Environment
Effects
Statement

VHM Limited
Goschen Rare Earths and Mineral Sands Project

Chapter 16 Agriculture and soils

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VHM Ltd

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16. Agriculture and soils

This chapter provides an assessment of the potential impacts associated with the construction, operation, decommissioning and closure of the Goschen Rare Earths and Mineral Sands Project (the Project) on agriculture and soils.

More detailed information is provided in Technical Report L: Agriculture impact assessment and Technical Report M: Soil and land resource impact assessment, prepared in support of the Environment Effects Statement (EES).

Overview

The Project would be located among land predominately used for agricultural purposes. The predominant land use within the study area is dryland winter cereal cropping, with wheat, barley, oats and canola the most commonly sown crops. A calcic red-brown calcarosol was identified as the dominant soil type within the project area. Soils were determined to have a moderate to moderately high dispersion rating according to the Emmerson aggregate test (EAT) and would therefore be prone to erosion. The dispersion ratings generally increased between the A horizon (topsoil) and B horizon (subsoil) at each soil site.

This chapter considers the impacts of the Project on soil and agricultural productivity during the life of the mine, as well as post-mining operations. At the conclusion of mine operations, the land would be returned to conditions suitable for agricultural use. As such, maintaining soil health and the agricultural productivity of the land is of high importance.

Soil and land resource

Soil stripping would occur during the construction phase, as part of site establishment and progressively during Project operation. Stripping and stockpiling activities have the potential to impact soils and lower agricultural activity post-mining operations and rehabilitation. This would occur by increasing erosion and soil loss.

To mitigate potential impacts to soils, the following would be implemented. Prior to stripping disturbance areas, the soil surface would have 5 to 10 tonnes per hectare of natural gypsum applied. This would help facilitate the mixing of soil and gypsum and prevent the exposure of dispersive soils, resulting in a more stable stockpile with an increased potential for agricultural use post rehabilitation. During the construction of the water pipeline, the trench would be progressively backfilled to minimise the duration of time that the more dispersive subsoil is exposed to rainfall events.

To avoid the degradation of soils during stockpiling, soil stripping during excessively wet or dry conditions would be avoided, less aggressive soil handling techniques would be adopted to scrape, or grade and push soils into windrows and soils removed would be placed into designated stockpile areas. The implementation of additional management and mitigation strategies, such as treating stockpile surfaces with ameliorants and ensuring a maximum topsoil stockpile height of 2 m would ensure any potential impacts are minimised.

The exposure of dispersive soils during Project operation would also be managed by treatment with gypsum and ameliorants. Cover crops would be seeded to provide stockpiles with appropriate protection during rainfall events. To avoid weed seeding during stockpiling and a subsequent increase in weeds once topsoil has been placed post rehabilitation, weed control would be undertaken in areas yet to be mined to prevent seed set prior to topsoil stripping. During stockpiling, weeds should be controlled biannually and stockpiles should be seeded with cover crop to provide competition for weed species.

By adopting these mitigation measures, it is expected that impacts to soils would be minimal during Project construction and operation and that the agricultural productivity of the land would be so that it can be returned to agricultural use following rehabilitation, and at the conclusion of mine operations.

Agriculture

With regard to agricultural productivity, during the life of the mine there may be some disruption from road closures and increased vehicle movements. Parts of Bennett Road will be closed and require road diversions and Thompson Road is expected to be closed for approximately 12 years during construction and operation of the Project. As part of the Project, a traffic management plan (TMP) would be prepared and implemented to manage road closures and detours to ensure impacts on the local road network are minimised and managed. As a result, residual impacts on agricultural productivity from road closures and increased vehicle movements are expected to be minor.

Once the water supply pipeline is constructed, water would be sourced from Goulburn Murray Water via the open water market with no constraints put on existing or future agricultural availability. The Project would purchase or lease water licences for the required 3.1 gigalitres per annum during operation (and up to 4.5 gigalitres for the Project's start up), which would represent less than 1% of available surface water licenses in the Goulburn Murray Water system. The construction of the water supply pipeline would not be expected to impact agricultural productivity in the area and may provide the local area with opportunities to source irrigation water once the Project ceases operation.

Despite progressive rehabilitation and restoration of parts of the Project land, the agricultural use may be impacted for approximately 25 years and has the potential to reduce the local employment pool which may impact agricultural productivity in the community. There would be a reduction in the locally available employment pool for seasonal agricultural operations and a reduction of available agricultural employment during the life of the Project, however the Project is estimated to sustain net employment gains of around 480 full time equivalent employees per annum. Impacts to the agricultural sector from a reduced employment pool would be offset by this increase in full time equivalent employees associated with the Project, and the positive impacts to other local sectors, such as the service sector, worth approximately $61 million in terms of an average annual net increase.

Regarding agricultural revenue, the existing potential gross margin from growing winter cereal crops in the study area was calculated at up to $340,170 per annum (or $481,651 with a 25% assumed yield increase for the Cannie Ridge) and with a variable cost of $624,138. The potential revenue represents 0.12% of the $264 million that regional agricultural production contributes to the Shire. Given the Project area has the potential to generate 0.12% of the agricultural production value within the Shire and comprises 0.4% of the total land area, impact of the Project to agricultural production within the Shire would be minimal. Additionally, it is estimated that the Project would generate $2 billion in additional gross regional product for the Loddon-Mallee region, which equates to an average output of $206 million per annum.

With implementation of the proposed mitigation measures, the Project would avoid or minimise other potential impacts on current and future agricultural productivity, including poor final land use, the spread of weeds and dust emissions.

EES evaluation objective

The scoping requirements provided by the Minister for Planning for the project set out the specific environmental matters to be investigated and documented in the project EES. The scoping requirements inform the extent and scope of the EES technical studies. The following EES evaluation objective is relevant to the agriculture impact assessment:

To minimise potential adverse social and land use effects, including on agriculture and transport infrastructure.

In the absence of an evaluation objective directly relating to the soil and land resource impact assessment, the following requirement was adopted from Section 1.2 of the scoping requirements as a key matter to examine:

Effects on land stability, erosion and soil productivity associated with the construction and operation of the project, including progressive rehabilitation works.

Technical Report L: Agriculture impact assessment and Technical Report M: Soil and land resource impact assessment were prepared in support of the project EES. The technical reports provide more detailed information on the investigations and impact assessments conducted in response to the EES scoping requirements.

16.1 Methodology

The following approach was adopted for the agriculture impact assessment and soil and land resource impact assessment:

- Establishment of the study area.
- Characterisation of the existing environment.
- Review of the project description, comprising the key project components, proposed construction, operation and rehabilitation activities.
- Undertaking a desktop review of relevant databases.
- Review of relevant assessments.
- Undertaking targeted soil surveys.
- Assessment of impacts to agriculture and soils during construction, operation and rehabilitation of the Project.
- Developing mitigation measures in response to identified impacts.
- Evaluating the residual environmental impacts once mitigation has been implemented.

16.2 Study area

The study area for the agriculture impact assessment and the soil and land resource impact assessment consists of the Project area. 14 soil sites were visited and sampled as part of a soil survey, as presented in Figure 16-1. The agriculture impact assessment also considers the general region surrounding the Project area.

