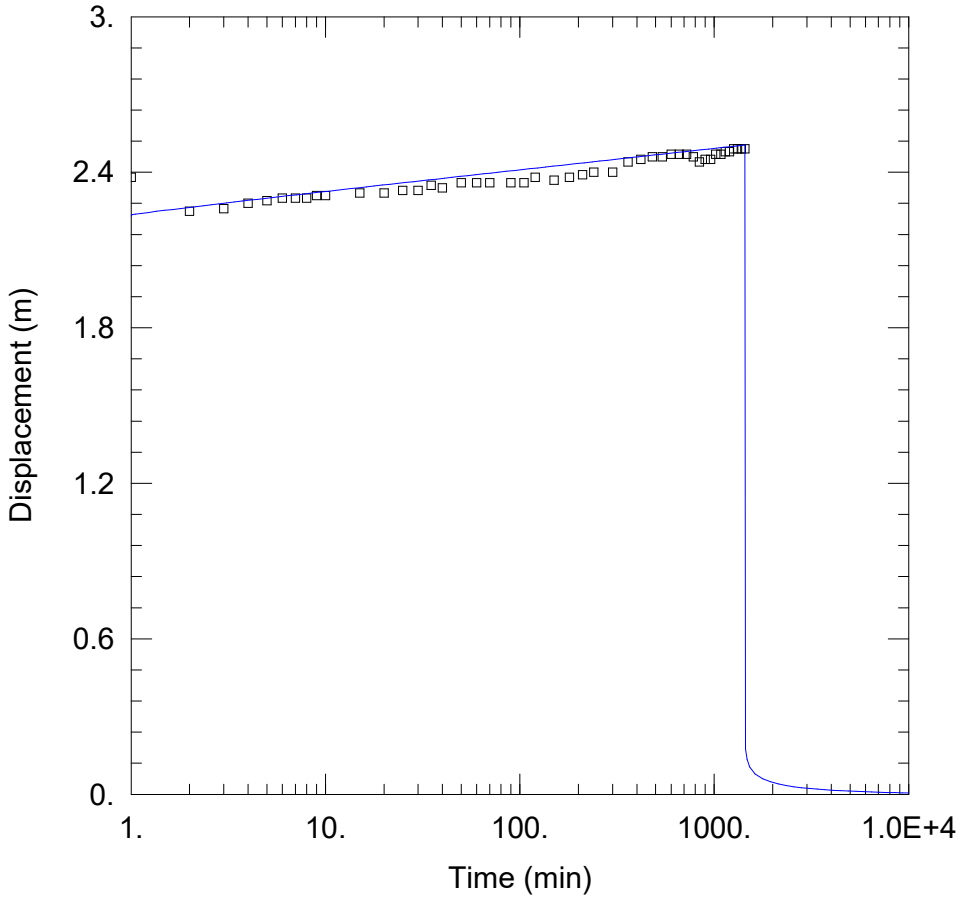
K = T/b = 7.775 m/day (0.008999 cm/sec)
Ss = S/b = 1.269E-6 1/m

STEP TEST ANALYSIS RESULTS

Jacob-Rorabaugh Step Test Model: $s(t) = BQ + CQ^P$
t = 1.min
Q in cu.m/min
B = 12.68
C = 0.
P = 2.

Eden-Hazel Step Test Model: $s(t) = (a + b \log_{10}(t))Q + CQ^P$
Q in cu.m/min
a = 2.509
b = 0.4243
C = 0.
P = 2.

Well Efficiency: 79.99% (Q from last step)



TMB01 CONSTANT RATE PUMPING TEST

PROJECT INFORMATION

Company: Rockwater Pty Ltd
Client: Australian Vanadium Limited
Project: 538-0
Location: Tenindewa
Test Well: TMB 01
Test Date: October 2021

AQUIFER DATA

Saturated Thickness: 80. m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
TMB 01	330532	6825096

Observation Wells

Well Name	X (m)	Y (m)
TMB 01	330532	6825096

SOLUTION

Aquifer Model: Confined

T = 622.3 m^2/day
Kz/Kr = 1.
r(w) = 0.108 m

Solution Method: Dougherty-Babu

S = 0.0001015
Sw = 6.346
r(c) = 0.0625 m

Data Set: I:\538-0\Aqtesolv\TMB01 CRT.aqt
Title: TMB01 Constant Rate Pumping Test
Date: 02/04/22
Time: 07:44:19

PROJECT INFORMATION

Company: Rockwater Pty Ltd
Client: Australian Vanadium Limited
Project: 538-0
Location: Tenindewa
Test Date: October 2021
Test Well: TMB 01

AQUIFER DATA

Saturated Thickness: 80. m
Anisotropy Ratio (Kz/Kr): 1.

PUMPING WELL DATA

No. of pumping wells: 1

Pumping Well No. 1: TMB 01

X Location: 330532. m
Y Location: 6825096. m

Casing Radius: 0.0625 m
Well Radius: 0.108 m

Partially Penetrating Well
Depth to Top of Screen: 20. m
Depth to Bottom of Screen: 50. m

No. of pumping periods: 2

Pumping Period Data

Time (min)	Rate (L/sec)	Time (min)	Rate (L/sec)
0.	3.25	1440.	0.

OBSERVATION WELL DATA

No. of observation wells: 1

Observation Well No. 1: TMB 01

X Location: 330532. m
Y Location: 6825096. m

Radial distance from TMB 01: 0. m

Partially Penetrating Well
Depth to Top of Screen: 20. m
Depth to Bottom of Screen: 50. m

No. of Observations: 46

Observation Data

Time (min)	Displacement (m)	Time (min)	Displacement (m)
1.	2.38	180.	2.38
2.	2.25	210.	2.39
3.	2.26	240.	2.4
4.	2.28	300.	2.4
5.	2.29	360.	2.44
6.	2.3	420.	2.45
7.	2.3	480.	2.46
8.	2.3	540.	2.46
9.	2.31	600.	2.47
10.	2.31	660.	2.47
15.	2.32	720.	2.47
20.	2.32	780.	2.46
25.	2.33	840.	2.44
30.	2.33	900.	2.45
35.	2.35	960.	2.45
40.	2.34	1020.	2.47
50.	2.36	1080.	2.47
60.	2.36	1140.	2.48
70.	2.36	1200.	2.48
90.	2.36	1260.	2.49
105.	2.36	1320.	2.49
120.	2.38	1380.	2.49
150.	2.37	1440.	2.49

SOLUTION

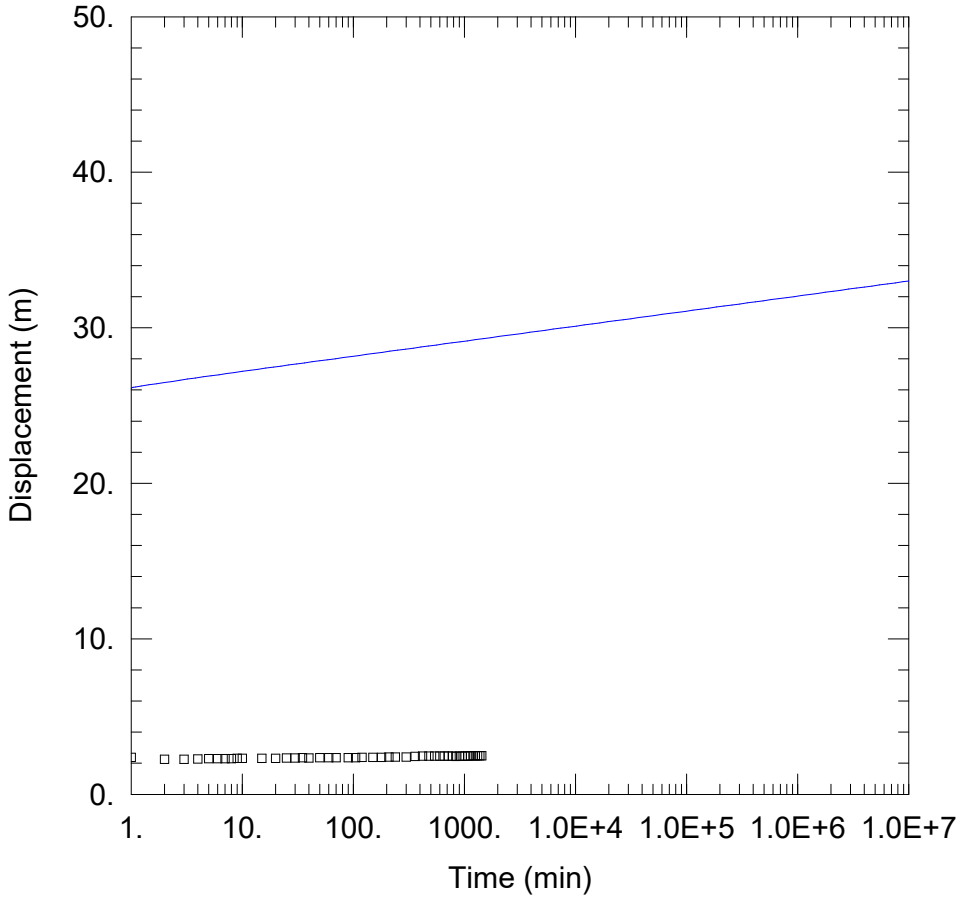
Pumping Test
Aquifer Model: Confined
Solution Method: Dougherty-Babu

