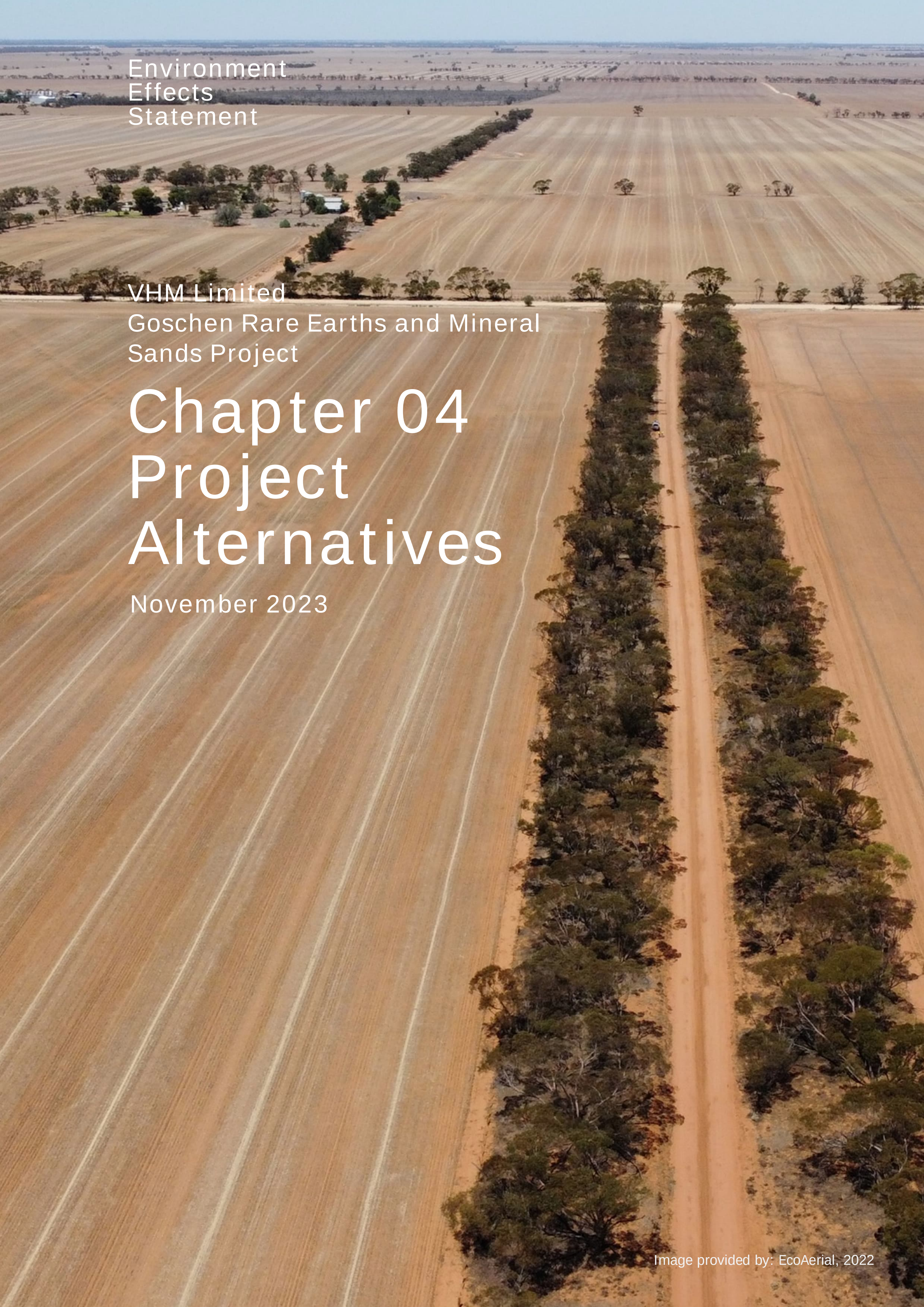

Environment Effects Statement

VHM Limited
Goschen Rare Earths and Mineral Sands Project

Chapter 04 Project Alternatives

November 2023

Image provided by: EcoAerial, 2022

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4. Project Alternatives

This chapter presents an overview of the feasible design alternatives for the various components of the Project, how they have been identified, and their likely environmental, social and economic effects. The preferred design option for the Project is as described in EES Chapter 3: Project description.

4.1 Overview

The design of the Goschen Rare Earths and Mineral and Project (the Project) was developed through an iterative process, with consideration given to the findings of various feasibility studies and the EES impact assessments, together with community and stakeholder feedback. Various aspects of the Project have been refined over the course of the design and EES preparation period, so as to optimise recovery of the mineral resource and feasibility of the Project, avoid and minimise potential adverse environmental, social and economic impacts, and enhance the expected socioeconomic benefits of the Project to the region and State.

4.2 Iterative and Alternative Assessment Process

The Project as described in Chapter 3 was first conceptualised in 2015 and has undergone significant design development following various feasibility and environmental studies that commenced in 2017.

The ultimate Project design taken into this EES is the conclusion of an iterative process to assess a range of alternatives, with the aim of creating a project that provides long term local socioeconomic benefits whilst avoiding and minimising adverse environmental and social impacts.

The design process has incorporated specialist input from engineers, environmental consultants, geologists and construction and mining contractors. Investigations and studies completed to inform the EES have assessed the identified options and helped to refine the design to maximise recovery of the resource and address the environmental, social and economic impacts of the proposed mine to achieve a sustainable development. These studies included:

- Modelling of various mine locations and layout options within VHM’s exploration and retention licence areas so as to optimise resource recovery and avoid or minimise adverse impacts, particularly to native vegetation and groundwater
- Designing mine sequence scenarios that minimised material movement (double handling) and disruption to local roads
- Assessment of tailings management options that avoided the need for an above ground tailings storage facility and allowed for the return of the land to the pre-mining agricultural use
- Assessment of transport modes and routes to:
  - minimise Project road traffic and deterioration of the public road network
  - avoid clearing of significant roadside vegetation
  - reduce amenity issues for sensitive receptors and communities
- Assessment of water supply options that are sustainable and do not exclude existing users
- Investigation of rehabilitation methods to achieve stable and sustainable land use post mining as soon as practicable.

The selection of the most feasible option(s) at different stages of the Project development was informed by technical feasibility and engineering constraints, practical issues (including health and safety), capital and operating costs, potential socioeconomic and environmental impacts, energy and water efficiency, and community benefits.

The most feasible options for different aspects of the Project are assessed in this chapter for their relative environmental, community and amenity impacts, and economic impacts:

- Environmental risks and opportunities: including potential clearing of native vegetation, potential for impacts on listed species and overall disturbance footprint.
- Stakeholder feedback: Community and amenity impacts, including aspects such as noise, air and visual amenity, public and other use of resources
- Project cost implications and limitations: Economic, including the capital and operating costs and potential benefits to local communities

The alternatives include those that relate to the location of the mine site, mine layout and planning, mining methods, mineral processing, tailings management, water sources and management options, transport, rehabilitation and closure.

