Silverleaf Solar Farm Pty Ltd

Narrabri 120 MW Solar Farm

Environmental Impact Statement

August 2019

Certification

I certify that I have prepared the contents of this environmental impact statement in response to the Secretary's environmental assessment requirements dated 6 May 2019 and the relevant provisions of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*. To the best of my knowledge the information contained in the environmental impact statement is not false or misleading.

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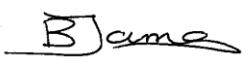
Signature:	
Date:	09/08/2019

Executive summary

The proposal

Silverleaf Solar Farm Pty Ltd (ENGIE) proposes to construct and operate a 120 megawatt (MW) solar farm, known as the Silverleaf Solar Farm. The site is about four kilometres north of Narrabri between the Newell Highway in the east, and Logans Lane in the west ("the proposal").

The proposal would consist of the following components:

- Solar arrays consisting of about 440,000 single-axis tracking panels up to four metres in height, supported by about 5,150 tracker units.
- Construction of a transmission corridor, supporting 132 kV power lines, connecting the proposal site to the existing TransGrid substation located on Stoney Creek Road.
- Inverter and transformer stations evenly distributed across the site, with onsite cabling and electrical connections between solar arrays and panel inverters.
- Internal solar farm substation.
- Cables and trenches.
- Internal access tracks including car parking areas.
- Operational and maintenance office including staff amenities block.
- Perimeter security fencing.
- Landscaping around the perimeter of the site where required.

Subject to planning and environmental approvals, the construction of the proposal is expected to take between nine and 12 months. The proposal has a planned operational lifespan of 35 years. If the proposal is not reconditioned with updated technology, it would be decommissioned at the end of this period. Decommissioning would involve removing all above ground infrastructure, and rehabilitating the site to allow for other uses.

Proposal need

Australia is one of the largest emitters of carbon dioxide per capita, with a historic reliance on coal-fired power generation. The development of renewable energy projects is one of the most effective ways to achieve reductions in greenhouse gas emissions, which led to the implementation of the Renewable Energy Target (RET) Scheme in Australia. As of January 2011, the RET has operated in two parts: the Large Scale Renewable Energy Target (LRET) and the Small Scale Renewable Energy Target (SRET). As of 31 January 2018, the Clean Energy Regulator expects the LRET of 33,000 gigawatt hours to be achieved by 2020.

A global climate agreement was agreed under the United Nations Framework Convention on Climate Change in Paris in 2015 ("Paris Agreement"). The Paris Agreement sets in place a framework for all countries to take climate action from 2020. This includes a global goal to hold average temperature increase to below 2°C and pursue efforts to keep warming below 1.5°C above pre-industrial levels. Australia has set a target to reduce emissions by 26-28 per cent below 2005 levels by 2030, which builds on previous emission reduction targets.

Driven by the Paris Agreement, federal government policy, state government renewable energy targets, and falling costs of renewable energy technologies, the National Electricity Market ("NEM") is undergoing a transformation from centralised generation to de-centralised renewable generation.

The AEMO 2018 Electricity Statement of Opportunities highlights that without additional investment in new generation, and as existing generation reaches end of technical life and retires, (Liddell in 2022, Bayswater in 2035), there is an emerging electricity supply issue developing in New South Wales.

To manage the changing generation mix in the NEM, the Australian Energy Market Operator ("AEMO") and the Australian Energy Regulator ("AER") have introduced new regulations for new generators to maintain the strength of the electrical system. These new technical rules would apply to Silverleaf Solar Farm.

The proposal is being developed to produce renewable energy and in doing so will provide the following benefits:

- Reduce greenhouse gas emissions by providing an alternative renewable energy source.
- Contribute towards meeting Australia's international emission reduction commitments.
- Comply with electrical system strength requirements for new generators.
- Provide direct and indirect employment opportunities during construction and operation leading to social and economic benefits for the local community.
- Diversification of revenue for local land holders.
- Allowance for a future battery energy storage system that will contribute to grid system stability.

Key environmental issues

Biodiversity

The proposal site is used for agricultural purposes, including cropping and grazing. There are several small patches of remnant woodland on site, though these have all been modified as a result of agricultural activities. No threatened flora species were identified within the proposal site.

A local occurrence of an endangered ecological community (EEC) listed under the *Biodiversity Conservation Act 2016* is located on the northern portion of the proposal site. While highly disturbed from agricultural development, a large area in the southern portion of the proposal site also supports an EEC of derived native grasslands. Credits will be required to offset impacts on this area.

Two species of birds and two species of bats, listed as threatened species under the *Biodiversity Conservation Act 2016*, were identified passing the proposal site. None of these species occupy the proposal site, as no suitable habitat is provided.

Aboriginal heritage

Two previously unrecorded Aboriginal sites were identified during the archaeological survey: Silverleaf IF-1 and Silverleaf IF-2. Both sites are isolated artefacts located in disturbed contexts without associated subsurface deposits. There is low potential for further sites or *in situ* subsurface archaeological deposits being present within the remainder of the study area.

Silverleaf IF-1 site consists of a single, silcrete proximal flake fragment at a tertiary stage of reduction. The flake is in the 2–4 centimetre size range situated within a large patch of erosion in a paddock used for grazing. No additional artefacts were identified in this location.

Silverleaf IF-2 consists of a single, quartzite proximal flake fragment at a tertiary stage of reduction. The flake is smaller than two centimetres and was found in a patch of erosion. There were no additional artefacts identified in this location.

Visual impacts

The landscape surrounding the proposal site is relatively flat, with only gradual changes in elevation in the surrounding area. The proposal site is visually consistent with the rural properties located in the surrounding area which are predominately used for grazing and cropping. The proposal would involve changing the land use of the site from agricultural production to solar power generation.

The boundary of the proposal site is largely void of vegetation with the exception of some isolated trees. The proposal would be visible from surrounding areas, including a number of dwellings. The installation of appropriate vegetation as screening along the site boundary would assist in minimising visual impacts, including potential glare. This would be discussed with adjoining owners to determine the positioning of screening vegetation, and any potential safety issues.

Noise and vibration

During construction, the proposal is likely to result in exceedances of the construction noise criteria at two nearby residential dwellings. These impacts would be short-term, and would take place during standard construction hours. Construction noise impacts would be minimised by implementing mitigation measures. Operation of the proposal would not produce noise impacts on surrounding properties.

Land use and land capability

The proposal represents an activity that differs from the agricultural activities on surrounding properties. Changing the use of the land from agricultural production to solar power generation would result in the loss of agriculturally productive land for the operating life of the solar farm. After which time the solar farm would either be re-powered, subject to relevant approvals and agreements with landowners, or decommissioned and removed from the land. The loss agricultural land would not create a significant impact on agricultural properties in the surrounding area.

A risk assessment, based on the Department of Industry's *Land Use Conflict Risk Assessment Guide*, determined that risks to surrounding properties, and the broader area, as a result of the proposal would be low. Future farming operations on the adjoining properties will be similar to current operations with no expected reduction in productivity or employment on the adjoining properties.

The proposal site is located adjacent to a private airstrip known as the Oakville Aerodrome. The proposal would not impact on the operation of the aerodrome. The aerodrome is not equipped with instrument procedures, and would not affect any obstacle limitation surfaces at Oakville aerodrome. Appropriate landscaping to minimise the potential for glare would be discussed with the aerodrome operators. This would include incorporating safety considerations such as tree heights and species.

Traffic, transport and access

The construction of the proposal would increase traffic volumes in the locality, but would only occur in the construction period. Construction of the proposal has the potential to affect local traffic conditions as a result of large trucks delivering equipment to the site. Oversized vehicles are likely to be required to deliver large plant and components such as the transformer for the substation. A construction traffic management plan would be developed in consultation with NSW Roads and Maritime Services and Narrabri Shire Council. This would include the proposed intersection upgrade at the Kamilaroi Highway and Logans lane intersection, and other measures that would be required.

Operation of the proposal would not impact highway traffic or access to adjoining properties. Only light vehicles would regularly be required at the proposal site once operational.

Hydrology, groundwater and water quality

Soil disturbance during construction has the potential to impact water quality in receiving waters. The existing central drain within the site would be retained. The retention of this drain would minimise changes to flow paths, therefore minimising the potential for downstream impacts. The removal of site dams has the potential to result in a small increase in total discharge volumes from the site. This increase would not result in appreciable changes in the flood response downstream of the site. Small areas of hardstand are proposed for site infrastructure. Groundwater at the proposal site is greater than five metres below surface level. Groundwater would not be reached for the installation of site infrastructure.

Local controls, such as stormwater management systems, rainwater harvesting, and erosion and scour protection measures, would be considered during the detailed design stage to minimise potential impacts.

Hazards and risks

A dangerous goods and transport screening assessment, completed in accordance with SEPP 33, indicates that the proposal does not exceed any of the thresholds, and a preliminary hazard analysis (PHA) is not required. Construction of the proposal would not require the movement of dangerous goods to or from site.

There would be limited exposure to electromagnetic fields (EMF) from the existing transmission lines, the proposed transmission line and the proposed substation during construction. Access to the substation would only be available to suitably trained workers.

The proposal site and the transmission corridor are not identified as bushfire prone land. Due to the lack of vegetation at the proposal site, the bushfire risk is low. The risk of the transmission line starting a fire is relatively minor, and would be similar to existing power lines elsewhere.

Management of impacts

Impact avoidance and minimisation measures have been incorporated into the design of the proposal. These measures are considered practical and achievable by the proponent. They are set out for each area of investigation in Sections 6 and 7 and summarised in Section 8.2 of this EIS.

All commitments and environmental safeguards would be managed by implementing an Environmental Management Plan (EMP). The EMP would include a Construction Environmental Management Plan, an Operation Environmental Management Plan and a Decommissioning Environmental Management Plan. These plans would be prepared sequentially and submitted to the Department of Planning and Environment, prior to each stage of works commencing. Sub-plans would be developed to manage specific environmental aspects and impacts such as traffic, soil and erosion, Aboriginal heritage and others as appropriate.

Conclusion

This EIS has assessed the potential impacts of the proposal and concludes that the proposal is unlikely to result in any significant environmental impacts provided the recommended mitigation measures are implemented. The proposal would contribute to NSW and Commonwealth Government commitments to reduce greenhouse gas emissions, and to increase the proportion of electricity that is generated by renewable energy technologies.

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Terms and definitions

Term	Definition
ABS	Australian Bureau of Statistics
AC	Alternating Current
ARENA	Australian Renewable Energy Agency
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
Associated landowners	Landowners that have a lease agreement with Silverleaf Solar Farm for the use of land
BCA	Building Code of Australia
BOM	Australian Bureau of Meteorology
CEEC	Coalition for Energy Efficient Comminution
CEMP	Construction Environmental Management Plan
COP21	Conference of the Parties
dBA	A measure of A-weighted (c.f.) sound levels
DC	Direct Current
DECC	Department of Climate Change (now Office of Environment and Heritage)
DECCW	Department of Climate Change and Water (now Office of Environment and Heritage)
DOE	Department of the Environment
DPI	Department of Primary Industries
EEC	Endangered ecological community
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and magnetic fields
EMR	Electro Magnetic Radiation
EPA	(NSW) Environment Protection Authority
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPI	Environmental planning instruments
ESCP	Erosion and Sediment Control Plan
FBA	Framework for Biodiversity Assessment
GDE	Groundwater Dependent Ecosystems
GHG	Green House Gas
GWh	Gigawatt Hours
ICNG	Interim Construction Noise Guideline
ICNIRP	International Commission on Non-Ionizing Radiation Protection
INP	Industrial Noise Policy
IPP	Independent Power Producer
ISEPP	*State Environmental Planning Policy (Infrastructure) 2007*
Km	Kilometres
KTP	key threatening process
KV	Kilovolts
kV/m	kilovolts per metre
LEP	Local Environmental Plan
LRET	Large-scale Renewable Energy Target

Term	Definition
LUCRA	Land use Conflict Risk Assessment
MR	Main Road
MRET	Mandatory Renewable Energy Target
MW	Megawatt
MW AC	Megawatt Alternating Current
NES	National Employment Standards
NHMRC	National Health and Medical Research Council
Non-Associated landowners	Private property owners near the proposal site that do not have a property agreement with Silverleaf Solar Farm
OEH	Office of Environment and Heritage
OEMP	Operational Environmental Management Plan
OSMS	On-site sewage management
POEO Act	*Protection of the Environment Operations Act 1997*
PCT	Plant Community Types
RBLs	Rating Background Level
REAP	Renewable Energy Action Plan
REP	Regional Environmental Plan
RNP	Road Noise Policy
RTA	Road and Traffic Authority (now Roads and Maritime Services)
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policies
SISD	Safe Intersection Sight Distance
TSC Act	*Threatened Species Conservation Act 1995*
TSR	Travelling Stock Reserves
V/m	Volts per metre

1. Introduction

1.1 Purpose and scope of this document

Silverleaf Solar Farm Pty Ltd (ENGIE) proposes to construct and operate a 120 megawatt (MW) solar farm about four kilometres north of Narrabri between the Newell Highway in the east and Logans Lane in the west (referred to as the 'proposal').

The proposal requires development consent from the Minister for Planning under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This Environmental Impact Statement (EIS) has been prepared to support the development application and identifies and assesses the environmental issues associated with the proposal.

The EIS addresses the requirements of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) and Section 4.15 of the EP&A Act. The EIS has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) which were issued on 22 June 2018 by the Department of Planning and Environment. Appendix A provides a copy of the SEARs and details where each requirement is addressed.

The EIS addresses the assessment requirements of the *Biodiversity Conservation Act 2016* (BC Act) and the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

1.2 Location and context

1.2.1 Location of the proposal site

Solar farm site

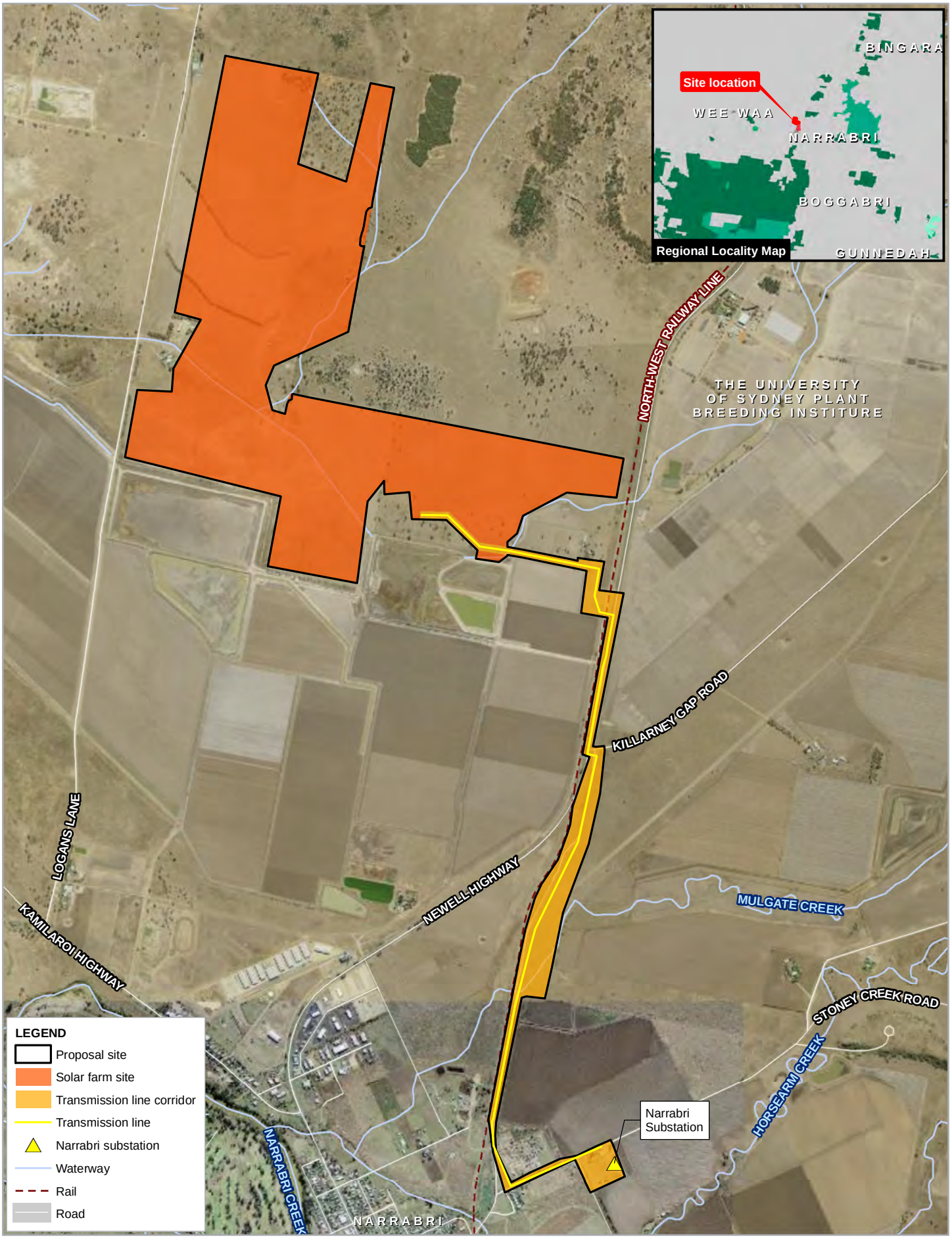
The proposal site is located about four kilometres north of Narrabri and is within the Narrabri Shire Council local government area. The proposal site consists of two rural properties located between Newell Highway in the east and Logans Lane in the west and includes the following lots:

- 330 Logans Lane – Lots 21 to 23 of DP 1174848 (property referred to as the Logans Lane property in this EIS)
- 12461 Newell Highway – Lot 2 DP 586990 (property referred to as the Newell Highway property in this EIS)

The location and extent of the proposal site is shown in Figure 1-1. Further detail regarding the existing properties are shown in Figure 1-2.

Transmissions line corridor

The proposal includes constructing a transmission line between the proposal site and the TransGrid substation located about four kilometres to the south on Stoney Creek Road. The alignment of this transmission line corridor is shown in Figure 1-1.



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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Engie
Silverleaf Narrabri Solar Farm EIS

Site location

Project No. 21-26998
Revision No. 1
Date 25 Jun 2019

FIGURE 1-1

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Data source: General topo - NSW LPI DTDB 2015 & 2015; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Inset map - Geoscience Australia. Created by:jrprice

1.2.2 The proposal site

Solar farm site

The proposal site has an area of approximately 450 hectares and is currently used for agricultural purposes, with the primary use being grazing with some past cropping. The proposal site contains three residential dwellings. Two are located on the Logan's Lane property and one on the Newell Highway property. Existing property access points are available adjacent to each of the dwellings from either Logans Lane or the Newell Highway. The Logans lane property also has a number of sheds to support agricultural activities and these are located around and east of the dwellings. These Associated Landowners have property agreements with Silverleaf Solar Farm for the use of the land for the proposal. Surrounding private properties that do not have agreements with Silverleaf Solar Farm are described as non-associated landowners. These are shown in Figure 6-1.

The proposal site is largely cleared of vegetation, however there are a number of areas of vegetation located along internal and boundary fence lines. Some isolated stands of vegetation are also located within the site, primarily in the northern part of the proposal site.

A low voltage transmission line runs through the southern part of the Logans Lane property and provides power to the dwellings on this property. This low voltage line also provides power to the private airstrip located adjacent to the north-western corner of the proposal site. The alignment of this transmission line is shown in Figure 1-2.

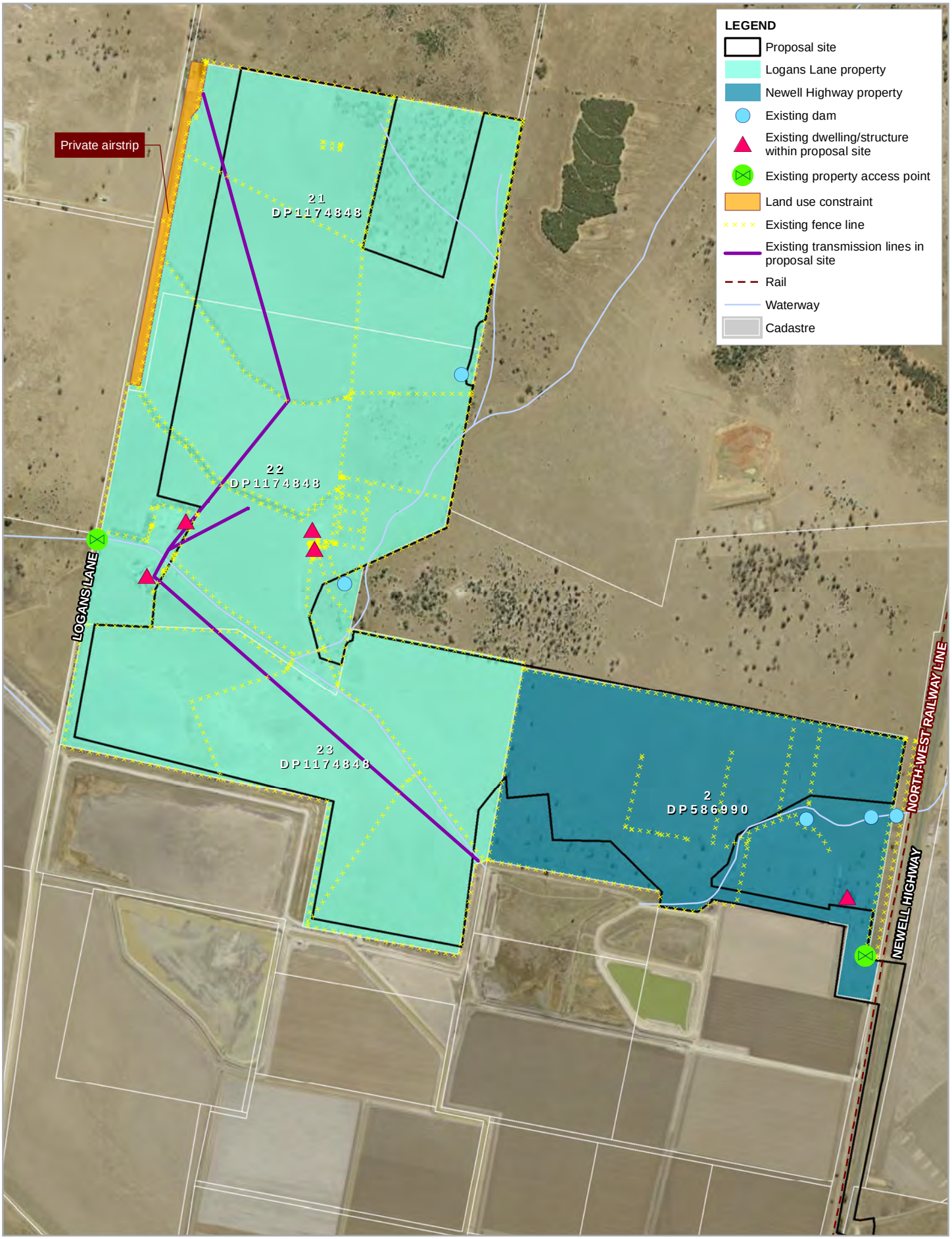
The private airstrip located adjacent to the north-west corner of the solar farm site is used by crop dusting aircraft. The airstrip is located on a separate property and does not form part of the proposal site. The private airstrip is described further in Section 6.6.

A drainage channel is present on the southern part of the Logans Lane property (as shown in Figure 1-2). This channel runs through the site from Logans Lane to the property to the south where gates are located to control water flow. A number of small farm dams are also located across the site, as shown in Figure 1-2.

Transmission line corridor

The 132 kV transmission lines will cross properties owned by Narrabri Shire Council and Road and Maritime Services (RMS). An easement will be required for the transmission line. An indicative corridor width of 90 metres has been identified to allow for design flexibility. The width of the final easement would be significantly reduced once the detailed design has been completed and is anticipated to be around 30 to 45 metres wide depending on detailed design and final arrangement of the 132 kV transmission line.

The proposed transmission line corridor is approximately five kilometres long, running east from the proposed substation at the proposal site to the Newell Highway. It would follow the highway south to a point near the intersection with Killarney Gap Road. The route would diverge from the highway and continue south parallel to the railway line and Old Cemetery Road. It would then turn east at Stoney Creek Road to its connection point at TransGrid's Narrabri substation (refer to Figure 1-1).



Paper Size ISO A4

0 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Engie
Silverleaf Narrabri Solar Farm EIS

Existing site layout

Project No. 21-26998
Revision No. 1
Date 25 Jun 2019

FIGURE 1-2

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Data source: General topo - NSW LPI DTDB 2015 & 2015; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

1.3 Overview of the proposal

Silverleaf Solar Farm Pty Limited (ENGIE) proposes to construct, operate and eventually decommission or recondition a 120 megawatt (MW) AC solar farm to the north of Narrabri in the NSW North West Slopes.

The proposal would consist of the following components:

- Solar arrays consisting of about 440,000 single-axis tracking panels about four metres high, supported by about 5,150 tracker units.
- Construction of a transmission corridor, supporting 132 kV power lines, connecting the proposal site to the existing TransGrid substation located on Stoney Creek Road.
- Inverter and transformer stations evenly distributed across the site, with onsite cabling and electrical connections between solar arrays and panel inverters.
- A step-up substation to increase the voltage to 132 kV to allow connection to TransGrid's substation (final step-up voltage to be confirmed during further consultation with TransGrid).
- Cables and trenches.
- Internal access tracks.
- Operational and maintenance office, including staff amenities block and car parking areas.
- Site storage and maintenance shed.
- Perimeter security fencing.
- Landscaping around the perimeter of the site where required.

No subdivision is planned as part of the proposal. Further details are provided in Section 3.

1.4 The proponent

In Australia, ENGIE S.A., via a joint venture with Mitsui & Co. Ltd. (Mitsui), owns and operates approximately 1,200 MW (gross) of renewable (wind) and gas-fired generating plants in South Australia and Western Australia. ENGIE's joint venture with Mitsui is part of the group of entities that comprise ENGIE ANZ. Silverleaf Solar Farm is the company established by ENGIE ANZ to develop and operate the proposed Silverleaf Solar Farm. A summary of ENGIE ANZ operations is provided in Table 1-1.

Table 1-1 ENGIE ANZ operations

Plant Name	State	MW	Technology
Canunda	SA	46	Wind
Pelican Point	SA	487	Gas CCGT
Synergen	SA	396	Gas/Distillate OCGT
Kwinana	WA	123	Gas Cogen
Willogoleche*	SA	119	Wind

* Currently under construction

In January 2018, ENGIE ANZ demonstrated its firm commitment to the decarbonisation of the energy system by the closure of the Hazelwood Power Station in March 2017 and the sale of the Loy Yang B Power Station. Since early 2017 ENGIE ANZ has been actively developing utility-scale renewable power plants and energy storage infrastructure in Australia.

Also included in ENGIE ANZ are:

- Simply Energy, the ENGIE/Mitsui joint venture's Australian retail energy business with over 670,000 customer accounts.
- The group of companies referred to as ENGIE Services that deliver, among other things, energy and efficiency services, as well as install HVAC, refrigeration, fire, electrical, communications and data systems.

ENGIE ANZ employs over 1,800 people in almost 30 locations across Australia and New Zealand. Globally, ENGIE S.A. and its affiliates (ENGIE Group) have approximately 7 GW of solar and wind power plants in operation and a secured pipeline (with signed contracts) of a further 1.3 GW of solar and 1.3 GW of wind projects.

To deliver projects locally, ENGIE ANZ draws on the operational expertise of the ENGIE Group including ENGIE Solar, which is an expert large-scale solar EPC company with over 11 years' experience and operations in France, USA, India, Africa, Latin America and Asia.

1.5 Structure of this environmental impact statement

The EIS has the following structure:

- Chapter 1 – Introduction – provides a broad overview of the proposal and where it is located.
- Chapter 2 – Need and options considered – describes the need for the proposal, the objectives of the proposal and the options and alternative considered during the proposal's development.
- Chapter 3 – Proposal description – describes the proposal during the construction, operation and decommissioning phases.
- Chapter 4 – Stakeholder consultation – outlines the consultation activities undertaken during preparation of this EIS, matters raised and how these have been addressed.
- Chapter 5 – Planning context – outlines the statutory requirements and explains the steps in the assessment and approval process.
- Chapter 6 – Key environmental issues – Identifies the key environmental issues, assesses the impacts and proposes environmental management measures.
- Chapter 7 – Other environmental issues – identifies other environmental issues, assesses the impacts and proposes environmental management measures.
- Chapter 8 – Environmental management – outlines the environmental management processes for the proposal and also provides a consolidated list of mitigation measures proposed in Chapters 6 and 7.
- Chapter 9 – Proposal justification and conclusion – presents the justification for the proposal, including consideration of the principles of ecologically sustainable development and the objects of the EP&A Act.
- Chapter 10 – References.

2. Need and options considered

2.1 Proposal need

2.1.1 Emission reductions

Australia is one of the largest emitters of carbon dioxide per capita. Electricity generation contributes 33 per cent of Australia's greenhouse gas emissions and is the dominant source of emissions in Australia (Climate Council, 2018). The development of renewable energy projects is one of the most effective ways to achieve reductions in emissions.

The Commonwealth Government established the Renewable Energy Target (RET) Scheme. Since January 2011, the RET has operated in two parts: the Large Scale Renewable Energy Target (LRET) and the Small Scale Renewable Energy Target (SRET). The Clean Energy Regulator expects the LRET of 33,000 gigawatt hours to be achieved by 2020.

A global climate agreement was signed under the United Nations Framework Convention on Climate Change in Paris in 2015. The Paris Agreement sets in place a framework for all countries to take climate action. This includes a global goal to hold average temperature increase to below 2°C, and to pursue efforts to keep warming below 1.5°C above pre-industrial levels. Australia has set a target to reduce emissions by 26-28 per cent below 2005 levels by 2030, which builds on previous emission reduction targets.

2.1.2 Energy reliability

The Commonwealth Government's energy security policies support the development of renewable energy sources. Renewable energy sources contribute to improving the reliability of national energy supplies, and the reliability of the National Electricity Market.

Australia's coal-fired power stations are ageing and becoming increasingly expensive to maintain and upgrade. High energy demand on the network during heat waves in recent years has seen a number of existing coal-fired power stations fail, resulting in blackouts for large areas of Australia. The development of new renewable electricity projects is required to provide new supply to the network, and reduce reliance on ageing coal-fired power stations.

Significant economic investment would be required to upgrade ageing and emission intensive coal-fired power stations, and to construct new coal-fired power stations. Renewable energy developments have become cheaper to construct compared to new coal-fired power stations.

2.1.3 NSW Government Renewable Energy Action Plan

In September 2013 the NSW Government released the NSW Renewable Energy Action Plan (REAP). The plan details the Government's plans to increase renewable energy in NSW at the least cost to the consumer.

The REAP was launched with three goals, and 24 actions. In December 2018 The NSW Government completed the implementation of the REAP. The three goals that have been successfully implemented are:

- Attract renewable energy investment
- Build community support for renewable energy
- Grow and attract renewable energy expertise

The development of the proposal achieves all of the NSW Government goals under the REAP. The proposal assists to meet the NSW Government's goals of providing a secure, affordable and renewable energy future for NSW.

2.1.4 Project benefits

The proposal achieves a number of complimentary benefits by increasing supply to the network in the most economical way, while assisting to achieve Australia's emission reduction targets. The proposal is being developed to produce renewable energy and in doing so will provide the following benefits:

- Reduce greenhouse gas emissions by providing an alternative renewable energy source.
- Contribute towards meeting Australia's commitments to the Paris Agreement.
- Provide direct and indirect employment opportunities during construction and operation leading to social and economic benefits for the local community.
- Diversification of revenue for affected land holders.
- Allowance for a future battery energy storage system to be installed that would contribute to electrical grid system stability.
- Improved reliability of electricity supply and assist in reducing energy supply costs.

2.2 Proposal objectives

The objectives of the proposal are to:

- Select and develop a site which is suitable for commercial scale solar electricity generation.
- Provide a clean and renewable energy source to assist the NSW and Commonwealth Governments to meet Australia's renewable energy and greenhouse gas reduction targets.
- Develop a proposal which is acceptable to the local community.
- Provide local and regional employment opportunities and other social benefits during construction and operation.
- Construct a proposal with minimal adverse environmental impacts.

2.3 Alternatives and options considered

During the development of the proposal, a number of alternatives were considered. Options in relation to the location of the site, generation capacity and the proposed technology were all assessed.

2.3.1 The 'do nothing' option

The 'do nothing' option would involve not constructing the solar farm. An opportunity to construct a renewable energy source would be lost. This would have the following implications:

- Reductions in emissions due to the proposal and its contribution to the LRET would not be realised.
- The move towards cleaner electricity generation would not be achieved.
- No additional electricity generation and supply into the Australian grid would be provided.
- No social and economic benefits by creating direct and indirect employment opportunities during construction, operation and decommissioning of the solar farm would be achieved.

The 'do nothing' option would avoid the potential environmental impacts associated with the construction and operation of the proposal. These potential impacts include vegetation impacts, construction noise, traffic and dust, visual impacts and a loss of agricultural production at the site. Given the benefits of the proposal, the 'do nothing' option is not considered to be a preferred option.

2.3.2 Alternative technologies

Alternative renewable energy solutions

The LRET and Renewable Energy Action Plan (REAP) outline the commitment by both Australia and NSW to reduce greenhouse gas emissions and increase the supply of renewable energy. Other forms of large scale renewable energy accounted for in the LRET include wind, hydro-electric, biomass, and tidal energy. The feasibility of solar, wind, hydro-electric, biomass, and tidal projects depends on the availability of energy resources, site location and grid capacity.

ENGIE currently has interests in wind projects. Wind projects were considered to be more suitable to South Australia's world-class wind resources. Superior solar resources were identified in New South Wales, providing excellent opportunities for solar projects.

ENGIE proposes to develop solar farms to diversify its portfolio within Australia. This will build upon its experience from constructing and operating solar projects across the globe. One of the benefits of solar development is that this technology is generally more readily deployable and easier to establish than other types of renewable energy such as wind.

Alternative photovoltaic technologies

ENGIE is exploring a range of solar photovoltaic (PV) technologies for this site. This includes mono and poly crystalline, as well as bi-facial panels. The difference between mono and poly crystalline PV panels is mainly due to manufacturing process and generally results in more energy efficient panels (mono) with an increased cost. Bi-facial PV panels use the rear of the panel to capture light reflected off the ground. Bi-facial is the most recent evolution of PV panel technology and based on proven manufacturing processes.

The proposal would use solar photovoltaic (PV) technology. This technology was selected due to the following benefits:

- It is commercially proven, with a lower technical risk.
- It has a lower environmental impact than other technologies.
- The Narrabri region is very suitable in terms of solar resources.
- It has developed rapidly, and has the potential for further technological efficiencies.
- Solar PV systems are comparatively easy to decommission, and the land is then able to be rehabilitated to other productive uses.

A number of PV module and mounting technologies have been considered. The final arrangement will be determined in the detailed design.

Panel mounting systems

Panel mounting systems that have been considered include fixed-tilt, north-facing and single-axis mounting systems. The proposal would incorporate the single-axis mounting system.

Single-axis mounting systems are typically aligned north-south and track east to west following the path of the sun throughout the day. This system is more expensive to install, but provides a higher yield per panel. This also allows for a smaller development footprint compared to a fixed-tilt system with an equivalent generation capacity.

Preferably, the panel mounting system would be mounted on piles to be either screwed or pile driven depending on geotechnical conditions. This would eliminate the need for concrete foundations, reduce ground disturbance and improve the ability to decommission equipment and rehabilitate the land.

Battery storage

Battery storage has been considered for the proposal. Battery storage allows for the electricity delivery to the grid to be “smoothed”, particularly in times of high demand or at night when power is not being generated by the panels.

Although not included as part of the proposal at present, the proposal may be modified in the future to include battery storage. The project layout has been developed to provide space for a batter storage facility. A separate environmental assessment would be completed if battery storage is proposed in the future.

2.3.3 Alternative site locations

A number of alternative locations were considered across NSW during the site selection process. The consideration of alternative sites looked at minimising environmental impacts, while also maximising the generation capacity.

The proposal site was identified as the preferred location, based on the following:

- Availability of an abundant solar resource.
- Proximity to an existing electricity substation with capacity to connect.
- Availability of appropriately sized land.
- Suitability in terms of environmental constraints due to past disturbance, meaning the site would not require large-scale vegetation clearing.
- Absence of flood risk.
- Access to major transport routes such as the Newell and Kamilaroi Highways.
- Proximity to a large regional centre.
- Absence of any high value agricultural land.

2.3.4 Alternative site layouts

During the development of the proposal, a number of alternate site layouts were investigated. These layouts were generally in response to environmental considerations and consultation with landowners (both on the subject properties or adjacent to the proposal site). The site layout has been developed to reduce the potential environmental impacts. Key features of the site layout that reduce environmental impacts are:

- Minimising impacts on areas of threatened vegetation communities, with a focus on high value vegetation.
- Inclusion of a buffer around the existing airstrip located adjacent to the north-west corner of the proposal site to minimise potential impacts to operation of this business.
- Following consultation with landowners, inclusion of buffer zones around residential dwellings that are to remain on site.
- Inclusion of buffers around the edge of the site to allow for potential vegetation screening.
- Inclusion of buffers around the two sites of Aboriginal heritage significance.
- Location of the primary site access on Logans Lane and not the Newell Highway to minimise vehicle movements from the Highway directly into the property.
- Retention of the existing drainage channel running through the southern part of the Logans Lane property.

2.4 Proposal justification and summary of benefits

The proposal is justified as it meets the objectives set out in Section 2.2, while minimising impacts to the environment. The site selection process involved a rigorous assessment of the site's suitability for a solar farm development, whilst minimising environmental impacts and avoiding land use conflicts.

The proposal site was selected because it has the required attributes to achieve the power generating objectives which include a large area of developable land, abundant solar resource and proximity to an existing electricity substation. Other factors that make the site suitable for a solar farm development include minimal flood risk, absence of high-value agricultural land or the need for large areas of vegetation clearance. The development of the proposal would not compromise the agricultural production of adjoining properties. The proposal would not prevent the site being returned to agricultural uses, following appropriate rehabilitation, at the end of its operational life.

The design of the proposal has been developed to minimise environmental impacts at the site and in surrounding areas. The proposal would make a positive contribution to the environment. Together with other renewable energy developments, it would contribute to a reduction in greenhouse gas emissions from the generation of electricity. This would assist in meeting Australia's international commitments to reduce emissions.

The proposal would assist the Commonwealth Government's targets of increasing the proportion of electricity generated from renewable sources. It would also assist in providing improvements to the reliability of the national electricity network by adding capacity in the most economical way.

3. Proposal description

3.1 The proposal

ENGIE proposes to construct, operate and eventually decommission or recondition a 120 megawatt (MW) AC solar farm to the north of Narrabri. The proposal site is located at the following properties:

- 330 Logans Lane – Lots 21 to 23 of DP 1174848
- 12461 Newell Highway – Lot 2 DP 586990 (part of property)

The proposal site has an area of approximately 450 hectares. The solar installation would occupy in the order of 380 hectares, which constitutes the majority of the proposal site (84%). The location and layout of the proposal are shown in Figure 1-1.

3.1.1 Elements of the proposal

The proposal would consist of the following components:

- Solar arrays consisting of about 440,000 solar panels four metres in height.
- The arrays would be supported by approximately 20,000 piles, driven or screwed into the ground to support the solar array's mounting system.
- The arrays would be single-axis tracking panels, which would consist of about 5,150 tracker units.
- Construction of 132 kV overhead power lines, connecting to TransGrid's substation located on Stoney Creek Road approximately five kilometres from the proposal site.
- Between 25 and 30 inverter and transformer stations evenly distributed across the site.
- Onsite cabling and electrical connections between the solar arrays and panel inverters.
- A step-up substation to increase the voltage to 132 kV to allow connection to TransGrid substation (final step-up voltage to be confirmed during further consultation with TransGrid).
- Cables and trenches.
- Internal access tracks to provide access throughout the site during operation.
- Operational and maintenance office, including staff amenities block and parking areas.
- Perimeter security fencing.
- Landscaping around the perimeter of the site where required.

Construction of the proposal is expected to take up to 12 months. The solar arrays and associated components have an estimated operational life of 35 years. At the end of its operational life, the proposal would be either reconditioned or decommissioned.

Reconditioning would involve replacing original components with new components that reflect technology available at that time. Decommissioning would involve removing all above ground infrastructure and rehabilitating the site to allow it to be used for other purposes such as agriculture.

The proposal has a capital investment in the order of $180 million.

3.2 Key features of the proposal

3.2.1 Site layout

The site layout is shown in Figure 3-1 and shows the elements listed in Section 3.1.1. The following areas would not be used for the installation of solar panels:

- Buffer area around the private airstrip located adjacent to the north-west corner of the proposal site.
- Existing dwellings on the Logans Lane property including the near sheds and other support buildings.
- Existing dwelling on the Newell Highway property.
- Existing drainage channel traversing the southern component of the Logans Lane property.
- Footprints of the proposed access track network, proposed substation, operational and maintenance office building.
- A buffer around the perimeter fencing, allowing vegetation to be planted as a visual buffer.
- Buffer areas around two site of Aboriginal heritage significance (refer to Section 6.3).

The extent of the land to be excluded from development for the proposal is shown in Figure 3-1. No subdivision is required for the proposal.

3.2.2 Solar array layout

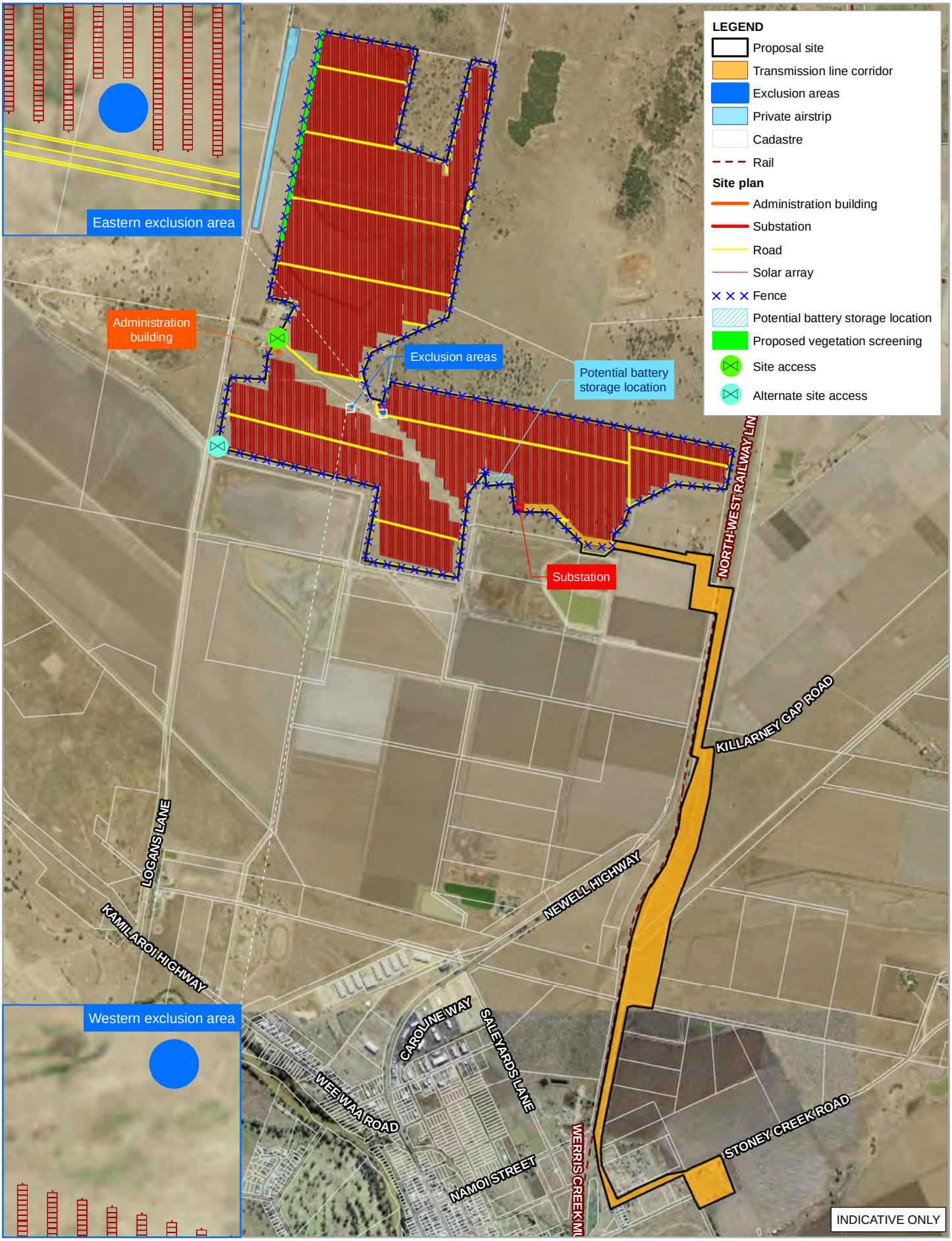
The panels convert sunlight into electric current (direct current). The inverters convert the variable direct current output of the photovoltaic solar panels into an alternating current that can be fed into the electricity grid. More details on the inverters are provided in Section 3.2.4.

The detailed design will confirm the final layout, quantity and type of panel to be installed. The concept layout for the solar arrays and their position in relation to the solar farm boundary are shown in Figure 3-1.

The panels would likely consist of 72 cell polycrystalline solar photovoltaic panels. ENGIE is currently investigating the use of bi-facial photovoltaic panels on a South American solar farm. Should this technology prove to be beneficial, this technology would be considered for the proposal.

The panels would be mounted on single-axis tracking structures. In total there would be about 5,150 tracking units on site, each controlling 85 panels.

The selected panels and mounting system would be installed on approximately 20,000 piles which would be driven or screwed into the ground. The mounting system would be placed with rows of panels approximately six metres apart. Racks would then be installed on the poles to allow solar panels to be installed. Examples of the mounting system with and without panels are shown in Figure 3-2 and Figure 3-3 respectively.



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Engie
Silverleaf Narrabri Solar Farm EIS

The proposal

Project No. 21-26998
Revision No. 1
Date 25 Jun 2019

FIGURE 3-1

N:\AU\Orange\Projects\21\26998\GIS\Maps\Deliverables\EIS\21_26998_Z003_EIS_SolarFarmLayout.mxd

Data source: General topo - NSW LPI DTDB 2015 & 2015; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

Figure 3-2 Example of single-axis mounting system before panel installation

Figure 3-3 Example of single-axis mounting system after panel installation

3.2.3 Transmission corridor

The 132 kV transmission lines would be installed overhead and extend approximately five kilometres from the proposed substation at the proposal site to TransGrid's substation located on Stoney Creek Road (refer to Figure 3-1). The lines would be installed on wood or concrete poles, between 20 and 30 metres high and spaced at intervals of around 50 metres. Stays would be required at locations where the transmission line changes direction.

The transmission line would cross from the west to the east of the Newell Highway just south of the existing Newell Highway property access point. At this location it would also cross the North-West Railway Line which runs parallel to the Newell Highway. RMS and the Australian Rail Track Corporation (ARTC) have been consulted regarding the crossing point design and further consultation will be undertaken during detailed design to confirm that it meets both RMS and ARTC design standards. The transmission lines will cross properties owned by Narrabri Shire Council and RMS. ENGIE has consulted with these landowners.

An indicative width of 90 metres has been identified for the transmission corridor to allow for design flexibility. An easement will be required for the transmission line. The width of the final easement would be significantly reduced once the detailed design has been completed and it is anticipated to be between 30 and 45 metres wide depending on detailed design and final arrangement of the transmission line.

3.2.4 Inverters and transformers

The proposal may either use centralised inverters or string (decentralised) inverters. The preferred option would be selected during detailed design. The inverters convert the variable direct current output of the photovoltaic solar panels into an alternating current that can be fed into the electricity grid.

Between 25 and 30 inverter and transformer stations would be installed across the site. Each of the stations would contain a centralised inverter and a transformer (either 11 kV, 22 kV or 33 kV). The overall voltage would be matched to the operating input voltage range of the inverters.

Centralised inverters have a higher capacity than de-centralised inverters, which enables them to be connected to a larger number of solar arrays. String inverters have a lower capacity and connect to a single solar array string. These inverters would be installed directly onto the mounting structures. If string inverters are implemented, the centralised inverter in or on each of the boxes or skids would not be required.

The module interconnections would be as short as possible to reduce the length of the cabling loops. This would minimise the potential for adverse impacts from events such as lightning strikes.

The indicative dimensions of the inverter and transformer stations are 11 metres long by 2.5 metres wide and 2.5 metres high. The dimensions would depend on the type of station selected and this would be determined during detailed design. Examples of an inverter and transformer station is shown in Figure 3-4.

Figure 3-4 Example of an inverter and transformer station

This station would be positioned within the infrastructure corridor shown in Figure 3-1 along the existing transmission line corridor. The exact location would be confirmed during detailed design. It is likely that the delivery station would be combined with the substation.

3.2.5 Site cabling

Direct current cabling would run from the back of the panels, along the mounting structure in cable trays, to a combiner box. The combiner box would have a consolidated run of direct current cabling to connect with the main transformer and inverter station. The cable run from the combiner box to the inverter and transformer would be buried in trenches.

Alternating current cables would connect the inverters and transformers with the on-site substation. The on-site alternating current voltage would be determined at the detailed design stage, but is likely to be 33 kV. Alternating current cables would have diameters between 70 mm and 300 mm and be buried in trenches. All junctions and turning points would be clearly marked with cable warning markers.

Site cable trenches

The final depth of the cable trenches would be determined at the detailed design stage, but is likely that trenches would be up 0.9 metres deep. Sand would be used to backfill the trenches around the cables, with excavated spoil placed over the sand. Trenches would be backfilled to match existing surface levels.

Underground cabling on site would be designed to comply with all relevant standards. This would take into account the temperature of the ambient environment in which the cables and ancillaries would operate. The allowable currents would be compatible with an acceptable warming-up as stated in the standards and the manufacturers' recommendations.

Trenches would accommodate and protect the cables and would contain:

- Power cables to export the production from the solar arrays to the combiner boxes
- Power cables to export the production from the combiner boxes to the inverter and transformer stations

- Copper wire for equipotentiality (earthing)
- Medium voltage power cables to connect the inverter and transformer stations and the substation
- A fibre optic cables
- Communications cables

3.2.6 Substation

A 33 kV to 132 kV step-up substation would be constructed within the proposal site. The potential substation location is shown in Figure 3-1.

The substation would convert power generated by the solar farm to 132 kV to allow transfer to the network. The transfer will be via a new 132 kV transmission line to the TransGrid substation as described in Section 3.2.3.

The substation would contain the following infrastructure:

- 33 kV switchgear
- 33 kV/132 kV transformer
- Circuit breakers for the connection of the 132 kV transmission line
- Anti-lightning poles about 21 metres high

The substation would be constructed on concrete pads and crushed rock with dimensions of 55 metres long by 40 metres wide. Figure 3-5 provides an example of a 132 kV substation.

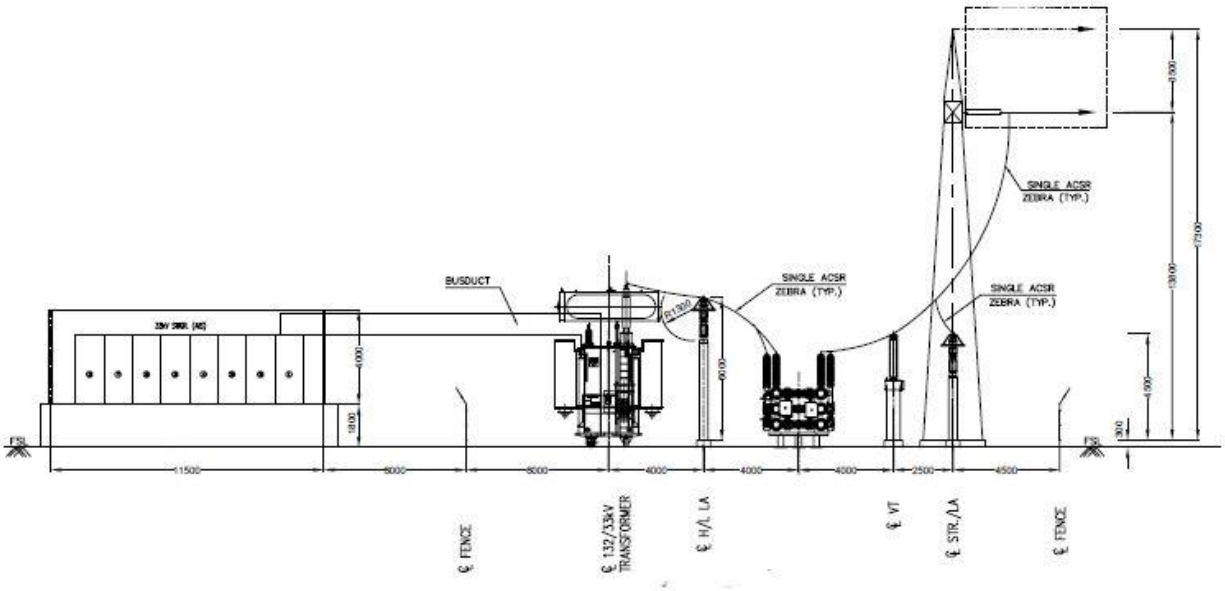


Figure 3-5 Example of substation to be located on site

3.2.7 Operation and maintenance office

The proposal would require a site office which would be used by maintenance personnel during operation. ENGIE is investigating the use of the farm manager's residence on the Logans Lane property as a potential site office. Discussions with the landowner will determine if this residence is suitable.

If this residence is not suitable for any reason, a site office would be developed. This may either be a prefabricated structure that is imported to site, or constructed at site.

If a new building is required to house the office it would have dimensions of 20 metres long by 10.5 metres wide and about 6.75 metres high. The indicative office location of a new site office is shown in Figure 3-1. The layout of a typical administration building is shown in Figure 3-6.

The building would include office space and staff amenities. Water for the office would be delivered to site and stored in a small water tank. Toilet facilities would be connected to a septic tank that is installed in accordance with Council requirements. This structure would comply with all relevant Australian Standards and building codes.

