AGRICULTURAL IMPACT ASSESSMENT

Finley Battery Energy Storage System

BESS Pacific Pty Ltd

Report No: P001993 AIA R01
Rev: G
11 April 2025

Premise

DOCUMENT AUTHORISATION					
Revision	**Revision Date**	**Proposal Details**			
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Prepared By		**Reviewed By**		**Authorised By**	
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1. EXECUTIVE SUMMARY

The Finley Battery Energy Storage System (Finley BESS) will involve the development, construction, operation, and eventual decommissioning of a BESS with a capacity of 100 Megawatt AC (MW_{AC})/ 200 Megawatt Hour (MWh) connecting via underground transmission line directly to the existing Transgrid Finley Substation.

The purpose of this Agricultural Impact Assessment is to support the Finley BESS Environmental Impact Statement (EIS) through identification, assessment and mitigation of any potential impacts to agriculture and soils that may occur and specifically address the requirements stated in the Departmental Secretary's Environmental Assessment Requirements (SEARs).

The methodology used is in accordance with the Large-Scale Solar Energy Guideline (NSW Department of Planning and Environment, August 2022). The Land and Soil Capability classification was verified onsite as Class 3 and a Detailed Assessment (Level 3) was completed. The assessment content and form from the guidelines was adopted for this report, with the Land Use Conflict Risk Assessment provided separately. The impacts to agricultural land and regional agricultural production were assessed in accordance with the Large-Scale Solar Energy Guideline and are considered to be minimal due to the relatively small size and low annual production value of the site.

With regards to soils, an erosion assessment using the Revised Universal Soil Loss Equation was completed to predict the long-term, average, annual soil loss from rill and sheet erosion and provide an erosion risk rating, stabilisation requirements and the level of sediment control required for the site. The erosion risk rating was determined to be *very low* and 'general erosion control measures' in accordance with *Managing Urban Stormwater: Soils and construction – Volume 1* (Landcom, 2004) recommended. Impacts on soils during construction, operation and decommissioning were identified, assessed and measures to mitigate the impacts have been recommended.

The site is considered suitable for development in regards to it's classification in the local planning instrument, current land use, proximity to the existing electricity substation and limited effects on agriculture.

2. INTRODUCTION

1.1 Overview

2.1.1 PROJECT DESCRIPTION

BESS Pacific c/o Gransolar Development Australia (Pacific) propose to develop a 100MW/200MWh Battery Energy Storage System (BESS) on land adjacent to the Transgrid Finley substation. The development site is known as Lot 3, DP740920 and is within the Berrigan Shire Council Local Government Area (LGA). The proposed development is known as Finley BESS and is a State Significant Development (SSD-72430958). Although the project works necessarily include a connection to the electrical substation nearby, only Lot 3, DP740920 has been considered for the purposes of this assessment as it is the one containing a lease area for the BESS installation and is the only part which will therefore be alienated from agricultural purposes. **Figure 2** shows the proposed development and the area assessed by this report.

2.1.2 PLANNING PATHWAY

The proposal is classified as State Significant Development (SSD) under the *State Environmental Planning Policy (Planning Systems) 2021* and the applicable consent authority for the proposal is the NSW Minister for Planning or the Minister's delegate. Therefore, the requirements of the assessment are based primarily on the Secretary's Environmental Assessment Requirements (SEARs) and generally in accordance with the *Large-Scale Solar Energy Guideline* (NSW Department of Planning and Environment, August 2022) as described in the following sections.

2.1.2.1 Secretary's Environmental Assessment Requirements (SEARs)

The Secretary's Environmental Assessment Requirements (SEARs) were issued on 18th July 2024 and contain requirements to assess the impact of the project to agriculture, land and soils of the site and wider regional. This Agricultural Impact Assessment (AIA) has been developed to address these requirements.

The Secretary's Environmental Assessment Requirements (SEARs) and attached SEARS advice, issued 18th July 2024, identify the following requirements for the Environmental Impact Statement (EIS) in relation to agricultural land and soil:

Table 1 – SEARS requirements

SEARS requirement	Section addressed
Detailed justification of the suitability of the site and that the site can accommodate the proposed development having regard to its potential environmental impacts, land contamination, permissibility, strategic context and existing site constraints.	A LUCRA has been completed as an appendix to the EIS which addresses these issues.

SEARS requirement	Section addressed
An assessment of the potential impacts of the development on existing land uses on the site and adjacent land, including:	-
> agricultural land, flood prone land, Crown lands, mining, quarries, mineral or petroleum rights; and	> Agricultural is assessed in **Section 7.1** > A LUCRA has been completed as an appendix to the EIS which addresses the remaining issues.
> a soil survey to determine the soil characteristics and consider the potential for salinity, acid sulfate soils and erosion to occur;	> A Site verification: soil survey is included in **Section 4** > Acid sulfate soils are considered in **Section 2.3.6** > An erosion assessment is included in **Section 6.** > A Salinity assessment is included in **Section 2.3.8.**
> a cumulative impact assessment of nearby developments,	A LUCRA has been completed as an appendix to the EIS which partially addresses these issues. A cumulative impact assessment is provided in the body of the EIS.
An assessment of the compatibility of the development, including any proposed accommodation camps with existing land uses, during construction, operation and after decommissioning, including:	-
> consideration of the zoning provisions applying to the land, including subdivision in consultation with Council (if proposed);	> Land zoning is discussed in **Section 2.3.13**. > Further consideration of land zoning provisions is given in the LUCRA and Section 4 of the EIS.
> completion of a Land Use Conflict Risk Assessment in accordance with the Department of Industry's *Land Use Conflict Risk Assessment Guide*;	A LUCRA has been completed as an appendix to the EIS which addresses these issues.
> assessment of impact on agriculture resources and agricultural production on the site and region."	Effects on agriculture are discussed in **Section 7.1**

2.1.2.2 *Large-Scale Solar Energy Guideline*

Although there are currently no guidelines relating specifically to soil survey for the development of Battery Energy Storage Systems (BESS), this Agricultural Impact Assessment (AIA) has been prepared generally in accordance with the *Large-Scale Solar Energy Guideline* (NSW Department of Planning and Environment, August 2022).

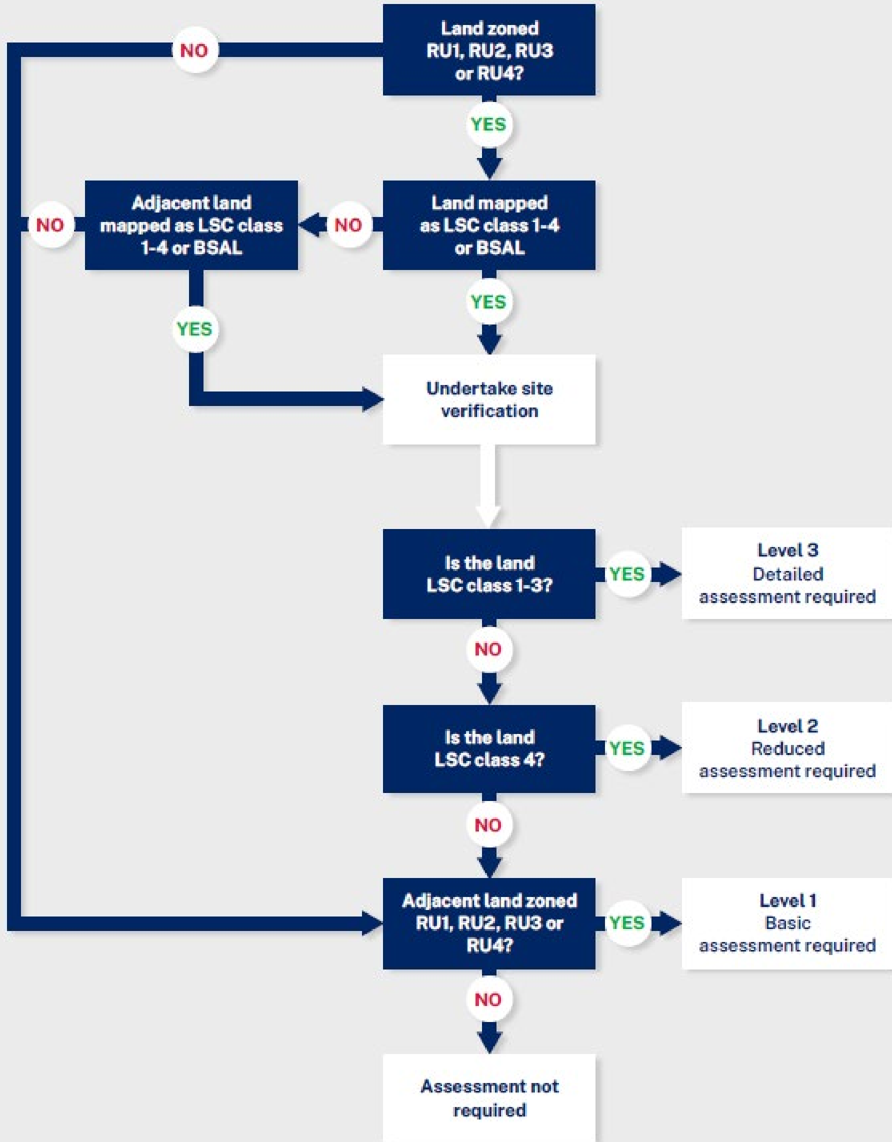
The *Large-Scale Solar Energy Guideline* involves steps to determine the level of assessment required to determine the impact of the proposal on agricultural land in Appendix A of the guidelines. The land on which the site is located is zoned as RU1 and is mapped by eSpade (2020) as Land and Soil Capability (LSC) Class 3. Therefore, a site verification and assessment of the LSC Class (OEH, 2012) was performed.

The results of the site verification and LSC verification confirmed that the site is Class 3- High capability according to the *Land and Soil Capability Assessment Scheme* (OEH, 2012). Further detail of the site verification and LSC verification is included in **Section 4** and **Section 5** respectively.

Due to the verified LSC Class of the land, a Level 3-detailed agricultural impact assessment was performed according to the requirements of Section 3.3 and Table 6, Appendix A of the *Large-Scale Solar Energy Guideline.* This included a project description, regional context, site characteristics and land use description, detailed assessment of impacts on local and regional agricultural industry and mitigation strategies. These requirements are met throughout this AIA report and scope. Justification for the project and analysis of site design to reduce impacts are included in the EIS for the project.

Appendix A – Agricultural Impact Assessment Requirements

Figure 4: Determining the level of assessment required for large-scale solar energy projects



2.2 Scope

This agricultural impact assessment supports the EIS for the proposal by being a means to identify, assess and mitigate any potential impacts to agriculture and soils that may occur during the development. The key objectives of this report are to:

- Describe the nature, location, intensity and duration of the project;
- Describe the regional and agricultural context of the development site;
- Identify the site characteristics and land use description and describe the current agricultural status;
- Assess potential impacts of the development on agricultural land and the wider region related to soil, erosion, and agricultural production;
- Address the SEARs in relation to agricultural land and soil; and
- Highlight or recommend strategies to help mitigate potential for impacts to land and soil occurring during the construction, operation and decommissioning of the project.

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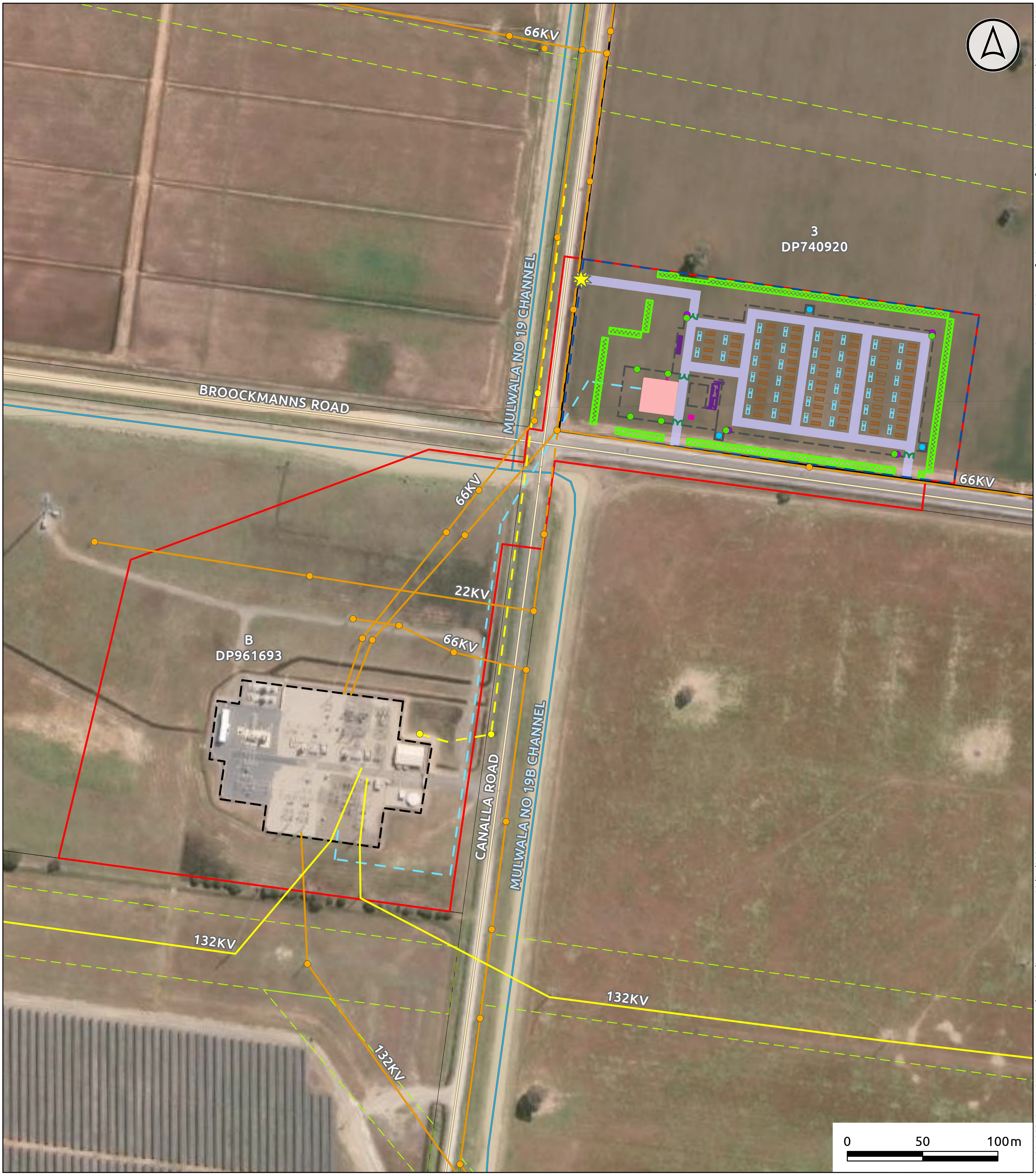
Legend