4.3 EES scoping requirements

Section 3.5 of the EES scoping requirements requires the proponent to outline feasible alternatives considered for the Project and to include an explanation of how specific alternatives were shortlisted for evaluation within the EES. The EES is also required to assess and document the likely environmental, social and economic effects of the feasible alternatives, particularly where these offer a potential to achieve beneficial outcomes, while meeting the project objectives.

The scoping requirements state that the assessment of feasible alternatives and their effects should include:

- *The basis for selecting the area proposed to be mined within the broader exploration licence(s), in the context of the concept mine plan and alternative mine layout staging*
- *The site selection process for any ancillary infrastructure, including processing facilities*
- *The technical feasibility and environmental implications of alternative construction, mining, ore processing, tailings management and site rehabilitation methods*
- *Alternatives for electricity, water, gas and fuel supply, transport of products and workers and solid and liquid waste disposal.*

Where appropriate, the assessment of environmental effects of design alternatives should address matters set out in the scoping requirements. The depth of investigation of feasible alternatives should be proportionate to their potential to minimise potential adverse effects as well as meet project objectives.

4.4 Mine site development and alternatives

In 2015 VHM undertook a desktop review of a large geological data set dating back to 1970s. In this review VHM concluded that the Project area was highly prospective for mineral sands due to both fine-grained sheet style heavy mineral mineralization deposited in an off-shore environment and overlying strandline heavy mineral mineralization deposited on an active beach. Other fine-grained, off-shore heavy mineral deposits in the Murray Basin are often referred to as 'WIM' (Wimmera Industrial Mineral) deposits.

Pre EES Referral Option

The 2015 review produced a geological model which was then supported by a 2017 drilling program to identify potential areas of mineralisation suitable for development. Five resource areas were defined as shown in Figure 4-1, and were used as the basis for the Project definition when VHM referred it to the Minister for Planning under the *Environment Effects Act 1978* in 2018 (2018 EES referral).

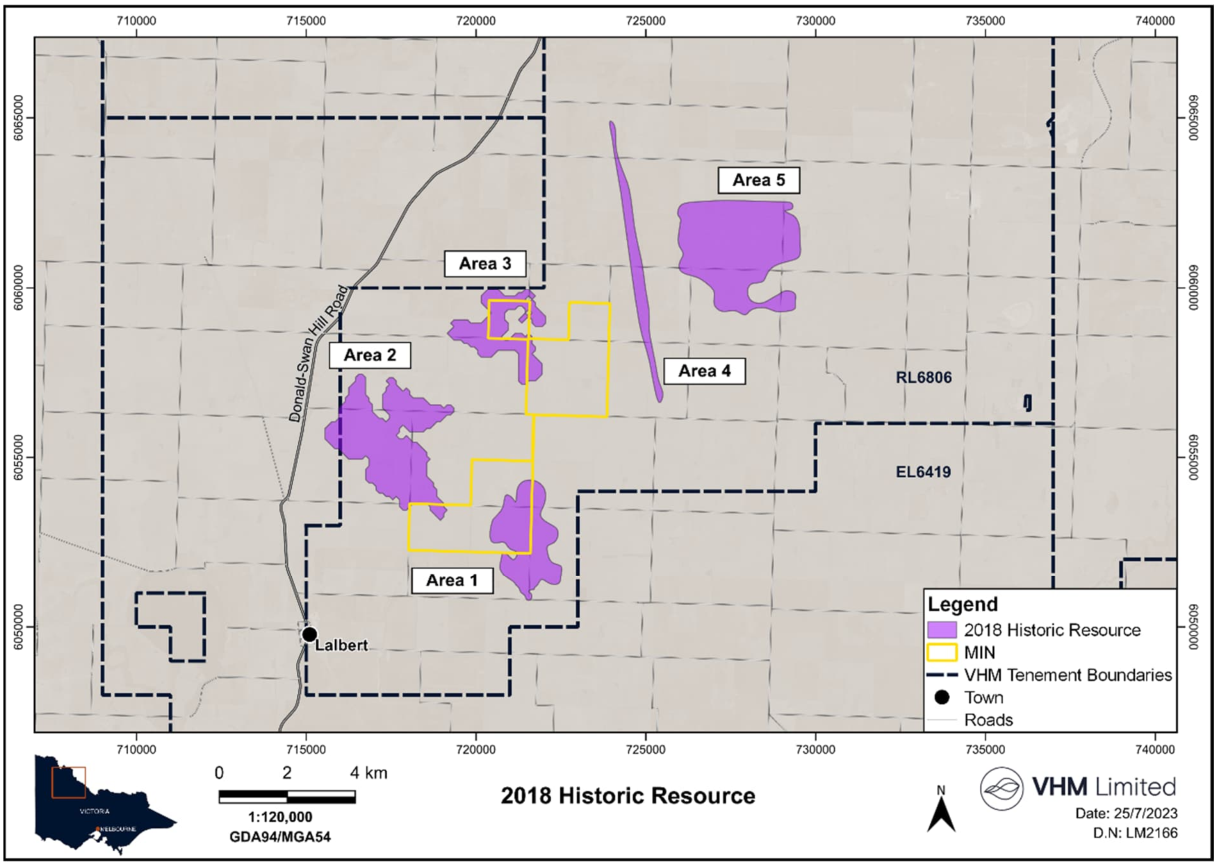

Figure 4-1 2018 concept extent in comparison to final Project extent

At the stage of the 2018 EES referral, VHM wanted to maximise the extractable mineral resource and referred an area that covered Areas 1 to 5 (inclusive). However, at that stage, VHM was unaware that historic drill data was sub optimal and not representative of the in-situ resource, nor had it undertaken detailed assessments of land access requirements, impacts to native vegetation and overall scale and commercial viability of the Project.

Post EES Referral Option

In 2018 mine planning work commenced with consultants that had specialist skills in ore reserve estimation, which resulted in new resource definition data being developed. The review of the resource reshaped the overall Project thinking as the new data demonstrated higher grades in ore zones across the deposit and different geometry compared to the interpretation of the historic data. This allowed the Project area to be refined and remain economically viable.

In addition, VHM undertook to build positive working relationships with landholders and prioritised its exploration activities on land where landowners had appetite to support the Project.

Ultimately, VHM decided to move forward with the development of Area 1 and Area 3 only for the following key reasons:

1 - Desire to keep the mine in a discrete land area, and thus:

- limit scale of a greenfield project in an area not familiar with mining
- minimise operating costs and capex
- minimise energy and water consumption

2 - A resource which provides confidence of a viable project of a scale that:

- is profitable
- is able to be funded by a new/emerging resource company, noting that the larger the scale, the greater the funding demands, which, for a new company, makes it more difficult to get to production. Essentially the decision was made to not include Areas 2, 4 and 5 in the Project area for the following reasons:
  - The resource base in Areas 2, 4 and 5 is not sufficiently defined or understood

  - Areas 2, 4 and 5, whilst prospective, would have resulted in a significantly larger scale project with larger start-up costs (including all cost areas such as land acquisition, permitting, environmental studies and approvals etc etc) and, therefore, more difficult to finance
  - To include Areas 2, 4 and 5 would have required further up-front investment and materially delayed the Project – again requiring more investment.