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
T	622.3	m^2/day
S	0.0001015	
Kz/Kr	1.	
Sw	6.346	
r(w)	0.108	m
r(c)	0.0625	m

K = T/b = 7.779 m/day (0.009004 cm/sec)
Ss = S/b = 1.268E-6 1/m



TMB01 CONSTANT RATE PUMPING TEST

PROJECT INFORMATION

Company: Rockwater Pty Ltd
Client: Australian Vanadium Limited
Project: 538-0
Location: Tenindewa
Test Well: TMB 01
Test Date: October 2021

AQUIFER DATA

Saturated Thickness: 80. m

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
TMB 01	330532	6825096

Observation Wells

Well Name	X (m)	Y (m)
□ TMB 01	330532	6825096

SOLUTION

Aquifer Model: Confined

Solution Method: Dougherty-Babu

T = 622.3 m^2/day
Kz/Kr = 1.
r(w) = 0.108 m

S = 0.0001015
Sw = 6.346
r(c) = 0.0625 m

APPENDIX VII

WATER QUALITY CERTIFICATE OF ANALYSIS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP2110685**	Page	: 1 of 4
Client	: **ROCKWATER PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: STEVE BOLTON	Contact	: Nick Courts
Address	: 1ST FLOOR, 76 JERSEY ST WEMBLEY WA, AUSTRALIA 6014	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: +61 08 9284 0222	Telephone	: +61-8-9406 1301
Project	: 538-0 Tenindewa Hydrostratigraphic	Date Samples Received	: 10-Sep-2021 16:45
Order number	: ----	Date Analysis Commenced	: 10-Sep-2021
C-O-C number	: ----	Issue Date	: 14-Sep-2021 17:04
Sampler	: DAVID MURRIE		
Site	:		
Quote number	: EP/237/20		
No. of samples received	: 1		
No. of samples analysed	: 1		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Efua Wilson	Metals Chemist	Perth Inorganics, Wangara, WA

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the Chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP2112021**	Page	: 1 of 4
Client	: **ROCKWATER PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: STEVE BOLTON	Contact	: Nick Courts
Address	: 1ST FLOOR, 76 JERSEY ST WEMBLEY WA, AUSTRALIA 6014	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: +61 08 9284 0222	Telephone	: +61-8-9406 1301
Project	: 538-0 Tenindewa	Date Samples Received	: 07-Oct-2021 16:45
Order number	: ----	Date Analysis Commenced	: 08-Oct-2021
C-O-C number	: ----	Issue Date	: 14-Oct-2021 15:35
Sampler	: Chantel Weidenmann		
Site	:		
Quote number	: EP/237/20		
No. of samples received	: 1		
No. of samples analysed	: 1		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Daniel Fisher	Inorganics Analyst	Perth Inorganics, Wangara, WA

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	TMB01	----	----	----	----
				Sampling date / time	06-Oct-2021 13:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP2112021-001	--------	--------	--------	--------
					Result	----	----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**6.60**	----	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**11000**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		**6850**	----	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		**1180**	----	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**67**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**67**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**625**	----	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		**3480**	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**148**	----	----	----	----
Magnesium	7439-95-4	1	mg/L		**198**	----	----	----	----
Sodium	7440-23-5	1	mg/L		**1810**	----	----	----	----
Potassium	7440-09-7	1	mg/L		**66**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L		**1.14**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.170**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		**29.4**	----	----	----	----
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		**1.23**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		**34.2**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	TMB01	----	----	----	----
			Sampling date / time	06-Oct-2021 13:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2112021-001	--------	--------	--------	--------
				Result	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG052G: Silica by Discrete Analyser								
Reactive Silica	----	0.05	mg/L	**10.8**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**1.84**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.03**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.03**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**2.2**	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**2.2**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.04**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	----	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**112**	----	----	----	----
ø Total Cations	----	0.01	meq/L	**104**	----	----	----	----
ø Ionic Balance	----	0.01	%	**3.89**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	TMB01	----	----	----	----
				Sampling date / time	10-Sep-2021 11:30	----	----	----	----
Compound	CAS Number	LOR	Unit		EP2110685-001	--------	--------	--------	--------
					Result	----	----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**6.56**	----	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**10600**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		**6430**	----	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		**1200**	----	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**49**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**49**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**607**	----	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		**3320**	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**146**	----	----	----	----
Magnesium	7439-95-4	1	mg/L		**204**	----	----	----	----
Sodium	7440-23-5	1	mg/L		**1700**	----	----	----	----
Potassium	7440-09-7	1	mg/L		**67**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.02**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L		**1.27**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.017**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		**12.6**	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	TMB01	----	----	----	----
				Sampling date / time	10-Sep-2021 11:30	----	----	----	----
Compound	CAS Number	LOR	Unit		EP2110685-001	--------	--------	--------	--------
					Result	----	----	----	----
EG052G: Silica by Discrete Analyser									
Reactive Silica	----	0.05	mg/L		**9.02**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**2.23**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		**0.01**	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.01**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**2.5**	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**2.5**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.04**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	----	----	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**107**	----	----	----	----
ø Total Cations	----	0.01	meq/L		**99.7**	----	----	----	----
ø Ionic Balance	----	0.01	%		**3.64**	----	----	----	----

APPENDIX C

Greenhouse Gas Management Plan - Tenindewa Vanadium Processing Facility

GREENHOUSE GAS MANAGEMENT PLAN

Tenindewa Vanadium Processing Facility

DRAFT

April 2022

GREENHOUSE GAS MANAGEMENT PLAN

Tenindewa Vanadium Processing Facility

DRAFT

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Australian Vanadium Limited

Project Director:	Emma Molloy
Project Manager:	Emma Molloy
Report No.	6183/R12b
Date:	April 2022

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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
1	Emma Molloy	4 April 2022	Emma Molloy	4 April 2022
2	Trevor Smith	11 April 2022	Emma Molloy	12 April 2022

Executive Summary

Vanadium is a critical mineral and battery metal and contributes to a low carbon economy. Although Australia has a large vanadium resource, there is currently no operational vanadium mine or processing facility in Australia (Summerfield, 2019).

Vanadium is primarily used for strengthening steel, which reduces the volume of steel that is required to be used for applications such as rebar. If the entire volume of vanadium pentoxide planned to be produced by Australian Vanadium Limited (AVL) each year was used in high strength low alloy steel, it would result in reduced carbon emissions from downstream steel production of approximately 14,700,000 tonnes carbon dioxide equivalent per annum (t CO_2-e pa).

A growing use of vanadium is in vanadium redox flow batteries, which support the transition to a lower-carbon economy. This application is expected to drive increasing demand for vanadium and demonstrates the value of vanadium as a critical mineral and a battery metal.

Vanadium production by AVL will have 50% lower carbon emissions intensity than 70% of vanadium produced globally.

During feasibility studies, AVL focused on improving cost and energy efficiency of the processing facility. The design improvements developed during feasibility studies were calculated to reduce GHG emissions by over 20,000 t CO_2-e pa.

Further mitigation strategies that are feasible to implement straightaway upon commencement of the proposal were predicted to reduce GHG emissions by 11,000 t CO_2-e pa.

The peak annual average GHG emissions for the Tenindewa vanadium processing facility incorporating these immediate mitigations were calculated as 95,575 t CO_2-e pa, which is below the threshold that would require EPA assessment.

Additional mitigation strategies are expected to be feasible to implement during operations as technologies become available, which will further reduce the GHG emissions during operations.

Scope 3 GHG emissions associated with vanadium concentrate production and transport onshore were calculated as 114,584 t CO_2-e pa. The calculated transport emissions are expected to be mitigated over time as technologies become available.

Australian Vanadium Limited is committed to mitigating GHG emissions as much as practicable to support the transition to a low-carbon economy. This will be undertaken in a way that is financially sustainable for the operation of their facilities.

AVL acknowledges the expectations of stakeholders to continually improve GHG management and transition to net zero emissions.

GHG emissions and performance will be reviewed and reported each year in a publicly available report.

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Graphs

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1.0 Context

1.1 Purpose of this Management Plan

This Greenhouse Gas Management Plan (GHGMP) addresses greenhouse gas emissions and management measures to reduce emissions for the Australian Vanadium Limited (AVL) processing facility located at Tenindewa within the City of Greater Geraldton on Lot 40 and Lot 41 on Plan 28736 (the proposal). This GHGMP has been developed to:

- communicate to stakeholders the approach for greenhouse gas (GHG) emissions management for the Project
- demonstrate compliance with relevant legislation, government policies and guidelines and expectations of key stakeholders
- validate that all reasonable and practicable measures have been taken to reduce and mitigate GHG emissions
- facilitate effective management of GHG emissions and continuous improvement throughout operations.

1.2 Relevant Legislation, Policies and Guidelines

The legislation, government policies and guidelines relevant to assessment and management of GHG emissions at the Project are listed in **Table 1.1**.

Key requirements are to estimate Scope 1 GHG emissions at the facility level and reduce GHG emissions as much as practicable.