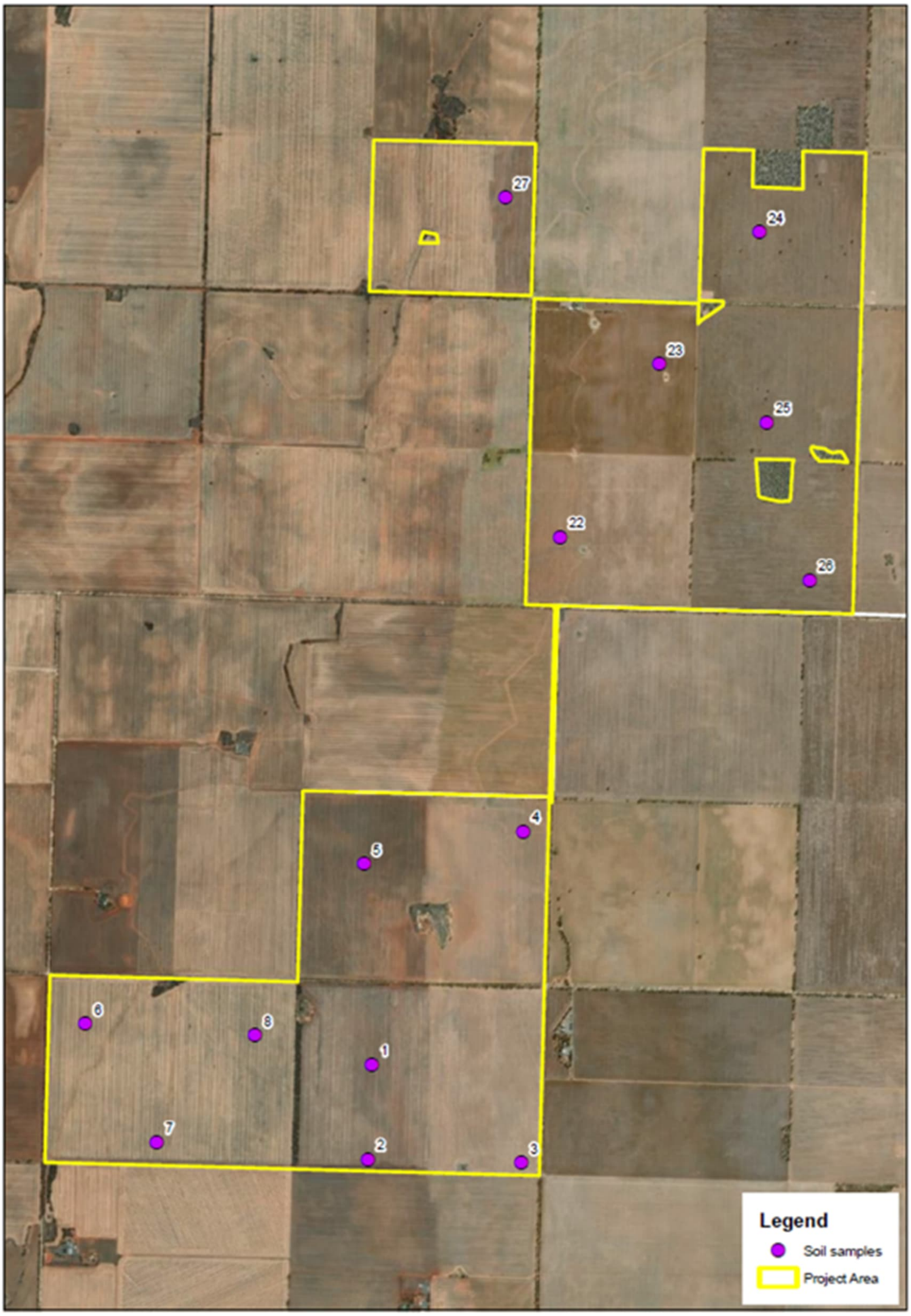

Figure 16-1 Soil and land resource study area and soil sampling sites within the Project mining area

16.3 Existing environment

An assessment was undertaken to understand the existing environment of the study area and to inform the agriculture and soils impact assessment. Assessments included database searches and targeted soil surveys.

16.3.1 Environmental conditions

Climate

Climate data was obtained from the Bureau of Meteorology Lake Boga (Kunat) weather station, ID 77021, located approximately 10 km north east of the study area. The annual mean minimum temperature is 9.7 degrees Celsius (°C) and the annual mean maximum temperature is 23 °C. Average annual rainfall and evaporation in the area is approximately 320 mm and 1620 mm, respectively. The study area experiences a relatively dry climate, where average monthly rates of rainfall are exceeded by evaporation in all months of the year.

The area is classed as a low rainfall cropping zone according to the 2022 Farm Gross Margin and Enterprise Planning Guide (GRDC), with an average annual rainfall less than 350 mm. The growing season rainfall for winter cropping falls between April and October, with rainfall spread reasonably evenly across all months. Monthly rainfall averages collected between 1933 and 2022 are presented in Table 16-1 below.

Table 16-1 Monthly rainfall averages (1933 to 2022)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
23.9	21.0	20.4	21.4	31.3	26.9	33.8	33.2	31.0	34.9	27.8	20.7	327.3

Topography

The topography in the study area ranges from approximately 75 to 125 m Australian height datum (AHD). The topography is characterised by a north-south orientated ridge that transects the project area, elevated around 100 to 125 m AHD.

Geology

The outcropping geology of the project area comprises of a thin quaternary cover of sandy clay, and ranges in thickness from approximately 5 to 10 metres below ground surface. The quaternary material overlays the Loxton Parilla Sands, which hosts the target mineralisation zone. The Loxton Parilla Sands has an average thickness of 50 metres across the basin and consists of an unconsolidated to weakly cemented yellow-brown fine to coarse well-sorted quartz sand, sandstone, and clay.

In the broader study area, the Loxton Parilla Sands is underlain by the Geera Clay, which is underlain by the Renmark Group. The Renmark Group is made up of the Olney Formation and the Warina Sand.

In regard to acid generation potential, it is noted that sediments are slightly acidic after being subjected to oxidisation, this is due to very little carbonate material being present and only minor amounts of sulfide material. In addition the minor amount of acidity generated long term would be neutralised by alkalinity in the natural waters.

Sand tails have no detectable sulfide material or carbonate alkalinity and net acid generation is below the detection limit. Acid drainage is not considered to pose a significant risk. In general the tailings have no risk of acid drainage.

Given that the Geera Clay would not be intersected or dewatered, potential acid sulfate soils in the Geera Clay have not been assessed.

Further information on the geology of the Project area is provided in EES Chapter 14: Groundwater.

Hydrogeology

Four hydrogeological units were identified in the study area:

- The Loxton Parilla Sands form the main aquifer in the study area and range in thickness between 35 to 55 metres.
- Underlying the Loxton Parilla Sands, the Geera Clay forms a significant aquitard and consists of a dark grey to black clay of low plasticity.
- Part of the Renmark Group, the Olney Formation forms an aquifer underlying the Geera Clay.

- The Warina Sand forms an aquifer underlying the Olney Formation and is encountered at depths of approximately 105 metres below ground level (m bgl).

Based on the available information groundwater is not used for human consumption, stock watering, irrigation or industrial purposes within 10 kilometres of the study area.

Further information on the hydrogeology of the project area is provided in EES Chapter 14: Groundwater.

16.3.2 Soil type

One soil map unit (SMU), a calcic red-brown calcarosol, was identified in the study area. SMUs refer to a soil landscape and usually comprise a number of soil types. The following table, Table 16-2, summarises the Australian soil classification (ASC) soil types within the study area as informed by soil survey field data and laboratory analysis. Soil site locations are presented in Figure 16-1.

Table 16-2 ASC soil types

SMU	ASC soil type	Soil type group	Detailed site	Hectares
1	Calcic red calcarosol	Dominant	1,2,5,6,8,22,23,27	1,479
	Calcic brown calcarosol		24,25,26	
	Eutrophic red chromosol	Sub-dominant	4,7	
	Subnatric brown sodosol		3	
		Total	14	1,479

According to the ASC, a solum refers to surface and subsoil layers which have undergone the same soil forming conditions. A solum includes soil layers known as the A horizon and B horizon. The A horizon generally refers to topsoil and the underlying B horizon generally refers to subsoil.

The characteristics of the three different soil types, calcarosol, chromosol and sodosol are as follows:

- Calcarosols are soils which are calcareous throughout the solum, or calcareous at least directly below the A1 horizon, or within a depth of 0.2 metres. Calcareous soils contain carbonate segregations. Carbonate accumulations within calcareous soils must be judged to be pedogenic, referring to the process of soil formation. Calcarosols do not have a clear or abrupt texture contrast between the A horizon and the B horizon.
- Sodosols are soils with strong texture contrasts between A horizons and sodic B horizons, which are not strongly acidic. Sodic soils are classified as soils with an exchangeable sodium percentage (ESP) greater than 6.
- Chromosols are soils with strong texture contrast between A horizons and B horizons, where the B horizon is not strongly acidic or sodic.

Further information on each soil type, based on field observations, is presented below.

Calcic red calcarosol

A summary of the calcic red calcarosol and its observed soil horizons is presented in Table 16-3. This observation was made at soil site two (refer to Figure 16-1).

Table 16-3 Calcic red calcarosol summary, site two

Profile	Horizon / depth (m)	Description
	A1 0.0 – 0.15	Dark reddish-brown clay loam, weakly crumb structured 5-10 mm peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, nil segregations, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.0 – 0.10.
	B21 0.15 – 0.30	Reddish-brown medium clay, moderately structured 10-20 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, 20% soft calcium carbonate nodules, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.20 – 0.30.
	B22 0.30 – 0.60	Yellowish-red light clay, moderately structured 15-30 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, 20% soft calcium carbonate nodules, coarse roots common. Well drained with a gradual and even boundary. Sampled 0.40 – 0.50.
	B23 >0.60	Yellowish-red medium clay, massively structured. Nil mottling, nil stone content, nil segregations, coarse roots common. Well drained, layer continues beyond sample depth. Sampled 0.65 – 0.75 and 0.90 – 1.0.

Calcic brown calcarosol

A summary of the calcic brown calcarosol and its observed soil horizons is presented in Table 16-4. This observation was made at soil site 24 (refer to Figure 16-1).