- demonstrates to the community that it can be low-impact and have social/economic benefits
- demonstrates to government that it can make a meaningful contribution to the global supply chain security for critical minerals.
- enjoys the support of the landowners on which the deposit is hosted.

The refinement of the Goschen project to focus on Areas 1 and 3 differs in the following respects from the project described in the initial referral to the Minister for Planning in 2018:

- Social:
  - Seven residential dwellings were estimated to be located within the mineralisation zone from aerial imagery (2018 Referral), whereas only two dwellings are directly impacted by mining within Areas 1 and 3
  - Twenty two residential dwellings located within 2km of the mineralisation zone (2018 Referral), whereas only five dwellings are located within 2km of the proposed Mining Licence boundary for Areas 1 and 3.
- Environment:
  - 215 ha of native vegetation was estimated to be potentially cleared within the mineralisation zone (2018 Referral), whereas only 14 ha of native vegetation removal is now proposed for the Project.
  - Four ecological vegetation classes were found within the Referral survey area (2018), two of which were listed as endangered. However, the Project ultimately found these four plus two additional ecological vegetation classes, one of which is endangered.

With this in mind, a subsequent iterative design development process was undertaken on Area 1 and Area 3 to establish an initial Project design for assessment, which was then further refined and optimised during preparation of the EES. The design stages were informed by a range of specialists who have investigated and advised on geological, geotechnical, processing, radiation, hydrogeological, ecological and socio-economic constraints.

The key refinements that were made to the Project and from that descried in the initial referral to the Minister for Planning in 2018 as a result of this process, were to design the Project so as to:

- avoid patches of significant native vegetation
- mining operations could occur wholly above the groundwater table with no dewatering and resultant risk to wetlands and other groundwater dependent ecosystems.

Because VHM decided to move forward with Areas 1 and 3 for the reasons outlined above, it follows that Areas 2, 4 and 5 will not be developed as part of the Goschen project as assessed in this EES. Because its focus has been on Areas 1 and 3, VHM has not entered into agreements with landowners of Areas 2, 4 and 5, nor has it undertaken any environmental or social impact assessment of any mining outside Areas 1 and 3 or designed mining operations outside Areas 1 and 3.

VHM will continue to invest in exploration and evaluation work within its exploration and retention licence areas, as it is required to do under the conditions of its licences and the MRSD Act, to determine the viability and scope of any future mining projects beyond Areas 1 and 3. The hope is that this may result in further mineral sands and critical mineral projects in the future, in which case those future project(s) would undergo social and environmental impact assessments, including an assessment of the cumulative impacts of the Goschen Project with any future project, as part of the approval processes at that time.

4.5 Mining method

4.5.1 Mining ore and overburden

The selected mining method for the Project is conventional strip-mining. Strip mining is a ‘moving hole’ mining method, which enables progressive rehabilitation over the life of the Project. It is considered to be the most efficient and effective mining method where the mineral resource is relatively shallow, as it avoids the need for having large open pits and allows tailings and overburden to be deposited directly into mined voids as the mining front advances. This reduces the double handling of overburden and tailings, avoids the need for an above-ground tailings storage facility. Given the advantages of strip mining relative to open cut mining, open cut mining methods have not been further considered.

Due to the absence of hard rock within the Project area, drilling and/or blasting are not required as part of mine operations and have not been further considered. The following potentially viable alternative strip mining methods for excavation, haul and placement of overburden and ore, were assessed:

A. Conventional excavator and truck fleet
B. Dredge
C. In-pit screening and conveyor (IPSC)

The options analysis is presented below:

Table 4-1 Mining Method Options

	Summary	Design Constraints	Environmental Risks and Opportunities	Project Costs and Implications
(A) Conventional Mobile Excavator Fleet	Use of a conventional (and available) fleet of 100-200t excavators, and 100-300t rigid body haul trucks	Designed, and most efficient, for relatively short haul (<2km) Currently limited power (fuel) options for mobile fleet.	Higher noise and dust emissions as compared to dredge mining and use of conveyors, but these can be managed. Mobile fleet relatively agile and can move, reduce, and stop works if necessary to reduce emissions during abnormal atmospheric conditions. Allows the best opportunity to accurately remove overburden immediately above the ore zones and thus minimise dilution of the ore. Allows rehabilitation sooner, due to not having to wait for fixed plant (IPSC) to be moved.	Lower capital costs and higher operational costs compared to conveyors.
(B) Dredge (wet) mining	Creation of a mine (dredge) pond to allow excavation below water, and hydraulic transfer of ore to Mining Unit Plant (MUP).	Designed for mining below groundwater level – thus significant volumes of water required to maintain mine pond for this project's setting. Technically not suitable to mine setting due to the inferred induration (hard layers), inter-burden, high clay content	Relatively low noise and limited air emissions as compared to mobile fleet. Significant water losses (and thus mounding) to groundwater given mine zone above water table. Delays in being able to rehabilitate and return mined areas to agricultural as mine pond used for large areas. High risk of waste due to not being able to map ore – overburden interface in real time.	Unknown whether possible to source necessary volumes of water required to create dredge pond and maintain necessary levels.
(C) In-pit screen and Conveyor	Use of fixed conveyor network for overburden and/or ore zone mining.	Designed, and most efficient, for long term, long haul (>2km) material movement Unproven in the mineral sands industry in Australia Limited flexibility, restrict access to the pit Require specialist operators and maintenance crews	Relatively low noise and limited air emissions as compared to mobile fleet. Still require mobile fleet for loading conveyor and unload (spreading) at end	Lowest unit cost for overburden movement Highest capital costs

In summary, the alternatives assessment concluded that mining the overburden and ore using a mobile excavator and haul fleet (Option A) where the contact between the overburden and ore is visible is technically viable, will offer the most flexibility/agility to adapt to the prevailing conditions, offers the best flexibility in sourcing equipment and provides the lowest dilution and ore loss.

4.5.2 Scheduling and staging

The typical objective for a mining project is to ensure the schedule and stages allow higher grades of ore to be targeted early to recover initial capital costs as soon as possible. The proposed mine plan for the Project, as assessed in this EES, is based on first targeting high-grade areas of the deposit in the northern areas of Area 1 and progressing to the southern portions, before moving into Area 3.

Other factors influencing mine planning and scheduling are:

- the need to provide consistent ore to the process plant in terms of both tonnage and grade
- the need manage production within a certain footprint and constraints such as road closures

A number of sequencing alternatives were assessed but ultimately, it was found that sequencing did not materially change the associated environmental effects given that the mining will operate within the same defined footprint. Thus, the final schedule and staging proposed for the Project is based on the optimal extraction outcome having regard to ore grade and material handling as this then has secondary benefits of minimising secondary handling (and associated additional air and noise emissions) and allows for the mining to be completed as soon as possible.

4.5.3 Tailings Management

Approximately 95-98% of the ore mined (5Mt/year) will be returned to the mined voids as tailings. Before they are deposited back in the mined voids, the various tailings streams (sands/clay and silt slimes) are homogenised. The overall Project objectives with regards to tailings management are:

- optimise water recovery and minimise seepage losses
- no above ground tailings storage facility (TSF), and thus avoid associated operational risks and requirement for long term (closure) facility management
- direct placement of tailings back into the mine voids to allow land to be rehabilitated and pre-mining surface and land use returned as soon as practicable.