Table 1.1 Legislation, Policies and Guidelines Relevant to Management of GHG Emissions for the Project

Document	Key Requirements	Relevance and Application
Environmental Factor Guideline – Greenhouse Gas Emissions (EPA, 2020)	The environmental objective of the Greenhouse Gas Emissions factor is to reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change.	GHG emissions for the processing facility have been reduced during the design process and will be further reduced and mitigated as described in **Section 5.0**.
	Scope 1 GHG emissions are the emissions as a direct result of activities at a facility level.	Scope 1 emissions have been estimated at the facility level in this GHGMP.
	GHG emissions from a proposal will be assessed where they exceed 100,000 t CO_2-e of scope 1 emissions each year.	The scope 1 emissions for the proposal do not exceed 100,000 t CO_2-e pa. Therefore, GHG emissions is not expected to be a key environmental factor for the EPA assessment.

Document	Key Requirements	Relevance and Application
	The approach as outlined in the guideline will be applied to consideration of GHG emissions to ensure projects are assessed and conditioned in an effective, consistent and equitable manner.	Recent EPA assessments for GHG emissions were reviewed to understand the current expectations and approach for assessment. For example, Eneabba Rare Earth Refinery referral calculated Scope 1 emissions from the facility only and did not consider cumulative GHG emissions from all Iluka operations in WA nor cumulative emissions from mining and transport of ore as a Scope 1 emission. Scope 3 emissions were not estimated. Estimated Scope 1 and 2 GHG emissions from the Eneabba Rare Earth Refinery were 87,680 t CO_2-e per year, and EPA decided in January 2022 not to assess this proposal. Similarly for the Tenindewa vanadium processing facility, Scope 1 emissions were calculated as emissions from the facility only and do not include all AVL predicted emissions in WA nor emissions from mining and transport of concentrate.
	EPA may request credible estimates of scope 1, 2 and 3 GHG emissions (annual and total) over the life of a proposal; a breakdown of emissions by source; and projected emissions intensity benchmarking against comparable projects.	This GHGMP includes estimates of scope 1, 2 and 3 GHG emissions by source (annual), estimated emissions intensity, and benchmarking against other vanadium production operations.
	The EPA supports public reporting by proponents against interim targets as outlined in the GHGMP, ideally aligned with five-year milestones set out in the Paris Agreement (2025, 2030, etc.).	Public reporting of GHG emissions is proposed – see **Section 7.1**.
	The EPA encourages the application of all practicable measures to avoid, reduce and offset GHG emissions.	All practicable measures to avoid, reduce and offset GHG emissions have been applied. The approach to mitigation of GHG emissions is described in **Section 5.0**.
	Where carbon offsets are to be implemented, they should meet offset integrity principles and be based on clear, enforceable and accountable methods, for example the Australian Carbon Credit Units meet these standards.	These standards will be considered for any future offsets.

Document	Key Requirements	Relevance and Application
Western Australian Greenhouse Gas Emissions Policy for Major Projects (Government of Western Australia, 2019)	The Policy is intended to apply to new significant proposals that meet the criteria of a designated large facility under the Australian Government's Safeguard Mechanism. The Safeguard Mechanism applies to facilities with Scope 1 covered emissions of more than 100,000 tonnes per annum.	The proposal is not a major project for the purpose of this policy and will not be a large facility under the Safeguard Mechanism, as Scope 1 emissions do not exceed 100,000 t CO_2-e pa at the Tenindewa processing facility.
Guideline: Defining a 'facility' for the purposes of the National Greenhouse and Energy Reporting legislation (Clean Energy Regulator, 2021)	*A facility* is an activity, or a series of activities (including ancillary activities) that: - involve the production of greenhouse gas emissions, the production of energy or the consumption of energy - form a single undertaking or enterprise and meet the requirements of the regulations, and - are attributable to a single industry sector. Regulation 2.16(1): Activities that together produce one or more products or services (the primary production process) will form part of a single undertaking or enterprise if the activities occur at a single site.	The process site industry sector is ANZSIC code 213 basic non-ferrous metal manufacturing (or similar). The mine site industry sector is ANZSIC code 080 metal ore mining. As the mine site and process site are different industry sectors and are located more than 400 km apart, they are two separate facilities for the purpose of GHG reporting. All the activities at the Tenindewa process site form a single undertaking that together produce one or more products at a single site. Therefore, all activities at the process site form one facility. The facility and activities are described in **Section 1.4**.
Supplementary Guideline: Operational control (Clean Energy Regulator, 2021)	Once registered, a controlling corporation is required to report emissions for facilities that are under its operational control. Operational control is determined at the facility level, based on the entity that has the greatest authority to introduce and implement operating and environmental policies for the facility.	AVL is the controlling corporation for the Tenindewa process site facility, and as such will report emissions. Although some aspects of the site will be operated by third parties (e.g. power plant), as the overall owner and the operator of most of the activities at the site, AVL has the greatest operational control of the facility.
National Greenhouse and Energy Reporting Act 2007 (NGER Act)	A controlling corporation is required to register to report under the NGER Act if it has operational control of a facility that emits more than 25,000 t CO_2-e in a financial year.	The processing facility is expected to emit more than 25,000 t CO_2-e in a financial year. Therefore, AVL will apply to be registered under the NGER Act and will report when activities exceed the relevant threshold.
The Equator Principles July 2020	Principle 2: Undertake a climate change risk assessment that aligns with the physical and transition risk categories of the *Recommendations of the Task Force on Climate-related Financial Disclosures* (TCFD).	The requirements of the TCFD are listed as a separate item in this table.
	Principle 2: An alternatives analysis should be completed to evaluate lower GHG intensive alternatives. Annex A: The alternatives analysis requires the evaluation of technically and financially	As the proposal is in a carbon intensive sector, an alternatives analysis has been undertaken in the form of benchmarking (**Section 4.0**), consideration of alternatives during feasibility studies

Document	Key Requirements	Relevance and Application
	feasible and cost-effective options to reduce GHG emissions of the Project, including comparison to other viable technologies used in the same industry and country.	(**Section 5.2**) and further mitigation that can be applied during detailed design, construction and operations (**Section 5.0**).
Recommendations of the Task Force on Climate-related Financial Disclosures (TCFD)	Transition Risks: Risks relating to transition to a lower-carbon economy, including changes in policy to constrain actions that contribute to climate change, climate-related litigation, emerging technologies to support a lower-carbon economy that affect the demand for products and services, changes in market demand, and reputation risk associated with changing customer or community perceptions.	Transition climate risks are assessed in **Section 1.5.1**.
	Physical Risks: Risks relating to physical climate changes from acute events and chronic shifts in climate patterns, causing changes in water availability and extreme temperatures.	Physical climate risks are assessed in **Section 1.5.2**.

1.3 Stakeholders and Expectations

Stakeholders for the Project that have expectations relating to GHG emissions and management include the Western Australian and Australian government and the Environmental Protection Authority (EPA), the AVL Board and its subsidiary VSUN Energy, potential investors and shareholders, and the public.

The expectations of stakeholders are listed in **Table 1.2**. Detailed evaluation of proposed GHG mitigation options will consider stakeholder expectations such as power supply requirements, financial sustainability, and benefits to local communities.

Table 1.2 Key Stakeholders and Expectations Regarding GHG Management

Stakeholders	Expectations	Relevance and Application
Government of Western Australia	The *Western Australian Climate Policy* (2020) supports growth of Western Australia's future battery industries and development of a renewable hydrogen industry. The *Future Battery Industry Strategy Western Australia* (Government of Western Australia, 2019) vision for 2025 is that Western Australia has a world leading, sustainable, value-adding future battery industry that provides local jobs, contributes to skill development and economic diversification, and benefits regional communities. This vision will be supported by improving the competitiveness of WA's future battery minerals industry and increasing the scale of processing activities across the battery value chain in Western Australia. The *Western Australian Renewable Hydrogen Strategy* (Government of Western Australia, 2021) vision is for Western Australian to be a significant producer, exporter, and user of renewable hydrogen.	Vanadium is a battery metal and a critical mineral. The Australian Vanadium Project includes an onshore downstream processing plant in support of the *Future Battery Industry Strategy Western Australia*. GHG mitigation strategies include consideration of renewable hydrogen use and production for processing, power generation and transport, in support of the *Western Australian Renewable Hydrogen Strategy*. Potential sites for processing facilities in Australia are often in regional and remote areas, which are not grid-connected and have large transport distances for inputs and products. Benchmarking of carbon emissions intensity needs to be undertaken on like-for-like operational basis where possible. Downstream mineral processing is energy intensive. The Western Australian and Federal Government strategies to develop downstream mineral processing facilities in Australia need to be supported by strategic consideration of the carbon emissions from these facilities. In July 2021 AVL received a $3.69 million grant from the Australian Federal Government under the *Resources Technology and Critical Minerals Processing National Manufacturing Priority Road Map*. The grant and matched funding from the company is intended to advance the development of a domestic battery processing industry by enabling construction of a vanadium electrolyte manufacturing facility and the manufacture of prototype standalone power systems (SPS) based on VRFB technology. In March 2022 AVL received a $49 million grant from the Australian Federal Government under the *Modern Manufacturing Initiative Collaboration Stream*. The grant will be used to support development of the mining and processing projects including collaboration with ATCO for green hydrogen.
Australian Federal Government	*Australia's Critical Mineral Strategy* (Commonwealth of Australia, 2019) aims to develop and increase investment in Australia's critical minerals sector, including downstream processing and manufacturing opportunities. The *National Manufacturing Priority Road Map* (Commonwealth of Australia, 2021) includes a vision for Australia to have a strategic critical minerals processing industry that captures significant additional value, strengthens our global position downstream from our resource endowments and underpins a range of advanced manufacturing opportunities.	