- Development Site
- BESS Lease Area
- Substation
- Indicative BESS Security Fence
- Lot
- Road
- Water Body
- Watercourse
- Essential Energy OH
- Essential Energy UG
- Transgrid Optic Fibre
- Easement

Premise

Finley BESS

Figure 1: Local Context



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Legend

- Development Site
- BESS Lease Area
- Substation
- Primary Site Access (Heavy Vehicle)
- Subject Site
- Substation Site
- Lot
- Road
- Watercourse
- Easement
- Essential Energy Pole
- Transgrid Pit
- Essential Energy OH
- Essential Energy UG
- Transgrid OH
- Transgrid Optic Fibre

Proposed Layout

- Substation Switch Area
- Internal Road
- BESS Battery
- BESS Inverter Line
- BESS Buildings
- Fence
- Gate
- BESS Substation
- Proposed BESS underground line
- Vegetation
- Watertank
- CCTV Mast
- BESS Lighting Mast

Premise

Finley BESS

Figure 2
Development Site and Concept Layout

2.3 Existing environment

2.3.1 LOCATION

The proposed Finley BESS will be located on land immediately adjacent to the Transgrid Finley substation. This is Lot 3 DP740920 (**Figure 2**) and is a parcel currently used for cropping, without further improvements being built on the overall land parcel. As the project is for electrical storage and discharge from a battery system, there of course needs to be a connection to the substation nearby. The substation connection is not alienating land from agriculture or use and is not further considered in the following report.

The Lot 3 DP740920 has an area of approximately 49 hectares, of which the BESS Lease Area would occupy an area of approximately 3 hectares, with a leasehold tenure. Only the BESS Lease Area of the lot would be removed from agricultural use and therefore only this section has been assessed by following report. The site is within the Berrigan Shire and is approximately 5km west of Finley township (**Figure 1**).

2.3.2 LANDFORM

The development site is a rectangularly-dimensioned paddock within a modified cropping agricultural landscape. It has a high point of approximately 110 m Average Height Datum (AHD) and a low point of 109 m AHD, making for a generally flat topography typical of the cropping lands in the wider area. The average slope value across the site is 0.6% and **Figure 3** shows the slope and landform of the site.

2.3.3 VEGETATION

At the time of inspecting the site, it was predominantly covered by a wheat crop (site visit on 20th September 2024). The site appears to have been used for cropping for some time, with the only overstory being scattered examples of trees in isolated placement on the land. Volunteer oats and canola were observed around the perimeter of the cropped area.

2.3.4 HYDROLOGY

The site sits within the Murray Irrigation Area of New South Wales. Water for irrigated agriculture is diverted from the Murray River to a network of artificially constructed irrigation channels throughout the region. Artificially constructed waterways with proximity to the site include the Malwala Canal, the Mulwala No 19 Channel, and the Ulupna Channel.

The Malwala Canal is approximately 1 km north of the development site. The Mulwala No 19 Channel borders the western and northern side of the site approximately 30 m to the west of the development site and 800 m north of the site. The Ulupna channel is located approximately 700 m west of the development site. Remaining watercourses in the locality are limited to irrigation infrastructure and dams associated with existing agricultural land uses (**Figure 2**).

2.3.5 GEOLOGY

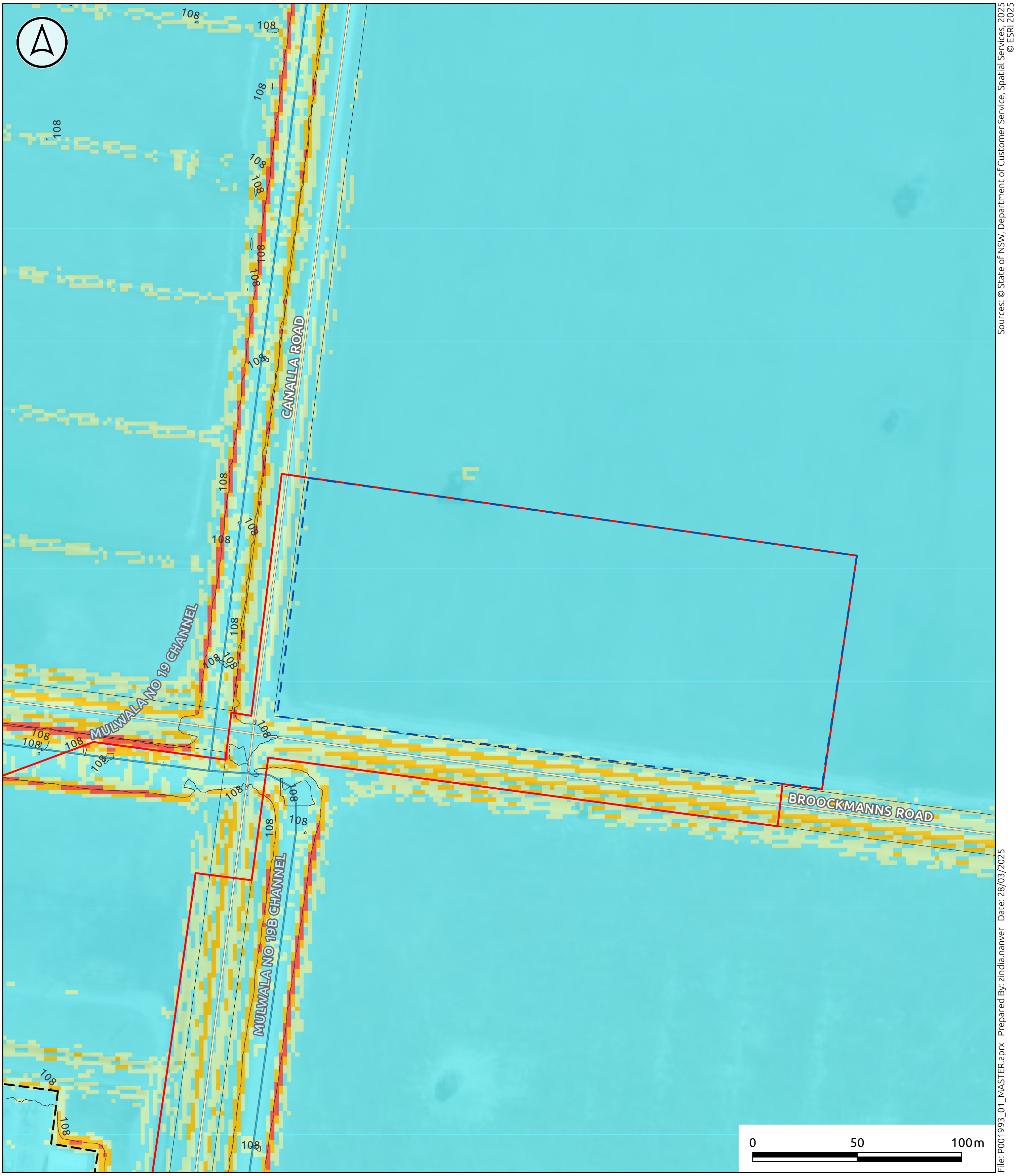
Underlying geology influences agricultural productivity as parent rock contributes to soil fertility, minerology, and hydrogeological activity. The entirety of the site is within the Shepparton (Czsws) Formation (Figure 4) which are described by eSpade mapping as:

"Unconsolidated to poorly consolidated mottled variegated clay, silty clay with lenses of polymictic, coarse to fine sand and gravel; partly modified by pedogenesis, includes intercalated red-brown paleosols."

2.3.6 ACID SULFATE SOILS

Acid sulfate soils are soils which are natural high in iron sulphides and are at risk of producing sulfuric acid (H_2SO_4) if disturbed by drainage, excavation or construction. Acid sulfate soils commonly occur in coastal areas under waterlogged conditions. Exposure of these soils to oxygen through digging or draining can cause acidification and have adverse environmental impacts.

Acid sulfate soils are not mapped within the development site or locality (SEED portal, 2020). The likelihood of acid sulfate soils occurring within the study area is considered very low due to its position away from the coast.



Legend

- Development Site
- BESS Lease Area
- Substation
- Lot
- Road
- Watercourse

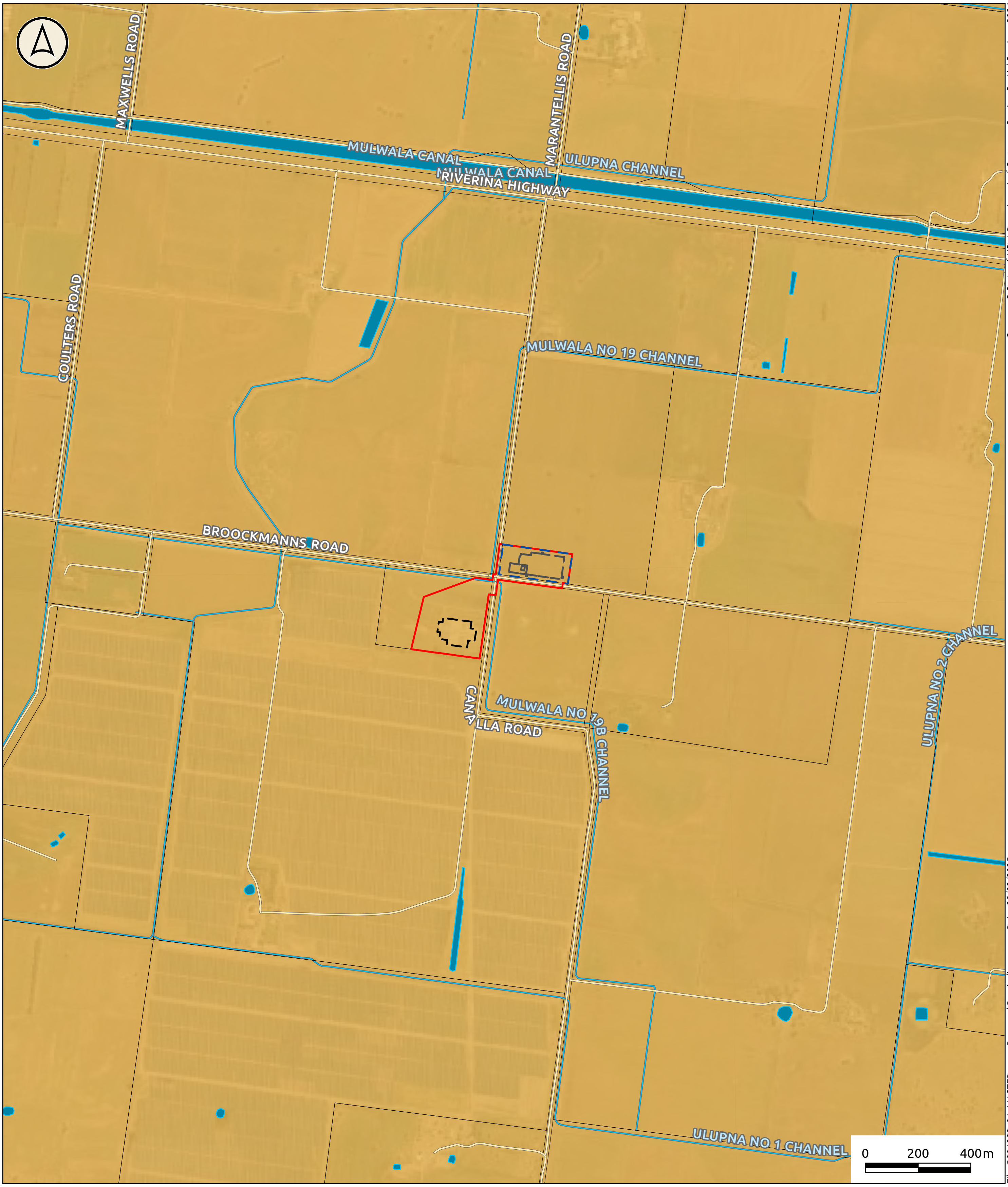
Slope (%)

- <=4
- 4-10
- 10-18
- >18
- Natural Contour (2m Interval)

Premise

Finley BESS

Figure 3: Slope



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Legend

- Development Site
- BESS Lease Area
- Substation
- Indicative BESS Security Fence
- Lot
- Road
- Watercourse
- Water Body

Geological Unit

- Shepparton Formation

Premise

Finley BESS

Figure 4: Geology

2.3.7 SOILS

Soil information was assessed with a combination of desktop research and a site inspection. Information was assessed online from:

- Australian Soil Classification system soil type mapping of NSW (DPE, 2024);
- Land and Soil Capability Assessment Scheme (OEH 2012);
- Estimated Inherent Soil Fertility of NSW mapping (DPIE, 2021);
- The Central Resource for Sharing and Enabling Environmental Data in NSW (SEED Mapping, 2020);
- NSW Soil and Land Information (eSpade Mapping, 2020);
- NSW Planning Portal Spatial Viewer (NSW ePlanning Spatial Viewer, 2024); and
- The Soil Landscapes of Central and Eastern NSW mapping (DPIE 2020) did not contain information on the study area and was excluded from the desktop assessment.