The option of having an above ground TSF for the short term (1 to 3 years) was considered as it would result in a better financial return as compared to having tailings disposal in-pit given there would be no need to excavate and stockpile ore prior to the commencement of processing. However, the following factors resulted in the decision being made not to proceed with a temporary TSF for the Project:

- higher comparative capital, operating and closure costs
- footprint resulted in significant sterilisation of resource
- higher environmental risk as TSF will be a high consequence category dam
- does not meet the closure objective of returning the site to pre-mining profile

The following potentially viable alternatives for the method of placing tailings back into the mine void were assessed:

A. Hydraulic (slurry) transfer and placement in-pit
B. Centrifuge
C. Geobags

The options analysis is presented below:

Table 4-2 Tailings Management Options

	Summary	Design Constraints	Environmental Risks and Opportunities	Project Costs and Implications
(A) Hydraulic transfer and placement in-pit	Homogenisation of all tailings streams, hydraulic pumping to pit, and discharge with flocculates in-pit.	Well developed, known, and proven technology in mineral sand mines. Initially, relatively high water requirements needed to commission water circuit.	High water recovery, when used in conjunction with flocculants, underdrainage, and solar drying. Minimal emissions of dust and noise with hydraulic transfer via pipeline. Hydraulic placement of homogenised tailings in-pit optimal for ensuring no risk of 'hot-spots' in regards concentrating certain tailings streams and/or residual radiation levels.	Lower overall power use and thus GHG emissions compared to centrifuges. Lower capital and operational costs compared to centrifuges.
(B) Centrifuge	Physical separation of water and tailings with flocculant to release and recover water. Solid tailings then stockpiled and transferred to pit by loader and haulage trucks. Refer below (Section 4.6.3) for further description of process.	Technology not previously used or proven at large scale mineral sand operations.	Highest water recovery of all three options. Although seepage risks remain post deposition from rainfall recharge. Significantly higher dust and noise emissions during haul and placement/compaction in-pit. Geotechnical risks to be managed with placement/stacking of tailings. Able to place overburden immediately following filling to target level.	Significantly higher power and fuel requirements for centrifuges and haulage/placement of dry tailings. Highest GHG emissions. Highest capital and operating costs.
(C) Geobags	Dewatering Bag (Geobag) placed in-pit, then filled with slurred tailings that filters sediment, and water is discharged outside bag and collected.	Technology not suitable for large scale mineral sand mines. Comes in various sizes which are designed for turbid water management at construction sites or small scale.	Bags buried at end of dewatering cycle. Major impact on mine schedule – as takes longest time to dewater tailings, and extends rehabilitation timelines.	High level of logistical scheduling with filling, collecting and burying bags.

The methodology for placing tailings back into the mine voids that was selected for the Project is option A - homogenisation and hydraulic transfer, with in pit water recovery. This methodology can be broadly summarised as follows:

- Thickening the clay and silt slimes stream in a thickener and using a flocculant to release additional water
- Combining the dominant tailings and pumping at approximately 47% w/w solids content
- Construction of in-pit tailings storage cells using overburden to create embankments/bunds
- Pipe head flocculation with a secondary flocculant to achieve early release of water in the in-pit storage cells
- Hydraulic deposition into in-pit cells, with upstream toe drainage, a floor level underdrainage system and removal of tailings bleed runoff decant water using a floating water return pump and solar drying.

This general methodology is considered to be current best practice, with the acknowledgment that the size and shape of the cells for tailings deposition will have an impact on the overall performance of the tailings management plan (water recovery) and specialist laboratory tailings testing will be undertaken to establish critical design parameters to inform detailed design.

With the in-pit storage option preferred, three alternatives were considered in regards deposition:

- homogenised prior to deposition – Where the coarse tails stream and fine tails streams are blended via a mixing box prior to hydraulically transferred into the mining void
- homogenised in the mining void – Where coarse tails stream is dewatered and mixed with the fines tails stream, then either hydraulically or mechanically handled and blended in-pit prior to placement into final position
- segregated and placed in layers/sections – Where a structured plan is predetermined in layers and rows within the mining void to discretely place the coarse tails and fine tails to satisfy a designed geotechnical ground conditions.

The selected approach of homogenising the tails prior to deposition is based on specific test work, a review of dewatering technologies, dewatering performance and geotechnical requirements. It was selected for the following reasons:

- high confidence in being able to homogenise the tailings and minimising a risk of creating segregated pockets of tailings with associated geochemical and geotechnical risks
- allows for optimisation of deposition cell and spigot (discharge point) design

To optimise water recovery the in-pit tailings storage cells will be designed with temporary embankments, formed from overburden, to allow sequential mining and filling of tailing. The embankment would be in the order of 20 m high and designed as a barrier to stop slumping in storms and to collect process water seepage from the deposited tailings for reuse at the mining unit plant (MUP) or wet concentrator plant (WCP).

Subject to the detailed tailings study findings, it is possible that when sufficient mine voids become available, separate cells would be developed by minor additional earthworks, each at a different phase of settling / drying to further assist in water recovery and drying / consolidation time.

4.6 Project infrastructure

4.6.1 Power

The Project’s power requirements vary over the life of operations as a consequence of the progressive development of process plant (Phase 1, Phase 1A and Phase 2) and the gradual increase in distance of mining operations from processing. The maximum demand is estimated to be approximately 9.5 MW when Phase 2 process plant is operational and mining is in Area 3.

The Project assumes on-site fuel powered generation using generators that can be run on diesel, LNG and/or LPG with an objective of utilising either local renewable generation suppliers (i.e., wind and solar farms in the region that could supply power directly) and/or enter into a Power Purchase Agreements or other commercial arrangement for the supply of renewable energy within 5 years.

The option of an initial direct grid connection to the existing powerlines in the near vicinity of the Project was concluded to be not viable given the risks of not having an adequate and reliable power for at least the early stages.

It was determined that inclusion of a powerline in the EES from the Mine Site area to a point in the grid which would provide high reliability was not feasible for the following reasons:

- Uncertainty on the optimal connection point given the potential future works being currently planned on the network
- Timeline to assess connection point and optimal route and then engage with relevant landowners

For this reason, an on-site power plant is the option included for the Project. However, VHM is committed to commence assessment and planning of a grid connection options as soon as practicable, with an aim of having the mine site supplied by renewable power sources within 5 years of the commencement of operations.

It is likely that even with the grid connection the Project would need to maintain a fuel fired power station to ensure reliable back-up electrical power supply in the event of potential interruptions ‘brown-outs’ to the network.

In summary, on-site fuel power station is considered the optimal solution for the delivery of electrical energy to the Project site for the EES.

Alternatives to the LNG trucked delivery service proposed is to instate a fixed LNG delivery line from the nearest connection point identified as Kerang. This would require a moderate sized pipeline (with potential compressor stations) to be instated in the regional area. This would require a considerable capital and project delivery scope to be undertaken to achieve. This would also require approvals process to be undertaken which likely would not fit within the Project delivery timeframes established.