Stakeholders	Expectations	Relevance and Application
AVL Board	The Project requires a technically sound power solution, providing reliable power supply (>98% availability) to meet design production and revenue targets for financial sustainability in a volatile market.	Detailed evaluation of GHG mitigation options is required to determine whether the proposed renewable energy options will meet power supply availability requirements.
	The Bankable Feasibility Study and GHG mitigation commitments must demonstrate that the Project is financially viable. The required capital investment must be funded for the Project to proceed, and operational costs must be viable even at low commodity prices for the Project to be financially sustainable.	Detailed evaluation of GHG mitigation options will consider financial modelling of the Project lifecycle that incorporates possible future scenarios including: carbon pricing; preferential demand for products with low embedded carbon at international borders; and the likely cost of carbon offsets in the short and long term.
	The Project seeks to provide benefits to local communities where possible.	Detailed evaluation of GHG mitigation options will include criteria to assess benefits to local communities.
VSUN Energy (AVL subsidiary and battery supplier)	Vanadium Redox Flow Batteries (VRFBs) have a service life of around 20 years and are most suitable for stationary storage applications (Commonwealth of Australia, 2021). They can discharge 100% of their storage energy over a typical discharge profile of 3-10 hours. As the initial life of mine is 25 years, installation of VRFBs early in the project will provide a long-term carbon mitigation strategy and demonstrate the viability of VRFBs. The long discharge profile of VRFBs provides a mechanism to shift intermittent renewable generation from solar or wind over a longer timeframe to suit site demand.	Short and long term GHG mitigation strategies consider application of VRFBs (see **Section 5.0**).
Potential investors and shareholders	Comply with the Equator Principles, a financial industry benchmark for determining, assessing, and managing environmental and social risk in projects.	Principle 2 of the Equator Principles requires a climate change risk assessment and alternatives assessment. Relevant requirements of the Equator Principles are listed in the above **Section 1.2.**
	Recent actions and decisions taken by shareholders and by international and national courts demonstrate an increasing awareness of the role of corporations in mitigating the risk of climate change. Potential investors and future shareholders may expect AVL to commit to a pathway to net zero carbon emissions.	AVL will reduce and mitigate GHG emissions as far as practicable. Detailed evaluation of GHG mitigation options will include modelling of the cost of reaching net zero using further mitigation options or offsets, including likely scenarios with increased cost of carbon offsets.

Stakeholders	Expectations	Relevance and Application
General public	Comply with EPA objective to reduce net greenhouse gas emissions to minimise the risk of environmental harm associated with climate change. Apply leading practice GHG emissions controls so that any residual emissions are manageable and not significant.	GHG emissions for the Project have been reduced during the design process and will be further reduced and mitigated as described in **Section 5.0**. Benchmarking with comparable operations has been undertaken to identify opportunities for GHG mitigation (see **Section 4.0**).

1.4 Scope of this Management Plan

This GHGMP has been prepared for the proposed Tenindewa vanadium processing facility (the proposal). The processing facility will produce vanadium pentoxide and iron-titanium co-product from vanadium concentrate.

Scope 1 activities at the processing facility during commissioning and operations include:

- mixing & pelletising
- roasting
- leaching (generation of the washed iron-titanium co-product)
- desilication
- precipitation
- barren solution treatment
- vanadium pentoxide production (generation of vanadium pentoxide solid flakes)
- power generation (hybrid renewable-gas plant)
- diesel use in light vehicles and heavy vehicles on-site
- transformation of sodium carbonate to carbon dioxide in the roasting kiln
- revegetation

Production of vanadium concentrate is undertaken at a separate facility and therefore is a Scope 3 emission.

The vanadium source may vary due to market conditions. The vanadium concentrate will primarily be sourced from vanadium mines within Western Australian (base case) but can also use other sources that are rich in vanadium, such as slag from steel operations.

While the source of concentrate may vary, this GHGMP uses the estimated emissions from the AVL Mining and Beneficiation Operations as the basis of the Scope 3 upstream emissions from production and transport of the concentrate. Scope 3 emissions associated with vanadium concentrate are:

- mining and production of concentrate

- transport of upstream inputs to mining and beneficiation operations
- transport of concentrate from the mining and beneficiation operations to the processing facility.

Transport of other large-volume inputs and the products from the processing facility were also estimated for the GHG emission calculation. As transport is not part of a facility and would be undertaken by a third party, it is a Scope 3 emission. The following onshore transport components were estimated:

- fuel to the processing facility
- largest volume reagents (ammonium sulphate and sodium carbonate) to the processing facility
- vanadium pentoxide from the processing facility to Fremantle Port for export
- iron-titanium co-product from the processing facility to Geraldton Port for export.

All transportation will be undertaken by diesel-fuelled trucks as the base case.

Construction activities are not included in the estimation of GHG emissions in this management plan, as they are difficult to quantify and would primarily comprise Scope 3 emissions from transport, concrete production, and construction contractors.

There are no Scope 2 emissions as the site is not grid-connected. Electricity generation from the on-site power plant is included in Scope 1 emissions.

1.5 Climate-Related Risks and Opportunities

This section assesses climate-related risks and opportunities, in alignment with the TCFD.

1.5.1 Transition Risks

Risks to the Tenindewa processing facility relating to the transition to a lower-carbon economy are assessed in **Table 1.3**. The highest rated risks are changes to Western Australian environmental assessment expectations or international policy, which may require increasingly stringent GHG mitigation and offsets.

Table 1.3 Climate Change Transition Risks to the Tenindewa Processing Facility

Risk Category	Potential Risk Scenario	Likelihood	Most Reasonable Worst Case Consequences	Risk Rating
Policy change	Changes to Western Australian or Australian environmental assessment guidelines and expectations relating to GHG emissions, which may require increasingly stringent GHG mitigation and offsetting.	Likely	Moderate If all Scope 1 GHG emissions from the processing facility are required to be reduced to net zero by 2050, and the price of offsets is $45/t, the annual cost by 2045 could be $2.3-2.5 million.	High

Risk Category	Potential Risk Scenario	Likelihood	Most Reasonable Worst Case Consequences	Risk Rating
Policy change Market demand	Changes to international policy imposing carbon tariffs on imports at international borders, which may increase prices for products with higher embedded carbon.	Likely	Moderate Change in market demand for zero embedded carbon products, resulting in inability to sell product in a market with sufficient supply of zero or lower carbon products. Noting that the proposal has 50% lower carbon emissions intensity than most vanadium produced globally.	High
Litigation	Citizen litigation against corporations to seek stronger action on climate change. To date, this type of litigation has targeted large and highly carbon intensive industries such as fossil fuel production.	Unlikely	Moderate Possible consequences may be an expectation to reduce Scope 1 emissions to net zero by 2050, even if this isn't required by regulators. The annual cost (at $45/t offsets) could be $2.3-2.5 million based on predicted residual GHG emissions after 2045.	Moderate
Reputation risk	Shareholders and investors demanding stronger action on climate change. This GHGMP is intended to demonstrate management to meet stakeholder expectations.	Rare	Severe Possible consequences may be an inability to obtain the full required funding for the Project if GHG management doesn't meet investor expectations (e.g. >$20 million deficit in required capital funding).	Moderate

This GHGMP aims to address the above risks by demonstrating strategies to minimise GHG emissions and further mitigate emissions as additional technologies become viable.

1.5.2 Physical Risks

The physical risks of climate change assessed in **Table 1.4** are based on examples of events under 1.5°C to 3°C of global warming, as described in *The Risks to Australia of a 3°C Warmer World* (Australian Academy of Science, 2021). The current global commitments to manage climate change would lead to 3°C of global warming (Hoegh-Guldberg, 2021). The potential consequences may be more severe if this scenario occurs.

With climate change, the maximum temperature is expected to increase and be more frequent, and rainfall is predicted to decrease as well as become more variable (**Table 1.4**).

The current climate of Mullewa is described as hot dry summer and cold winter with summer drought (Bureau of Meteorology, 2022a). In 2021, the average monthly maximum temperate was highest in December to March, when it was 29-31 degrees C (World Weather Online, 2022). On average, between December and March there are 69 days with maximum temperature exceeding 35 degrees C (Farm Online Weather, 2022). The average annual rainfall is 332 mm (Bureau of Meteorology, 2022b). In 2021, the driest months were September to February, when monthly rainfall was 0.1-10 mm (World Weather Online, 2022).

The highest-rated risk is workplace health and safety due to increasingly frequent and hotter temperatures.

Table 1.4 Climate Change Physical Risks to the Tenindewa Processing Facility Operations

Risk Category	Potential Risk Scenario	Likelihood	Most Reasonable Worst Case Consequences	Risk Rating
Temperature	More frequent and hotter high temperatures. More frequent heatwaves lasting for more days each.	Almost certain	Minor Workplace medical treatment.	High
Acute events – rainfall and tropical cyclones	Extreme rainfall events become more intense. Higher variability in rainfall. Less frequent tropical cyclones but increased intensity, increased precipitation, and tropical cyclones extending further southwards.	Likely	Minor Damage to infrastructure such as roads, powerlines, process plant, overflooding of waste containment infrastructure, over topping of bunds.	Moderate
Chronic change	Increased evapotranspiration and length and severity of droughts, long-term decreased rainfall leading to overall reduction in water availability.	Almost certain	Insignificant Water for the proposal will be abstracted from a deep aquifer. Water quality and availability from this source is not expected to be impacted by climate change.	Moderate

1.5.3 Climate-Related Opportunities

Climate-related opportunities for the Tenindewa processing facility are listed in **Table 1.5**.