Site inspection and soil sampling was conducted on 20th September 2024. Further information on the methodology and results of the soil survey are included in **Section 4.**

Soil type according to the Australian Soil Classification System (ASC) (Isbell, 2002) is included in **Section 4.2.3** and verification of the Land and Soil Capability Class (LSC Class) under the *Land and Soil Capability Assessment Scheme* (OEH, 2012) is included in **Section 5.**

2.3.7.1 Inherent Soil Fertility

The Estimated Inherent Soil Fertility of NSW mapping (Seed portal, 2020) provides an approximation of the inherent soil fertility of soils in NSW. The soils of the study area are mapped with an inherent soil fertility of 'Moderate (3)'.

2.3.8 SALINITY

Soil salinity is the accumulation of soluble minerals and salts which can adversely impact the growth of crops and trees. Soil salinity is measured by passing an electrical current between two electrons of a salinity meter in a sample of soil. Salts increase the electrical conductivity of a solution, so high Electrical Conductivity (EC) values indicate a high salinity level.

The soils on site had EC values which were rated as slightly saline and sodic subsoils by the system designed by Hazelton, P. and Murphy, B. (2016).

2.3.9 HAZARDS

A review of the NSW ePlanning Spatial Viewer (2024) and the SEED portal (2020) mapping did not identify any known geological hazards within the development site or locality, including:

- Acid sulfate soils are not mapped within the development site or locality (SEED portal, 2020).
- No mine subsidence districts, or underground coal mining is mapped at or within 1 km of the development site (NSW ePlanning Spatial Viewer, 2024).
- No landslide risk land is mapped within the development site or locality (NSW ePlanning Spatial Viewer, 2024).

- No Naturally Occurring Asbestos (NOA) at or within one (1) kilometre of the development site (SEED Portal, 2020).

2.3.10 BIOPHYSICAL STRATEGIC AGRICULTURAL LAND (BSAL)

Biophysical Strategic Agricultural Land (BSAL) is land with high quality soil and water resources capable of sustaining high levels of productivity.

A review of relevant mapping indicates that no BSAL is located within the development site.

2.3.11 DRAFT STATE SIGNIFICANT AGRICULTURAL LAND

The Draft State Significant Agricultural Land Map was developed by NSW Department of Primary Industries to represent the most capable, fertile and productive agricultural lands. Draft maps are comprised of an audit of mapping datasets relevant to a sites agricultural capacity, including rainfall, inherent soil fertility, land and soil capability, soil pH, BSAL, land zoning, irrigation and North Coast farmland mapping. The draft map was published in 2021 and a figure cannot be included as the map is in early draft stage.

A review of the Draft State Significant Agricultural Land Map indicated that the development site is identified as within the mapped as State Significant Agricultural Land. There are currently no guides applying to such areas.

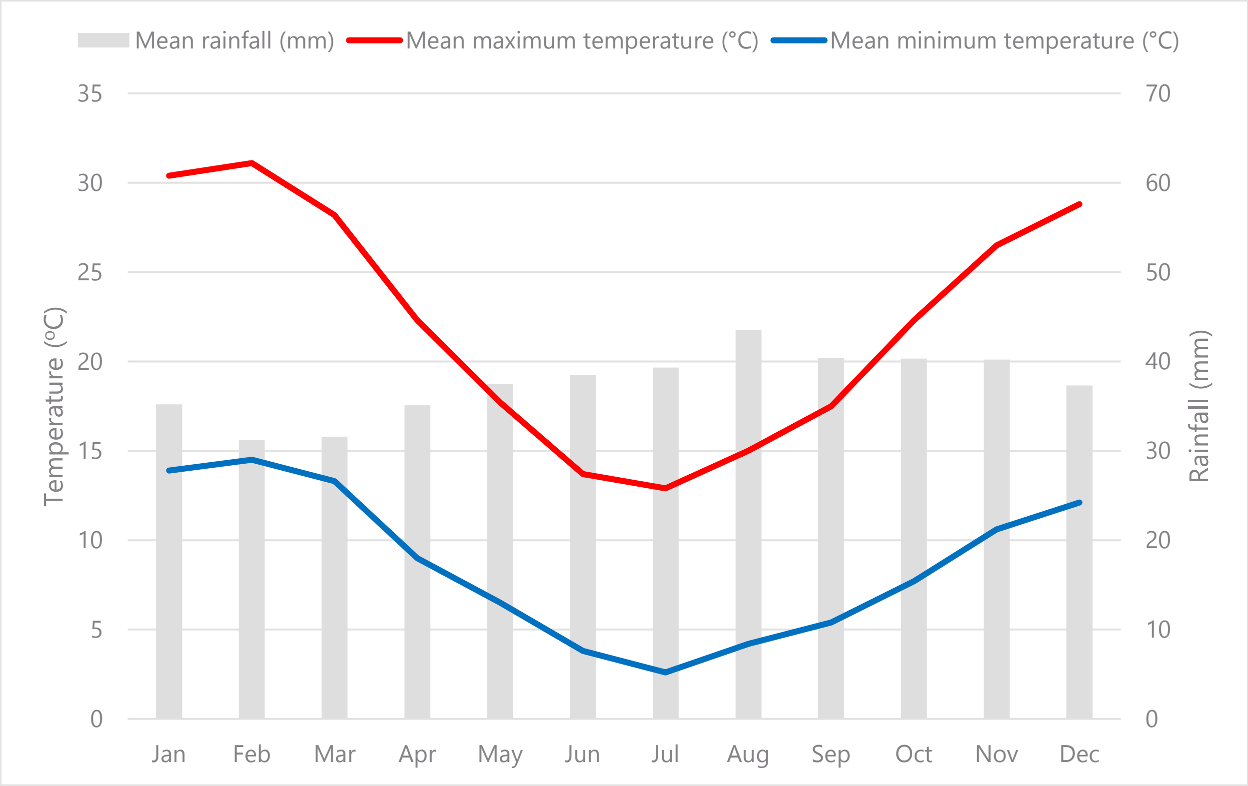
2.3.12 CLIMATE

The closest Australian Bureau of Meteorology (BoM) weather station with daily weather observations is Numurkah VIC (Station 080101), located approximately 50 km south of the site.

Summary climate statistics are provided below and depicted in **Figure 5**:

- The mean annual maximum temperature is 22.5°C and the mean annual minimum temperature is 8.6°C. Records indicate that February is the hottest month and July is the coldest (BoM, 2024).
- Mean annual rainfall is 449.6 mm and records indicate monthly mean rainfall received at the site is highest in the month of August (BoM, 2024).

Figure 5 – Climate Statistics for the Locality

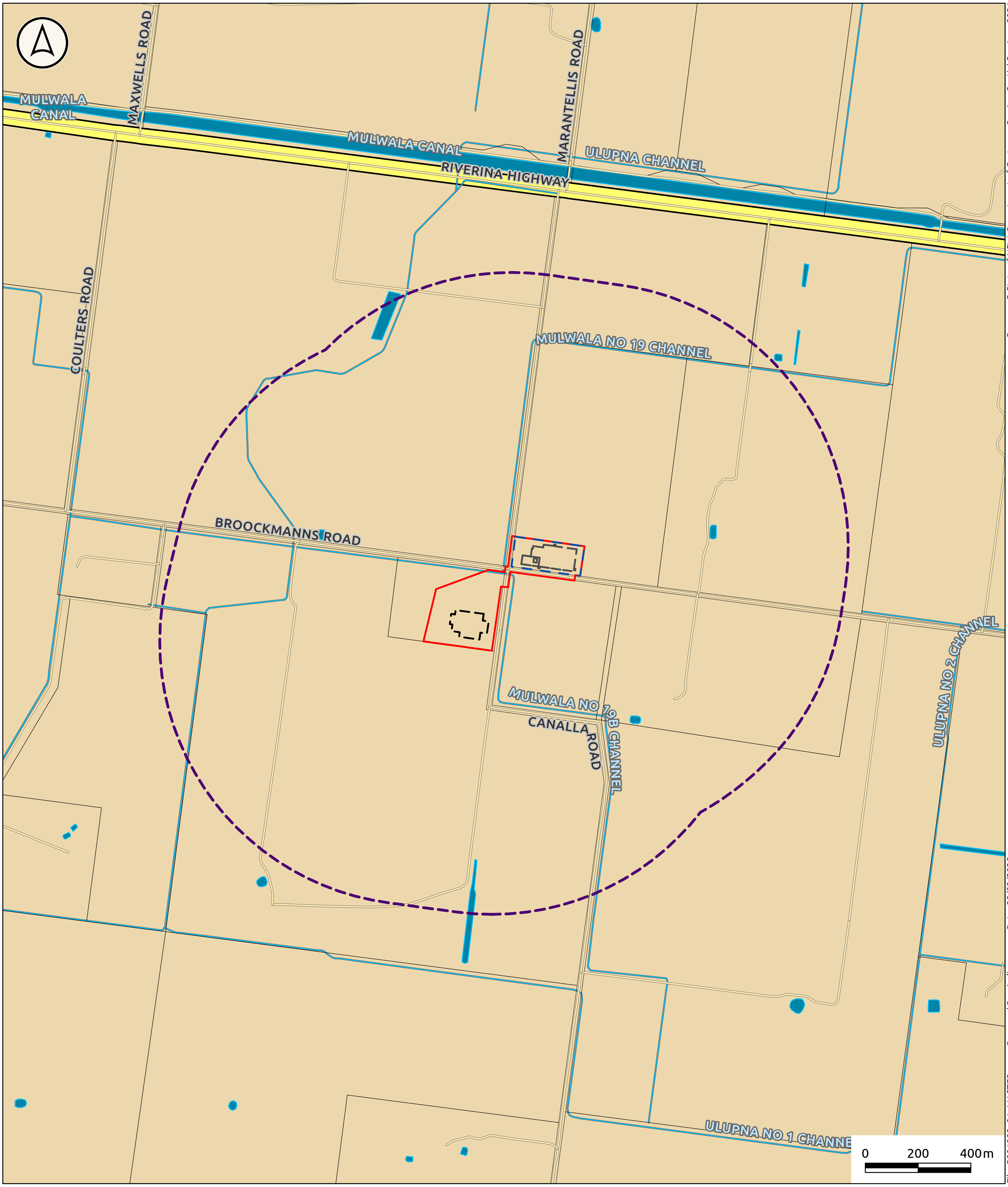


2.3.13 LAND ZONING

The entirety of the site is classified as RU1 – Primary Production via the Berrigan Local Environmental Plan (**Figure 6**).

Table 2 –Land use zones and objectives

Zone	Objectives
RU1	> To encourage sustainable primary industry production by maintaining and enhancing the natural resource base. > To encourage diversity in primary industry enterprises and systems appropriate for the area. > To minimise the fragmentation and alienation of resource lands. > To minimise conflict between land uses within this zone and land uses within adjoining zones. > To permit development that enhances the agricultural and horticultural production potential of land in the locality. > To permit low-key tourist and visitor accommodation that is compatible with the scenic amenity, and promotes the character, of the area. > To enable function centres to be developed in conjunction with agricultural uses.



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Legend

- Locality (1km Buffer)
- Development Site
- BESS Lease Area
- Substation
- Indicative BESS Security Fence
- Road
- Lot
- Water Body
- Watercourse

Land Zoning

- RU1 - Primary Production
- SP2 - Infrastructure

Premise

GRANSOLAR DEVELOPMENT

Finley BESS

Figure 6: Land Zoning

3. LAND USE AND AGRICULTURAL HISTORY

3.1 Land use

The NSW Landuse 2017 maps (DPIE, 2020) shows the site use as irrigated cropping (**Figure 7**). Discussions with the site provider on 26 November 2024 added further detail to this, that the land has intermittently been used for dryland cropping during favourable weather conditions for at least the last seven years.

The surrounding area primarily consists of land used for irrigated cropping and grazing, and the substation on the adjacent land. Land uses within the site and locality (1 km radius of the site) are outlined in **Table 3** and **Figure 7.**

Review of land uses within the locality indicate that land is predominately used for the purposes of irrigated cropping.

Table 3 – Land uses within the locality

Land use	Area (ha)	%
4.3.0 Irrigated cropping	372.05	94.78
5.7.0 Transport and communication	7.94	2.02
5.4.0 Residential and farm infrastructure	5.87	1.49
2.1.0 Grazing native vegetation	6.67	1.70
TOTAL	**393.07**	**100%**

Sources: © State of NSW, Department of Customer Service, Spatial Services, 2025
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Legend

- Locality (1km Buffer)
- Development Site
- BESS Lease Area
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- Lot
- Road
- Water Body
- Watercourse

Land Use 2017

- 2.1.0 Grazing native vegetation
- 3.2.0 Grazing modified pastures
- 3.3.0 Cropping
- 4.3.0 Irrigated cropping
- 5.2.0 Intensive animal production
- 5.4.0 Residential and farm infrastructure
- 5.7.0 Transport and communication
- 6.4.0 Channel/aqueduct

Premise

Finley BESS

Figure 7: Land Use

3.2 Regional agricultural production

Based on the 2020-21 Australian Agricultural Census (ABARES, 2021), the most important agricultural commodities with the highest gross value for the Berrigan Shire were wheat ($36 million), canola ($19 million), dairy cattle ($14 million), barley ($10 million) and sheep and lambs ($10 million). These five commodities represent approximately 63% of the total agricultural revenue of the Berrigan LGA ($140 million).