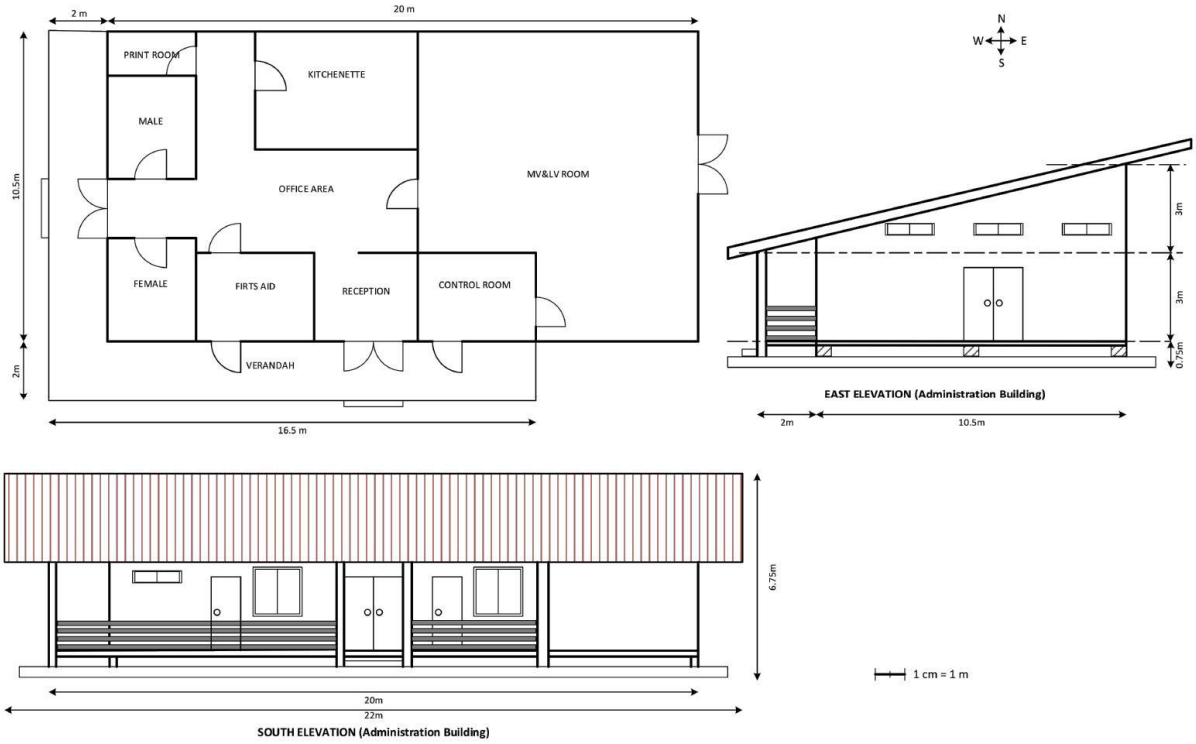


Figure 3-6 Administration building

3.2.8 Storage building

A storage building would be required to house maintenance equipment, spare parts and other operational needs. The storage building would have dimensions of 40 metres long, 20 metres wide and nine metres high. The location of the storage building is shown in Figure 3-1. The layout of a typical storage building is shown in Figure 3-7.

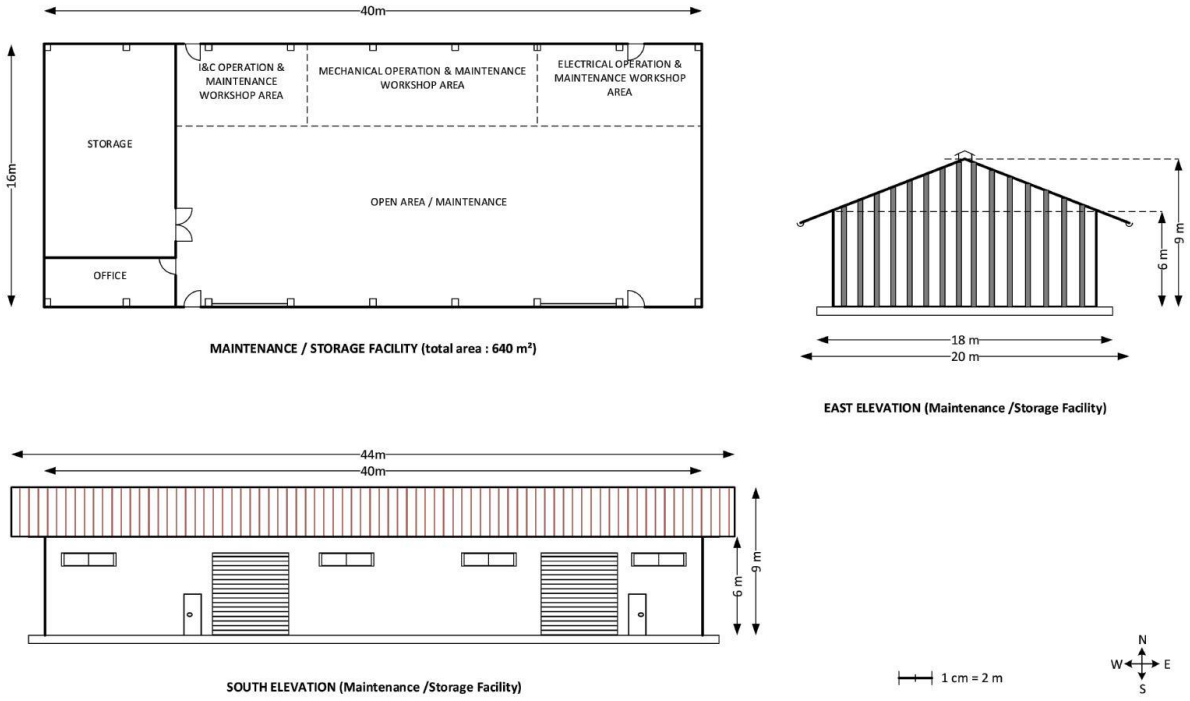


Figure 3-7 Storage building

3.2.9 Battery storage

The site layout includes the allowance for a battery storage system to be installed in the future (refer to Figure 3-1). The design of this area, including the type of batteries and the size of the storage facility, would be undertaken as a subsequent phase of work if ENGIE decides to proceed with installing battery storage. Further environmental assessment would be considered at a later stage once the nature of this storage facility is known.

3.2.10 Site access and access tracks

Site access

Vehicular access would be either from a new driveway along the property frontage near the southern boundary of the site, or via the existing Logans Lane property access points. The location of the driveway would be determined during detailed design. Its location would be sited to avoid the need to clear native vegetation located along Logans Lane or within the site. This access would be constructed to comply with Narrabri Shire Council's standards. The potential access locations are shown in Figure 3-1.

Intersection treatments

The proposed treatment option for the Kamilaroi Highway and Logans Lane intersection is the Basic Right turn (BAR) that includes shoulder widening. This will provide a safer movement for vehicles travelling on the Kamilaroi Highway, allowing them to slow and pass to the left of turning vehicles entering Logans Lane. It would reduce the potential risk of rear-end accident for vehicles travelling west along the Kamilaroi Highway. This type of intersection treatment is shown in Figure 3-8.

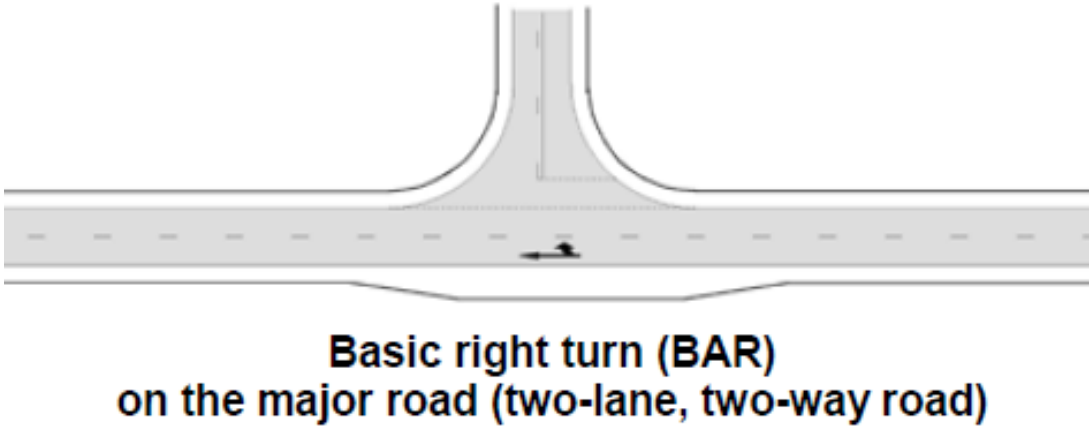


Figure 3-8 BAR Intersection for Rural road

Upgrade to Logans Lane

If required, Logans Lane would be upgraded prior to construction to accommodate large trucks required for deliveries and construction equipment. Logans Lane would be re-graded to remove ruts and uneven surfaces. A layer of compacted gravel, certified as being free of contamination, would be installed.

The intersection of Logans Lane and the Kamilaroi Highway will be upgraded to meet safety standards and accommodate the movement of large trucks. Consultation with Narrabri Council and RMS would be completed as part of the detailed design to confirm the intersection design. Section 6.7 describes the road network in the proposal area.

Internal tracks

Internal access tracks would be provided to all site facilities including the office building and substation. A car park would also be provided on site near the office. An internal network of tracks, including a perimeter track around the entire boundary fence, would provide access to the solar arrays and site equipment. Access tracks would be located in order to minimise any vegetation clearance. The design of access tracks would be dependent on the final site layout and would be confirmed during detailed design.

All tracks would consist of a compacted gravel layer. The gravel would be clean material that is certified as being free of contamination. If required, geotextile would be laid between the soil and the gravel.

3.2.11 Site security

Security fencing about 2.1 metres high would be installed around the perimeter of the site. A security gate of a similar height to the fencing would be installed at the site access points outlined in Section 3.2.10. The fencing is expected to consist of cyclone fencing. This would be confirmed during detailed design.

3.2.12 Landscape plan

A landscape plan would be developed in consultation with adjacent landowners. The aim of the plan would be to minimise the visual impacts of the proposal (in particular the arrays and the ancillary infrastructure) on the adjacent landowners. Planting within the site to assist in providing visual screening would consist of locally occurring species, with a particularly focus on using native species removed by construction.

Vegetation would be planted within an approximately five-metre-wide buffer zone around the perimeter of the site in the vicinity of potentially impact properties. Vegetation (i.e. trees) would be planted in two staggered rows.

Figure 3-1 includes an indicative layout of the proposed screen plantings based upon the location of dwellings at which visual impacts maybe experienced. The position of any screening vegetation would be confirmed during detailed design and following consultation with the relevant landowners as described in the landscape and visual assessment in Section 6.4.

3.3 Construction activities

3.3.1 Indicative timeline

Construction is expected to take 12 months and is planned to commence in the first half of 2020.

3.3.2 Indicative work methodology

The main construction activities would include:

- Site establishment and preparation including:
  - Establishing site access
  - Removing any existing infrastructure on site (e.g. haysheds, water tanks) which are not to be retained
  - Adjustment of existing low voltage transmission line traversing the site, the alignment of this transmission line is to be confirmed during detailed design
  - Removing existing internal fences (if required)
  - Establishing compound area and laydown areas
  - Installing environmental controls
- Construction of internal access tracks and any drainage infrastructure
- Installing the steel post foundation system for the solar panels, followed by mounting system and then panels
- Installing underground cabling (trenching), invertor and transformer station and delivery station, and connecting communications equipment
- Constructing the substation and associated transmission line
- Landscaping works as required
- Fencing works as required
- Construction of the operations and maintenance office and storage building
- Removing temporary construction facilities and rehabilitation of disturbed areas

3.3.3 Construction hours

Construction hours would be in accordance with the *Interim Construction Noise Guideline* (DECC 2009) (ICNG) which defines the standard construction working hours as follows:

- Monday to Friday: 7:00 am to 6:00 pm
- Saturday: 8:00 am to 1:00 pm
- Sundays and public holidays: no work

Works outside of these hours is unlikely to be required. Should works outside these hours be required nearby residents would be notified. This would involve justifying why works are required outside the standard hours and outlining the timing, duration and potentially expected noise levels.

3.3.4 Plant and equipment

Equipment used during construction would include earth-moving equipment for civil works, diesel generators, trucks and cranes. Noise outputs are similar to farm machinery such as tractors. Pile driving of the solar panel foundations would be undertaken using a machine which screws or hammers poles into the ground.

Construction of the proposed transmission line would use equipment such as excavators, cranes, jinker trailers (for delivery of poles), elevated work platforms, brake and winch trucks.

3.3.5 Earthworks

The proposal would involve minimal earthworks because the poles supporting the solar array's mounting system would be driven or screwed into the ground. The proposal would not result in any substantial earthworks to level the ground as the array can be positioned on land with a 5 to 10 per cent slope. Minor localised earthworks may be required to areas where there is a sharp change in the slope that exceeds 10 per cent, although this is not anticipated as part of the proposal.

Earthworks would be required in the northern part of the proposal site in order to level the ground in the location of an existing borrow pit used by the landowner. Some earthworks would also potentially be required to fill any existing dams on site that are not to be retained.

The majority of ground disturbance would be in relation to levelling ground for ancillary structures such the substation, and invertor and transformer stations. Some minor earthworks would be required to construct the internal access tracks and to excavate trenches for the cables. The trenches would be backfilled to match the adjacent land surface.

3.3.6 Construction compounds and laydown areas

A temporary construction compound would be established on site. The temporary compound would include a site office and amenities. The location of the compound would be determined during the detailed design phase and would be positioned in an area which is not required for the final site layout. The construction office and staff amenities building would include the following facilities:

- Bathroom facilities
- Changing rooms
- Dining room
- Administrative office
- Undercover storage area

The use of the existing residential dwellings on site as a construction site office is to be investigated further during detailed design. In the event these dwellings are not suitable for use as an office, a prefabricated structure would be installed. This temporary structure would be delivered to site by truck and removed from site when required. Parking areas would also be provided in the vicinity of the amenities building.

Designated laydown areas would be developed on site for the delivery and storage of materials. Temporary hardstand areas, consisting of compacted gravel or similar, would be constructed and then progressively rehabilitated when no longer required. The location would be determined during detailed design and construction planning. All laydown areas would be located within the proposal site.

3.3.7 Construction workforce

It is anticipated that a maximum of up to 120 construction personnel (including labourers, construction supervisors and technicians) would be required during the peak construction periods. Outside of these peak periods a workforce of about 50 is expected to be on site.

3.3.8 Construction traffic and access

Construction traffic numbers

Peak traffic activities would be expected in months 4-8 of the 12 month construction program as there would be frequent deliveries of equipment and infrastructure during this period. Non-peak periods would be months 1-3 which would involve site establishment and minor traffic movements, and months 9-12 when traffic would be associated with demobilisation and site reinstatement works.

There would be a maximum short-term peak of 60 heavy vehicle movements per day (i.e. to and from site is two movements). This peak would not last for more than two or three days and would take place in the peak construction period in months 4-8. Outside of this peak period, approximately 80 heavy vehicle movements per week (13 per day on average) would access the site. This number could be lower if B-doubles are used rather than semi-trailers. The peak vehicle movements would likely occur during the installation of the panels as trucks would be delivering panels, and mounting structures to site during this phase.

A maximum of 240 light vehicle movements per day would be required during peak periods of construction. Consideration would be given to using buses to transfer workers from Narrabri to site, however this would be confirmed during detailed design and would be outlined in the traffic management plan to be developed for the proposal.

Vehicle movements would generally occur during standard construction hours and just before and after to allow workers to enter and leave site at the beginning and end of shift.

Oversized vehicles may be required to access the site after hours in line with any RMS, Narrabri Shire Council or NSW Police requirements. It is anticipated that three over-sized vehicle trips will be required to deliver large plant and components such as the transformer for the substation. Three oversized vehicle trips would also be required during decommissioning. Oversized vehicles such as a 50 tonne crane may also need to access the site to place the infrastructure such as the substation components. A maximum of ten to twelve oversized vehicle and large crane movements are expected for the life of the proposal, including construction and decommissioning phases. Details on construction traffic and transport management are provided in Section 6.7.

Construction parking

All vehicles used by construction workers would be parked in designated car parking areas on site. These areas would be determined during detailed design and construction planning, and would be identified in the traffic management plan to be prepared for the proposal.

Construction access

Construction access to the site would be via Logans Lane. Logans Lane is accessible off the Kamilaroi Highway which is located to the south of the proposal site. Access to the Kamilaroi Highway from Narrabri would be via the Newell Highway.

Transmission line traffic and access

Access to the proposed transmission line corridor would be from the nearest available public road. Where possible, the number of access points to the corridor would be limited and existing access points along the corridor would be used where possible. Access to the corridor would be determined following further consultation with all relevant stakeholders and landowners.

3.3.9 Construction materials

Approximate volumes of the following materials would be required for construction:

- 8,000 m^3 of gravel for access tracks and preparation of sites for all ancillary infrastructure
- 10,000 tonnes of steel for the piles to support the panel array mounting systems
- 900 m^3 of concrete for foundations for any structure such as the operation and maintenance office
- 10,000 m^3 of sand to backfill cable trenches

Water would be required during construction primarily for dust suppression, but also for other activities such as vehicle washing. It is estimated that about 100 mega litres of water would be required during construction.

Where possible this would be sourced from rain water tanks already on site or those to be installed on any temporary structures on site. If water from tanks is not available water would be sourced from a Council water filling station or a similar alternative location and trucked to the site. The source of water would be determined during detailed design and construction planning.

3.4 Commissioning of the proposal

Commissioning is expected to take up to two months and would commence following the completion of construction. The commissioning phase would involve the testing all aspects of the proposal and would include the connection of the proposal to the electricity network.

3.5 Operation of the proposal

3.5.1 Hours of operation

Daily operations and maintenance by site staff would be undertaken during standard working hours:

- Monday – Friday 7:00 am to 6:00 pm
- Saturday 8:00 am to 1:00 pm

Operation and maintenance work may be occasionally extend beyond standard working hours. Outside of maintenance activities or emergencies, night works or work on Sundays or public holidays are unlikely to be required. The solar farm would generate electricity during daylight hours which means that during summer months when days are longer, it would operate prior to 7:00 am and after 6:00 pm.

3.5.2 Workforce

The proposal would employ up to six full time workers. The workforce requirements would be confirmed at the commencement of operations. These workers would work on site Monday to Friday. The site would also be remotely operated (particularly during the weekends when full time staff are not working).

The number of site workers would potentially increase when maintenance activities are required. The number of people on site would further increase during any major outages for the solar farm. These events are likely to be rare and short-term in nature.

3.5.3 Maintenance activities

Once operational, daily activities would include operations and maintenance tasks such as:

- Visual inspection of the solar arrays and other infrastructure, including the potential use of drones.
- General maintenance of infrastructure including cleaning activities.
- Management of vegetation on the site including both landscaping and the grass located below the arrays. This would include a monitoring program to manage any bare areas to minimise erosion.
- Response to security breaches.
- Response to major outage events.
- Replacement of equipment and infrastructure, as required.

It is expected that the majority of maintenance activities would be undertaken by the full time staff employed for the site. During normal operation, the number of vehicles present on the site would be limited to staff vehicles. During periods of increased maintenance activities the number of people and vehicles on site would increase. Operational activities such as maintenance would be undertaken primarily during standard work hours.

Major outage works would potentially be required outside the standard hours; however these would be infrequent. During major outages 20 to 30 vehicles may be present at any one time, including some larger vehicles such as trucks.

3.5.4 Water use during operation

Water would be required during the operation to clean the panels during maintenance works. It is estimated that about 2.5 mega litres of water would be required per year. Water would be source from onsite rainwater tanks where possible, however the use of town water (which would be trucked to site) may also be required.

3.6 Reconditioning or decommissioning of the proposal

At the end of its operational life, proposed to be 35 years, the proposal site would be either reconditioned or decommissioned.

3.6.1 Reconditioning

Towards the end of the proposal's operational life, there is potential for the infrastructure to be upgraded to extend the life of the plant by replacing components with technology that is current at the time.

It is likely that the reconditioned proposal would operate in a similar manner to the proposal described in this EIS. A review of the operations would be undertaken to confirm whether the operation of the reconditioned plant is consistent with the project approval for which this EIS has been prepared. Should further land be required as part of the reconditioning works, further assessment and environmental approvals may be required.

3.6.2 Decommissioning

In the event that reconditioning of the proposal is not feasible, the proposal would be decommissioned. It would be disconnected from the electrical transmission network and all above ground infrastructure would be removed from site. Decommissioning would take approximately six months to complete.

The solar panels would be removed for recycling, together with the steel associated with the single-axis tracking system, the inverter and transformer systems. Associated cabling and conduits would be removed where possible.

Under the proposed lease agreements with the landowners, ENGIE must remove the solar farm infrastructure except for any cables which are over 500 millimetres underground. Internal access roads may remain if the landowner can make use of them, otherwise these would be removal with the land rehabilitated.

Key elements of proposal decommissioning would include:

- The solar farm's generator would be disconnected from the metering point.
- The solar arrays would be removed, including the foundation poles, with the materials to be reused or recycled where possible.
- All site amenities and equipment would be removed and materials recycled or reused, wherever possible.
- Poles and cabling would be removed and recycled (some infrastructure 50 centimetres below ground may be left in place).
- Fencing would be removed unless it is requested by the landowner to remain.
- Rehabilitation of the site would comply with requirements that will be agreed during consultation with the landholder.

ENGIE would also restore the ground surface to a suitable condition for pastoral or other agricultural use and leave the land in a safe condition. ENGIE intends for wire, transformers, and switchgear to be recycled in accordance with all national and international regulations through a local third party. ENGIE would seek out decommissioning and recycling partners that hold R2 Certification (for electronics) or are members of the Australian Metal Recycling Industry Association (for bulk metals). Traffic generated during decommissioning would be similar in type but of shorter duration than that required for the construction phase.

4. Stakeholder consultation

4.1 Community consultation

A consultation strategy was implemented when preparing the EIS to assist to identify key stakeholders and issues for consideration. This involved consultation with a range of community stakeholders. The strategy was used to inform stakeholders of the proposal and to allow any matter of concern to be raised at an early stage of the planning process for incorporation into the EIS.

Silverleaf Solar Farm is committed to consulting with the community to allow the social and environmental impacts of the proposal's built outcomes to be identified and minimised where practicable. The community will be informed and mechanisms are in place to record and manage any issues, concerns or complaints that are received during the environmental approvals process.

The objectives of the stakeholder engagement process are to:

- Provide information about the proposal to all community members and other stakeholders that are potentially impacted by the proposal
- Seek and collate feedback about the proposal from the community and other stakeholders
- Develop appropriate documentation that successfully communicates the benefits and potential impacts of the proposal
- Maintain records of the consultation process, the stakeholders that have been engaged as part of the proposal, and of the feedback gained
- Prepare a consultation report that shows how stakeholder feedback has been addressed in the proposal

4.2 Stakeholder Engagement Plan

A stakeholder engagement plan was developed to manage communication and consultation activities for the proposal by:

- Informing relevant stakeholders about the proposal and providing the opportunity to give feedback
- Providing stakeholders with an opportunity to ask questions and to identify areas of concern
- Demonstrating that concerns and issues raised by stakeholders have been considered in the EIS
- Implementing an approach to stakeholder communications that is transparent and timely
- Effectively and proactively identify and manage issues
- Keeping accurate records of consultation with stakeholders

4.3 Key stakeholders

Table 4-1 summarises of the key stakeholder groups and organisations consulted in relation to the proposal. These stakeholders are likely to be participating in, affected by or have an interest in the proposal.

Table 4-1 Key stakeholders

Stakeholder Group	Stakeholder organisation/role/name
Project site landholders	Private land holders
Local Government	Narrabri Shire Council
State Government	Department of Planning and the Environment
	Office of Environment and Heritage
	Department of Industry – Crown Land
	Roads and Maritime Services
Federal Government	Inland Rail project (ARTC)
Utility Authorities	TransGrid
Adjoining landowners	Landowners within a 2 km radius and additional properties up to 3 km south of the project boundary
Businesses	University of Sydney Plant Breeding Institute Australian Grain Technologies
Community	Broader community and interest groups outside the immediate area of the project site
Media	The Courier
	ABC North West

4.4 Engagement activities

ENGIE engaged with regulatory approvals agencies, stakeholders and the local community. Table 4-2 summarises communication and engagement activities undertaken by ENGIE.

Table 4-2 Summary of engagement activities undertaken to date

Activity	Description	Timing and outcome
Consultation database	An Excel spreadsheet was created to manage ongoing communication with stakeholders and record all consultation activities and feedback.	Updated as required, ongoing
Feedback forms	Hard copy feedback forms were available to gather informal feedback from the community at the community drop-in session held on 6 September 2018 at the Narrabri Bowling Club.	One form received from the drop-in session
Doorknock	Representatives from ENGIE and GHD door-knocked properties within two kilometres of the site, and additional properties up to three kilometres from the project boundary, to speak to property owners and tenants about the project, provide information and record feedback.	5 and 6 September 2018 23 properties doorknocked
Fact Sheet	A double-sided A4 fact sheet was prepared containing information about ENGIE, the project, the EIS process and how the community could provide feedback.	Distributed on door-knock and at community drop-in session

Activity	Description	Timing and outcome
Posters	A1 posters containing project information, including a project site map, were developed for display at the community drop-in session, held on 6 September 2018 at the Narrabri Bowling Club.	Three posters
Flyers	“Sorry we missed you” flyers were left in mailboxes on properties that were visited during the doorknock and no one was home/answered the door. The flyer contained a brief project summary, information about the drop-in session and contact details for the project team.	Distributed on doorknock on 5 and 6 September 2018
Project phone and email	A toll free 1800 number was established for the community to call to speak to a member of the project team and provide feedback or information. A community inbox was also established to receive and respond to enquiries, complaints and feedback.	Ongoing
Print advertisement	An advertisement was placed in the local paper The Courier to promote the community drop-in session.	30 August 2018
Media interviews and coverage	Media interviews were encouraged at key project stages. Media coverage helped to promote the community drop-in session and broadly inform people about the project.	Planning proceeds for Narrabri solar farm – 20 September 2018, Narrabri Courier A new solar farm planned for Narrabri – 5 September 2018, ABC North West Narrabri sun ideal for solar systems – 19 July 2018, ABC North West
Letters	Project information letters were sent to stakeholders to invite them to attend the drop-in session or make an appointment to meet with representatives from the project team.	Letter sent to 48 adjoining properties as described in Table 4-1, including stakeholders on Bald Hill Road, Logans Lane, Kamilaroi Highway, Namoi Street, Barwan Street, Maitland Street
Community drop-in session	An informal session was held for the community to attend at a time that was convenient to them where they could meet the project team, provide feedback and raise concerns.	6 September 2018 – Narrabri Bowling Club Eight attendees

4.5 Consultation with sensitive receivers

Table 4-3 provides a summary of consultation with sensitive receivers, key matters raised and proposed mitigation measures.

Table 4-3 Consultation with sensitive receivers

Sensitive Receiver	Consultation	Mitigation
R04	ENGIE has engaged in consultation with the operator of Oakville Aerodrome. Concerns identified by the Aerodrome relate to the safe operation of the aerodrome: appropriate setback from airstrip, address potential for glare, minimise construction traffic and dust, and maintain ability for aircraft to dump fuel in the event of an emergency. Visual impact was also identified as a potential issue. ENGIE proposed to the Oakville Aerodrome, a private airstrip, to apply Civil Aviation Safety Authority infrastructure setback requirements for commercial aerodromes. In discussion with Oakville Aerodrome, ENGIE engaged Aviation Projects to assess if the solar farm would affect the operation of the private airstrip and appropriate mitigation measures. A copy of this report has been shared with Oakville Aerodrome.	Comply with the recommendations of the Aviation Projects Aeronautical Impact Assessment Report contained within Appendix G. ENGIE will continue to consult with Oakville Aerodrome to ensure construction traffic, activities, and dust are managed to minimise operational impacts to the aerodrome.
R05	The property at R05 is occupied by a tenant. ENGIE engaged with both tenant and landlord of the property. This included doorknocking, in person discussions with the tenant, and subsequent phone discussions with the landowner. The tenant raised visual impact as potential impact of the solar farm. The landlord raised concern about potential impact to operation of the aerodrome and potential visual impact to rental property.	ENGIE has proposed vegetation screening along the North-West boundary of the solar farm to address visual impact concerns.
R17 & R18	ENGIE has consulted with the owner of the dwelling designated as R017 & R018. This includes in person meetings, phone calls, and attendance to the community drop in session. The owner of the property has indicated concern with construction traffic and dust.	ENGIE has proposed to discuss with Narrabri Shire Council sealing 500 m of Logans Lane, starting immediately North of the Kamilaroi Highway.
R19 & R20	Consultation with the owners of dwellings at R19 & R20 identified the concerns related to construction traffic, dust impacts, change to flood waters, potential for more overhead powerlines, and impacts to the aerodrome.	The overhead powerline is proposed to be located on the Newell Highway and Stoney Creek Road. The solar farm is not expected to change the flow of flood waters.
Bailey Street	ENGIE has undertaken consultation activities with dwellings on the overhead transmission line route near Bailey Street and Stoney Creek road. This includes door knocking, letter drop of project information sheets, providing contact information to raise concerns, and invitation to attend the community consultation session. ENGIE has not been contacted by residents of Bailey Street.	Locate overhead transmission line on the northern side of Stoney Creek road, in the road reserve, away from houses on Stoney Creek Road and Bailey Street.

4.6 Issues raised

A summary of the key issues raised by stakeholders during engagement activities, and a reference to where they are addressed in the EIS is provided in Table 4-4.

Table 4-4 Issues raised during community consultation

Theme	Issues	Section addressed
Construction impacts	A key issue raised in community consultation was the risk of dust being generated from construction vehicles using Logans Lane. The dust could cover property and also affect resident rainwater tanks.	Section 7.1
	The intersection of Kamilaroi Highway and Logans Lane was raised as a potential safety issues. Additional traffic generated by construction vehicles using Logans Lane and the Kamilaroi Highway intersection was raised as a safety concern.	Section 6.7
	An issue was raised regarding the possible encroachment onto private land for the proposed intersection upgrade at Logans Lane and Kamilaroi Highway.	Section 6.7
	A safety issues was raised, suggesting a possible change to speed zone on the Kamilaroi Highway near intersection with Logans Lane to reduce traffic conflicts with construction vehicles.	Section 6.7
	A private landowner expressed concerns with security of nearby storage sheds and facilities due to the number of construction workers entering the area.	Section 6.11
	It was noted that there is a school bus stop near the intersection of the Kamilaroi Highway and Logans Lander. Any upgrades to the intersection would need to account for the school bus stop near this off at intersection.	Section 6.7
Water	A landowner raised concerns about changes to water flow and potential impacts to existing retention ponds on southern project boundary.	Section 6.8
	Australian Grain Technologies requested that access to bore on western lot of project site is maintained.	Section 6.8
	Concerns were raised about potential changes to water flow and impacts to flooding on the project site and impact to water flows to creek and river.	Section 6.8
	Groundwater flows should not be impacted.	Section 6.8
Visual amenity	Potential visual impacts on neighbouring residents were raised as one the main issues.	Section 6.4
	The potential height of the solar panel structures could obstruct views from neighbouring properties.	Section 6.4
	Glare from the solar panels was raised as a potential safety risk for residents and highway traffic travelling along the Newell Highway and Logans Lane.	Section 6.4
Transmission lines	Stakeholders with existing power lines do not want any more on their land.	Section 6.11
	Stakeholder requested that existing easements/road reserves are used for the transmission lines.	Section 6.6
	Impact on low-flying planes/crop dusters.	Section 6.6

Theme	Issues	Section addressed
Costs of local electricity	Some stakeholders have linked the development of the proposal with a reduction in the cost of electricity locally.	Section 2.1
Airstrip	The operator of the private airstrip expressed concerns that the proposal may impact the safety of operations of the airstrip.	Section 6.6
Grass and weed management	Stakeholders questioned whether the use of sheep or slashing would be used to maintain grass underneath the panels.	Section 6.2
	Noxious weed management on site was raised as an issue, as non-associated landowners were concerned about the potential spread of noxious weeds if the proposal site is not adequately maintained.	Section 6.2
Vegetation	Stakeholders requested more information on the extent of land clearing and vegetation removal on the proposal site.	Section 6.2
Animals	Management/exclusion of wild pigs and kangaroos.	Section 6.2
Inland rail	Stakeholders noted that the proposed Inland Rail corridor borders the proposal site to the east and sought information on potential conflicts with the Inland Rail Project.	Section 7.4
Jobs	Stakeholders raised the issue of employment prospects during construction and ongoing, and opportunities for local businesses.	Section 6.11

ENGIE provided a copy of the Aeronautical Impact Assessment Report (refer to Appendix G) to the operator of the private airstrip. The operator confirmed in an email dated 9 May 2019 that there were no objections to the findings of the report.

4.6.1 Community drop-in Session

On 6 September 2018 ENGIE conducted a community drop-in session at the Narrabri Bowling Club. Eight attendees met with the ENGIE project team to discuss the proposal. A summary of the issues raised by attendees at the drop-in session is provided in Table 4-5.

Table 4-5 Issues raised at the community drop-in session

Resident location	Issues raised
Kamilaroi Highway, Logans Lane, and near Logans lane	• Construction traffic • Dust generated from using Logans Lane for construction • Duration of construction • Noise from using Logans Lane for construction • Will Logans Lane be sealed? • Alternative access routes • Noted school bus stop near intersection of Kamilaroi Highway and Logans Lane • Property encroachment if Logans Lane is to be widened for access • Concerns with flooding. Noted that hydrology has changes since levy bank was installed • Location of substation • Height of panels • Use of vegetation for screening • Potential glare from the panels

Resident location	Issues raised
	• Impacts on the airfield • Noted proximity of the train line, potential effects of vibration on the panels
Old Gunnedah Road	Enquired on how the panels track, and the capacity (MWh) of the project
Narrabri Town	Supportive of the development
Maules Creek Road	• On-site animal management • Project commencement date?

4.7 Consultation with Narrabri Shire Council

ENGIE consulted with Narrabri Shire Council during development of this proposal and EIS. This included telephone calls, meetings at council offices, on site meetings, and correspondence via email. Table 4-6 below describes a non-exhaustive list of the issues raised.

Table 4-6 Issues raised by Narrabri Shire Council

Issues raised
• Coordinate with ARTC regarding the proposed inland rail project • Ability for the proposed solar farm to connect to the grid • Suitability of proposed transmission line route • Proposed transport access route, road upgrades, and coordination with RMS • Potential benefits for community and the region

4.8 Government and agency stakeholder consultation

4.8.1 Consultation undertaken

ENGIE consulted with a number of government and agency stakeholders during the development of the proposal and EIS. This consultation was undertaken via telephone, meetings on site and written correspondence. The following government and agency stakeholders were consulted:

- Office of Environment and Heritage – Aboriginal heritage
- Office of Environment and Heritage – Biodiversity
- Department of Industry – Crown Lands
- RMS – road safety and positioning of overhead power lines in road reserves
- ARTC – overhead power line clearance for rail lines and the Inland Rail Projects

4.8.2 Issued raised

Issues raised during consultation with government agencies are summarised in Table 4-7.

Table 4-7 Issues raised during consultation with government agencies

Government Agency	Issue raised	Where addressed in EIS
Department of Industry	Requirement for soil testing as part of the EIS.	Soil classification and assessment provided in Section 6.6.
	Inclusion of a Land Use Conflict Risk Assessment (LUCRA).	Section 6.6
	Provide separate and detailed sections on the operation and decommissioning phases (including the requirement to remove all structures and underground cables).	Section 6.6
Office of Environment and Heritage	Aboriginal heritage assessment – due diligence process to be followed if the proposal can be designed to avoid impacts on Aboriginal objects.	Section 6.3
	Biodiversity offsets – confirmation that the Biodiversity Assessment Method and Biodiversity Conservation Register are to be used to assess offset requirements.	Section 6.2

4.9 Other key stakeholders

4.9.1 Aboriginal consultation

The following representatives of Aboriginal community groups participated in the fieldwork program:

- Narrabri Local Aboriginal Land Council: 23–25 October 2018
- Gomeroi Native Title Claim Group: 25 October 2018

Further details of engagement activities and fieldwork undertaken with Aboriginal stakeholders are provided in Section 6.3 and Appendix C.

4.10 Future consultation

Following submission of the EIS, it is anticipated the Department of Planning and Environment would place the EIS on public exhibition for at least 30 days to enable the community to provide further feedback on the proposal.

If the project is approved, ENGIE will continue to engage with the local community and all relevant stakeholders during construction and operation. ENGIE and its solar PV construction contractor, ENGIE Solar, will continue to identify and manage issues of interest or concern to the community. ENGIE has committed to conducting site visits at the detailed design stage with neighbouring property owners to incorporate management measures into the detailed design where feasible.

The aims of ongoing communications and consultation are to provide the community with:

- Accurate and accessible information regarding the processes and activities associated with the proposal
- Information in a timely manner
- Appropriate avenues for the community to comment or raise concerns
- A high level of responsiveness to issues and concerns throughout development and delivery of the proposal

This consultation would be undertaken by both ENGIE and ENGIE Solar. The community would be updated about the progress of construction and notified in advance of any construction activities that have the potential for off-site impacts, such as any temporary road closures or night works.

5. Planning context

5.1 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) and its associated regulations provide the framework for assessing environmental impacts and determining planning approvals for developments and activities in NSW. The need or otherwise for development consent is set out in environmental planning instruments – State Environmental Planning Policies (SEPPs), Regional Environmental Plans (REPs) or Local Environmental Plans (LEPs).

Clause 1.3 (b) of the EP&A Act states that one of the objects of the Act is to facilitate ecologically sustainable development by integrating relevant economic, environmental and social considerations in decision-making about environmental planning and assessment. An assessment of the proposal's merits under ecologically sustainable development provisions is provided in Section 9.1.2.

5.1.1 Part 4 of the EP&A Act

Part 4 of the EP&A Act provides for the control of development that requires development consent from a consent authority. Depending on the circumstances of the proposal, the consent authority may be the local Council or the Minister for Planning.

Part 4, Division 4.7 of the EP&A Act establishes an approval regime for development that is declared to be State Significant Development by either a state environmental planning policy (SEPP) or Ministerial Order. In accordance with Section 4.38 of the EP&A Act, the Minister for Planning is the consent authority for State Significant Development. Pursuant to Clause 8 of Section 4.12 of the EP&A Act, an Environmental Impact Statement (EIS) is required to support a development application for State Significant Development.

5.1.2 Approval process

State Significant Development to which Division 4.7 of the EP&A Act applies is identified in the *State Environmental Planning Policy (State and Regional Development) 2011* (State and Regional Development SEPP) and in declarations made by the Minister for Planning. The proposal is considered to be 'State Significant Development' as it is of a type listed in Schedule 1 (20) of the State and Regional Development SEPP (refer to Section 5.2.1).

The NSW Minister for Planning is the consent authority for the proposal. An EIS is required to accompany the development application lodged with the NSW Department of Planning and Environment (DPE) for assessment on behalf of the Minister.

Before preparing the EIS, the applicant must request the Secretary's Environmental Assessment Requirements (SEARs). The request for SEARs is accompanied by a Preliminary Environmental Assessment (PEA), which is a supporting document that outlines the location, nature and scale of the proposal as well as a preliminary assessment of environmental issues. The PEA and SEARS identify key issues for further assessment in the EIS. ENGIE submitted the request for SEARs for the proposal on the 21 May 2018.

The Department of Planning and Environment consulted with relevant public authorities to obtain input to the SEARs. The Department issued SEARs to ENGIE on 22 June 2018.

This EIS has been prepared to address the SEARs and the requirements set out in Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*. The EIS will be submitted to the Department for review before it is publicly exhibited for at least 30 days. During the exhibition period, the public and agencies are invited to make submissions. After the exhibition period closes, the Department may request that the proponent respond to issues raised in the submissions.

5.2 Environmental planning instruments

Environmental planning instruments (EPIs) are legal documents that are prepared under the EP&A Act to regulate land use and development. EPIs determine the relevant part of the EP&A Act under which a development proposal must be assessed and therefore determine the need or otherwise for development consent. EPIs consist of SEPPs, regional environmental plans (REPs), and local environmental plans (LEPs).

5.2.1 State environmental planning policies

State Environmental Planning Policy (State and Regional Development) 2011

The State and Regional Development SEPP identifies development:

- To which the State Significant Development assessment and approval process under Part 4 of the EP&A Act applies
- That is State Significant Infrastructure and critical State Significant Infrastructure

Development that is specified in Schedule 1 or Schedule 2 is declared to be State Significant Development. Clause 20 of Schedule 1 relates to electricity generating developments and states that the following development is State Significant Development:

> *Development for the purpose of electricity generating works or heat or their co-generation (using any energy source, including gas, coal, biofuel, distillate, waste, hydro, wave, solar or wind power) that:*
>
> *(a) has a capital investment value of more than $30 million, or*
>
> *(b) has a capital investment value of more than $10 million and is located in an environmentally sensitive area of State significance.*

As the proposal is for an electricity generating facility and has a capital investment of over $30 million, it is State Significant Development.

State Environmental Planning Policy (Infrastructure) 2007

The *State Environmental Planning Policy (Infrastructure) 2007* (the Infrastructure SEPP) aims to facilitate the effective delivery of infrastructure across the State through increased regulatory certainty, improved efficiency and flexibility in the location of infrastructure and service facilities, while also providing for adequate stakeholder consultation.

Clause 34(1) of the Infrastructure SEPP states that:

> *Development for the purpose of electricity generating works may be carried out by any person with consent on any land in a prescribed rural, industrial or special use zone.*

A prescribed rural zone is defined as the following in Clause 33 of the Infrastructure SEPP:

> ***prescribed rural zone*** *means any of the following land use zones or a land use zone that is equivalent to any of those zones:*
>
> *(a) Zone RU1 Primary Production,*
>
> *(b) Zone RU2 Rural Landscape,*
>
> *(c) Zone RU3 Forestry,*
>
> *(d) Zone RU4 Rural Small Holdings.*

As the proposal would be an electricity generating works and be located on land that is zoned RU1 Primary Production zone under the *Narrabri Local Environmental Plan 2012* (Narrabri LEP) (refer to Section 5.2.2), it is permissible with consent under clause 34(1) of the Infrastructure SEPP.

Clause 34(7) of the Infrastructure SEPP states that:

> *Except as provided by subclause (8), development for the purpose of a solar energy system may be carried out by any person with consent on any land.*

Subclause (8) relates to photovoltaic electricity generating systems in prescribed residential zones. As the proposal is not located in a prescribed residential zone, the proposal is permissible with consent.

Clause 101 of the Infrastructure SEPP relates to development with frontage to a classified road. The proposal site has a frontage with the Newell Highway which is a classified road. The proposal is considered to be consistent with the objectives of this clause because it has been designed so the access point is off Logans Lane which is not a classified road. The proposal would not compromise the operation of the classified road, and it is not sensitive to the impacts associated with a classified road.

State Environmental Planning Policy No. 44 – Koala Habitat Protection

State Environmental Planning Policy 44 (SEPP 44) aims to encourage the 'proper conservation and management of areas of natural vegetation that provide habitat for Koalas (*Phascolarctos cinereus)* to ensure a permanent free-living population over their present range and reverse the current trend of Koala population decline'.

Schedule 1 of SEPP No. 44 identifies the local government areas that SEPP 44 applies to. The Narrabri local government area is listed in Schedule 1 of SEPP 44 as having the potential to contain Potential Koala Habitat and/or Core Koala Habitat which is defined as:

- Potential Koala Habitat are areas of native vegetation where the trees of the types listed in Schedule 2 constitute at least 15 per cent of the total number of trees in the upper or lower strata of the tree component.
- Core Koala Habitat is an area of land with a resident population of koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population.

Section 6.2 and the Biodiversity Development Assessment Report contained in Appendix B address the suitability of the site for development in accordance with SEPP 44.

State Environmental Planning Policy No. 33 Hazardous and Offensive Development

State Environmental Planning Policy No. 33 Hazardous and Offensive Development (SEPP 33) presents a systematic approach to planning and assessing proposals for potentially hazardous and offensive development for the purpose of industry or storage. SEPP 33 applies to any proposals which fall under the policy's definition of 'potentially hazardous industry'. SEPP 33 ensures that only those proposals which are suitably located, and able to demonstrate that they can be built and operated with an adequate level of safety and pollution control, can proceed. Section 6.9 addresses the requirements of SEPP 33.

State Environmental Planning Policy No. 55 Remediation of Land

State Environmental Planning Policy No. 55 Remediation of Land (SEPP 55) integrates the management of contamination into the planning and development control process. SEPP 55 aims to ensure that changes of land use do not increase the risk to health or the environment, inappropriate restrictions on land use are avoided, and information used to support decision making is provided to the community. Sections 3.6 and 6.6 address the requirements of SEPP 55.

5.2.2 Regional environmental plans

The *New England North West Regional Plan 2036* outlines the NSW Government's vision for the New England North West region. The Plan's vision is "Nationally valued landscapes and strong, successful communities from the Great Dividing Range to the rich black soil plains".

The Government has set regionally-focused goals to achieve this vision. These goals are:

- A strong and dynamic regional economy
- A healthy environment with pristine waterways
- Strong infrastructure and transport networks for a connected future
- Attractive and thriving communities

The proposal would assist in achieving these goals by providing employment during construction and operation, minimising environmental impacts, providing renewable electricity generation infrastructure that helps to diversify the local economy and provides new employment opportunities.

5.2.3 Local environmental plans

The proposal is located within the Narrabri local government area and therefore *Narrabri Local Environmental Plan 2012* (Narrabri LEP) applies to the site. The relevant provisions under the Narrabri LEP are discussed below.

Narrabri Local Environmental Plan 2012

The proposal site and the transmission corridor are zoned RU1 Primary Production under the Narrabri LEP. Under the Narrabri LEP, the proposal is prohibited within this zone as electricity generating developments are not listed as permissible with or without consent. Regardless of the permissibility of the proposal under the Narrabri LEP, the provisions of the Infrastructure SEPP (refer to Section 5.2.1), override the LEP and therefore allow the proposal to be undertaken with consent.

5.3 Other NSW legislation

5.3.1 Legislation to be applied consistently

Under Section 4.42 of the EP&A Act, the following authorisations cannot be refused if they are necessary for the carrying out of State Significant Development that is authorised by development consent and are to be substantially consistent with the consent:

- *Fisheries Management Act 1994* – aquaculture permit under Section 144
- *Mine Subsidence Compensation Act 1961* – approval under Section 15
- *Mining Act 1992* – a mining lease under this act
- *Petroleum (Onshore) Act 1991* – a production lease under Division 5 of Part 3
- *Protection of the Environment Operations Act 1997* – an EPL under Chapter 3 of the Act
- *Roads Act 1993* – a permit under Section 138 to impact on public roads
- *Pipelines Act 1967* – a licence under Section 11 to construct and/or operate a pipeline

The above mentioned acts relevant to the proposal are discussed below.

Roads Act 1993

The *Roads Act 1993* is administered by Roads and Maritime Services (RMS), local councils or the Department of Industry – Crown Lands. Roads and Maritime Services has jurisdiction for classified roads, local councils have jurisdiction for non-classified roads and the Department of Industry – Crown Land has road reserves or Crown roads.

Under Section 138 of the *Roads Act 1993*, a person must not impact or carry out work on or over a public road otherwise than with the consent of the appropriate roads authority.

The proposal would require an upgrade to the intersection of the Kamilaroi Highway and Logans Lane to improve road safety during the construction period. This would also include recommendations for lowering the speed limit on the Kamilaroi Highway in the vicinity of the intersection during construction. Minor works may also be required within Logans Lane to improve the condition of the road during construction.

An approval from RMS will be required for the proposed upgrade of the Kamilaroi Highway and Logans lane intersection, and for the lowering of the speed limit on the Kamilaroi Highway during construction. A permit is required from Narrabri Shire Council for works on Logans Lane. No works are proposed for the Newell Highway as part of the proposal. If works on the Newell Highway are identified, an approval from RMS would be sought.

Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) establishes, amongst other things, the procedures for issuing licences for environmental protection on aspects such as waste, air, water and noise pollution control. The owner or occupier of premises engaged in scheduled activities is required to hold an environment protection licence (EPL) and comply with the conditions of that licence.

Schedule 1 of the POEO Act outlines the activities which are considered to be scheduled activities to which an EPL is required to be obtained. Electricity generating works (Clause 17 of Schedule 1) with the capacity to generate over 30 megawatts require an EPL. As outlined in Clause 17(1) of Schedule 1 of the POEO Act, general electricity works does not include the generation of electricity through solar and wind power. As the proposal would generate power from solar energy, an EPL is not required for the proposal.

5.3.2 Approvals that do not apply

Section 4.41 of the EP&A Act specifies certain authorisations which are not required for State Significant Development, authorised under a development consent. These include the following authorisations, which may otherwise have been relevant to this proposal:

- NSW *Fisheries Management Act 1994* – permit for work or structures within a waterway under Sections 201 and 219
- NSW *Heritage Act 1977* – approval to disturb an item or an excavation permit under Section 39
- NSW *National Parks and Wildlife Act 1974* – an Aboriginal heritage impact permit under Section 90
- NSW *Rural Fires Act 1997* – a bush fire safety authority under Section 100B
- NSW *Water Management Act 2000* – water use approval, water management work approval or activity approval under Sections 89, 90 and 91

The above approvals would not be required if the Minister grants development consent to carry out the proposal under Division 4.7 of Part 4 of the EP&A Act.

5.3.3 Other relevant legislation

Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) came into effect on 25 August 2017, replacing the *Threatened Species Conservation Act 1995*, together with the fauna and flora provisions of the *National Parks and Wildlife Act 1974*. The aim of the BC Act is to conserve biodiversity and deliver ecologically sustainable development through a market-based approach, particularly for higher risk projects. The market based approach has a regional and state focus, rather than a local focus on biodiversity.

The BC Act established a new biodiversity assessment methodology (BAM) for the calculation of biodiversity credits. The BAM applies to State Significant Development that will impact biodiversity values, including paddock trees and remnant vegetation. Where the BAM applies, a Biodiversity Development Assessment Report (BDAR) is required. The BDAR must identify the biodiversity values that would be impacted by a development, detail the avoidance methods proposed to minimise impacts, and identify any offset requirements. The BC Act also requires the Minister for Planning to consider biodiversity impacts before deciding whether to approve a project, and if any relevant conditions of consent should be imposed.

An assessment of the proposal's potential impacts on the biodiversity values of the proposal site is discussed in Section 6.2. Section 6.2 provides a summary of the BDAR prepared for the proposal, together with a determination of the biodiversity credits required.

Crown Land Management Act 2016

The *Crown Land Management Act 2016* provides for the ownership, use and management of the Crown land of New South Wales. It requires environmental, social, cultural heritage and economic considerations to be taken into account in decision-making about Crown land. It provides for the consistent, efficient, fair and transparent management of Crown land for the benefit of the people of New South Wales, together with facilitating the use of Crown land by the Aboriginal people of New South Wales.

The transmission corridor traverses a number of parcels of Crown Land. This area is shown in Figure 6-20. An approval to construct transmission infrastructure on Crown Land will be required prior to construction.

5.4 Commonwealth legislation

5.4.1 Environment Protection and Biodiversity Conservation Act 1999

The primary objective of the *Environment Protection and Biodiversity Conservation Act* (EPBC Act) is to 'provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance'.

Environmental approvals under the EPBC Act may be required for an 'action' that has, will have or, is likely to have a significant impact on:

- Matters of National Environmental Significance (MNES)
- The environment on Commonwealth land (whether or not the action is occurring on Commonwealth land)
- The environment anywhere in the world, where the action is to be undertaken by a Commonwealth agency

An 'action' is considered to include a project, development, undertaking, activity or series of activities. MNES matters include:

- World heritage areas
- National heritage places
- Wetlands of international importance (i.e. Ramsar wetlands)
- Nationally listed threatened species and ecological communities
- Listed migratory species
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mines)
- A water resource, in relation to coal seam gas development and large coal mining development

If the proponent considers that an action will have, or is likely to have, significant impacts on a MNES or on Commonwealth land, a referral is made to the Commonwealth Department of the Environment. A proponent may also, but is not required to, be referred to the Commonwealth Department of the Environment where an action will not have, or is not likely to have, a significant impact.

If the referral process by the Commonwealth Department of the Environment determines that an action is likely to have a significant impact on a MNES, or on Commonwealth land, then the project is a 'controlled action' and approval from the Minister would be required.

An EPBC Act protected matters search was undertaken on 26 April 2019. The search identified several MNES with the potential to occur in, or that may relate to, an area of 10 kilometres around a polygon which includes the proposal site. Table 5-1 provides a summary of the results of the protected matters search.

Table 5-1 EPBC protected matters search results

NES matters	Results
World heritage areas	None
National heritage places	None
Wetlands of international significance (Ramsar sites)	Three including Banrock Station Wetland Complex, Riverland and the Coorong, Lake Alexandrina and Albert Wetland. All of these wetlands are located at least 100 kilometres downstream of the proposal. The proposal would not impact on these wetlands.
Commonwealth marine areas	None
Great Barrier Reef Marine Park	None
Threatened ecological communities	Five including the following: • Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions • Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia • Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland • Weeping Myall Woodlands • White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland
Threatened species	25: • Seven bird species • One fish species • Seven mammal species • Seven plant species • Three reptiles species
Listed migratory species	10: • One marine bird • Four terrestrial species • Five wetland species

The results of the biodiversity assessment, including the proposal's potential impacts on matters protected under the EPBC Act, are provided in Section 6.2. The proposal would not impact upon any world heritage areas, national heritage places, or wetlands of international importance.

The proposal would not significantly affect any Commonwealth marine areas, the Great Barrier Reef Marine Park, threatened species, threatened ecological communities, or migratory species that are listed under the EPBC Act (refer to Section 6.2).

As the investigations undertaken as part of this EIS indicates that the proposal is unlikely to significantly impact on any MNES or Commonwealth land, it has not been referred to the Commonwealth Department of the Environment.

5.4.2 Native Title Act 1993

The objectives of the *Native Title Act 1993* are to:

- Recognise native title rights and sets down basic principles in relation to native title in Australia.
- Provide for the validation of past acts which may be invalid because of the existence of native title.

- Provide for a future regime in which native title rights are protected and conditions imposed on acts affecting native title land and waters.
- Provide a process by which native title rights can be established and compensation determined, and by which determinations can be made as to whether future grants can be made or acts done over native title land and waters.
- Provide for a range of other matters, including the establishment of a National Aboriginal and Torres Strait Islander Land Fund.

The Gomeroi People (Tribunal File No. NC2011/006) have lodged a claim over the proposal's study area. It is understood that the native title claim has not been registered by the National Native Title Tribunal. The Native Title Tribunal has not determined the claim by the Gomeroi People.