Alternatives to the delivery of diesel via trucks are not available as this fuel type is critical to the energy supply for various fixed and mobile equipment operating on site.

4.6.1 Water supply

The Project's water requirements vary over the life of operations as a consequence of commissioning phases (lag in full water recovery from tailings deposition) and the progressive development of process plant (Phase 1, Phase 1A and Phase 2). The maximum demand from an off-site source is estimated to be approximately 4.5 GL/year during the commissioning of Phase 2. The maximum 'steady-state' water demand is estimated to be 3.2 GL/year (Phase 2). This compares to what was descried in the initial referral to the Minister for Planning in 2018 of a range of between 3 to 5.5 GL/year.

Alternatives for water supply include drawing from the local groundwater through local bores and adjacent aquifers. However, this was discounted early for the following reasons:

- Relatively low yield of the upper most aquifer (Parilla Sand Aquifer) and resultant size and scale of a wellfield (4-5 km^2 with more than 20 wells) to meet even a portion of water demand
- Lack of reliability for the aquifer to be able to supply a water source for the life of the Project
- Project objective to minimise impacts to the wider regional water resources and connected systems

Similarly trucking water into the Project site was considered and quickly discounted, due to operational cost being prohibitive and would require a large fleet of trucking and road networks to be established.

In summary, sourcing water from GMW via a Kangaroo Lake pumpstation and pipeline is considered the optimal solution for the delivery of water to the Project site given the water availability from the GMW system and lack of impact on existing users.

4.6.2 Ore processing

The location of the processing plant was developed on the basis of the following:

- Logistical:
  - To be located in Area 1 – as this is where mining will commence due to higher ore grades and thus minimises initial operating costs
  - Ease of access to Donald-Swan Hill Road, which limits a site entrance to a Bennett Road location
- Mineral Resource:
  - Minimises sterilisation of ore.

For the reasons outlined above the only location considered is that outlined in Chapter 3 (Project Description).

In regards alternative type and level of processing of ore considered, the 2018 EES Referral[1] outlined two options:

- Option 1 – processing producing heavy mineral concentrate only
- Option 2 – processing producing zircon and rutile concentrate, titanium concentrate and rare earth concentrate

These two options represent a minimal processing alternative (Option 1) with exporting HMC offshore for additional processing, versus additional on-site processing (Option 2) to produce a suite of higher value products.

VHM's decision to progress with Option 2 was based on a series of metallurgical test work programs undertaken between 2018 and 2021 which delivered flow sheet designs for 5 Mtpa process plant MUP, WCP and MSP options. This work included engineering and capital and operating expenditure estimation and proved the viability of the processing.

During feasibility studies conducted by VHM, processing option 2 was determined to be the preferred alternative when considering capital and operating costs, product specification and value and market risks as well as being

[1] Referral for assessment under the *Environment Effect Act 1978* – dated August 2018

the objective aligned with the Critical Minerals Strategy[2]. Processing option 2 was subsequently modified as presented in Table 4-3 below.

Table 4-3 Processing option 2

	Processing		
Phase	1	1A	2
Timing	At commencement of operations.	Construction planned to commence during Phase 1 construction to allow commissioning around 6 to 12 months after project commencement.	Construction planned to commence around 2 to 3 years after project commencement.
Processing plant or circuit	Mining unit plant (MUP) Wet concentrator plant (WCP) Rare earth mineral concentrate (REMC) flotation plant	MUP WCP REMC flotation plant Hydrometallurgical circuit	MUP WCP REMC flotation plant Hydrometallurgical circuit Mineral separation plant (MSP)
Products	Zircon/titania HMC REMC	Zircon/titania HMC REMC Mixed rare earth carbonate (MREC)	Zircon/titania HMC REMC MREC Premium zircon Zircon concentrate HiTi/rutile HiTi leucoxene Low chromium ilmenite

As described in Chapter 3: Project description, VHM would implement a staged development approach to the processing consisting of three phases (Phase 1, 1A and 2). Phase 1 would initially involve a MUP, WCP and REMC flotation plant until a hydrometallurgical plant (HMP) is added as part of Phase 1A. The product suite for Phase 1 would consist of a zircon/titania heavy mineral concentrate (HMC) and rare earth mineral concentrate (REMC) until Phase 1A is completed, which would then enable a mixed rare earth carbonate (MREC) to also be produced. Phase 2 would commence approximately two years post-production and consist of an additional mineral separation plant (MSP) and, subject to prevailing market circumstances, hot acid leach (HAL) and chrome removal circuit. The additional plant would allow for the production of premium zircon, zircon concentrate, high grade titanium (HiTi) rutile, HiTi leucoxene, low grade titanium (LoTi) leucoxene and low chromium ilmenite.

Mining and processing would take place at a throughput of approximately 5 million tonnes per annum (Mtpa) for 20 to 25 years. Throughputs of 10 Mtpa and 20 Mtpa were also considered, however a throughput of 5 Mtpa was identified during feasibility assessments as the preferred alternative.

4.6.3 Water recovery options

Water is being used by the Project as the primary medium of transporting ore from the mine to the process plant, and then following ore processing, to return the homogenised tailings to be deposited back into the mine void so that rehabilitation can take place.

In regards the options for water recovery, and minimising seepage, the options are:

Conventional Slurry Recovery

- recovery of water from tailings will initially occur via cyclones and a thickener
- second stage of water recovery would take place as water is released from the homogenised coarse and fine tailings deposited in-pit following ore processing. Water released and recovered from tailings in-pit would be returned to the processing plant for reuse.
- during the second stage, solar drying of the tailings would occur and contribute to ‘dewatering’ albeit water recovery will not occur

[2] https://www.industry.gov.au/publications/critical-minerals-strategy-2023-2030

- a third stage of water recovery is the combination of methods to intercept a portion of seepage emerging from beneath the deposited tailings:
  - embankment underdrain
  - dewatering system designed to capture mounded water intercepting adjacent mining blocks

While some seepage losses to groundwater will occur, this method results in significantly less GHG emissions from lower energy consumption, more efficient material movement (piping versus trucking) and reduced risks of dust and noise impacts, than the use of centrifuges. See further discussion in Section 4.5.3 (Tailings Management).

Centrifuges

Centrifuges can be used as an alternative to recover water from tailings during ore processing, ahead of deposition into the mine void. See assessment of this option in Section 4.5.3 (Tailings Management) above.

Dewatering centrifuges work by:

- increasing the gravitational forces that act on the slurry, which facilitates separation of the solids from the water in the tailings
- flocculant being added to the slurry in the centrifuge to increase coagulation of the clay particles in the tailings
- typical operating centrifuge rotational speeds are in the 1,000 to 1,800 revolutions per minute range, increasing the gravitation force to between 600 and 1,800 times.

The primary advantage of using centrifuges for dewatering tailings is that a high degree of dewatering is achieved, with tailings dewatered to the point where only residual water remains due to the capillary action between water and solid particles. This means that any water that remains in the tailings would not drain freely from the material, even when deposited back into the mine void. Despite this, centrifuges have not found widespread application in the mineral sands industry due to high capital operating costs overriding the benefits of centrifuging, when compared to conventional water recovery methods.