The primary income generation on the study area is dryland cropping including wheat, oaten hay and canola. The indicative value of the five main commodities for the Berrigan Shire is calculated in **Table 4**.

Table 4 – 2020-21 Commodity Production Value for the Berrigan Shire (ABARES, 2021)

Commodity	Production Value ($m)	Units produced	Average value per unit
Wheat	$36 million	121,368 tonnes	$296.61
Canola	$19 million	33,640 tonnes	$564.80
Dairy cattle	$14 million	6,196 animals	$2,259.52
Barley	$10 million	45,868 tonnes	$218.01
Sheep and lambs	$10 million	117,915 animals	$84.80

3.3 Agricultural history

The following sections provide an overview of the agricultural history of the study area. This information was obtained via discussions with the property manager as part of this assessment.

3.3.1 PROPERTY HISTORY

A review of historical aerial imagery available on the Historical Imagery Viewer (NSW Govt, 2024) identified that the land which Finley BESS is proposed to be constructed on has been used for cropping since at least 1968 **(Figure 8).** The residential dwelling and associated infrastructure located to the east of the BESS Site has been present since at least 1968 while the Transgrid Finley Substation appears to have been constructed between 1976 and 1991 (**Figure 9)**

The paddock on which the study area is located was purchased by the property manager approximately seven years ago. The use of cropping has continued since purchase. Finley experienced a boom in the rice industry in the 1970's and it is reasonably speculated that the paddock was used for irrigated rice growing during this time, given the very level surface. The paddock has been levelled flat in the past and contains evidence of previous irrigation including channels on each boundary.

Figure 8 – Historic Aerial Imagery 1968

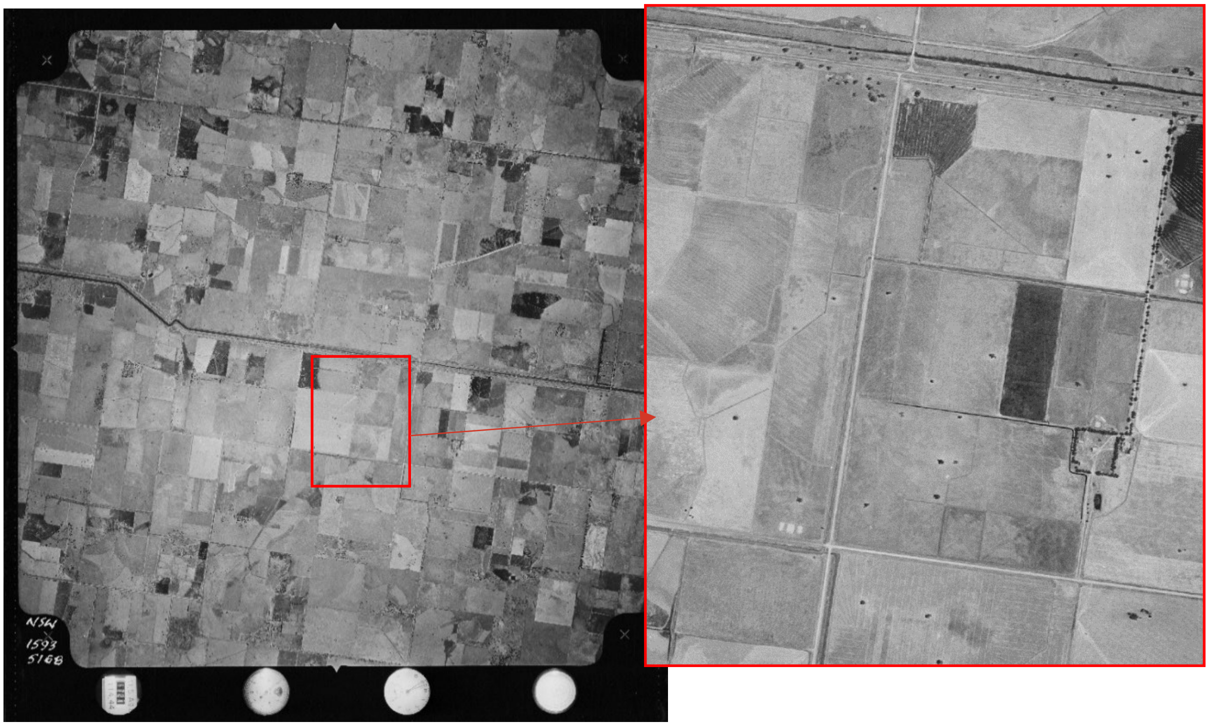
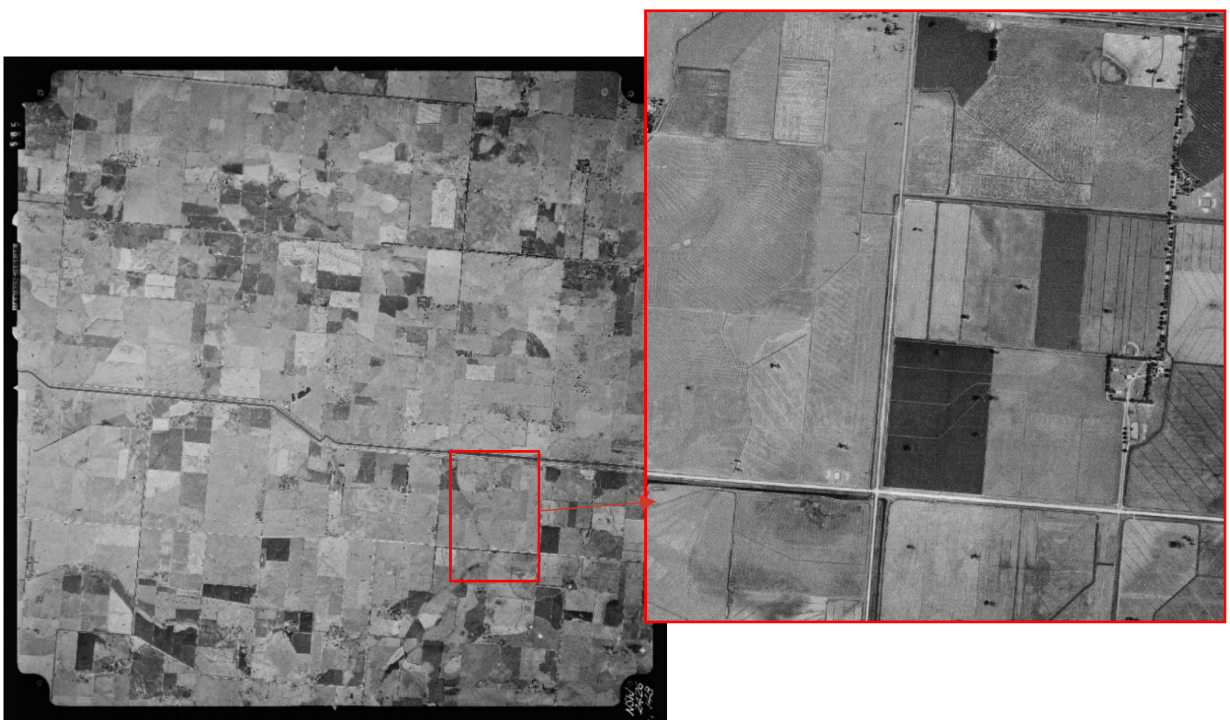


Figure 9 – Historic Aerial Imagery 1976



3.3.2 CURRENT LAND MANAGEMENT PRACTICES

Current land management practices, both identified in site inspection and in conversation with the site provider, are identified as primarily dryland cropping during the winter season only. Wheat, oats, canola, and oaten hay have been successfully grown on the site in previous winter seasons. The site is allowed to fallow over the summer season with light cultivation and retained stubble from the previous winter crop.

Sheep are occasionally agisted on the site at a rate of approximately 4 dry sheep equivalent per hectare (DSE/ha). Sheep are allowed to graze on the site for no more than one month following crop harvest to remove crop residue and stubble.

3.3.3 CROP AND SOIL AMENDMENTS

The site was dominated by plantings of winter wheat at the time of the site visit (20 September 2024). Previous crop rotations were evident with volunteer populations of oats and canola observed around the perimeter of the site. Discussions with the property manager indicated that this season's wheat crop will be harvested for hay.

The current property manager regularly applies the following soil amendments and fertilisers to the site:

- Lime: agricultural lime (calcium carbonate) is applied to the site to neutralise surface soil acidity and raise the soil pH at 2.5 tonnes per hectare (t/ha). The most recent application was in 2022.
- DAP and MAP: Diammonium phosphate (DAP) or Monoammonium phosphate (MAP) is applied at 100 kilograms per hectare (kg/ha) when crops are sown to supply the crop with nitrogen and phosphorus.
- Urea: Granular urea (CO(NH2)2) fertiliser is occasionally applied at 100 kg/ha during the crop growth period to supply the crop with nitrogen.
- Ammonia: sulfate of ammonia fertiliser is occasionally applied at 200 kg/ha during the crop growth period to supply the crop with nitrogen. Sulfate of ammonia was applied this season.

The advised recent use of fertilisers and soil amendments was reflected in the soil results which showed a fairly neutral soil pH, very high available phosphate levels and very high available nitrogen levels (**Section 4.1.2**).

3.3.4 IRRIGATION AND WATER ENTITLEMENTS

The site provider advised that property on which the study area is located has a 5 megalitre (ML) water right for stock and domestic use. Dryland crops are grown on the site in the winter season with no irrigation. There are disused irrigation channels around the perimeter of the paddock which are likely remnant infrastructure from likely use to grow rice in the 1970's. There is currently no advised intent to convert the site to irrigated farming.

3.3.5 PRODUCTIVITY

3.3.5.1 Cropping

Consideration of income generated by cropping for the study area has been calculated off the estimated average tonnage of crops produced per year. **ONE** of the following crops are planted for the winter growing season and harvested for profit each year. The average annual income from crops has been calculated using the average annual profit from these crops to represent one year with one crop type.

3.3.5.1.1 Hay

- The site provider estimated that 6 t/ha of wheaten hay can be produced from the site in a "normal season".
- Assuming the median tonnage is produced across the entire 3 hectares of the development site, 18 tonnes of wheaten hay may be produced from the study area.
- While the 2020-21 Australian Agricultural Census (ABARES, 2021) does not provide a commodity price for wheaten hay, the average 2023 market price is considered to be $288 / tonne of wheaten hay (Feed Central, NSW).
- The calculated average annual income for wheaten hay on the study area is **$5,184.00**.

3.3.5.1.2 Wheat (grain)

- The property manager estimated that 3 t/ha of wheat can be produced from the site in a "normal season".
- Assuming the median tonnage is produced across the entire 3 hectares of the development site, 9 tonnes of wheat may be produced from the study area.
- It can be extrapolated from the 2020-21 Australian Agricultural Census (ABARES, 2021) that the average value of one tonne of wheat in the Berrigan LGA is $296.61 **(Table 4).**
- The calculated average annual income for wheat on the study area is **$2,669.49**

3.3.5.1.3 Canola

- The site provider estimated that 2 t/ha of canola can be produced from the site in a "normal season".
- Assuming the median tonnage is produced across the entire 3 hectares of the development site, 6 tonnes of canola may be produced from the study area.
- It can be extrapolated from the 2020-21 Australian Agricultural Census (ABARES, 2021) that the average value of one tonne of canola in the Berrigan LGA is $564.80 **(Table 4).**
- The calculated average annual income for wheat on the study area is **$3,388.80.**

3.3.5.2 Livestock

Consideration of income generated from the study area has considered an area of 3 ha, inclusive of the entire area of the proposed BESS development. Sheep are occasionally agisted on the site at a rate of approximately 4 dry sheep equivalent per hectare (DSE/ha). Sheep are allowed to graze on the site for no more than one month following crop harvest to remove crop residue and stubble.

- The carrying capacity of sheep within the study area is estimated to be 4 Dry Sheep Equivalent (DSE) per hectare. The study area covers 3 hectares and would therefore represent 12 Dry Sheep Equivalent (DSE). However, as sheep are only grazed on the site for one month per year following crop harvest, the total DSE has been divided by 12 and the resulting output of the site is 1 DSE annually.
- It can be extrapolated from the 2020-21 Australian Agricultural Census (ABARES, 2021) that the average value of sheep and lambs in the Berrigan LGA is $84.80 per head (**Table 4**).
- Assuming that there is 1 Dry Sheep Equivalent (DSE) produced annually on the study area, the estimated annual agricultural production of sheep and lambs for the study area is **$84.80.**

3.3.5.3 Total estimated income

The average annual farm income of the study area has been estimated based on the site provider estimation of average outputs per crop and the average values of 2020-21 Australian Agricultural Census (ABARES, 2021) for the Berrigan LGA. The final estimation of the annual farm income is **$3,832.23,** as calculated in **Table 5**. It should be noted that average annual farm income does not represent farm profits as it does not include capital costs (machinery, land, structures) or fixed or variable costs (insurance, rates, taxes, labour, fertiliser, farm chemicals). It also does not account for other variable factors that influence farm productivity year on year (weather, climate, commodity prices, pests and disease).