The proposal site is located on free hold land, and would not be subject to this claim. Sections of the proposed transmission corridor, and a portion of the northern section of Logans Lane are located on Crown Land. The Crown Land on Logans Lane will not be affected by the proposal as the site will be accessed from the southern section of Logans Lane.

5.4.3 Renewable Energy (Electricity) Act 2000

The *Renewable Energy (Electricity) Act 2000* aims to:

- Encourage the additional generation of electricity from renewable sources
- Reduce emissions of greenhouse gases generated by the electricity sector
- Ensure that renewable energy sources are ecologically sustainable

Section 17 of the *Renewable Energy Act 2000* defines renewable energy sources eligible under the Commonwealth governments renewable target scheme, including solar.

Certificates for the generation of electricity are issued using eligible renewable energy sources. This required purchasers (called liable entities) to surrender a specified number of certificates for the electricity they acquire.

In January 2011, renewable energy certificates were reclassed as either large-scale generation certificates or small-scale technology certificates following changes to the scheme. The proposal is the subject of an application to the Clean Energy Regulator under the Renewable Energy Act and would receive large scale generation certificates.

6. Key environmental issues

6.1 Environmental constraints

The PEA, together with the SEARs have identified the key environmental constraints associated with the proposal. These have been assessed in this EIS, and are represented in Figure 6-1.

The key constraints for the proposal are:

- Biodiversity, including the requirement to clear native vegetation
- Two items of Aboriginal heritage significance
- Land use, including the adjoining private airstrip
- Visual impacts on adjoining properties
- Construction noise
- Water, including surface water flows and water quality during construction
- Hazards and risks
- Socio-economic impacts

The proposal's design has considered these constraints. Further consideration and management of these constraints will occur during the detailed design stage. The proposal's potential impacts on these constraints have been addressed to meet the requirements of the SEARs in this chapter. Other environmental considerations are addressed in Chapter 7.

Sensitive receivers

Sensitive receivers, such as residences, have been identified to assess potential impacts from the proposal. Sensitive receivers were identified by an assessment of which landowners could be potentially affected by the Proposal's likely key impacts which are visual impacts and construction noise. A review of properties potentially affected was based on a preliminary viewshed analysis which took into consideration topography, together with those potentially affected by construction noise including traffic. Sensitive receivers along the transmission line were identified by those that could experience construction noise impacts in exceedance of noise guidelines during construction of the transmission line.

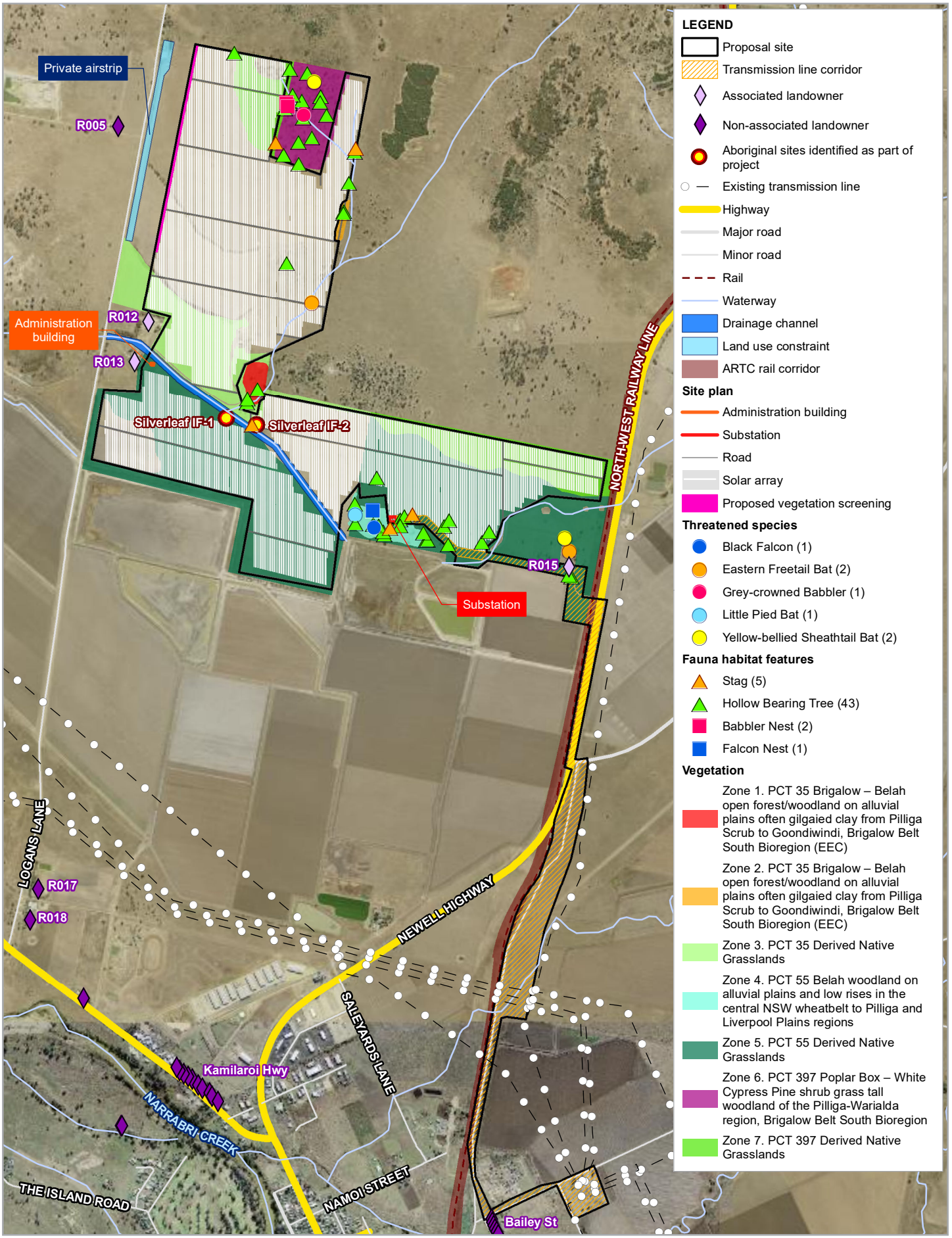
All sensitive receivers located within three kilometres of the Proposal site were included. A number of properties outside this radius with potential views of the Proposal site were also included. Sensitive receivers, such as non-associated landowners, together with associated landowners near the proposal site, are shown in Figure 6-1. Table 6-1 provides distances from the proposal site boundary to sensitive receivers.

Table 6-1 Distances to sensitive receivers

Sensitive receiver	Distance in metres from property boundary
R001	2,692
R002	2,767
R003	788
R004	123
R005	372
R006	1,891
R007	2,384
R008	2,838
R009	3,456

Sensitive receiver	Distance in metres from property boundary
R010	3,092
R011	2,157
R012*	6
R013*	29
R014	924
R015	52
R016	1,218
R017	2,179
R018	2,763
R019	2,924
R020	3,022
R021	3,738
R022	1,730
Newell Highway	975

* Owners at receivers R012 and R013 are associated landowners that have entered commercial agreements with ENGIE, and will not occupy these sites.



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Engie
Silverleaf Narrabri Solar Farm EIS

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Revision No. **2**
Date **18 Aug 2019**

Key environmental constraints

FIGURE 6-1

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Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

6.2 Biodiversity

Biodiversity values at the proposal site, and the likely biodiversity impacts of the proposal must be assessed in accordance with the *Biodiversity Conservation Act 2016* (BC Act), including the Biodiversity Assessment Method (BAM). This section summarises the biodiversity assessment undertaken for the proposal. The full Biodiversity Development Assessment Report (BDAR) is included in Appendix B.

6.2.1 Methodology

The following section provides a summary of the methodology used for the biodiversity development assessment report which was undertaken for the proposal. Further detail on the methodology is located in Appendix B.

Desktop assessment

A desktop assessment was undertaken to identify threatened flora and fauna species, populations and ecological communities (threatened biota) listed under the BC Act and the EPBC Act that could be expected to occur in the locality.

The desktop assessment included a review of publicly available databases for a 10 kilometre radius around the proposal site. Following collation of database records and threatened species and community profiles, a 'likelihood of occurrence' assessment was prepared for threatened biota and migratory species with reference to the broad vegetation types and habitats contained within the proposal site. Further details of the desktop assessment are outlined in Appendix B.

Field survey

Staged surveys of the proposal site were conducted with reference to the BAM and appropriate threatened species survey guidelines for targeted species. Site surveys included:

- Initial site stratification and vegetation mapping
- Sampling of vegetation integrity plot/transects
- Habitat assessments
- Targeted surveys for threatened flora
- Targeted surveys for threatened fauna

The survey effort is summarised in Table 6-2. More details on site survey methodologies is located in the Biodiversity Assessment Report located in Appendix B.

Table 6-2 Survey techniques and timing

Stage	Date	Survey Technique
BAM assessment survey	14 to 16 March 2018	Vegetation mapping Vegetation integrity plots Fauna survey Habitat assessment Spotlighting Anabats
Candidate species credit flora survey and additional plots	19 to 21 September 2018	Vegetation integrity plots Targeted flora searches Opportunistic fauna survey
Candidate species credit flora survey and additional plots	13 November 2018	Vegetation integrity plots Targeted flora searches Opportunistic fauna survey

Vegetation and flora surveys

Vegetation was surveyed with reference to the BAM (OEH 2017a) and appropriate threatened species survey guidelines (DEC 2004a)). Regional vegetation mapping was ground-truthed in the field via driven and walked transects across the proposal study area.

Plot surveys were conducted on site in accordance with the BAM to obtain vegetation integrity data for the calculation of biodiversity credits. The site value was determined by assessing ten attributes related to the function, composition and structure of vegetation within a 50 metre by 20 metre plot. All flora species within a 20 metre by 20 metre quadrat nestled within the 50 metre by 20 metre plot were identified according to the nomenclature of the Royal Botanic Gardens and Domain Trust (2018). Each species identified was allocated a growth form group and designated as either native, exotic or high threat exotic in accordance to the lists provided in the BAM calculator. Plots were sampled according to the minimum number of plots required by Table 4 in the BAM.

Searches for threatened plant species were conducted in areas of native vegetation or suitable habitat in the proposal site. The suite of threatened plants potentially present was identified based on the desktop assessment results and the species credit-type species identified by preliminary BAM Credit Calculations. Habitat for these species was identified based on OEH threatened species profiles and the experience and judgement of field ecologists. The majority of the proposal site is highly modified and is dominated by exotic species, grazed, and can be readily discounted as containing any threatened plant species.

Fauna habitat assessment

Fauna habitat assessments were undertaken throughout the proposal site during all survey periods, including observation of potential shelter, basking, roosting, nesting and/or foraging sites. Specific habitat features and resources such as water bodies, food trees, the density of understorey vegetation, the composition of ground cover, the soil type, presence of hollow-bearing trees, leaf litter and ground debris were noted.

Indicative habitat criteria for targeted threatened species (i.e. those determined as having the potential to occur within the proposal site following the desktop review) were identified prior to fieldwork. Habitat criteria were based on information provided in OEH and Commonwealth Department of Environment and Energy (DEE) threatened species profiles, field guides, and the knowledge and experience of field ecologists.

Habitat assessments included searches for resources of potential value to threatened fauna including:

- Trees with bird nests or other potential fauna roosts
- Rock outcrops or overhangs providing potential shelter sites for fauna
- Burrows, dens and warrens
- Distinctive scats or latrine sites, owl white wash and regurgitated pellets under roost sites
- Tracks or animal remains
- Evidence of activity such as feeding scars, scratches and diggings
- Specific food trees and evidence of foraging such as chewed *Allocasuarina* cones

The locations and quantitative descriptions of significant habitat features were captured with a handheld GPS unit and photographed where appropriate. The field survey effort included dawn and dusk observations of hollows for evidence of occupancy.

Opportunistic and incidental observations of fauna species were recorded at all times during field surveys. This included a conscious focus on suitable areas of habitat during flora surveys, for instance fallen timber was scanned and/or turned for reptiles and mature trees and stags were scanned for roosting birds.

Targeted surveys

Under the BAM, targeted surveys are not required for threatened fauna species that can be reliably predicted to occur at the subject site based on habitat surrogates (predicted/ecosystem credit species). These species are assumed to be present within certain Plant Community Types (PCT), given a certain patch size and condition. Nonetheless these species and their habitats were recorded along with fauna that are not listed as threatened, as a general guide to the condition and biodiversity value of the proposal site.

Targeted, seasonal surveys are required for candidate threatened species entities i.e. species credit species and specific habitat resources such as nesting or roosting habitat for dual credit species. Candidate species credit entities that have a moderate potential to occur at the proposal site were targeted during these surveys, and are listed in Table 6-3.

Table 6-3 Candidate fauna species credit entities targeted during surveys

Common name	Scientific name	Appropriate survey period	Survey Method/s
Australian Bustard	*Ardeotis australis*	All year	Diurnal bird surveys
Black-breasted Buzzard (breeding)	*Hamirostra melanosternum*	Sep-Nov, Jan	Habitat assessment – no breeding habitat present Diurnal bird surveys
Superb Parrot (breeding)	*Polytelis swainsoni*	Sep-Nov	Diurnal surveys

Survey effort was stratified across the entire proposal study area, noting that fauna species are mobile and may rely upon habitat resources in the subject site even if not directly observed at the subject site. All fauna observations were recorded on pro forma field data sheets. Further details on the fauna survey techniques and survey effort are provided in the Biodiversity Assessment Report located in Appendix B.

Aquatic habitat assessment

A rapid aquatic habitat assessment was undertaken along the drainage line in the proposal site. The character and condition of the drainage line was noted.

An assessment of potential habitat for threatened aquatic species was based on the habitat assessments undertaken during the field survey and published habitat preferences of threatened biota. Key fish habitat maps for the area (DPI 2007) were reviewed and key fish habitat was identified according to the following classifications as detailed in DPI (2013):

- Type 1 – highly sensitive fish habitat (includes freshwater habitats that contain in-stream gravel beds, rocks greater than 500 millimetres in two dimensions, snags greater than 300 millimetres in diameter or three metres in length, or native aquatic plants; known or expected protected or threatened fish habitat; and areas of critical habitat).
- Type 2 – moderately sensitive key fish habitat (freshwater habitats other than those defined in Type 1).
- Type 3 – minimally sensitive key fish habitat (ephemeral aquatic habitat not supporting native aquatic or wetland vegetation).
- Not key fish habitat (includes first and second order streams on gaining streams).

Transmission line

The transmission line follows the alignment of existing transportation corridors, including the North West Railway Line, the Newell Highway, Old Cemetery Road and Stoney Creek Road. These areas are highly disturbed from infrastructure land uses, and have a low probability of supporting threatened flora or fauna species, habitat or endangered ecological communities.

Publicly accessible portions of the transmission line alignment were assessed through driven and walked transects. Vegetation along the transmission line was mapped based on the visual inspections and from aerial photography interpretation. Vegetation in the transmission corridor is comprised of non-native or planted species.

Geographical Information System (GIS) analysis

GIS was used to:

- Plot the proposal site on a high resolution aerial photo base and to map vegetation zones, survey effort, habitat resources and biodiversity values
- Calculate the extent of native vegetation to be impacted
- Confirm the relevant IBRA bioregion, IBRA subregion and Mitchell Landscape for the site

Additional GIS analysis was used to plot a 1,500 metre buffer area surrounding the proposal site in which site context components were calculated. Native vegetation cover, extent and connectivity were assessed using aerial photography. Air photo interpretation was used to identify and record distinct vegetation patches, determine the broad condition state of vegetation types and the location and extent of vegetated habitat corridors. The buffer area and GIS area calculations were used to enter information about landscape value and to determine the change in Landscape Value score by assessing the impact of the proposal on native vegetation cover and connectivity as well as the patch size.

BAM calculations

The proposal was assessed according to the methodology presented in the BAM, and the *Biodiversity Assessment Methods Calculator Users Guide* (OEH 2017b). The credit calculator is a software application that is used to apply the BAM. Data is entered into the credit calculator based on information collected in the desktop assessment, site surveys and from using GIS mapping software.

The BAM credit calculations were performed using credit calculator version 1.2.1. The data and assumptions used to perform the BAM credit calculations and the biodiversity credit report are included in Appendix B.

6.2.2 Existing environment

Landscape features

The BAM requires the assessment of landscape features to help describe the biodiversity values of the proposal site, and to assess the impacts of the proposal. Landscape features relevant to the BAM calculations are summarised in Table 6-4 and are shown in Figure 4-1 of Appendix B.

The proposal site has an area of approximately 450 hectares. It is currently used for agricultural purposes, with the primary use being grazing, together with some cropping. The site contains three residential dwellings.

Table 6-4 Landscape features

Landscape feature	Study area
IBRA bioregions and subregions	Brigalow Belt South Bioregion/Liverpool Plains subregion
NSW landscape regions (Mitchell landscapes)	Kaputar Slopes
Local Government Area (LGA)	Narrabri
Rivers and streams	A predominantly 2nd order stream runs across the site. This channel runs through the site from Logans Lane to the property to the south where gates are located to control water flow. This drainage line is not mapped as key fish habitat (DPI 2007).
Important and local wetlands	No wetlands occur at the site.
Connectivity features	Vegetation at the site provides limited connectivity with areas outside the site.
Areas of geological significance and soil hazard features	There are no karst, caves, crevices, cliffs or other areas of geological significance located within the subject site or buffer area surrounding the site.
Areas of outstanding biodiversity value	No declared areas of outstanding biodiversity value occur in or near the study area.
Landscape features listed in the SEARs	No additional landscape features listed in the SEARs.

Vegetation

The majority of the proposal site has been cleared and used for agriculture (primarily grazing). The dominant vegetation is represented by native and exotic pasture. A large proportion of the northern part of the proposal site has been cultivated and is comprised of improved pasture dominated by exotic species. The southern portion of the proposal site has been cleared but supports derived native grasslands dominated by a few native grass species. A number of windbreaks have been planted at the proposal site and are comprised of species that are not indigenous to the Narrabri region.

Native vegetation cover (woody and non-woody) was assessed on the proposal site and within a 1,500 metre buffer area surrounding the boundary of the proposal site. Several small patches of remnant woodland are present within the proposal site. These patches have been highly modified as a result of agricultural activities, with much of the understorey affected by grazing activities.

The proposed transmission easement was inspected during vehicular and pedestrian traverses along roadsides. This inspection indicated that the majority of this land contains cleared cultivated lands and exotic grassland. No native vegetation would be removed for the construction of the transmission corridor.

Flora species

No threatened flora species were identified during the field survey. A total of 143 species from 36 families were identified, including 104 native species and 39 exotic species.

Two priority weeds (Common Prickly Pear (*Opuntia stricta*) and African Boxthorn (*Lycium ferocissimum*)) listed in the North West region (which includes the Narrabri local government area) were recorded during the field survey. These are also Weeds of National Significance declared under the National Weed Strategy.

The following exotic species were recorded and are classified as high threat weeds for the purposes of the BAM:

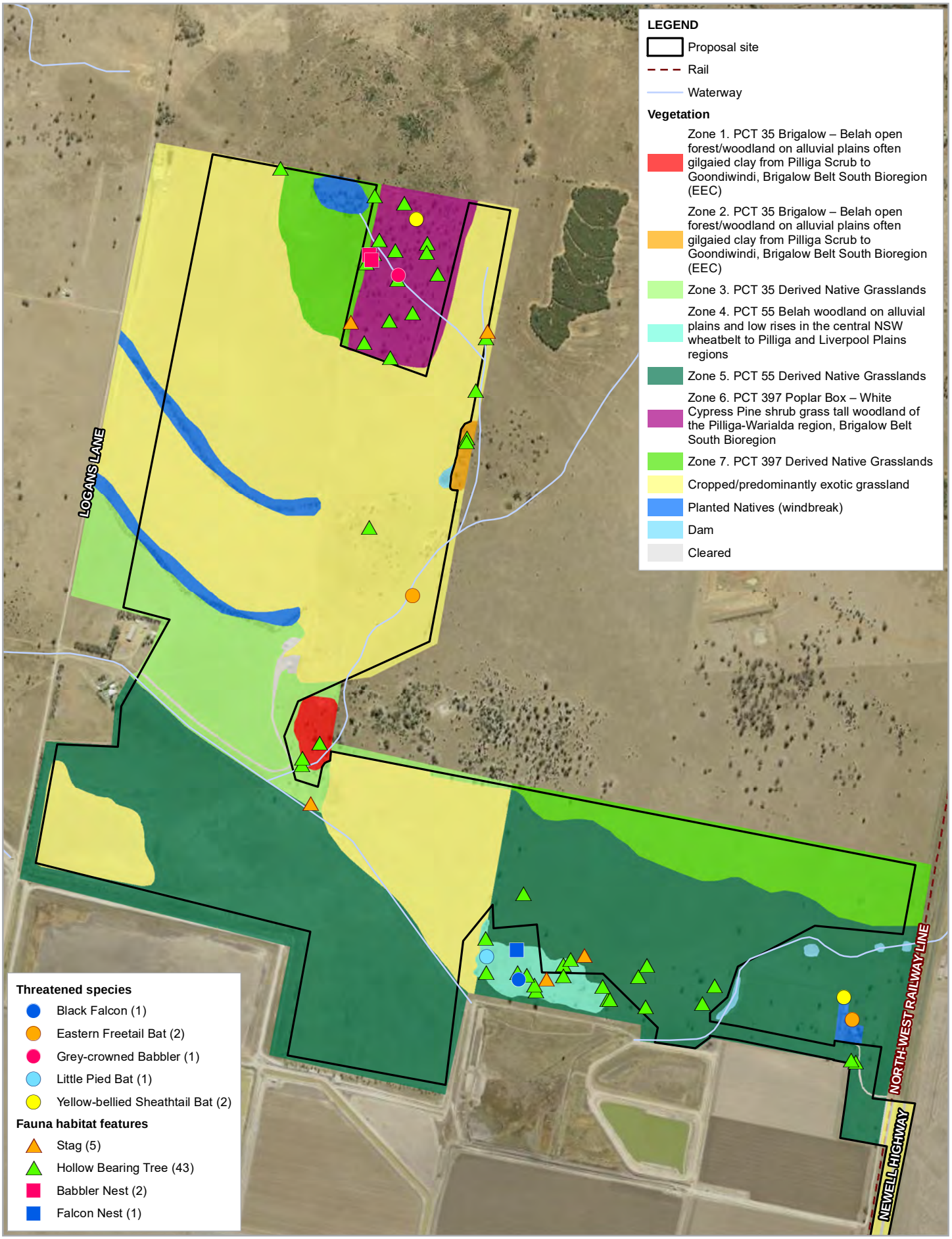
- *Carthamus lanatus* (Saffron Thistle)
- *Vachellia farnesiana* (Mimosa Bush)
- *Chloris gayana* (Rhodes Grass)
- *Paspalum dilatatum* (Paspalum)
- *Paspalum urvillei* (Vasey Grass)

Plant community types

Remnant woodland patches have been mapped and described at the proposal site in accordance with the BAM. The remnant woodland patches are shown in Figure 6-2 and correspond to three Plant Community Types (PCTs):

- PCT 35 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion
- PCT 397 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion
- PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions

The derived native grasslands that occur in the proposal site are continuous with the understories of the remnant woodland patches. These grasslands are considered to be derived from the clearing of the original woodland PCT. PCTs within the proposal site are shown in Figure 6-2 and described in Table 6-5.



Paper Size ISO A4

0 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Engie
Silverleaf Narrabri Solar Farm EIS

Vegetation and habitat resources

Project No. 21-26998
Revision No. 1
Date 25 Jun 2019

FIGURE 6-2

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Data source: General topo - NSW LPI DTDB 2015 & 2015; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

Table 6-5 Plant community types within the proposal site

Plant Community Type (OEH, 2018b)	PCT ID	Condition	Area Within Proposal Site	Conservation Significance
Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion_Moderate	35	Moderate	0.71	Ecological Endangered Community (EEC) under BC Act and EPBC Act
Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion_Derived Grassland	35	Derived grassland	26.81	Does not meet the criteria for an Ecological Endangered Community (EEC)
Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Moderate	55	Moderate	0.69	Not listed
Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Derived Grassland	55	Derived grassland	121.92	Not listed
Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Moderate	397	Moderate	1.15	Not listed
Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Derived Grassland	397	Derived grassland	32.69	Not listed

Endangered ecological communities

Moderate condition stands of Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion (PCT 35) within the proposal site are commensurate with the endangered ecological community (EEC) listed under the BC Act as Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions. It is also commensurate with the EEC listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as Brigalow (*Acacia harpophylla*) dominant and co-dominant. The proposal site boundary has been redesigned to avoid these small patches.

Based on the NSW Scientific Committee (2001) determination for the community, the derived grassland form of PCT 35 does not meet the condition criteria, and impacts on this area would not constitute impacts on the EEC. Similarly, based on the Commonwealth listing advice for the community (DotE 2013), the derived grassland form of PCT 35 does not meet the condition criteria for the EEC. The BioNet Vegetation Classification Database (OEH, 2018c) notes that PCT 397 is estimated to be 45 percent cleared.

Groundwater dependent ecosystems

The *NSW State Groundwater Dependent Ecosystems Policy* defines groundwater dependent ecosystems (GDEs) as ecosystems which have their species composition, and their natural ecological processes determined by groundwater (DLWC 2002). Ecosystems vary dramatically in the degree of dependency of groundwater, from having no apparent dependence through to being entirely dependent on it.

A search of the Atlas of GDEs (BOM 2018a) was used to determine any dependence (or interaction) on groundwater for the vegetation communities within the proposal site. This Atlas predicts the occurrence of groundwater dependent ecosystems and ecosystems that potentially use groundwater. It shows ecosystems that interact with the subsurface expression of groundwater, including vegetation ecosystems, or the surface expression of groundwater such as rivers and wetlands. The Atlas also shows the likelihood that landscapes are accessing water in addition to rainfall, such as soil water, surface water or groundwater.

Native vegetation within the proposal site is not mapped as vegetation with a potential for being reliant on the subsurface presence of groundwater. It is also unlikely to be an in-flow dependant ecosystem, i.e. an ecosystem that is "*accessing a water source in addition to rainfall, such as water stored in the unsaturated zone, surface water or groundwater*" (Australian Government, 2012).

Fauna

A total of 50 species of fauna were recorded during the field survey. These included 30 bird species (including three introduced species), 15 mammal species (including three introduced species and 11 microbat species), three reptile species and two frog species.

Threatened fauna species

Five threatened fauna species listed under the BC Act were recorded during surveys:

- Black Falcon (*Falco subniger*)
- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)
- Eastern Freetail Bat (*Mormopterus norfolkensis*)
- Little Pied Bat (*Chalinolobus picatus*)
- Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)

There is broadly suitable habitat for one candidate threatened fauna species listed in Table 6-3 (the Australasian Bustard). Targeted field surveys were undertaken at a suitable time of year to detect this species if present at site. There were no observations on site, and there are no local records of the species. The Australasian Bustard can be reliably discounted as occurring at the proposal site based on the survey effort employed. No breeding habitat for any of the dual credit fauna species was recorded at the site, and thus no species credit habitat is considered present for these species.

Fauna habitat

Fauna habitats comprise small patches of highly modified woodland and large areas of derived grassland or cropped land. There are no caves or culverts, cliff lines, substantial rock outcrops, wetlands or waterbodies at the proposal site. Fauna habitat features of the proposal site are detailed in Table 6-6, Table 6-7 and Table 6-8, and shown in figures 6-3 to 6-5.

Table 6-6 Fauna habitats: grassland with scattered trees

Grassland with scattered paddock trees	
Description	The proposal would be located in mostly cleared farmland, dominated by exotic crop species (e.g. Oats) or derived native grassland. Occasional isolated paddock trees or small groups of paddock trees are present (see Figure 6-3 and Figure 6-4). Paddock tree species comprise Narrow-leaved Grey Box (*Eucalyptus pilligaensis*) and occasional White Cypress Pine (*Callitris glaucophylla*). Many of the Narrow-leaved Grey Box were hollow-bearing.
Fauna recorded	A number of bird species typically associated with open grazing country were recorded. Galahs (*Eolophus rosiecapillus*), Red-rumped Parrot (*Psephotus haematonotus*) and Eastern Rosella (*Platycercus eximius*) were recorded, often near hollows. The introduced Common Myna (*Sturnus tristis*) and Common Starling (*Sturnus vulgaris*) are likely to compete with native bird species for hollows. Small flocks of the Noisy Miner (*Manorina melanocephala*) were observed. Occasional ravens (*Corvus* spp.) and Pied Butcherbirds (*Cracticus nigrogularis*) were seen perching on fences and powerlines. Flocks of Welcome Swallows (*Hirundo neoxena*) were seen foraging above and in the pasture and grassland. Whistling Kites (*Haliastur sphenurus*) were observed at a nest in a paddock tree. The introduced Brown Hare (*Lepus capensis*) and Fox (*Vulpes vulpes*), and Eastern Grey Kangaroo (*Macropus giganteus*) were observed in open paddocks. A range of microbats were recorded and would forage over the proposal site. Potential roosting habitat is present in hollow trees. South-eastern Morethia Skinks (*Morethia boulengeri*) and ragged Snake-eyed Skinks (*Cryptoblepharus pannosus*) were seen basking on fallen timber, and Tree Dtellas (*Gehyra variegata*) were observed on paddock trees while spotlighting.
Threatened species	A Black Falcon (*Falco subniger*) was observed roosting in a leafy paddock tree.

Figure 6-3 Grassland with scattered paddock trees

Table 6-7 Fauna habitats: woodland patches

Woodland patches	
Description	Woodland vegetation is present in small patches within the site. This vegetation comprises a canopy of eucalypts and Cypress Pine, with a sparse understory and grassy ground layer. A higher density of leaf litter and fallen timber is present in these areas. Hollow-bearing trees are also present. These are not considered breeding habitat for large owls and cockatoos as they are not located along riparian corridors. There is some connectivity to larger patches of vegetation in adjacent properties, however vegetation is generally fragmented.
Fauna recorded	A number of woodland bird species were recorded in these areas but not in adjacent paddocks. These included the Apostlebird (*Struthidea cinerea*), Pied Butcherbird (*Cracticus torquatus*) and White-winged Chough (*Corcorax melanorhamphos*). A Barn Owl (*Tyto javanica*) was observed flying into woodland. Many of the bird species recorded in the cleared agricultural land were also observed in the woodland patches.

Woodland patches	
Threatened species	The Grey-crowned Babbler was recorded in the patch of Poplar Box – White Cypress Pine woodland in the northern portion of the site. A number of nests were also recorded in this area. The Little Pied Bat (*Chalinolobus picatus*) and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) were recorded in small woodland patches using Anabat analysis. These species could roost and breed in hollow-bearing trees at the site. While the woodland patches constitute potential Koala habitat under SEPP 44, this habitat is unlikely to be important habitat for the species. Local records are concentrated around the Pilliga, with none near the proposal site. Koalas may occur on rare occasions, but would be unlikely to breed at the site.

Figure 6-4 Woodland patches

Table 6-8 Fauna habitats: farm dams and waterbodies

Farm dams	
Description	Two farm dams are present in the proposal site. These had limited emergent vegetation and are used as watering points by sheep. Small, undefined drainage lines are also present, leading to and from these dams. These tended to be depressions in the grassland, with occasional sedges present. No defined channel, standing water or pools are present. No woody debris or snags are present. A number of tanks with pumps are also present.
Fauna recorded	Common frogs such as the Spotted Grass Frog (*Limnodynastes tasmaniensis*) and Broad-palmed Frog (*Litoria latopalmata*) were observed at the dams. Tadpoles were observed in puddles adjacent to the tank. Apostlebirds and Magpie-larks were recorded at the dams. The dams and tanks would provide a source of water for other birds, microbats and macropods. Microbats are also likely to forage for insects above the dams, and a variety of microbats were recorded at these locations.

Farm dams	
Threatened species	The Eastern Freetail Bat (*Mormopterus norfolkensis*), Little Pied Bat (*Chalinolobus picatus*) and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) were recorded at dams in paddocks using Anabat analysis. These species could roost and breed in paddock trees at the site.

Figure 6-5 Farm dam

6.2.3 Potential impacts

Vegetation

The construction of the solar farm would impact predominantly areas of derived native grassland and cropped land, together with small patches of remnant woodland. In total, the proposal would impact about 183 hectares of native vegetation (remnant woodland and derived grassland) at the proposal site as summarised in Table 6-9.

The proposed transmission easement contains cleared cultivated lands and exotic grassland. No native vegetation would be removed for the construction of the transmission corridor.

Direct impacts on native vegetation at the proposal site would include the removal areas of tree and shrub vegetation across the proposal site, but would not involve removal of large areas of ground layer vegetation. There will be direct impacts associated with the installation of approximately 20,000 piles as supports for the panels. These would be driven or screwed into the ground, however groundcover will be retained under the panels. There would be temporary disturbance of groundcover during laying of cables, however trenches would be backfilled to the existing ground layer and groundcover would be able to regrow.

The height and spacing of the solar panels will produce some shading throughout the day, however sunlight and rain will enable continued growth of the groundcover. Remaining vegetation would receive rainfall and sunlight so that the majority of the native understorey vegetation, soil profiles and other habitat features in the proposal site would be retained in a similar condition to their current state during operation of the proposal. These areas would be modified through shading by solar panels and periodic operational activities such as infrastructure maintenance and slashing to reduce fuel loads.

Appropriate buffers would be established around trees that are to be retained. Where construction activities are required in the buffer areas, work be completed to avoid damage to the structural root zones (SRZ) of the trees to be retained. Details for calculating the SRZs are provided within *Australian Standard 4970-2009-Protection of trees on development sites*.

Table 6-9 Direct impacts on native vegetation

Plant Community Type (OEH, 2018b)	PCT ID	Condition	Area Within Proposal Site	Conservation Significance
Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion_Derived Grassland	35	Derived grassland	26.81	Does not meet the criteria for an Ecological Endangered Community (EEC)
Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Moderate	55	Moderate	0.69	Not listed
Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Derived Grassland	55	Derived grassland	121.92	Not listed
Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Moderate	397	Moderate	1.15	Not listed
Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Derived Grassland	397	Derived grassland	32.69	Not listed

Habitat and habitat resources

The proposal would involve clearing approximately 1.84 hectares of woodland from the total proposed 183 ha of vegetation that would be impacted. This would include removing scattered mature trees and hollow-bearing trees. Mature trees have value for fauna populations as sources of foraging such as leaves, nectar, sap or seed and substrate for invertebrate prey. In the context of the areas of remaining native vegetation surrounding the proposal site, the proposal would remove a small proportion of available foraging resources for local populations of native fauna.

The proposal would remove or modify up to 198.2 hectares of non-native vegetation associated with cropped land and exotic grassland, cleared land, planted windbreaks and dams. Non-native vegetation provides minimal habitat for most threatened species. Raptors may hunt over non-native grassland on occasion. Similarly, microchiropteran bats would forage above the non-native grassland. Small bird species that forage in woodland areas may also forage in the adjacent non-native grassland on occasion. No fauna species would rely on these areas for their survival in the locality, but may use these areas on occasion as part of a much larger home range.

No areas of geological significance, such as caves for breeding of bats are present. No human-made structures such as buildings, culverts or bridges that could provide habitat for bats would be removed.

Fragmentation or isolation of habitat

Habitat fragmentation through the clearing of vegetation can increase the isolation of remnant vegetation and create barriers to the movements of small and sedentary fauna such as ground dwelling mammals, reptiles and amphibians. Furthermore, habitat fragmentation can create barriers to the movement of pollinator vectors, such as insects, or seed vectors, such as birds, and consequently affect the life cycle of both common and threatened flora.

The proposal site provides limited connectivity for fauna given the predominantly cleared native of the proposal site. The proposal would remove clumps of paddock trees which may provide 'stepping stones' of connectivity between roadside vegetation to the east and west for mobile species such Galahs and other birds. Removal of these patches and trees would reduce the availability of these stepping stones to a small degree. Species that require larger tracts of connected vegetation would not occur in these small, fragmented patches. The removal of this vegetation is not considered to substantially limit the movement of species due to suitable other vegetation in the surrounding area. No patches of intact native vegetation would be removed.

Aquatic habitats

No habitat for threatened biota listed under the FM Act would be impacted. Indirect impacts could include sedimentation and erosion during construction. There would be no blockage of fish passage or removal of snags as a result of the proposal.

None of the aquatic habitats at the proposal site or transmission line corridor are classified as Key Fish Habitat and would not provide potential habitat for threatened fish. Aquatic habitats may provide limited breeding and shelter resources for common frog and reptile species.

Two farm dams may be removed for the proposal. This would reduce the number of watering points in the wider area by a small degree. Threatened species that may use these (such as the Grey-crowned Babbler and microchiropteran bats) would likely use a number of similar farm dams throughout their home range.

Aquatic habitats at the proposal site are limited to a small first order drainage line in the western portion of the site. The proposal would not impact this drainage line. The ephemeral nature of these drainage lines means negligible habitat for threatened species is provided.

Fauna

Construction may result in the injury or mortality of some individuals of less mobile fauna species and other small terrestrial fauna that may be sheltering in vegetation during clearing activities. There is a potential risk of injury or mortality to any species which may be using these hollows, such as microbats, arboreal mammals or hollow-nesting birds.

The potential for impacts on fauna utilising hollows would be reduced through pre-clearance surveys of habitat trees and protocols for less-impact felling of habitat trees. More mobile native fauna such as native birds, bats, terrestrial and arboreal mammals that may be sheltering in vegetation in the proposal site are likely to evade injury during construction activities.

The proposal would involve the removal of hollow-bearing trees or stags. Hollows are a limited resource, relied on by many native fauna for shelter and breeding. Galahs, Eastern Rosellas and Red-rumped Parrots were observed during surveys at these hollows. Introduced species such as the Common Starling competes with native fauna for hollows. The removal of these hollows would reduce breeding habitat for native species in the area, and could potentially remove breeding habitat for threatened species such as the Yellow-bellied Sheathtail bat, Little Pied Bat and Eastern Freetail Bat, which were recorded during surveys.

Mitigation measures outlined in Section 6.2.4 would assist in minimising the risk of impacts on fauna species during vegetation clearance activities.

Indirect impacts

Indirect impacts that may occur as a result of the proposal are described in Table 6-10. Mitigation measures proposed to minimise the risk of these impacts are detailed in Section 6.2.4.

Table 6-10 Indirect impacts

Impact	Description
Weed invasion and edge effects	'Edge effects' refer to increased noise and light or erosion and sedimentation at the interface of intact vegetation and cleared areas. Edge effects may result in impacts such as changes to vegetation type and structure, increased growth of exotic plants, increased predation of native fauna or avoidance of habitat by native fauna. Altered environmental conditions along new edges can allow invasion by pest animals specialising in edge habitats and/or change the behaviour of resident animals. Edge effects would result from construction activities and then continue to affect vegetation and habitats adjoining the project area. The project area and adjoining land has been extensively cleared for agricultural purposes. Small patches of woodland vegetation occur at scattered locations. Various weeds and exotic pasture species are present throughout the site. Construction of the proposal would result in new edges along already fragmented woodland patches, and has the potential to introduce or spread weeds.
Pests and pathogens	Construction activities, in general, have the potential to introduce or spread pathogens such as Phytophthora (*Phytophthora cinnamomi*), Myrtle Rust (*Uredo rangelii*) and Chytrid fungus (*Batrachochytrium dendrobatidis*) into native vegetation. The potential for impacts associated with these pathogens is low, given the disturbed nature of much of the study area, lack of permanent flowing water on site, and the environmental safeguards that would be implemented during the construction process.
Noise, light and vibration	Construction of the project would require the use of additional vehicles and plant in the site. Fauna that occupy habitats within the project area and adjacent areas are likely to be accustomed to some existing noise and vibration originating from vehicles, agricultural machinery and light aircraft. There is limited light spill currently at the site. Noise and vibration disturbance during construction could disturb resident fauna. While there would be localised increases in noise, vibration and light that would temporarily create substantial disturbance, increases above existing background levels during construction are unlikely to result in a significant impact on fauna that occur in the study area.
Sedimentation and erosion	Construction of the project has the potential to result in sedimentation and erosion within the subject site and adjoining native vegetation and aquatic habitats, through soil disturbance and construction activities. Sediment laden runoff to waterways can alter water quality and adversely affect aquatic life. Given the modified nature of drainage lines in adjacent areas and limited native vegetation, the potential for impacts is negligible.
Aquatic disturbance and pollution	Construction of the project has the potential to result in the mobilisation of contaminated sediments into waterways, or chemical spills from vehicles or plant. The introduction of pollutants from the project into the surrounding environment, if uncontrolled, could potentially impact on water quality further downstream. Given the modified nature of drainage lines in adjacent areas and limited native vegetation, the potential for impacts is negligible.

Assessment of serious and irreversible impacts

Under the BC Act, a determination of whether an impact is serious and irreversible (known as serious and irreversible impact or SAII) must be made in accordance with the principles set up in Section 6.7 of the *Biodiversity Conservation Regulation 2017*.

The principles are aimed at capturing impacts which are likely to contribute significantly to the risk of extinction of a threatened species or ecological community in New South Wales. These include impacts that will:

- Cause a further decline of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to be in a rapid rate of decline, or
- Further reduce the population size of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very small population size, or
- Impact on the habitat of a species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very limited geographic distribution, or
- Impact on a species or ecological community that is unlikely to respond to measures to improve habitat and vegetation integrity and is therefore irreplaceable

PCT 35 within the proposal site is commensurate with the EEC listed under the BC Act as Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions, which is an identified SAII entity. Currently there is no threshold of impact for Brigalow EEC/SAII (OEH 2017c).

To avoid impacts on PCT 35 EEC at the proposal site, the proposal site boundary has been redesigned to avoid remnant woodland patches of the PCT 35 EEC. The proposal avoids impacts on SAII entities. No detailed assessment of this SAII entity is considered necessary.

Consideration of matters of National Environmental Significance

The proposal has been designed to avoid direct impacts on Brigalow (*Acacia harpophylla* dominant and co-dominant) EEC listed under the EPBC Act. Given the close proximity of stands of this EEC to the proposal, an assessment of significance has been prepared in accordance with the '*Matters of National Environmental Significance Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999'* (DoE 2013). This assessment is provided in Appendix B.

Given the avoidance of direct impacts, and limited potential for indirect impacts, the proposal would not constitute a significant impact, and referral of the proposal is not considered necessary.

6.2.4 Safeguards and mitigation measures

Safeguards and management measures provided in Table 6-11 would be implemented to minimise potential impacts on biodiversity.

Table 6-11 Biodiversity mitigation measures

Impact	Environmental safeguards	Timing
General management of biodiversity	A Biodiversity Management Plan would be prepared prior to construction. This would detail fauna management protocols including management of tree hollows and fauna handling.	Pre-construction
	Ensure all workers are provided with an environmental induction prior to starting work on site. This would include information on the ecological values of the site and protection measures to be implemented to protect biodiversity.	Construction
Retained trees	Appropriate buffers would be established around trees that are to be retained. Work would avoid damage to the structural root zones (SRZ) of the trees.	Construction
Erosion impacts on biodiversity	Use of and regular inspection and maintenance of erosion and sediment control measures developed in the Erosion and Sediment Control Plan.	Construction
Clearance of vegetation	Fence off or mark trees to be retained, to avoid additional impacts on vegetation. Fencing would protect the entire Tree Protection Zone (i.e. 10 times the diameter of the trunk at breast height).	Pre-construction
	Any hollow-bearing trees to be felled would be marked prior to clearing of vegetation. The removal of hollow bearing trees is to be undertaken in accordance with a tree hollow management protocol set out in the CEMP, and would involve the presence of a qualified ecologist or wildlife specialist experienced in the rescue of fauna.	Pre-construction Construction
	Any trees with raptor nests would be felled outside the breeding season.	Construction
	Habitat features such as hollow trunks and limbs within the proposal site would be salvaged and replaced within areas proposed for screening vegetation where practicable.	Construction
Impacts form construction areas	Restrict stockpiles of construction materials, fill or vegetation to existing cleared areas and not within areas of adjoining native vegetation.	Construction
	Water would be applied to stockpile areas during windy conditions.	Construction
	Reinstatement of stabilised surfaces as quickly as practicable after construction.	Construction
Site rehabilitation	Planting of locally endemic tree species in areas proposed for vegetated screens.	Construction Operation

6.2.5 Offsetting – BC Act

Offsetting under the BC Act is required for impacts on native vegetation and predicted threatened species habitat, and for impacts on threatened species that cannot be reliably predicted by a vegetation surrogate.

For native vegetation and predicted threatened species habitat, offsetting (by satisfying an ecosystem credit obligation) is only required when the native vegetation or predicted threatened species habitat is above certain condition thresholds. The condition thresholds related to ecosystem credit offsetting are expressed in terms of vegetation integrity scores and are set out in Sections 10.3.1 and 10.3.2 of the BAM.

For threatened species that cannot be reliably predicted by a vegetation surrogate, offsetting (by satisfying a species credit obligation) is only required if the threatened species has been confirmed to be present, or the species is assumed to be present.

Offsets are not required for impacts on non-native vegetation that does not provide habitat for threatened species.

Offsetting obligations for the proposal

The proposal would be required to meet an ecosystem credit obligation to address impacts on native vegetation comprising habitat for predicted threatened species, including the Black Falcon, Grey-crowned Babbler, Eastern Freetail Bat, Little Pied Bat and Yellow-bellied Sheathtail Bat (which were recorded within the proposal site during field surveys). Ecosystem credits that would be required to offset the impacts of the proposal are shown in Table 6-12 and take into account the nature of the impacts as described in Section 6.2.3. The ecosystem credits listed below would offset the impacts on foraging and breeding habitat for all predicted threatened species, including those confirmed through survey.

Table 6-12 Ecosystem credits required to offset impacts of the project

Vegetation zone/PCT	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	BC Act status	Ecosystem credits required
Zone 3 – PCT 35 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion_Derived Grassland	26.81	12	11.2	Not listed	0*
Zone 4 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Moderate	0.69	45.3	25.6	Not listed	7
Zone 5 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Derived Grassland	121.92	28.4	21.9	Not listed	395
Zone 6 – PCT 397 Poplar Box-White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Moderate	1.15	52.6	17.5	Not listed	15
Zone 7 – PCT 397 Poplar Box-White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Derived Grassland	32.69	15.1	9.6	Not listed	0*

* No offset is required because the current vegetation integrity score is less than 17[1]

No offsetting is required for, "*a vegetation zone that has a vegetation integrity score of ≥ 17 where the PCT is associated with threatened species habitat (as represented by ecosystem credits), or is representative of a vulnerable ecological community*" (Section 10.3.1.1, subclause (a) of the BAM).

Options for offsetting

In accordance with the offset rules established by the *Biodiversity Conservation Regulation 2017* there are various means by which offsetting obligations can be met. These include:

- Retiring the appropriate credits from an established stewardship site
- Monetary payment directly into the Biodiversity Conservation Trust Fund, or
- Funding an approved biodiversity action. Funding a biodiversity action may be available as a last resort, subject to consultation with approval authorities, if all other options are determined to be unsuitable

Existing biodiversity credits

The preferred approach to offset the residual impacts of the proposal is to secure and retire appropriate credits from stewardship site/s that fit within the trading rules of the Biodiversity Offset Scheme and in accordance with the 'like for like' report generated by the credit calculator. The like for like trading rules for the ecosystem credits required for the proposal are summarised in Table 6-13.

Table 6-13 'Like for like' ecosystem credits required to offset impacts of the project

Credit Class	Any PCT in the below class	And in any of below trading groups	Containing hollow-bearing trees	In the below IBRA subregions
Credit classes for PCT 55	North-west Floodplain Woodlands (including PCT's 55)	North-west Floodplain Woodlands - ≥ 70% - <90% cleared group (including Tier 4 or higher).	Yes	Liverpool Plains, Castlereagh-Barwon, Kaputar, Liverpool Range, Northern Basalts, Northern Outwash, Peel, Pilliga and Pilliga Outwash. or Any IBRA subregion that is within 100 kilometres of the outer edge of the impacted site.
Credit classes for PCT 397	Pilliga Outwash Dry Sclerophyll Forests (including PCT's 88, 141, 148, 397, 411, 702, 1090, 1384)	Pilliga Outwash Dry Sclerophyll Forests - < 50% cleared group (including Tier 7 or higher).	Yes	Liverpool Plains, Castlereagh-Barwon, Kaputar, Liverpool Range, Northern Basalts, Northern Outwash, Peel, Pilliga and Pilliga Outwash. or Any IBRA subregion that is within 100 kilometres of the outer edge of the impacted site.

Payment into the Biodiversity Conservation Fund

A payment to the Biodiversity Conservation Trust (BCT) could be considered if a suitable number and type of biodiversity credits could not be secured from third parties. Table 6-14 provides an estimate of the biodiversity credit purchase for the proposal.

It should be noted that payment for offsets are subject to change and that credit payment prices are reviewed by the BCT quarterly. The payment amounts presented within this report were calculated and valid as of 27 February 2019.

Table 6-14 Estimated biodiversity offset credit payment price

Credit class	Price per credit	Number of credits required	Final credit price
55 - Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions.	$2,017.01	402	$810,837.21
397 - Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	$2,017.01	15	$30,255.12
Subtotal (excl. GST)			***$841,092.33***
GST			***$84,109.23***
Total			**$925,201.56**

6.2.6 Offsetting – EPBC Act

Offsets would be required for any significant residual impacts on matters of national environmental significance (MNES), according to the requirements of the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy October 2012* (EPBC Act Offsets Policy) (DSEWPaC 2012).

The assessments of significance prepared for Brigalow (*Acacia harpophylla* dominant and co-dominant) EEC indicated that the proposal is unlikely to have a significant impact on this MNES, and thus no offsets are required.

6.3 Aboriginal heritage

This section summarises the Aboriginal heritage assessment undertaken for the proposal. The full Aboriginal Heritage Impact Assessment Report is provided in Appendix C.

6.3.1 Methodology

The Aboriginal heritage assessment follows the standards outlined in the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b) and the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in New South Wales* (OEH 2011). The Aboriginal heritage assessment used a combination of desktop studies, consultation with local Aboriginal groups and fieldwork.

The desktop assessment and consultation were used to develop a predictive model of site occupation. The predictive model assisted in identifying areas with the highest potential for sites and objects of Aboriginal heritage significance to be recorded. In conjunction with the Office of Environment & Heritage (OEH), it was decided that an Aboriginal Cultural Heritage Assessment Report (ACHAR) was not required, as the proposal will include a buffer to protect known Aboriginal sites.

A pedestrian survey of the study area was undertaken by OzArk archaeologists on Tuesday 23 to Thursday 25 October 2018. The pedestrian survey was conducted to the standard outlined in the *Code of Practice for Archaeological Investigations* (OEH). Representatives of the Narrabri Local Aboriginal Land Council and Gomeroi Native Title Claim Group were present during the survey.

Desktop studies

A number of previous studies were researched to understand the context of Aboriginal occupation of the area prior to European settlement. According to Tindale (1974), the proposal site is in the centre of the lands occupied by the Kamilaroi tribe. The name Narrabri is derived from an Aboriginal word, meaning 'Forked Waters'. Prior to European settlement, the Kamilaroi people practiced a hunting, gathering and fishing economy with the Naomi River and the Gwydir River areas.

The early 1830s saw the expansion of European settlement into northern New South Wales including Narrabri and its close surroundings. The first squatting settlement run 'Nurrabry' started in 1834 (Hunt 1998). Continued settlement in the region lead to violent interactions between the Europeans and the Kamilaroi.

From a broader perspective (Liverpool Plains District) the available data indicates variable use of the local landforms, with known sites indicating ephemeral, casual or limited use, and other sites showing more intensive or repeated use. The most frequent site type recorded in the broader region is the small open camp site, which is most often found on level, well drained terrain close to permanent water. Artefacts at these sites usually number less than 50, although the site size appears to be greatly affected by ground surface visibility conditions at the time of recording. Some sites are associated with grinding grooves and/or modified trees. Details of relevant studies within the broader region are provided in Appendix C.

Database searches

Databases were investigated to identify any previously-recorded heritage items or places within the study area. The following databases were searched:

- Australian Heritage Database – Department of Environment and Energy
- National Native Titles Claims Search
- OEH Aboriginal Heritage Information System (AHIMS)
- Narrabri LEP

The results of this search are summarised in Table 6-15 and detailed in Section 6.3.2.

Predictive model for site location

The predictive model is a tool used to highlight areas with higher potential to contain items or places of heritage significance. Knowledge of the environmental contexts of the study area, and a desktop review of the known local and regional archaeological record, has allowed a predictive model for the proposal site to be developed.

Across Australia, numerous archaeological studies in widely varying environmental zones and contexts have demonstrated a high correlation between the permanence of a water source and the permanence and/or complexity of Aboriginal occupation. Site location is also affected by the availability of and/or accessibility to a range of other natural resources including: plant and animal foods; stone and ochre resources and rock shelters; as well as by their general proximity to other sites/places of cultural/mythological significance. Consequently sites tend to be found along permanent and ephemeral water sources, along access or trade routes or in areas that have good flora/fauna resources and appropriate shelter.

In formulating a predictive model within any landscape it is also necessary to consider post-depositional influences on Aboriginal material culture. In all but the best preservation conditions, very few organic material cultural artefacts of ancestral Aboriginal communities survive to the present. Generally it is the more durable materials such as stone artefacts, stone hearths, shell, and some bones that remain preserved in the current landscape. Even these however may not be found in their original depositional context since these may be subject to either:

- The effects of wind and water erosion/transport - both over short and long time scales, or
- The historical impacts associated with the introduction of European farming practices

These practices include grazing and cropping; land degradation associated with exotic pests such as goats and rabbits and the installation of farm related infrastructure including water-storage, utilities, roads, fences, stockyards and residential quarters. Scarred trees may survive for up to several hundred years but rarely beyond.

Evidence and artefacts associated with Aboriginal occupation

The following sites and artefacts are common indicators of Aboriginal occupation of an area, and of cultural significance to a site.

Isolated finds

Isolated finds may be indicative of random loss or deliberate discard of a single artefact, the remnant of a now dispersed and disturbed artefact scatter, or an otherwise obscured or sub-surface artefact scatter. As isolated finds can occur anywhere, particularly within disturbed contexts, it is predicted that this site type could be recorded within the study area.

Open artefact scatters

Open artefact scatters are defined as two or more artefacts, not located within a rock shelter, and located no more than 50 metres away from any other constituent artefact. This site type may occur almost anywhere that Aboriginal people have travelled and may be associated with hunting and gathering activities, short or long term camps, and the manufacture and maintenance of stone tools. Artefact scatters are most likely to occur on level or low gradient contexts, along the crests of ridgelines and spurs, and elevated areas fringing watercourses or wetlands. Larger sites may be expected in association with permanent water sources.