Table 16-4 Calcic brown calcarosol summary, site 24

Profile	Horizon / depth (m)	Description
	A1 0.0 – 0.10	Dark reddish-brown clay loam, weakly crumb structured 5-10 mm peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, nil segregations, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.0 – 0.10
	B21 0.10 – 0.25	Reddish-brown medium clay, moderately structured 10-20 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, 20% soft calcium carbonate nodules, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.20 – 0.30
	B22 0.25 – 0.50	Yellowish-red light clay, moderately structured 15-30 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, 20% soft calcium carbonate nodules, coarse roots common. Well drained with a gradual and even boundary. Sampled 0.40 – 0.50
	B23 >0.50	Yellowish-red medium clay, massively structured. Nil mottling, nil stone content, nil segregations, coarse roots common. Well drained, layer continues beyond sample depth. Sampled 0.65 – 0.75 and 0.90 – 1.0

Eutrophic red chromosol

A summary of the eutrophic red chromosol and its observed soil horizons is presented in Table 16-5. This observation was made at soil site four (refer to Figure 16-1).

Table 16-5 Eutrophic red chromosol summary, site four

Profile	Horizon / depth (m)	Description
	A1 0.0 – 0.10	Dark reddish brown sandy loam, weak crumb structure 5-10 mm peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, nil segregations, abundant fine roots. Well drained with a clear and even boundary. Sampled 0.0 – 0.10.
	B21 0.10 – 0.40	Dark reddish brown light-medium clay, moderately structured 10-20 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, 10% soft calcium carbonate nodules, abundant fine roots. Well drained with a gradual and even boundary. Sampled 0.20 – 0.30.
	B22 0.40 – 0.70	Dark red medium clay, moderately structured 15-30 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, 20% soft calcium carbonate nodules, coarse roots common. Well drained with a gradual and even boundary. Sampled 0.40 – 0.50.
	B23 >0.70	Yellowish red heavy clay, massively structured. Nil mottling, nil stone content, 10% soft calcium carbonate nodules, coarse roots common. Well drained, layer continues beyond sample depth. Sampled 0.70 – 0.80.

Subnatric brown sodosol

A summary of the subnatric brown sodosol and its observed soil horizons is presented in Table 16-6. This observation was made at soil site three (refer to Figure 16-1).

Table 16-6 Subnatric brown sodosol summary, site three

Profile	Horizon / depth (m)	Description
	A1 0.0 – 0.10	Dark brown clay loam, weak crumb structure 5-10 mm peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, nil segregations, abundant fine roots. Well drained with a clear and even boundary. Sampled 0.0 – 0.10.
	B21 0.10 – 0.30	Light reddish brown heavy clay, moderately structured 10-20 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, 10% soft calcium carbonate nodules, abundant fine Sampled 0.20 – 0.30.
	B22 0.30 – 0.60	Reddish brown heavy clay, moderately structured 15-30 mm blocky peds with moderate consistence and a rough fabric. Nil mottling, nil stone content, 20% soft calcium carbonate nodules, coarse roots common. Well drained with a gradual and even boundary. Sampled 0.40 – 0.50.
	B23 >0.60	Yellowish red medium clay, massively structured. Nil mottling, nil stone content, 10% soft calcium carbonate nodules, coarse roots common. Well drained, layer continues beyond sample depth. Sampled 0.65 – 0.75 and 0.90 – 1.0.

16.3.3 Soil properties

Soil profiles were assessed at 14 soil sites throughout the project area in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST, 2009). This involved field assessments and laboratory assessments. Laboratory assessments were undertaken at 11 of the 14 soil sites and involved sample collection and analysis from each major soil horizon, or layer.

Properties assessed as part of the laboratory assessment included particle size, soil reaction (measures as pH), electrical conductivity (EC) and cation exchange capacity (CEC) and exchangeable cations. Emerson Aggregate Tests (EAT) were also undertaken in order to measure the potential for dispersion in the soils. Dispersion refers to the separation of clay particles in soil, generally resulting in structural decline and erosion. Understanding these properties, including the dispersion potential of the soils, is important to understand what activities may impact soils and how they should be mitigated.

Soil stripping depths

Topsoil (A horizon) and subsoil (B horizon) profile stripping depths were determined from field observation and laboratory results for each soil site (refer to Figure 16-1). The outcomes are presented in Table 16-7 below. Comment has been made where the B horizon becomes strongly sodic (ESP >14), or when field dispersion is rated as high.

Given the similarity in soil types across the Project area, there is the opportunity to strip and stockpile a greater topsoil resource than is currently available. Stripping topsoil to a depth of 20 centimetres will increase the clay content, cation exchange capacity (nutrient retention potential) and water holding capacity by blending the lighter sandy loams and loams with the higher clay content upper B21 horizon soils. Although there will be a slight increase in sodicity this can be mitigated by the application of gypsum prior to stripping works being undertaken (refer to Section 16.4.1).

Table 16-7 Soil stripping depths

Site	Analysis	Soil type	Strip A (cm)	Strip B1 (cm)	Strip B2 (cm)	Comment
1	Detailed	Red calcarosol	10	10-30	+30	High field dispersion at +30
2	Detailed lab	Red calcarosol	15	15-30	+30	ESP >14 at +30
3	Detailed lab	Red calcarosol	10	10-30	+30	ESP >14 at +30
4	Detailed lab	Red calcarosol	10	10-70	+70	ESP >14 at +70
5	Detailed lab	Red calcarosol	10	10-60	Nil	Weathered parent material at +60
6	Detailed lab	Red calcarosol	10	10-90	+90	ESP >14 at +90
7	Detailed lab	Red calcarosol	10	10-65	+65	ESP >14 at +65
8	Detailed	Red calcarosol	10	10-65	+65	High field dispersion at +65
22	Detailed lab	Red calcarosol	10	10-40	+40	ESP >14 at +40
23	Detailed lab	Red calcarosol	40	40-65	+65	ESP >14 at +65
24	Detailed lab	Brown calcarosol	10	10-40	+40	ESP >14 at +40
25	Detailed lab	Brown calcarosol	20	20-65	+65	ESP >14 at +65
26	Detailed lab	Brown calcarosol	15	15-40	+40	ESP >14 at +40
27	Detailed	Red calcarosol	15	15-65	+65	High field dispersion at +65

Summary of chemical parameters

Laboratory analysis was undertaken at 11 of the 14 soil sites assessed, with soils collected from each major soil horizon. Table 16-8 below summarises the chemical parameters of the samples collected at each soil site (refer to Figure 16-1).

Table 16-8 Summary of soil chemical parameters

Analyte	Rating	A horizon sites	B21 horizon sites
pH	Neutral (6.6 – 7.3)	2,5,7	Nil
	Mildly alkaline (7.4 – 7.8)	6	Nil
	Moderately alkaline (7.9 – 8.4)	4,22	Nil
	Strongly alkaline (8.5 – 9.0)	3,23,25,26	4,5,6,7,23
	Very strongly alkaline (>9)	24	2,3,22,24,25,26
ESP	Non-sodic (<6)	2,3,4,5,6,7,22,23,24,25,26	4,5,6,7,23
	Marginally sodic (6.1 – 9.9)	Nil	2,3,22,26
	Sodic (10.0 – 13.9)	Nil	24,25
	Strongly sodic (>14)	Nil	Nil
EC	Non-saline (<2)	2,3,4,5,6,25,26	2,4,5,6,23
	Slightly saline (2.1 – 4.0)	7,22,23,24	3,7,22,26
	Moderately saline (4.1 - 8.0)	Nil	24,25
	Highly saline (8.1 – 16.0)	Nil	Nil
Ca:Mg	Balanced (4.1 – 6.0)	3,4,22,24,25,26	Nil
	Calcium low (1.0 – 4.0)	2,5,6,7	2,3,4,5,6,7,22,23,24,25,26
	Magnesium deficient (>10)	23	Nil
Texture	Sandy loam	4,5,7,23	Nil
	Loam	26	Nil
	Sandy clay loam	Nil	23
	Clay loam	1,2,3,6,8,22,25,27	5
	Silty clay loam	24	Nil
	Light clay	Nil	1,6,7,8,26,27
	Light medium clay	Nil	4,22,25
	Medium clay	Nil	2,24
	Heavy clay	Nil	3

The observed and tested soil parameters demonstrate the similarity in soil types across the study area. Stripping topsoil to a depth of 20 centimetres would increase the clay content and water holding capacity of the lighter sandy loams and loams. Although there would be a slight increase in sodicity, this could be mitigated by the application of gypsum prior to stripping works being undertaken, as discussed in Section 16.4.1.

Erosion potential

The dispersion class and erosive potential of soils within the study area was determined using the Emmerson aggregate test (EAT). All soil horizons within the study area were classified as having moderate to moderately high dispersion ratings and would therefore be prone to erosion. The dispersion ratings generally increased between the A horizon and B horizon at each soil site.

Appropriate erosion and sediment control measures would be undertaken, including the management of water flows over and through dispersive soils and the application of gypsum, wherever surface disturbance is to be undertaken (refer to Section 16.4.1).

Potential for acid sulfate soils

The presence of acid sulfate soils would be extremely unlikely given the soil types present in the study area (calcarosols, chromosols and sodosols) and given the alkaline pH measurements to a depth of 1 m in the soil profile (refer to Table 16-8). Calcarosols and sodosols are not considered to be strongly acidic soils, as the pH is greater than 5.5.