In addition, centrifuges would result in significantly increased plant equipment maintenance costs, increased truck movements associated with transporting filtered tailings from the processing plant to the mine void, increased energy requirements and demand on the site power plant, increased GHG emissions associated with the increased truck movements and energy demand, the potential for increased dust generation from the temporary stockpiling of filtered tailings and an increased plant footprint. Operating centrifuges is also likely to increase impacts on nearby sensitive receptors due to increased noise, vibration and air emissions.

Considering this, the Project has opted for the more conventional recovery of water, incorporating cyclones and a thickener to the ore processing and implementing in-pit recovery. This recovery method is more economically and environmentally viable compared to centrifuges and is well known and accepted throughout the mineral sands industry.

4.6.4 Transport and haulage

VHM's objective is to utilise rail infrastructure for the Project and thus minimise road haulage as much a practical, and this was the reason several alternatives were originally considered for the transport of product from the Project site to a port facility.

At the time of the 2018 EES referral, the options considered utilising the then available rail heads (intermodals) of Manangatang, Sea Lake, Hopetoun and Ouyen for transport to the ports of Portland, Port Adelaide, Geelong and Melbourne. The assessment of these alternatives was based on road haulage route and distance to the rail head and viability of each port for accepting containerised product.

While Hopetoun originally represented the shortest distance to Port and thus potentially the preferred option, in 2019 an intermodal terminal opened in the town of Ultima, approximately 25 km north-west of the project. For this reason, the selected option for transport of product is from mine site was changed to Ultima.

As described in EES Chapter 3: Project description, the Ultima terminal has approved high productivity freight vehicle (HPFV) access for A Doubles to the site via Swan Hill-Sea Lake Road rail access to the Port of Melbourne, approximately 360 km away.

Table 4-4 below presents each of the transport routes.

Table 4-4 Transport routes considered in 2018 EES referral – with Ultima included for comparison

Railhead (intermodal)	Distance to Port km				Approximate road haulage distance from mine to railhead (intermodal) km	Rail infrastructure owner
	Portland	Port Adelaide	Geelong	Melbourne		
Manangatang	460	797	471	543	101	V-line ARTC
Sea Lake	420	757	432	757	60	V-line ARTC
Hopetoun	319	384	376	488	118	ARTC
Ouyen	N/A	350	N/A	504	149	V-line GWA ARTC
Ultima	N/A	N/A	N/A	420	47	V-line ARTC

ARTC – Australian Rail Track Corporation; GWA - Genesee & Wyoming Australia

4.6.5 Water supply pipeline

In order to service an approximate annual (steady-state) water demand of approximately 3.2 G/L a year (with a maximum demand of 4.5 GL/year for Phase 2 start up), a buried water supply pipeline between Kangaroo Lake and the Project site is required as part of the ancillary works. The original concept consisted of a 38 km pipeline which followed the alignment presented in Figure 4-2 below.

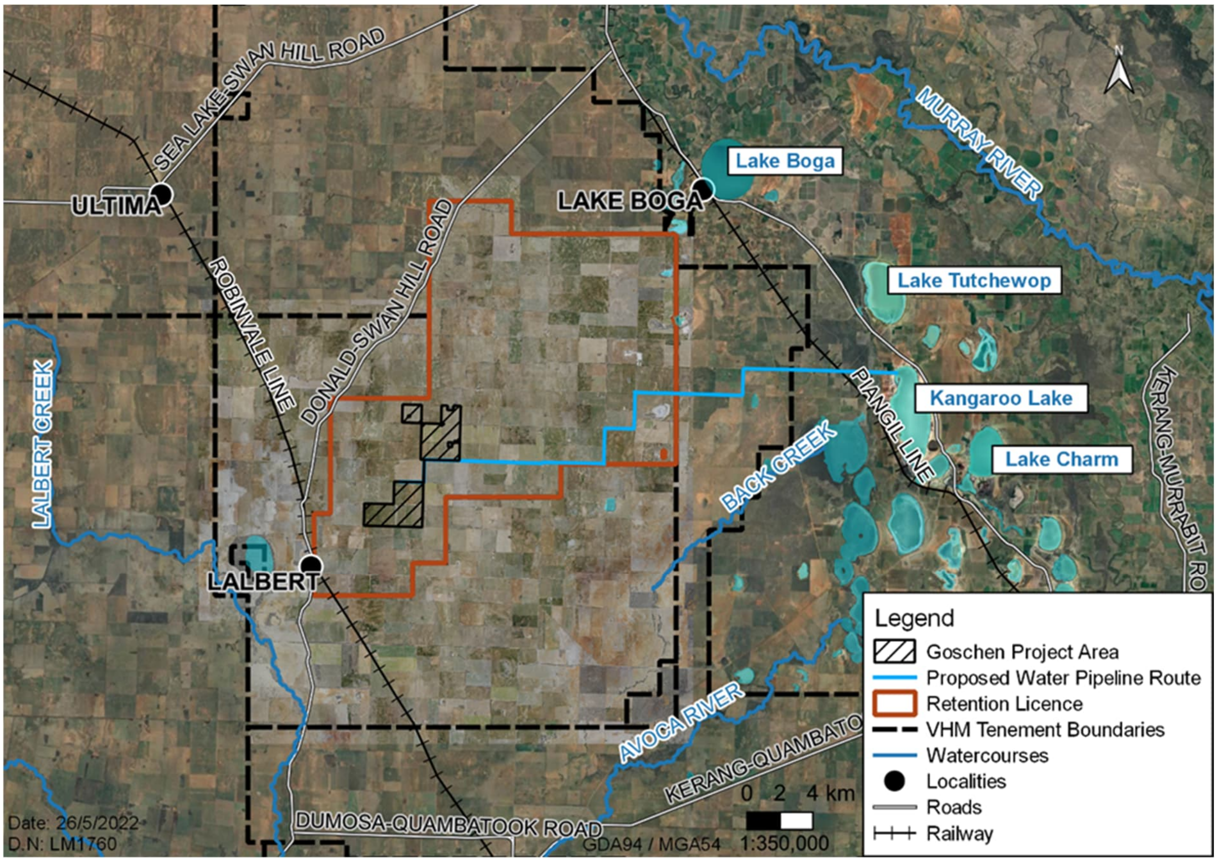

Figure 4-2 Water supply pipeline option (prior to ecological assessments)

The initial pipeline route considered was proposed to travel west from Kangaroo Lake along Mystic Park East Road and Mystic Park – Beauchamp Road. The pipeline would then continue along Mystic Park – Meatian Road, Steer Toad, Thompson Road and Jampot Road before re-joining Mystic Park – Beauchamp Road.

Following results of the Native vegetation and flora impact assessment (Technical Report A) and Fauna ecology impact assessment (Technical Report B) it was estimated that the construction of the overall project would result in a maximum loss of 19.8 ha of native vegetation, including 2,459 trees. The direct removal and fragmentation of vegetation would also potentially result in losses of fauna habitat. It was determined that most of these losses would occur along the initially proposed pipeline alignment.