Artefact scatters, as well as isolated stone artefacts, are the predominant site types occurring in the region. This site type is likely to be in a secondary context from disturbances such as erosion and ploughing. It is likely that any sites are likely to have a low artefact density and a low complexity of tool types. These sites are either one-off events, or only infrequently used due to the lack of a permanent or semi-permanent water source.

Aboriginal scar trees

Scar trees contain evidence of the removal of bark (and sometimes wood) in the past by Aboriginal people, in the form of a scar. Bark was removed from trees for a wide range of reasons including the manufacture of various tools, vessels and commodities such as string, water containers, and roofing for shelters, shields and canoes. Scarred trees may occur anywhere old growth trees survive. The identification of scars as Aboriginal cultural heritage items can be problematic because some forms of natural trauma and non-Aboriginal bark extraction, such as for roofing, create similar scars.

Vegetation within the study area includes remnant native species. These stands of native vegetation include trees of a type, age and size well suited to scar-producing activities. This site type therefore may be encountered and it is also noted that this site type has been recorded locally. However, high levels of vegetation clearing reduce the likelihood of recording scar trees.

Quarry and stone procurement sites

Quarry and stone procurement sites typically consist of exposures of stone material where evidence for human collection, extraction and/or preliminary processing has survived. This site type is not considered likely to be recorded within the proposal area.

Burials

Burials are generally found in soft sediments such as elevated sandy contexts or in alluvial silts. They are also associated with rock shelter deposits, or with rivers and major creeks. No such features exist at the proposal site and therefore burials are unlikely to occur.

Consultation and fieldwork

The following representatives of Aboriginal community groups participated in the fieldwork program:

- Narrabri Local Aboriginal Land Council, 23–25 October 2018
- Gomeroi Native Title Claim Group, 25 October 2018

Further informal consultation was undertaken with the Narrabri Local Aboriginal Land Council and the Gomeroi Native Title Claim Group and this is detailed in Appendix C.

The archaeological methods utilised in the Aboriginal archaeological assessment followed the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (Code of Practice, OEH) and the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH, 2011). Standard archaeological field survey and recording methods were employed in this study (Burke & Smith 2004).

The fieldwork was undertaken by OzArk on Tuesday 23 to Thursday 25 October 2018. There were no significant constraints in completing the archaeological assessment of the study area. Ground surface visibility (GSV) posed the greatest constraint during field inspection, however, not to the extent that the efficacy of the survey was unduly diminished.

The entirety of the proposal area was assessed by pedestrian transects, excluding the areas surrounding existing houses, farm infrastructure and the TransGrid substation, which will not be impacted by the proposal. The surveyors were spaced approximately 30 to 50 metres apart. All mature, native trees within the proposal area with the potential to contain Aboriginal scarring were inspected. Sites were recorded with digital photography and GPS. General notes pertaining to the survey and ground covered by the archaeologist was kept as well. Further details of the field survey methodology are provided in Appendix C.

6.3.2 Existing environment

The proposal site is situated in two landforms: the Kaputar Slopes and the Liverpool Alluvium Plains. The Kaputar Slopes is characterised by a general elevation of 300 to 500 metres. The Liverpool Alluvial Plains are characterised by undulating hills and sloping plains with alluvial channels and floodplains, with a general elevation of 300 to 350 metres (Mitchell 2002).

The closest watercourse to the proposal area is Mulgate Creek, approximately 150 metres east of the proposed transmission line corridor. All other watercourses, including Narrabri Creek, Doctors Creek, Horse Arm Creek and the Namoi River, are over one kilometre from any section of the proposal site.

The proposal site is predominantly ploughed and grazed paddocks which have been cleared of vegetation. There are also farm buildings, fences and stockyards present in the main section of the proposal area. The proposed transmission line corridor is made up of existing electricity easements and road reserves.

The proposal site has two distinct types of survey units, based on landform or land use. The northern section of the proposal site consists of a gentle slope declining north to south, until evening into flat pastures. The southern section of the study area is flat.

Database search results

Native Title search results

The Gomeroi People (Tribunal File No. NC2011/006) have lodged a claim over the proposal's study area. It is understood that the native title claim has not been registered by the National Native Title Tribunal. The Native Title Tribunal has not determined the claim by the Gomeroi People.

The proposal site is located on free hold land, and would not be subject to this claim. Sections of the proposed transmission corridor, and a portion of the northern section of Logans Lane are located on Crown Land. The Crown Land on Logans Lane will not be affected by the proposal as the site will be accessed from the southern section of Logans Lane.

The grant of any interests to the developer of the transmission line over Crown land will need to comply with the "future act" provisions of the *Native Title Act 1993* unless the State is satisfied that native title has historically been extinguished.

AHIMS search results

A search of the AHIMS resulted in 29 Aboriginal sites being located within 10 kilometres of the proposal site. There are no previously recorded sites within the proposal site.

The majority of previously recorded sites are artefact scatters (34%), followed by scarred/carved trees (31%). Burials, grinding grooves and isolated artefacts are all equally represented (7%), with a limited number of other site types also being present (3% each). The closest AHIMS sites to the proposal site are AHIMS #19-3-0133 and #19-3-0136 located approximately 1.4 kilometres southwest from the proposed transmission line easement.

Artefact sites and modified trees are the most commonly recorded Aboriginal sites in the 10 kilometre radius of the proposal site. These types of sites are often located in the vicinity of watercourses and large areas of native vegetation. It is unlikely that large campsites or modified trees will be located within the proposal site, due to the site's distance from permanent or semi-permanent watercourses, and the lack of large areas of native vegetation.

Table 6-15 summarises the results of the database searches.

Table 6-15 Database search results

Database	Date searched	Area of search	Result
Australian Heritage Database – Department of Environment and Energy	14/11/2018	Narrabri LGA	One place listed on the Commonwealth Heritage List: Narrabri Post Office and former Telegraph Office 138-140 Maitland Street. This item is located 5.5 kilometres south of the proposal site. This is not relevant to the Aboriginal heritage assessment.
National Native Title Claims Search	14/11/2018	NSW	The Gomeroi People (Tribunal File No. NC2011/006) have an active claim over the study area

Database	Date searched	Area of search	Result
OEH Aboriginal Heritage Information Management System (AHIMS)	4/10/2018	Easting 757488–779112 Northing 6633883–6658196 No buffer.	No sites are within the proposal site. Twenty nine sites were recorded in the 21.6 x 24.3 kilometre search area.
Local Environmental Plan (LEP)	14/11/2018	Narrabri LEP 2012	No Aboriginal places listed

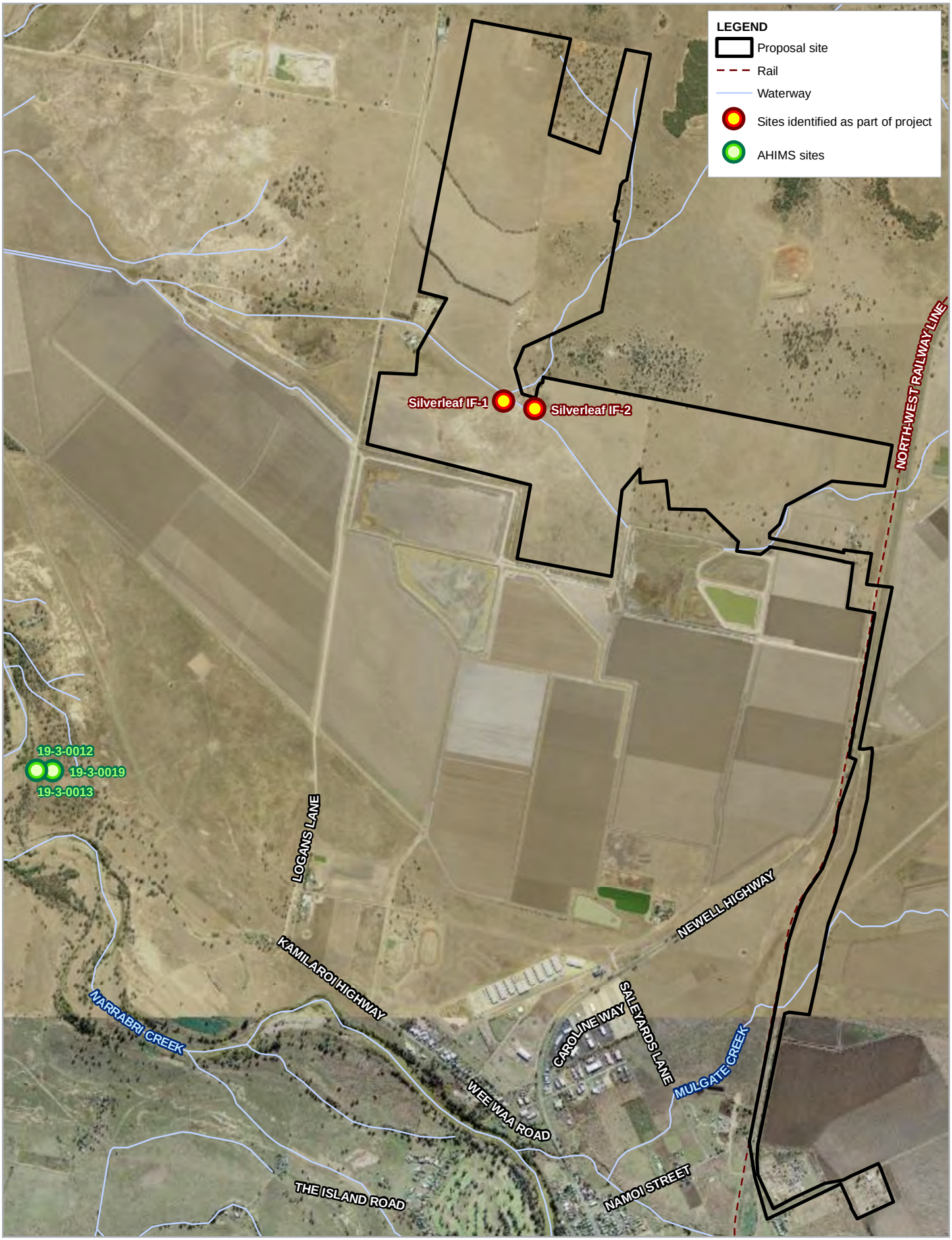
6.3.3 Potential impacts

Two previously unrecorded Aboriginal sites were identified during the pedestrian survey: Silverleaf IF-1 and Silverleaf IF-2. Details are provided in Table 6-16.

Table 6-16 Aboriginal sites recorded

Site name	Coordinates (GDA) (centre point)	Site type	Artefact count	Site dimensions (metres)
Silverleaf IF-1 (#19-3-0163)	766916E/6647274N	Isolated artefact	1	1 x 1
Silverleaf IF-2 (#19-3-0164)	767094E/6647233N	Isolated artefact	1	1 x 1

Figure 6-6 shows the location of where these sites were recorded.



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Location of recorded Aboriginal sites

Project No. 21-26998
Revision No. 1
Date 25 Jun 2019

FIGURE 6-6

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Data source: General topo - NSW LPI DTDB 2015 & 2015; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Aboriginal sites - OzArk; AHIMS - OEH. Created by:jrprice

Silverleaf IF-1 (#19-3-0163)

The Silverleaf IF-1 site is located 780 metres east of Logans Lane and 22 metres south of the artificial water drainage channel. Narrabri Creek is the closest watercourse and is located three kilometres southwest of the proposal site. It is situated within a large patch of erosion 16 metres east of a gate and fence line in a paddock used for grazing.

The Silverleaf IF-1 site consists of a single, silcrete proximal flake fragment at a tertiary stage of reduction. The site extent covers one metre square around the artefact location. The flake is within the two to four centimetre size range.

There were no additional artefacts located at the Silverleaf IF-1 site. There is limited potential for *in situ* sub-surface deposits. Figure 6-7 shows the immediate context of the Silverleaf IF-1 site, with a view to the east of the surrounding paddock environment.

Figure 6-7 View east from Silverleaf IF-1 (#19-3-0163)

Silverleaf IF-2 (#19-3-0164)

The Silverleaf IF-2 site is located 970 metres east of Logans Lane, north of the water drainage channel. Silverleaf IF-2 is located approximately 190 metres east of Silverleaf IF-1.

Narrabri Creek is the closest watercourse and is located 3.3 kilometres southwest of the proposal site. The Silverleaf IF-2 site is located in a paddock currently used for grazing, but that has also been ploughed and cropped.

The Silverleaf IF-2 site consists of a single, quartzite proximal flake fragment at a tertiary stage of reduction. The flake is smaller than two centimetres and was found in a patch of erosion. There were no additional artefacts located at the location and the Silverleaf IF-2 site is assessed as having limited potential for *in situ* sub-surface deposits. Figure 6-8 shows a photograph of the isolated find, and Figure 6-9 shows the context of this site, with a view to the southeast of the surrounding paddock environment.

Figure 6-8 Artefact located at Silverleaf IF-2 (#19-3-0164)

Figure 6-9 View southeast of Silverleaf IF-2 (#19-3-0164)

Assessment of significance

The two previously unrecorded Aboriginal sites that were located during field investigations are isolated artefacts located in disturbed contexts without associated subsurface deposits. There is low potential for further sites or *in situ* subsurface archaeological deposits being present within the remainder of the study area.

The results of the assessment confirm the predictive model in that there are no archaeologically significant landforms or watercourses within the proposal area. This means large complex sites (such as camp sites) are unlikely. While the presence of the two isolated artefact sites is not uncommon in such landforms, they can be described as a 'background' scatter, indicating there were Aboriginal people in the area, but not providing any further scientific information.

The scientific, cultural and historic values of any site are assessed to determine the significance of a site, place or area. The combination of these elements determines their overall cultural heritage values.

Scientific value

Scientific assessments examine the site in a broader regional framework, as well as the site's individual merits. This type of value relates to the ability of a site to answer current research questions and is also based on a site's condition (integrity), content and representativeness. Establishing whether or not a site can contribute to current research also involves defining 'research potential' and 'representativeness', and whether the site can contribute information that no other site can.

The scientific significance of Silverleaf IF-1 and Silverleaf IF-2 are assessed as low. Both sites represent isolated artefacts in secondary contexts. These sites are assessed as having low scientific/archaeological values based on the following:

- Low density of artefacts.
- No formal tool types.
- The area is affected by widespread past and current disturbance through the use of the property for cropping and grazing, and the creation of the artificial drainage line.

Cultural values

Cultural values concern the importance of a site or its features to the relevant cultural group, in this case the Aboriginal community. Aspects of social value include assessment of sites, items, and landscapes that are traditionally significant or that have contemporary importance to the Aboriginal community. This importance involves both traditional links with specific areas, as well as an overall concern by Aboriginal people for their sites generally and the continued protection of these.

The cultural value of Aboriginal sites is generally determined through consultation with Aboriginal people. Aboriginal sites have significance to the local Aboriginal community in the Narrabri region, providing tangible links to the occupation of the land by their ancestors.

In consultation with the members of the Aboriginal community that were present for fieldwork, Silverleaf IF-1 and Silverleaf IF-2 have been provisionally assigned high social/cultural value**.**

Historic values

Historic values refer to the associations of a place with a historically important person, event, phase or activity in an Aboriginal community. Historic places do not always have physical evidence of their historical importance (such as structures, planted vegetation or landscape modifications). They may have 'shared' historic values with other (non-Aboriginal) communities.

There are no known historical associations for Silverleaf IF-1 and Silverleaf IF-2. They have been assigned nil historical value.

Summary of impacts

ENGIE has developed a design that avoids the footprint of the two identified sites, incorporating an appropriate buffer around these locations. As such, the sites will not be impacted by the proposal.

6.3.4 Safeguards and mitigation measures

Appropriate management of cultural heritage items is primarily determined on the basis of their assessed significance as well as the likely impacts of the proposed development. Safeguards and management measures provided in Table 6-17 would be implemented to minimise potential impacts on Aboriginal heritage.

Table 6-17 Aboriginal heritage mitigation measures

Impact	Environmental safeguards	Timing
Management of Aboriginal heritage impacts	Development of an Aboriginal Cultural Heritage Management Plan (ACHMP) which would include details of the on-going management of Silverleaf IF-1 and Silverleaf IF-2 during construction and operation and procedures for unanticipated finds.	Prior to construction
Impacts to known items	A five-metre buffer zone with high-visibility fencing around the two sites.	During and post-construction
Impacts to known items	Induction for site workers detailing the location of the two sites, their cultural values and the legislative requirements for their management.	Prior to and during construction
Impacts to known items	In the event that the proposal would impact upon Silverleaf IF-1 and Silverleaf IF-2, further assessment would be required in the form of an Aboriginal Cultural Heritage Assessment Report (ACHAR). Further consultation would also be required in accordance with the OEH Aboriginal community consultation requirements.	Pre-construction
Identification of previous unknown item	In the event that a previously unidentified Aboriginal site is discovered within the study area at any point during the operational life of the Project, an AHIMS site card for that site would be submitted to OEH as promptly as possible. Timing protocols for the submission of AHIMS site cards should be included in the ACHMP for the proposal.	Construction
Identification of potential human remains	In the event that potential human skeletal remains are identified within the study area at any point during the life of the proposal, the following standard procedure would be followed: • All work in the vicinity of the remains would cease immediately. • The location would be cordoned off and the NSW Police notified. • If the Police suspect the remains are Aboriginal, they would contact the Office of Environment and Heritage and arrange for a forensic anthropologist or archaeological expert to examine the site. Subsequent management actions will be dependent on the findings of the inspection undertaken under Point 3: • If the remains are identified as modern and human, the area would become a crime scene under the jurisdiction of the NSW Police. • If the remains are identified as pre-contact or historic Aboriginal, OEH and all RAPs are to be formally notified in writing. Where impacts to exposed Aboriginal skeletal remains cannot be avoided an appropriate management mitigation strategy would be developed in consultation with OEH and RAPs. • If the remains are identified as historic non-Aboriginal, the site would be secured and the NSW Heritage Division contacted. • If the remains are identified as non-human, work can recommence immediately.	Construction

6.4 Landscape and visual

The development of the proposal, and associated infrastructure such as the transmission line, has the potential to affect the visual character of the site and surrounding areas. The proposal also has the potential to affect the operation of the adjoining airstrip and land uses as a result of reflection and glare from the solar panels.

This visual impact assessment has been completed to identify potential visual impacts on residences, and scenic or significant vistas, or adjoining transportation operations. Management and mitigation measures have been developed to minimise impacts where required.

6.4.1 Methodology

The methodology used to complete the landscape character and visual impact study is summarised as follows:

- Reviewing the concept design and supporting material to gain an appreciation of the proposal in the context of the locality
- Identifying the visual catchment of the solar farm and transmission line through the preparation of a view shed analysis
- Describing the landscape character and identifying visually sensitive receivers with views of the proposal and grouping receivers into key viewpoints where appropriate
- Assessing the potential for reflection and glare to affect the adjoining airstrip
- Evaluating the visual impact of the proposal by comparing the sensitivity of viewpoints and the magnitude of the impact upon them

Visual impact assessment

Locations from where the solar infrastructure and the transmission line may be visible have been determined. These are known as viewpoints. The potential visual impacts have been assessed in relation to each of these viewpoints. Viewpoints were generally identified by grouping similar visually sensitive receivers based on type of land use, distance from the proposal and direction of views.

The significance of the proposal's visual impacts on surrounding areas is a function of the magnitude of visual change, together with its proximity to the viewer. It also considers the sensitivity in relation to the quality of the view, and sensitivity to the proposed changes. The significance of impacts can depend on a number of variables including the viewer's perception, and the viewer's emotional ties to a locality.

The proposal's potential visual impact has been determined based on a combination of the following:

- Sensitivity rating – the sensitivity of the viewpoint (i.e. receivers) to changes in the visual landscape
- Magnitude rating – the nature of the proposed changes resulting from the proposal including the physical size and scale of the proposal within the viewpoint

The above two ratings are then combined using the matrix outlined in Table 6-18 to determine the overall level of impacts on each of the viewpoint.

Table 6-18 Visual impact assessment grading matrix

		Magnitude			
		High	Moderate	Low	Negligible
Sensitivity	High	High impact	High to moderate impact	Moderate impact	Negligible
	Moderate	High to moderate impact	Moderate impact	Moderate to low impact	Negligible
	Low	Moderate impact	Moderate to low impact	Low impact	Negligible
	Negligible	Negligible	Negligible	Negligible	Negligible

View shed analysis

A view shed analysis was carried out to determine where the proposal would be visible from in the surrounding landscape. Two separate view shed analyses were undertaken, including one for the proposed solar farm and one for the proposed transmission line corridor. These components of the proposal have different heights, visual elements and occupy different parts of the landscape. They were separated in the analyses to avoid either component influencing the accuracy of the assessment of visual impacts for the other.

Details of the proposal's components that were assessed in each view shed analysis are outlined in Table 6-19. A conservative approach has been taken in nominating the heights of the infrastructure, to capture all potential views of the proposal. The view shed analyses consider views based on the terrain only, and do not account for the effects of screening from existing vegetation in the intervening landscape. The description below is considered to be conservative and many areas assessed as having views of the proposal site may not have a view of the site, or views may be partially screened.

Table 6-19 Proposal components assessed in the view shed analysis

View shed	Overview of the components of the proposal assessed
Solar farm site (Figure 6-13)	The view shed analysis for the solar farm site involved the assessment of the following infrastructure (including their assumed maximum heights) located within the northern and southern solar farm development areas: • Substation (five metres) • Control building (five metres) • Solar panels, including inverter containers (four metres) across the entire site with the exception of the substation, control building and the perimeter buffer • Administration building (four metres).
Transmission line (Figure 6-14)	The view shed analysis for the transmission line considered a 30 metre high transmission line located along the boundary of the transmission line corridor (as shown on Figure 6-14). As previously mentioned, this assessment conservatively assumes that the entire transmission line would be aboveground.

6.4.2 Existing environment

Landscape character

The landscape surrounding the proposal site is relatively flat, with only gradual changes in elevation in the immediately surrounding area. The surrounding area consists primarily of farming land, with a mix of cropping and grazing properties. Narrabri township is located to the south of the intersection of the Newell and Kamilaroi Highways about four kilometres away. Views of the proposal site would not be available from Narrabri township.

In general, the landscape rises to the north-east towards a localised highpoint located about 1.7 kilometres away from the proposal site. Areas to the west of the proposal site are slightly elevated, while areas to the east are below the site. Areas to the south of the proposal site are generally at a similar elevation to the proposal site, with the exception of portions of the Australian Grain Technologies site, which are elevated above natural ground level.

At the southern end of the transmission line route, near the connection point with the TransGrid substation on Stoney Creek Road, there are smaller lots containing a mix of land uses. There is a livestock saleyard, a cemetery, and six residential lots located on Bailey Street. This area is comparatively low lying.

Solar farm site

The proposal site is used for agricultural purposes which has resulted in it being largely being cleared of trees and shrubs. The proposal site is visually consistent with the rural properties located in the surrounding area which are predominately used for grazing and cropping.

Figure 6-10 View south across the proposal site from the northern paddock near the existing dam

Figure 6-11 View north across the proposal site from southern boundary

Figure 6-12 View east across the proposal site

Figure 6-10 to Figure 6-12 show the typical landscape character of the proposal site from different locations across the site. The proposal site is relatively flat in the southern portion of the site. The northern section of the Logans Lane site rises towards the northern boundary.

The boundary of the proposal site is largely void of vegetation with the exception of some boundary planting along Logans Lane south of the dwelling access points, and also along the southern boundary of the Logans Lane property. Some vegetation is located along other sections of the property boundary, however these are mostly isolated trees or small stands of vegetation. The property boundary along the Newell Highway also contains isolated trees.

The following more substantial stands of vegetation are located across the site:

- Vegetation along the northern side of the dwelling located on the Logans Lane property
- Two rows of vegetation north of the dwellings on the Logans Lane property, installed as wind breaks
- Patchy vegetation in the northern part of the Logans Lane property

Due to the rural nature of the locality, sensitive visual receivers are limited, with isolated rural-residential dwellings located surrounding the site in all directions. The location of these sensitive receivers is shown in Figure 6-13. It is noted that three existing dwellings are present within the proposal site as shown in Figure 6-13. The continued use of these dwellings is to be confirmed as part of the development of the lease agreements. These dwellings are not considered to be sensitive receivers as their continued use would be subject to the lease agreement.

Transmission line corridor

The visual landscape of the transmission line route is set in a primary rural landscape. The northern part of the transmission line corridor, while having a largely rural outlook, is located in an area where the transport corridors of the Newell Highway and North-West Railway Line dominate the visual landscape. South of Killarney Gap Road the transmission corridor diverges to the east away from the Highway corridor, but follows the North-West Railway Line alignment. The railway line in this location is not a dominant aspect of the landscape as it is single track with no overhead infrastructure.

The southern sections of the transmission line corridor are located in a landscape with industrial and other urban development becoming more dominant closer to Narrabri. These areas are generally in the middle or background of any views. Just north of Salesyard Lane, a corridor of existing transmission lines have an increased presence due to their positioning within predominately cleared agricultural land.

Along the southern end of Old Cemetery Road, some road side vegetation and the presence of the Narrabri Cemetery provide a differing landscape to the surrounding cleared agricultural land. The visual landscape along Stoney Creek Road is semi-rural with a small isolated group of single storey detached dwellings breaking up the areas of cleared agricultural land. The landscape east along Stoney Creek Road changes from a residential area to rural landscape containing a number of transmission lines which enter the TransGrid Substation.

View shed analysis

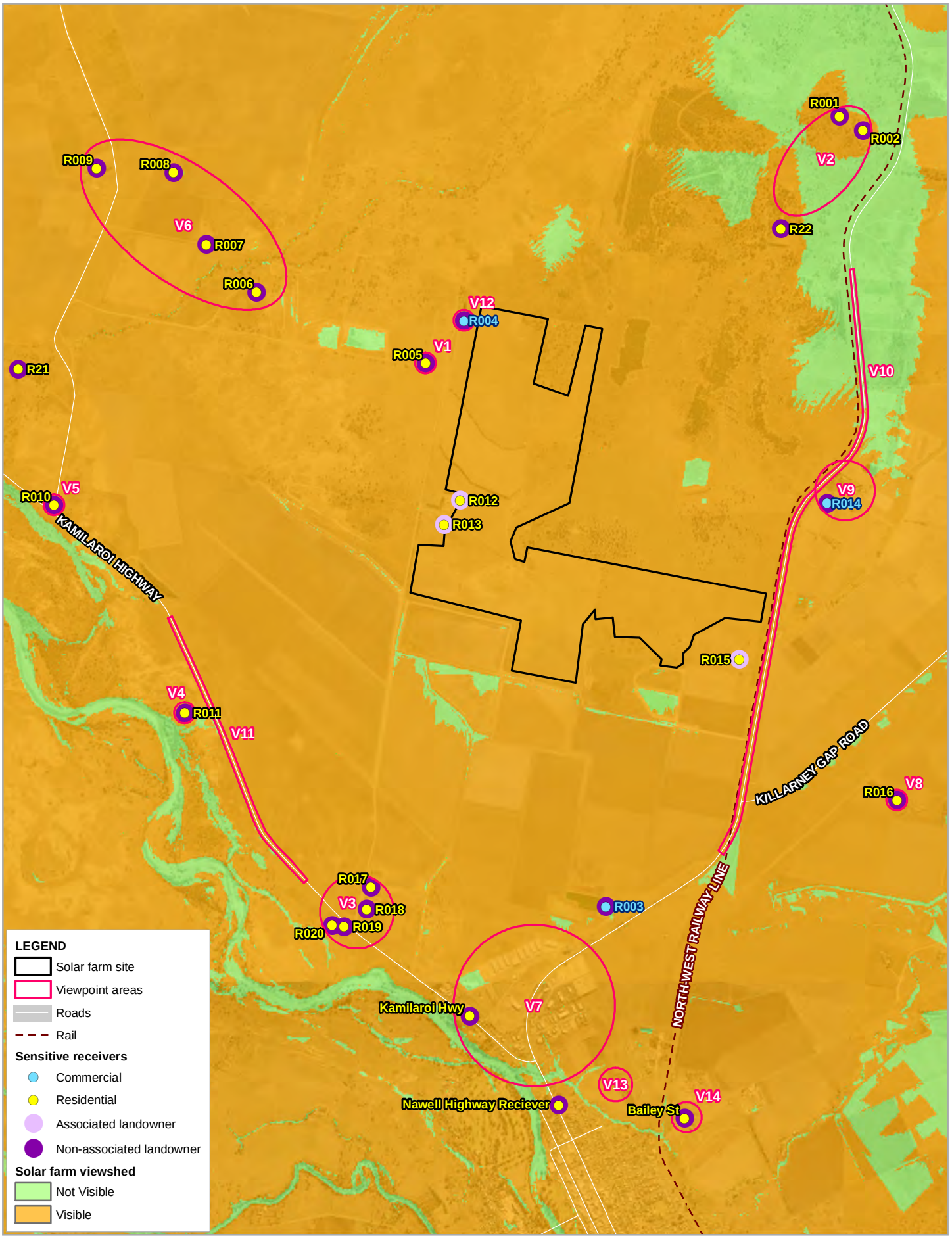
Solar farm

Figure 6-13 shows the results of the view shed analysis for the areas that would have views of the proposed solar farm site. As shown in Figure 6-13, the solar farm would be visible from much of the surrounding area when considering the landform only. This view shed does not account for the screening effect of vegetation, or localised topography changes not captured by the contours such as the embankments at Australian Grain Terminal site located to the south. The solar farm site is not highly visible from the area to the north-east due to an elevated area in the vicinity of viewpoint 2 to the north-east of the proposal site off the Newell Highway.

Based on the view shed analysis, a number of visually sensitive receivers were identified for further assessment. These receivers, or groups of receivers, are described further below in section 6.4.3.

Transmission line

Figure 6-14 shows the results of the view shed analysis for the areas that would have views of the proposed transmission line corridor. Like the solar farm site, much of the surrounding area would have views of the proposed transmission line due largely to the relative flat nature of the surrounding landscape. Views from the north of the solar farm site would not be possible due to differing elevations. Overall the transmission line would have a large view shed due to its increased height of about 30 metres when compared to infrastructure within the solar farm site (no taller than five metres).



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Engie
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Project No. 21-26998
Revision No. 2
Date 08 Aug 2019

Solar farm viewshed analysis

FIGURE 6-13

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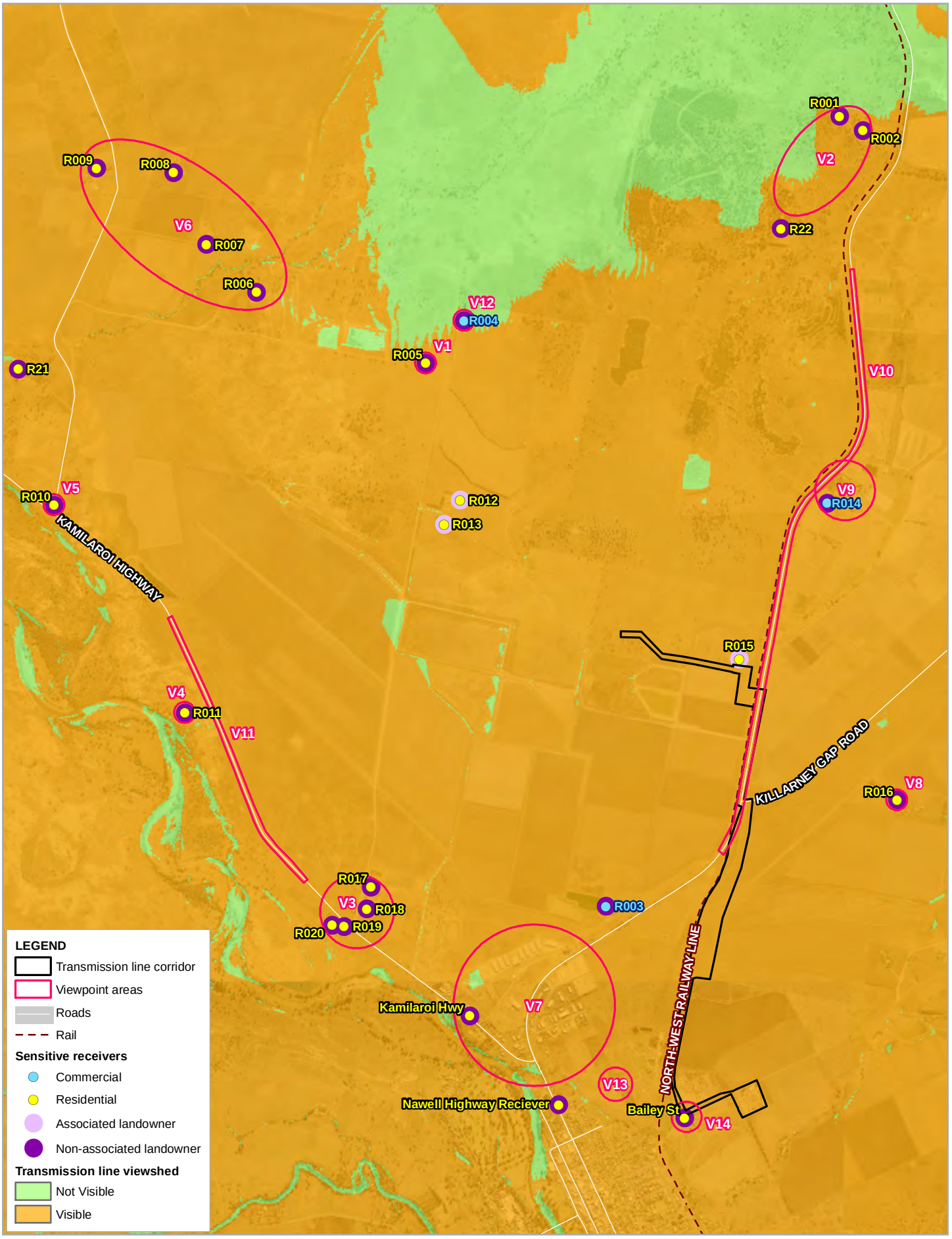
Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Land use zoning - NSW DPE 2018. Created by:jrprice



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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GHD

Engie
Silverleaf Narrabri Solar Farm EIS

Project No. 21-26998
Revision No. 2
Date 08 Aug 2019

Transmission line viewshed analysis

FIGURE 6-14

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Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Land use zoning - NSW DPE 2018. Created by:jrprice

6.4.3 Potential Impacts

The viewpoints identified as a result of the view shed analysis for both the solar farm and the transmission line are shown in Figure 6-13 and Figure 6-14 respectively.

Solar farm site

Based on the view shed analysis the following viewpoints were identified in the landscape surrounding the solar farm site where views are likely.

Viewpoint 1 - dwelling located west of proposal site off Logans Lane

This viewpoint is from a residential dwelling located on a rural property to the north-west corner of the solar farm. This dwelling is about 240 metres west of the western boundary of the proposal site. Figure 6-15 shows the view of the proposal site (shown in yellow) from the dwelling.

Views from this dwelling towards the proposal site are unscreened with no vegetation located between this dwelling and the proposal site. This view includes the private airstrip, predominately the runway, located on the eastern side of Logans Lane opposite the dwelling. Views from this dwelling would be limited to infrastructure along the western boundary of the proposal site as the rest of the site slopes away from the dwelling and therefore views are not available.

Figure 6-15 View from Logans Lane adjacent to viewpoint 1

This viewpoint constitutes the most affected receptors due to the proximity of the proposal site to the dwelling, and the absence of vegetation that would screen views. This viewpoint is considered to have a moderate sensitivity as this dwelling, while having views of a rural landscape, does currently have the private airstrip operations within its views and would also not have views to the majority of the proposal site. The proposal would result in a change to the visual landscape from this viewpoint due to the construction of the solar farm, which would not be screened by any existing vegetation.

Adjoining landholders will be consulted during development of a landscape plan and this will consider whether vegetation screening is to be provided. Ongoing consultation with the airstrip operator will be required to confirm safety and operational requirements, including any areas which need to remain vegetation free. All endeavours will be made to achieve appropriate screening. As future planting requirements have not been confirmed, this visual assessment has been based on the worst-case scenario that no vegetation screening is planted.

Overall based on the sensitivity of the viewpoint and the magnitude of impacts, visual impacts on viewpoint 1 are considered high to moderate. Should screening vegetation be provided, overall impacts would reduce to moderate due to the reduction in the magnitude of impacts.

Viewpoint 2 – dwellings located north-east of the proposal site off the Newell Highway

This viewpoint consists of a small collection of residential dwellings located on rural properties to the north-east of the proposal site. These dwellings are located at a minimum of 1.7 kilometres to the north-east. These properties are located on a localised highpoint and are above the elevation of the proposal site.

This viewpoint has a potentially high sensitivity as dwellings have an existing rural outlook. This outlook, is dominated by vegetation which surrounds the dwellings. Views of the proposal site from these properties are not available due to dense vegetation which surrounds the dwellings.

Figure 6-16 View north-east from proposal site towards dwellings in viewpoint 2

Figure 6-16 shows a view from the proposal site towards these residences. Dense vegetation surrounding the residences completely blocks views between the two locations. Overall based on the sensitivity of the viewpoint and the magnitude of impacts, visual impacts on viewpoint 2 would be negligible.

Viewpoint 3 – dwellings located south of the proposal site just north of the Logans Lane/Kamilaroi Highway intersection

This viewpoint consists of a number of residential dwellings located near the intersection of Logans Lane and the Kamilaroi Highway. Two of these dwellings are located on the northern side of the highway, while a third is located to the south. These dwellings are located at least 2.4 kilometres south of the proposal site.

Any views of the proposal site would be distant and partially screened by vegetation located around the dwellings, and the limited vegetation located along the southern boundary of the proposal site. Existing views north from these dwellings currently contain the existing electricity transmission line, which is about 500 metres north of the closest dwelling. This transmission line is in the foreground to middle ground of these views.

Due to the nature of the topography, including the presence of some embankments on the Australian Grain Terminal site to the south of the proposal site, views from this viewpoint are limited distant views to the northern part of the proposal site only. Figure 6-17 shows the positioning of the proposal site in the views from the northern most dwelling.

Figure 6-17 View north towards the proposal site from dwellings in viewpoint 3

This viewpoint is considered to have moderate sensitivity. While in a rural area, views from these dwellings contain the existing transmission line corridor which runs just north of the properties. The proposal would introduce new infrastructure into the views from this location.

Due to the distance of the dwellings from the proposal site, and the elevation increase, any views would be in the background and would be limited to the northern part of the proposal site. Coupled with existing vegetation screening around these dwellings, visual impacts on viewpoint 3 would be moderate to low.

Viewpoint 4 – dwelling located south of Kamilaroi Highway south-west of the proposal site

This viewpoint consists of a residential dwelling located on the southern side of the Kamilaroi Highway, approximately two kilometres south-west of the proposal site. Views of the proposal site from this location are partially screened by vegetation located around the dwelling and by some vegetation located along the boundaries of the south-west corner of the proposal site.

Views of the proposal site from viewpoint 4 are similar to those shown in Figure 6-17, albeit from a more acute angle from the south. Views are distant with the southern areas of the proposal site screened by embankments located on the Australian Grain Terminal site. Views from this location are currently dominated by the Kamilaroi Highway which is located in the foreground of these views.

While located in a rural landscape, this dwelling is located just south of the Kamilaroi Highway with views towards the site are dominated by views of the highway. The proposal would introduce new infrastructure into the views from this location.

Due to the distance of the dwelling from the proposal site, any views would be distant. These views would also be limited to the northern part of the proposal site due to the elevation increase in this part of the site. In addition, views to the proposal site from this dwelling are partially screen by vegetation around the dwelling. This viewpoint would have moderate sensitivity, and the magnitude of potential impacts would be low. The overall visual impacts on viewpoint 4 would be moderate to low.

Viewpoint 5 – dwelling located north of Kamilaroi Highway at Bald Hill Road west of the proposal site

This viewpoint is from a residential dwelling located on the northern side of the Kamilaroi Highway at Bald Hill Road. Figure 6-18 was taken from road adjacent to the dwelling. As shown in Figure 6-18 views from this dwelling are distant with the proposal site visible across rural land, with some scattered vegetation located within paddocks. Screening vegetation is also located around the dwelling, further reducing views of the proposal site from the dwelling. Overall views of the proposal site from this viewpoint are largely restricted to the northern part of the proposal site due to local elevation and some glimpses of the southern part of the site.

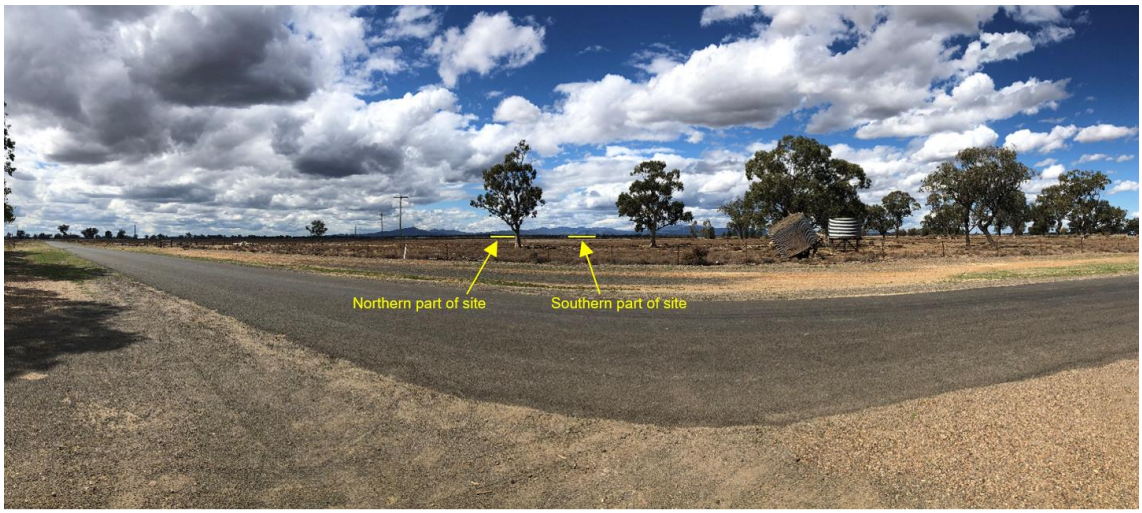


Figure 6-18 View from Bald Hill Road near viewpoint 5

This viewpoint would have a moderate sensitivity. The dwelling is located in a rural landscape with views of the Kamilaroi Highway to the south. Views east to the proposal site are largely free of the highway.

The proposal would introduce new infrastructure into the views for this location. Due to the distance of the dwelling from the proposal site any views would be in the background. This is shown as yellow in Figure 6-18. In addition, views to the proposal site from this dwelling are partially screened by vegetation around the dwelling. Overall based on the sensitivity of the viewpoint and the magnitude of impacts, visual impacts on viewpoint 5 would be moderate to low.

Viewpoint 6 – dwellings located west of the proposal site off Bald Hill Road

This viewpoint consists of a small collection of residential dwellings located on rural properties, located over 1.7 kilometres to the west of the northern portion of the proposal site. The distance of the nearest dwelling to the proposal site means that any views are in the background. One dwelling has limited views of the northern portion of the proposal site, screened by vegetation surrounding the dwelling. Views from the dwellings further west of this are further screened by vegetation located along Spring Creek.

The proposal would introduce new infrastructure into the views for this location. Due to the distance of the dwellings from the proposal site, any views would be in the background and would be limited to the northern part of the proposal site due to the elevation increases.

This viewpoint would have a high sensitivity as these dwellings are located in a rural landscape that is largely free of any other development such as highways or transmission lines. When considering that views to the proposal site from these dwellings are partially screened by vegetation around the dwellings, the magnitude of impacts would be low. Only the easternmost dwelling in this viewpoint would have views of the proposal's northern section. The remaining dwellings are further screened by vegetation along Spring Creek. Overall based on the sensitivity of the viewpoint and the magnitude of impacts, visual impacts on viewpoint 6 would be moderate.

Viewpoint 7 – dwellings and industrial land uses located south of the proposal site adjacent to the Kamilaroi Highway

This viewpoint consists of a mixture of industrial and residential land uses located on the northern side of the Kamilaroi Highway. Views from these land uses would be distant due to the southern part of the site being located about 2.7 kilometres from the viewpoint. Views from these land uses are dominated by the Australian Grain Technologies site and the existing transmission line corridor which are both located north of these land uses.

Due to the nature of the topography and the presence of some embankments on the Australian Grain Technologies site, views from this viewpoint are limited distant views to the northern part of the proposal site. Views towards the proposal site are similar to that shown in Figure 6-17.

Views from some residential dwellings in this location are screened by industrial properties. Views from the industrial land uses in this location are not considered sensitive. The assessment of any impacts on this viewpoint has been based on the residential dwellings in this location which are not screened by the industrial properties.

This viewpoint is considered to have a low sensitivity due to the largely industrial nature of the area. This includes the residential dwellings which would otherwise generally be a sensitive land use. These residential dwellings have a reduced sensitivity due to their position within an industrial area, and due to their limited views of the proposal site due to distance and the embankments on the Australian Grain Technologies site. The majority of views north towards the proposal site include industrial land uses.

The proposal would introduce new infrastructure into these views from the residential dwellings, however these are likely to be minimal due to the existing screening provided by the industrial land uses. The distance to the site also means that any views of the proposal would be in the background and be very minor. Based on the existing screening and industrial land uses in the foreground, the magnitude of impacts on the residential dwellings in this location would be negligible.

Viewpoint 8 – dwelling located east of the proposal site on the eastern side of the Newell Highway

This viewpoint consists of a residential dwelling located east of the Newell Highway (off Killarney Gap Road) about 1.7 kilometres south-east of the proposal site. Views of the proposal site from this viewpoint are distant and partially screened by limited vegetation around the dwelling.

The eastern part of the proposal site would be visible in the middle ground of this viewpoint. The remainder of the site would be in the background or not visible due to localised topography. Views from this location includes the Australian Grain Technologies site, Newell Highway and Mungindi Railway line (also known as the North-West Line) in the foreground which draws the receptors attention away from the proposal site.

This viewpoint would have a moderate sensitivity, as the dwelling is in a rural landscape with views across the Newell Highway and North-West Railway Line towards the proposal site.

The proposal would introduce new infrastructure into the views from the residential dwelling. The new infrastructure would be located in the middle to background of the existing views. Views to the eastern most part of the Newell Highway property would be available, however views of the proposal site are limited due to the following:

- Retention of the south-east corner of this property around the existing dwelling includes some screening vegetation
- Infrastructure within the Australian Grain Technologies site including raised embankments
- Vegetation located between the viewpoint (and dwelling) and the Newell Highway

Any views would include solar arrays primarily, but may also include the site office and substation (however these would likely be limited to the tops of these structures. The proposal would not result in any substantial increase in infrastructure in the views of this viewpoint and therefore with the limited screening available the impacts of the proposal would be moderate for this dwelling.

Overall based on the sensitivity of the viewpoint and the magnitude of impacts, visual impacts on viewpoint 8 are considered to be moderate.

Viewpoint 9 – Australian Grain Technologies facility and one residential dwelling located north-east of the proposal site, eastern side of the Newell Highway

This viewpoint is from the Australian Grain Technologies site, on the eastern side of the Newell Highway. There is a residential dwelling on this property, located approximately 695 metres from the proposal site. The industrial development on this property is located about one kilometre north-east of the proposal site. Views from the industrial property would be less sensitive, therefore potential impacts have been assessed from the residential dwelling located on this property.

Views of the eastern part of the proposal site, adjacent to the Newell Highway, would be available from the residential dwelling at this viewpoint. Views of other areas of the proposal site would be screened to varying degrees by vegetation on the adjacent property and due to local topography. Views are also screened by vegetation located around the dwelling. The Newell Highway and the North-West Rail Line are also located in the foreground of this view.

The sensitivity of this dwelling is considered to be moderate due to the presence of the Newell Highway and North-West Rail Line within the existing views, and due to screening by existing vegetation.

The proposal would introduce new infrastructure into the views from the residential dwelling. The new infrastructure would be located in the middle ground of the existing views with the eastern part of the proposal visible. This would consist primarily of solar arrays, but may also include the site office and substation.

Existing vegetation around the dwelling, particularly along its southern side, would provide some screening of the proposal site. Due to the introduction of infrastructure and the availability of some screening vegetation the magnitude of impacts would be moderate for this dwelling. Consultation with Australian Grain Technologies has indicated that this dwelling is not used and is proposed to be removed and replaced with a new storage shed. Based on this the impacts on this location are considered negligible.

Viewpoint 10 – Newell Highway transport corridor

This viewpoint consists of the users of the Newell Highway and the North-West Rail Line. Both run parallel to the eastern edge of the proposal site. Views of the eastern part of the proposal site would be readily available, with views of other areas diminishing with distance travelled, and also due to vegetation and topography. Any views from this location would be short term in nature as the users travel along the corridor at speed.

Views for motorists and passengers travelling along the Newell Highway, and for passengers along the North-West Rail Line would be altered. The proposal site is close to these users, and the proposal would be visible from the road and rail line as there is limited screening available.

Viewpoint 10 has a low sensitivity as views from this viewpoint would be short term in nature. The users of the Newell Highway are generally focused on the task of driving. Therefore the sensitivity of the view is reduced, despite views of the eastern part of the proposal site being relatively close to this viewpoint.

Based on the scale of the proposed new infrastructure and the changes in the existing character of the immediate area, impacts have the potential to be high. However due to the fleeting nature of these views from this viewpoint, the overall magnitude of visual impacts on viewpoint 10 would be moderate.

Viewpoint 11 – Kamilaroi Highway corridor

This viewpoint would be from users of the Kamilaroi Highway, looking to the north of the roadway. Views of the proposal from the highway would be distant views and short term in nature as users of the highway travel along the corridor at speed.

Viewpoint 11 is considered to have a low sensitivity as receivers within this viewpoint are short term in nature as they travel past the site. The users of the Kamilaroi Highway are also generally focused on the task of driving.

Due to the distance of the proposal site from the highway, and the screening effect of small stands of vegetation, views of the proposal at this viewpoint would not be substantial. Based on the distance of the proposal from the highway and the screening of vegetation and industrial developments in adjacent properties the magnitude of the changes on this viewpoint would be low. Overall visual impacts from this viewpoint would be negligible.

Viewpoint 12 – Airstrip located adjacent to north-eastern corner of the proposal site

This viewpoint consists of the private airstrip adjacent to the north-west corner of the proposal site on Logans Lane. Views of the proposal site from this property would be readily available due to the close proximity of the proposal site on the eastern side of the boundary fence.

Views would generally be of the northern component of the proposal site. Views to the southern part of the proposal site are screened by vegetation planted in rows within the adjacent property, and by vegetation located around the two existing dwellings on the proposal site.

Viewpoint 12 is considered to have a low sensitivity as the receiver is primarily an industrial development. Workers at this site are generally focused on their tasks associated with the business.

The proposal would include the installation of solar arrays on the land adjacent to the airstrip. The nearest panels would be located about 200 metres from the airstrip operations. Due to the close proximity of the proposal to the airstrip, the magnitude of change resulting from the proposal would be high.

This magnitude has the potential to be reduced with screening vegetation provided along the property boundary. Further consultation with the airstrip operator is required to confirm operational and safety requirements. The ability to provide screening is not yet confirmed and therefore this assessment assumes that not screening will be available. Overall based on the sensitivity of the viewpoint and the magnitude of impacts, visual impacts on viewpoint 12 would be moderate. Potential impacts on the operation of the airstrip from glare are discussed further in the following section.

Transmission line corridor

The proposed transmission line would result in impacts on different viewpoints due to its alignment away from the proposal site. The below viewpoints are considered relevant to the transmission line. This include viewpoints which are also potentially impacted by the solar farm site but also some additional viewpoints which would only be impacted by the transmission line. The following viewpoints were identified for the transmission line corridor.

Viewpoint 8 – dwelling located east of the proposal site on the eastern side of the Newell Highway

This viewpoint consists of a residential dwelling located east of the Newell Highway (off Killarney Gap Road) about 1.7 kilometres south-east of the proposal site. Views of the transmission line from this viewpoint would be distant with the proposed transmission line to be in the middle ground. Views would also be partially screened by limited vegetation around the dwelling.

This viewpoint would have a moderate sensitivity, as the dwelling is in a rural landscape with views across the Newell Highway and North-West Railway Line towards the proposal site.

The introduction of the transmission line as part of the proposal would result in an intensification of views of infrastructure along the existing transport corridor with the Newell Highway, North-West Railway Line and an existing transmission line (smaller than the proposed) located in the view from this viewpoint.

The introduction of the new transmission line, although larger than existing transmission line, would be in character with this existing transmission line, and also the transport corridor. Overall the bulk of the new transmission line would be minimal. The transmission line would not dominate the landscape particularly due to the distance between the dwelling and the line.

Due to the distance from this viewpoint, the reduced bulk of the transmission line and the nature of existing views (both existing screening and the views of an existing transport corridor) the impact of the proposal would be moderate from this viewpoint.

Viewpoint 10 – Newell Highway transport corridor

This viewpoint consists of the users of the Newell Highway and the North-West Rail Line. Views of the transmission line corridor would be readily available as the transmission line would both cross, and run adjacent to, the road corridor. The distance from the corridor at which the transmission line would run would be confirmed during detailed design. Regardless of the final siting, views would be available from the highway and railway line. Any views from this location would be short term in nature as the users travel along the corridor at speed.

Views for motorists and passengers travelling along the Newell Highway, and for passengers along the North-West Rail Line would be altered due to the introduction of the transmission line. The proposed transmission line would be visible from both the road and rail line as there is limited screening available.

This viewpoint has a low sensitivity as views from this viewpoint would be short term in nature due to the speed at which views occur as people travel along the corridor. The users of the Newell Highway are also generally focused on the task of driving and therefore the sensitivity of views is reduced.

Based on the scale of the proposed new infrastructure and the changes in the existing character of the immediate area, impacts have the potential to be high. However due to the fleeting nature of these views from this viewpoint, the overall magnitude of visual impacts from this viewpoint would be moderate.

Viewpoint 13 – Dwellings located at Salesyard Lane and Namoi Street

This viewpoint consists of a number of residential dwellings located near the intersection of Salesyard Lane and Namoi Street west of the proposed transmission line. Views of the transmission line corridor would be partially screened from these dwellings due to the presence of vegetation around the dwellings. Views from this location also contain a number of existing transmission lines of varying size which connect to the Narrabri Substation to the east of this viewpoint.

This viewpoint has a moderate sensitivity as views are from residential dwellings, however the views available currently include existing electricity infrastructure and the North-West Railway Line.

Based on the scale of the proposed transmission line, the impacts to the visual landscape are considered moderate as the new infrastructure would be visible in the middle ground of views. The presence of existing transmission lines in this view also reduces the impacts of introducing an additional transmission line into views from this viewpoint.