Potential for soil acidification

Given the alkaline pH and high clay content throughout the soil profile to a depth of 1 m, the soil types in the study area would have a very low potential for acidification.

Potential for salinity

The majority of soil profiles are non-saline in the topsoil (A horizon) and slightly to moderately saline in the subsoil (B horizon). Given the very good drainage chrematistics of the soils, highlighted by the presence of calcium carbonate nodules and lack of mottling, the potential for an increase in salinity is low.

16.3.4 Regional land use

Agriculture is the main employer and economic driver within the Gannawarra Shire (the Shire) with a value of around $284 million per annum, employing approximately 1,058 people. The Shire has a diverse agricultural economy comprised of dairy, cereal and legume cropping, livestock including beef, lamb and pork, viticulture and horticulture comprising walnuts, olives, tomatoes, apples, peaches and citrus along with small plantings of vegetables and herbs.

A variety of soil types combined with a suitable climate can support a range of enterprises across both irrigated and dryland properties. The Shire is split distinctively between the riverine plain to the east and the Mallee to the west. Soils in the Mallee are dominated by calcarosols, chromosols and sodosols, which are suited to dryland winter cropping. Cropping comprises approximately 30% of agricultural land use in the Gannawarra Shire.

Irrigation plays an important role in agricultural production within the Shire. Water is supplied from the Murray River and Goulburn River systems via a network of automated channels and natural lakes and creeks. Lake Charm, Kangaroo Lake and the Gunbower Creek are natural assets that play a key role in the distribution of irrigation water from the Murray River.

Irrigation farms have undergone an efficiency transformation with laser grading and re use systems developed for flood irrigation farms. The implementation of subsurface irrigation, centre pivot irrigators, pipes and risers and automation has assisted in further efficiency gains for irrigation farmers.

Crops grown with irrigation include:

- Tree crops including walnuts, olives, stone fruit, citrus and apples.
- Tomatoes, onions, broccoli and pumpkin.
- Wine grapes.
- Hay including oaten, vetch, lucerne and clover.

Other non-irrigation crops grown in the region include wheat, barley, canola, cotton, corn, peas, beans, sorghum, vetch and oats.

16.3.5 Study area land use

The predominant land use within the study area is dryland winter cereal cropping, with wheat, barley, oats and canola the most commonly sown crops. Crops are sown using minimum or zero tillage techniques with an emphasis on minimal ground disturbance and stubble retention to protect the topsoil from wind and water erosion. Grazing of sheep and cattle is undertaken opportunistically, however dryland winter cereal cropping is the predominant land use.

There is limited irrigation within or in the vicinity of the study area.

16.3.6 Existing value of crop production in the study area

The existing crop yield and crop values for the study area were sourced from the 2022 Farm Gross Margin and Enterprise Planning Guide (GRDC, 2022), with crop yields determined from the long term averages for the low rainfall cropping zone (less than 350 millimetres). Two crop value scenarios have been considered. The 2022 GRDC price forecast (refer to Table 16-9) and the most recent five year price average (refer to Table 16-10).

Assuming the total cropping area is divided evenly between wheat, barley canola, lentils and hay, as it would be in a typical cropping rotation, the gross margin would range between $164 to $230 per hectare, with a nominal variable cost of $422 per hectare (refer to Table 16-9 and Table 16-10). Giving a potential gross margin of $242,556 to $340,170 across the 1,479 hectare project area, with variable costs of approximately $624,138 to sow, grow and harvest the crop. Cost includes (but is not limited to) expenses related to seed, fertiliser, freight, chemicals and levies.

Table 16-9 2022 Gross margin per hectare - GRDC price forecast

Crop	Grade	Yield (t/ha)	$ per tonne	Gross income	Variable cost	$ per hectare
Wheat	Australian premium white	1.8	$350	$630	$300	$330
Barley	Feed	1.8	$260	$468	$361	$107
Canola	42% oil	0.8	$750	$600	$495	$105
Lentils	Red	0.9	$700	$630	$357	$273
Oaten-Hay	Export	3.2	$290	$928	$595	$333
			Average per hectare	$651	$422	$230

Table 16-10 Gross margin per hectare - Five year price average forecast

Crop	Grade	Yield (t/ha)	$ per tonne	Gross income	Variable cost	$ per hectare
Wheat	Australian premium white	1.8	$330	$594	$300	$294
Barley	Feed	1.8	$271	$488	$361	$127
Canola	42% oil	0.8	$622	$498	$495	$3
Lentils	Red	0.9	$650	$585	$357	$228
Oaten Hay	Export	3.2	$238	$762	$595	$167
			Average per hectare	$585	$422	$164

Given that the Project area incorporates part of the Cannie Ridge, which is considered by local growers as one of the best cropping areas in the region, if the GRDC low rainfall cropping zone yields are increased by 25%, the average gross margin increases to $326 per hectare (5 year price average) with a total gross margin of $481,651 per annum (refer to Table 16-11).

Table 16-11 Gross margin per hectare - 25% yield increase

Crop	Grade	Yield (t/ha)	$ per tonne	Gross income	Variable cost	$ per hectare
Wheat	Australian premium white	2.3	$330	$759	$300	$459
Barley	Feed	2.3	$271	$623	$361	$262
Canola	42% oil	1.0	$622	$622	$495	$127
Lentils	Red	1.2	$650	$780	$357	$423
Oaten Hay	Export	4.0	$238	$952	$595	$357
			Average per hectare	$747	$422	$326

16.3.7 Project employment, expenditure, revenue and benefits

The number of full-time equivalent (FTE) labour units required to undertake activities on a typical 2,000-hectare southern region cropping farm was determined in order to understand employment in proximity to the Project area. The Fair Work Act and Modern Pastoral Award define a full-time employee as working an average of 38 hours per week or 152 hours over a four-week period. Considering that peak labour demand occurs during sowing (April and May) and harvest (November and December) and given that the Project area is 1,479 hectares, the total FTEs to undertake cropping activities within the Project area was determined to be an average of 1 per annum and would not exceed 2.2 per annum during the course of a calendar year. Further information is provided in EES Technical Report L: Agriculture impact assessment.

The Project is estimated to sustain 480 full-time equivalent positions on average per annum over the 25 year operational period (refer to EES Chapter: 18 Socio-economics). This is relative to the current local labour force in the Loddon-Mallee region, which totals 160,283.

Modelling undertaken as part of the economic impact assessment (refer to EES Chapter: 18 Socio-economics) estimated the net impact of the additional investment in the local economy to develop and maintain the Project, and the resultant reallocation of labour and capital from other regions and sectors of the economy, to the local area.

Estimates of the forecast capital and operating expenditure required to develop the project were provided by VHM and reflect the size and scale of the project at the detailed feasibility study stage. The total development capital expenditure is estimated at $626 million, while the on-going operational and sustaining capital expenditure is forecast to total $2.8 billion over the life of the Project.

The Project is estimated to generate $2 billion in additional gross regional product for the Loddon-Mallee region which equates to an average impact to output of $206 million per annum, which is an average annual increase in economic activity for the Loddon-Mallee region of around 0.5%.

Due to the Project's size, relative to the local economy, development and operational activity is expected to draw labour and capital from other regions and sectors of the Victorian economy. These movements of labour and capital are termed 'crowding-out effects'.

As a result of the movement of capital and labour to the region, the economic impact of the Project to the state of Victoria is expected to be lower, than to the study area.

Across Victoria, the Project is estimated to deliver $1.3 billion in additional gross state product, which equates to an average output impact of $126 million per annum. The Project is estimated to sustain an additional 230 full time equivalent positions on average, per year in Victoria, relative to the base case.

The Project is expected to create both positive and negative spill-overs on the local economy. Positive economic spill-overs would be generated across the broader economy, predominately in the service sector, which is expected to experience an average uplift to economic output of $61 million (undiscounted) per year. This would be a result of real incomes rising and leading to additional spending in service industries.

Negative spill-overs (i.e. crowding out) are expected to be most prominent in capital intensive industries that employ specialised labour such as heavy manufacturing, agriculture, and the mining industries. Overall however, while crowding out effects are expected, these are small in scale relative to the larger spill-over benefits projected for other sectors as a result of the development of the Project.

16.4 Soil and land resource

16.4.1 Construction impact assessment

Soil stripping would occur during the construction phase, as part of site establishment and progressively during Project operation. Construction activities, such as stripping and stockpiling, have the potential to impact soils by increasing erosion and soil loss, loss of soil structure and lowering the agricultural productivity of the soils post mining operations and rehabilitation. Soil stripping refers to the removal of the topsoil layer as part of construction works. Impacts to soils may occur during soil stripping and stockpiling through the mixing of soil types, degradation of soil structure and through the exposure of dispersive soils. Mitigation measures are presented in Section 16.7.

Mixing of soil types during stripping

It is recommended to strip all disturbance areas, including haul roads, infrastructure areas, subsoil and overburden stockpile locations, and water supply pipeline to a depth of 20 cm for topsoil, with the remaining mine pit areas stripped to 80 cm of subsoil. This would give a profile reinstatement potential of 0.9 to 1 metres. Deeper stripping would not occur in areas with deeper A horizons. Reinstated soil profiles will have a deeper average A horizon than is currently present. Given that the predominant land use is cropping, reinstating 20 cm of topsoil would be conducive to attaining, or even improving, pre-disturbance yields.