A key outcome of ecological impact assessments was the opportunity to avoid and minimise environmental impacts further by modifying the alignment of the underground pipeline. Two additional pipeline alignments were subsequently proposed (refer to Figure 4-3 below).

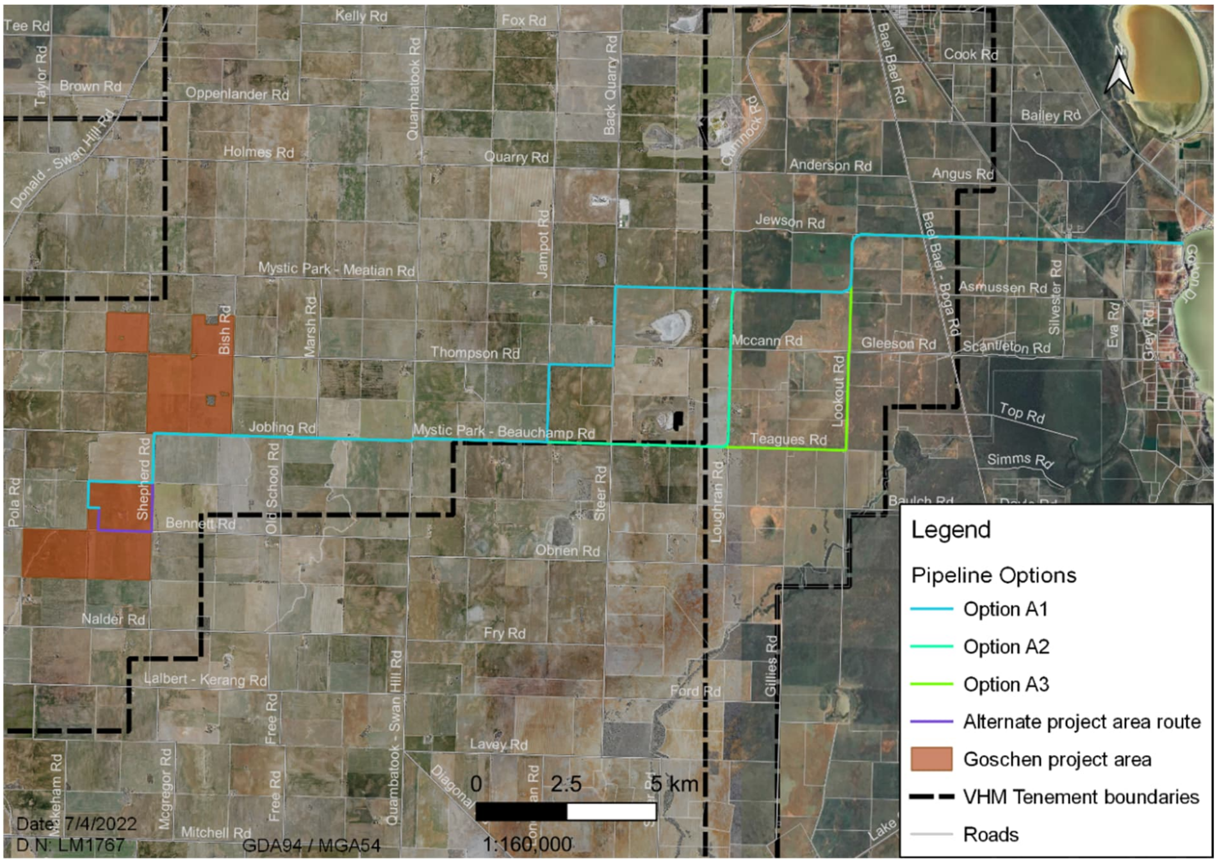

Figure 4-3 Water supply pipeline option (post ecological and arborist assessments)

Alignment option A1 represents the original pipeline alignment. Option A2 follows Mystic Park – Beauchamp Road south and to the west and option A3 follows Lookout Road south and Teagues Road west, before joining Mystic Park – Beauchamp Road.

In May 2022, an arborist was engaged to undertake a preliminary assessment of each pipeline alignment. The likely number of trees that would be lost for each option was estimated and a preferred pipeline alignment was recommended. The assessment considered the construction of each road, proximity of trees to the road and tree size.

The preliminary arboricultural impact assessment together with the assessment of alternatives determined a significant reduction in loss, with a conclusion that constructing the underground pipeline along option A1 would result in a loss of approximately 112 trees. 46 of these trees would be lost along Thompson Road, which despite being short in length, is very narrow with minimal road compaction and a dense concentration of trees along the roadway. Both option A2 and option A3 would result in a loss of approximately 61 trees, however option A3 was identified as the preferred route given that no trees would be lost from the construction of the pipeline along Lookout Road and Teagues Road. Additionally, consideration was given to natural constraints along the proposed pipeline route, such as waterways and irrigation channels, and the possible alignment of the pipeline within the proposed route during the selection of the preferred alignment.

Figure 4-4 Vegetation encountered along the originally proposed water supply pipeline route (left) and realignment to areas, where practicable, with minimal vegetation (right)

With the preferred pipeline route revised to avoid and minimise environmental impacts, additional detailed surveys were undertaken as part of the flora and fauna impact assessments. The outcomes of these assessments are contained in Technical Report A: Native vegetation and flora impact assessment and Technical Report B: Fauna ecology impact assessment.

To further minimise impacts to native vegetation the concept of putting the pipeline within agricultural (private freehold) land adjacent to the various road alignments was considered. However, an initial investigation determined that the pipeline would need to cross between 40 to 80 parcels and this concept was not assessed further for the following reasons:

- initial engagement with a number of landowners indicated no willingness to consider the option of an easement on their property
- for the concept to be viable, a large number of adjacent property owners would need to agree to ensure the pipeline alignment avoided too many bends
- timeline to engage with relevant landowners and negotiate a positive outcome and to have enough land accessible to make the engineering and construction feasible.

4.6.6 Waste disposal

The Project will generate various non-hazardous recyclable and non-recyclable wastes and waste hydrocarbons during construction, operation and closure:

Solid waste

All solid waste will be collected and stored on-site in suitable containers and transported off-site by licensed contractor(s) in accordance with EPA requirements. Recyclable materials will also be collected and sent to a licensed recycler by a licensed waste contractor.

Alternative solid waste management such as onsite composting of putrescible waste or in-pit disposal of solid, non-putrescible waste (construction waste) were not considered as it did not align with the overall philosophy of minimising risk of harm and is inconsistent with VHM's environmental policies.

Waste hydrocarbons

Waste hydrocarbons such as oils, greases and hydraulic fluids will be collected and stored on-site in suitable containers and transported off-site by licensed contractor(s) in accordance with EPA requirements.

Alternative waste hydrocarbon management system includes a site based hydrocarbon biological treatment systems (bioremediation pads). This is relatively common where the mining operations are remote and in arid areas. This option was not considered as alternative approach to disposing of, or treating, waste hydrocarbons due to the relative closeness of licenced contractors and facilities in Swan Hill and Kerang, and the added risk of contaminating portions of the site which will require clean-up as part of closure.

Wastewater

Significant effort has been put into designing the plant and tailings management system to maximise overall water recovery, all of which will be reused in the process water circuit. All collected process water will be stored in the Process Water Dam separate from the Raw Water Storage.