Overall based on the sensitivity of the viewpoint and the magnitude of impacts, visual impacts on viewpoint 8 due to the transmission line would be moderate.

Viewpoint 14 – Dwellings located on Stoney Creek Road at Bailey Street

This viewpoint consist of a small group of residential dwellings located south of Stoney Creek Road on Bailey Street. Views from this viewpoint currently are of a semi-rural area with increased development (Narrabri residential areas) and also existing electrical infrastructure including the Narrabri Substation and the associated transmission line.

This viewpoint has a moderate sensitivity as views are from residential dwellings, however the views available currently include existing electricity infrastructure and the increased development associated with the edge of the Narrabri urban area.

The introduction of the transmission line is not considered to have a substantial impact on views in this location as the proposed alignment would be in a similar location to the existing transmission line feeding the Narrabri Substation. This includes a number of transmission lines running along Stoney Creek Road. Due to the existing infrastructure the impact of the proposal is considered to be low.

Overall based on the sensitivity of the viewpoint and the magnitude of impacts, visual impacts on viewpoint 8 due to the transmission line would be moderate-low.

Summary of visual impacts

Table 6-20 provides a summary of the visual impacts to be experienced within each of the viewpoints.

Table 6-20 Summary of visual impacts

Viewpoint	Sensitivity	Magnitude	Visual impact
Solar Farm site			
1	Moderate	High	High to moderate
2	High	Negligible	Negligible
3	Moderate	Negligible	Negligible
4	Moderate	Low	Moderate to low
5	Moderate	Low	Moderate to low
6	High	Low	Moderate
7	Low	Negligible	Negligible
8	Moderate	Moderate	Moderate
9	Moderate	Moderate	Moderate
10	Low	High	Moderate
11	Low	Low	Low
12	Low	High	Moderate
Transmission line corridor			
8	Moderate	Moderate	Moderate
10	Low	High	Moderate
13	Moderate	Moderate	Moderate
14	Moderate	Low	Moderate to low

Construction and decommissioning

Impacts on surrounding land uses

During the construction and decommissioning phases of the proposal, surrounding properties would have views of construction activities. The delivery of site infrastructure, and the movement of construction machinery to and from the site, would be visible from adjoining properties. Visual impacts would include the following:

- Movement of vehicles to site in particularly along Logans Lane which typically conveys a low number of vehicles each day
- Movement of vehicles, plant and equipment around the site
- Generation of dust, which would be visible to residents of surrounding properties

These potential impacts would be short-term, covering the construction or decommissioning period of up to 12 months.

Construction activities associated with the transmission line would be visible from a number of properties along the approximately five kilometre route. Impacts would include the presence of large construction equipment such as cranes, trucks and piling rigs. These impacts would be short-term, covering the construction period of approximately 16 weeks.

Impacts of lighting

Construction at the proposal site is proposed for standard daylight hours. There would be no impact on adjoining properties from construction lighting at the proposal site.

The construction of the transmission line would be primarily done during standard daylight work hours. In certain circumstances, such as works near the Newell Highway, the North-West Rail Line or other roads, night work may be required and construction lighting would be required at night time. Impacts would be short-term, covering localised works for short durations of one or two nights at any one location.

Operation

The proposal would be visible from surrounding areas, including a number of dwellings. The proposal would involve changing the land use of the site from agricultural production to solar power generation. This would change the visual character of the site.

The majority of views to the site are partially screened by existing vegetation located along road reserves, around dwellings or scattered vegetation in paddocks. The visual impacts associated with the operation of the proposal from the identified viewpoints is summarised in Table 6-20.

Glare and reflectivity of solar panels

The potential for glare associated with non-concentrating photovoltaic systems that do not involve mirrors or lenses, is limited. Any impacts would be short-term at any given vantage point as the angle of the sun moves and changes the direction of the reflection.

Photovoltaic solar panels are designed to reflect as little sunlight as possible, generally around two per cent of the light received (Spaven Consulting 2011), resulting in negligible glare. This is because photovoltaic panels are designed to absorb as much solar energy as possible to generate the maximum amount of electricity or heat. The panels would not generally create noticeable glare when compared with an existing roof or building surface (DoP 2010).

Based on this, the potential impacts of glare on adjacent land uses would be minor. Such impacts are further reduced by the installation of the tracking system. The tracking system allows the panels to follow the path of the sun from east to west during the day, orientating the panels so that they are perpendicular to the incoming direction of solar radiation. Any reflection of sunlight tends to go directly from the panel back into the atmosphere.

Potential glare impacts from other infrastructure on the proposal site, such as the substation, would be minimal and similar to existing structures on nearby properties. In particular the large industrial and agricultural buildings surrounding the proposal site.

Aircraft (both private and commercial)

Glare has the potential to impact on aircraft operating in the vicinity of the proposal. Glare from the solar panels, albeit minimal, would be reflected back into the atmosphere due to the tracking system, which orientates the panels so that they are perpendicular to the incoming direction of solar radiation.

The main potential impact would be on the aircraft operating out of the private airstrip located adjacent to the north-west corner of the proposal site. These operations utilise small and light aircraft which generally fly at very low altitudes. Once airborne, these flights may also be potentially impacted by glare.

The airstrip is located to the west of the proposal site and is orientated north-south. Aircraft would not operate directly above the proposal site and the arrays would generally be orientated to the north and east, except for the late afternoon.

Some potential glare impacts would be experienced during the afternoon when the panels are orientated towards the western sun. In the afternoon this would mean that any potential glare would be directed to the west towards the airstrip. Such impacts are would only impact aircraft during take-off as the airstrip only allows aircraft to take-off in a southerly direction.

The installation of appropriate vegetation as screening along the site boundary would assist in minimising glare impacts. This would be discussed with the airstrip operator to determine any potential safety issues with the positioning of screening vegetation.

Larger commercial aircraft generally operate at an altitude where glare is not considered to be an issue. The exception to this may be smaller commercial aircraft operating out of Narrabri Airport, located about five kilometres south-east of the proposal site.

Due to the north-south orientation of the runway at Narrabri Airport and the direction of the destinations, east to Sydney and north to Brisbane for the majority of aircraft using the airport, glare from the proposal is unlikely to impact commercial flights from Narrabri Airport. The low reflectivity of the panels, and the distance to the airport would greatly diminish any potential glare.

Operational lighting

During operation some security lighting may be installed on site around structures such as the substation and office building. The remainder of the proposal site would not be lit for the standard operation. Lighting of the solar panels would only be required during maintenance activities if completed at night. Such lighting would not result in any light spill on adjacent properties, with the lighting on site considered to be similar to that of a residential dwelling located on a rural property.

6.4.4 Safeguards and mitigation measures

Safeguards and management measures in Table 6-21 would be implemented to minimise potential visual impacts.

Table 6-21 Visual impact mitigation measures

Impact	Environmental safeguards	Timing
Visual impacts of solar farm (including glare)	A landscape plan would be developed to detail the location and type of plantings that would minimise views of the proposal site from nearby properties. The landscape plan would be prepared in consultation with the adjacent landholders and the airstrip operators to confirm any operational requirements which would affect the location and type of landscape screening. The plan would detail the species to be used on site. Native vegetation communities found in the local area will be used where suitable.	Detailed design
	Native vegetation is proposed as screening along the north-west boundary of the proposal site adjacent to the private airstrip. The species to be planted would be agreed in consultation with the airstrip operator to provide effective screening but not compromise safety for the operation of planes.	Detailed design
	A review of the landscaping plan would be carried out within six months of operation commencing. This would include consultation with nearby landowners to discuss the adequacy of the provided screening.	Operation

Impact	Environmental safeguards	Timing
Visual impacts of structures (including glare)	The materials and colour of on-site infrastructure would, where practical, be non-reflective and be of a colour that would blend with the landscape.	Detailed design
	Security fencing posts and wire would be non-reflective.	Detailed design
Visual impacts during construction	Construction plant, equipment, waste and excess materials would be contained within the designated boundaries of the work site and would be removed from the site following the completion of construction.	Construction Post-construction
	Work sites would be kept tidy at all times.	Construction Post-construction

6.5 Noise and vibration

Construction of the proposal has the potential to create noise and vibration impacts on surrounding properties. Noise and vibration impacts would be generated from the use of construction equipment and vehicles delivering materials to the proposal site and during the construction of the transmission line. The operation of the proposal would not generate any noise or vibration impacts on surrounding properties.

6.5.1 Methodology

The potential noise and vibration impacts associated with the proposal have been assessed with consideration of the following documents:

- *Interim Construction Noise Guideline* (ICNG) (DECC 2009)
- NSW *Road Noise Policy* (RNP) (DECCW 2011)
- NSW *Noise Policy for Industry* (NPI) (EPA 2017)

Construction noise

Equipment used during construction would include earth-moving equipment for civil works, diesel generators, trucks, cranes and other construction machinery. Noise outputs would be similar to farm machinery such as tractors. Pile driving for the solar panel foundations would be undertaken using a machine which screws or hammers poles into the ground, similar to that used for driving farm fence poles into the ground.

Noise levels of construction equipment and trucks delivering equipment to site have been obtained from Australian Standard, *AS 2436 – 2010 "Guide to Noise Control on Construction, Maintenance and Demolition Sites"*, the Department for Environment Food and Rural Affairs (DEFRA) "*Noise Database for Construction Sites"* 2005 and the RMS *"Construction Noise and Vibration Guideline" 2016*. The noise emissions from construction activities have been assessed using a quantitative assessment undertaken with consideration to the *Interim Construction Noise Guideline* (DECC, 2009) (ICNG) at the surrounding sensitive receivers.

To simulate the worst-case scenario, the two loudest items of mechanical plant have been modelled as point source to calculate the activity sound power level. As the proposal site is very large, this is a conservative approach. It is unlikely that these two pieces of construction equipment would work side-by-side for long periods.

For each construction activity, the potential noise impacts on the surrounding sensitive receivers have been predicted. Sensitive receivers are rural-residential dwellings in the area surrounding the proposal site.

Noise modelling was undertaken using CadnaA 2018 which calculates environmental noise propagation according to the CONCAWE noise algorithm. The following assumptions and calculation parameters were used in the noise model:

- Land was modelled assuming a mixture of hard and soft ground with a ground absorption coefficient of 0.75. This has been considered representative of the grassy, agricultural land surrounding the site.
- The noise model was used to predict noise levels during a typical worst case 15 minute period of operation where all equipment is operating at full power.
- Meteorological conditions was based on Concawe D-class during the day period simulate worst-case meteorological conditions for noise propagation.
- Atmospheric absorption was based on an average temperature of 10 °C and an average humidity of 70%.

Construction traffic noise

A separate model was created using the noise modelling software CadnaA 2018 in order to determine the effects of the additional light and heavy vehicle movements on residential receivers along Logans Lane, Kamilaroi Highway and Newell Highway. Road traffic noise propagation was calculated according to the *Calculation of Road Traffic Noise* (CoRTN) 1998 standard.

Vibration impacts

Safe working buffer distances to comply with the human comfort and cosmetic damage criteria were sourced from the *Construction Noise and Vibration Guideline* (CNVG).

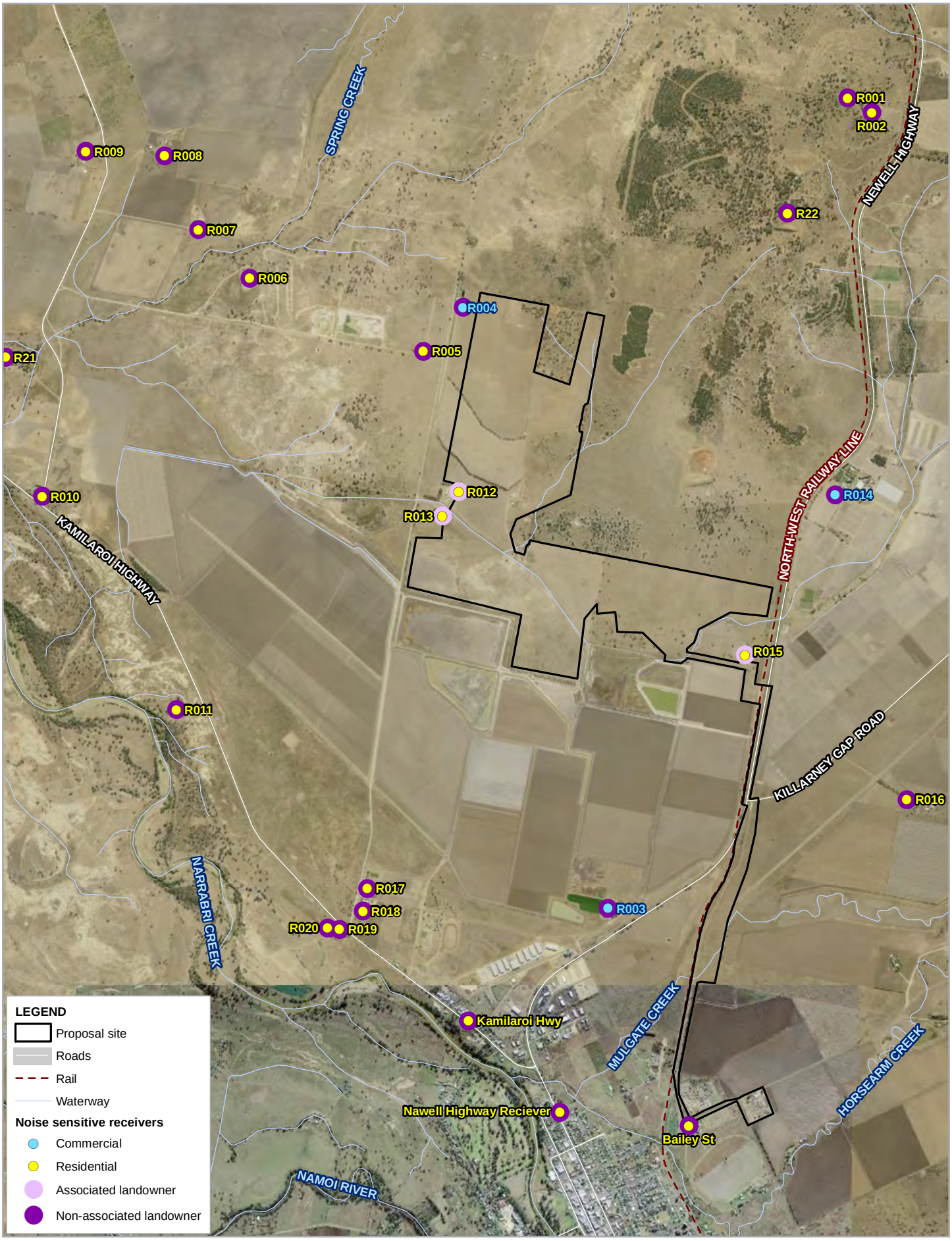
Operational noise

To assess compliance with the noise criteria, noise predictions were undertaken using CadnaA 2018 which calculates environmental noise propagation according to *ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors* and meteorological conditions according to CONCAWE algorithms. The noise predictions are considered conservative, as the predictions assume worst-case scenario meteorological conditions for noise propagation (Concawe F-Class) during the night period.

Based on past noise measurements of transformers, there is the potential for the site transformer and the transformer/invertor power stations to have tonal noise characteristics. A conservative +5 dB tonality factor adjustment has been applied to the contributions from the transformers to the received noise levels, in accordance with the *Noise Policy for Industry* (EPA, 2017) (NPI).

6.5.2 Existing environment

The proposal site is approximately four kilometres north of the Narrabri town centre, to the east of Logans Lane and to the west of Newell Highway. The location of the proposal site, the nearest sensitive receivers, and the transmission line corridor are shown in Figure 6-19.



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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Engie
Silverleaf Narrabri Solar Farm EIS

Noise sensitive receivers

Project No. 21-26998
Revision No. 2
Date 08 Aug 2019

FIGURE 6-19a

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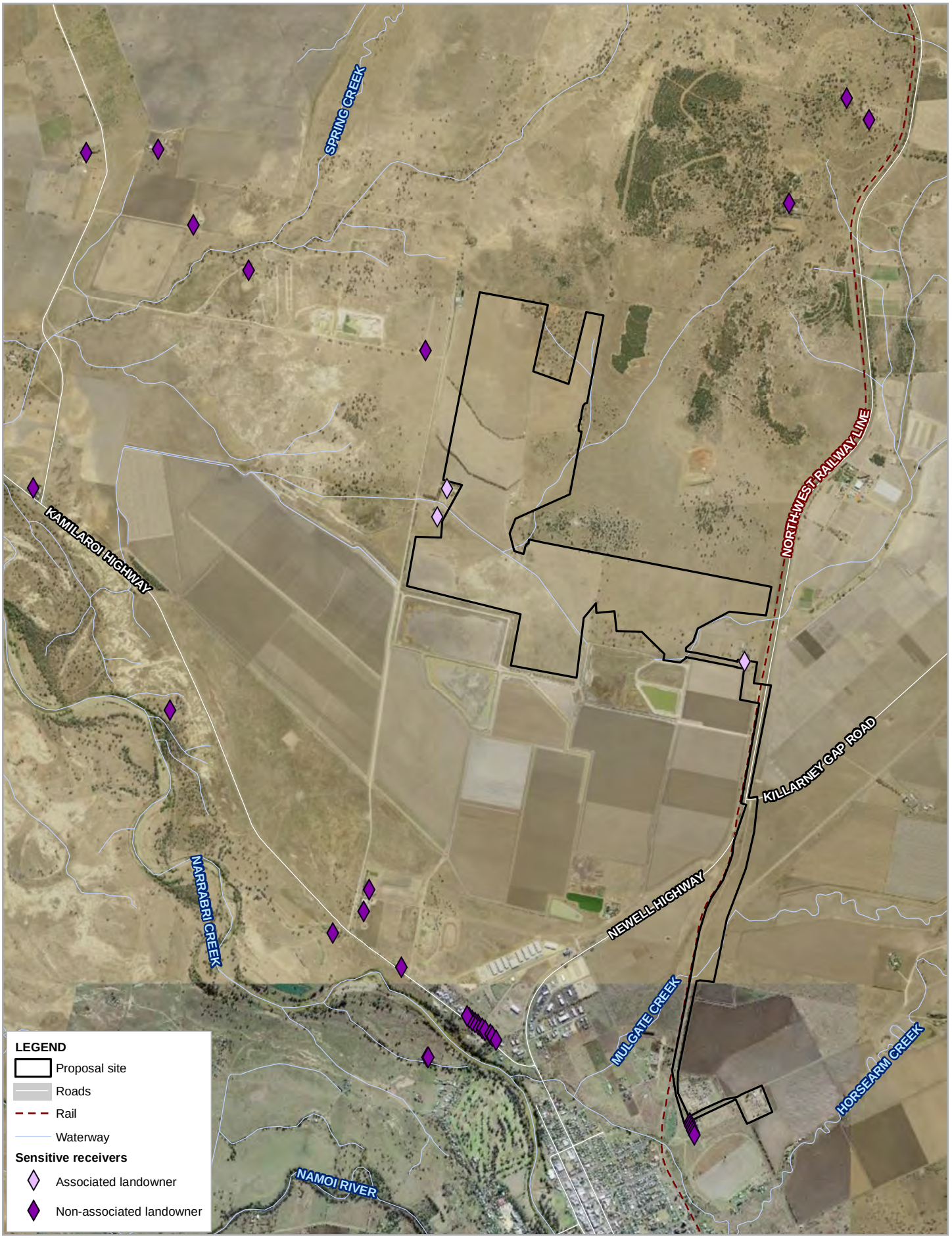
Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Land use zoning - NSW DPE 2018. Created by:jrprice



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Engie
Silverleaf Narrabri Solar Farm EIS

Sensitive receivers

Project No. 21-26998
Revision No. 2
Date 08 Aug 2019

FIGURE 6-19b

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Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Land use zoning - NSW DPE 2018. Created by:jrprice

Sensitive receivers

The definitions for noise sensitive receivers are based on the type of occupancy and the activities performed in the land use. Sensitive noise receivers could include residences, educational institutes, hospitals, place of worship, recreational areas and commercial/industrial premises.

Seventeen isolated residential receivers have been identified as being potentially impacted by construction noise associated with the proposal. These are homesteads on agricultural properties. Three commercial receivers that may be potentially affected by construction noise have been identified.

Two residential receivers (identified as R12 and R13) have commercial agreements with ENGIE, and would not occupy these residences during operation of the proposal. These two properties have not been assessed against the *Interim Construction Noise Guideline* (ICNG) (DECC 2009) or the *Noise Policy for Industry* (NPI 2017). However, noise levels have been predicted for these residential receivers for reference.

6.5.3 Criteria

Construction noise criteria

The *Interim Construction Noise Guideline* (ICNG) (DECC 2009) is used to assess noise impacts associated with construction works. The guideline recommends standard hours for construction activities as Monday to Friday: 7:00 am to 6:00 pm, Saturday: 8:00 am to 1:00 pm and no work on Sundays or public holidays.

The ICNG acknowledges that the following activities have justification to be undertaken outside the recommended standard construction hours assuming all reasonable and feasible mitigation measures are implemented to minimise the impacts to surrounding sensitive land uses:

- The delivery of oversized plant or structures that police or other authorities require special arrangements to transport along public roads.
- Emergency work to avoid the loss of life or damage to property, or to prevent environmental harm.
- Works where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours.
- Works which maintain noise levels at receivers to below the noise management levels outside of the recommended standard construction hours.

Table 6-22 details the ICNG construction noise management levels at residential receivers in the study area. For commercial noise receivers within the study area, the noise management level is 70 dBA.

Table 6-22 Construction noise management levels at residences

Time of day	Management level [1] $L_{Aeq(15min)}$		How to apply
Recommended standard hours: • Monday to Friday 7:00 am to 6:00 pm • Saturday 8:00 am to 1:00 pm • No work on Sundays or public holidays	**45 dBA** + 10 dBA	Noise affected Rating background level	The noise affected level represents the point above which there may be some community reaction to noise: • Where the predicted or measured $L_{Aeq(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	75 dBA	Highly noise affected	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
OOHW1 - Outside recommended standard hours – weekends (Saturdays 1:00 pm to 6:00 pm, Sundays 8:00 am to 6:00 pm)	**40 dBA** + 5 dBA	Noise affected Rating background level	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.
OOHW2 - Outside recommended standard hours – evenings/nights (Sunday to Thursday 6:00 pm to 7:00 am, Fridays and Saturdays 6:00 pm to 8:00 am)	**35 dBA** + 5 dBA	Noise affected Rating background level	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

1: Table 2 of the ICNG. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Project noise trigger levels

The Noise Policy for Industry 2017 (NPI) has been developed by the NSW EPA to provide guidance on the assessment of operational noise impacts. The guideline includes both intrusiveness and project amenity noise levels that are designed to protect receivers from noise significantly louder than the background level, and to limit the total noise level from industry near a receiver.

The NPI project noise trigger levels provide an objective for assessing a proposal and are not mandatory limits required by legislation. The project noise trigger levels assist the regulatory authorities to establish licensing conditions. Where project noise trigger levels are predicted to be exceeded, feasible and reasonable noise mitigation strategies should be considered. In circumstances where noise criteria cannot be achieved, residual noise impacts are used to assess noise impacts and manage noise from the site in negotiation between the regulatory authority and community. The regulatory authority then sets statutory compliance levels that reflect the achievable and agreed noise limits from the development.

The intrusiveness noise level controls the relative audibility of operational noise compared to the background level at residential receivers. The amenity noise level limits the total level of extraneous noise for all receiver types. Both levels are calculated and the lower of the two in each time period is set as the project noise trigger level. The intrusiveness noise level is assessed over a 15 minute period however the amenity noise level is assessed over the day, evening or night time period. For the purposes of assessment, and to standardise the approach, the NPI recommends that the $L_{Aeq(15min)} = L_{Aeq(period)} + 3$ dBA unless an alternative approach can be justified.

Intrusiveness noise level

The intrusiveness noise level is determined by a 5 dB addition to the measured or adopted background noise level. A minimum intrusiveness noise level of 35 dBA is adopted for the evening and night period, and 40 dBA for the day period. The NPI recognises that in rural locations the background noise levels may be the same for day, evening and night. It recognises that noise generating activities during the day would have a different impact than they would during the evening or night during sleep or relaxation time. The intrusiveness noise levels are only applicable to residential receivers.

Project amenity noise levels

For residential receivers, the noise trigger levels are provided in Table 6-23. The noise trigger levels reflect the most stringent noise level requirements derived from the intrusiveness and project amenity noise levels. Project noise trigger levels at the sensitive receivers have been determined based on the minimum background noise level thresholds, as no background noise monitoring has been undertaken.

Summary of proposal's noise trigger levels

For residential receivers, the proposal's noise trigger levels are provided in Table 6-23. These noise trigger levels reflect the most stringent noise level requirements derived from the intrusiveness and amenity noise levels. The proposal's noise trigger levels at the sensitive receivers have been determined based on the minimum background noise level thresholds, as no background noise monitoring has been undertaken.

Table 6-23 The proposal's noise trigger levels – residential noise receivers, dBA

Criteria $L_{Aeq(15min)}$	Residential Receivers		
	Day	Evening	Night
Intrusiveness noise level	40	35	35
Project amenity noise level (rural)	48	43	38
Project noise trigger levels	40	35	35

Notes:

- The NPI defines Day as 7:00 am to 6:00 pm Monday to Friday and 8:00 am to 6:00 pm Saturday, Sunday and Public Holidays, Evening 6:00 pm to 10:00 pm and Night as the remaining periods.
- In accordance with the NPI, the minimum assumed Rating Background Level (RBL) during the daytime is 35 dBA and 30 dBA for the evening and night periods (no background noise monitoring was undertaken as part of this assessment).
- Noise from the site is to be measured at the most affected point within the residential boundary, or at the most affected point within 30 metres of the dwelling where the dwelling is more than 30 metres from the boundary, to determine compliance with the proposal's noise trigger levels, except where otherwise specified below.

For industrial receivers, the proposal's noise trigger levels are provided in Table 6-24.

Table 6-24 Proposal's noise trigger levels – commercial and industrial receivers

Receiver	Time of day	L_{Aeq}, dBA
Commercial premises	When in use	65

Road traffic noise criteria

The *Road Noise Policy* (RNP) (DECCW), 2011) provides traffic noise criteria for residential receivers in the vicinity of existing roads, shown in Table 6-25. The criteria is applied to operational and construction traffic on public roads to identify potential road traffic impacts and the requirement for reasonable and feasible mitigation measures.

The RNP application notes state that *"for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level as a result of the development should be limited to 2 dB above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dB of or exceeds, the relevant day or night noise assessment criterion."*

If road traffic noise increases from the proposal are within 2 dBA of current levels then the objectives of the RNP are met and no specific mitigation measures are required.

Table 6-25 Road traffic noise criteria, $L_{Aeq(period)}$ dBA

Type of Development	Day 7:00 am to 10:00 pm	Night 10:00 pm to 7:00 am
Existing residence affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	60 $L_{eq(15hr)}$	55 $L_{eq(9hr)}$

The Roads and Maritime Services' *Noise Criteria Guideline* (2015) defines sub-arterial, collector and local roads as shown in Table 6-26. Based on these definitions, the Kamilaroi and Newell Highways have been classified as sub-arterial roads under the criteria outlined in Table 6-26. Logans Lane has been classified as a local road.

Table 6-26 Roads and Maritime road classification criteria

Road	Definition
Sub-arterial	Connects arterials to regions of development and carry traffic from one part of a region to another. Provide connection between arterial roads and local roads. May support arterial roads during peak periods. A road that collects local traffic leaving a locality and connects to another local road, sub-arterial or arterial. Note not all networks are large enough to have both sub-arterial and collector roads.
Collector	Connects the sub-arterial roads to the local road system in developed areas. May support sub-arterial roads during peak periods. May have been designed as local streets but can serve major traffic-generating developments or support non-local traffic. Note not all networks are large enough to have both collector and sub-arterial roads. The Road Noise Policy does not provide separate noise criteria for collector roads. Roads and Maritime applies sub-arterial noise criteria to collector roads and still considers collector roads and sub-arterial roads to be different functional classes.
Local	Provide vehicular access to abutting property and surrounding streets. They are the subdivisional roads within a particular developed area.

6.5.4 Potential impacts

Construction noise sources

Equipment used during construction would include earth-moving equipment for civil works, diesel generators, trucks and cranes with similar noise outputs to farm machinery such as tractors. Pile driving for the solar panel foundations would be undertaken using a machine which screws or hammers poles into the ground, similar to that used for driving farm fence poles into the ground.

The typical construction equipment likely to be the main noise sources are shown in Table 6-27 with the corresponding noise level. The typical construction activities associated with the proposal, the relevant construction equipment, hours of construction and activity sound power levels are presented in Table 6-27.

The noise levels of construction equipment have been obtained from Australian Standard, *AS 2436 – 2010 "Guide to Noise Control on Construction, Maintenance and Demolition Sites"*, the Department for Environment Food and Rural Affairs (DEFRA) "*Noise Database for Construction Sites"* 2005 and the RMS *"Construction Noise and Vibration Guideline" 2016* (CNVG).

Table 6-27 Construction equipment sound power levels, dBA

Equipment	Sound power level (typical)	Source
4WD	105	AS2436
Bored piling rig	111	AS2436
Cable winch	96	DEFRA
Concrete mixer	110	AS2436
Concrete truck	110	AS2436

Equipment	Sound power level (typical)	Source
Crane	104	AS2436
Delivery truck	107	AS2436
Dozer	115	AS2436
Dump truck	110	CNVG
Excavator	107	AS2436
Forklift	98	CNVG
Generator	99	AS2436
Grader	110	AS2436
Hand tools	102	AS2436
Impact pile driver	121	AS2436
Roller	108	AS2436
Scissor lift	100	CNVG
Trenching machine	112	DEFRA
Water truck	107	AS2436
Welding machine	105	CNVG

To simulate the worst-case scenario to calculate the activity sound power level, the two loudest items of mechanical plant have been modelled as a point source. As the proposal site is very large, this is considered conservative as it is likely that there will be greater distances between the items of construction equipment during construction.

Table 6-28 provides details on the construction scenarios modelled for the proposal. The activity sound power level is calculated from the logarithmic sum of the two loudest construction equipment items to simulate the worst-case scenario. The sound power levels shown in Table 6-28 are modelled at the source. These levels do not account for sound dissipation over distance, or the blocking effect of topography or intervening obstacles.

Table 6-28 Construction scenarios associated with the proposal

CS	Scenario	Construction area location	Construction hours	Construction equipment		Activity sound power level at the source, dBA
S1	Site establishment, preparation works and construction compound	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Grader	Water truck	116
				Dozer	Hand tools	
				Dump truck	Roller	
				Excavator	4WD	
S2	Installing steel post foundations	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Impact pile driver	Crane	122
				Hand tools	Bored piling rig (optional)	
S3	Installation of underground cabling, power station and delivery station	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Trenching machine	Water truck	114
				Excavator	Grader	
S4	Construction of the 33 kV/132 kV substation	Substation area	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Generator	Concrete truck	116
				Forklift	Grader	
				Crane	Dozer	
				Concrete mixer	Hand tools	
S5	Landscaping works	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Excavator	Grader	113
				Dump truck	-	
S6	Removal of temporary construction facilities and rehabilitation of disturbed areas	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Excavator	Generator	112
				Welding machine	4WD	
				Dump truck	-	
S7	Construction of the transmission line	Potential transmission line corridor area	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Dump truck	Scissor lift	114
				Bored piling rig	Cable winch	

Note: 1) The activity sound power level is calculated from the logarithmic sum of the two loudest construction equipment items to simulate the worst-case scenario.

The predicted noise levels for nearby receivers are provided as worst case. This is because the proposal site is large, covering approximately three kilometres (north to south and east to west). Noise levels will vary significantly depending on the distance of the construction equipment to the sensitive receiver.

The predicted noise level is calculated from the closest point from the receiver to both the nearest and furthest point of the relevant construction equipment. The predicted noise levels for commercial receivers is a maximum noise level from the shortest distance from the receiver to the relevant construction equipment.

All exceedances as a result of the construction scenarios detailed in Table 6-28 are presented in Table 6-29. This table shows the worst-case modelling scenario of any exceedance of the noise management levels (NML) and the highly noise affected criteria at sensitive receivers.

Table 6-29 Exceedances of noise management levels

Construction Scenario	Receiver number, and exceedance NML, dB	Maximum duration of exceedance	Exceedances - Highly Noise Affected, 75 dBA
S1	R05 – 4 dB	n/a	None
	R15 – 6 dB	n/a	
S2	R04 – 2 dB	n/a	None
	R05 – 10 dB	Three days maximum	
	R15 – 12 dB	Three days maximum	
S3	R05 – 2 dB	n/a	None
	R15 – 4 dB	n/a	
S4	None	n/a	None
S5	R05 – 1 dB	n/a	None
	R15 - 3 dB	n/a	
S6	R15 – 2 dB	n/a	None

Under the worst case modelling scenario, noise levels are predicted to exceed the noise affected construction noise management levels at residential receivers R05 and R15 and the commercial receiver at R04.

The highest exceedances would occur during the installation of the steel post foundations (construction scenario S2). These exceedances are expected to be short term and would reduce as the plant and equipment move further away from the sensitive receiver.

The installation of the steel post foundations will produce the highest noise levels, but would only be short in duration. Each pile would take approximately ten minutes to install. The exceedances at the receivers would therefore not be constant for this time, but would be intermittent.

For the area of the proposal site near residential receiver R05, the installation of the piles would take place at a distance of over 200 metres from the receiver. The private airstrip is located directly between the receiver and the proposal site. The noisiest works associated with the installation of the steel post foundations in this area would take less than three days in total, and would be intermittent. Noise would reduce as the plant and equipment move further away.

For the area of the proposal site near residential receiver R015 only a limited number of steel post foundations are required as the panel rows in this area of the proposal site are narrow. The noisiest works associated with the installation would take place at a distance of over 300 metres from this property. The installations would not take more than two days to complete in total, and would be intermittent. Noise would reduce as the plant and equipment move further away.

Transmission line construction impacts

Buffer distances have been calculated to determine when the construction noise management level would potentially be exceeded by the construction of the transmission line. The calculations are based on the following assumptions:

- The activity sound power level is 114 dBA (based on the construction equipment listed in Table 6-28). This is a conservative estimate based on worst-case operating conditions.
- The use a of a ground absorption co-efficient of 0.75.
- Use of the ISO 9613 algorithm for noise propagation.
- No ground elevation difference between the source and receiver.
- Construction equipment is at 2.0 metres and the receiver height is 1.5 metres above the ground.

Based on the assumptions above, the calculations indicate the following:

- The construction noise management level of 45 dBA is predicted to be exceeded when the distance between construction works and a residential receiver is 440 metres or closer.
- The highly noise affected criteria of 75 dBA is predicted to be exceeded when works are within 39 metres of a residential receiver.
- The construction noise management level of 70 dBA is predicted to be exceeded when the distance between construction works and a commercial receiver is 44 metres or closer.

The maximum noise levels predictions are conservative and would only be experienced for limited periods during construction when the distance between the construction works and the sensitive receiver is the closest. A small section of transmission line construction would take place within 39 metres of a residence at 12 Bailey Street, which is situated on the corner of Stoney Creek Road and Bailey Street. As such, this receiver will experience noise levels that may exceed the highly affected noise criteria of 75 dB(A). All other receivers along Bailey Street are predicted to experience noise levels exceeding the construction noise management level of 45 dB(A), but below the highly affected noise criteria of 75 dB(A). Even though the construction noise levels in this area are anticipated to be elevated during the construction of the transmission line, the Works are scheduled to occur no longer than two days duration.

Works in any location would not continue for longer than a week. For the majority of the time, the predicted construction noise levels will be below the construction noise management levels at nearby receivers.

Construction traffic noise impacts

Peak traffic activities would be expected in the middle of the 12 month construction program. Months 1-3 would involve site establishment and minor off-peak traffic movements. Months 4-8 would be peak construction traffic time with deliveries of equipment and infrastructure. Months 9-12 would be off peak associated with demobilisation and site make ready works. Traffic noise impacts would be mostly associated with peak construction times, in months 4-8.

Construction of the proposal would generate approximately 60 heavy vehicles movements per week (maximum of two movements per hour) and about 240 light vehicle movements (20 movements per hour) during the peak construction period. Movements would occur during the daytime period only, with access to the site occurring from Logans Lane via the Kamilaroi Highway.

A separate model was created using the noise modelling software CadnaA 2018 in order to determine the effects of the additional light and heavy vehicle movements on residential receivers along Logans Lane, Kamilaroi Highway and Newell Highway. Road traffic noise propagation was calculated according to the *Calculation of Road Traffic Noise* (CoRTN) 1998 standard. The assumptions used in the modelling including traffic volumes, traffic speeds and road surface information is provided in Appendix D.

Noise levels were predicted at the nearest residential buildings along Logans Lane, Kamilaroi Highway and Newell Highway using CadnaA. Noise level predictions are presented in Table 6-30.

Table 6-30 Predicted road traffic noise levels

Road	Distance between road edge and nearest residential facade	Existing hourly traffic	Expected additional vehicles per hour	RNP criteria, dBA	Predicted level during construction, dBA	Compliance
Logans Lane	45 metres	0 light/0 heavy	20 light/2 heavy	$L_{Aeq(1hour)}$ 55	$L_{Aeq(1hour)}$ 51	Yes
Kamilaroi Highway	11 metres	164 light/71 heavy	20 light/2 heavy	$L_{Aeq(15hour)}$) 60	$L_{Aeq(15hour)}$) 59	Yes
Newell Highway	12 metres	205 light/125 heavy	20 light/2 heavy	$L_{Aeq(15hour)}$ 60	$L_{Aeq(15hour)}$) 58	Yes

The expected traffic along Logans lane, the Kamilaroi Highway and Newell Highway would not exceed the day time noise criteria of Road Noise Policy at any residential receivers along these roads. The expected additional traffic along Old Cemetery Road and Stoney Creek Road during the construction of the transmission line would not be significant enough to increase road traffic noise levels at the nearest residential buildings along these roads. As such, compliance with the Road Noise Policy would be achieved during the construction of the transmission line at the nearest residential buildings along Old Cemetery Road and Stoney Creek Road.

Vibration impacts

Safe working buffer distances to comply with the human comfort and cosmetic damage criteria were sourced from the Construction Noise and Vibration Guideline (CNVG). Calculations are presented in Table 6-31.

Table 6-31 Vibration safe working buffer distances

Activity	Human comfort, metres	Cosmetic damage to standard dwellings, metres
Vibratory Roller (> 18 tonnes)	100	25
Vibratory Roller (18 - 13 tonnes)	100	20
Pile boring	4	2
Impact sheet piling[1]	175	45
Note: 1. Based on GHD calculations to comply with the human comfort and cosmetic damage criteria within the CNVG		

Vibratory rolling, bored piling and screw piling works have the potential to cause adverse human comfort, and cosmetic vibration impacts at nearby receivers. Based on the buffer distances presented in Table 6-31 and a review of the location of sensitive receivers, the following has been identified:

- No vibratory rolling activities are expected within 100 metres of residential dwellings. As such no human comfort or cosmetic damage impacts would occur.

- No bored piling activities are expected within 4 metres of residential dwellings. As such no human comfort or cosmetic damage impacts would occur.
- Residential buildings within 175 metres of impact sheet piling works may experience adverse human comfort impacts, and residential buildings within 45 metres of impact sheet piling works have the potential to receive cosmetic damage during impact sheet piling works. Impact sheet piling works would not be undertaken within 175 metres of any off-site residences, and piles would be bored where feasible.

Operational noise

At maximum operation, noise generating equipment and activities on the proposal site would include:

- Single-axis tracking systems (including approximately 5,150 trackers) on which the photovoltaic modules (solar array panels) are installed
- Twenty five (25) transformer/invertors stations (11 m x 2.5 m x 2.5 m) containing inverters and a single 33 kV transformer
- A 33 kV/132 kV substation, with one 140 MVA switchgear and transformer

The tracking motors would operate during the daylight hours. The substation and power stations would operate on a 24-hour basis. To simulate the worst-case scenario, all noise sources have been assessed against the NPI amenity night criteria for rural residential receivers as the tracking motors may operate between 6:00 am and 7:00 am. It is uncertain when the nearby non-residential sites are in use, so it has been assumed that these sites operate on a 24-hour basis a worst-case scenario.

Noise levels for the single-axis tracking panels were sourced from manufacturer data provided in Appendix A of the *Moree solar farm Operational noise prediction report* (Blackett Acoustics, 2014). The proposal's single-axis trackers would be similar. The assessment was time-adjusted to assess for a one minute operation within a 15 minute period.

Noise levels for the 140 MVA transformer were sourced from *AS 2374.6 (1994) – Power transformers Park 6: Determination of transformer and reactor sound levels*. Noise levels for the transformer/invertor stations were provided from ENGIE.

The exact layout of the transformer/interceptor stations and the tracking motors would be confirmed during detailed design. Accordingly, they have been modelled as area sources across the entire solar farm with each point source sound power level distributed evenly across the area source.

The exact location of these point sources would have a negligible effect on the predicted noise levels at sensitive receivers, provided the tracking motors are evenly spread throughout the proposal area. For the purposes of the noise assessment, the single-axis tracking panel case has been conservatively considered.

The operational noise sources and associated sound power levels at the noise source are summarised in Table 6-32. The predicted noise levels at surrounding sensitive receivers from operation of the proposal at night time are shown in Table 6-33. The receivers R012 and R013 are subject to lease from Silverleaf Solar Farm and are therefore not considered sensitive receivers for night time operations. There would be no exceedances of the NPI from the operation of the proposal.

Table 6-32 Operational equipment sound power levels and sound transmission losses, dBA

Equipment	Number of units	Octave-band noise level (Frequency, Hz), dBA									Overall noise level, dBA	Source	Modifying factor Noise penalty	Adjusted sound power level $L_{Aeq,adj}$ dBA
		31.5	63	125	250	500	1k	2k	4k	8k				
Single-axis tracking panel motor	5,150	No octave-band data available (generic motor spectrum used)									SWL 66 (each)	Blackett Acoustic MSF report	None	66
Transformer/Inverter station	25	17	41	62	72	84	84	81	85	65	SWL 89 (each)	ENGIE	+ 5 dBA (tonal)	94
140 MVA substation transformer	1	-	48	58	67	79	71	64	57	55	SWL 88	AS 60076-10:2009 (Transformer noise – max)	+ 5 dBA (tonal)	93

Table 6-33 Predicted noise levels at surrounding receivers

Receiver	Receiver Category	Assessment Period	Project noise trigger level	Predicted noise level, $L_{Aeq(15min)}$	Exceedances
R001	Residential	Night	35	12	No
R002	Residential	Night	35	11	No
R003	Commercial	Night	65	18	No
R004	Commercial	Night	65	37	No
R005	Residential	Night	35	32	No
R006	Residential	Night	35	18	No
R007	Residential	Night	35	15	No
R008	Residential	Night	35	12	No
R009	Residential	Night	35	9	No
R010	Residential	Night	35	12	No
R011	Residential	Night	35	15	No
R012	Residential	Night	35	45	N/A
R013	Residential	Night	35	42	N/A
R014	Commercial	Night	65	23	No
R015	Residential	Night	35	32	No
R016	Residential	Night	35	16	No
R017	Residential	Night	35	16	No
R018	Residential	Night	35	15	No
R019	Residential	Night	35	14	No
R020	Residential	Night	35	14	No
R021	Residential	Night	35	11	No
R022	Residential	Night	35	17	No

Operational road traffic noise

During operation, the proposal is considered unlikely to impact on the operation of the surrounding road network. Noise from light vehicles during operation would be negligible at all nearby receiver locations. Vehicle numbers would be low and limited to those associated with maintenance activities which would occur infrequently. As such, compliance with the acoustic requirements of the Road Noise Policy would be achieved during the operation of the proposal.

Summary of impacts

The construction of the proposal is predicted to exceed the construction noise management levels at two residential receivers, and one commercial receiver during the noisiest construction works, being impact pile driving. Noise mitigation measures have been proposed to reduce construction noise levels to these receivers. Any impacts due to construction works would be temporary in nature, and would not represent a permanent impact on the community or surrounding environment.

No adverse vibration impacts would occur at any sensitive receivers during construction of the proposal.

The operation of the proposal would comply with the relevant operational project noise trigger levels (PNTLs) and would not adversely affect the acoustic amenity of the surrounding sensitive receivers.

The construction and operation of the proposal will comply with the requirements of the Road Noise Policy.

6.5.5 Safeguards and mitigation measures

Safeguards and management measures have been summarised in Table 6-34.

Table 6-34 Noise mitigation measures

Impact	Environmental safeguards	Timing
Construction noise	A noise management plan would be prepared and implemented as part of the Construction Environmental Management Plan (CEMP). The following project-specific noise mitigation measures would be implemented: • If possible, bored piling (rather than impact piling) would be considered as an alternative to install the steel post foundations. • If impact piling is required, no impact piling would be undertaken within 45 metres of adjacent dwellings without prior notice being given to occupants.	Pre-construction and construction
Construction noise	Consultation and cooperation with the nearest sensitive receivers: • The construction contractor would establish contact with residents affected by construction noise and communicate the construction program and progress on a regular basis, particularly when noise generating activities are planned. Communication with the local community would be maintained throughout the construction period. • The construction contractor would provide a community liaison phone number and permanent site contact so that noise complaints can be received and addressed in a timely manner. • Upon receipt of a noise complaint, monitoring would be undertaken and reported as soon as possible. If exceedances are detected, the situation would be reviewed to identify means to attempt to reduce the impact to acceptable levels.	Pre-construction and construction
Construction noise	Work ethic – management of worker generated construction noise All site workers would be briefed on the potential for noise impacts on local residents and the requirement to implement practical and reasonable measures to minimise noise impacts during the course of their activities. This would include: • Avoiding the use of loud radios. • Avoiding shouting and slamming doors. • Where practical, machines would be operated at low speed or power and switched off when not being used rather than left idling for prolonged periods • Inform truck drivers of designated vehicle routes, parking locations and delivery hours. • Minimising reversing. • Avoiding dropping materials from height and avoiding metal to metal contact on material. • Keeping engine covers closed while equipment is operating.	Construction
General	The following general noise mitigation measures would be implemented to mitigate construction noise impacts: • All engine covers would be kept closed while equipment is operating. • As far as possible, heights from which materials are dropped, into or out of trucks, would be minimised. • Machines found to produce excessive noise compared to industry best practice would be removed from the site or stood down until repairs or modifications can be made.	

Impact	Environmental safeguards	Timing
	• Once the selection of equipment has been finalised, a review should be undertaken to ensure that the noise levels do not exceed the assumed levels in this assessment. • To reduce the annoyance associated with reversing alarms, broadband reversing alarms (audible movement alarms) would be used for all site equipment. Satisfactory compliance with occupational health and safety requirements would need to be achieved and a safety risk assessment may need to be undertaken to determine that safety is not compromised.	

6.6 Land use, soils and land capability

The rural land assessment was completed to assess the proposal's potential impacts on the agricultural land at the proposal site, and its compatibility with land uses of surrounding properties.

The rural land assessment included an examination of the proposal's potential impacts on soils, and the potential for erosion during construction, operation and decommissioning. A full copy of the Rural Land Study is located in Appendix E. A full copy of the Geotechnical, Hydrological and Topographic Survey is provided in Appendix F.

6.6.1 Methodology

Rural land assessment

The rural land assessment was completed using a range of statistical and mapping data. The study also involved written and verbal correspondence with NSW Department of Industry (DPI), and consultation with the community, including adjacent landowners.

The DPI publications *Land Use Conflict Risk Assessment Guide* (DPI Guide) and the *Living and working in rural areas handbook* (DPI Handbook) were used to assess potential land use conflicts.

Aerodrome assessment

Aviation Projects completed an aeronautical impact assessment to determine if the proposal would affect the operation of this private airstrip. A full copy of the Aviation Projects Aeronautical Impact Assessment Report is contained within Appendix G.

The scope of work for this assessment involved:

- Assessing the obstacle limitation surfaces (OLS) of the airstrip based on the runway alignment
- Reviewing Manual of Safety (MOS) 139 aviation standards as mandated by CASA (Civil Aviation Safety Authority)
- Determining minimum setbacks based on maximum heights allowable
- Accounting for the Runway End Safety Area (RESA) as applicable
- Researching other (inter)national commercial aerodromes which have solar arrays under the flight paths
- Completing a glare analysis for pilot safety operations (required for safety assessment) Providing information on possible jet blast emitted from critical aircraft type (noting no modelling has been allowed for)

6.6.2 Existing environment

Land use

Proposal site

The proposal site is described in Section 1.2.2, has an area of approximately 450 hectares and is currently used for agricultural purposes, with the primary use being grazing with some cropping.

Adjacent land uses

The land surrounding the proposal site is used for primary production such as cropping and pasture land, or is associated with agriculture. There are two Australian Grain Technologies sites adjacent in the area. One is located immediately to the south off the Kamilaroi Highway, and another is located to the north-east on the Newell Highway. There is some light industrial development on the Kamilaroi Highway to the south, with residences on the southern side of the highway.

There is a Coal Exploration Licence covering an area of 1,443 square kilometres located immediately south of the proposal site. This licence is current until February 2021, but does not cover the proposal site. There is an expired Petroleum Exploration Licence that covers a large area of Narrabri Shire, including the proposal site. This licence expired in August 2016.

Oakville aerodrome

The proposal site is located adjacent to a private airstrip known as the Oakville Aerodrome. Oakville aerodrome is an uncertified privately-owned aerodrome, meaning that it is not regulated by the Civil Aviation Safety Authority (CASA). The aerodrome features one runway – 01/19 which is approximately 1,100 metres long. The aerodrome is operated by Aircair Aviation, a family owned business.

The following types of aircraft operate from Oakville aerodrome:

- Air Tractor AT502
- Air Tractor AT802
- Light aircraft (i.e., Cessna)

Soil and contamination

Soil characteristics

The results of the geotechnical results (refer to Appendix F) and the eSpade database search, showing the soil characteristics at the proposal site, are provided in Table 6-35.

Table 6-35 Soil characteristics

Soil stratum	pH	Characteristics	Identified hazards
Alluvium	Alkaline across the site ranging between pH of 8.2 to 10. The exception was one bore recording with a of a pH of 5.4	Very shallow (A horizon), compacted with cracking below the vegetation Mixture of sandy loams, silty clay, sandy clay and clay, very stiff to hard. Depth ranges from 1.5 metres to limit of drilling at 5.45 metres deep No salinity identified	Wind erosion Erosion from surface water flows
Residual soil and extremely weathered rock		Sandstone weathered down and exhibiting clayey sand and sand soil properties	

The Office of Environment and Heritage's eSpade soil and land information database shows that the proposal site is mapped as containing primarily vertosol soils in line with the Australian Soil Classification. The transmission line corridor also contains sodosols.

Fertilisers have been used at the proposal site to accommodate site soil requirements. Fertilisers used at the site include gypsum and urea. Gypsum was used in alkaline soils, primarily at the southern end of the proposal site.

Contamination

A search of the Environment Protection Authority's contaminated land record was undertaken on 26 February 2019 for the Narrabri Shire local government area. No sites were identified in close proximity to the proposal site. The EPA's "List of NSW Contaminated Sites Notified to EPA" did not identify contaminated sites within close proximity to the proposal site.

Historical agricultural practices have included the use of sheep dips on both the Logans Lane and Newell Highway properties. Sheep and cattle have been treated with synthetic pyrethroid such as bifenthrin. The Australian Government Department of Health website states that synthetic pyrethroids are generally low in toxicity to humans, but are very effective against a wide variety of insect pests.

Herbicides have been used to treat weeds at site such as thistles, turnip weed and African Box Thorn. Herbicides that were mainly used include methyl chlorophenoxyacetic acids (MCPA) and glyphosate. MCPA is used to control broadleaf weeds such as thistle in cereal crops and pasture. Glyphosate has been commonly used in agriculture for its effectiveness at weed control and is not known as a persisting soil contaminant.

Land and soil capability

Land in NSW is commonly classified according to the capability of land to remain stable under particular land uses. The 8-class classification is shown in Table 6-36, while Table 6-37 compares the land capability classifications of the proposal site with the Narrabri LGA.

Land within the proposal area comprises Class 3 (4.5 ha, 1%) and Class 5 (444.7 ha, 99%) land. As such, the majority of the land is not capable of being regularly cultivated but is suitable for grazing with occasional cultivation as per the definition in Table 6-36.

The comparison of land capability with the whole of the Narrabri LGA in Table 6-37 shows that the site has a lower proportion of better quality land compared to the LGA as a whole.

Within the proposal site, there is an area of Class 3 land (4.5 ha) along the southern boundary that has been classed as Biophysical Strategic Agricultural Land. This area will be retained as part of the buffer zone around the site.

Table 6-36 Land and soil capability

Broad category	Class	Description
Land capable of being regularly cultivated (Slope < 10%)	Class 1	No special soil conservation works or practices necessary.
	Class 2	Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotation.
	Class 3	Structural soil conservation works such as diversion banks, graded banks and waterways, together with soil conservation practices as in Class 2.
Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation (Slope 10% - 25%)	Class 4	Soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or reestablishment of permanent pastures.
	Class 5	Structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with the practices as in Class 4.
Land not capable of being cultivated but suitable for grazing (Slope > 25%)	Class 6	Soil conservation practices including limitation of stock, broadcasting of seed and fertiliser, prevention of fire and destruction of vermin. This class may require some structural works.
Other lands	Class 7	Land best protected by green timber.
	Class 8	Cliffs, lakes or swamps and other land incapable of sustaining agricultural or pastoral production.

Table 6-37 Land and soil capability at the proposal site and Narrabri LGA

Land and soil capability class	Proposal site		Narrabri LGA	
	Area (Ha)	Percent	Area (Ha)	Percent
1	-	-	-	-
2	-	-	246,238.8	18.9%
3	4.5	1%	288,097.1	22.1%
4			255,493.3	17.3%
5	444.7	99%	446,231.0	34.3%
6	-	-	27,062.5	2.1%
7	-	-	63,625.6	4.9%
8			4,648.0	0.4%
Not defined			997.1	0.1%
Total	**449.3**	**100%**	**1,332,393**	**100%**

Source: Office of Environment and Heritage (2017), Land and Soil Capability Mapping for NSW, NSW Office of Environment and Heritage, Sydney

In alignment with the land capability, land use at the proposal site is split between cropping (54%) and grazing (46%). The proposal site has a higher proportion of cropping and grazing compared to the Narrabri LGA. The total land area of the proposal site is 449.3 hectares and represents 0.03 per cent of the total land area of Narrabri LGA (1,302,438 hectares).