The dominant ASC soil type across the study area is a red-brown calcarosol, with two sub-dominant soil types, chromosol and sodosol (refer to Section 16.3.2). These soils generally demonstrate consistent properties and textures at each soil horizon. For example, loams were typically observed in the A horizon, while clays were typically observed in the B horizon.

Mixing significantly different ASC soil types during soil stripping may promote erosion and lower the agricultural productivity of the soils post rehabilitation. This would occur if dispersive soils, prone to erosion, are mixed with less dispersive soils and exposed to rainfall events.

More dispersive soils were generally observed in the B horizon (refer to Section 16.3.3). Prior to stripping disturbance areas, the soil surface would have 5 to 10 tonnes per hectare of natural gypsum applied (MM-SLR01). This would mitigate the mixing of the more dispersive B horizon, or subsoil, with the less dispersive A horizon, or topsoil and it would also increase the calcium and sulfur content of the soil.

Application of gypsum prior to stripping would also ensure thorough mixing of the gypsum throughout the top 20 cm of the soil, resulting in more a stable stockpile with an increased potential for agricultural use post mining operations and rehabilitation. Implementing this mitigation would ensure that potential impacts from mixing soil types are minimised to the extent practicable.

Degradation of soil structure

Soil degradation refers to the physical, chemical or biological decline of soil quality. Degradation of the soil structure during stripping and stockpiling has the potential to result in increased erosion and the lowering of agricultural productivity post mining operations and rehabilitation.

A number of mitigation measures would be required to minimise the potential impacts to soil (refer to Section 16.7). Soil would be stripped in a slightly moist to moist condition, whereby soil is pliable when hand texturing (15-30% soil moisture), wherever possible. Material would not be stripped in either an excessively dry, powdery, or very friable when hand texturing (<15% moisture), or wet condition where soil loses integrity when hand texturing or leaves mud on hands (>30% moisture) (MM-SLR02). During excessive dry periods, stripping would not be undertaken to prevent pulverisation of the natural soil aggregates. Stripping during wet periods would not be undertaken to prevent damage of the resource through compaction by equipment. Given the normally dry climate (refer to Section 16.3.1), consideration would be given to stripping and stockpiling large areas of topsoil when soil moisture conditions are favourable or application of water prior to stripping.

To reduce soil degradation during stripping, preference would be given to using equipment which can grade or push soil into windrows (MM-SLR01). This includes using equipment such as laser buckets, graders or dozers, where soil would be collected later by open bowl scrappers or loaded into rear dump trucks by front-end loaders. This would minimise impacts associated with the compaction of soils by heavy equipment. These techniques are examples of preferential, less aggressive soil handling systems which would be adopted.

All soils removed during construction and operation would be placed into designated stockpile areas (MM-SLR01). Topsoil would be stripped from these designated stockpile areas and would be returned during rehabilitation. Stockpiles would be placed on the subsoil. Freshly stripped and placed topsoil retains seed that is more viable and a greater number of micro-organisms and nutrients in comparison to stockpiled soil. Vegetation establishment is generally improved by the direct return of topsoil and is considered ‘best practice’ topsoil management. Should longer term storage of stockpiles be proposed (six months or greater), accurate records are required, indicating stockpile volumes and areas to be covered by each stockpile upon rehabilitation and final decommissioning. Soil stockpiles within construction areas could be utilised as long term batters or bunds to facilitate noise, visual screening and surface water diversion where required.

The following management and mitigation strategies would be implemented to reduce degradation during stockpiling operations (MM-SLR01):

- Topsoil and subsoil stockpiles would be stored separately.
- A maximum stockpile height of two metres would be maintained.

- The location of stockpiles would be recorded using GPS, along with data relating to the soil type and volume. An inventory of available soil would be maintained and updated regularly to ensure adequate topsoil and subsoil materials are available for planned activities.
- The surface of soil stockpiles would be left in as coarsely structured condition as possible, to promote rainfall infiltration and minimise erosion, prior to cover vegetation becoming established. The coarse structure would also prevent anaerobic zones forming.
- Stockpile storage time would be minimised, where possible. If long-term stockpiling is planned (greater than three months), such as those stockpiles which will be formed during the initial pit and infrastructure development, stockpiles would be seeded with an annual cover crop species and/or covered with light jute mat. A rapid growing and healthy cover crop would not persist later in rehabilitation areas, but would provide sufficient competition for emerging weed species, enhance the desirable micro-organism activity in the soil and minimise the stockpile's potential for erosion. Crop growth on stockpiles would provide protection from wind and water erosion by shielding the stockpile surface and through root growth binding the soil together.
- Where possible, freshly stripped subsoil and topsoil would be re-spread directly onto rehabilitation areas and to depths according to target requirements. Topsoil would be spread, treated with fertiliser and seeded in one consecutive operation. This would reduce the potential for compaction and topsoil loss to wind and water erosion.
- Stockpiles would not be disturbed until required for rehabilitation, weed management, erosion control or for seeding and fertilising purposes.
- The surface of all stockpiles would be treated with ameliorants such as gypsum and Granulock 15 to create the most suitable growth medium for chosen rehabilitation crop species. Granulock 15 consists of nitrogen, phosphorus and sulfur.

Impacts to soil as a result of degradation would be minimised to the extent practicable following the implementation of these mitigation measures.

Exposure of dispersive subsoil during water supply pipeline construction

Sodic and dispersive subsoils are expected to be encountered during the construction of the water supply pipeline, consistent with subsoils observed in the project area. Therefore, there is the potential to mix topsoil and subsoil and expose dispersive subsoil to rainfall events, resulting in erosion and soil loss.

Topsoil would be stripped to a depth of 20 cm prior to any trenching activities. The trench would be progressively backfilled to minimise the duration of time that the more dispersive subsoil is exposed to rainfall events. The subsoil would be backfilled first, followed by topsoil and ameliorant application (including gypsum application to the surface of in-filled material) (refer to MM-SLR02).

Impacts to soil would be minimised to the extent practicable following the implementation of these mitigation measures.

16.4.2 Operation impact assessment

During operation and rehabilitation of the project, dispersive soils may be exposed to rainfall events throughout stockpiling activities, mining operations and during decommissioning. This would result in an increased potential for erosion and soil loss which would lower the agricultural productivity of the soils post mining operations and rehabilitation. Additionally, weed infestations during soil stockpiling may reduce agricultural productivity post rehabilitation.

Exposure of stockpiles dispersive subsoil

Stockpiles containing dispersive subsoils may result in erosion and loss of soils to be used in rehabilitation, through exposure of the subsoil to rainfall events.

As described in Section 16.4.1, measures to mitigate impacts to stockpiled soil include treating the surface of all subsoil stockpiles with ameliorants and seeding with suitable cover crop (MM-SLR01). This would provide appropriate protection from rainfall events. Where timing may not be conducive to cover crop germination, appropriate erosion and sediment control measures would be applied, as per a site specific Erosion & Sediment Control Plan, to be developed ahead of the Project's construction and operation.

Implementing such mitigation measures would mean that impacts would be minimised to the extent practicable.

Exposure of dispersive subsoil during mining

During mining operations, the exposure of dispersive subsoil to rainfall events on open mine pit faces may result in erosion and soil loss. The subsoil within the Project area is typically 20 cm to 100 cm below surface level.

Mine pit faces would be as steep as recommended in the geotechnical assessment (a maximum of 32 degrees for pits up to 42 metres deep and 31 degrees for pits up to 47 metres deep), in order to minimise the surface area of exposed subsoil layers during the mining process. Refer to EES Technical Report J: Geotechnical for further information on the recommended pit geometry. Progressive rehabilitation would be undertaken as the mine advances to minimise the duration of time that subsoils are exposed to potential rainfall events. Depending on the steepness of the mine pit, applying gypsum to the subsoil would be considered (MM-SLR03).

Additional mitigation measures have not been proposed. Any subsoil which may be eroded by rainfall events would remain in the bottom of the mine pit and therefore potential impacts would be considered minimal.

Exposure of dispersive subsoil during decommissioning

During decommissioning activities, exposure of the dispersive subsoil may result in erosion and soil loss.

In addition to measures described in Section 16.4.1 (refer to MM-SLR01), rehabilitation and topsoil placement would be undertaken as soon as practical. If rehabilitation is delayed, the exposed subsoil would be treated with gypsum and the appropriate erosion and sediment control measures would be applied (MM-SLR04).

Implementing such mitigation measures would mean that impacts would be minimised to the extent practicable.

Weed infestation during topsoil stockpiling

During stockpiling, there may be an increase in weed seeding resulting in an increase in weeds once the topsoil has been placed post rehabilitation. This may impact agricultural productivity post mining operations.