Transition to lower emission energy sources and increased demand for vanadium for VRFBs are expected to present high opportunities to lower cost and increase revenue.

Table 1.5 Climate Related Opportunities for the Tenindewa Processing Facility

Risk Category	Potential Opportunity	Likelihood	Most Reasonable Best Case Consequences	Opportunity Rating
Resource efficiency	Reduce operational costs by improving resource use efficiency, such as water and energy use efficiency.	Possible	Insignificant Reduced operational costs <$0.5 million per year.	Low
Transition to lower emission energy sources	Transition a major proportion of energy generation for the processing facility to renewable or other low-emission alternatives.	Almost certain	Minor Reduced operational costs $0.5-$2 million per year.	High
New markets	Increased global and local investment into climate change adaption driving increased demand for vanadium to use in VRFBs.	Likely	Moderate Increased revenue due to higher prices in a demand-driven market.	High

2.0 Calculated Peak Greenhouse Gas Emissions

The Scope 1 and Scope 3 GHG emissions estimates presented in the below sections are calculated from the Bankable Feasibility Study (BFS) data including:

- design improvements to reduce GHG emissions (see **Section 5.2**)
- mitigation of GHG emissions feasible to incorporate straightaway upon proposal commencement (see **Section 5.3**)

Further mitigation of GHG emissions will be undertaken throughout operations (see **Section 5.4**). Mitigation measures have been incorporated into the GHG emission targets in **Section 6.0**.

Section 2.3 also calculates the reduction in global GHG emissions associated with downstream use of vanadium that would be produced from the proposal, which is a further category of Scope 3 (indirect) emissions / reductions.

2.1 Scope 1

Scope 1 emissions for the Tenindewa processing facility comprise all activities undertaken at the facility, including aspects operated by other parties (such as the power plant). The *Environmental Factor Guideline – Greenhouse Gas Emissions* (EPA, 2020) and the *Guideline: Defining a 'facility' for the purposes of the National Greenhouse and Energy Reporting legislation* (Clean Energy Regulator, 2021) have been used to inform the development of this GHGMP. All the activities at the processing plant facility form a single undertaking that together produce one or more products at a single site, comprising one facility (for more details see the legislation summary in **Section 1.2**).

Peak average annual Scope 1 (direct) emissions from the processing facility are calculated as 95,575 t CO_2-e pa base case. This is below 100,000 tpa. Therefore, the processing facility will not be a large facility under the Safeguard Mechanism and greenhouse gas emissions at the processing facility are not expected to require assessment by the EPA.

Table 2.1 presents the sources of emissions and estimated average emissions per year for the processing facility, including mitigations feasible to implement straightaway upon commencement (see **Section 5.3**).

Table 2.1 Estimated Scope 1 (direct) Emissions for the Processing Facility

Emission Source	Basis of Estimate	Average Annual GHG Emissions (t CO_2-e pa)
Direct gas use	Roasting kiln, drying, deammoniation and fusion	62,569
Electricity	Used by processing plant	16,557
Vehicles	Heavy and light vehicles	897
Direct gas emissions	Sodium carbonate transformation to carbon dioxide	15,553
Total		**95,575**

There are no Scope 2 emissions from purchase of electricity from an off-site facility, as power is generated from an on-site power plant and included in the Scope 1 emissions in **Table 2.1**.

2.2 Scope 3 – Onshore

Estimated Scope 3 (indirect) emissions comprise mining and beneficiation of concentrate and transport to the processing facility (assumed to be sourced from AVL's Mining and Beneficiation Operations for the purpose of this estimate), transport of other large volume inputs to the processing facility, and transport of products to ports. **Table 2.2** presents the estimated Scope 3 average emissions per year.

Table 2.2 Estimated Scope 3 Emissions

Component	Basis of Estimate	Average Annual GHG Emissions (t CO_2-e pa)
Vanadium concentrate production	Mining and production of concentrate, based on AVL Mining and Beneficiation Operations, including transport of inputs to mine	63,853
Vanadium concentrate transport	Transport of concentrate, based on AVL Mining and Beneficiation Operations	39,444
Inputs to processing facility	Transport of diesel, ammonium sulphate and sodium carbonate using road transport	2,808
Products to port	Transport of vanadium pentoxide and iron-titanium co-product using road transport	8,479
Total		**114,584**

Scope 3 emissions that have not been estimated are: putrescible waste disposal from accommodation village, lifecycle emissions from inputs other than vanadium concentrate, and employee travel to site. These emissions are expected to be relatively minor compared to the emissions that have been calculated.

Emissions associated with construction have not been estimated as there is an unacceptably high number of uncertainties and large number of assumptions that would have to be made.

2.3 Scope 3 – Downstream Product Use

Downstream use of vanadium is a further category of Scope 3 (indirect) emissions. In the case of vanadium, downstream use leads to a considerable net reduction in GHG emissions, as explained in the following sections.

2.3.1 Vanadium Uses

The predominant uses of vanadium bring about net reduction of GHG emissions.

Approximately 90% of worldwide vanadium production is used as an additive in steelmaking such as high strength low alloy steel. This application contributes to a large reduction in net GHG emissions. Estimated GHG emission reduction from vanadium use in steel is provided in **Section 2.3.2**.

Although the vanadium market is primarily steel focused, Vanadium Redox Flow Batteries (VRFBs) are gaining momentum. VRFBs provide a long-term energy storage solution and can be paired with wind, solar, and other intermittent power sources to smooth supply and demand spikes. Further information about VFRBs is provided in **Section 2.3.3**.

High purity vanadium is also used in diverse chemical and technology applications. Vanadium catalysts are used in the production of sulphuric acid, and a variety of processes for the removal of sulphur and nitrogen in gas and oil refining. Vanadium aluminium master alloys are used in demanding applications where strength, heat resistance, and light weight are required, such as aircraft frames and rotors for jet engines and landing gear. Although these are a small portion of the overall vanadium market, vanadium is invaluable in manufacturing and chemical processing.

2.3.2 Steel Reinforcement Bars

Vanadium in high strength low alloy steel increases hardness and tensile strength, leading to reduced steel volume for required strength compared to use of low-grade steels. The reduction in overall material usage by replacing low-grade reinforcement bars with high strength low alloy vanadium steel results in an overall reduction in carbon emissions (Pranav Pradeep Kumar, 2021).

Use of vanadium to increase the strength of steel reinforcement bars results in reduced carbon emissions of 1,200 to 4,400 tonnes of carbon dioxide per tonne of vanadium pentoxide (t CO_2/t V_2O_5) used for this purpose. This calculation is based on lifecycle analysis of the global rebar market for high strength low alloy steel at 400 megapascals (MPa) and includes carbon emissions for production of vanadium pentoxide of 39.1 t CO_2/t V_2O_5 (Pranav Pradeep Kumar, 2021). The lower bound 1,200 t CO_2/t V_2O_5 estimates global savings with a bias towards China and relies on marginally greater data than the 4,400 t CO_2/t V_2O_5 value which estimates global savings with a bias towards the European Union (EU). Based on 2019 market data, China consumed approximately 30 times more vanadium for steel reinforcement bars than the EU (Pranav Pradeep Kumar, 2021).

The BFS forecasts that the Tenindewa processing facility will produce 11,306 tpa of high purity 99% vanadium pentoxide flake. If the vanadium pentoxide produced by AVL each year was used to produce 400 MPa rebar, the carbon emissions offset would range from 13,000,000 to 50,000,000 t CO_2-e compared to use of low-strength 250 MPa rebar, for each year of AVL production. A weighted average of estimated annual offsets from AVL production, considering the higher production of steel reinforcement bars in China, is approximately 14,700,000 t CO_2-e pa.

Note that this estimate includes the carbon emissions for production of vanadium pentoxide, which is accounted separately as Scope 1 emissions for the Tenindewa processing facility. Therefore, the potential GHG emission reduction is likely to be higher than calculated above.

2.3.3 Vanadium Redox Flow Batteries

This technology has several benefits over other storage options. Battery life is essentially unlimited, as vanadium electrolyte solution does not degrade. Energy storage capacity is virtually limitless and modular, with power and energy being scaled separately. The batteries can be cycled continuously without degradation. At the end of the battery's mechanical life the vanadium electrolyte can either be reused or reduced to vanadium pentoxide, whilst the battery power unit and structure can be fully recycled.

Use of vanadium pentoxide produced by AVL in VRFBs would support the transition to a lower-carbon economy by providing a sustainable energy storage solution for intermittent renewable energy production. Additionally, the vanadium produced by AVL will play a substantial role in reducing the carbon footprint of VRFBs as AVL vanadium is of significantly lower emissions intensity than other vanadium co-production operations (see **Section 4.2**).