Based on land use and land capability information, the site does not currently fit the classification of “Important Agriculture Land”. The lack of any foreseeable irrigation development, combined with the generally lower land capability of the proposal site, also means it is unlikely to have the potential to be classified as “Important Agriculture Land” in the future.

Land adjacent to the southern and eastern boundaries appears to be used for irrigated cropping and is on land with capability classes 2 and 3. Current agricultural practices on these adjoining properties is expected to continue.

Agricultural land use

Value of agricultural production in Narrabri

Agriculture is an important component of the economy of the Narrabri LGA, accounting for $375 million per annum (ABS 2018). The majority of the value of production is from cropping with cotton and wheat contributing approximately $140.3 million and $78.9 million per annum respectively. Livestock slaughtering (mainly cattle and sheep) and livestock products (mainly wool) also make smaller contributions. Table 6-38 provides a breakdown of the value of agricultural production by commodity type.

Table 6-38 Gross value of agricultural production Narrabri LGA (2015-16)

Commodity	Narrabri LGA ($M)
Total crops (including hay)	$331.9
Horticulture	$0.3
Livestock slaughtering – cattle	$32.6
Livestock slaughtering – sheep and lambs	$3.6
Livestock slaughtering - poultry	$1.6
Livestock slaughtering – other	$0.3
Livestock products – wool	$4.6
Total	**$375 ($M)**

Source: ABS (2018) Value of Agricultural Commodities Produced–New South Wales and Local Government Areas–2015-16, Cat. No. 7503.0 (Table 2), Statistics for Narrabri (A).

Value of agricultural production at the proposal site

To provide an indicative value of agriculture at the proposal site, an estimate of the value of production was derived using a combination of publically available data from the NSW Department of Primary Industries’ (DPI) website and knowledge gained from undertaking similar agricultural assessments in the region.

Table 6-39 outlines the average gross income ($/ha/year) indicative of major agricultural enterprises in the Narrabri area. This data has been sourced from the NSW DPI website (http://www.dpi.nsw.gov.au/agriculture/farm-business/budgets).

Table 6-39 Value of agricultural production at the proposal site

Enterprise	Gross income ($/ha/year)
Cropping	
Wheat Long Fallow, No Till (Winter)	$726
Average crop gross income ($/ha/year)	$726
Grazing	
Feeder steers	$52.00

Enterprise	Gross income ($/ha/year)
1st Cross Ewes/Terminal meat rams	$70.34
Merino ewes (20 micron)	$60.98
Average gross income ($/DSE)	$61.11
Stocking rate (DSE/ha)	5.7
Average livestock gross income ($/ha/year)	$348.31

Source: NSW DPI 2017 for Livestock and NSW DPI 2012 Cropping adjusted for inflation.
DSE = Dry sheep equivalent

Using the above information on gross income per hectare, and applying this to the proposal site's land use areas, the gross annual potential production value of the proposal site has been calculated at $247,974. This represents 0.07% of the total value of agriculture in the Narrabri LGA. This is based on a long-term seasonal conditions and it is assumed the proposal site is being run as a single agricultural entity and able to take advantage of economies of scale.

Development of the proposal would cause a reduction in agricultural income at the proposal site for the life of the proposal. This would be offset by the rent paid to the landholder by ENGIE.

In addition, the proposal is expected to have a "light" impact on land capability. At the end of its operational life, planned to be 35 years, the site could be rehabilitated to a state that would allow agricultural production similar to its current status.

Australian Bureau of Agricultural Economics (ABARES)

Gross income assessments from agricultural activities provide an indication of the gross value of production, but are not a measure of farm profitability. Gross income assessments do not include capital (machinery, land, buildings etc.) or fixed or variable costs (insurance, rates, taxes, variable costs incurred in agricultural enterprises). The Australian Bureau of Agricultural Economics (ABARES) publishes *Financial Performance: all broadacre industries for NSW, 2015-16 to 2017-18* which provides an estimate of farm performance.

The ABARES study is an average across all of NSW. In relation to the proposal site, the following is noted:

- The proposal site's area is half the average farm size for the survey sample.
- Average seasonal conditions for the proposal site have not been prevalent in recent years due to drought.

Table 6-40 provides a summary of average financial performance for all broad-acre industries across NSW.

Table 6-40 Financial Performance: all broad-acre industries for NSW, 2015-16 to 2017-18

Measure	Unit	2015-16	2016-17 (p)	2017-18 (y)	Proposal site average
Total Cash Receipts	$	509,580	547,900	518,000	262,580
Total Cash Costs	$	334,820	364,500	352,000	175,220
Farm Cash Income	$	174,760	183,400	166,000	87,360
Farm Business Profit	$	89,320	107,200	65,000	43,856

p=preliminary estimate y=provisional estimate

The farm business profit is calculated as the addition of farm cash income and change in trading stocks less, depreciation and owner labour. This would result in an estimated average farm business profit of $43,856 for a property of similar size to the proposal site.

6.6.3 Potential impacts

The proposal represents an activity that differs from the agricultural activities on the proposal site, and on surrounding properties. To minimise potential land use conflicts, it is important that the proposal does not impact on the continuing ability of neighbouring properties to pursue their current activities. It is also important that the proposal does not affect the ability of neighbouring properties to change land uses in the future. The proposal's potential impacts have been addressed in the following sections.

Construction impacts

Soils

The construction of the proposal would disturb soils due to the following activities:

- Vegetation clearance
- Installing the mounting structures for solar arrays
- Establishment of solar farm and internal access tracks
- Excavation for cable routes
- Movement of vehicles around the site
- Minor earthworks for levelling small localised sections of site such the substation and office building
- Works to upgrade Logans Lane
- Installation of the new transmission line

The disturbance of soils has the potential to result in the following impacts:

- Erosion and sedimentation which could result in a reduction in top soils in parts of the site
- Water quality impacts from erosion and sedimentation
- Mixing of the soil horizons which could impede vegetation growth on site

The construction and operation of the proposal would require minor ground disturbance. Construction would largely follow the existing landform, and no significant cut and fill landform changes would be required. Disturbance would be primarily associated with vegetation clearance, installation of the panel array supports and the construction of access tracks, and the consequent erosion potential.

Erosion potential

An assessment of the erosion potential of the soils was completed using the Revised Universal Soil Loss Equation (RUSLE) calculation method. The RUSLE method is a model that describes the soil erosion process, and is used to predict long-time average soil loss rates from sheet and rill flow.

The assessment confirmed that the removal of vegetation at the site would increase the erosivity of the soils significantly compared to existing conditions with vegetation cover. It also confirmed that the erosion potential would significantly decrease after revegetation.

The RUSLE calculation estimates that under current conditions with established vegetation cover, the site would average an annual soil loss of 0.44 tonnes per hectare per year (t/ha/yr). During construction the potential loss would rise to 10.80 t/ha/yr. Once revegetated, the potential loss would reduce to 1.08 t/ha/yr. This figure would reduce further over time as the vegetation becomes established and stabilises the soil.

Where possible groundcover on site would be retained, particularly in the areas of the solar arrays. The installation of the poles for the panel mounting structures, would require minor excavations, and would affect only a small area in each location. Any disturbed areas (with no existing groundcover) would be stabilised as soon as possible after construction to prevent erosion of soils.

Operational soils impacts

Impacts to soils

Soil impacts during operation would be minimal and would be limited to maintenance activities. These activities would not produce any substantial soil disturbance on a regular basis and therefore impacts are considered minimal.

Contamination

The proposal has the potential to result in the localised contamination of soils as a result of spills and leaks from equipment and machinery during construction on site. There is also potential for localised contamination of soils due to maintenance activities. The potential for these impacts would be minimised with the implementation of safeguards and mitigation measures outlined in Table 6-42.

Operational land use

Land use conflict risk assessment and potential cumulative impacts

The Department of Industry (DoI) documents *Land Use Conflict Risk Assessment Guide* (DPI Guide) and *Living and working in rural areas handbook* (DoI Handbook) were referenced for this risk assessment.

The DPI Guide provides methods for conducting Land Use Conflict Risk Assessments (LUCRA), and examines potential conflicts arising from proposed agricultural developments or other developments in rural areas. The DoI Handbook is more focussed on the NSW North Coast, but contains relevant tools used for reducing potential land use conflicts.

A land use conflict occurs when one land use is perceived to infringe on the rights, values or amenity of another. Rural amenity issues are the most common land use conflict issues, followed by environmental protection issues (DoI Guide). Table 6-41 lists the potential sources of land use conflict from the proposal, assesses the risk and suggests management strategies to reduce possible conflicts. The list is adapted from the DPI Handbook.

The LUCRA is a valuable tool in allowing land managers, site developers or other proponents that may be planning a change in the existing use of a property to identify the effects of a proposed land use on neighbouring land uses. It allows for management strategies to be developed to minimise the potential impacts.

The four key steps of the LUCRA are:

- Gather information
- Evaluate the risk level of each activity
- Identify risk reduction management strategies
- Record LUCRA results

The results of the LUCRA completed for the proposal are described in Table 6-41.

The DoI Handbook identifies a number of common causes of rural conflicts. These were also used in the LUCRA to provide a guide to potential land use conflicts that may arise as a result of the proposal.

A number of issues listed in the DoI Handbook are considered to pose a negligible risk for the proposal and have been assessed as not applicable (N/A). The risk assessment is based on separation distances as described in Section 1.2 and also the following features:

- Adjoining properties along Logans Lane, Kamilaroi Highway and Newell Highway will continue to be actively used for agricultural purposes in the future.
- Future farming operations will be similar to current operations with no expected reduction in productivity or employment on the adjoining properties as a result of the proposal.

Table 6-41 Land use conflict risk assessment

Issue	Risk	Issue management
Agricultural aerial spraying	Minor	The heights of infrastructure are similar to existing infrastructure on surrounding land. Glare from the infrastructure will be very low and screening will be provided where appropriate and in consultation with adjacent land owners.
Airstrip	Minor	A buffer has been included around the existing airstrip located adjacent to the north-west corner of the proposal site to limit the potential for negative impacts on the operations of this business.
Biosecurity	Minor	Refer to biosecurity section below.
Catchment management	Minor	The proposal will have no to minimal impact on natural resource management of surrounding agricultural properties. The existing drainage channel running through the southern part of the Logans Lane property will be retained. ENGIE will be responsible for ensuring site plans (e.g. stormwater) meet guidelines for discharges into waterways.
Dogs	Negligible	
Dust	Minor	Construction is expected to generate low levels of dust. Once construction is completed there will be minimal dust generation as result of vehicles accessing the site for maintenance purposes. In this respect, it is expected that dust generation would be similar to that occurring on adjacent agricultural land. Landscaping to be located on site (to be confirmed following consultation with nearby residents) would potentially reduce dust moving beyond the site boundary.
Dwellings	Minor	Existing dwellings are present on the site and the continued use of these dwellings will be confirmed as part of the development of the lease arrangements. As such these dwellings are not considered to be sensitive receivers as their continued use would be subject to the lease agreement. The next closest dwelling is 240 metres to the west of the western boundary of the proposal site. A draft landscape plan has been developed and considers the positioning of additional screening vegetation on the proposal site to minimise any visual impacts to nearby visually sensitive receivers. Adjoining landowners have been consulted on the draft landscape plan.

Issue	Risk	Issue management
Fencing	Minor	Fences separating adjoining agricultural land will be maintained in a condition to minimise the possibility of livestock straying onto the site from adjoining properties. The maintenance of shared boundary fencing is the responsibility of all land owners.
Fire	Minor	A bushfire management plan will be prepared for the proposal. Further detail is provided in Section 6.10.
Lights	Minor	Construction of the proposal would be limited to standard construction hours and therefore no artificial lighting would be required. During operation some lighting would be present on site, however this would be limited to the office building and would generally only be used when personnel are on site. This lighting is unlikely to impact on adjacent land use.
Mines or other extractive industries	Minor	No exploration licences or extractive industry approvals are valid for the proposal site. The proposal would not prevent these types of developments on surrounding properties.
Noise	Minor	The proposal is predicted to exceed construction noise management levels calculated in accordance with the Interim Construction Noise Guideline for short periods of time. This would be limited to the construction of the support piles and would have minimal impact on adjacent land use. Operation of the proposal is predicted to comply with noise criteria calculated in accordance with the Industrial Noise Policy and is unlikely to adversely impact on adjacent land use.
Odours	Negligible	
Pesticides	Minor	Pesticide use within the proposal site will be minimal such as for weed control, and any product are likely to be similar to those used by surrounding landholders.
Roads	Minor	There will be an increase in traffic numbers during construction. Increased traffic volumes are not expected to have any increased impact on local roads. Construction traffic and access has been addressed in the EIS.
Straying livestock	Minor	See Fencing
Subdivision	Moderate	The proposal includes a long-term lease of the proposal site, for the expected operational life of 35 years. Sub-division is not proposed as part of the proposal.
Theft/vandalism	Minor	The relative isolation and nature of the boundary fencing is expected to reduce the risk posed by theft/vandalism at the site and with adjacent holdings.
Visual amenity	Minor	Section 6.4 assesses the potential visual impacts of the proposal (including any glare, reflectivity and night lighting) on surrounding residences, scenic or significant vistas, air traffic and road corridors in the public domain, including a draft landscaping plan for on-site perimeter planting. This has been developed in consultation with adjoining landowners.
Weeds and pests	Minor	Weed and pest control, including for noxious weed and pests, will be subject to ongoing routine monitoring and management. See also biosecurity below.

Impacts to Oakville Aerodrome

Instrumentation

Oakville Aerodrome is not equipped with instrument procedures. The proposal would therefore not affect the operation of any aeronautical instruments. The proposal would not affect any obstacle limitation surfaces at Oakville aerodrome. The proposal would not interfere with any aviation radar facilities.

Glare

Solar photovoltaic panels can produce glint (a momentary flash of bright light) and glare (a continuous source of bright light), which could result in an ocular impact to pilots. A glare analysis was prepared using the ForgeSolar application, which is recommended by the Federal Aviation Administration.

In terms of adherence to the FAA policy, the glare analysis found that:

- Analysis time interval and eye characteristics used are acceptable
- Flight path receptor(s) do not receive yellow glare

The analysis was prepared on the basis that there is no anti-reflective coating on the solar panels and as such represents the worst-case scenario.

Windshear and turbulence

Solar photovoltaic panels can produce windshear by reflecting north east and south east winds, which are common in the area of the project. The windshear could affect aircraft airspeed during take-off and landing. This has been identified as a specific cause for concern to pilots operating at Oakville aerodrome.

The Department of Infrastructure, Regional Development and Cities released the National Airports Safeguarding Framework (NASF) Principles and Guidelines. *Guidelines B Managing the Risk of Building Generated Windshear and Turbulence at Airports* provides guidance to Commonwealth, state/territory and local government decision makers and airport operators to manage the risk of building generated windshear.

The project is located within 1200 m perpendicular from the Oakville aerodrome runway 01/19 centreline and could pose a safety risk to aircraft operating from/to aerodrome. The rule adopted in Australia, based on Guideline B, is that buildings should not penetrate a 1:35 surface extending perpendicular from the runway centreline.

The maximum proposed height of the panel is 4.1 metres above ground level (AGL). Therefore, a solar panel with a height of 4.1 metres AGL would be acceptable if it is located more than 143.5 metres from the Oakville aerodrome runway 01/19 centreline, providing the site is relatively level. The proposal layout, relative to Oakville aerodrome, includes a buffer of approximately 176 metres from the runway 01/19 centreline and is therefore not within the distance that could contribute to turbulence.

Airspace and flight paths

The proposal site is located outside of controlled airspace (wholly within Class G airspace) and is not located in any Prohibited, Restricted and Danger areas. The nearest restricted area R524 is located approximately 24 kilometres (13 nautical miles) west of the proposal site. The area is vertically limited from the ground surface up to 2500 feet AMSL and operated by CSIRO Narrabri 24 hours/day.

The proposal site is outside the R524 restricted area and would not have an impact on controlled or designated airspace. The proposal would not affect air routes or grid lowest safe altitudes.

The Aviation Projects report determined that the proposal:

- Would not penetrate any OLS surfaces
- Would not affect any instrument procedures
- Would not have an impact on nearby designated air routes
- Would not have an impact on designated airspace
- Is wholly contained within Class G airspace
- Is outside the clearance zones associated with aviation navigation aids and communication facilities

Further details on the assessment of potential impacts on the Oakville Aerodrome are provided in Appendix G.

Decommissioning

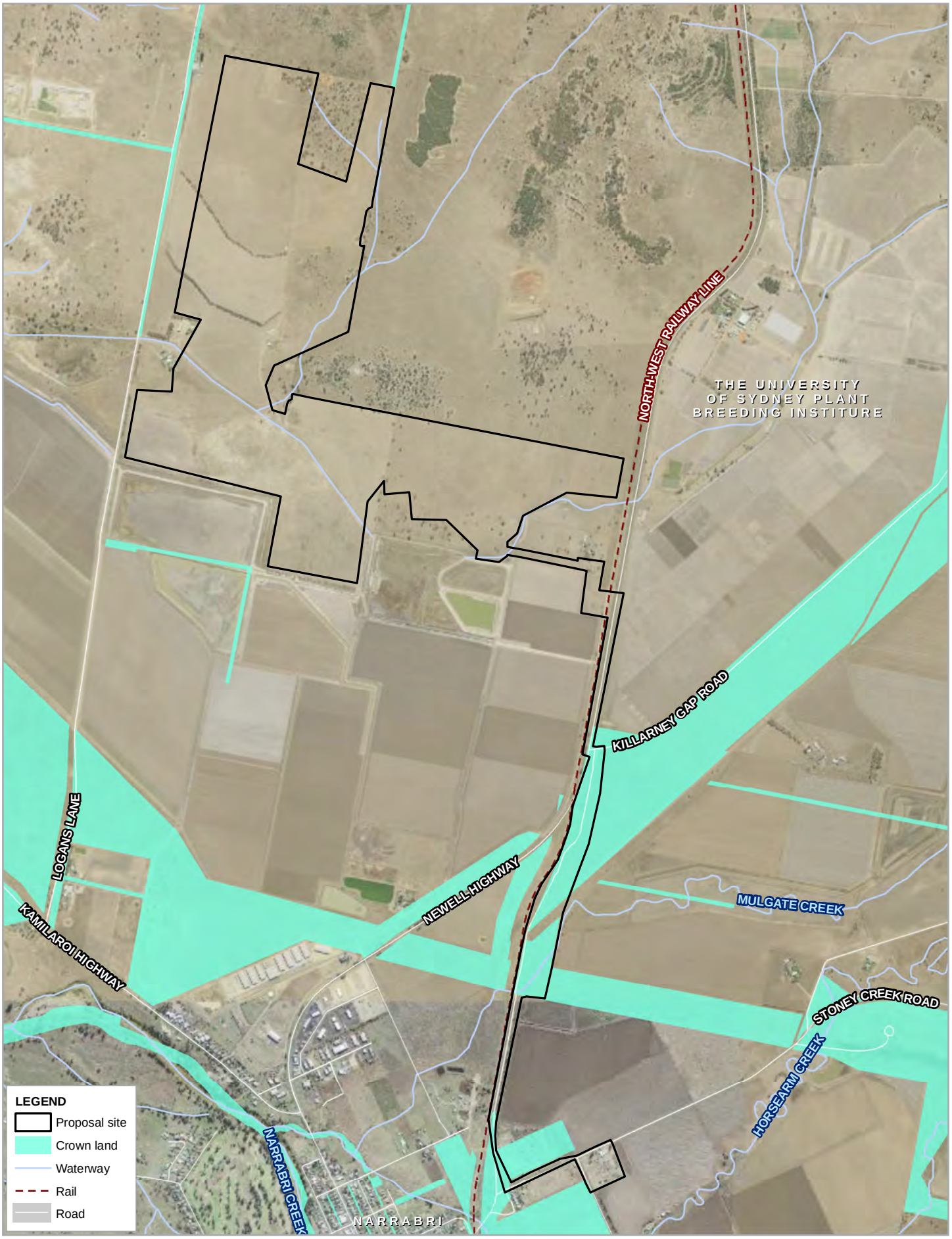
At the end of life, the solar farm will be disconnected from the electrical transmission network. This entails disconnecting and removing solar panels for recycling, recycling the steel associated with the single-axis tracking system, removing the containerised inverter and transformer systems, and associated cabling and any conduit.

Under the proposed lease agreements with the project landowners, ENGIE must remove the solar farm infrastructure except for any cables which are underground to a depth of greater than 500 mm and solar farm access roads which need not be removed. ENGIE must also restore the surface of the solar farm land to a suitable condition for pastoral or other agricultural use and leave the land electrically safe and otherwise in a safe condition. ENGIE intends for wire, transformers, and switchgear to be recycled in accordance with all national and international regulations through a local third party. ENGIE would seek out decommissioning and recycling partners that hold R2 Certification (for electronics) or is a member of the Australian Metal Recycling Industry Association (for bulk metals). At the completion of decommissioning the land would be suitable for reversion to agricultural use.

Impacts to Crown Land

The northern portion of Logans Lane is Crown Land. The proposal site will be accessed by the existing access off the southern portion of Logans Lane, which is a Council Road. No Crown Land will be required for access to the proposal site.

The transmission corridor traverses a number of parcels of Crown Land. This area is shown in Figure 6-20. An approval to construct transmission infrastructure on Crown Land will be required prior to construction.



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Engie
Silverleaf Narrabri Solar Farm EIS

Crown Land

Project No. 21-26998
Revision No. 1
Date 25 Jun 2019

FIGURE 6-20

N:\AU\Orange\Projects\21\26998\GIS\Maps\Deliverables\EIS\21_26998_Z012_EIS_CrownLand.mxd

Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

Biosecurity

The productivity and profitability of agricultural production depends in part on the management of pests and diseases, including the prevention of incursion of pests and diseases onto properties. Biosecurity is a term that is commonly used for such management and the set of measures adopted to protect a property from the entry and spread of pests, diseases and weeds.

Farms generally prepare an on-farm biosecurity plan based on industry guidelines such as those available on the website: farmbiosecurity.com.au. The guidelines include risk assessments and control options to minimise impacts. The major biosecurity risk from the proposal relates to the movement of people, vehicles and machinery. These risks apply for both the construction and operation phases. Table 6-42 outlines the potential biosecurity risk and potential measures that may mitigate the risks.

Flood prone land

The proposal site is not located on land that is mapped as flood prone. The construction and operation of the proposal would not significantly impact on flood regimes on the proposal site or on surrounding properties. Section 6.8 assesses impacts on site hydrology.

Summary of impacts

The proposed conversion of agricultural land to a solar farm has been assessed for its impact on agricultural land at the proposal site and surrounding LGA. Using information combining land use, land capability, gross value of agricultural production and employment statistics, the land use impact assessment analysed the impact the removal of this parcel of land on the broader agricultural economy within the Narrabri LGA.

Development of the proposal would represent a continuing annual reduction in agricultural income over the life of the proposal at the proposal site. This will be offset by the value of future solar energy sales. In addition, the proposal is expected to have a “light” impact on land capability such that when it is at the end of its operational life (estimated to be after 35 years), the site could be rehabilitated to a state that would allow agricultural production similar to its current status.

The proposal site represents 0.0003% of land use and 0.07% of the total value of agricultural production within the Narrabri LGA. Therefore, removal of the land from agricultural production would have minimal impact within the broader region.

A land use conflict risk assessment determined that the likelihood of potential conflict was low and that current agricultural land use on surrounding land could continue with minimal impact. The construction and operation of the proposal would not significantly affect the soil on the proposal site, or on adjoining properties.

The aeronautical impact assessment determined that the proposal would not:

- Penetrate OLS of Oakville aerodrome
- Affect any instrument procedures
- Have an impact on nearby designated air routes
- Have an impact on designated airspace
- Encroach beyond Class G airspace
- Encroach on the clearance zones associated with aviation navigation aids and communication facilities

6.6.4 Safeguards and mitigation measures

Table 6-42 provides a summary of management and mitigation measures to reduce potential land use conflicts and soil impacts.

Table 6-42 Summary of land use and soil management and mitigation measures

Impact	Environmental safeguards	Timing
Soil and erosion	An Erosion and Sediment Control Plan (ESCP) would be prepared prior to construction to minimise impacts on soils during construction.	Construction
	Spill management and materials handling measures would be included in the ESCP to minimise the potential for fuel or chemical spills.	Construction
	Ground cover would be reintroduced after construction to stabilise soils during operation.	Operation
Biosecurity – site workers	Limit entry points to the property.	Construction and operation
	All construction equipment and boots would be cleaned upon entering the property in a wash-down bay.	Construction and operation
	Limit worker contact with livestock, crops or plant materials as much as possible and eliminate any unnecessary contact altogether.	Construction and operation
	Keep a visitor register.	Construction and operation
Biosecurity – vehicles	Limit the number of entry and exit points for vehicles.	Construction and operation
	Clearly sign and lock restricted access areas.	Construction and operation
	Clean construction vehicles and park in a designated area away from livestock or crops.	Construction and operation
	Establish a vehicle high pressure wash down facility well away from livestock and crops to clean vehicles and equipment which need to enter the property.	Construction and operation
	Vehicles to remain on designated tracks.	Construction and operation
Biosecurity – equipment	Clean machinery and equipment from the top down.	Construction and operation
Operation of private airstrip	Native vegetation is proposed as screening along the north-west boundary of the proposal site adjacent to the private airstrip. The species to be planted would be agreed in consultation with the airstrip operator to provide effective screening but not compromise safety for the operation of planes.	Prior to operation

6.7 Traffic, transport and access

6.7.1 Methodology

The traffic, transport and access study involved reviewing existing information on traffic and road safety data for the roads surrounding the proposal site. The study focussed on examining the existing capacity of these roads, including key intersections, to determine whether the construction and operation of the proposal would negatively affect the capacity of the road network, or the safety of road users. The study involved reviewing relevant information on existing road conditions, including the intersection of the Kamilaroi Highway and Logans Lane.

Desktop study

A desktop assessment was completed to gain information on existing traffic and transportation conditions in the area surrounding the proposal site. The reference documents used in this assessment included:

- RMS Traffic Volume Viewer Website (http://www.rms.nsw.gov.au/about/corporate-publications/statistics/traffic-volumes/aadt-map/index.html#/?z=6)
- Transport of NSW – Centre for Road Safety Website –Crash Statics Map (https://roadsafety.transport.nsw.gov.au/statistics/interactivecrashstats/index.html)
- Austroads Guide to Road Design Part 4 – Intersections and Crossings – June 2017
- Austroads Guide to Traffic Engineering Practice – Part 5: Intersections at Grade
- RMS Supplement to Austroads guide to road Design

Intersection assessment

The intersection assessment included:

- An assessment of the traffic volumes along Kamilaroi Highway near the intersection with Logans Lane based on the traffic data available in the Roads and Maritime Service (RMS) database
- An assessment of the existing intersection configuration to determine its suitability for use by construction vehicles
- Examining an alternative intersection layout based on:
  - Traffic Impact Assessment
  - Sight distances, and RMS/Austroads intersection requirements
  - Road operating speed
  - Road and utility infrastructure found on public databases such as Google view, Dial Before You Dig (DBYD)
  - Assessing the configuration of alternative intersection designs
  - Overlaying these on an aerial photograph to determine the extent of any required road widening

Rail projects

The proposal site is located immediately adjacent to the North West Rail Line. The rail line runs north-south, parallel to the Newell Highway along the proposal site's eastern boundary. The ARTC Narrabri to North Star project, known as the N2NS Project, would follow the existing rail alignment north from Narrabri to the village of North Star. The N2NS Project is adjacent to the eastern boundary of the proposal site.

An EIS has been prepared for the N2NS Project under State Significant Development for approval by the NSW Minister for Planning. The EIS has been placed on public exhibition. If approved by the Minister, the project will be referred to the Commonwealth Minister for Environment for consideration under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EIS was reviewed, including the traffic and transport assessment, to examine the proposal's interaction with the N2NS Project.

6.7.2 Existing environment

Existing road infrastructure

Narrabri Township is located south of the intersection of the Newell Highway and the Kamilaroi Highway. The proposal site is located to the north of this intersection, approximately four kilometres from town. During construction and operation the proposal site will be accessed from Logans Lane, via the Kamilaroi Highway.

Newell Highway

The Newell Highway is a state highway (HW 17) which runs from Tocumwal on the NSW-Victoria border in the south, to the Queensland border at Goondiwindi in the north. The section of the Newell Highway located to the east of the proposal site is the main route between the towns of Moree and Narrabri. In the vicinity of the proposal site, the highway has one lane in each direction and a speed limit of 110 kilometres per hour. The Newell Highway to the east of the proposal site, and its proximity to the North West Railway Line, is shown in Figure 6-21.

In 2008, approximately 3,100 vehicles per day in each direction used the section of the Newell Highway located north of the intersection with the Kamilaroi Highway (Roads and Maritime data, 2008). Light vehicles accounted for 62 per cent of these vehicles in both directions, with the remaining 38 per cent heavy vehicles.

Figure 6-21 Newell highway looking south, east of the proposal site

Kamilaroi Highway

The Kamilaroi Highway is a state highway (HW 29) which runs from the Willow Tree in the southeast to Bourke in the northwest. The Kamilaroi Highway is located to the south of the proposal site. To the west of the intersection with the Newell Highway, the Kamilaroi Highway is the main route to Logans Lane, the primary access point for the proposal. This intersection is shown in Figure 6-22.

In the vicinity of the proposal site, the Kamilaroi Highway has one lane in each direction. The speed limit changes immediately east of the intersection with Logans Lane. The westbound speed limit changes from 80 kilometres per hour to 100 kilometres per hour. The eastbound limit changes from 100 kilometres per hour to 80 kilometres per hour.

Figure 6-22 Kamilaroi Highway looking east from Logans Lane intersection

Logans Lane

Logans Lane is a local road which runs from the intersection of the Kamilaroi Highway north for approximately five kilometres, after which it changes to a private road. The southern section of Logans Lane is the primary access road to the proposal site.

In the vicinity of the proposal site, Logans Lane does not have a recognised speed limit. The entire length of the road is unsealed. Logans Lane looking north is shown in Figure 6-23.

Figure 6-23 Logans Land looking north

Intersection of Kamilaroi Highway and Logans Lane

The geometric parameters of the Kamilaroi Highway and Logans Lane intersection have been checked against the Austroads design guideline requirements. The intersection is located within the 100 km/h speed zone. The 80 km/h speed change signage is located 80 metres east of the intersection.

Safe Intersection Sight Distance (SISD) is the minimum sight distance which needs be provided on a major road at any intersection. The required SISD for the intersection of the Kamilaroi Highway and Logans Lane is 248 metres based on the following criteria:

- Design Speed of 100 km/h (same as existing posted speed)
- Driver Reaction time of 2 seconds (the general minimum reaction time)
- Vertical alignment has not been considered

The preliminary sight distance check has been undertaken for the existing intersection based on the Austroads Part 4a requirements. Aerial photos have been used for sight distance check in the absence of 3D survey data. No obstruction to visibility has been identified in the sight distance check. The required sight distance of 245 metres is provided in both directions for this intersection.

The existing intersection is an un-channelised (no traffic island) and unflared (no additional lane/taper) type of T intersection. This type of intersection is adequate where a major road intersects with a minor road. In normal operating conditions, this type of intersection does not require turning lanes or traffic islands due to the low amount of turning traffic. Details of the treatment proposed for this intersection for construction purposed are provided in Section 6.7.4.

Old Cemetery Road

Old Cemetery Road is a local road which runs from an intersection with Kaputar Street in the south to an intersection with Killarney Gap Road in the north. The section of the Old Cemetery Road located to the east of Narrabri is a main route to the existing TransGrid substation.

The road has a stop sign signalled railway crossing approximately 100 metres from the intersection with Kaputar Street. It also has a one lane bridge crossing Horse Arm Creek with a 16 tonne load limit immediately north of this. In the vicinity of the proposal, the road has 50 kilometre per hour speed limit in both directions and is sealed with no lane or road markings.

Stoney Creek Road

Stoney Creek Road is local road which runs from an intersection with Old Cemetery Road in the west and continues eastward for approximately eight kilometres until its finish. The section of the Stoney Creek Road located to the east of Narrabri is the main access road to the TransGrid substation.

In the vicinity of the proposal, the road has a 50 km/h speed limit in both directions which changes to 100 km/h approximately 200 metres east of the TransGrid substation. The road is sealed, but has no lane or road markings.

Access

The proposal site is accessed via an existing gate on Logans Lane, off the Kamilaroi Highway. The intersection of the Kamilaroi Highway and Logans Lane is located 400 metres west of the intersection of the Kamilaroi Highway and Newell Highway.

There are no merging lanes in either an eastbound or westbound direction on the Kamilaroi Highway at this intersection. Based on Roads and Maritime Services data in 2008, approximately 2,200 vehicles per day used this section of the Kamilaroi Highway.

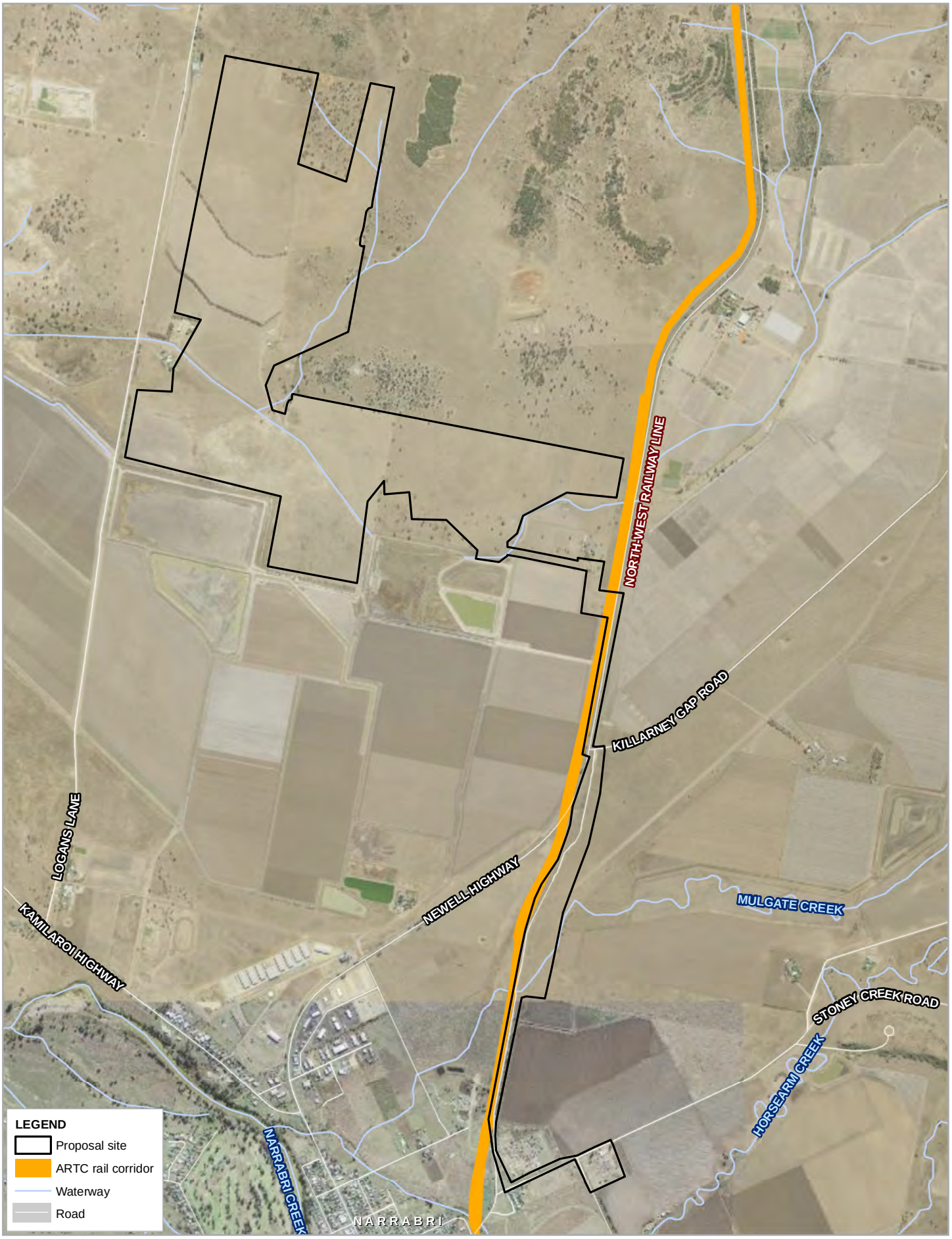
The eastern part of the proposal site (Newell Highway property) can also be accessed from the Newell Highway. This eastern access includes a level crossing of the existing North-West Railway Line, which runs along the western side of the Newell Highway.

North West Rail Line – ARTC Inland Rail Project

The section of the North West Railway Line immediately adjacent to the Proposal site is subject to a development application as part of ARTC's Inland Rail Project. This section of rail is planned to be upgraded within the existing rail corridor as part of the Narromine to North Star (N2NS) section of the Inland Rail Project.

ARTC has a second project in development for the Inland Rail Project. The Narromine to Narrabri (N2N) project is still in the early phases of development. The Narromine to Narrabri Options Report details the route selection options. A review of ARTC's project documents indicates that the N2N Project would tie in with the existing rail to the west of Narrabri Township. This is more than five kilometres from the proposal site.

Figure 6-24 shows the location of these two projects.



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Engie
Silverleaf Narrabri Solar Farm EIS

North West Railway Line

Project No. 21-26998
Revision No. 1
Date 25 Jun 2019

FIGURE 6-24

N:\AU\Orange\Projects\21\26998\GIS\Maps\Deliverables\EIS\21_26998_Z013_EIS_NorthWestRailwayLine.mxd

Data source: General topo - NSW LPI DTDB 2017, 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

Traffic

Based on the RMS traffic volume viewer, there are two (temporary) traffic counter stations on Kamilaroi Highway (Wee Waa Road) near the Logans Lane intersection as follows:

- Station 92726: This station is located approximately 1.5 km south-east of the Logans Lane intersection. This station collected traffic data in 2008.
- Station 92732: This station is located approximately 22 km north-west of the Logans Lane intersection. This station collected traffic data in 2006, 2008, 2009 and 2012.

Table 6-43 summarises the traffic data from these stations.

Table 6-43 Summary of traffic data for Kamilaroi Hwy

Data from RMS Traffic Counters					
Station ID	Location	Year	ADT 1	AM PEAK2	PM PEAK3
92726	1.5 km south of the site intersection	2008	2178	674	697
92732	22 km north of the site intersection	2006	1015	318	320
92732	22 km north of the site intersection	2008	1137	349	376
92732	22 km north of the site intersection	2009	1206	359	397
92732	22 km north of the site intersection	2012	1226	338	373
Notes:					
1-ADT (Annual Daily Traffic) is based on Vehicle per day.					
2- AM Peak is traffic volume during the hours of 6:00 am to 10:00 am					
3- PM Peak is traffic volume during the hours of 3:00 pm to 7:00 pm					

Crash data

A review of the crash and casualty statistics from NSW Centre for Road Safety (Transport for NSW Centre for Road Safety website) revealed there have been no recorded crashes at the intersection of the Kamilaroi Highway and Logans Lane between 2013 and 2017.

6.7.3 Potential impacts

Traffic volumes

In the absence of site-specific data for traffic modelling, an annual growth rate of 2 percent has been applied to the observed 2008 traffic volumes to determine the horizon year traffic. It has been assumed that the construction of the solar farm will start in the first half of 2020.
Table 6-44 provides a summary of the estimated traffic volume for the Kamilaroi Highway in 2020.

Table 6-44 Summary of the estimated traffic volume for Kamilaroi Hwy

Year	ADT(Veh/day)	Peak Hour (Veh/hr)	Peak Hour Factor
2008 (Observed)	2178	232	10.6%
2019 (Estimate)	2708	288	10.6%
2020 (Estimate)	2762	293	10.6%

Construction

Traffic generation and impacts on operation of network

As described in Section 3.3.8, preliminary construction planning indicates that a peak of about 80 heavy vehicle movements (i.e. to and from site is two movements) would be required to site per week throughout the construction period. These number could be lower depending on the types of vehicles to be used (i.e. if B-doubles are used the number of heavy vehicle movements would reduce). Average heavy vehicle movements would be substantially less than this peak number as heavy vehicles deliveries would not be required constantly during construction.

A maximum of 240 light vehicle movements per day would be required during peak periods of construction. Average light vehicle movements would be considerably lower as peak construction periods would take place over shorter periods. The contribution of the average daily light vehicle numbers to the Kamilaroi Highway traffic volumes would be negligible during construction. Consideration would be given to using buses to transfer workers from Narrabri, however this would be confirmed during detailed design and would be outlined in the traffic management plan to be developed for the proposal.

Vehicle movements would be undertaken during standard construction hours (or just before to allow workers to get to site). Oversized vehicles may be required to access the site after hours in line with any Roads and Maritime Services, Narrabri Shire Council or NSW Police requirements. The Newell Highway and Kamilaroi Highway have sufficient capacity to accommodate the increase in construction traffic.

Kamilaroi Highway and Logans Lane intersection

Oversized vehicles would be required to deliver large plant and components such as the transformer for the substation. Oversized vehicles such as a 50 tonne crane may also need to access the site to place the infrastructure such as the substation components.

Based on the types of vehicles likely to supply materials and personnel to site, the largest vehicle that will regularly use the intersection during construction is likely to be a 19 metre long semi-trailer (Design vehicle). B-doubles of up to 25 metres long may also access the site. This is likely to be infrequent.

The turning path envelope of the above vehicles at the intersection have been run by AutoTURN software. Due to the width of the existing pavement on Logans Lane, the swept path of the left turn movement from the Kamilaroi Highway to Logans Lane cannot fit within the existing intersection pavement.

The intersection of the Kamilaroi Highway and Logans Lane will require upgrading to accommodate large vehicles turning from the Highway onto Logans Lane. Roads and Maritime Services and Narrabri Shire Council would be consulted at the detailed design stage to confirm intersection upgrade design. Details of the proposed intersection upgrade are provided in Section 6.7.4.

Road safety

As outlined in Section 3.3.8 there would be an increase in the number of heavy vehicles on the network during construction of the proposal. These vehicles would access the site via the Kamilaroi Highway and Logans Lane intersection. Sight distances at the intersection are sufficient to allow a vehicle to slow down if a slow moving truck turned onto the highway. With no merging lanes at this intersection however, heavy vehicles entering and exiting the site via this intersection would potentially pose a risk to traffic on the Kamilaroi Highway.

Roads and Maritime Services and Narrabri Shire Council would be consulted prior to construction to determine whether a reduction in speed limits on the Kamilaroi Highway near the intersection would be appropriate. Other measures such as warning signs would be provided on the highway. The consultation would also determine requirements for additional traffic safety measures, including public transport such as school bus stops.

Road condition

The increase in vehicle movements on the surrounding road network has the potential to impact on the condition of these roads. The Newell Highway and Kamilaroi Highway are both sealed and are both considered suitable to accommodate the proposed construction traffic. The proposal would involve upgrading Logans Road to provide all weather access to the site.

Pre- and post-construction condition surveys would be undertaken to determine whether construction of the proposal has caused the sections of these roads in the vicinity of the site to deteriorate. Any damage attributed to the proposal would be rectified.

Access to surrounding properties

The proposal is unlikely to impact on access to surrounding properties. During the upgrade of Logans Road, access along the road would be maintained at all times. Works would be staged to avoid the need to fully close the road for any extended period of time. Temporary partial closures would be required.

Where works are required in the vicinity of a property access, such as during the upgrade of Logans Road, potentially affected property owners would be consulted to discuss their access requirements. If closures are required, consultation would be undertaken with affected landowners to notify them of the proposed closures and to organise any alternate access.

Operation

During operation, the proposal would not impact on the operation of the surrounding road network. Vehicle numbers would be low and limited to those associated with maintenance activities, which would occur infrequently.

6.7.4 Safeguards and mitigation measures

Intersection treatment

The intersection of the Kamilaroi Highway and Logans Lane will require upgrading to accommodate large vehicles turning from the Highway onto Logans Lane. Roads and Maritime Services and Narrabri Shire Council would be consulted at the detailed design stage to confirm intersection upgrade design. The proposed intersection treatment is the BAR treatment as shown in the following illustration.

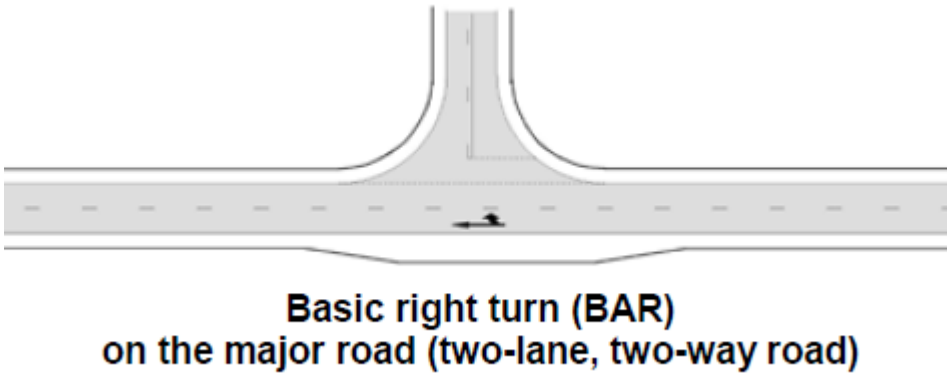


Figure 6-25 Proposed intersection treatment

Speed limit on the Kamilaroi Highway during construction

A potential reduction of the posted speed limit on the Kamilaroi Highway to the west of the intersection with Logans Lane would be discussed with RMS prior to construction commencing. The potential reduction in the speed limit from 100 km/h to 80 km/h would apply only during the construction period to improve the safety of the intersection when in use by trucks delivering equipment and construction equipment.

Management Measures

Safeguards and management measures provided in Table 6-45 would be implemented to minimise potential traffic and access impacts.

Table 6-45 Traffic mitigation measures

Impact	Environmental safeguards	Timing
Construction traffic management	A traffic management plan would be prepared and implemented as part of the CEMP. The plan would be prepared in accordance with any Roads and Maritime and Narrabri Shire Council requirements. The plan would include but not be limited to: • Details of the haulage routes for the proposal • Measures to maintain access along roads and to properties • Site specific control measures (including signage) to manage and regulate traffic movements • Requirements and methods to consult and inform the community of changes to the road network • A response plan for any traffic incident • Mechanisms to monitor the results of the plan and any subsequent reviews and revisions • Outline timing of deliveries and site access • Consideration of carpooling/shuttle bus arrangements to minimise the number of vehicles accessing the site each day	Construction Decommissioning
	Signage on Kamilaroi Highway to be erected to alert drivers of trucks entering and exiting Logans Road.	Construction Decommissioning
	Access along Logans Road is to be maintained.	Construction
	Upgrade the intersection of the Kamilaroi Highway and Logans Lane to a BAR type intersection.	Construction Decommissioning

Impact	Environmental safeguards	Timing
	Temporarily reduce speed limits to the west of the intersection of the Kamilaroi Highway and Logans Lane from 100 km/h to 80 km/h.	Construction Decommissioning
Upgrades to roads	ENGIE would consult with Narrabri Shire Council during detailed design in regard to the proposed upgrades to Logans Road. The works will be undertaken in accordance with Council requirements.	Detailed design
	Notification to affected landowners would be undertaken for any works located along Logans Road, particularly if temporary closures would be required.	Construction
Access impacts	Consultation with any properties where access would be impacted would be undertaken to determine whether additional measures are required to maintain access.	Construction
Impacts to existing roads	Condition surveys would be undertaken prior to the construction commencing. Following construction, surveys would confirm if any damage attributed to the proposal has occurred. Should damage be identified (outside of normal wear and tear), repair works would be undertaken by ENGIE (or its contractor) in line with any relevant council requirements.	Pre-construction Post-construction Decommissioning

6.8 Hydrology, groundwater and water quality

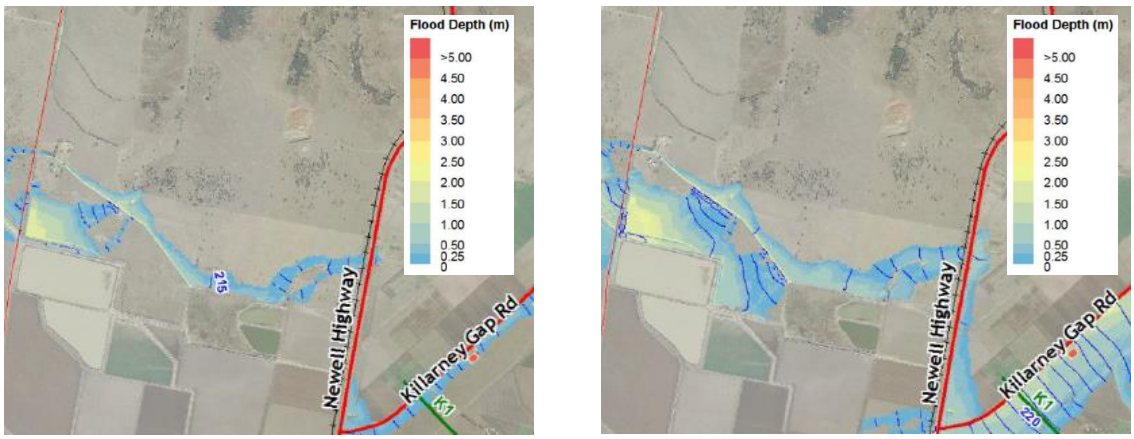
6.8.1 Existing environment

Hydrology

The site is located within the Spring Creek catchment, a tributary of Narrabri Creek which is part of the Namoi River system. The proposal site includes a number of constructed drains that receive flows from the upper catchment area to the east via a culvert under the Newell Highway, as well as intercepting local surface water runoff. These drains direct flows towards a series of farm dams, used for agricultural purposes, before continuing westwards into Spring Creek. The drainage system is ephemeral, with flows only observed following large or prolonged rainfall events.

The proposal site also includes a number of small farm dams, currently used for stock watering. These dams intercept runoff generated by the local catchment, and would overtop during larger rainfall events.

The Narrabri Flood Study (WRM 2016) indicates that parts of the proposal site are affected by flooding for the 20% annual exceedance probability (AEP) event. Figure 6-26 shows flood depths for the 20% AEP and the 1% AEP events. The flood affected areas are generally limited to the central drain and the south-western corner of the site where flood water collects behind an existing dam wall, creating an area of ponding. Outside of these areas, flood depths are generally less than about 0.5 metres during the 20% AEP event. The flood study indicates that the modelled flood depths do not substantially increase for the 1% AEP flood event, with depths typically around 0.5 metres outside of the principal ponding areas, albeit over a slightly increased affectation area.



(a) Local 20% AEP flood event

(b) Local 1% AEP flood event

Figure 6-26 Flood depths (WRM 2016)

Water quality

Due to the ephemeral nature of the constructed drain, no water quality data has been collected. However, the NSW Department of Primary Industries – Lands and Water maintains a monitoring station on the Namoi River at Mollee (station number 419039), about four kilometres west and downstream of the proposal site. This monitoring station recorded salinity (as electrical conductivity: EC) and turbidity within the river from June 2012 to July 2015. A summary of the recorded salinity and turbidity is included in Table 6-46, whilst a summary of the monthly variation in water quality is included in Figure 6-27.

The data suggests that salinity levels within the Namoi River vary seasonally, with levels typically higher during winter (Figure 6-27), frequently exceeding the default water quality trigger for NSW aquatic ecosystems, but consistently below the threshold for stock watering (ANZECC 2000). Turbidity levels are more varied throughout the year, with no clear seasonal variation, but frequently exceed the default trigger value for NSW aquatic ecosystems (ANZECC 2000).

Table 6-46 Water quality data summary – Namoi River at Mollee (419039)

Metric	Trigger [A]	Average	Median	Maximum
Salinity	350 µS/cm [A] 6000 µS/cm [B]	484 µS/cm	453 µS/cm	982 µS/cm
Turbidity	25 NTU [A]	355 NTU	160 NTU	2062 NTU

Source: www.bom.gov.au/waterdata

[A] Default trigger value for aquatic ecosystems in NSW rivers, as per ANZECC (2000) Table 3.3.3.

[B] Default trigger value for beef cattle as per ANZECC (2000) Table 4.3.1.

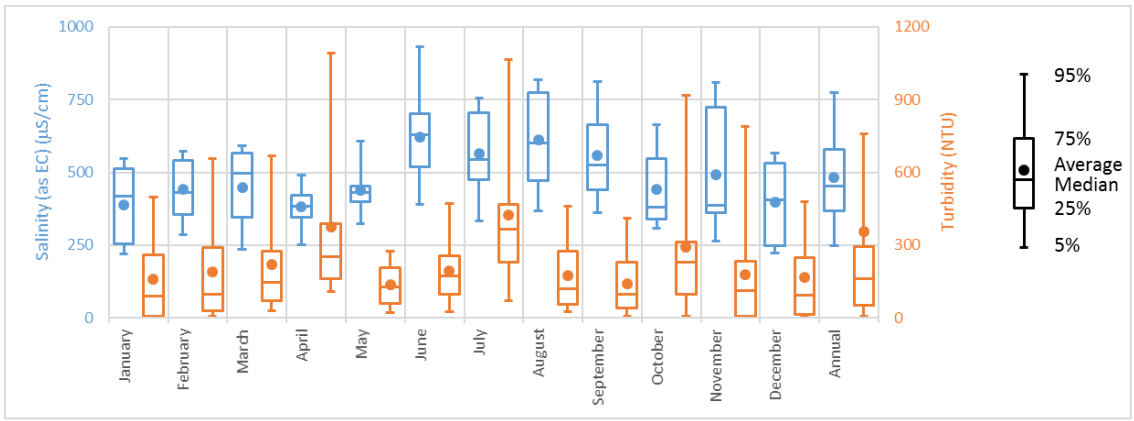


Figure 6-27 Monthly water quality variability

Groundwater

The Namoi catchment in the vicinity of the proposal site has two hydrogeological units that are relevant to the proposal site (Golder, 2018). These are:

- The Pilliga Sandstone which underlies the site and is a significant aquifer in NSW. Groundwater bearing zones are typically encountered at depths between 20 and 40 metres, and to depths greater than 200 metres.
- The alluvial sediments along the alignment of the Namoi paleochannel which locally comprises the sands, silts, clays and gravels along the low lying river valleys and floodplains immediately to the south and further to the west of the proposal site. Groundwater bearing zones are typically encountered at depths between five and 10 metres, and to depths greater than 200 metres.