Weed control would be undertaken in areas yet to be mined in order to prevent seed set prior to topsoil stripping (MM-SLR05). During stockpiling, weeds would be controlled biannually and stockpiles would be seeded with cover crop to provide competition for weed species. This proposed management frequency would control summer and winter weeds, which is commonly accepted as good agronomic practice. Only grass species would be seeded on stockpiles to allow for the use of selective herbicides to control broadleaf weeds.

Implementing such mitigation measures would mean that impacts would be minimised to the extent practicable.

16.5 Agriculture

16.5.1 Construction impact assessment

Construction activities may impact agricultural productivity during the life of the mine in the area surrounding the Project through potential impacts to the local road network. The construction and use of the underground water supply pipeline from Kangaroo Lake may impact the agricultural availability of water, although potential impacts are not expected to be significant.

Traffic network

During construction and operation of the Project, road closures and increased vehicle movements have the potential to impact the local road network, although such impacts are expected to be minimised to the extent practicable.

During the traffic and transport impact assessment (refer to EES Chapter 10: Traffic and transport), major highway and arterial roads surrounding the project area were observed to be lightly trafficked and generally in good condition, with an adequate sealed road surface. Local roads in the vicinity of the project area and the water pipeline were found to be generally unsealed, narrower and with little to no traffic. Considering the predominant local agricultural land use, traffic volumes would likely increase during harvest delivery.

Parts of Bennett Road would involve a diverted access and Thompson Road is expected to be closed for approximately 12 years during construction and operation of the Project. Bennett Road and Thompson Road travel through Project Area 1 and Area 3 respectively. A traffic management plan (TMP) would be developed and implemented to manage road closures and detours (MM-AG02) (refer to EES Chapter 10: Traffic and transport). No delays to public transport services would be expected to occur and local property access would be maintained during the closures.

As such, potential impacts to the local road network and agricultural productivity during mine operations would be minimised to the extent practicable. During development of the TMP, consideration would be given to alternative access points during construction and operation of the Project, with scheduling taking into account harvest vehicle and machinery requirements. Thompson Road would be fully reinstated upon completion of the Project. There are considerations for intersection and road section upgrades to ensure that safe vehicle movements can be facilitated during the construction and operation of the Project and such upgrades would result in positive impacts for the local road network and agricultural productivity. Further information on traffic and transport impacts is presented in Chapter 10: Traffic and transport.

Water supply pipeline

While the construction of the water supply pipeline between Kangaroo Lake and the mining areas may impact the availability of water for agricultural production during mine operations, there would be no constraints on water availability and the potential exists for the beneficial use of irrigation water from Kangaroo Lake once the Project is complete.

Water licences would be purchased or leased for the required 3.1 gigalitres per annum during operation, which represents less than 1% of available surface water licenses in the Goulburn Murray Water system. Water not required during each licencing period could be made available for temporary transfer to other users. Given that only currently licenced surface water would be purchased or leased, no additional surface water which is currently available in the Goulburn Murray Water system would be removed as a result of the Project. No constraints would be placed on existing or future water for agricultural availability.

The underground water supply pipeline would be trenched, laid and backfilled, with the proposed alignment traversing existing road easements wherever possible (refer to EES Chapter 3: Project description). The pipeline has been designed to avoid direct impacts on surrounding agricultural land.

VHM will consult with Responsible authority and other stakeholders as to the possibility of the pipeline remaining at completion of the Project, whereby surface water would be available for purchase by landholders along the pipeline route via Goulburn Murray Water. The TMP would provide alternative access points during construction of the water supply pipeline, with scheduling taking into consideration harvest vehicle and machinery requirements (MM-AG02).

Once the pipeline is constructed, water would be sourced from Goulburn Murray Water via the open water market with no constraints put on existing or future agricultural availability. During operation and following completion of the Project, there is potential for the beneficial use of irrigation water from Kangaroo Lake for the local area, such as for establishment of high value horticultural crops on rehabilitated areas, or for use in irrigated crop and fodder production. As such, no mitigation measures have been proposed. The construction of the water supply pipeline would not be expected to impact agricultural productivity during mine operations and may in fact provide benefits.

16.5.2 Operation impact assessment

Progressive rehabilitation of the land would be undertaken during the life of the mine. If the post mining land use is not satisfactory, post-mining agricultural activity may be impacted.

Additionally, during mining operations itself, the temporary removal of agricultural land, a reduced employment pool, property restrictions, the loss of agricultural infrastructure, access restrictions, the spread of weeds and dust emissions may also impact agricultural productivity.

Final land use

Upon rehabilitation of the Project, the land would be returned to its pre-existing agricultural use. There is the potential that land disturbed by the Project would not be satisfactory for the resumption of agricultural production post mining operations, however impacts would not be expected, particularly with the implementation of mitigation measures.

As described in Section 16.4.1, reinstatement of a soil profile to a depth of 1 metre, comprising 20 cm of topsoil and 80 cm of subsoil, would provide the required rooting depth for growth of crops and pasture (MM-AG01). The final landform would be designed to represent pre-disturbance gradients and flow paths. With all disturbed soil profiles being approximately 1 m in depth, there would be a substantial soil resource available for rehabilitation. This post-mining landform would be a gently undulating plain which would be consistent with the existing landform. The goal would be to restore final landform levels and local relief similar to current conditions, avoiding sharp reliefs between the existing and rehabilitated landscapes.

Topsoil and subsoil would be ameliorated as required during stripping and stockpiling activities to ensure pre-disturbance agricultural productivity is attained or improved (MM-SLR01) (refer to Section 16.4.1). Gypsum would be spread prior to topsoil stripping (MM-SLR01) to ensure thorough mixing prior to stockpiling to minimise the potential for dispersion. Topsoil would be tested prior to respreading to determine any further ameliorant requirements. Implementing such mitigation measures provides rehabilitation an opportunity to improve the post-mining agricultural productivity of the land through the addition of ameliorants. As such, impacts to the final land use and agricultural productivity post mining operations would not be expected.

Loss of agricultural revenue

During operation of the Project, land would be temporarily removed from agricultural production. This would result in a loss of agricultural revenue within the local community, however this loss would be more than offset by the construction and operation of the Project.

The potential gross margin from growing winter cereal crops in the study area was calculated at up to $340,170 per annum (or $481,651 with a 25% assumed yield increase for the Cannie Ridge) with a variable cost of $624,138 to grow the crop (refer to Section 16.3.6). The potential revenue represents 0.12% of the $264 million agricultural production contributes to the Shire. A similar decrease in revenue earnt by local suppliers from cropping variable cost inputs would also be expected.

Given the Project area has the potential to generate 0.12% of the agricultural production value within the Shire and comprises 0.4% of the total land area, impact of the Project to agricultural production within the Shire would be minimal. Whilst there is a potential loss of $624,138 in variable costs which would otherwise be spent with local rural suppliers, it should be noted that 20% to 30% of this value comprises fertiliser which is traditionally a low margin, high turnover product. Therefore, the loss of cropping area during the life of the Project would not impact upon the viability of winter cropping in the Shire, given the small area to be temporarily removed and its minor contribution to the overall revenue generated by agriculture.

Additionally, this lost agricultural income is considered insignificant when compared to the projected revenue generated by the Project. It is projected that the Project would generate $2 billion in additional gross regional product for the Loddon-Mallee region, which equates to an average output of $206 million per annum.

Additionally, the loss in farming generated revenue for local agricultural businesses such as rural suppliers, farm contractors and grain haulage, would potentially be offset by increased service supply opportunities during construction and operation of the Project. Operation of the Project would be more intensive and would require high input for rural commodities, such as soil ameliorants, water infrastructure, fencing and product haulage in comparison to a grain cropping operation. VHM proposes to engage with local suppliers during the life of the Project.

While there would be loss of agricultural income during the life of the Project, this loss would be considerably offset by the additional income streams and employment opportunities provided by the Project.

Reduced employment pool

In addition to land being temporarily removed during the operation of the Project, there would be a reduction in the locally available employment pool for seasonal agricultural operations and a reduction of available agricultural employment during the life of the Project. The potential impacts of a reduced employment pool on the agricultural sector would be small in scale compared to the larger benefits of the Project on other sectors.

As described in Section 16.3.7, the loss of FTEs required to undertake cropping operations within the Project area would not exceed a maximum of 2.2 over a 12 month cropping cycle. Given that acquiring and maintaining quality, skilled farm labour is an increasing challenge, if these FTEs were sourced externally it would be reasonably expected that alternate agricultural employment would be secured within the local area.

Over the evaluation period, the Project is estimated to sustain net employment gains of around 480 FTEs per annum. This estimate represents the average net number of jobs sustained each year as opposed to new, annual job creation. Peak employment is expected to be generated at the end of the evaluation period, with 640 additional FTEs per annum. This is relative to an estimated total workforce size in the Loddon-Mallee region of 160,283.