The alternatives considered to this re-use of process water included use of recovered process water for dust control management. The use of recovered process water in the process water circuit is a more efficient use of this water from an operations viewpoint.

All wastewater from ablutions and the administrative offices within the Process Plant area will be treated with a sequencing batch reactor (SBR) that has a design capacity of 20,000 L/day that will discharge Class A EPA recycled water classification. The Class A effluent would be collected and used in process water circuit. Excess biosolids from the SBR will be pumped out to a 10 m^3 sludge holding tank for thickening and ultimately be disposed of off-site by an EPA licenced contractor.

Alternative options included collecting and storing all wastewater and periodic collection from site by a licenced waste contractor and or a hybrid system where a portion of wastewater is periodically collected from site by a licenced contractor, but administration offices and workshops are treated via an in-ground (septic) system onsite.

The first alternative would remove all wastewater from site with associated additional vehicle movements to and from the project area compared to the preferred option. The second alternative would treat some effluent onsite using a smaller system but would involve discharge to land/groundwater. Overall, all options (along with the preferred option) would have negligible environmental impact, but the preference was given to optimise the volume of water re-use on-site.

4.7 Workforce and accommodation

4.7.1 Construction

VHM will appoint a contractor to execute the construction phase of the project. The onsite and offsite construction workforce is estimated to be up to 260 people.

Workforce numbers will vary during the different stages of construction, with preferred option to source construction workers from within the local area for all stages. This option will result in direct and indirect benefits to the local economy. Where the skill set and/or required experience is unavailable in the local area, workers will be employed from within Victoria, and further afield as necessary to meet project requirements.

An influx of workers into the area during construction could lead to a range of socioeconomic impacts, such as accommodation shortages in nearby towns and reduced access to health and social services. The potential impacts are addressed in the socioeconomic impact assessment (see Chapter 18).

A draft Workforce accommodation strategy has been developed and it is expected that adequate accommodation will be available in towns within 1 hour’s drive of the site (such as Kerang, Swan Hill, Lake Boga, Sea Lake) for the expected non-local construction workers. Contractors and employees may be transported by bus from neighbouring towns to the mine site, which will reduce road traffic and the area required for vehicle parking.

An alternative considered to using local accommodation was to build a dedicated construction camp at or near the Project area to accommodate contractors during the construction phase of the Project. This option was discounted early given community feedback which raised concerns about social impacts associated with such a construction camp and VHM’s objective of employing workers from the local area where possible.

4.7.1 Operation

The Project objective is to ultimately source the majority of the operations workforce (approximately 400 people) locally. As soon as practicable, VHM will offer training opportunities for local personnel to support this approach.

Some specialist skills and previous experience are required for a range of positions such as mine manager, process engineers, geologists and environment, health and safety personnel. These roles are likely to be sourced from both within and outside the local area.

Increased accommodation availability for workers who move into the region for the Project is expected to be progressively become available in nearby towns for the operations workforce, including in Kerang and Swan Hill, and is a focus for the Memorandum of Understanding with two of the local Councils (Swan Hill City Council and Gannawarra Shire Council).

An alternative to VHM's local employment policies and not selected would be to focus on employing a greater number of workers from further afield in Victoria or from interstate. This approach would likely be via a fly-in, fly-out or drive-in, drive-out basis, which would result in a more transient workforce, reduced opportunities for local residents, more social disruption for workers and the local community, and fewer direct and indirect economic benefits to the local community and businesses.

4.8 Closure and rehabilitation alternatives

Successful closure of the Project will require progressive rehabilitation throughout the life of the mine. Options for final land use and decommissioning of infrastructure are discussed below.

Decommissioning

Project infrastructure, such as buildings, fencing, pipelines, powerlines, haul roads and other pavements, will be decommissioned and removed for closure. Processing plant including the MUPs, WCP, loading facilities and thickeners will be dismantled and removed during final closure.

The mine site will be cleared of any debris, rehabilitated and revegetated. Some infrastructure may be retained at the request of landholders, Gannawarra Shire, GMW or other stakeholders. Stakeholder consultation will be a critical process in planning for closure. Some assets may be viewed by the community and government agencies as beneficial beyond the life of the mine. These assets may include the raw water storage and pipeline and the electricity powerlines and substation.

VHM is open to exploring these opportunities and the options for retaining infrastructure will be discussed with key stakeholders closer to the time of closure.

Final land use

Determining the final land use for rehabilitation and closure considered existing land uses, land capability and potential for diversification. During stakeholder engagement, the local community was clear that it wanted the land returned to the same agricultural use and accordingly, no significantly different land use alternatives were considered for closure.

It is noted that some areas will be revegetated with trees, shrubs and grasses and ideally will have restricted grazing regimes to provide protection from erosion. However, the majority of the land will be returned to productive agricultural use with an aim to improve productivity due to soil conditioning and increased water holding capacity.

Progressive rehabilitation

Rehabilitation of the mined areas will be conducted progressively as the active mining face advances. Progressive rehabilitation typically has a better outcome than if rehabilitation is left until the end of mining as it allows for changing weather conditions and for continuous improvement. VHM will conduct rehabilitation trials and acknowledges that there will be lessons to be learnt during active rehabilitation of the mine site. The application of knowledge from local landholders and agronomists will help to achieve successful soil conditioning and pasture establishment.

4.9 'No project' alternative

The Project has been considered in the context of a 'No project' alternative. This alternative assumes that the mineral sands mining and processing operation at Goschen would not proceed and that the land proposed to be occupied by the Project would continue to be used for broadacre farming.

4.9.1 Implications of the Project not proceeding

Negative consequences of the Project not proceeding would largely be social and economic. The Project would represent added value to the Australian economy, including major value to the region surrounding the Project area. This would be a result of direct and indirect employment and its flow on benefits. It is estimated that locally, the Project would sustain an additional 400 full-time equivalent (FTE) positions on average per annum during operations. Such benefits would not be realised if the Project did not proceed.

Additionally, consumer demand and government policy are driving global economies to a carbon neutral future. The Project would support a transition to more sustainable technologies and carbon neutrality. Rare earth minerals are the building blocks of sustainable technologies, and the Project would produce critical mineral products essential for the automotive industry to transition from internal combustion engine vehicles to battery electric vehicles and plug-in hybrid electric vehicles.

Positive outcomes of the Project not proceeding would include avoidance of the potential environmental, social and economic impacts associated with the development of the Project, as assessed in this EES.

4.10 Conclusion

The final selected Project as outlined in Chapter 3 (Project Description) represents the culmination of an iterative geological and economic evaluation process that was undertaken as more detailed modelling results and engineering design was generated. Superimposed on these outcomes was the result of various environmental impact assessments which further refined the Project, specifically in regards the following areas:

- Mining and ancillary (pipeline) footprints to avoid native vegetation
- Mining depth to avoid regional groundwater dewatering
- Product transport via rail to minimise traffic impacts.

The final Project therefore includes the inherent controls to minimise as much as practical environmental impacts, while maintaining an economically viable project. Each environmental impact Chapter in this EES includes further measures to avoid and minimise environmental effects over the life of the Project.