As only a small proportion of vanadium use globally is in VRFBs, the impact on GHG emissions from this use of vanadium was not calculated.

3.0 Cumulative and Holistic Impacts

There are numerous approaches that can be taken for cumulative impact assessment, as outlined in the *Cumulative Environmental Impact Assessment Industry Guide* (Minerals Council of Australia, 2015). The approach adopted for this GHGMP is to assess the cumulative impacts from all AVL proposals where sufficient information is known, and where the environmental impacts occur in the same region. As GHG emissions relate to a global region, this encompasses the Tenindewa Processing Facility and the Mine and Beneficiation Operations proposal.

Assessment of holistic impacts considers the impact of the proposal on the environment as a whole. For GHG emissions, this is interpreted to mean GHG emissions throughout the proposal lifecycle regardless of where they occur.

This assessment of cumulative and holistic impacts considers the impacts of the proposal, including direct and indirect emissions, within the global receiving environment.

3.1 Summary of Cumulative Global Emissions

The proposal is estimated to result in a **net reduction** in GHG emissions of approximately 14.5 million t CO_2-e per annum, considering direct and indirect GHG emissions.

Table 3.1 presents a summary of cumulative and holistic GHG emissions associated with the proposal, comprising peak annual Scope 1 emissions from the Tenindewa processing facility, Scope 3 onshore emissions from production of vanadium concentrate and onshore transportation, and reduction in emissions associated with downstream use of vanadium. Further details regarding the calculated emissions components are provided in the report sections indicated in the table below.

Table 3.1 Summary of Estimated GHG Emissions and Reductions Associated with the Processing Plant Proposal

Component	Report Section	Average Annual GHG Emissions (t CO_2-e pa)
Scope 1 – Tenindewa processing facility	**2.1**	95,575
Scope 3 onshore – Mine and Beneficiation Operations direct and indirect, including concentrate transport	**2.2**	103,297
Scope 3 onshore – other transport upstream and downstream of processing facility	**2.2**	11,287
Scope 3 – Downstream use	**2.3**	-14,700,000
Total net		**-14,489,841**

Any incremental increase in the volume of vanadium pentoxide production at the Tenindewa processing facility would lead to a proportional acceleration in the net reduction of global GHG emissions. An increase in vanadium pentoxide production would result in an increase in direct and scope 3 onshore emissions, and an even greater decrease in scope 3 emissions from downstream use. The increase in direct and onshore emissions are more than offset by the decrease in emissions from downstream use.

4.0 Benchmarking

4.1 Vanadium Production Methods

There are three major categories of vanadium production globally: co-production with iron smelting, primary production, and recycling.

Approximately 70% of the global vanadium supply by volume is sourced from smelting iron rich ores to produce pig iron, with vanadium rich slag as a co-product (Office of the Chief Economist, 2021). This is an energy-intensive process and is predominantly undertaken in China and Russia, where the electrical grid is carbon-intensive coal-fired power. While this method of vanadium production is not directly comparable to the AVL process, it is included as a benchmark to represent most of the vanadium produced globally.

Approximately 18% of global vanadium supply is mined and processed as a primary product (Office of the Chief Economist, 2021). There are two major operational primary vanadium producers globally, in Brazil (Largo Resources Ltd) and South Africa (Bushveld Minerals). Details from Largo Resources were available for benchmarking. Publicly available information about Bushveld Minerals was insufficient to calculate carbon emissions intensity.

The remaining 12% of the global supply is sourced from spent catalysts and other recycling (Office of the Chief Economist, 2021). This recycling process is the smallest source of vanadium and is not considered comparable as a benchmark.

Comparison with current primary vanadium producers was also undertaken to identify technically and financially feasible options to reduce GHG emissions intensity.

4.2 Benchmark Carbon Emissions Intensity

AVL will supply primary produced vanadium with carbon emissions intensity 50% lower than most vanadium produced globally. The projected carbon emissions intensity of vanadium produced from the AVL mine site and processing facility (base case) is 16.2 t CO_2-e / t V_2O_5, which is 52-59% lower in emissions intensity than vanadium co-production operations.

Available benchmark operations had carbon emissions intensity ranging from 8.8 to 39.1 t CO_2-e / t V_2O_5 (see **Table 4.1** and **Graph 4.1** below).

The 70% of global vanadium supply from co-production of vanadium has high carbon emissions intensity. Two co-production operations with data for benchmarking had the highest carbon emissions intensity of the available benchmarks (33.5 and 39.1 t CO_2-e / t V_2O_5).

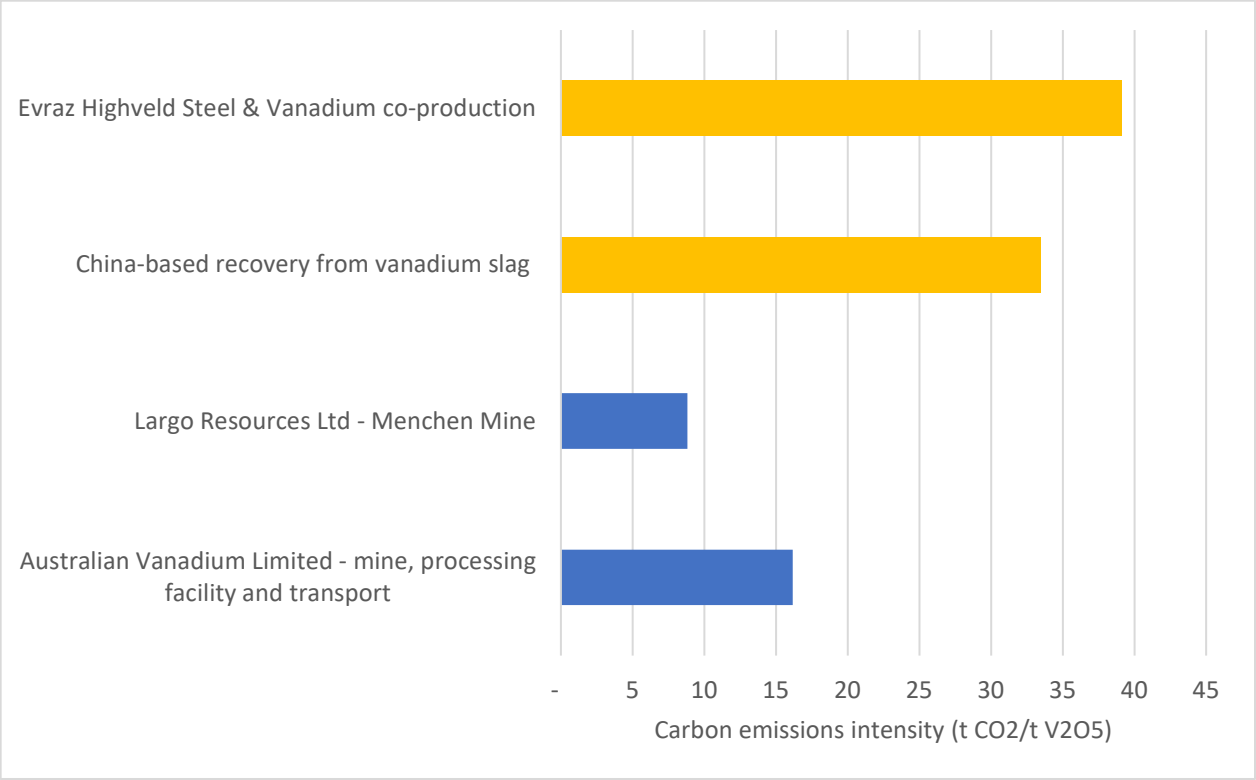
Only one current primary vanadium producer had sufficient information to benchmark against – Largo Resources. The carbon emissions intensity of Largo Resources was calculated as 8.8 t CO_2-e / t V_2O_5. Aspects such as land clearing and direct carbon dioxide emissions from transformation of sodium carbonate in the kiln were not available for Largo Resources. These items were excluded from the Australian Vanadium Limited emissions for the purpose of benchmarking.

Both the Largo Resources and Australian Vanadium Limited calculations include activities from mining of ore to production of vanadium pentoxide, for the purpose of benchmarking.

The carbon emissions intensity of primary vanadium production by Largo Resources is significantly lower than predicted for vanadium produced by AVL. The key contributor to the low carbon emissions intensity of Largo Resources is the high proportion of renewable generation in the power grid in Brazil (45% renewable component).

As vanadium processing has a large electricity demand, a high renewable electricity component leads to significantly lower carbon emissions intensity. Grid power is not available at the AVL mine or processing facilities. Opportunities to utilise renewable energy generation are included in the GHG mitigations for the proposal (**Section 5.0**).

In **Graph 4.1** below co-production of vanadium is shown in yellow, and primary vanadium production is shown in blue.



Graph 4.1 Carbon Emissions intensity for Vanadium Production Operations

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The carbon emissions intensity of vanadium production is variable. Comparison of primary vanadium producers demonstrates that there are differences in the operations that significantly influence the carbon emissions intensity, such as renewable proportion of electricity generation, type of fuel used in the kiln, and transport distance.

The operations of two current primary vanadium producers were reviewed to identify opportunities for carbon mitigation (**Table 4.2**). The following opportunities were identified:

- Seek high renewable proportion for on-site power plants.

- Explore even lower carbon emissions intensity fuels for combustion in the kiln, such as hydrogen mix.
- Explore alternative lower-emissions transport such as alternative fuels or more efficient transport methods.