As presented in Section 16.3.7, given the size of the Project relative to the local economy, Project activity is expected to draw labour and capital from other regions and sectors of the Victorian economy. This would be offset by the estimate that there would be a positive impact to the services sector in the study area, worth approximately $61 million in terms of an average annual net increase (refer to Section 16.3.7). There would also be positive impacts to the wholesale trade and construction sector worth $19 million per annum in additional average annual output and the dwellings sector, worth 18 million per annum in additional average annual output.

Therefore, while the potential loss of available employees for agriculture cannot be readily mitigated, the large increase in FTEs as a result of the Project would contribute significant economic benefit to the local Shire

Agricultural infrastructure

Local agricultural infrastructure may be impacted by the construction and operation of the Project. This would include farm fences, gates, access roads, water access points, stock watering points and storage facilities. VHM would undertake consultation with impacted landholders through the proposed Neighbourhood Agreement model which is an explicit recognition that agricultural landholders living near the project would be living and working within a modified environment. The agreement would reduce, if not fully ameliorate, perceived imbalances between the benefits of the project for the broader community, and the negative effects of the project for affected neighbours (refer to Chapter 18 – Socio-economics).

Access restrictions

A restriction on access to farming areas for existing landholders may result in a decreased agricultural production, however impacts are not expected with the implementation of mitigation measures.

The proposed area to be mined within the Project footprint would be confined to approximately nine paddocks. Mining and rehabilitation would occur progressively (refer to EES Chapter 3: Project description). Area 1 will be mined in the first 10 years before operations switch to Area 3. This would mean that only a portion of the 1,479 hectare project area would be unavailable for agricultural production at any one time, with rehabilitation of mine pit areas proposed within 3 years of initial disturbance.

Landholders would be consulted prior to, and during the development of each mining stage, as to the requirement for alternative entry points and additional fencing, gates or grids to allow continued access to paddocks surrounding the project area (MM-AG02). As surrounding paddocks are in a grid formation, access impacts are expected to be minimal during construction and operation of the Project.

During construction of the water supply pipeline, access would be managed through landholder consultation and measures outlined in the Project Traffic Management Plan (refer to MM-AG02), such as alternate access routes for temporary road closure and livestock/machinery entry points for paddocks. As such, any potential impacts to access would be minimised to the extent practicable.

Weeds and biosecurity

The operation of the project may impact agricultural productivity through the spread of agricultural weeds and pests, however with the implementation of mitigation measures, impacts would not be expected.

As described in Section 16.4.2, weed control would be continued on areas which are not under current agricultural production to minimise the weed seed bank and prevent the spread of weeds. Disturbance areas, soil stockpiles and rehabilitation areas would be monitored for weed growth, with control measures undertaken as necessary (MM-AG03).

The Invasive Plants and Animals Policy Framework is the Victorian Government's approach to the management of existing and potential invasive species, which would be incorporated into the Project's relevant Weed and Pest Management Plan.

Any import of equipment or machinery from interstate or overseas would follow the standard procurement safeguards and quarantine procedures as per Victorian and Australian requirements (MM-AG03). Once on site, the majority of equipment to be used for the Project would site-dedicated and would pose no biosecurity risk.

Dust

Potential dust emissions from the construction and operation of the Project may impact surrounding agricultural productivity during the life of the mine, however impacts are not expected to be significant following the implementation of mitigation measures.

Dust or particles falling onto plants can physically smother the leaves affecting photosynthesis, respiration and transpiration. Literature suggests that the most sensitive species appear to be affected by dust deposition at levels above 1,000 mg/m^2/day which is five times greater than the level at which most dust deposition may start to cause a perceptible nuisance to humans. Most species appear to be unaffected until dust deposition rates are at levels considerably higher than this. (Farmer, 1993).

Alternately in a grazing system, Connell Hatch (2008) concluded that cattle did not find feed unpalatable if coal mine dust was present at a level equivalent to a dust deposition rate of 4,000 mg/m^2/day (which is a typical guideline used to protect against amenity impacts). At this level of dust cattle did not preferentially eat feed that did that did not contain coal mine dust and livestock production was not affected.

The air quality impact assessment found that the study area is already impacted by dust from agricultural activities, wind erosion during dry and windy conditions and the long range transport of fine particulate matter from other regions (refer to Chapter 12: Air quality). Dust deposition was not quantitatively assessed as part of the air quality impact assessment, due to the great uncertainty in emission source estimations.

The mining schedule, which would generally include the mining of only 3-4 active mine blocks (each block being 6.25 hectares) at any one time, would limit the exposure of disturbed areas that would be subject to wind erosion. Surface consolidation, revegetation and rehabilitation would continue to occur progressively throughout the Project life. With progressive rehabilitation being undertaken, the actual extent of impact before being returned to agricultural production for any given area would generally be three to five years from initial disturbance.

Wheel generated dust from haul roads would be the primary potential source of dust emissions. Preparing and maintaining level and well finished haul road surfaces would be considered a priority. Best practice dust emission mitigation measures would be employed for all aspects of Project operations. This would include the use of water sprays, misting systems and water trucks (refer to Chapter 12: Air quality). The use of live monitoring data and the visual assessment of fugitive dust generation is also recommended, especially dust emissions leaving the site boundary and dust deposition on the vegetation surrounding the site. Visual assessment may also include the use of remote close circuit television in areas where site activities are of regular concern with regard to dust emissions and impacts.

The potential impacts to agricultural productivity, health and the environment due to dust emissions were assessed as negligible to low with the application of recommended dust management strategies and measures.

16.6 Residual impacts

Residual impacts refer to those impacts that remain once mitigation measures have been implemented. Impacts to agricultural production throughout the life of the mine may result from road closures and increased vehicle movements during construction and operation of the Project, and there may be a loss of agricultural revenue and a reduced employment pool from the operation of the Project.

Access to agricultural land adjoining the Project will be impacted for up to 12 years while a combination of Shepherd Road, Thompson Road and Bennett Road are expected to be closed at different stages of the project. Impacts to the transport network during construction and operation are expected to be managed through the Traffic Management Plan for the project. While the road network is assessed as sufficient to accommodate anticipated traffic volumes, diversions which may add between 5-10 minutes would be required for existing agricultural landholders who require access to land via Shepherd Road, Thompson Road and Bennett Road.

The Project would result in the temporary loss of approximately 1,479 hectares of land for agricultural use at varying points in time over its 20-25 year life. While no mitigation measures have been proposed for a loss of agricultural revenue and a reduced employment pool resulting from the operation of the Project, the potential loss of agricultural revenue is considered modest when compared to the estimated $2 billion in additional gross regional product that the Project would generate for the Loddon-Mallee region. Any impacts to the agricultural sector from a reduced employment pool would be offset by an increase in FTEs associated with the Project and positive impacts to other local sectors, such as the service sector, worth approximately $61 million in terms of an average annual net increase. The residual impact in terms of extent of loss of agricultural revenue must also be considered in the context of the mining sequencing. For example, in most of the mining area of Area 1 (excluding the processing plant area which will remain in situ during the mining of Area 3) the land would be rehabilitated and returned to agricultural use after the cessation of mining activities in that area. The residual impacts relating to the loss of agricultural revenue will be confined in extent to a portion of the total mining area based on the sequencing of the mining operations. For example, the agricultural use in Area 3 can continue whilst Area 1 is being mined prior to the mining operations moving to Area 3.

Additionally, construction and use of the water supply pipeline may impact the availability of water for agricultural production, however water used by the Project would represent less than 1% of available water as part of Goulburn Murray Water's water allocation and there would be no constraints on existing or future water for agricultural availability. VHM will consult with the relevant stakeholders as to the possibility of the water supply pipeline remaining at completion of the Project, whereby water would be available for purchase by landholders along the pipeline route via Goulburn Murray Water.

Remaining potential impacts to agricultural productivity, including those associated with a poor final land use, the spread of weeds and dust emissions would be reduced to the extent practicable following the implementation of mitigation measures. These measures would include consultation with landholders, landholder compensation, the use of water sprays and surveillance to minimise dust impacts and monitoring for weed growth in areas of disturbance, rehabilitation and soil stockpiles.

During construction activities, stripping and stockpiling may impact soils by increasing erosion and soil loss and by lowering the agricultural productivity of the soils post rehabilitation. Prior to stripping disturbance areas, the soil surface would have 5 to 10 tonnes per hectare of natural gypsum applied and to avoid the degradation of soils during stockpiling, soil stripping during excessively wet or dry conditions would be avoided, less aggressive soil handling techniques would be adopted to grade and push soils into windrows and soils removed would be placed into designated stockpile areas. Additionally, to avoid weed seeding during stockpiling and a subsequent increase in weeds once topsoil has been placed post rehabilitation, weed control would be undertaken in areas yet to be mined to prevent seed set prior to topsoil stripping. Following the implementation of these measures, residual soil and land resource impacts would not be expected to be significant during construction and operation of the Project.

16.7 Summary of mitigation measures

The mitigation measures proposed to manage potential impacts to agriculture and soils are presented in Table 16-12.