Groundwater in the Pilliga Sandstone is managed and regulated under two water sharing plans:

- The *NSW Great Artesian Basin Shallow Groundwater* Water Sharing Plan – for groundwater at depths of less than 60 metres
- The *NSW Great Artesian Basin Groundwater* Water Sharing Plan – for groundwater at depths of greater than 60 metres

Groundwater in both the Upper and Lower Namoi Alluvium Groundwater Management Units immediately to the south of the proposal site is managed under two water sharing plans:

- The *Namoi Unregulated and Alluvial Sources* plan
- The *Upper and Lower Namoi Groundwater* plan

Groundwater recharge

Recharge of the unconfined aquifers in the Pilliga Sandstone is likely to occur by several mechanisms including:

- Infiltration of excess rainfall
- Irrigation and other on-farm water losses, in particular where water is drawn from the deeper confined aquifers in the Pilliga Sandstone or from nearby alluvial aquifers
- Upward leakage of groundwater from the underlying aquifers

Recharge to the alluvial aquifers to the south and west of the site is likely to occur via:

- Leakage from the nearby Namoi River and its tributaries, particularly during flooding events
- Rainfall infiltration
- Irrigation
- Flows from surrounding aquifers
- Upward leakage of groundwater from the underlying aquifers

Irrigation is thought to constitute a significant component of recharge for the alluvial aquifers. In some areas it is thought to be a major contributor to rising groundwater levels and salinity.

Groundwater discharge

Discharge of groundwater from the Pilliga Sandstone is expected to primarily occur in "upwelling" areas along the boundary of the Great Artesian Basin. Discharge is likely to flow to the overlying alluvial aquifers to the south of the proposal site. Other discharges includes pumping for irrigation, commercial, stock and domestic purposes.

Groundwater discharge from the alluvial aquifers is likely to be directed to the Namoi River or deeper alluvial aquifers below. Other discharges include pumping for irrigation, commercial, stock and domestic purposes.

Groundwater quality

Groundwater in the Pilliga Sandstone is likely to have total dissolved solids (TDS) contents of between 500 and 1,500 mg/L and is suitable for domestic, stock and some irrigation purposes. Groundwater in the alluvial aquifer is likely to have TDS contents of less than 500 mg/L and is therefore suitable for stock, domestic, municipal supply and most irrigation purposes.

No occurrences of brackish or saline water have been recorded for bores drilled within five kilometres of the proposal site. Some recordings of brackish and saline water have occurred approximately 100 km to the southeast of Narrabri. Groundwater salinity generally increases away from the main recharge areas to the east of Narrabri, ultimately becoming super-saline in and around the town of Walgett, approximately 160 km to the west.

Welsh et al. (2014), as noted on the Australian Government Bioregional Assessment website (Golder, 2018), state that recent groundwater levels and geochemical sampling of alluvial groundwater in the Lower Namoi catchment indicates:

- Groundwater levels downstream of Narrabri have declined between 1.5 and four metres since the late 1970s.
- Chloride and sodium are the dominant anion and cation in all alluvial aquifers.
- The beneficial use of groundwater has deteriorated at some bores in the Narrabri Formation so that some are no longer suitable for stock, in the Gunnedah Formation so that some are no longer suitable for some crops including cotton, and the Cubbaroo Formation so that some are no longer suitable for some crops including cotton.
- Some Gunnedah Formation bores showed a long-term increasing trend in salinity.

Registered boreholes near the proposal site

A search of the Department of Primary Industries – Water groundwater monitoring data (DPI Water 2016) was undertaken on the 20 April 2018. Four bores were located within the proposal site with another two located within 500 metres of the proposal site boundary. Where feasible, access to existing groundwater wells would be made available during operation. This would be determined during the detailed design. Table 6-47 provides an overview of the existing bores which are located in the vicinity of the proposal. Groundwater at the site is greater than five metres below the ground surface.

Table 6-47 Existing boreholes located in the vicinity of the proposal site

Borehole	Use of bore	Location in relation to site	Depth to standing water
GW012154	Stock	500 metres south of the northernmost boundary. East side of road.	6.90 metres
GW966867	Stock, domestic	60 metres north of the dwelling on the westernmost boundary	No data available

Borehole	Use of bore	Location in relation to site	Depth to standing water
GW067438	Stock, domestic	250 metres west of easternmost boundary near the south-eastern dwelling	No data available
GW053461	Stock, domestic, irrigation	200 metres west of easternmost boundary near the south-eastern dwelling	No data available
GW012129	Irrigation	400 metres south of the south-eastern dwelling	7.30 metres
GW012113	Stock, domestic, irrigation	500 metres south of the south-eastern dwelling	5.50 metres

6.8.2 Potential impacts

Construction and decommissioning

Hydrology

The existing central drain within the proposal site would be retained during construction. Works within the drain will be minimised during construction, and limited to the establishment of formal crossing points which would be retained for the life of the proposal. As the central drain is the primary point of discharge from the proposal site, the retention of this drain during construction would minimise the changes to flow paths, therefore minimising the potential for downstream impacts.

The proposal involves filling the majority of dams, as they will not be required for stock or watering purposes during the operation of the proposal. Given the relatively small capacity of the existing farm dams, it is reasonable to expect that they would be full, or partially full, in conditions other than drought. Therefore, the potential changes to flood flows as a result of the removal of the dams would be minor, as major storm events would cause these small dams to overtop.

The removal of these dams has the potential to result in a small increase in total discharge volumes from the site, largely as a result of smaller rainfall events no longer being intercepted and stored by the dams. This increase would not result in appreciable changes in the flood response downstream of the site. Some of the existing farm dams may be temporarily retained to provide construction water (for dust control) or sediment control (as sediment dams). The retained dams would be removed and rehabilitated when no longer required for construction purposes.

The proposal would increase the area of impermeable surfaces on site due to the amenities building, car parking area, substation, and access tracks. This has the potential to increase run-off which in turn can increase erosion and sedimentation impacts. Local controls, such as stormwater management systems, rainwater harvesting if feasible, and erosion and scour protection measures, would be considered during the detailed design stage to minimise the potential impacts associated with these hardstand areas. Given the relatively small extent of the proposed impermeable areas (less than one per cent of the total site area), the likely increase in runoff volumes would be minor.

Water use

The proposal would require water throughout the construction period (and decommissioning), primarily for dust suppression and revegetation. It is estimated that up to 20 kilolitres of water would be required per day of construction. Some water may be sourced from the existing farm dams, with supplementary water sourced from a town supply such as Narrabri under a commercial arrangement.

Water quality

Construction activities would disturb soils, which would increase the risk of erosion during rainfall events. During construction this has the potential to impact on water quality of site discharges. The erosion and displacement of disturbed soils has the potential to impact on water quality in downstream areas and increase sedimentation in receiving watercourses. There is also the potential for spills and leaks of chemicals from construction equipment. These could potentially impact on water quality in downstream watercourses.

Activities which have the potential to impact water quality include:

- Clearance of vegetation on site
- Excavations required for the levelling of the site for predominately the substation, sheds, car park areas and the office building
- Installation of the support piers for the solar panels
- Trenching for underground cables routes
- Preparation of land for the construction access tracks
- Installation of poles for the transmission line
- Works associated the upgrade of Logans Lane

Although the proposal would disturb soils, the extent of this disturbance would be minor. There would be minimal earthworks, and installation would require minor cut and fill activities. The solar arrays would be installed on supports that are screwed or driven into the ground. Trenching would be required for the installation of underground cables. These trenches would be backfilled, and compacted to match adjacent levels.

Groundwater

Groundwater at the proposal site is greater than five metres below surface level. The installation of the panel support piers would involve screwing or piling to a depth no greater than two metres. These installation would not intercept or interfere with groundwater.

The construction of the transmission line would involve installing poles up to seven metres deep. There is a potential for the foundations for these poles to intercept the local groundwater table. The volume of groundwater to be displaced during construction of the transmission line poles is expected to be minimal. An approval from the NSW Department of Industry (Water) would be sought in the event that dewatering is required which exceeds three mega litres per year.

Operation

Water use

The proposal is expected to use about 2.5 mega litres of water per year to clean the solar arrays as part of maintenance activities. Rainfall is generally sufficient to clean the solar arrays, and therefore the volume of water required for cleaning is dependent on annual rainfall. A small volume of water would also be required for the amenities building. All water requirements beyond what can be supplied by site water harvesting would be sourced from a town supply such as Narrabri (under a commercial arrangement) and would be trucked to site.

Water quality

Water quality impacts during operation would be minimal. Runoff from the site would continue to follow the existing drainage patterns to ephemeral waterways.

Maintenance activities at the proposal site could potentially result in spills and leaks from equipment or vehicles. Due the infrequent nature of such works, and the implementation of safeguards and mitigation measures, impacts would be minor.

Groundwater

Due to the depth of groundwater at the proposal site, groundwater would not be impacted during operation of the proposal.

6.8.3 Safeguards and mitigation measures

Safeguards and management measures provided in Table 6-48 would be implemented to minimise potential hydrology and water quality impacts.

Table 6-48 Hydrology and water quality management measures

Impact	Environmental safeguards	Timing
General	An Erosion and Sediment Control Plan (ESCP) shall be prepared as part of the CEMP. All erosion and sediment control measures shall be designed, implemented and maintained in accordance with relevant sections of "*Managing Urban Stormwater: Soil and Construction Volume 1*" (Landcom, 2004) ('the Blue Book) (particularly Section 2.2) and "*Managing Urban Stormwater: Soil and Construction Volume 2A – Installation of Services*" (DECC, 2008)". The ESCP shall include stockpiles, stormwater run-off, trees, site boundaries, site access and storage areas.	Pre-construction Construction
	The Department of Primary Industries – Water controlled activity guidelines would be considered as part of the detailed design of the proposal.	Pre-construction Construction
	The provision of sedimentation basins on site would be considered in the detailed design. This could involve converting existing farm dams into basins for the duration of the construction period.	Construction
Rehabilitation	Rehabilitation works are to commence as soon as practicable to stabilise the land surface after works are completed in any area.	Construction

Impact	Environmental safeguards	Timing
Contamination of surface water	All fuels, chemicals, and liquids will be stored at least 50 metres away from waterways and will be stored in an impervious bunded area within the compound site.	Construction
	The refuelling of plant and maintenance of machinery will be undertaken in impervious bunded areas in the compound site.	Construction
	Vehicle wash downs and/or concrete truck washouts will be carried out within a designated bunded area on an impervious surface or carried out off-site.	Construction
	Machinery would be checked daily to ensure there is no oil, fuel or other liquids leaking from the machinery. All staff would be appropriately trained through toolbox talks for the minimisation and management of accidental spills.	Construction
Spills and leaks	A site specific emergency spill plan would be developed, and include spill management measures in accordance relevant EPA guidelines. The plan would address measures to be implemented in the event of a spill, including initial response and containment, notification of emergency services and relevant authorities (including Roads and Maritime and EPA officers).	Construction
	An emergency spill kit would be kept on site at all times. All staff will be made aware of the location of the spill kit and trained in its use.	Construction

6.9 Hazards and risk

Methodology

A preliminary screening was completed to determine if the proposal is “Potentially Hazardous” in accordance with the requirements of *State Environment Planning Policy No. 33 - Hazardous and Offensive Development* (SEPP 33). SEPP 33 presents a systematic approach to planning and assessing proposals for potentially hazardous and offensive development for the purpose of industry or storage. SEPP 33 applies to any proposals which fall under the policy’s definition of ‘potentially hazardous industry’.

The risk screening and hazard analysis was completed to determine whether a preliminary hazard analysis (PHA) is required. The screening assessment has found that there will be no appreciable quantities of dangerous goods stored at site for the operation of this project.

The risk screening process concentrates on the storage of specific dangerous goods classes that have the potential for significant offsite effects. Specifically, the assessment involves the identification of classes and quantities of all dangerous goods (DG) to be used, stored or produced on site with an indication of storage locations.

The aim of the hazard identification and risk screening process is to highlight any risks associated with the interaction of the facility, as a whole, with the surrounding environment. It is a systematic process to document all possible events that could lead to a hazardous incident.

Figure 6-28 details the SEPP 33 risk screening process.

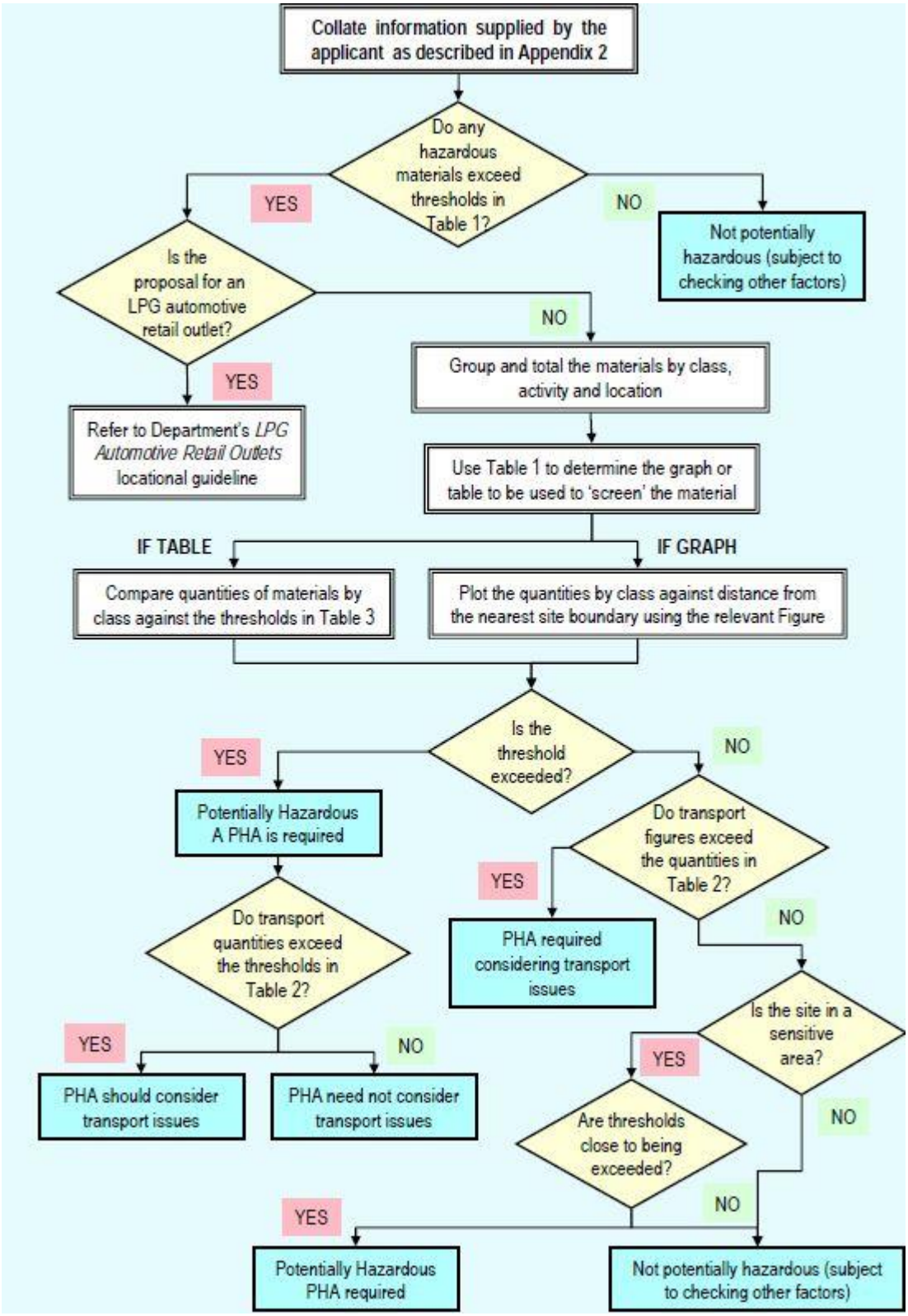


Figure 6-28 SEPP 33 Risk Screening Process

6.9.1 Potential impacts

A summary of the quantities of goods that could potentially be classed as dangerous goods (DG) that would be handled and/or stored on-site are shown in Table 6-49. Details of other goods that may be stored on site are provided in Table 6-50.

Table 6-49 Summary of dangerous goods handled/on site

Chemical/product	DG Class	UN #	Maximum storage quantity	Exceedance of SEPP 33 Threshold
Naphthenic Transformer Oil	Not DG	N/A	140 mVA transformer (45,000 L at 850 kg/m^3) 38,250 kg	Does not exceed SEPP 33 threshold as it is not classed as a DG

Table 6-50 Other goods stored on site

Chemical/product	Comment
Petrol or diesel (i.e. fuel for vehicles etc.)	The site is located 5 km from Narrabri – there is no requirement for storage of fuels on site as vehicles will refuel in Narrabri.
Natural gas pipelines	No gas pipelines on-site, or nearby.
Cleaning chemicals for Solar Cells	It is proposed that water only will be used to clean the panels. Cleaning of the panels will be undertaken by contractors and therefore the storage of any chemicals (if required under special circumstances) is not required on-site.
Toxic and flammable gases (e.g. for operations and maintenance)	Not used on-site.
Toxic chemicals (e.g. for weed and plant control)	Maintenance of vegetation (i.e. mowing, weed spraying) will be undertaken by contractors and therefore the storage of these goods is not required on-site.
Electrical Cleaning and maintenance compounds	Only brought to site as required for maintenance.

Battery storage is to be considered at the proposal site in the future. It does not form part of this assessment. The potential use of battery energy storage at the proposal site would be assessed under a separate environmental assessment.

Transport

Construction of the proposal would not require the movement of dangerous goods. Heavy vehicles would be required to deliver site equipment. The mitigation measures, as proposed in Section 6.7.4, would minimise the potential impacts associated with delivering equipment to site.

Operation of the proposal would require a small number of traffic movements and occasional heavy vehicle movements. It is expected that up to four operational/maintenance staff will be on-site during the operation of the solar farm. On occasions, heavy vehicles may visit the site for delivery of spare parts, maintenance, removal of waste etc.

There will be no movement of dangerous goods on-site (as there are no goods classified as DG for the proposal development) and therefore, the SEPP33 movement thresholds are not exceeded.

Summary of SEPP 33 screening results

According to SEPP 33, if any of the screening thresholds are exceeded then the proposed development should be considered a 'potentially hazardous industry' and a preliminary hazard analysis (PHA) is required. The results of the dangerous goods and transport screening indicate that the proposal does not exceed any of the thresholds, and a PHA is not required.

6.9.2 Electric and magnetic fields

Electric and magnetic fields, also known as electromagnetic fields, (EMF) are part of the natural environment. Electric fields are present in the atmosphere and static magnetic fields are created by the earth's core. EMF is also produced wherever electricity or electrical equipment is in use. Transmission lines, electrical wiring, household appliances and electrical equipment all produce EMF.

An electric field is the force that fills the space around every electric charge, including any powered electrical appliance or conductor (e.g. transmission line). Electric fields are measured in volts per metre (V/m) or kilovolts per metre (kV/m). They occur both naturally and as a result of power generation, and are produced every time voltage runs through a wire. The higher the voltage, the stronger the electric field. Electric fields are strongest closest to the wires and the level reduces quickly with distance. Most materials act as a shield or barrier to electric fields.

In Australia, transmission lines and other electrical devices and infrastructure, including substations, operate at a frequency of 50 hertz. This frequency falls within the Extremely Low Frequency (ELF) range of 0 to 300 hertz.

Regulation and guidelines

Fields of different frequencies interact with the human body in different ways. The scientific literature on EMF exposure is extensive, complex and inconclusive. In addressing the question of adverse health effects, electricity authorities in NSW rely on expert advice on EMF from competent health authorities in Australia and from around the world. This includes the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), which is the Federal Government agency responsible for providing health assessments and recommendations to the Government on matters relating to EMF.

ARPANSA has adopted the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to EMF, published in 2010. The ICNIRP Guidelines express limits in terms of 'Reference Levels' and 'Basic Restrictions' under general public and occupational exposure conditions.

The Reference Level is based on the minimum levels at which adverse health effects can be caused by the lowest radiofrequency exposure levels. These levels are based on worst-case modelling and are extremely conservative. They are used to assess compliance with the ICNIRP Guidelines and compliment the protection provided by the Basic Restrictions.

The Basic Restrictions are safety levels designed to limit potentially negative health effects from the exposure to EMF. The Basic Restriction values are expressed as the internal electric fields which can be induced in the body without adverse health outcomes. As the Basic Restriction values apply within body tissue, it is difficult and impractical to measure them. For that reason, Reference Levels, which are simpler to measure, are provided as an alternative means of showing compliance with the Basic Restrictions. If a desktop study and/or direct field measurements show that the EMF is below the Reference Levels, the EMF is well within the Basic Restrictions. The reference levels may be exceeded if it can be demonstrated that the Basic Restrictions are still met.

Australia does not currently have a standard regulating exposure to extremely low frequency electric or magnetic fields. ARPANSA refers to the limits in the National Health and Medical Research Council's (NHMRC) Interim guidelines on limits of exposure to 50/60 hertz electric and magnetic fields (1989). A summary the Reference Levels of these Interim guidelines is provided in Table 6-51.

Table 6-51 Summary of the interim guidelines on limits of exposure

Exposure characteristics	Electric field strength (volts per metre – V/m)	Magnetic flux density (microteslas - µT)
Occupational		
Whole working day	10,000	500
Short term	30,000	5,000
General public		
Up to 24 hours per day	5,000	100
A few hours per day	10,000	1,000

Potential impacts

Construction and decommissioning

The possibility of an onsite fire propagating to an offsite fire during operation is the only credible scenario with a potential offsite impact. The likelihood of an onsite fire however is low due to the nature of the facility. Whilst there is potential for transformer fires, the likelihood is very low. This is not considered to be an offsite risk in terms of immediate harm or safety to personnel.

There would be limited exposure to EMF during construction. The only sources of EMF would be the existing transmission lines, the proposed transmission line and the substation. The magnetic field exposure of the existing transmission line and proposed transmission line would be under the limits outlined in Table 6-51 for occupational and public exposure.

Workers would not work in close vicinity to the existing transmission line for an extended period of time. The proposed solar arrays would not be installed within this transmission line easement. Installation of the proposed transmission line would be completed by industry accredited technicians, trained in the safe installation of transmission infrastructure.

Workers would be in close vicinity to the Narrabri substation for a short period of time during construction works, connecting the transmission line with the proposed site substation. These works are unlikely to present a health risk to workers, who would follow industry standards, and health and safety guidelines for installation of electrical infrastructure.

Operation

During operation of the proposal the following sources of EMF would be present:

- Proposed on-site substation
- Existing TransGrid Narrabri Substation
- Existing subtransmission line
- Solar arrays including associated cabling
- Proposed transmission line

Solar farm

The main source of EMF would be the proposed on-site substation. The layout of the substation and the selection of equipment, to be confirmed during detailed design and, would be in line with the design of similar substations throughout Australia. The principles of prudent avoidance would be implemented. Careful positioning and selection of equipment would result in exposure levels at the boundary of the substation being similar to existing background levels. Fencing around the substation (and wider site) would restrict access. Members of the public would be at negligible risk of exposure from the substation. Access to the substation would only be available to suitably trained workers.

The other items of electrical equipment to be located on site would generate magnetic fields. Due to the substantial distance to the nearest sensitive receivers, the proposal would comfortably comply with limits for both public and occupational exposure. Security fencing to be erected around the site would prevent access to the site by members of the public, limiting public exposure.

Transmission lines

Magnetic fields in the immediate vicinity of high voltage transmission lines (132 kV to 500 kV) are typically (TransGrid 2018):

- 1-20 microteslas directly under the transmission line
- 0.5-20 microteslas directly above an underground transmission line
- 0.2-5 microteslas at the edge of the easement (typically 22.5 to 35 metres from the centre line)

These magnetic fields are well below the levels contained within the interim guidelines on limits of exposure (see Table 6-51). The overhead transmission line would have an easement width of around 30 metres. Houses, buildings and other substantial constructions would be prohibited within the proposed easement. The transmission line would operate in the same way as existing power lines in the area and would present a minimal EMF risk to the general public or workers.

6.9.3 Safeguards and mitigation measures

Safeguards and management measures provided in Table 6-52 would be implemented to minimise potential EMF impacts.

Table 6-52 EMF mitigation measures

Impact	Environmental safeguards	Timing
Offsite risks	Siting of key components would minimise any current or future offsite risk. The majority of the hazards identified are considered onsite risks, and are not considered offsite risks.	Detailed design
EMF	Design and selection of all electrical equipment is to minimise EMF levels and comply with the ICNIRP exposure levels.	Construction
	Monitoring of electromagnetic levels would be undertaken during the commissioning of the substation to confirm exposure levels. Should levels be above the ICNIRP exposure levels the potential need for further mitigation would be considered.	Commissioning

6.10 Bushfire

6.10.1 Existing environment

The proposal site is agricultural land and historical land uses have cleared vegetation from the majority of the site. A search of the NSW Rural Fire Service Bushfire Prone Land Mapping Tool determined that the proposal site and the transmission corridor are not identified as bushfire prone land. Due to the lack of vegetation at the proposal site, the bushfire risk is low.

The proposal site is predominantly grassland which at times can be dry, and although it is not mapped as bushfire prone land, there is a risk of grass fires. The nearest bush fire prone land is approximately three kilometres from any of the proposed works.

Existing bushfire hazards

There is limited vegetation located on the site, comprised of mostly grassland. The grass can be dry, particularly in times of drought, and although not mapped as bush fire prone, there is a risk of bushfire.

The proposal site is most at risk to fire if adjoining land is ignited and fire spreads. The majority of surrounding land is used for agriculture, similar to that of the proposal site. The highest risk of an ignition source would come from the road and rail corridors along the eastern boundary. Some of the main hazards with the potential to result in a fire include car accidents and the incorrect disposal of cigarettes and other rubbish from vehicles, or sparks from trains along the railway line.

The existing transmission line in the southern section of the proposal site also represents a potential ignition source. This risk is considered to be relatively minor as there is limited vegetation in close proximity to the transmission line and the likelihood of arcing between the line and grassland is limited. The vegetation within the corridor is currently managed by TransGrid in accordance with standard procedures to maintain safe electrical and operational clearances between vegetation and the conductors.

As the proposal site is located within the Narrabri Shire local government area it is within the Castlereagh Bush Fire Management Committee Area. The Narrabri/Moree Bush Fire Risk Management Plan (Narrabri/Moree Bush Fire Management Committee 2013) states that the main sources of fires in the area are:

- Lightning
- Escape from legal burns
- Farm machinery
- Incendiaries

6.10.2 Potential impacts

Construction and decommissioning

Construction of the proposal has the potential to increase the risk of fires due to:

- Hot works, such as welding, resulting in ignition of surrounding vegetation
- Equipment or vehicles being used in long grass
- Construction workers smoking or rubbish left at the site
- Storage of combustible materials and liquids on site

These activities have the potential to ignite a bushfire which could have an impact on the proposal site, the transmission line corridor and potentially spread to surrounding areas. Overall, bushfire risks during the construction and decommissioning phases are considered to be low and would be managed by implementing mitigation measures detailed in Table 6-53.

Operation

Operation of the proposal is unlikely to result in any substantial additional bushfire risks. The proposal would not result in any substantial sources of ignition. Potential risks would be managed in the detailed design stage. Further mitigation measures are provided in Table 6-53.

Maintenance activities have the potential to result in ignition if hot works, such as welding, are required. These impacts are considered to be unlikely as hot works would be required infrequently. A bushfire management plan would be implemented to minimise potential risks. Maintenance of the site would ensure that groundcover below the solar arrays is appropriately manage to minimise build-up of fuel for bushfires.

Transmission Line

The installation of the proposed transmission line would involve the use of heavy machinery, together with light vehicles. There is a risk of the machinery and vehicles igniting long grass or vegetation.

The design, installation and operation of the transmission line would be undertaken in accordance with TransGrid operation requirements. TransGrid's safety and management procedures include assessing and managing the risk of ignition sources from electricity lines. The risk from ignition from the transmission line would be managed by implementing standard operating procedures, such as vegetation clearing and trimming that are required to be implemented under the *Electricity Supply Act 1995*.

6.10.3 Safeguards and mitigation measures

Safeguards and management measures provided in Table 6-53 would be implemented to minimise potential impacts.

Table 6-53 Bushfire management measures

Impact	Environmental safeguards	Timing
Bushfire management	A bushfire management plan would be prepared in consultation with the Rural Fire Service. This plan would include but not limited to the following: • Management of activities with a risk of fire ignition • Management of fuel loads onsite • Storage and maintenance of firefighting equipment including siting and provision of adequate water supplies • The below requirements of Planning for Bush Fire Protection 2006: – Identifying asset protection zones – Providing adequate egress/access to the site – Emergency evacuation measures • Operational procedures relating to mitigation and suppression of bush fire relevant to the operation of a solar farm	Detail design (develop in line with design to ensure design includes provisions for bushfires) Construction Operation

6.11 Socio-economic impacts

6.11.1 Existing environment

The proposal is located within a rural area within the Narrabri LGA. Narrabri Township is located approximately four kilometres south of the proposal site. The 2016 Census Data (Australian Bureau of Statistics) was used to gather information on the demographic overview of Narrabri. Key features are shown in Table 6-54.

Table 6-54 Locality statistic for Narrabri LGA

Statistic	Narrabri
Population	13,084
Gender split	49.9% male: 50.1% female
Average age	40
Full-time work	60.6%
Major employment source	Coal mining, grain and cotton growing, education and grocery stores.

Employment

Narrabri is a large locality with a town centre, surrounded by residential development, and a collection of rural-residential properties surrounding the town. Narrabri is the main administrative centre for the broader LGA and supports a range of employment including retail trade, health care and social assistance, education and training, construction, and accommodation and food services.

Table 6-55 summarises employment for the Narrabri LGA. The agriculture, forestry and fishing industry accounts for the second largest proportion (17%) of those employed in the local economy, after mining (19%).

Table 6-55 Employment by occupation in Narrabri LGA (2016 Census)

	Total number	% of total
Agriculture, forestry and fishing	1,033	17%
Mining	1,124	19%
Manufacturing	160	3%
Electricity, gas, water and waste services	67	1%
Construction	269	4%
Wholesale trade	154	3%
Retail trade	498	8%
Accommodation and food services	370	6%
Transport, postal and warehousing	250	4%
Information media and telecommunications	30	0%
Financial and insurance services	59	1%
Rental, hiring and real estate services	46	1%
Professional, scientific and technical services	259	4%
Administrative and support services	161	3%
Public administration and safety	279	5%
Education and training	407	7%
Health care and social assistance	581	10%
Arts and recreation services	30	0%
Other services	249	4%

6.11.2 Potential impacts

Construction and decommissioning

The proposal is expected to employ a maximum of 120 personnel during the peak construction period. This work force would be sourced from the local region including the towns of Narrabri and surrounding areas where possible. If workers from outside the region are required they may temporarily relocate to the area. This would stimulate the local economy through accommodation and retail expenditure. This increase in employment would benefit the region for the 12 month construction period.

An increase in population could also produce an increased demand for local services. As the workforce would be sourced from the local region where possible, the demand is not considered to be substantial to the point where services would be strained. Workers would not have access to any properties other than the proposal site, unless arranged with the landowner.

Operation

Operation of the proposal would require small numbers of staff to attend site for maintenance purposes. This would produce only a minor increase in full-time jobs as the proposal would largely be operated remotely.

The operational of the proposal would reduce the ability of the land to be used for agricultural purposes, which provides an economic benefit for the landowner. As outlined in Section 6.6.2, the land is estimated to have a gross production potential of $250,000. The proposal would remove this source of income for the landowner. However, as the property owner is to be provided with rental income for the use of the site, the loss of grazing income would be offset by rental.

There is potential for grazing to continue on the site as this practice is used at other solar farms to control vegetation below the solar arrays. A decision to graze within the site would be undertaken following consultation with the landowner. If grazing is allowed, the abovementioned impacts of removing income from agricultural production would be reduced.

One potential concern for surrounding land owners is that the proposal may decrease land values in the vicinity. Any impact on property values from a particular project is difficult to determine because there are natural changes in the value of property due to other outside factors. These factors include demand, and in the case of agricultural land, climatic conditions.

Studies (Urbis 2016 and Jones *et al* 2014) have been undertaken around the world for both solar farms and other renewable energy farms such as wind farms. Both studies suggest that the operation of renewable energy projects cannot be directly linked to decreases in property values. With the implementation of mitigation measures, in particular the establishment of screening vegetation to mitigate the proposal's potential visual impact, the main potential impact to adjacent properties, would be minimised.

The proposal would not produce off-site amenity based impacts such as air quality, water quality, noise, or traffic that would be likely to adversely affect nearby property values.

Benefits

The establishment of the proposal, in conjunction with other similar renewable energy projects, would contribute to the reduction in dependence on non-renewable power generation such as coal. This would contribute to a reduction in the generation of greenhouse gases.

Global warming scenarios predict that temperatures would increase in western NSW and water availability would decrease. This would potentially impact the region's agricultural land uses which are reliant on rainfall (refer to Section 7.1.1).The reduction in greenhouse gases, and the effects of global warming, would ultimately benefit the local area which heavily relies on agricultural as source of income.

6.11.3 Safeguards and mitigation measures

Safeguards and management measures provided in Table 6-56 would be implemented to minimise potential socio-economic impacts.

Table 6-56 Socio-economic mitigation measures

Impact	Environmental safeguards	Timing
Community consultation	A community consultation plan would be implemented to manage the concerns and impacts on stakeholders including adjacent property owners. The plan would include (but not be limited to) the following: • Protocols to keep the community updated about the progress of the project and its benefits • Protocols to inform relevant stakeholders of potential impacts • Protocols for allow the community to identify any concerns or issues with the project, particularly during construction and decommissioning The plan would be prepared in consultation with Narrabri Shire Council.	Construction

7. Other environmental issues

7.1 Air quality and climate change

7.1.1 Existing environment

Air quality

A search of the National Pollutant Inventory (DotEE 2018) identified that nine facilities in the local area (postcode 2650) emit 35 substances to the atmosphere. Three of these facilities are located within seven kilometres of the proposal site, and include:

- Lowes Petroleum Narrabri depot – mineral, metal and chemical wholesaling
- Boland Petroleum Narrabri depot – mineral, metal and chemical wholesaling
- Cargill Processing Narrabri – oil and fat manufacturing

Other sources of air pollution in the vicinity of the proposal site would be typical of a rural environment and include:

- Dust from vehicles travelling on unsealed roads in particular along Logans Lane, west of the proposal site.
- Emissions from vehicles on local roads, particularly heavy vehicle movements along the Newell Highway and Kamilaroi Highway.
- Emissions from diesel powered freight trains along the eastern boundary of the proposal site. Emissions from this source may increase due to the increase in freight volumes as part of the Inland Rail upgrade by ARTC.
- Dust from agricultural activities.
- Dust from three quarry operations to the south-east of the proposal site.
- Smoke from paddock stubble burn-off in agricultural areas during autumn.

The nearest receivers to the proposal site are:

- A residence approximately 240 metres west of the proposed western boundary.
- Residences located to the east of the Newell Highway, approximately 695 metres to the north-east.
- Residences located to the south of the proposal site on the Kamilaroi Highway.
- Residences located on Bailey Street and Stoney Creek Road to south of the proposed transmission line on Stoney Creek Road.

Climate

Climate data in the vicinity of the proposal site was sourced from a weather station located at Narrabri Bowling Club. These readings are considered to be representative of the proposal site which is located about five kilometres from Narrabri.

Average annual temperatures at the site are 26.7° C for the maximum and 11.6° C for the minimum. The average monthly maximum temperatures range between 35.3° C in January to 17.0° C in July.

Rainfall data is available at the Narrabri Bowling Club. The annual average rainfall is 646 mm with a monthly range of 26.8 mm millimetres in April to 56 mm in February. Overall rainfall is relatively consistent throughout the year, however rainfall is skewed towards the summer months (December, January, and February).

Solar exposure is measured at the Narrabri Bowling Club. This records the amount of solar energy which hits a horizontal surface. The average solar exposure for this station is 19.4 MJ m^{-2} and this is an average across the year (over a number of years). The highest solar exposure occurs in December with 26.8 MJ m^{-2}, while a low of 10.7 MJ m^{-2} is experienced in June.

Climate change

Climate change refers to the warming temperatures and altered climate conditions associated with the concentration of greenhouse gases in the atmosphere. Changes in future climatic conditions have the potential to impact existing and new infrastructure.

In 2014, the NSW Office of Environment and Heritage published climate change projection snapshot reports for the NSW and ACT governments as part of the NSW and ACT Regional Climate Modelling (NARCliM) project. The study focused on projections for two future 20 year time periods: 2020-2039 as the near future and 2060-2079 as the far future. The snapshot included the analysis of over 100 climate variables, including temperature, rainfall and wind.

The projected climatic changes by 2030 (near future) for the New England and North West region of NSW (OEH 2014) include the following:

- Maximum temperatures are projected to increase by 0.4 to 1.0° C.
- Minimum temperatures are projected to increase by 0.5 to 1.0° C.
- The number of hot days will increase and cold night decrease.
- Rainfall is projected to decrease in winter and summer, and increase in autumn and spring.
- The risk of fire is projected to increase during summer.

7.1.2 Potential impacts

Construction and decommissioning

The proposal has the potential to impact on air quality during construction by generating dust from excavation, vegetation clearance, construction vehicles driving over exposed soils or unsealed roads, and wind blowing over stockpiles and exposed surfaces. Dust has the potential to impact on the amenity of those occupying nearby properties. Due to the distance to nearby properties, potential impacts would be minor.

The proposal would require minimal earthworks. The generation of dust from such activities is likely to be limited to the works required for minor levelling of the land, and to install the arrays and associated cabling trenches.

Impacts due to the generation of dust and exhaust emissions would be short term, covering the anticipated construction period of 12 months. Impacts would be relatively minor in nature due to the small number of receptors and their distance from the proposal site. Safeguards and mitigation measures outlined in Section 7.1.3 would be implemented to minimise the scale and duration of impacts.

Potential impacts on air quality would be similar for the decommissioning phase, without activities such as vegetation clearing and earthworks that would occur during construction. Decommissioning phase impacts would be minor. The measures outlined in Section 7.1.3 would be implemented to minimise any air quality impacts during the decommissioning phase.

Operation

Maintenance activities would require predominantly light vehicles to access the site. Occasional site visits by larger vehicles may be required to deliver equipment or spares to the proposal site. The operation of vehicles and equipment would result minor exhaust emissions. As only low numbers of vehicle visits would be required for minor maintenance, emissions from operation of the proposal would be negligible.

The proposal is unlikely to result in any substantial air quality impacts during operation. Maintenance activities of the site have the potential to result in the generation of dust due to vehicle movements over unsealed roads. These activities would occur infrequently and any air quality impacts would be minor and short term. Access tracks would be maintained, and if dust is generated from vehicles during maintenance activities, management measures would be adopted to reduce impacts. Measures may include avoiding driving in windy conditions, or use of water carts.

The proposal would generate electricity from a renewable source. This would reduce the dependence on fossil fuels for the generation of power. The proposal would contribute to reducing greenhouse gas emissions, and assist in meeting Australia's international obligations to reduce greenhouse gas emissions. The proposal would make a positive contribution to reducing the effects of climate change.

7.1.3 Safeguards and mitigation measures

Safeguards and management measures provided in Table 7-1 would be implemented to minimise potential air quality and climate change impacts.

Table 7-1 Air quality mitigation measures

Impact	Environmental safeguards	Timing
General air quality impacts	The CEMP would include measures to minimise impacts on air quality including: • A map identifying locations of sensitive receivers • Identification of potential risks/impacts due to the work/activities as dust generation activities • Management measures to minimise risk including a progressive stabilisation plan • A process for monitoring dust on-site and weather conditions • A process for altering management measures as required • A process of the review of the plan prior to the decommissioning works to ensure it is update at the time of the works occurring	Pre-construction
Dust emissions	Surveillance for visible dust generation would occur at all times.	Construction
	Works that disturb vegetation, soil or stockpiles would not be carried out during strong winds (over 40 km/h) when this may affect receivers (visibility on roads, dust and debris near recreational areas, residences and commercial premises).	Construction
	Stockpiled materials would be covered, stabilised or stored in areas not subject to high wind.	Construction

Impact	Environmental safeguards	Timing
	All trucks would be covered when transporting material to and from the site.	Construction
	Work activities would be reprogrammed if the safeguards and management measures are not adequately restricting dust generation.	Construction
	Maximum speed limits would be enforced for construction traffic within the site to limit dust generation.	Construction
	Use of a water tanker or similar to spray unpaved roads and exposed areas during construction where required.	Construction
Exhaust emissions	Construction plant and equipment would be maintained in a good working condition in order to limit impacts on air quality.	Construction
	Construction equipment, plant and vehicles would be appropriately sized for the task.	Construction
	Equipment would be serviced frequently to ensure they are operating efficiently.	Construction
Impacts on sensitive receivers	Local residents would be advised of hours of operation and duration of work and supplied with a contact name and number for queries or complaints regarding air quality. The CEMP will also include a procedure for handling any queries or complaints.	Construction
Climate change	The use of alternative fuels and power sources for construction plant and equipment would be investigated and implemented, where appropriate.	Construction
	The energy efficiency and related carbon emissions would be considered in the selection of vehicle and plant equipment.	Construction
	Materials would be delivered as full loads and local suppliers will be used where possible.	Construction

7.2 Non-Aboriginal heritage

7.2.1 Methodology

Standard archaeological field survey and recording methods were employed during the site inspection and visual assessment (Burke and Smith 2004). The historic heritage field survey was completed concurrently with the Aboriginal heritage field assessment by OzArk Project Archaeologists, Dr Alyce Cameron and Stephanie Rusden, on Tuesday 23 to Thursday 25 October 2018. The assessment was undertaken using pedestrian transects of four to five surveyors. GPS data was captured via a handheld GPS device equipped with GIS software.

7.2.2 Existing environment

European colonisation of north-central NSW occurred relatively late, as the expansion had halted at Wellington Valley during the 1820s. Land was taken up around Dubbo in the early 1830s and subsequent colonisation beyond Wellington was rapid, tending to follow the major river courses (Heritage Concepts 2009: 49).

The Moree plains area between Narrabri and Moree began to be occupied by pastoralists shortly after Mitchell passed through the area in 1831 and Coxen in 1835. Each reported good pastoral land (NSW Heritage Office and DUAP 1996: 80-81).

Urban development prior to 1850 was very limited. Travellers' accounts indicate that isolated inns were scattered across the landscape, catering to travellers and local recreation. Some of these inns developed into towns like Narrabri, while others were eventually abandoned or burned (NSW Heritage Office and DUAP 1996: 81).

A nearby early pastoral settlement was established at Wee Waa. In 1880, the larger town of Narrabri was established on a water reserve on Narrabri Creek, a tributary of the Namoi River, at an important crossing place on the droving route. By 1871, Narrabri's population was 350 and the town included stores, inns, a bank and school. The railway reached the town in 1882 and Narrabri became an official municipality the following year, when a courthouse was also built (NSW Heritage Office and DUAP 1996: 84).

Database searches

A desktop search was conducted on the following databases to identify any potential previously-recorded heritage within the study area. The results of this search are summarised in Table 7-2.

Table 7-2 Historic heritage: desktop-database search results

Database	Date of Search	Type of Search	Comment
National and Commonwealth Heritage Listings	14/11/2018	Narrabri LGA	The Narrabri Post Office and former Telegraph Office (Place ID 105495): located 930 metres southwest of the study area.
NSW State Heritage Register (SHR)	14/11/2018	Narrabri LGA	The Narrabri Goal and Residence (SHR 00344): located one kilometre southwest of the study area.
Local Environment Plan (LEP) 2012	14/11/2018	Narrabri LGA	Cemetery (I018): located adjacent to the study area (transmission corridor) at the corner of Stoney Creek Road and Old Cemetery Road.

The search did not identify any heritage items on the proposal site, the transmission route corridor or adjoining properties. The Narrabri Old Cemetery located on Stoney Creek Road is listed under the *Narrabri Local Environmental Plan 2012*. This item is not located in the transmission corridor route, but is adjacent to the alignment.

7.2.3 Potential impacts

There are no historic sites within the proposal site. As such, there will be no impact to any historic sites during the proposed works.

No historical sites were recorded during the pedestrian survey. The buildings within the proposal site, in particular the three private houses and associated farm infrastructure, are not of historical age or interest.

There is one heritage item, the Narrabri Old Cemetery (I018) listed on the *Narrabri LEP 2012*, which is adjacent to the transmission line corridor. As the proposed works will not be undertaken on this property, there will be no impact on the cemetery itself.

7.2.4 Safeguards and mitigation measures

Safeguards and mitigation measures are detailed in Table 7-3.

Table 7-3 Non-Aboriginal heritage mitigation measures

Impact	Environmental safeguards	Timing
Unexpected finds	In the event that a site or artefact (as defined by the *Heritage Act 1977*) is identified during construction works, works would cease at the location.	Construction
	The find would be immediately reported to ENGIE, and the regulator (OEH Heritage Division) in accordance with legislation. No work would commence in the vicinity of the find until any required approvals have been given by the regulator.	Construction

7.3 Waste management

7.3.1 Existing environment

Waste generation

The proposal site is used for agricultural purposes and therefore does not generate any substantial waste that requires specific management measures. The only wastes likely to be generated at the site are domestic waste from farm workers and any waste from operation and maintenance of the property (including but not limited to redundant equipment, empty drums or offcuts of fencing wire).

Waste policy

Legal requirements for the management of waste are established under the *Protection of the Environment Operations Act 1997* (POEO Act) and the *Protection of the Environment Operations (Waste) Regulation 2014*. Unlawful transportation and deposition of waste is an offence under Section 143 of the POEO Act.

The *Waste Avoidance and Resource Recovery Act 2001* includes resource management hierarchy principles to encourage the most efficient use of resources and to reduce environmental harm. The proposal's resource management options would be considered against a hierarchy of the following order:

- Avoidance of unnecessary resource consumption
- Resource recovery (including reuse, reprocessing, recycling and energy recovery)
- Disposal

Adopting the above principles would encourage the most efficient use of resources, and reduce costs and environmental harm in accordance with the principles of ecologically sustainable development.

7.3.2 Potential impacts

Construction

Waste that would be generated at the proposal site during construction may include:

- Surplus materials used during site establishment such as safety fencing and barriers which may include plastics and metal. The volume of waste would be minimal as mostly prefabricated structures would be used.
- General construction waste such as excess concrete, timber, paper, plastic and metal.
- Vegetation waste from site clearing. This would be minimal and generally limited to any paddock trees or grasses required to be cleared.

- Demolition waste from the removal of the existing shed and stock yards on site.
- Domestic waste including food scraps, aluminium cans, glass bottles, plastic and paper containers, and putrescible waste generated by site construction personnel.
- Surplus spoil from earthworks required on site. Excess spoil would be reused elsewhere on site where possible.
- Waste from onsite amenities, this waste would be collected by the supplier of any such systems in line with their general practices.
- Wastewater generated from the construction compounds.

All waste would be transported and disposed of in accordance with the *Waste Classification Guidelines* (EPA 2014) and the *Protection of the Environment Operations Act 1997*. Following construction, a search of the site would be completed so that no waste is left behind.

Operation

During operation, the generation of wastes would be limited to maintenance activities and would include redundant equipment which is replaced and general waste from maintenance workers. All waste during maintenance activities would be removed from site when activities are complete by appropriately licenced contractors in accordance with the *Waste Classification Guidelines (EPA 2014)* and the *Protection of the Environment Operations Act 1997*.

Decommissioning

It the proposal is decommissioned (and not upgraded) at the end of its operational life, the entire facility would be removed from site for recycling where feasible. Some below ground infrastructure, in the form of metal piers used to support the panel array, may remain. All aspects of the proposal, where possible would be recycled or reused. Any items which are unable to be recycled or reused would be disposed of at an appropriately licenced facility.

7.3.3 Safeguards and mitigation measures

Safeguards and management measures provided in Table 7-4 would be implemented to minimise potential waste management impacts.

Table 7-4 Waste management mitigation measures

Impact	Environmental safeguards	Timing
General	A Waste Management Plan would be developed for the proposal and would form part of the CEMP. It would include but not be limited to the following: • Identification of opportunities to avoid, reuse and recycle, in accordance with the waste hierarchy and WARR Act • Quantification and classification of all waste streams • Provision for recycling management onsite • Provision of toilet facilities for onsite workers and how sullage would be disposed of (i.e., pump out to local sewage treatment plant) • Tracking of all waste leaving the site • Disposal of waste at facilities permitted to accept the waste • Requirements for hauling waste (such as covered loads)	Construction Operation

Impact	Environmental safeguards	Timing
Construction waste	Where possible, waste would be removed on a daily basis, or as soon as reasonably practical, to maintain the site in a tidy and litter free condition.	Construction
Wastewater management	Septic tanks would be installed and operated in accordance with Narrabri Shire Council's requirements.	Construction Operation

7.4 Cumulative impacts

7.4.1 Existing environment

A search of the Department of Planning and Environment (DPE) major projects register, RMS project website, Narrabri Shire Council website and ARTC's Inland Rail project website was completed in February 2019. The searches were completed to identify any major projects which may contribute to cumulative impacts in the Narrabri area.

DPE Major Projects Register

Narrabri South Solar

Canadian Solar (Australia) Pty Ltd received Planning Consent from the NSW Minister of Planning on 21 December 2018 for the proposed 60 MW Narrabri South Solar Project. This project is located 10 km south-east of Narrabri on the northern side of Old Gunnedah Road. As this project has received development consent it is likely to be constructed prior to the proposal. This would be monitored as planning for construction of the proposal commences to determine any overlap in construction periods.

Wee Waa Solar

Overland Sun Farming has received SEARs for the proposed 55 MW Wee Waa Solar Farm on a property south-east of Wee Waa township. Wee Waa is located approximately 40 km north-west of Narrabri. As the EIS is yet to be submitted with DPE, the timing of construction for this project is not determined.

Coal mining

A number of coal mine applications, including modifications to existing consents, have been approved in the Narrabri LGA. None of these projects would be affected by the development of the proposal.

Roads and Maritime Services (RMS)

RMS has committed funding to plan for the upgrade of the Newell Highway between Narrabri and Moree. The project includes planning for new road pavement, intersection improvements, widening of road shoulders and provision of new overtaking lanes. The project will deliver at least 30 additional overtaking lanes, providing over 45 kilometres of new overtaking lanes.

The closest RMS Newell Highway upgrade project to the proposal site is near the town of Edgeroi, approximately 20 km to the north. This would involve constructing a north-bound overtaking lane.

RMS has two projects planned for Pilliga to the south of Narrabri. Both projects involve constructing overtaking lanes on the Newell Highway. These projects are approximately 60 km south of Narrabri. These projects are not located close to the proposal site, and would not create cumulative impacts in the immediate area.

Australian Rail Track Corporation

Two projects proposed by ARTC are located in the Narrabri area. The two projects form part of ARTC's Inland Rail Project. The Inland Rail Project is a 1,700 km route that will link Melbourne and Brisbane via regional Victoria, New South Wales and Queensland.

The Inland Rail Project closest to the proposal site is the Narrabri to North Star (N2NS) Project. The N2NS Project involves upgrading the rail line within the existing rail corridor. This section of line includes the North West Rail Line located directly east of the proposal site, adjacent to the Newell Highway. The project has been placed on public exhibition, with ARTC reviewing submissions and preparing a Submissions and Preferred Infrastructure Report. Construction tenders are planned for release in mid-2019. The southern section of the N2NS project is adjacent to the proposal site and would commence construction prior to the northern section, north of Moree. The construction of the southern section of the N2NS Project would be monitored to determine any overlap in construction periods as planning for construction of the proposal commences.

The second ARTC project it is the Narromine to Narrabri (N2N) Project. This project is located to the south of Narrabri, and would involve a new rail alignment. The N2N project is at the EIS preparation stage, with studies being prepared throughout 2019. This project is located on the southern side of Narrabri and not in the vicinity of the proposal site. The timing of the N2N project would be monitored as construction planning for the proposal progresses, in order to determine any overlap in construction periods.

7.4.2 Potential impacts

Construction

During the construction of the proposal there is the potential for cumulative impacts to accrue with impacts from the ARTC Narrabri to North Star Project (N2NS) if construction programs overlap. The N2NS project is located immediately adjacent to the proposal site's eastern boundary. While not located close to the proposal site, there are also potential cumulative impacts from the RMS Newell Highway upgrade projects.

If these projects are constructed at the same time as the proposal, there may be cumulative impacts associated with traffic and noise, and impacts on resources within Narrabri from workers requiring accommodation and town services. These would be restricted to the construction phase of the projects.

Cumulative construction noise impacts would potentially occur if the proposal is constructed at the same time as the N2NS project. The cumulative construction noise sources would be on the eastern side of the proposal site, adjacent to the North West Railway Line where the N2NS construction work would occur. Construction noise sources would include trucks, heavy machinery, piling works and other construction activities.

Noise impacts during construction of the proposal may increase noise impacts from the operation of the nearby airstrip. These impacts would be restricted to the construction phase of the proposal.

Operation

The operation of the proposal would not add significantly to potential impacts of adjoining projects, or noise from the adjoining airstrip. The operation of the proposal would not cause any cumulative impacts.

7.4.3 Safeguards and mitigation measures

Safeguards and management measures provided in Table 7-5 would be implemented to minimise potential cumulative impacts.

Table 7-5 Cumulative impact mitigation measures

Impact	Mitigation Measures	Timing
Cumulative traffic impacts	Consultation with ARTC and RMS to identify if the construction phase of the proposal will overlap with ARTC Inland Rail or RMS Newell Highway projects. Traffic management plans would be developed to address potential traffic impacts caused by concurrent projects generating construction traffic.	Pre-construction Construction
Cumulative noise impacts	Cumulative construction noise impacts would be addressed in a Noise Management Plan. Consultation with ARTC and RMS, and other proponents if applicable, would be completed to determine if construction activities may take place in close proximity to adjoining projects. Where possible, noise generating activities would be scheduled for different areas of the proposal site to avoid cumulative construction noise impacts. This would include periods where the nearby airstrip is in regular use.	Pre-construction Construction
Cumulative impacts on services and accommodation	If there is potential for construction of multiple projects to occur in and around Narrabri at the same time, and large workforce numbers are required, consideration would be given to alternative accommodation options such as neighbouring towns.	Pre-construction Construction

8. Environmental management

8.1 Environmental managements plans (or system)

This EIS identifies safeguards and mitigation measures to minimise adverse environmental impacts which could potentially arise as a result of the proposal. These are outlined throughout Chapters 6 and 7. These management measures would be incorporated into the detailed design and applied during the construction and operation of the proposal.