Table 5 – Average estimated annual farm income (study area)

Commodity	Type	Av. annual production units	Av. Value Per Unit	Production value	Av. Annual Production value
Crops (One crop type per year only)	Hay	18 tonnes	$288.00	$5,184.00	$3,747.43
	Wheat	9 tonnes	$296.61	$2,669.49	
	Canola	6 tonnes	$564.80	$3,388.8	
Livestock	Sheep	1 sheep	$84.80	$84.80	$84.80
Total					**$3,832.23**

4. SITE VERIFICATION: SOIL SURVEY

4.1 Methodology

Although there are currently no guidelines relating specifically to soil survey for the development of BESS, this AIA has been prepared generally following guidelines contained in:

- *Large-Scale Solar Energy Guideline* (NSW Department of Planning and Environment, August 2022)
- *The Australian Soil Classification: Third Edition* (Isbell, R. F. 2002)
- *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain, 2009)
- *Interpreting soil test results: What do all the numbers mean?* (Hazelton and Murphy, 2016)

The *Large-Scale Solar Energy Guideline* (NSW Department of Planning and Environment, August 2022) (Appendix A) states that "soil surveys should be completed at an inspection density of 1 site per 5 ha to 25 ha". Based on the total BESS Lease Area (3 ha), four (4) detailed soil investigation sites were analysed in field, of which one (1) representative core was sent for laboratory analysis.

Sample locations were determined prior to and during the field soil survey using available soil mapping, landform features, vegetation changes and any other biophysical markers in the landscape. Visual assessment was undertaken during the field survey to confirm major soil types, boundaries and the suitability of each soil sample location. All sample locations and site observations were recorded by GPS and field mapping.

A drill rig sampler was used to extract soil samples to 1.2 m or until equipment refusal. Soil samples were photographed in soil display units and split into four (4) depths to analyse physical and chemical traits. The number of intervals and depth ranges varied to reflect identified soil horizons during sampling.

4.1.1 FIELDWORK

The soil survey was conducted on 20 September 2024 by Grace Scott (Environmental Scientist) and Brandon Searl (Environmental Technician). Conditions were dry and sunny.

The soil survey entailed the full extent of the proposed 3-hectare area lease tenure area, considered to therefore be the area of disturbance. A free-survey technique was employed, with soil profile and observation sites located to best represent all soil types present within the survey area.

Samples were collected with a trailer-mounted hydraulic soil corer to a maximum depth of 1 metre. The location of all observation and sample sites were recorded via GPS. Photographs were taken at all sample sites and for all soil cores.

A total of four cores were analysed for physical properties on site, and one representative core which best reflected the conditions across the site was selected and sent for laboratory analysis.

An overview of the soil survey details is provided in . The location of all soil sample sites is provided in **Figure 10**. The sample sent for laboratory analysis was Sample 3.

Table 6 – Soil Survey Details

Parameter	Soil Survey Details
Total Study Area	3 hectares
Number of soil cores observed	4
Laboratory analysed sites	1
Detailed soil profile analysed	F3

4.1.2 LABORATORY ANALYSIS

Selected samples were analysed to provide sufficient information to classify soils in accordance with the Australian Soil Classification (ASC) (Isbell, 2002) and soil taxonomic class. Samples were analysed by a National Association of Testing Authorities Australia (NATA) accredited laboratory (SGS). Samples selected for analysis are identified in the following section.

4.2 Soil survey results

4.2.1 FIELD CHARACTERISTICS

Sites 1, 2, 3 and 4 had similar field characteristics across the flat paddock. Topsoil pH (tested in field with a Manutec soil pH test kit) ranged from pH 5-6 across all site (moderately acid), with alkalinity increasing through the subsoil down to pH 9 (strongly alkaline). Gypsum crystals were visible in the subsoil, likely contributing to the increasing alkalinity at depth. Soil texture across these sites was dominated by a silty loam topsoil, with clay abruptly increasing to light and medium clay subsoils past 15cm. Soil colour was brown topsoil with strong brown subsoils (10YR 4/3 topsoil and 7.5YR 4/6 subsoils) (Munsell Soil Colour Book, 2012). These soils are classified under the Australian Soil Classification (Isbell, 2002) as Brown Sodosols, due to the abrupt textural change and a B horizon which is sodic and not strongly acid.

4.2.2 SOIL CHEMISTRY RESULTS

The sample sent for laboratory analysis was Sample 3 as it was considered to best represent the dominant soil type across the site. Two National Association of Testing Authorities (NATA) accredited laboratories, SGS Australia and Nutrient Advantage, were used to analyse this sample.

The sample was split into four (4) depths of 0-15 cm, 15-40 cm, 40-80 cm and 80-100 cm based on soil horizon observations. Each layer was sent for basic analysis and the topsoil (0-15cm) was sent for additional laboratory analysis.

Table 7 and **Table 8** contain the analysis parameters and **Table 9** and **Table 10** contain the results.

Legend

- Development Site
- BESS Lease Area
- Substation
- Indicative BESS Security Fence
- Lot
- Road
- Watercourse
- Samples

Before you Dig

- EE 22kV OH
- EE 22kV UG
- EE 66kV OH
- Telstra Cable
- Telstra Optic Fibre
- Transgrid Optic Fibre
- EE Pole
- Telstra Elevated Joint
- Telstra Marker
- Telstra Pit
- Transgrid Pit

Premise

Finley BESS

Figure 10: Soil Sample Sites

Table 7 – Analyses at ALL depths

Tests	Units
pH (CaCl2)	pH Units
EC	dS/m
Moisture	%
ECEC/CEC	Cmol(+)/kg
Calcium	Cmol(+)/kg
Magnesium	Cmol(+)/kg
Potassium	Cmol(+)/kg
Sodium	Cmol(+)/kg
Aluminium (if pH <6.0)	Cmol(+)/kg

Table 8 – Analyses for TOPSOIL only

Tests	Units
PSA	Percentage of gravel, sand, silt, and clay
Emerson Test	Category
Nitrate	mg/kg
Phosphorus	mg/kg
Organic Carbon	%
Sulphur	mg/kg
Boron	mg/kg
Iron	mg/kg
Manganese	mg/kg
Copper	mg/kg
Zinc	mg/kg

Table 9 –ALL Depths Soil Chemistry Data

Sample F3		0-15cm		15-45cm		45-80cm		80-100cm	
Parameter	**Unit**	**Result**	**Rating[1]**	**Result**	**Rating**	**Result**	**Rating**	**Result**	**Rating**
pH	**1:5 H_2O**	6.4	Slightly acid	7.3	Neutral	8.8	Strongly alkaline	9.1	Very strongly alkaline
Electrical Conductivity	**µS/cm**	67	-	53	-	360	-	400	-
	dS/m	0.067	-	0.053	-	0.36	-	0.4	-
	Texture	Silty loam	-	Light clay	-	Medium Clay	-	Medium Clay	-
	Multi-factor	8.6	-	8.6	-	7.5	-	7.5	-
	ECe	0.5762	Non-saline	0.4558	Non-saline	2.7	Slightly saline	3	Slightly saline
Cation Exchange Capacity (CEC)	**meq/100g**	13	Moderate	21	Moderate	45	Very high	44	Very high
Cations cmol(+)/kg	**Ca^{2+}**	7.2	Moderate	9.1	Moderate	25	Very high	23	Very high
	K^+	1	High	1.3	High	1.8	High	1.6	High
	Mg^{2+}	4.4	High	9.5	Very high	15	Very high	15	Very high
	Na^+	0.4	Moderate	1.1	High	3	Very high	4.1	Very high
	Al^{3+}	pH>6	-	pH>6	-	pH>6	-	pH>6	-
Exchangeable Sodium Percentage	**-**	3.1	Non-sodic	5.1	Marginally sodic	6.7	Sodic	9.4	Sodic

[1] Ratings based on Hazelton, P. and Murphy, B. (2016)

Sample F3		0-15cm		15-45cm		45-80cm		80-100cm	
Parameter	Unit	Result	Rating[1]	Result	Rating	Result	Rating	Result	Rating
Moisture Content	%	5	-	9.3	-	10.7	-	11.3	-

Table 10 – Topsoil Chemistry Data

Soil Layer				0-15cm		
Parameter	Unit	Size	Type	Result	Rating[2]	MASCC Rating[3]
Particle Size (%)	%w/w	<0.002mm	**Clay**	10	Silty loam	-
	%w/w	0.002-0.06mm	**Silt**	40		-
	%w/w	0.02–0.2 mm	**Fine Sand**	7.8		-
	%w/w	0.2–2 mm	**Coarse Sand**	42.2		-
	%w/w	>2 mm	**Gravel**	0		-
Emerson Class	-	-	-	3	Moderately dispersive	
Phosphorous (Colwell)	mg/kg	-	-	51	Very high	
Total Organic Carbon	%w/w	-	-	1.5	Moderate	
Organic Matter	%w/w	-	-	2.6	Moderate	
Nitrate/Nitrite Nitrogen	mg/kg			1.9	Very high	
Sulphur (KCl-40 extractable)	mg/kg	-	-	20	-	-

[2] Ratings based on Hazelton, P. and Murphy, B. (2016)
[3] Ratings based on Maximum Allowable Soil Contamination Concentrations for Agricultural Land (MASCC Limits)

Soil Layer				0-15cm		
Parameter	**Unit**	**Size**	**Type**	**Result**	**Rating[2]**	**MASCC Rating[3]**
Boron (CaCl extractable)	**mg/kg**	**-**	**-**	1.3	-	-
Copper	**mg/kg**	**-**	**-**	1.9	-	Not exceeded
Zinc	**mg/kg**	**-**	**-**	0.55	-	Not exceeded
Manganese	**mg/kg**	**-**	**-**	20	-	Not exceeded
Iron	**mg/kg**			180	-	Not exceeded

4.2.3 AUSTRALIAN SOIL CLASSIFICATION

Australian Soil Classification system soil type mapping of NSW (DPIE 2021) maps the soils across the BESS site as Chromosols. However, site investigation and subsequent laboratory analysis found that the subsoil B horizon was sodic, and therefore the soils must be classified as Brown Sodosols. Brown Sodosols are described in **Table 11.** Mapping of the soil types is included in **Figure 11.**

Table 11 – Soil Units Within Study Area

ASC Soil Type	ASC Description	Detailed Sites	Constraints	Total Area Mapped Within Project Area
Brown Sodosol	Soils with a strong texture contrast between the A and B horizons, where the B horizon is sodic.	1, 2, 3 and 4	> Sodic subsoil which contains a high proportion of sodium > Moderate to strongly alkaline subsoils	3.01 ha

Legend

- Development Site
- BESS Lease Area
- Indicative BESS Security Fence
- Lot
- Road
- Watercourse
- Samples

ASC Soil Type (verified on site)

- Brown Sodosols

Premise

Finley BESS

Figure 11: Verified Australian Soil Classification

File: P001993_01_MASTER.aprx Prepared By: zindia.nanver Date: 28/03/2025

5. LAND AND SOIL CLASSIFICATION VERIFICATION

5.1 Methodology

The *Land and Soil Capability Assessment Scheme* (OEH, 2012) ranks the capacity of land to sustain a range of land uses without causing degradation of the land and soil at the site and off-site environment. The LSC Scheme considers the biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics. The final LSC class of the land is based on the most limiting factor.

The LSC Classes are described in **Table 12** and the factors that influence LSC class calculations are listed in **Section 5.1.1** .

Table 12 – LSC Definitions

Class	General definition
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, conservation)	
1	**Extremely high capability land:** Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	**Very high capability land:** Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	**High capability land:** Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
4	**Moderate capability land:** Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
5	**Moderate–low capability land:** Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
6	**Low capability land:** Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.

Class	General definition
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
7	**Very low capability land**: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	**Extremely low capability land:** Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

5.1.1 DETERMINING LAND AND SOIL CAPABILITY CLASS

The physical capability of land is assessed against criteria from Table 3 of the *Land and Soil Capability Assessment Scheme* (OEH, 2012) (LSC Scheme). Consideration of each hazard has been provided in the following subsections.

5.1.1.1 Hazard 1: Water Erosion

Assessment of water erosion hazard is based on slope class and the NSW division of the site. The site lies within the Eastern NSW Division and the slope class (%) for the site is 0.6%. A slope analysis for the property is shown in **Figure 3.** The water erosion hazard class of a site in the Eastern NSW division with a slope class of 0.6% is Class 1.

5.1.1.2 Hazard 2: Wind Erosion

Wind erosion hazard is the likelihood for soil detachment and movement from wind blowing across the soil surface. Wind erosion hazard class is assessed on surface soil texture, site exposure to prevailing winds, wind erosive power, and average annual rainfall. The three criteria based on the soil type across the site include:

> The surface soil texture is silty loam with 10% clay. This is classed as a surface soil texture with a "Moderate" wind erodibility.

> The wind erosive power for the site has been mapped as "Moderate" (NSW Department of Trade and Investment); and

> The site exposure to wind was determined to be "Low".

> The average annual rainfall of the region was determined to be 449.6 mm (**Section 2.3.12**) and therefore the site lies within the "300-500 mm rainfall" category.

The wind erosion hazard of the site was determined to be Class 3 according to Table 6 of the LSC scheme.

5.1.1.3 Hazard 3: Soil Structure Decline

Soil structural decline hazard is a measure of the soils resilience to physical and structural breakdown, typically as a result of compaction and tillage. Soil structural decline hazard is assessed on surface soil texture, sodicity and self-mulching properties. The site soil texture includes a weakly self-mulching surface soil with clay throughout the profile and is therefore determined to be Class 3 according to Table 7 of the LSC scheme.

5.1.1.4 Hazard 4: Soil Acidification

Soil acidification is a major limitation of agricultural production in NSW. Soil acidification hazard is assessed using texture/buffering capacity of surface soil, mean annual rainfall and pH of the natural surface soil. The natural surface soil is estimated to have a "High" buffering capacity and the average annual rainfall of the region was determined to be 449.6 mm (**Section 2.3.12**) and therefore lies withing the "mean annual rainfall >550mm" category. The pH of the natural surface soil lies within the 5.5-6.7 pH (water). Therefore, the soil acidification hazard was determined to be Class 2 according to Table 12 of the LSC Scheme.

5.1.1.5 Hazard 5: Salinity

Salinity hazard is determined by the recharge potential, the discharge potential and salt store of the site.