Table 16-12 Agriculture and soils mitigation measures

Mitigation measure ID	Mitigation measure	Project phase
Soil and land resource		
MM-SLR01	Minimise the effects on native soils – mine site The following management and mitigation strategies should be implemented to reduce degradation during stockpiling operations: • Prior to stripping disturbance areas, the soil surface would have 5 to 10 tonnes per hectare of natural gypsum applied • Soil would be stripped in a slightly moist to moist condition wherever possible. This occurs when soil is pliable while hand texturing (15-30% soil moisture). Material would not be stripped in either excessively dry, powdery or very friable conditions (i.e . <15% moisture, or >30% moisture). • Overburden stockpile areas to be stripped of topsoil and subsoil to a minimum of 1m prior to placement of stockpiled material. • Subsoil stockpiles to be stripped of topsoil to a minimum depth of 200 mm prior to placement of stockpiled material. • Preference given to using equipment which can scrape, grade or push soil into windrows. • Topsoil and subsoil stockpiles would be stored separately and clearly signposted. The location of stockpiles would be recorded using GPS, along with data relating to the soil type and volume. An inventory of available soil would be maintained and updated regularly to ensure adequate topsoil and subsoil materials are available for planned activities • Maximum stockpile height of two metres would be maintained • The surface of soil stockpiles would be left in as coarsely structured condition as possible, to promote rainfall infiltration and minimise erosion, prior to cover vegetation becoming established. • Stockpile storage time would be minimised, where possible. If long-term stockpiling is planned (greater than three months), such as those stockpiles which will be formed during the initial pit and infrastructure development, stockpiles would be seeded with an annual cover crop species. • Where possible, freshly stripped subsoil and topsoil would be re-spread directly onto rehabilitation areas and to depths according to target requirements. Topsoil would be spread, treated with fertiliser and seeded in one consecutive operation. • Stockpiles would not be disturbed until required for rehabilitation, weed management, erosion control or for seeding and fertilising purposes. • The surface of all stockpiles would be treated with ameliorants such as gypsum and Granulock 15 to create the most suitable growth medium for chosen rehabilitation crop species.	Construction Operation

Mitigation measure ID	Mitigation measure	Project phase
	• Appropriate erosion and sediment control measures would also be applied, as per a site-specific Erosion & Sediment Control Plan, particularly when the timing of stockpiling is not conducive to cover crop germination. • Gypsum rates of 10 tonnes per hectare are recommended where exchangeable sodium percentage (ESP) is greater than 14 (i.e. strongly sodic). The gypsum sourced would have a minimum 19% calcium and 15% sulfur.	
MM-SLR02	<u>Minimise effects on native soils - pipeline</u> Topsoil will be stripped to a depth of 20 cm prior to any trenching activities. The trench would be progressively backfilled to minimise the duration of time that the more dispersive subsoil is exposed to rainfall. The subsoil would be backfilled first, followed by topsoil and ameliorant application (including gypsum application to the surface of in-filled material).	Construction
MM-SLR03	<u>Minimise effects on land resource</u> Mine pit faces would be as steep as recommended in the geotechnical assessment (a maximum of 32 degrees for pits up to 42 m deep and 31 degrees for pits up to 47 m deep), in order to minimise the surface area of exposed subsoil layers during the mining process. Progressive rehabilitation would be undertaken as the mine advances to minimise the duration of time that subsoils are exposed to potential rainfall events.	Construction Operation
MM-SLR04	<u>Minimise effects on native soils</u> During closure, if rehabilitation is delayed, the exposed subsoil would be treated with gypsum and the appropriate erosion and sediment control measures would be applied.	Operation
MM-SLR05	<u>Minimise effects on native soils</u> Weed control would be undertaken in areas yet to be mined in order to prevent seed set prior to topsoil stripping. During stockpiling, weeds would be controlled biannually and stockpiles would be seeded with cover crop to provide competition for weed species.	Operation
MM-SLR06	<u>Spills and leaks</u> Spills and leaks would be managed in accordance with MM-SW01 and MM-GW03.	All phases
Agriculture		
MM-AG01	<u>Minimise potential adverse land rehabilitation effects</u> Reinstatement of a soil profile to a depth of 1 metre, comprising 20 centimetres of topsoil and 80 centimetres of subsoil. Topsoil and subsoil will be ameliorated as required during stripping and stockpiling activities to ensure pre-disturbance agricultural productivity is attained or improved. Wherever possible topsoil and subsoil will be respread directly onto active rehabilitation areas rather than stockpiling to minimise handling and possible structure decline.	Closure
MM-AG02	<u>Minimise potential adverse land use effects</u> Adjacent landholders must be consulted prior to, and during the development of each mining stage as to the requirement for alternative entry points and additional fencing, gates or grids. Development of a Traffic Management Plan to allow continued access during temporary road closures and diversions.	All phases

Mitigation measure ID	Mitigation measure	Project phase
MM-AG03	Minimise potential adverse biosecurity effects: Weed control will be continued on areas which are not under current agricultural production. Disturbance areas, soil stockpiles and rehabilitation areas will be monitored for weed growth, with control measures undertaken as necessary. Control of weeds must be undertaken biannually (both summer and winter weed species control) on stockpiles during autumn/winter and spring/summer. Any import of equipment or machinery from interstate or overseas will follow the standard procurement safeguards and quarantine procedures as per Victorian and Australian requirements from the *Biosecurity Act 2015*.	All phases

16.7.1 Monitoring and contingency measures

The monitoring and continency measures that are proposed to assess agriculture and soils impacts associated with the project are presented in Table 16-13.

Table 16-13 Agriculture and soils monitoring and contingency measures

Measure ID	Monitoring or contingency measure	Project phase
Agriculture and soils and land resource		
Agriculture and soils and land resource	Visual monitoring of stockpiles would be undertaken regularly, particularly after significant rainfall events. The following characteristics would form part of the checklist in both a site-specific Soil Stockpile Management Plan and an Erosion & Sediment Control Plan, which will include action triggers and contingency actions to be implemented: • Integrity of sediment control. • Effectiveness of drainage. • Integrity of erosion and sediment control measures. • Pasture growth. • Weed infestation. Samples would also be collected down slope or next to stockpiles to detect whether any mobilisation of solutes or solids is occurring. Sampling of topsoil stockpiles would occur prior to respreading with testing undertaken for agricultural nutrients.	Construction Operation

16.8 Conclusion

The assessment has shown that the construction, operation, decommissioning and rehabilitation phases of the Project can be managed such that the objective of minimising adverse effects on agriculture and soils can be met.

Soil stripping would occur during the construction phase, as part of site establishment and progressively during Project operation. During construction and operation of the Project, activities such as stripping and stockpiling may impact soils and lower agricultural activity post-mining operations and rehabilitation. This would occur by increasing erosion and soil loss. With the implementation of mitigation measures however, impacts to soil would be minimised and the agricultural productivity of the land would be so that it can be returned to agricultural use following rehabilitation.

Impacts to agricultural productivity during the life of the mine may result from traffic diversions, road closures and increased vehicle movements. Parts of Bennett Road would involve road diversions and Thompson Road is expected to be closed for approximately 12 years during construction and operation of the Project, however potential impacts to the local road network and agricultural productivity are considered to be minor following the implementation of mitigation measures. Once the water supply pipeline is constructed, water would be sourced from Goulburn Murray Water via the open water market with no constraints put on existing or future agricultural availability. The Project would purchase or lease water licences for the required 3.1 gigalitres per annum during operation, which would represent less than 1% of available surface water licenses in the Goulburn Murray Water system. The construction of the water supply pipeline would not be expected to impact agricultural productivity in the area and may in fact provide the local area with a source of irrigation water once the Project ceases operation.

The Project would replace the existing agricultural use for up to 25 years and has the potential to reduce the local employment pool which may impact agricultural productivity in the community during the life of the mine. There would be a reduction in the locally available employment pool for seasonal agricultural operations and a reduction of available agricultural employment during the life of the Project, however the Project is estimated to sustain net employment gains of around 480 full time equivalent employees per annum.

Regarding agricultural revenue, the existing potential gross margin from growing winter cereal crops in the study area was calculated at up to $340,170 per annum (or $481,651 with a 25% assumed yield increase for the Cannie Ridge) and with a variable cost of $624,138. The potential revenue represents 0.12% of the $264 million that regional agricultural production contributes to the Shire. Given the Project area has the potential to generate 0.12% of the agricultural production value within the Shire and comprises 0.4% of the total land area, impact of the Project to agricultural production within the Shire would be minimal. Additionally, it is estimated that the Project would generate $2 billion in additional gross regional product for the Loddon-Mallee region, which equates to an average output of $206 million per annum. Additionally, any potential impacts associated with a poor final land use, property restrictions, the loss of agricultural infrastructure, access restrictions, the spread of weeds and dust emissions during operation of the Project would be unlikely to impact agricultural productivity following the implementation of appropriate mitigation measures.

In response to the EES evaluation objective described at the beginning of this chapter, impacts of the Project on agriculture, soils and land resource have been assessed and mitigation measures have been identified to avoid and minimise adverse effects on agriculture, soil and land resources.