These mitigation opportunities are included in **Section 5.0**.

Benchmarking has confirmed that vanadium produced by AVL would have 50% lower carbon emissions intensity than most vanadium produced globally. The carbon emissions intensity can be further reduced by application of mitigation strategies such as maximising use of renewable energy generation. Mitigation strategies are presented in **Section 5.0**.

Table 4.1 Summary of Carbon Emissions Intensity for Vanadium Production Operations

Operation	Operation Details	Reference	Comparability	Carbon Emissions Intensity ($t CO_2/t V_2O_5$)
Evraz Highveld steel and vanadium co-production	This is a typical vanadium co-production operation. The primary product is pig iron, vanadium is recovered as by-product from slag. Titanomagnetite ore is pre-reduced with coal in a kiln, further reduced in an electric arc furnace - forms slag with 25% V_2O_5. Slag is ground, mixed with sodium salts, roasted, leached with sulfuric acid and ammonium, roasted to produce high purity V_2O_5.	(Selina Weber, 2018) quoted in (Pranav Pradeep Kumar, 2021)	Poor Similar ore to AVL but different process flow and fuel types. Preliminary emission from pig iron production allocated to V_2O_5 on volume basis.	39.1
China-based recovery from vanadium slag	This is a vanadium co-production operation. Few details available, assume similar to above process. Primarily coal-based electricity supply.	(Ligia da Silva Lima, 2021)	Poor	33.5
Largo Resources – Menchen Mine	Primary vanadium production. Process flow consists of three stages of crushing, one stage of grinding, two stages of magnetic separation, magnetic concentration roasting, vanadium leaching, ammonium meta-vanadate (AMV) precipitation, AMV filtration, AMV calcining and fusing to V_2O_5 flake. Electricity sourced from regional power station, approximately 45% renewable energy in Brazil grid (International Energy Agency, 2021). Fuel oil used for direct combustion in kiln. On-site concentrator and refinery. Road access to closest port approximately 450 km.	Largo Resources 2019 Sustainability Report (Largo Resources, 2019)	Good Primary vanadium producer, comparable process flow to AVL. But different fuel types and uncertain what is included in the fuel and electricity use in the Sustainability Report, which is the basis of the carbon emissions calculation.	8.8
Australian Vanadium Limited – mine, processing facility and transport	Primary vanadium production. Process flow consists of single stage semi-autonomous grinding mill circuit, following by combination of medium intensity magnetic separation and wet high intensity magnetic separation, then regrinding and reverse silica flotation. Then transport to downstream processing plant, which comprises roasting with sodium carbonate followed by grinding, leaching and purification of leach liquor to precipitate a high purity AMV solid for conversion to V_2O_5 flake. Electricity sourced from on-site power plant (diesel and gas). Roasting directly burns natural gas.	PFS Update greenhouse gas emissions (**Section 2.0**)	PFS Update carbon emissions for the mine and process site and transport between sites are included for comparison with single-site projects. Direct emissions from sodium carbonate excluded for comparability with Largo Resources available data.	16.2

Table 4.2 Comparison of GHG Emissions Aspects of Primary Vanadium Producers, to Identify Opportunities for Mitigation

GHG Emissions Aspect	Largo Resources	Bushveld	Australian Vanadium Limited (PFS Update, base case)	Comparison, Opportunities for Mitigation
Electricity supply	Grid supply (GE21, 2017). Brazil energy supply is almost 45% renewables (biofuels, waste, and hydro), which is one of the least carbon-intensive globally (International Energy Agency, 2021).	Grid supply (The MSA Group, 2020). Approximately 70% of the energy supply in South Africa is derived from coal, which contributes high carbon emissions (International Energy Agency, 2021).	Diesel power plant (mine facility) Natural gas power plant (process facility)	Grid power is not available at the mine or processing facilities and would be relatively low renewable proportion if it was available. Opportunity to seek high renewable proportion for on-site power plants.
Fuel used for kiln combustion	Fuel oil and diesel (GE21, 2017). Carbon emission factor 70-74 kg CO_2-e/GJ energy	Coal fines (The MSA Group, 2020). Carbon emission factor 90-94 kg CO_2-e/GJ energy	Natural gas Carbon emission factor 60 kg CO_2-e/GJ energy	AVL use of natural gas has lowest carbon emission factor of fuel types used for direct combustion. Opportunity to explore even lower carbon emissions intensity fuels for combustion, such as hydrogen mix.
Renewables, GHG mitigation projects	No specific GHG mitigation projects identified in Sustainability Report.	Planned 3.5 MW solar photovoltaic plant with VRFB capacity 1 MW / 4 MWh. Expected to reduce emissions by 5,700 t CO_2 pa.	No renewables included in PFS Update.	The renewables component at Bushveld is a relatively small reduction in GHG emissions but demonstrates a minimum feasible case for a comparable project. Opportunity to use solar and battery to reduce emissions from electricity use.
Transport	Road transport 405 km to Salvador, including 42 km of unsealed road.	Road transport to Johannesburg, then to Durban or Cape Town for shipping (The MSA Group, 2020). Total road transport distance ~700 km (Durban) or 1,500 km (Cape Town).	Road transport 450 km to processing site, then 460 km to Fremantle Port (vanadium pentoxide). Total distance 910 km. Not possible to export containerised product through the closer Geraldton Port.	All projects use road transport. Opportunities to explore alternative lower-emissions transport such as alternative fuels or more efficient transport methods including rail. All projects have relatively long transport distance for product to port, although product volumes are relatively small.

5.0 GHG Emissions Mitigation

5.1 Approach to GHG Mitigation

AVL is committed to mitigating GHG emissions as much as practicable to support the transition to a low-carbon economy. This will be undertaken in a way that is technically and financially feasible and cost-effective during commencement and operations. AVL will proactively seek opportunities to work with the local and regional communities and provide local benefits as part of GHG mitigation.

Further reducing GHG emissions intensity of the proposal will position AVL as a low-carbon vanadium producer. AVL acknowledges the expectations of stakeholders to continually improve GHG management and transition to net zero emissions. GHG emissions and performance will be reviewed and reported each year in a publicly available report.

5.2 Design of Project to Minimise GHG Emissions

The calculated peak annual average greenhouse gas emissions presented in **Section 2.0** draw on data compiled for the BFS. The following emissions reductions have been achieved from design improvements as the study has moved through the various stages of PFS, PFS Update and BFS:

- Use of a moving grate kiln and other design innovations as part of processing have improved energy efficiency and reduced gas volume required for direct combustion in the roasting kiln, cutting projected GHG emissions by 24,000 t CO_2 pa.
- Locating the processing site significantly closer to Geraldton and Fremantle Ports reduces the transport distance for products to port and inputs required for processing. There is a net reduction of GHG emissions resulting from transport of concentrate, products and reagents estimated as 5,700 t CO_2 pa. GHG emissions would also be significantly reduced during construction due to a short transport distance for personnel and equipment to construct the processing plant and associated infrastructure.

5.3 Mitigation During Proposal Commencement

Strategies will be applied during detailed design, contractor engagement, construction, and commissioning with the objective of reducing GHG emissions as much as practicable straightaway from proposal commencement.

The strategies listed in **Table 5.1** are considered feasible for implementation as part of proposal commencement. The target reductions in GHG emissions are stated as percent reduction and volume reduction (t CO_2 pa) from the unmitigated base case emissions.

These mitigation strategies are included in the calculated peak average annual Scope 1 GHG emissions for the Tenindewa processing facility operations to 95,575 t CO_2-e pa (**Section 2.0**).

Table 5.1 GHG Mitigation Strategies Feasible at Proposal Commencement

Mitigation Strategy	Description and Comments	Change from Calculated Base Case Emissions	
		Target % Reduction	Target GHG Reduction (t CO_2-e pa)
Renewables and battery at processing plant	Renewables (wind and/or solar) and VRFB at processing site. Could be used to power electric light vehicles (included below) and contribute to overall power generation and storage. To be implemented via selection criteria for the power plant build-own-operate contract.	35% (power generation)	9,200
Electric light vehicles at processing plant	A relatively small number of light vehicles would be used at the processing site during operations. It is considered feasible to source electric or hydrogen vehicles that are powered from green sources from the start of operations.	100% (light vehicle diesel use)	180
Green hydrogen in natural gas feed for the process site	Introduce a proportion of green hydrogen into the natural gas feed at the process site, which will be used for power generation and direct combustion. To be implemented via agreement with gas supplier.	2% (direct combustion gas and power plant feed)	1,800
Total	**Target reduction in emissions**		**11,180**

The mitigation strategies proposed to be implemented as part of proposal commencement will reduce the Tenindewa processing facility Scope 1 emissions by 11,180 t CO_2-e pa.

5.4 Mitigation Options for Future Implementation

Additional GHG mitigation options have been identified that may be viable for future implementation.

These mitigation options are listed in **Table 5.2**. The table also describes how the strategy could be applied, current or potential limitations, which facility or domain it relates to, the possible timeframe after proposal commencement that the mitigation may be viable to implement, and target reduction in GHG emissions that may result.

The target reductions in GHG emissions are stated as percent reduction and volume reduction (t CO_2 pa) from the unmitigated base case emissions.