- The average annual rainfall of the region was determined to be 449.6 mm (**Section 2.3.12**) with average annual pan evaporation of 1,400 mm (BOM, 2006). This would suggest a low recharge potential.
- Based on annual rainfall data (449.6 mm) and an average evapotranspiration rate of 500 mm (BOM, 2005), a moderate discharge potential exists for the site due to the relatively similar values.
- Laboratory tested ECe values indicate that the soils of the site are non-saline in the topsoil horizons, moving to slightly saline in the lower soil horizons. Therefore a "Low" salt store value has been accepted.

The salinity hazard of the site was determined to be Class 1 according to Table 13 of the LSC Scheme.

5.1.1.6 Hazard 6: Waterlogging

Waterlogging is a major limitation in low lying areas where it can restrict the supply of oxygen to plant roots during certain times of the year. Waterlogging hazard is determined by the typical waterlogging duration (months), return period and typical soil drainage of the site. The site is relatively flat and soil mottling was not observed throughout the soil profile which indicates the site is moderately well drained. The waterlogging hazard of the site was determined to be Class 2 according to Table 14 of the LSC Scheme.

5.1.1.7 Hazard 7: Shallow Soils and Rockiness

Shallow soils and rockiness reduce the capability of soils and land as there is less soil volume available for holding water and nutrients. This hazard is determined by an estimated percentage exposure of rocky outcrops and average soil depth. No rocky outcrops were observed and soil depth was >100 cm throughout all soil samples taken. The shallow soils and rockiness hazard was determined to be Class 1 according to Table 15 of the LSC Scheme.

5.1.1.8 Hazard 8: Mass Movement

Mass movement is a serious threat and involves the large-scale movement of earth under the force of gravity. Mass movement hazard is determined by mean annual rainfall, presence and slope percentage. The site is determined to be in the "<500mm annual rainfall" classification and mass movement is not present. The mass movement hazard was determined to be Class 1 according to Table 16 of the LSC Scheme.

5.1.2 LAND AND SOIL CAPABILITY VERIFICATION

The overall LSC class for the site was determined as LSC Class 3, as listed in **Table 13.**

LSC Class 3 is defined by the *Land and Soil Capability Assessment Scheme* (OEH, 2012) as "High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation."

The land within the site is considered moderately capable and limitations include wind erosion and soil structure decline.

A map of the verified LSC class is provided in **Figure 12.**

Table 13 – Land and Soil Capability Assessment

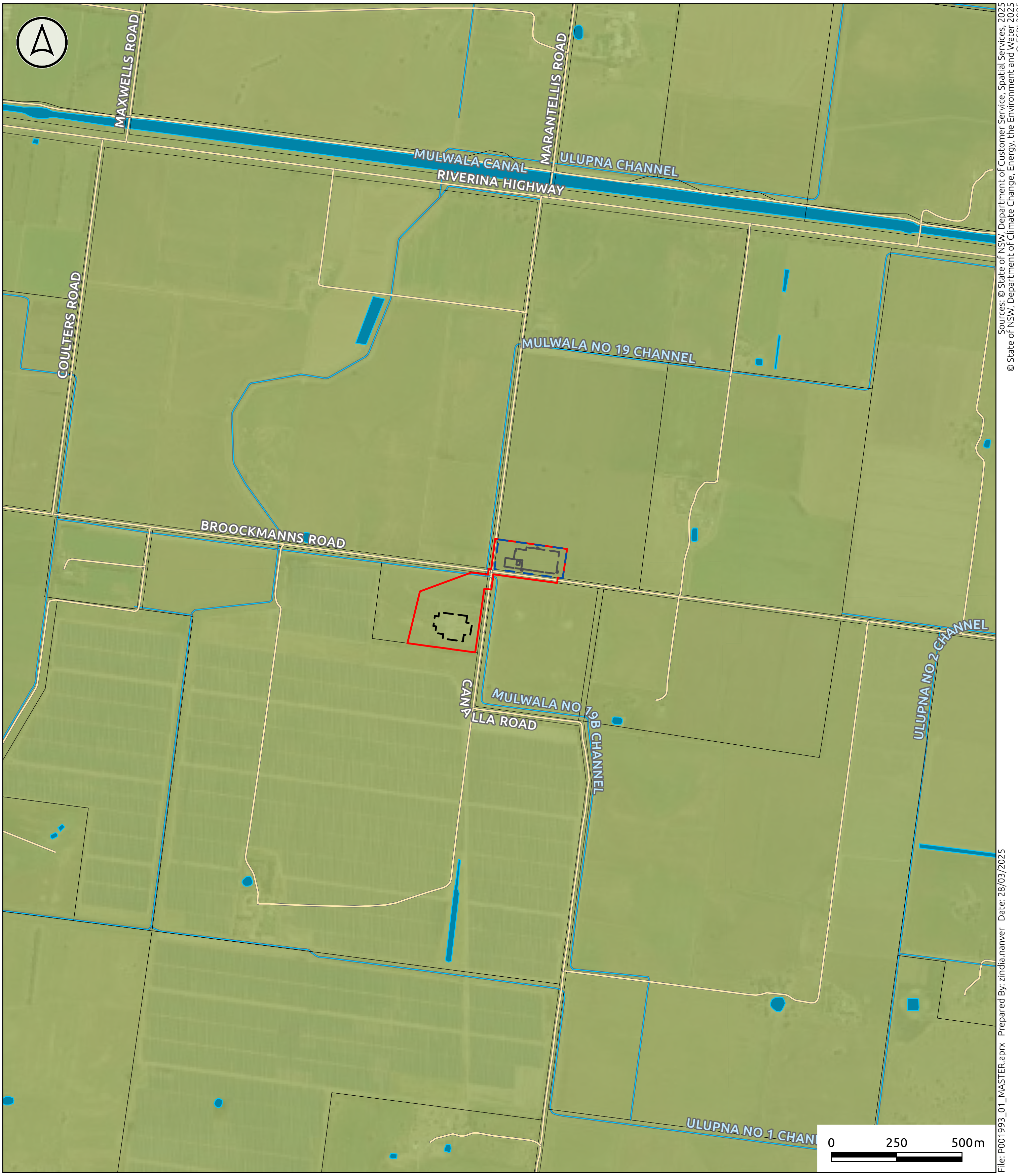
Sites	Soil type	Hazard criteria								Final LSC
		1 Water erosion	2 Wind erosion	3 Soil structure decline	4 Soil acidification	5 Salinity	6 Water logging	7 Shallow soils / rockiness	8 Mass movement	
1,2, 3,4	Sodosols	1	3	3	2	2	2	1	1	**3**

5.1.3 VERIFIED LAND AND SOIL CAPABILITY

The *Land and Soil Capability Assessment Scheme* (OEH, 2012) maps the soil of the site as Class 3- High capability land which was verified by site visit and soil analysis. The results of the LSC verification are included in **Table 13** and an updated map showing the verified LSC is included in **Figure 12.**

Table 14 – LSC Definitions (OEH, 2012)

Class	General definition
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, conservation)	
3	**High capability land:** Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.



Legend

- Development Site
- BESS Lease Area
- Substation
- Indicative BESS Security Fence
- Lot
- Road
- Water Body
- Watercourse

Land and Soil Capability

- 3 - Moderate limitations

Premise

Finley BESS

Figure 12: Land and Soil Capability

6. EROSION ASSESSMENT

6.1 The Revised Universal Soil Loss Equation (RUSLE)

RUSLE is specified in the IECA '*Best Practice Erosion and Sediment Control Guidelines*' (2008) ('IECA Manual') to predict the long-term, average, annual soil loss from rill and sheet erosion. The RUSLE equation provides an estimate of the annual soil loss and does not consider individual storm events. The annual soil loss due to erosion (A) is used to determine the erosion risk rating, stabilisation requirements and the level of sediment control required for the site.

In order to calculate the soil erosion hazard and the soil erosion risk, the Revised Universal Soil Loss Equation (RUSLE) from the IECA Manual was used using the following formula:

$$A = K \times R \times LS \times P \times C \qquad \text{(IECA, 2008)}$$

Where:

A: is the predicted soil loss per hectare per year

K: is the soil erodibility factor

R: is the rainfall erosivity factor

LS: is the slope length/gradient factor (varies for each catchment)

P: is the erosion control practice factor (1.3)

C: is the ground cover and management factor (default value of 1 adopted)

6.1.1 SOIL ERODIBILITY FACTOR (K FACTOR)

The K-Factor is a measure of the resistivity to erode of soil to the energy of rain. It is a parameter that effects the total soil loss as it increases. Generally, the particle distribution is the main factor in the measurement.

Soil testing was undertaken as part of the soil assessment for this project but it did not specifically include testing for a K-factor value. Emerson testing indicated that some soils across the site were moderately dispersive (Emerson Aggregate Class 3), but not within Emerson Aggregate Class 1 and 2 which require an increase K-factor value (*Managing Urban Stormwater: Soils and construction - Volume 1*, Landcom, 2004). Therefore a conservative K factor of 0.03 was estimated by using the default value in the IECA Manual.

It is noted that the values adopted for this assessment have been used for planning purposes only. The Construction Contractor shall undertake assessment of the soil types and extents when considering the proposed works methodology and construction staging.

6.1.2 RAINFALL EROSIVITY FACTOR

R-factor is a measurement of the energy associated with rainfall events, i.e. the erosive energy of the median rainfall for the area. The R-factor can be found in the IECA Manual or calculated using the methodology for estimating R factors from rainfall intensity.

The relevant formula is:

$R = R = 164.74x(1.1177)^{S} xS^{0.6444}$

Where:

R = Rainfall erosivity (MJ.mm/ha.t.yr)

S = 2-year ARI (equivalent to the 0.5EY) 6-hour rainfall event (5.78mm/hr for the site) sourced from BOM IFD for Lat -35.6371, Long 145.515.

Based on this data, rainfall erosivity (R factor) of 970 (MJ.mm/ha.t.yr) was calculated for the project area.

6.1.3 SLOPE LENGTH AND SLOPE GRADIENT (LS FACTOR)

This factor is a combination of the length (L) and steepness (S) of a slope. The way the formula uses this number is to assume that the whole catchment has this ratio. For safety generally the highest LS factor for the catchment is used. This gives the worst possible case of soil loss.

Within the project this will be calculated be 0.24 for the study area.

6.1.4 EROSION PRACTICE AND COVER (P AND C FACTORS)

The P-factor refers to Erosion Control Practice. This allows the user of the formula to adjust the total soil loss as a factor based on practices the erosion control with regards to the compaction of the ground. The industry standard for construction is default at 1.3, defined as '*Compacted and smooth*'.

The C-Factor is a function of cover over the soil. It represents methods for controlling erosion other than altering the soil. As standard practice there is no cover while areas are under construction.

6.1.5 CALCULATED SOIL LOSS

Calculated soil loss (RUSLE) was used to determine the erosion risk rating for implementation during the construction phase of the project and are presented in **Table 15.**

It should be noted that the soil loss estimate is not considered representative of actual annual soil loss for the project area and should be used rather as indicator of potential erosion risk and a link between risk and controls. If at any time circumstances affecting the above factors should change, a reassessment should be conducted immediately.

Table 15 – Calculated Soil Loss

Factor	Units	Study Area Value
Catchment size	Hectares	3 ha
Soil erodibility (K Factor)	t ha h $ha^{-1}MJ^{-1}mm$	0.03
Rainfall erosivity (R Factor)	MJ.mm/ha.t.yr	970

Factor	Units	Study Area Value
Cover (C Factor)	Factor (Landcom 2004)	1.0
Conservation practice (P Factor)	Factor (Landcom 2004)	1.3
Length/slope (LS Factor)	Factor (Landcom 2004)	0.24
Average soil loss	t/ha/yr	9.07
Average soil loss for area	t/yr	**27.23**
Erosion Risk	Rating (IECA,2008)	**Very Low**

6.1.6 DISCUSSION

Based on the above analyses the site has been assessed as a very low erosion risk site by the RUSLE guideline from the *Managing Urban Stormwater: Soils and construction – Volume 1* (Landcom, 2004). General erosion control measures are suggested in the mitigation measures in **Section 8**.

7. POTENTIAL EFFECTS

7.1 Agricultural

The proposed development would occupy a lease area of three (3) hectares of land which is currently used for dryland cropping and occasional agistment of sheep. The estimated average annual production value of this land is currently **$3,832.23**, as calculated in **Section 3.3.5**. Land on the study area will be fenced off and will not be used for agricultural purposes once the project commences. The remainder of the paddock outside of the fenced development would continue to be used for cropping and occasional grazing.

Engagement with the Finley community and neighbouring landholders on immediately adjacent land was conducted as part of the engagement outcomes report. A copy of the engagement report has been included in the EIS.

The engagement report identified that Berrigan Shire Council officers expressed interest in knowing if the land can be remediated back to agricultural use after decommissioning. Mitigation measures in **Section 8** of this report contain measures to ensure that impacts to agriculture, land and soil are minimised during the full duration of the project. A decommissioning plan shall also be developed which will ensure the land can be returned to agricultural use following decommissioning.

Consultation also identified that loss of arable agricultural land was a concern raised by neighbours within a 2km radius of the development and Berrigan Shire Council officers. While the development represents a reduction in annual agricultural farm productivity, there is a relatively small agricultural effect due to the small size and production value of the 3-hectare lease and study area. An economic impact assessment of the project is included in the EIS and contains an analysis of employment and value-added benefits to the surrounding region. The reduction in agricultural productivity is expected to be relatively small for the region and is considered unlikely to significantly negatively impact local agricultural communities and supply chains (grain traders, saleyards, abattoirs, agricultural suppliers).