Most of the identified future mitigation options are not viable to implement immediately due to current technological limitations (e.g. renewable or hydrogen-powered road trains are not available). Nevertheless, actions will be taken during proposal commencement to facilitate future implementation of these strategies where practicable. For example, this includes:

- establishing the power plant contract with five-yearly review and targets to decrease GHG emissions throughout the contract period for the processing facility
- appointment of a road haulage contractor with an acceptable emissions reduction strategy, measurable over the life of the project

- ensuring the processing facility infrastructure can be operated with a hydrogen component to the gas feed
- seeking to acquire electric light vehicles where practicable
- liaising with landowners of areas of unproductive agricultural land, regarding tree planting.

Progress towards implementing future GHG mitigation strategies will be reported annually, as described in **Section 7.0**.

Table 5.2 GHG Mitigation Strategies for Future Investigation and Implementation

Mitigation Strategy	Description and Comments	Limitations	Facility / Domain	Possible Timeframe	Change from Calculated Base Case GHG Emissions	
					Target % Reduction	Target GHG Reduction (t CO_2-e pa)
Review power plant contract every five years – Process site	Seek opportunities to introduce more renewables and battery storage, possibly staged through the contract. To be implemented as part of initial build-own-operate power plant conditions.	Financial viability and maintaining power supply requirements.	Process	Every 5 years	Year 10: 50% Year 15: 75%	Year 10: 13,100 Year 15: 19,700
Green hydrogen in natural gas feed for the process site	Introduce a proportion of green hydrogen into the natural gas feed at the process site, which will be used for power generation and direct combustion. To be implemented via agreement with gas supplier.	Availability of green hydrogen and plant operational constraints. More than 15% hydrogen requires further technological adaptations.	Process	5 years	Year 5: 15% Year 10: 25%	Year 5: 13,500 Year 10: 22,500
Green hydrogen or electric powered vehicles for off-site haulage	Possible on-site production of green hydrogen from renewables. Green hydrogen or electric vehicles for transport of concentrate to processing site, which is the largest transport contribution to GHG emissions. To be implemented as part of transport contract to explore options to reduce GHG emissions.	Availability of suitable quad prime movers or equivalent that can haul the required load using electric or hydrogen power.	Transport	10 years	100%	40,000

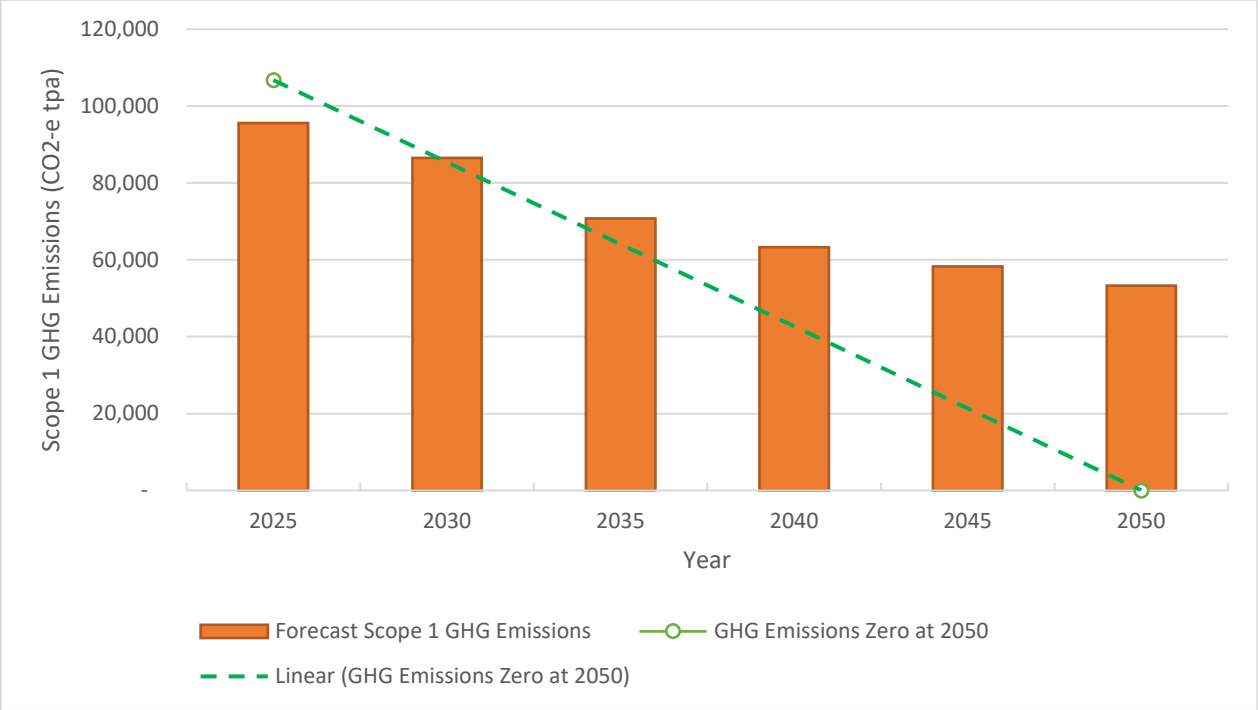
Mitigation Strategy	Description and Comments	Limitations	Facility / Domain	Possible Timeframe	Change from Calculated Base Case GHG Emissions	
					Target % Reduction	Target GHG Reduction (t CO_2-e pa)
Green hydrogen or electric powered heavy vehicles at processing site	Heavy vehicles include front end loaders, mobile cranes, forklifts. To be implemented via agreement with contractor.	Availability of suitable type and number of heavy vehicles, parts, and experienced maintenance personnel.	Process	10 – 15 years	Year 10: 10% Year 15: 100%	Year 10: 100 Year 15: 1,000
Generate offsets via tree planting at processing site	Use areas of unproductive agricultural land for tree planting, in consultation with landowner. Tree planting to be undertaken at project commencement, carbon sequestration increases gradually over years. GHG reduction assumes 50 ha of tree planting.	Would need to demonstrate suitable water supply for tree establishment.	Process	Immediate and ongoing	Not applicable	At Year 15: 127

6.0 Indicative Targets and Measurement

Implementation of the GHG mitigation strategies outlined in **Section 5.0** would result in reduction of Scope 1 GHG emissions. The indicative targets for the Tenindewa processing facility are presented below.

The indicative processing facility Scope 1 GHG emissions reduction over time is presented in **Graph 6.2**. The forecast GHG emissions incorporate the mitigation strategies and nominal timeframes presented in **Section 5.0** for the period from 2025 to 2040 and assumes a nominal reduction per five-year period of 5,000 tpa for the 2045 and 2050 timeframes. The green line is a linear trajectory from the unmitigated base case emissions to net zero at 2050.

It is not feasible to reduce the processing facility GHG emissions to net zero by reduction and mitigation strategies alone, as the facility uses gas for direct heating and emits carbon dioxide from sodium carbonate transformation. Nevertheless, AVL will seek further opportunities to mitigate GHG emissions proactively throughout the life of the processing facility.



Graph 6.1 Tenindewa Vanadium Processing Facility Scope 1 GHG Emissions (average tpa) Forecast

The indicative reductions per five-year period for the processing facility are presented in **Table 6.2** below.

Table 6.1 GHG Emission Reduction Targets – Processing Facility Scope 1

Timeframe	Maximum Annual Processing Facility GHG Emissions (t CO_2-e)
Commencement of full operations (nominally 2025) to Year 5	95,575
Five years after commencement of full operations (2030) to Year 10	86,477
Year 10 (2035) to Year 15	70,754
Year 15 (2040) to Year 20	63,309
Year 20 (2045) to Year 25	58,309
Year 25 (2050) and ongoing	53,309

AVL will measure and report performance against these targets each year, as described in **Section 7.1**.

7.0 Management of GHG Emissions

7.1 Reporting and Continuous Improvement

GHG emissions will be monitored and reported annually in accordance with the methods of the National Greenhouse and Energy Reporting (Measurement) Determination 2008.

Annual GHG emissions and progress with mitigation strategies and targets will be reported to AVL's Board.

Annual GHG emissions and performance will also be reported in a publicly available Annual Report or Sustainability Report.

7.2 Management Plan Review

This GHGMP will be formally reviewed every five years (i.e. five years from the date of this management plan). The review process will include:

- review of regulatory and stakeholder expectations (**Sections 1.2** and **1.3**)
- updated evaluation of climate-related risks and opportunities (**Section 1.5**)
- updated calculations of actual or predicted GHG emissions (**Section 2.0**)
- a collaborative process with representatives from top management and disciplines that contribute to GHG emissions and management, to review the short term and long term GHG mitigation strategies (**Section 5.0**)
- review of targets for future GHG emissions reduction (**Section 6.0**).

The outcomes of the GHGMP review will be communicated to relevant stakeholders.

The formal GHGMP review process will provide an opportunity to reflect on performance to date and respond to changes in expectations and available technologies to further reduce GHG emissions.

8.0 Abbreviations

Abbreviation	Name
AMV	Ammonium Metavanadate
AVL	Australian Vanadium Limited
EPA	Environmental Protection Authority
GHG	Greenhouse Gas
GHGMP	Greenhouse Gas Management Plan
MPa	Megapascals
PFS	Prefeasibility Studies
tpa	Tonnes per annum

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