Developing a renewable energy project on a rural property is considered to be likely to support a diversified income portfolio for the region, allowing financial flexibility in a changing and unpredictable climate. Additionally, the project is expected to have minimal impacts on long term agricultural productivity of the site. Once the project is decommissioned, land on the study area will be rehabilitated and returned to its pre-existing land use or another land use as agreed between the site provider and the project proponent.

7.2 Soil impacts

7.2.1 CONSTRUCTION

Potential impacts to soil associated with the construction of the development are detailed in **Table 16** below. Effects were identified and determined by identifying unmitigated risks associated with construction activities and potential impacts to the receiving land.

Table 16 – Potential construction impacts

Activity	Impact	Likelihood	Significance of impact
Vegetation clearing	Vegetation removal has the potential to increase the risk of erosion and sedimentation by exposing soils to weathering processes and reducing soil stability.	Moderate	Moderate
Earthworks and excavation (including trenching)	Increased the risk of erosion through soil disturbance if unmitigated.	Moderate	Moderate
	Exposing subsoils which may be saline or sodic and dispersive may increase the risk of erosion and reduce overall soil fertility.	Moderate	Moderate
	Excavation of buried soil contaminants (heavy metals, pesticides, hydrocarbons) may occur. If unmitigated this may cause impacts to human health and environmental safety.	Low	High
Stockpiling and removal of excavated material	Mixing of soil horizons may occur if soil is incorrectly removed or stockpiled during construction. Mixing topsoil and subsoil may impact long term soil quality and erosion hazard, especially with sodic subsoils.	Moderate	Moderate
Operating heavy machinery	Soil compaction may occur during the operation of heavy machinery on site if unmitigated. Soil compaction has impacts to erosion risk and long-term impacts to land and soil capability.	Moderate	Moderate
Earthworks, vehicle and pedestrian movements	Earthworks and movements of machinery, vehicles and pedestrians on site may introduce new pests, weeds and disease species to the area or spread species which are present at the site. Sources of biosecurity risks may include caked on organic material or mud in equipment, vehicles, heavy machinery and boots. Biosecurity risks may cause a long-term impact to the site and surrounding agricultural community if unmitigated.	Moderate	High
Waste and spills	Waste accumulated during construction activities, including litter and putrescible waste, has the potential to pollute soil and	Low	Moderate

Activity	Impact	Likelihood	Significance of impact
	groundwater resources if appropriate measures are not implemented.		
	The release of potentially harmful chemicals, substances or contaminated stormwater may occur accidentally during construction and has the potential to contaminate soil (i.e., leakage or spill of petroleum, oils or other toxicants from construction machinery and plant equipment resulting from inappropriate storage of contaminated materials, refuelling and/or maintenance activities, leakage from sewer infrastructure).	Low	High

7.2.2 OPERATION

Potential impacts to soil associated with the operation of the development are detailed in **Table 17** below. Impacts were determined by identifying unmitigated risks associated with construction activities and potential impacts to the receiving land.

Table 17 – Potential operation impacts

Activity	Impact	Likelihood	Significance of impact
Operating heavy machinery	Soil compaction may occur during the operation of heavy machinery on site if risks are unmitigated. Soil compaction has impacts to erosion risk and long-term impacts to land and soil capability.	Moderate	Moderate
Vehicle and pedestrian movements	Movements of machinery, vehicles and pedestrians on site during operation may introduce new pests, weeds and disease species to the area or spread species which are present at the site. Sources of biosecurity risks may include caked on organic material or mud in equipment, vehicles, heavy machinery and boots. Biosecurity risks may cause a long term impact to the site and surrounding agricultural community if unmitigated.	Moderate	High
BESS operation	Reduced soil permeability and localised erosion may occur around the BESS hardstand from water run-off during rainfall or cleaning. This is likely if groundcover is not promptly established around the BESS hardstand.	Moderate	Low
	Erosion, soil loss and sedimentation may continue to occur during operation if risks are unmitigated during construction.	Low	Moderate
	Downstream salinity impacts may occur if water infiltration to saline subsoils increases when crops are not harvested (i.e. by harvesting, grazing or baling).	Low	Moderate
	Impacts to metal or concrete structures may occur if they come into contact with acidic, alkaline or sodic soils.	Moderate	Low

Activity	Impact	Likelihood	Significance of impact
BESS operation	Erosion, soil loss and sedimentation may continue to occur during operation if risks are unmitigated during construction.	Low	Moderate
	Soil compaction may occur if traffic around the BESS is not appropriately managed and controlled.	Low	Moderate
Waste and spill	The release of potentially harmful chemicals, substances or contaminated stormwater may occur accidentally during operation and has the potential to contaminate soil (i.e., leakage or spill of petroleum, oils or other toxicants from construction machinery and plant equipment resulting from inappropriate storage of contaminated materials, refuelling and/or maintenance activities, leakage from sewer infrastructure, or heavy metal or microplastic contaminants from structures).	Low	High

7.2.3 FUTURE DECOMMISSIONING

Potential effects to soil during a future-time decommissioning and removal of the battery system are anticipated to be similar to construction effects. Long term effects of decommissioning may include:

- Failure to return the site to the existing or improved land and soil capability;
- Failure to return the site to a safe, stable and non-polluting landform.

8. MITIGATION MEASURES

The following mitigation measures are recommended to minimise effects on land, soil and agriculture throughout the duration of the project.

The mitigation measures have been formatted as a table and each mitigation measure is assigned a reference number, description of timing and responsibility.

Table 18 – Soil - Mitigation commitments

Ref No.	Potential impact	Commitment	Timing	Responsibility
S1	Erosion and Sedimentation	A Soil and Water Management Plan (SWMP) is to be prepared in accordance with *Managing Urban Stormwater – Soils and Construction Volume 1 (Landcom, 2004).* The SWMP will be prepared as part of a Construction Environmental Management Plan (CEMP) to manage potential risks to soils, surface and ground water. The construction SWMP is to be prepared with reference to relevant development controls within the DCP. Recommended measures for the construction SWMP include but are not limited to: > Measures to minimise and manage the potential for erosion and sediment transport within and from the project area. > Measures to manage accidental spills and waste storage. > Measures to manage stormwater and the potential for contaminated runoff from the development site. > Measures to ensure that excavation activities and any stockpiling are managed to minimise the potential for downstream contamination. > Measures to ensure that areas of exposed soil and the time in which they are exposed are minimised as far as practical.	Prior to Construction During Construction	Contractor
S2	Soil disturbance and sedimentation associated with vegetation clearing,	The construction of the development shall be managed in compliance with measures specified within the construction SWMP to ensure impacts to water quality are appropriately managed.	Prior to Construction During Construction	Contractor

Ref No.	Potential impact	Commitment	Timing	Responsibility
	excavation, stockpiling activities	Measures shall be implemented to ensure that areas of exposed soil and the time in which they are exposed, are minimised as far as practical during construction.		
S3	Wastes, Spill and Emergency Management	**Construction** The construction SWMP shall include procedures to reduce and manage the risk of emergency events and the potential for wastes and spills to contaminate soils. Recommended measures to manage the potential for contaminated discharge include: > The storage of all fuel chemicals and liquids in sealed bunded areas on level ground away from stormwater drainage lines and waterways. > Ensuring refuelling and maintenance activities are restricted to designated areas with appropriate bunding and spill capture controls. > Implementing controls as part of the construction SWMP that provide procedures to respond to emergencies and spills. > Ensuring visual inspections of drainage lines and disturbed areas are undertaken during construction to assess any potential soil or surface water issues. > The installation and maintenance of stormwater control measures including drainage networks that segregate stormwater runoff according to its contamination.	During Construction	Contractor
		Operation During operation procedures shall be developed to reduce the potential contamination of soils, surface and ground water, resulting from wastes, spills and/or emergency	Operation	Proponent

Ref No.	Potential impact	Commitment	Timing	Responsibility
		incidents. Suggested measures to control the potential for contamination during operation include: > The appropriate storage of equipment and hazardous substances during operation. > Ensuring that plant and stormwater control measures are maintained to prevent contamination of soil. > Preparation of appropriate procedures to response to emergency incidents, spills and leaks from the development site, including operational equipment and maintenance activities.		
		Decommissioning A decommissioning plan shall be developed which minimises the impacts to soils, surface and ground water, resulting from erosion, wastes, spills and/or emergency incidents. Suggested measures to control the potential for contamination during decommissioning including: > A soil sampling plan to be undertaken prior to decommissioning to assess any risk of contamination. > Remediation plan (if required) to ensure that the land can be returned to an agricultural capacity following decommissioning. > Preparation of procedures to minimise risk of contamination and soil erosion during decommissioning.	Decommissioning	Proponent
S4	Soil mixing / topsoil loss	As part of the CEMP for the Project, soil management measures should include: > Assessment of topsoil depth prior to stripping to minimise mixing of topsoil and subsoil.	Prior to Construction During Construction	Contractor

Ref No.	Potential impact	Commitment	Timing	Responsibility
		> Topsoil and subsoil should be stripped and stockpiled separately for rehabilitation works following excavation. > Avoid stripping and stockpiling soil following heavy rain periods > Avoid compaction of topsoil during stripping and stockpiling operations. > If required, amelioration of topsoil and/or subsoil during stripping in accordance with a soil scientist's recommendations. > Prevent erosion of stockpiles using soil stabilising biopolymers, cover crops or other forms of stabilisation. > Test stockpiled soils to determine amelioration requirements prior to reinstatement.	During Decommissioning	
S5	Soil compaction	As part of the CEMP for the project, soil compaction management measures should include: > Development of controlled traffic practices for plant machinery movements. > Avoid excavation and plant machinery movements on wet soils following heavy rain periods. > Prevent long term storage of plant machinery on clay or wet soils. > Avoid long term exposure of subsoils which are more susceptible to compaction. > Progressively stabilise and rehabilitate soil as soon as practically possible after excavation. > Ensure soil is replaced in correct subsoil/topsoil orders. > Ensure vegetative cover is re-established after soil rehabilitation.	Prior to Construction During Construction During Decommissioning	Contractor

Ref No.	Potential impact	Commitment	Timing	Responsibility
S1	Biosecurity risk	As part of the CEMP and operation plan for the project, biosecurity measures should include: > Implement a "Come Clean, Go Clean" policy (DPI NSW, 2024) for vehicles and machinery entering the site. Mud and plant material must be removed from vehicles and machinery prior to entering and leaving the site. > Prevent the spread of plant and soil material on to and off site by checking clothes and boots prior to entering and leaving the site. > Implement a weed management plan which involves regular monitoring, spraying and removal of weeds.	Prior to Construction During Construction During Operation During Decommissioning	Site Manager

9. CONCLUSION

9.1 Site suitability

The Land and Soil Capability Assessment Scheme (OEH, 2012) maps the soil of the site as Class 3- High capability land. The soil survey identified the soil types across the site as Brown Sodosols under the Australian Soil Classification System (Isbell, 2002). The proposed battery system development would occupy 3 hectares of land currently used for dryland cropping and occasional agistment of sheep. Implementing a land use change for the proposed development would have a minimal effect on surrounding agricultural land, production and wider regional agricultural production.

Soil chemical analysis indicated that the soils are moderately fertile throughout the profile. The subsoils are moderately alkaline and sodic at depth. Mitigation measures should be implemented during the construction period which prevent soil horizons being exposed or mixed during excavation or stripping.

The risk of erosion has been assessed as a very low erosion risk site by the RUSLE guideline from the *Managing Urban Stormwater: Soils and construction – Volume 1* (Landcom, 2004). Mitigation measures should be implemented during the construction and decommissioning phases which will minimise erosion risk during works.

The site is considered suitable for the development in respect to how the land is classified in the local planning instrument., current land use and especially close proximity to the existing electrical substation. Effects on adjacent agricultural land, soil, and agricultural production of the region are considered to be minimal due to the relatively small size and small production value of the proposal and therefore the study area.

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APPENDIX A

Soil Analytical Results

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Grace Scott	Manager	Jon Dicker
Client	PREMISE	Laboratory	SGS Cairns Environmental
Address	154 PEISLEY STREET ORANGE NSW 2800	Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	612 6393 5000	Telephone	+61 07 4035 5111
Facsimile	(Not specified)	Facsimile	+61 07 4035 5122
Email	Grace.scott@premise.com.au	Email	AU.Environmental.Cairns@sgs.com
Project	**Finley**	SGS Reference	**CE177583 R0**
Order Number	**P001993**	Date Received	25 Sep 2024
Samples	4	Date Reported	14 Oct 2024

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146)

SIGNATORIES

Alyson BERGAMO
Senior Laboratory Technician

Jon Dicker
Manager Northern QLD

Maristela GANZAN
Quality Manager

Mitsuko BALDWIN
Metals Team Leader

Parameter	Units	LOR	Sample Number / Sample Matrix / Sample Name: CE177583.001 Soil F3 0-15	CE177583.002 Soil F3 15-40	CE177583.003 Soil F3 40-80	CE177583.004 Soil F3 80-100

Moisture Content Method: AN002 Tested: 25/9/2024

Parameter	Units	LOR	F3 0-15	F3 15-40	F3 40-80	F3 80-100
% Moisture	%w/w	1	5.0	9.3	10.7	11.3

pH in soil (1:5) Method: AN101 Tested: 30/9/2024

Parameter	Units	LOR	F3 0-15	F3 15-40	F3 40-80	F3 80-100
pH	pH Units	0.1	6.4	7.3	8.8	9.1
pH (CaCl2)*	pH Units	0.1	5.5	6.1	8.1	8.3

Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 30/9/2024

Parameter	Units	LOR	F3 0-15	F3 15-40	F3 40-80	F3 80-100
Conductivity of Extract (1:5 as received)	µS/cm	2	67	53	360	400

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 30/9/2024

Parameter	Units	LOR	F3 0-15	F3 15-40	F3 40-80	F3 80-100
Exchangeable Sodium, Na	mg/kg	2	93	250	690	940
Exchangeable Sodium, Na	meq/100g	0.01	0.40	1.1	3.0	4.1
Exchangeable Sodium Percentage*	%	0.1	3.1	5.1	6.7	9.4
Exchangeable Potassium, K	mg/kg	2	390	500	710	620
Exchangeable Potassium, K	meq/100g	0.01	1.0	1.3	1.8	1.6
Exchangeable Potassium Percentage*	%	0.1	7.7	6.1	4.1	3.6
Exchangeable Calcium, Ca	mg/kg	2	1400	1800	4900	4600
Exchangeable Calcium, Ca	meq/100g	0.01	7.2	9.1	25	23
Exchangeable Calcium Percentage*	%	0.1	55.5	43.3	55.0	53.1
Exchangeable Magnesium, Mg	mg/kg	2	540	1200	1900	1800
Exchangeable Magnesium, Mg	meq/100g	0.02	4.4	9.5	15	15
Exchangeable Magnesium Percentage*	%	0.1	33.7	45.5	34.3	33.9
Cation Exchange Capacity	meq/100g	0.02	13	21	45	44
Sodium Adsorption Ratio*	No unit	0.1	0.2	0.4	0.7	0.9

Soil - Aluminium (KCL Extraction) Method: AN046 Tested: 1/10/2024

Parameter	Units	LOR	F3 0-15	F3 15-40	F3 40-80	F3 80-100
Exchangeable Aluminium	mg/kg	1	-	-	-	-

Particle sizing of soils by sieving Method: AN005 Tested: 11/10/2024

Parameter	Units	LOR	F3 0-15	F3 15-40	F3 40-80	F3 80-100
Passing 2.00mm	%w/w	1	100	-	-	-
Retained 2.00mm	%w/w	1	<1	-	-	-
Passing 600µm	%w/w	1	99	-	-	-
Retained 600µm	%w/w	1	<1	-	-	-
Passing 300µm	%w/w	1	97	-	-	-
Retained 300µm	%w/w	1	2	-	-	-
Passing 212µm	%w/w	1	96	-	-	-
Retained 212µm	%w/w	1	1	-	-	-
Passing 75µm	%w/w	1	89	-	-	-
Retained 75µm	%w/w	1	7	-	-	-

Parameter	Units	LOR	CE177583.001 Soil F3 0-15	CE177583.002 Soil F3 15-40	CE177583.003 Soil F3 40-80	CE177583.004 Soil F3 80-100

Particle sizing of soils <75µm by hydrometer   Method: AN005   Tested: 11/10/2024

Parameter	Units	LOR	CE177583.001	CE177583.002	CE177583.003	CE177583.004
Sedimentation Diameter 1	mm	0.0001	0.0527	-	-	-
Passing Sedimentation Diameter 1	%w/w	1	65	-	-	-
Retained Sedimentation Diameter 1	%w/w	1	24	-	-	-
Sedimentation Diameter 2	mm	0.0001	0.0377	-	-	-
Passing Sedimentation Diameter 2	%w/w	1	61	-	-	-
Retained Sedimentation Diameter 2	%w/w	1	4	-	-	-
Sedimentation Diameter 3	mm	0.0001	0.0269	-	-	-
Passing Sedimentation Diameter 3	%w/w	1	57	-	-	-
Retained Sedimentation Diameter 3	%w/w	1	3	-	-	-
Sedimentation Diameter 4	mm	0.0001	0.0191	-	-	-
Passing Sedimentation Diameter 4	%w/w	1	56	-	-	-
Retained Sedimentation Diameter 4	%w/w	1	1	-	-	-
Sedimentation Diameter 5	mm	0.0001	0.0140	-	-	-
Passing Sedimentation Diameter 5	%w/w	1	54	-	-	-
Retained Sedimentation Diameter 5	%w/w	1	2	-	-	-
Sedimentation Diameter 6	mm	0.0001	0.0099	-	-	-
Passing Sedimentation Diameter 6	%w/w	1	53	-	-	-
Retained Sedimentation Diameter 6	%w/w	1	1	-	-	-
Sedimentation Diameter 7	mm	0.0001	0.0070	-	-	-
Passing Sedimentation Diameter 7	%w/w	1	52	-	-	-
Retained Sedimentation Diameter 7	%w/w	1	1	-	-	-
Sedimentation Diameter 8	mm	0.0001	0.0050	-	-	-
Passing Sedimentation Diameter 8	%w/w	1	50	-	-	-
Retained Sedimentation Diameter 8	%w/w	1	2	-	-	-
Sedimentation Diameter 9	mm	0.0001	0.0036	-	-	-
Passing Sedimentation Diameter 9	%w/w	1	48	-	-	-
Retained Sedimentation Diameter 9	%w/w	1	2	-	-	-
Sedimentation Diameter 10	mm	0.0001	0.0015	-	-	-
Passing Sedimentation Diameter 10	%w/w	1	45	-	-	-
Retained Sedimentation Diameter 10	%w/w	1	3	-	-	-
Sedimentation Diameter 11	mm	0.0001	0.0010	-	-	-
Passing Sedimentation Diameter 11	%w/w	1	44	-	-	-
Retained Sedimentation Diameter 11	%w/w	1	1	-	-	-
Clay (<0.002mm)	%w/w	0.1	4.0	-	-	-
Silt and Clay (<0.005mm)	%w/w	0.1	6.0	-	-	-
Silt (0.002mm to 0.06mm)	%w/w	0.1	40	-	-	-
Fine Sand (0.06mm to 0.20mm)	%w/w	0.1	7.8	-	-	-

Emerson Class Number   Method: AN009   Tested: 25/9/2024

Parameter	Units	LOR	CE177583.001	CE177583.002	CE177583.003	CE177583.004
Emerson Class Number	No unit	1	3	-	-	-

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil   Method: AN248   Tested: 1/10/2024

Parameter	Units	LOR	CE177583.001	CE177583.002	CE177583.003	CE177583.004
Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.05	1.9	-	-	-

Colwell Phosphorus   Method: AN015   Tested: 30/9/2024

Parameter	Units	LOR	CE177583.001	CE177583.002	CE177583.003	CE177583.004
Colwell Phosphorus	mg/kg	1	51	-	-	-

Total Organic Carbon by Heanes Oxidation   Method: AN273   Tested: 2/10/2024

Parameter	Units	LOR	CE177583.001	CE177583.002	CE177583.003	CE177583.004
Total Organic Carbon	%w/w	0.05	1.5	-	-	-
Organic Matter	%w/w	0.1	2.6	-	-	-

Parameter	Units	LOR	Sample Number: CE177583.001 Sample Matrix: Soil Sample Name: F3 0-15	CE177583.002 Soil F3 15-40	CE177583.003 Soil F3 40-80	CE177583.004 Soil F3 80-100
Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 30/9/2024						
KCl-40-extractable Sulphur, S	mg/kg	1	20	-	-	-
Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 30/9/2024						
CaCl2-extractable Boron, B	mg/kg	0.05	1.3	-	-	-
DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 30/9/2024						
Copper, Cu	mg/kg	0.05	1.9	-	-	-
Zinc, Zn	mg/kg	0.05	0.55	-	-	-
Manganese, Mn	mg/kg	0.5	20	-	-	-
Iron, Fe	mg/kg	0.5	180	-	-	-

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Calcium Chloride Extractable Boron   Method: RL 12C2/AN320

Parameter	QC Reference	Units	LOR	MB
CaCl2-extractable Boron, B	LB133033	mg/kg	0.05	<0.05

Colwell Phosphorus   Method: ME-(AU)-[ENV]AN015

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Colwell Phosphorus	LB133061	mg/kg	1	<1	0%	105%

DTPA Extractable Metals in Soil   Method: ME-(AU)-[ENV]AN025/AN320

Parameter	QC Reference	Units	LOR	MB
Copper, Cu	LB133030	mg/kg	0.05	<0.05
Zinc, Zn	LB133030	mg/kg	0.05	<0.05
Manganese, Mn	LB133030	mg/kg	0.5	<0.5
Iron, Fe	LB133030	mg/kg	0.5	<0.5

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR)   Method: ME-(AU)-[ENV]AN122

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Exchangeable Sodium, Na	LB133032	mg/kg	2		2%	104%
Exchangeable Sodium, Na	LB133032	meq/100g	0.01	<0.01	2%	NA
Exchangeable Sodium Percentage*	LB133032	%	0.1		0%	NA
Exchangeable Potassium, K	LB133032	mg/kg	2		2%	107%
Exchangeable Potassium, K	LB133032	meq/100g	0.01	<0.01	2%	NA
Exchangeable Potassium Percentage*	LB133032	%	0.1		0%	NA
Exchangeable Calcium, Ca	LB133032	mg/kg	2		2%	110%
Exchangeable Calcium, Ca	LB133032	meq/100g	0.01	<0.01	2%	NA
Exchangeable Calcium Percentage*	LB133032	%	0.1		0%	NA
Exchangeable Magnesium, Mg	LB133032	mg/kg	2		2%	107%
Exchangeable Magnesium, Mg	LB133032	meq/100g	0.02	<0.02	2%	NA
Exchangeable Magnesium Percentage*	LB133032	%	0.1		0%	NA
Cation Exchange Capacity	LB133032	meq/100g	0.02	<0.02	2%	NA
Sodium Adsorption Ratio*	LB133032	No unit	0.1		1%	NA

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil   Method: ME-(AU)-[ENV]AN248

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate/Nitrite Nitrogen, NOx as N	LB133085	mg/kg	0.05	<0.05	1%	100%

Total Organic Carbon by Heanes Oxidation   Method: ME-(AU)-[ENV]AN273

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Organic Carbon	LB133086	%w/w	0.05	<0.05	5%	106%	102%
Organic Matter	LB133086	%w/w	0.1		5%		

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN005	The particle size distribution of a soil is determined by wet sieving, using a maximum of 900 mL of deionised water to sieve all fractions down to 75 µm. Referenced to AS1289.3.6.1 and AS1141.11.
AN005	Following wet sieving of the sample,(particles smaller than 75 µm) a dispersing solution is added and a hydrometer is used to measure sedimentation. Soil density is determined and the percentage of each size fraction calculated. Referenced to AS1289.3.6.3.
AN009	The method follows AS1289 3.8.1 - 2006. Soils are divided into seven classes on the basis of their coherence in water, with one further class being distinguished by the presence of calcium-rich minerals. Class 1: Air-dried crumbs of soil show a strong dispersion reaction, i.e., a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay.
AN009	Class 2: Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognisable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs. Class 3: The soil remoulded at the plastic limit disperses in water. Class 4: The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present. Class 5: The remoulded soil does not disperse in water and the 1:5 soil/water suspension remains dispersed after 5 min.
AN009	Class 6: The remoulded soil does not disperse in water and the 1:5 soil/water suspension begins to flocculate within 5 min. Class 7: The air-dried crumbs of soil remain coherent in water and swells. Class 8: The air-dried crumbs of soil remain coherent in water and do not swell.
AN015	Soil sample is extracted in an end over end roller in 0.5 N sodium bicarbonate at pH 8.5 with the supernatant liquor analysed for Phosphorous. Orthophosphate anion (PO43-) is reacted with ammonium molybdate and potassium antimony tartrate in sulfuric acid solution. The resulting phospho-molybdate complex is reduced, using ascorbic acid, to an intense blue coloured complex Molybdenum Blue. The absorbance of this complex is measured at 880 nm by Discrete Analyser, and compared with calibration standards to obtain the concentration of orthophosphate in the sample. Based on Rayment & Higginson 9B1.
AN025/AN320	A chelating agent is used to complex metal ions in solution. The extracted elements are determined byICP OES.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, sediments and sludges, an extract with water (or 0.01M CaCl2) is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract of as received sample with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Salinity can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. Reference APHA 2510 B.

METHOD	METHODOLOGY SUMMARY
AN122	Exchangeable Cations, CEC and ESP: Soil sample is extracted in 1 M Ammonium Acetate at pH=7 (or 1M Ammonium Chloride at pH=7) with cations (Na, K, Ca & Mg) then determined by ICP OES/ICP MS and reported as Exchangeable Cations. For saline soils, these results can be corrected for water soluble cations and reported as Exchangeable cations in meq/100g or soil can be pre-treated (aqueous ethanol/aqueous glycerol) prior to extraction. Cation Exchange Capacity (CEC) is the sum of the exchangeable cations in meq/100g.
AN122	The Exchangeable Sodium Percentage (ESP) is calculated as the exchangeable sodium divided by the CEC (all in meq/100g) times 100. ESP can be used to categorise the sodicity of the soil as below: ESP < 6% non-sodic ESP 6-15% sodic ESP >15% strongly sodic Method is referenced to Rayment and Lyons, 2011, sections 15D3 and 15N1.-
AN248	Nitrate / Nitrite in extract by Auto Analyser: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Reference APHA 4500-NO3- F.
AN273	The sample is digested in Dichromate / Sulfuric Acid to oxidise the organic carbon. The determination is completed colourimetrically by Discrete Analyser at 600 nm. Based on Rayment & Higginson 6B1.
RL 10D1/AN320	Air dried <2mm soil is extractedin 0.25M KCl at 40 deg C followed by analysis of filtrate for S by ICP OES. Referenced to Rayment and Lyons method 10D1.
RL 12C2/AN320	Air dried <2mm soil is extracted in 0.01M CaCl2 by refluxing gently for 30 minutes. Extract is then filtered and analysed by ICP OES. Referenced method Rayment and Lyon, 12C2.
SOL061	Soil sample is extrcated 1:10 in 1MKCl with aluminium determined by ICP OES.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
***	Indicates that both * and ** apply.	NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au/en-gb/environment-health-and-safety.

Premise