All safeguards and mitigation measures outlined in this document would be managed by implementing a Project Environmental Management Plan. The Project Environmental Management Plan would manage the impacts of all stages of the proposal and would include the following sub plans:

- Construction Environmental Management Plan (CEMP) to address the impacts of the construction phase.
- Operational Environmental Management Plan (OEMP) to address the impacts of the operational phase.
- Decommissioning Environmental Management Plan to address the impacts of the decommissioning phase, it is however noted that this plan would be similar to the CEMP as many of the measures to be implemented during this phase are similar to those in the CEMP.

Each of the above plans would be prepared prior to the commencement of the relevant stages and would include but would not be limited to the following:

- Roles of specific staff
- Reporting requirements
- Monitoring requirements
- Environmental targets and objectives
- Auditing and review timetables
- Emergency response requirements
- Details of training and inductions required
- Complaint response procedures
- Adaptive management mechanisms to encourage continuous improvement

The above plans would also potential contain sub plans for specific issues such as erosion and sedimentation and waste management plans.

8.2 Summary of safeguards and mitigation measures

Environmental safeguards and mitigation measures outlined in this document would be incorporated during construction, operation and decommissioning of the proposal. These safeguards would minimise any potential adverse impacts arising from the proposal on the surrounding environment; including human health and safety. The safeguards and management measures are summarised in Table 8-1.

Table 8-1 Summary of mitigation measures

Issues	Impact	Measure	Timing
Biodiversity	Pre-construction/clearing	A Biodiversity Management Plan would be prepared prior to construction. This would detail fauna management protocols including management of tree hollows and fauna handling.	Pre-construction
		Ensure all workers are provided with an environmental induction prior to starting work on site. This would include information on the ecological values of the site and protection measures to be implemented to protect biodiversity.	Construction
	Erosion, stockpile and soil impacts on biodiversity	Use of, and regular inspection and maintenance of, erosion and sediment control measures developed in an Erosion and Sediment Control Plan (ESCP). The ESCP shall be prepared and maintained as part of the Construction Environmental Management Plan (CEMP) in accordance with relevant sections of "*Managing Urban Stormwater: Soil and Construction Volume 1*" (Landcom, 2004) ('the Blue Book).	Pre-construction Construction
		Restrict stockpiles of construction materials, fill or vegetation to existing cleared areas and not within areas of adjoining native vegetation.	Construction
		Water would be applied to stockpile areas during windy conditions.	Construction
		Reinstatement of stabilised surfaces as quickly as practicable after construction.	Construction
	Clearance of vegetation	Fence off or mark trees to be retained, to avoid additional impacts on vegetation. Fencing should protect the entire Tree Protection Zone (i.e. 10 times the diameter of the trunk at breast height).	Pre-construction
		Any hollow-bearing trees to be felled would be marked prior to clearing of vegetation. The removal of hollow bearing trees is to be undertaken in accordance with a tree hollow management protocol set out in the CEMP, and would involve the presence of a qualified ecologist or wildlife specialist experienced in the rescue of fauna.	Pre-construction Construction
		Any trees with raptor nests would be felled outside the breeding season.	Construction
		Habitat features such as hollow trunks and limbs within the proposal site would be salvaged and replaced within areas proposed for screening vegetation where practicable.	Construction
	Site rehabilitation	Planting of locally endemic tree species in areas proposed for vegetated screens.	Construction Post-construction

Issues	Impact	Measure	Timing
Aboriginal heritage	Aboriginal heritage items	Development of an Aboriginal Cultural Heritage Management Plan (ACHMP) which would include details of the on-going management of Silverleaf IF-1 and Silverleaf IF-2 during construction and operation and procedures for unanticipated finds.	Pre-construction
		A five-metre buffer zone with high-visibility fencing around the two sites.	Construction
		Induction for site workers detailing the location of the two sites, their cultural values and the legislative requirements for their management.	Pre-construction
		In the event that the proposal would impact upon Silverleaf IF-1 and Silverleaf IF-2, further assessment would be required in the form of an Aboriginal Cultural Heritage Assessment Report (ACHAR). Further consultation would also be required in accordance with the OEH Aboriginal community consultation requirements.	Construction
		In the event that a previously unidentified Aboriginal site is discovered within the study area at any point during the operational life of the Project, an AHIMS site card for that site should be submitted to OEH as promptly as possible. Timing protocols for the submission of AHIMS site cards should be included in the ACHMP for the proposal.	Construction
	Identification of potential human remains	In the event that potential human skeletal remains are identified within the study area at any point during the life of the proposal, the following standard procedure would be followed. • All work in the vicinity of the remains should cease immediately. • The location should be cordoned off and the NSW Police notified. • If the Police suspect the remains are Aboriginal, they will contact the Office of Environment and Heritage and arrange for a forensic anthropologist or archaeological expert to examine the site. Subsequent management actions will be dependent on the findings of the inspection undertaken under Point 3. • If the remains are identified as modern and human, the area will become a crime scene under the jurisdiction of the NSW Police. • If the remains are identified as pre-contact or historic Aboriginal, OEH and all RAPs are to be formally notified in writing. Where impacts to exposed Aboriginal skeletal remains cannot be avoided an appropriate management mitigation strategy will be developed in consultation with OEH and RAPs. • If the remains are identified as historic non-Aboriginal, the site is to be secured and the NSW Heritage Division contacted. If the remains are identified as non-human, work can recommence immediately.	Construction

Issues	Impact	Measure	Timing
Landscape and visual	Visual impacts of solar farm (including glare)	A landscape plan would be developed to detail the location and type of plantings that would minimise views of the proposal site from nearby properties. The landscape plan would be prepared in consultation with the adjacent landholders and the airstrip operators to confirm any operational requirements which would affect the location and type of landscape screening. The plan would detail the species to be used on site. Native vegetation communities found in the local area will be used where suitable.	Pre-construction
		A review of the landscaping plan would be carried out within six months of operation commencing. This would include consultation with nearby landowners to discuss the adequacy of the provided screening	Construction
		The materials and colour of on-site infrastructure would, where practical, be non-reflective and be of a colour that would blend with the landscape.	Construction
		Security fencing posts and wire would be non-reflective.	Construction
		Construction plant, equipment, waste and excess materials would be contained within the designated boundaries of the work site and would be removed from the site following the completion of construction.	Construction
		Work sites shall be kept tidy at all times.	Construction
Noise and vibration	Construction noise	A noise management plan would be prepared and implemented as part of the Construction Environmental Management Plan (CEMP). The following project-specific noise mitigation measures would be implemented: • If possible, bored piling (rather than impact piling) would be considered as an alternative to install the steel post foundations. If impact piling is required, no impact piling should be undertaken within 45 metres of adjacent dwellings without prior notice being given to occupants.	Pre-construction Construction
		Consultation and cooperation with the nearest sensitive receivers: • The construction contractor would establish contact with residents affected by construction noise and communicate the construction program and progress on a regular basis, particularly when noise generating activities are planned. Communication with the local community would be maintained throughout the construction period. • The construction contractor would provide a community liaison phone number and permanent site contact so that noise complaints can be received and addressed in a timely manner. Upon receipt of a noise complaint, monitoring would be undertaken and reported as soon as possible. If exceedances are detected, the situation would be reviewed to identify means to attempt to reduce the impact to acceptable levels.	Pre-construction Construction

Issues	Impact	Measure	Timing
		Work ethic – management of worker generated construction noise All site workers would be briefed on the potential for noise impacts on local residents and the requirement to implement practical and reasonable measures to minimise noise impacts during the course of their activities. This would include: • Avoiding the use of loud radios • Avoiding shouting and slamming doors • Where practical, machines would be operated at low speed or power and switched off when not being used rather than left idling for prolonged periods • Inform truck drivers of designated vehicle routes, parking locations and delivery hours • Minimising reversing • Avoiding dropping materials from height and avoiding metal to metal contact on material • Keeping engine covers closed while equipment is operating	Construction
		The following general noise mitigation measures would be implemented to mitigate construction noise impacts: • All engine covers would be kept closed while equipment is operating. • As far as possible, heights from which materials are dropped, into or out of trucks, would be minimised. • Machines found to produce excessive noise compared to industry best practice would be removed from the site or stood down until repairs or modifications can be made. • Once the selection of equipment has been finalised, a review should be undertaken to ensure that the noise levels do not exceed the assumed levels in this assessment. To reduce the annoyance associated with reversing alarms, broadband reversing alarms (audible movement alarms) would be used for all site equipment. Satisfactory compliance with occupational health and safety requirements would need to be achieved and a safety risk assessment may need to be undertaken to determine that safety is not compromised.	Construction
Land use, soils and land capability	Soil and erosion	An Erosion and Sediment Control Plan (ESCP) would be prepared prior to construction to minimise impacts on soils during construction in accordance with relevant sections of "*Managing Urban Stormwater: Soil and Construction Volume 1*" (Landcom, 2004) ('the Blue Book).	Pre-construction Construction
		Spill management and materials handling measures would be included in the ESCP to minimise the potential for fuel or chemical spills.	Pre-construction Construction

Issues	Impact	Measure	Timing
		Ground cover would be reintroduced after construction to stabilise soils during operation.	Post-construction
	Biosecurity – site workers	Limit entry points to the property.	Construction Operation
		All construction equipment and boots would be cleaned upon entering the property.	Construction Operation
		Limit worker contact with livestock, crops or plant materials as much as possible and eliminate any unnecessary contact altogether.	Construction Operation
		Keep a visitor register.	Construction Operation
	Biosecurity – vehicles	Clean machinery and equipment from the top down and dismantle it as far as possible to gain access to internal spaces.	Construction Operation
	Operation of private airstrip	Vegetation screen planting to be installed on property boundary in consultation with airstrip operator.	Prior to operation
Traffic, transport and access	Construction traffic management	A traffic management plan would be prepared and implemented as part of the CEMP. The plan would be prepared in accordance with any Roads and Maritime and Narrabri Shire Council requirements. The plan would include but not be limited to: • Details of the haulage routes for the proposal • Measures to maintain access along roads and to properties • Site specific control measures (including signage) to manage and regulate traffic movements • Requirements and methods to consult and inform the community of changes to the road network • A response plan for any traffic incident • Mechanisms to monitor the results of the plan and any subsequent reviews and revisions • Outline timing of deliveries and site access Consideration of carpooling/shuttle bus arrangements to minimise the number of vehicles accessing the site each day.	Pre-construction Construction
		Signage on Kamilaroi Highway to be erected to alert drivers of trucks entering and exiting Logans Road.	Construction
		Access along Logans Road is to be maintained.	Construction

Issues	Impact	Measure	Timing
		Upgrade the intersection of the Kamilaroi Highway and Logans Lane to a BAR type intersection.	Construction Decommissioning
		Temporarily reduce speed limits to the west of the intersection of the Kamilaroi Highway and Logans Lane from 100 km/h to 80 km/h.	Construction Decommissioning
	Road conditions	ENGIE would consult with Narrabri Shire Council during detailed design in regard to the proposed upgrades to Logans Road. The works will be undertaken in accordance with Council requirements.	Pre-construction Construction
		Condition surveys would be undertaken prior to the construction commencing. Following construction, surveys would confirm if any damage attributed to the proposal has occurred. Should damage be identified (outside of normal wear and tear), repair works would be undertaken by ENGIE (or its contractor) in line with any relevant council requirements.	Pre-construction Construction
	Property access	Notification to affected landowners would be undertaken for any works located along Logans Road, particularly if temporary closures would be required.	Construction
		Consultation with any properties where access would be impacted would be undertaken to determine whether additional measures are required to maintain access.	Construction
Hydrology, groundwater and water quality	Water quality	An Erosion and Sediment Control Plan (ESCP) would be prepared as part of the CEMP. All erosion and sediment control measures shall be designed, implemented and maintained in accordance with relevant sections of "*Managing Urban Stormwater: Soil and Construction Volume 1*" (Landcom, 2004) ('the Blue Book) (particularly Section 2.2) and "*Managing Urban Stormwater: Soil and Construction Volume 2A – Installation of Services*" (DECC, 2008)". The ESCP shall include stockpiles, stormwater run-off, trees, site boundaries, site access and storage areas.	Pre-construction Construction
		The provision of sedimentation basins on site would be considered in the detailed design. This could involve converting existing farm dams into basins for the duration of the construction period.	Construction
	Spills and leaks	A site specific emergency spill plan would be developed, and include spill management measures in accordance relevant EPA guidelines. The plan would address measures to be implemented in the event of a spill, including initial response and containment, notification of emergency services and relevant authorities (including Roads and Maritime and EPA officers).	Construction
		An emergency spill kit would be kept on site at all times. All staff will be made aware of the location of the spill kit and trained in its use.	Construction

Issues	Impact	Measure	Timing
		All fuels, chemicals, and liquids will be stored at least 50 metres away from waterways and will be stored in an impervious bunded area within the compound site.	Construction
		The refuelling of plant and maintenance of machinery will be undertaken in impervious bunded areas in the compound site.	Construction
		Vehicle wash downs and/or concrete truck washouts will be carried out within a designated bunded area on an impervious surface or carried out off-site.	Construction
		Machinery would be checked daily to ensure there is no oil, fuel or other liquids leaking from the machinery. All staff would be appropriately trained through toolbox talks for the minimisation and management of accidental spills.	Construction
	Hydrology	The Department of Primary Industries (Water) controlled activity guidelines would be considered as part of the proposal's detailed design.	Pre-construction
	Rehabilitation	Rehabilitation works are to commence as soon as practicable to stabilise the land surface after works are completed in any area.	Construction
Hazards and risk	Offsite risks	Siting of key components will minimise any current or future offsite risk. The majority of the hazards identified are considered onsite risks, and are not considered offsite risks.	Construction
	EMF	Design and selection of all electrical equipment is to minimise EMF levels and comply with the ICNIRP exposure levels.	Construction
		Monitoring of electromagnetic levels would be undertaken during the commissioning of the substation to confirm exposure levels. Should levels be above the ICNIRP exposure levels the potential need for further mitigation would be considered.	Construction
Bushfire	Bushfire management	A bushfire management plan would be prepared in consultation with the Rural Fire Service. This plan would include but not limited to the following: • Management of activities with a risk of fire ignition • Management of fuel loads onsite • Storage and maintenance of firefighting equipment including siting and provision of adequate water supplies • The below requirements of Planning for Bush Fire Protection 2006: – Identifying asset protection zones – Providing adequate egress/access to the site – Emergency evacuation measures Operational procedures relating to mitigation and suppression of bush fire relevant to the operation of a solar farm.	Pre-construction Construction

Issues	Impact	Measure	Timing
Socio-economic	Community consultation	A community consultation plan would be implemented to manage the concerns and impacts on stakeholders including adjacent property owners. The plan would include (but not be limited to) the following: • Protocols to keep the community updated about the progress of the project and its benefits • Protocols to inform relevant stakeholders of potential impacts • Protocols for allow the community to identify any concerns or issues with the project, particularly during construction and decommissioning The plan would be prepared in consultation with Narrabri Shire Council.	Pre-construction Construction
Air quality and climate change	Air quality	The CEMP would include measures to minimise impacts on air quality including: • A map identifying locations of sensitive receivers • Identification of potential risks/impacts due to the work/activities as dust generation activities • Management measures to minimise risk including a progressive stabilisation plan • A process for monitoring dust on-site and weather conditions • A process for altering management measures as required • A process of the review of the plan prior to the decommissioning works to ensure it is update at the time of the works occurring	Pre-construction Construction
	Dust emissions	Surveillance for visible dust generation would occur at all times.	Construction
		Works that disturb vegetation, soil or stockpiles will not be carried out during strong winds (over 40 km/h) when this may affect receivers (visibility on roads, dust and debris near recreational areas, residences and commercial premises).	Construction
		Stockpiled materials would be covered, stabilised or stored in areas not subject to high wind.	Construction
		All trucks would be covered when transporting material to and from the site.	Construction
		Work activities would be reprogrammed if the safeguards and management measures are not adequately restricting dust generation.	Construction
		Maximum speed limits would be enforced for construction traffic within the site to limit dust generation.	Construction
		Use of a water tanker or similar to spray unpaved roads and exposed areas during construction where required.	Construction
	Exhaust emissions	Construction plant and equipment would be maintained in a good working condition in order to limit impacts on air quality.	Construction

Issues	Impact	Measure	Timing
		Construction equipment, plant and vehicles would be appropriately sized for the task.	Construction
		Equipment would be serviced frequently to ensure they are operating efficiently.	Construction
	Impacts on sensitive receivers	Local residents would be advised of hours of operation and duration of work and supplied with a contact name and number for queries or complaints regarding air quality. The CEMP will also include a procedure for handling any queries or complaints.	Pre-construction Construction
	Climate change	The use of alternative fuels and power sources for construction plant and equipment would be investigated and implemented, where appropriate.	Pre-construction Construction
		The energy efficiency and related carbon emissions would be considered in the selection of vehicle and plant equipment.	Pre-construction Construction
		Materials would be delivered as full loads and local suppliers would be used where possible.	Pre-construction Construction
Non-Aboriginal heritage	Unexpected finds	In the event that a site or artefact (as defined by the *Heritage Act 1977*) is identified during construction works, works would cease at the location.	Construction
		The find would be immediately reported to ENGIE, and the regulator (OEH Heritage Division) in accordance with legislation. No work would commence in the vicinity of the find until any required approvals have been given by the regulator.	Construction
Waste management	Construction waste	A Waste Management Plan would be developed for the proposal and would form part of the CEMP. It would include but not be limited to the following: • Identification of opportunities to avoid, reuse and recycle, in accordance with the waste hierarchy and WARR Act • Quantification and classification of all waste streams • Provision for recycling management onsite • Provision of toilet facilities for onsite workers and how sullage would be disposed of (i.e., pump out to local sewage treatment plant) • Tracking of all waste leaving the site • Disposal of waste at facilities permitted to accept the waste • Requirements for hauling waste (such as covered loads)	Pre-construction Construction
		Where possible waste would be removed on a daily basis, or as soon as reasonably practical, to maintain the site in a tidy and litter free condition.	Construction
	Wastewater	Septic tanks to be installed and operated in accordance with Narrabri Shire Council's requirements.	Construction Operation

Issues	Impact	Measure	Timing
Cumulative impacts	Cumulative traffic impacts	Consultation with ARTC and RMS to identify if the construction phase of the proposal will overlap with ARTC Inland Rail or RMS Newell Highway projects. Traffic management plans would be developed to address potential traffic impacts caused by concurrent projects generating construction traffic.	Pre-construction Construction
	Cumulative noise impacts	Cumulative construction noise impacts would be addressed in a Noise Management Plan. Consultation with ARTC and RMS, and other proponents if applicable, would be completed to determine if construction activities may take place in close proximity to adjoining projects. Where possible, noise generating activities would be scheduled for different areas of the proposal site to avoid cumulative construction noise impacts. This would include periods where the nearby airstrip is in regular use.	Pre-construction Construction
	Cumulative impacts on services and accommodation	If there is potential for construction of multiple projects to occur in and around Narrabri at the same time, and large workforce numbers are required, consideration would be given to alternative accommodation options such as neighbouring towns.	Pre-construction Construction

9. Proposal justification and conclusion

9.1 Justification

9.1.1 Proposal justification and benefits

The proposal is considered to be justified as it meets the proposal objectives outlined in Section 2.2, primarily the objective to develop a commercial scale solar farm that minimise impacts on the surrounding environment. The proposal (in conjunction with other renewable energy projects) would assist in reducing Australia's greenhouse gas emissions, while also ensuring that future demand for power is also met. The proposal would contribute to Australia's international commitment to reduce national greenhouse gas emissions.

The proposal site was selected due to its suitability for the development of a solar far. The proposal site has abundant solar resources, and is located near an electricity substation with connection capacity. The proposal site does not contain high value agricultural land, and is not subject to flooding risks.

The proposal site represents a very small proportion of agricultural land that is used for similar purposes in the broader region. The proposal would not negatively impact the agricultural values of surrounding properties. It would also not prevent the development of other solar or renewable energy developments on surrounding properties.

If the solar farm is not reconditioned at the end of the proposed 30 year operational life, and the site is decommissioned, the proposal site has the potential to be converted back to agricultural production. The proposal would not prevent the site from being used for other potential developments such as rural residential development or from being sub-divided.

The proposal would stimulate the economy in the Narrabri region by generating employment during the construction phase, and to a lesser extent during the operation and decommissioning phases. Although the operation of the proposal would reduce the area of land that is available for agricultural purposes, and therefore income derived from agriculture, the development of the proposal would generate rental income for the subject property owners.

Overall, the development of the proposal would not significantly impact the environment. The proposal would provide an environmental benefit by reducing dependence on fossil fuels for energy generation. The proposal would contribute to meeting Australia's commitment to reducing carbon emissions by developing a clean and renewable source.

9.1.2 Ecological sustainable development

An objective of the EP&A Act is to encourage ecologically sustainable development. The principles of ecologically sustainable development have been considered throughout development of the proposal.

The precautionary principle

The precautionary principle states *"if there are threats of serious or irreversible damage, lack of scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation".*

There would be no threats of serious or irreversible environmental damage as a result of the construction, operation and decommissioning of the proposal. Where potential environmental impacts have been considered likely to occur, safeguards and mitigation measures have been proposed to minimise and manage any environmental impacts. If not recommissioned, the proposal would be decommissioned at the end of its design life. The proposal site would be restored as close as practicable to pre-existing conditions to enable agricultural land uses to recommence.

Intergenerational equity

The intergenerational equity principle states, *"the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations".*

The proposal would not result in any impacts that are likely to adversely impact on the health, diversity or productivity of the environment for future generations. Furthermore, the proposal would contribute to reducing greenhouse gas emissions, which would assist in limiting the impacts of global warming on future generations.

Conservation of biological diversity and ecological integrity

The biological diversity and ecological integrity principle states the "*diversity of genes, species, populations and communities, as well as the ecosystems and habitats to which they belong, must be maintained and improved to ensure their survival"*.

The majority of vegetation has been cleared from the site as part of previous agricultural land use. Impacts on vegetation would be limited to paddock trees and impacts to grass cover. Where possible the need to clear land is to be avoided as part of the proposal. The offsets developed for the proposal would allow it to proceed without negatively affecting the biological diversity or ecological integrity of the vegetation affected.

Improved valuation, pricing and incentive mechanisms

This principle states that "*costs to the environment should be factored into the economic costs of a project".*

The basis for this principle is the concept that pricing and other financial arrangements relating to the proposal should reflect the social and environmental costs of the use of the resource on which it is based. This includes consideration of future values that may exceed current values as the resources become scarcer.

The development of the proposal has considered these potential impacts and has identified safeguards and mitigation measures to be implemented to minimise the risk of significant adverse impacts. The implementation of these environmental measures would increase both the capital construction and operating costs of the proposal (and decommissioning). This signifies that the environmental costs have been included in the costs of the proposal.

9.2 Conclusion

This EIS has been prepared to assess the potential environmental impacts of ENGIE's proposal to construct, operate and potentially decommission a solar farm north of Narrabri between the Newell Highway and Kamilaroi Highway. The proposal requires development consent from the Minister for Planning under Part 4 of the *Environmental Planning and Assessment Act 1979*. This EIS has been prepared to address the SEARs and support the development application.

The proposal involves developing a 120 megawatt (MW AC) solar farm. The proposal would consist of about 440,000 solar arrays and include ancillary infrastructure including but not limited to electrical infrastructure, transmission corridor, access roads, fencing, landscaping and site amenities. The site layout and technology to be used would be determined during detailed design once a contractor has been appointed by ENGIE.

The proposed solar arrays and associated components are expected to operate for 35 years. At the end of its operational life, the proposal would be either reconditioned or decommissioned. Reconditioning would involve replacing components that were originally installed with new components that reflect technology that is available at that time. Decommissioning would remove all above ground infrastructure and rehabilitating the site to allow it to be used for purposes such as agriculture.

This EIS has assessed the potential impacts and concludes that the proposal is unlikely to result in any significant environmental impacts provided the recommended mitigation measures are implemented. The site has been modified by previous land uses and this has cleared the majority of vegetation from the site. The proposal has been designed to avoid impacts on identified Aboriginal sites. The proposal would contribute to the NSW and Commonwealth government commitments to increase the proportion of electricity that is generated by renewable energy technologies. It would assist in meeting Australia's international obligations to reduce greenhouse gas emissions under the Paris Agreement.

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Appendices

Appendix A – Secretary's Environmental Assessment Requirements and response to SEARs

Environmental Assessment Requirements

State Significant Development

Section 4.12(8) and 4.12(9) of the *Environmental Planning and Assessment Act 1979 and* Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*

Application Number	SSD 9358
Proposal	Silverleaf Solar Farm Project which includes: • the construction and operation of a photovoltaic (PV) generation facility with an estimated capacity of 120 MW; and • associated infrastructure, including alignment of a transmission line between the solar farm site and the existing Narrabri substation on Stoney Creek Road, a grid connection and battery storage facilities.
Location	• Approximately 5 km north-west of Narrabri, between the Newell Highway in the east and Logans Lane in the west, within the Narrabri Shire local government area
Applicant	ENGIE
Date of Issue	22 June 2018
General Requirements	The Environmental Impact Statement (EIS) for the development must comply with the requirements in Schedule 2 of the *Environmental Planning and Assessment Regulation 2000.* In particular, the EIS must include: • a stand-alone executive summary; • a full description of the development, including: – details of construction, operation and decommissioning; – a site plan showing all infrastructure and facilities (including any infrastructure that would be required for the development, but the subject of a separate approvals process); – a detailed constraints map identifying the key environmental and other land use constraints that have informed the final design of the development; • a strategic justification of the development focusing on site selection and the suitability of the proposed site with respect to potential land use conflicts with existing and future surrounding land uses (including other proposed or approved solar farms, rural residential development and subdivision potential); • an assessment of the likely impacts of the development on the environment, focusing on the specific issues identified below, including: – a description of the existing environment likely to be affected by the development; – an assessment of the likely impacts of all stages of the development, (which is commensurate with the level of impact), including any cumulative impacts of the site and existing or proposed developments, taking into consideration any relevant legislation, environmental planning instruments, guidelines, policies, plans and industry codes of practice; – a description of the measures that would be implemented to avoid, mitigate and/or offset the impacts of the development (including draft management plans for specific issues as identified below); and – a description of the measures that would be implemented to monitor and report on the environmental performance of the development; • a consolidated summary of all the proposed environmental management and monitoring measures, identifying all the commitments in the EIS; and • the reasons why the development should be approved having regard to:

	– relevant matters for consideration under the *Environmental Planning and Assessment Act 1979*, including the objects of the Act and how the principles of ecologically sustainable development have been incorporated in the design, construction and ongoing operations of the development; – the suitability of the site with respect to potential land use conflicts with existing and future surrounding land uses; and – feasible alternatives to the development (and its key components), including the consequences of not carrying out the development. • a detailed consideration of the capability of the project to contribute to the security and reliability of the electricity system in the National Electricity Market, having regard to local system conditions and the Department's guidance on the matter. The EIS must also be accompanied by a report from a suitably qualified person providing: • a detailed calculation of the capital investment value (CIV) (as defined in clause 3 of the Regulation) of the proposal, including details of all assumptions and components from which the CIV calculation is derived; and • certification that the information provided is accurate at the date of preparation. The development application must be accompanied by the consent in writing of the owner/s of the land (as required in clause 49(1)(b) of the Regulation).
Specific Issues	The EIS must address the following specific issues: • **Biodiversity** – including: - an assessment of the biodiversity values and the likely biodiversity impacts of the project in accordance with Section 7.9 of the *Biodiversity Conservation Act 2016 (NSW)* the Biodiversity Assessment Method (BAM) and documented in a Biodiversity Development Assessment Report (BDAR), unless OEH and DPE determine that the proposed development is not likely to have any significant impacts on biodiversity values; - the BDAR must document the application of the avoid, minimise and offset framework including assessing all direct, indirect and prescribed impacts in accordance with the BAM; - an assessment of the likely impacts on listed aquatic threatened species, populations or ecological communities, scheduled under the *Fisheries Management Act 1994*, and a description of the measures to minimise and rehabilitate impacts; and - a strategy to offset any residual impacts of the development in accordance with *the Biodiversity Conservation Act 2016 (NSW)*; • **Heritage** – including an assessment of the likely Aboriginal and historic heritage (cultural and archaeological) impacts of the development, including adequate consultation with the local Aboriginal community; • **Land** – including: - an assessment of the impact of the development on agricultural land (including possible cumulative impacts on agricultural enterprises and landholders) and flood prone land; - an assessment of any impacts to Crown lands (including potential transfer of Logans Lane to Narrabri Shire Council and consent requirements for activities on Crown Land); - a soil survey to consider the potential for erosion to occur, and paying particular attention to the compatibility of the development with the existing land uses on the site and adjacent land (e.g. operating mines, extractive industries, mineral or petroleum resources, exploration activities, aerial spraying, dust generation, and biosecurity risk) during operation and after decommissioning, with reference to the zoning provisions applying to the land, including subdivision;

- an assessment of potential land use conflicts, including completion of a Land Use Conflict Risk Assessment in accordance with the Department of Industry's *Land Use Conflict Risk Assessment Guide*; and
- measures to remediate the land following decommissioning in accordance with *State Environmental Planning Policy No 55 - Remediation of Land.*

- **Visual** – including an assessment of the likely visual impacts of the development (including any glare, reflectivity and night lighting) on surrounding residences, scenic or significant vistas, air traffic and road corridors in the public domain, including a draft landscaping plan for on-site perimeter planting, with evidence it has been developed in consultation with affected landowners;

- **Noise** – including an assessment of the construction noise impacts of the development in accordance with the *Interim Construction Noise Guideline* (ICNG), operational noise impacts in accordance with the *NSW Noise Policy for Industry 2017*, and cumulative noise impacts (considering other operations in the area including the nearby airstrip), and a draft noise management plan if the assessment shows construction noise is likely to exceed applicable criteria;

- **Transport** – including an assessment of the site access route (including Logans Lane, Kamilaroi Highway and Newell Highway), site access points, rail crossing and safety issues (including the Narrabri to North Star - Inland Rail) and likely transport impacts (including peak and average traffic generation, over-dimensional vehicles and construction worker transportation) of the development on the capacity and condition of roads (including on any Crown land), a description of the measures that would be implemented to mitigate any impacts during construction (including cumulative impacts from nearby developments), and a description of any proposed road upgrades developed in consultation with the relevant road and rail authorities (if required);

- **Water** – including:
  - an assessment of the likely impacts of the development (including flooding) on surface water and groundwater resources (including groundwater bores, drainage channels, wetlands, riparian land, farm dams, groundwater dependent ecosystems and acid sulfate soils), related infrastructure, adjacent licensed water users and basic landholder rights, and measures proposed to monitor, reduce and mitigate these impacts;
  - details of water requirements and supply arrangements for construction and operation; and
  - a description of the erosion and sediment control measures that would be implemented to mitigate any impacts in accordance with *Managing Urban Stormwater: Soils & Construction* (Landcom 2004);

- **Hazards and Risks** – including:
  - a preliminary risk screening in accordance with *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development* and *Applying SEPP 33* (DoP, 2011), and if the preliminary risk screening indicates the development is "potentially hazardous", a Preliminary Hazard Analysis (PHA) must be prepared in accordance with *Hazard Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis (*DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011); and
  - an assessment of all potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure (including the proposed transmission line and substation) against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields*; and

	• **Socio-Economic** – including an assessment of the likely impacts on the local community and a consideration of the construction workforce accommodation.
Consultation	During the preparation of the EIS, you should consult with relevant local, State or Commonwealth Government authorities, infrastructure and service providers (including the Narrabri to North Star project), community groups, affected landowners, Registered Aboriginal Parties (RAPs), exploration licence holders, quarry operators and mineral title holders. In particular, you must undertake detailed consultation with affected landowners surrounding the development and Narrabri Shire Council. The EIS must describe the consultation process and the issues raised, and identify where the design of the development has been amended in response to these issues. Where amendments have not been made to address an issue, a short explanation should be provided.
Further consultation after 2 years	If you do not lodge a development application and EIS for the development within 2 years of the issue date of these EARs, you must consult further with the Secretary in relation to the preparation of the EIS.
References	The assessment of the key issues listed above must take into account relevant guidelines, policies, and plans as identified. While not exhaustive, the following attachment contains a list of some of the guidelines, policies, and plans that may be relevant to the environmental assessment of this proposal.

ATTACHMENT 1

Environmental Planning Instruments, Policies, Guidelines & Plans

Biodiversity	
	Biodiversity Assessment Method 2017 (OEH)
	Threatened Species Assessment Guidelines - Assessment of Significance (OEH)
	Biosecurity Act 2015
	Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (DPI)
	Policy and Guidelines for Fish Habitat Conservation and Management (DPI)
	Fisheries Management Act 1994
Heritage	
	Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010 (DECCW)
	Code of Practice for Archaeological Investigations of Objects in NSW 2010 (OEH)
	Guide to investigating, assessing and reporting on Aboriginal Cultural Heritage in NSW 2011 (DECCW).
	NSW Heritage Manual (OEH)
Land	
	Primefact 1063: Infrastructure proposals on rural land (DPI)
	Establishing the social licence to operate large scale solar facilities in Australia: insights from social research for industry (ARENA)
	Local Land Services Act 2013
	Australian Soil and Land Survey Handbook (CSIRO)
	Guidelines for Surveying Soil and Land Resources (CSIRO)
	The land and soil capability assessment scheme: second approximation (OEH)
	Land Use Conflict Risk Assessment Guide (DoI – L&W)
Noise	
	NSW Noise Policy for Industry (EPA)
	Interim Construction Noise Guideline (EPA)
	NSW Road Noise Policy (EPA)
Light	
	Dark Sky Planning Guideline: Protecting the observing conditions at Siding Spring (DPE)
Transport	
	Guide to Traffic Generating Developments 2002 (RTA)
	Austroads Guide to Road Design & relevant Australian Standards
	Austroads Guide to Traffic Management Part 12: Traffic Impacts of Development
Water	
	Guidelines for Fresh and Marine Water Quality 2000 (ANZECC)
	Climate Change Impacts and Risk Management
	Water Quality Objectives
	Managing Urban Stormwater: Soils & Construction (Landcom)
	Floodplain Development Manual (OEH)
	Guidelines for Controlled Activities on Waterfront Land (DPI Water)
	Water Sharing Plans (DPI Water)
	Floodplain Management Plan (DPI Water)
	Guidelines for Watercourse Crossings on Waterfront Land (DPI Water)
Hazards and Risks	
	Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis (DPE)
	Multi-Level Risk Assessment (DPE)
	Work Health and Safety (WHS) Act 2011
	State Emergency and Rescue Management Act 1989

Waste	
	Waste Classification Guidelines (EPA)
Electromagnetic Interference	
	ICNIRP Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields
Socio-Economic	
	Social Impact Assessment Guideline 2017 (DPE)
Environmental Planning Instruments	
	State Environmental Planning Policy (State and Regional Development) 2011
	State Environmental Planning Policy (Infrastructure) 2007
	State Environmental Planning Policy (Rural Lands) 2008
	State Environmental Planning Policy No. 44 – Koala Habitat Protection
	State Environmental Planning Policy No. 55 – Remediation of Land
	Narrabri Local Environmental Plan 2012

Requirement	Where addressed in the EIS
General requirements	
A stand-alone executive summary A full description of the development, including: • Details of construction, operation, upgrading and decommissioning; • A site plan showing all infrastructure and facilities (including any infrastructure that would be required for the development, but the subject of a separate approvals process); • A detailed constraints map identifying the key environmental and other land use constraints that have formed the final design of the development;	Executive Summary Chapter 3
A strategic justification of the development focusing on site selection and the suitability of the proposed site with respect to potential land use conflicts with existing and future surrounding land uses (including other proposed or approved solar farms, rural residential development and subdivision potential;	Chapter 2
An assessment of the likely impacts of the development on the environment, focusing on the specific issues identified below, including: • A description of the existing environment likely to be affected by the development; • An assessment of the likely impacts of all stages of the development (which is commensurate with the level of impact), including any cumulative impacts of the site and existing or proposed developments, taking into consideration any relevant legislation, environmental planning instruments, guidelines, policies, plans and industry codes of practice; • A description of the measures that would be implemented to avoid, mitigate and/or offset the impacts of the development (including draft management plans for specific issues as identified below); and • A description of the measures that would be implemented to monitor and report on the environmental performance of the development	Chapters 6 and 7
A consolidated summary of all the proposed environmental management and monitoring measures, identifying all the commitments in the EIS.	Section 8.2
The reasons why the development should be approved having regard to: • Relevant matters for consideration under the *Environmental Planning and Assessment Act 1979*, including the objects of the Act, and how the principles of ecologically sustainable development have been incorporated in the design, construction and ongoing operations of the development • The suitability of the site with respect to potential land use conflicts with existing and future surrounding land uses; and • Feasible alternatives to the development (and its key components) including the consequences of not carrying out the development A detailed consideration of the capability of the project to contribute to the security and reliability of the electricity system in the National Electricity Market, having regard to the local system conditions and the Department's guidance on the matter. The EIS must also be accompanied by a report from a suitably qualified person providing: • A detailed calculation of the capital investment value (CIV) (as defined in clause 3 of the Regulation) of the proposal, including details of all assumptions and components from which the CIV calculation is derived; and • Certification that the information provided is accurate at the date of preparation.	Section 9.1

Requirement	Where addressed in the EIS
The development application must be accompanied by the consent in writing of the owner/s of the land (as required in clause 49(1)(b) of the Regulation).	
Specific issues	
The EIS must address the following issues:	
Biodiversity – including: • An impact assessment of the biodiversity values and the likely biodiversity impacts of the project in accordance with Section 7.9 of the *Biodiversity Conservation Act 2016 (NSW)* the Biodiversity Assessment Method (BAM) and documented in a Biodiversity Assessment Report (BDAR), unless OEH and DPE determine that the proposed development is not likely to have any significant impacts on biodiversity values; • The BDAR must document the application of the avoid, minimise and offset framework including assessing all direct, indirect and prescribed impacts in accordance with the BAM; • An assessment of the likely impacts on listed aquatic threatened species, populations or ecological communities, scheduled under the *Fisheries Management Act 1994*, and a description of the measures to minimise and rehabilitate impacts; and • A strategy to offset any residual impacts of the development in accordance with the *Biodiversity Conservation Act 2016 (NSW)*	Section 6.2 Appendix B
Heritage – including an assessment of the likely Aboriginal and historic heritage (cultural and archaeological) impacts of the development, including adequate consultation with the local Aboriginal community	Sections 6.3 and 7.2 Appendix C
Land – including: • An assessment of the impact of the development on agricultural land (including possible cumulative impacts on agricultural enterprises and landholders) and flood prone land; • An assessment on any impacts to Crown lands (including potential transfer of Logans Lane to Narrabri Sire Council and consent requirements for activities on Crown Land); • A soil survey to consider the potential for erosion to occur, and paying particular attention to the compatibility of the development with the existing land uses on the site and adjacent land (e.g. operating mines, extractive industries, mineral or petroleum resources, exploration activities, aerial spraying, dust generation, and biosecurity risk) during operation and after decommissioning, with reference to the zoning provisions applying to the land, including subdivision; • An assessment of potential land use conflicts, including completion of a Land Use Conflict Risk Assessment in accordance with the Department of Industry's *Land Use Conflict Risk Assessment Guide*; and • Measures to remediate the late following decommissioning in accordance with State Environmental Planning Polity No 55 – Remediation of Land.	Section 6.6 Appendix E
Visual – including an assessment of the likely visual impacts of the development (including and glare, reflectivity and night lighting) on surrounding residences, scenic or significant vistas, air traffic and road corridors in the public domain, including a draft landscape plan for on-site permitter planting, with evidence it has been developed in consultation with affected landowners.	Section 6.4

Requirement	Where addressed in the EIS
Noise – including an assessment of the construction noise impacts of the development in accordance with the *Interim Construction Noise Guidelines* (ICNG), operational noise impacts in accordance with the *NSW Noise Policy for Industry 2017*, and cumulative impacts (considering other operations in the area including the nearby airstrip), and a draft noise management plan if the assessment shows construction noise is likely to exceed applicable criteria.	Section 6.5 Appendix D
Transport – including an assessment of the site access route (including Logans Lane, Kamilaroi Highway and Newell Highway), site access points, rail crossing and safety issues (including the Narrabri to North Star – Inland Rail) and likely transport impacts (including peak and average traffic generation, over-dimensional vehicles and construction worker transportation) of the development on the capacity and condition of roads (including Crown land), a description of the measures that would be implemented to mitigate and impacts during construction (including cumulative impacts from nearby developments), and a description of any proposed road upgrades developed in consultation with the relevant road and rail authorities (if required).	Section 6.7
Water – including: • An assessment of the likely impacts of the development (including flooding) on surface water and groundwater resources (including groundwater bores, drainage channels, wetlands, riparian land, farm dams, groundwater dependent ecosystems and acid sulfate soils), related infrastructure, adjacent licensed water users and basic landholder rights and emasures proposed to monitor, reduce and mitigate these impacts • Details of water requirements and supply arrangements for construction and operation; and • A description of the erosion and sediment control measures that would be implemented to mitigate any impacts in accordance with *Managing Urban Stormwater: Soils & Construction* (Landcom 2004).	Section 6.8
Hazards and Risks – including: • A preliminary risk screening in accordance with *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development* and *Applying SEPP 33* (DoP, 2011), and if the preliminary risk screening indicates the development is "potentially hazardous", a Preliminary Hazard Analysis (PHA) must be prepared in accordance with *Hazard Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011); and • An assessment of all potential hazards and risk including but not limited to bushfires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure (including the proposed transmission line and substation) against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields*: and	Sections 6.9 and 6.10
Socio-economic – including an assessment of the likely impacts om the local community and a consideration of the construction workforce accommodation	Section 6.11

Requirement	Where addressed in the EIS
Consultation	
During the preparation of the EIS, you should consult with relevant local, State or Commonwealth Government authorities, infrastructure and service providers (including the Narrabri to North Star project), community groups, affected landowners, Registered Aboriginal Parties (RAPs), exploration licence holders, quarry operators and mineral title holders. In particular, you must undertake detailed consultation with affected landowners surrounding the development and Narrabri Shire Council. The EIS must describe the consultation process and the issues raised, and identify where the design of the development has been amended in response to these issues. Where amendments have not been made to address an issue, a short explanation should be provided.	Chapter 4

Appendix B – Biodiversity assessment

Silverleaf Solar Farm Pty Ltd

Narrabri 120 MW Solar Farmls

Biodiversity Development Assessment Report

May 2019

Executive summary

Background

Silverleaf Solar Farm Pty Ltd (ENGIE) proposes to construct and operate a 120 megawatt (MW) solar farm about four kilometres north-west of Narrabri between the Newell Highway in the east and Logans Lane in the east (referred to as “the proposal”).

This Biodiversity Development Assessment Report (BDAR) considers the assessment requirements of the *Biodiversity Conservation Act 2016* (BC Act), *Fisheries Management Act 1994* (FM Act) and the Australian Government’s *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as well as the relevant Secretary’s Environmental Assessment Requirements (SEARs).

Surveys

Staged surveys of the proposal site were conducted with reference to the Biodiversity Assessment Method (BAM) and appropriate threatened species survey guidelines for targeted species. Detailed field surveys including vegetation mapping, vegetation integrity plots, habitat assessment and targeted threatened species searches were conducted in March, September and November 2018. The transmission line corridor was assessed by vehicular and pedestrian inspections. The “study area” includes the proposal site and the transmission line corridor, together with a 1,500 metre buffer used in for assessment in accordance with the BAM.

Existing environment

The majority of the proposal site has been cleared and used for agriculture and is subject to high intensity sheep and cattle grazing. The dominant vegetation is represented by native and exotic pastures. Several small patches of remnant woodland are present in the proposal site; these patches have been highly modified as a result of agricultural activities, with much of the understorey affected by grazing activities. These remnant woodland patches have been mapped and described in the proposal site in accordance with the BAM. The remnant woodland patches correspond to three PCTs:

- PCT 35 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion.
- PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions.
- PCT 397 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion.

The surrounding derived native grasslands that occur in the study area are continuous with the understories of the remnant woodland patches and are considered to be derived from the clearing of the original woodland PCT.

Moderate condition stands of Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion (PCT 35) within the study area are commensurate with the EEC listed under the BC Act as Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions, which is also identified as an entity subject to serious and irreversible impacts (SAII). It is also commensurate with the EEC listed under the EPBC Act as Brigalow (*Acacia harpophylla* dominant and co-dominant). The proposal site boundary has been redesigned to avoid clearing of these small patches.

No threatened flora species were identified within the proposal site during the field survey, and none are likely to be impacted by the proposal.

No candidate species credit species were recorded and none are likely to occur. Five threatened fauna species listed under the BC Act were recorded during surveys, all of which are ecosystem credit species:

- Black Falcon (*Falco subniger*)
- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)
- Eastern Freetail-bat (*Mormopterus norfolkensis*)
- Little Pied Bat (*Chalinolobus picatus*)
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)

Aquatic habitats are limited at the site. A number of small first order drainage lines occur that drain to dams that are used as watering points for stock. No key fish habitat or habitat for threatened species listed under the FM Act is present.

Potential impacts

The construction of the proposal would predominantly comprise impacts on areas of derived native grassland and cropped land. There would be minimal impacts on native woodland vegetation. In total, the proposal would remove about 183 hectares of native remnant woodland and derived grassland. Some hollow-bearing trees may also be removed. As noted above, the proposal site boundary has been redesigned to avoid clearing of small patches of moderate condition PCT 35 to avoid removal of this threatened ecological community and impacts on SAII entities.

Offset requirements

The data from the fieldwork and mapping was entered into version 1.2.6.00 of the BAM credit calculator as a 'Development Assessment' to determine the number and type of biodiversity credits that would be required to offset impacts of the proposal. It is assumed that the construction and operation of a solar proposal will not necessitate the removal of all vegetation layers and so the 'future vegetation integrity score' for the various vegetation zones was not entered as 0.

In total, the credit calculator identified 417 ecosystem credits requiring offset. The offset requirements are summarised below:

- Offsets are not required for impacts on non-native vegetation that does not provide habitat for threatened species. No credits were calculated for 'exotic/cleared land'.
- A biodiversity offset is not required if the vegetation integrity score of the impacted vegetation zone is <17 (Sections 10.3.1.1 and 10.3.2.1 of the BAM). In this regard, an ecosystem credit obligation of zero was found for the derived grassland forms of PCT 35 and PCT 397 (Zone 1 and 5).
- 7 ecosystem credits for Zone 2 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Moderate
- 395 ecosystem credits for Zone 3 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Derived Grassland.
- 15 ecosystem credits for Zone 4 – PCT 397 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Moderate.
- No species polygons were necessary and no species credits have been calculated.

The proposal has been redesigned to avoid moderate condition Brigalow near the boundary of the proposal site. The derived native grassland form of this PCT does not meet the condition criteria for the Brigalow (Acacia harpophylla dominant and co-dominant) EEC. The assessments of significance prepared for this EEC indicated that the proposal is unlikely to have a significant impact on this MNES, and thus the proposal would not be a controlled action and no offsets would be required under the EPBC Act.

Mitigation of impacts

A Construction Environmental Management Plan (CEMP) would be developed for the construction phase of the proposal. The CEMP would include, as a minimum, industry-standard measures for the management of soil, surface water, weeds and pollutants, and planting of vegetated screens. Planting of vegetated screens would include locally sourced species typical of the PCTs present on site. This would improve the condition of the retained vegetation in the long-term.

At the end of its operational life, the solar farm would be disconnected from the electrical transmission network and all solar farm infrastructure would be removed. ENGIE would also restore the surface of the solar farm land to a suitable condition for pastoral or other agricultural use.

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Appendices

1. Introduction

1.1 Overview

Silverleaf Solar Farm Pty Ltd (ENGIE) proposes to construct and operate a 120 megawatt (MW) solar farm about four kilometres north-west of Narrabri between the Newell Highway in the east and Logans Lane in the west (referred to as the 'proposal').

The proposal requires development consent from the Minister for Planning under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Secretary's Environmental Assessment Requirements (SEARs) were provided on 22 June 2018 by the Department of Planning and Environment

This Biodiversity Development Assessment Report (BDAR) considers the assessment requirements of the NSW *Biodiversity Conservation Act 2016* (BC Act), *Fisheries Management Act 1994* (FM Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as well as the relevant SEARs.

1.2 Key features of the proposal

The proposal includes constructing, operating and eventually decommissioning or reconditioning a 120 megawatt (MW) AC solar farm to the north of Narrabri in the NSW North West Slopes.

The proposal would consist of the following components:

- Solar arrays consisting of about 440,000 solar panels four metres in height, supported by about 20,000 piles, driven or screwed into the ground in order to support the solar array's mounting system. The mounting system would be placed with rows of panels approximately six metres apart. The arrays would be single-axis tracking panels, which would consist of about 5,150 tracker units.
- Construction of a transmission corridor, supporting 132 kV power lines, connecting to TransGrid's substation located on Stoney Creek Road approximately 5 kilometres from the proposal site. The transmission lines would be installed overhead on wooden or concrete poles, between 20 and 30 metres high and spaced at intervals of around 50 metres. Stays would be required at locations where the transmission line changes direction.
- Inverter and transformer stations evenly distributed across the site, with onsite cabling and electrical connections between solar arrays and panel inverters.
- Onsite cabling and electrical connections between solar arrays and panel inverters
- A step-up substation to increase the voltage to 132 kV to allow connection to TransGrid substation (final step-up voltage to be confirmed during further consultation with TransGrid).
- Cables and trenches.
- Internal access tracks to provide access throughout the site during operation.
- Operational and maintenance office, including staff amenities block and parking areas.
- Perimeter security fencing.
- Landscaping around the perimeter of the site where required.

Construction of the proposal would take about 12 months to complete.

The proposed solar arrays and associated components are expected to operate for about 35 years. At the end of its operational life, the proposal would be either reconditioned or decommissioned. Reconditioning would involve replacing components that were originally installed with new components that reflect technology that is available at that time. Decommissioning would remove all above ground infrastructure and rehabilitating the site to allow it to be used for purposes such as agriculture.

The proposal site and key features are mapped on Figure 1-1.

1.3 Secretary's environmental assessment requirements

This BDAR addresses the relevant SEARs for the EIS, as outlined in Table 1-1, the requirements of the NSW Office of Environment and Heritage (OEH), and relevant guidelines and policies. The Biodiversity SEARs are detailed in Table 1-1.

Table 1-1 **Secretary's environmental assessment requirements relevant to biodiversity**

Item	Section	Where addressed in this report
Biodiversity	The EIS must address the following specific issues:	
	an assessment of the biodiversity values and the likely biodiversity impacts of the project in accordance with Section 7.9 of the *Biodiversity Conservation Act 2016* (NSW), the Biodiversity Assessment Method (BAM) and documented in a Biodiversity Development Assessment Report (BDAR), unless OEH and DPE determine that the proposed development is not likely to have any significant impacts on biodiversity values;	This report is the BDAR prepared in accordance with the BAM
	the BDAR must document the application of the avoid, minimise and offset framework including assessing all direct, indirect and prescribed impacts in accordance with the BAM;	Section 7.1.1 (avoid impacts) Section 7.1.2 and 8 (mitigate impacts) Section 7.2 to 7.6 (assess direct, indirect and prescribed impacts) Section 9 (offset impacts)
	an assessment of the likely impacts on listed aquatic threatened species, populations or ecological communities, scheduled under the Fisheries Management Act 1994, and a description of the measures to minimise and rehabilitate impacts; and	Section 7.5

Item	Section	Where addressed in this report
	a strategy to offset any residual impacts of the development in accordance with the *Biodiversity Conservation Act 2016* (NSW)	Section 9

1.4 Purpose of this report

The purpose of this report is to assess the potential biodiversity impacts from the construction and operation of the proposal. The report:

- Outlines the methods used in the biodiversity assessment.
- Describes the existing environment of the study area, including the results of the desktop assessment and site surveys.
- Assesses the value and conservation significance of native vegetation and habitats at the proposal site and the potential for threatened biota and matters of national environmental significance (MNES) to occur at the proposal site or be affected by the proposal.
- Provides a description of the proposal, including potential impacts on biodiversity values and measures to avoid or mitigate impacts.
- Assesses the significance of impacts on threatened biota and MNES.
- Presents the data used to perform the BAM credit calculations for the proposal.
- Calculates the number and type of biodiversity credits that would be required to offset impacts of the proposal in accordance with the BAM.

1.5 Glossary of terms and acronyms

Term	Definition
AOBV	Areas of Outstanding Biodiversity Value
BC Act	*Biodiversity Conservation Act 2016*
BCT	Biodiversity Conservation Trust
BDAR	Biodiversity Development Assessment Report
Biodiversity Assessment Method (BAM)	The rules for biodiversity assessment established under the BC Act that determine credits created, credits required and the circumstances that improve or maintain biodiversity values.
Biodiversity credit	A unit of biodiversity value to measure specific development impacts or conservation gains in accordance with the BAM. Includes ecosystem credits and species credits.
Biodiversity credit report	Specifies the number and type of biodiversity credits: required to offset the impacts of a development to obtain a Biodiversity Certification Agreement; or that would be generated through conservation and management of a Stewardship site under a Biodiversity Stewardship site agreement.
Biodiversity offsets	Specific measures that are put in place to compensate for impacts on biodiversity values.
Biodiversity values	The composition, structure and function of ecosystems, including threatened species, populations and ecological communities, and their habitats.

Term	Definition
BOS	Biodiversity Offset Scheme
CEEC	Critically endangered ecological community
CEMP	Construction Environmental Management Plan
DEE	Department of the Environment and Energy
DPI	Department of Primary Industries
Ecosystem credit	A credit that relates to a vegetation type and the threatened species that are reliably predicted by that vegetation type (as a habitat surrogate).
EEC	Endangered ecological community
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FFMP	Flora and Fauna Management Plan
IBRA	Interim Biogeographic Regionalisation for Australia
LEP	Local Environment Plan
LGA	Local Government Area
Locality	The area within a 10 km radius of the proposal site.
Migratory species	Species listed under listed under international agreements (i.e Ramsar, JAMBA, CAMBA and ROKAMBA conventions) to which Australia is a party
MNES	Matters of National Environmental Significance
OEH	Office of Environment and Heritage
PCT	Plant community type
Proposal site	The area that would be directly impacted by construction and operation of the proposal. Encompasses the solar farm site and the transmission line corridor. Also the 'development site' as referenced in the BAM
SAII	Serious and irreversible impacts
SAII entity	Species and ecological communities that are likely to be the subject of serious and irreversible impacts (SAIIs)
SEPP	State Environment Planning Policy
Species credit	A credit that relates to an individual threatened species that cannot be reliably predicted based on habitat surrogates. Threatened species that require species credits are identified in the Threatened Biodiversity Data Collection
Study area	The area that was subject to a site survey and assessed for direct or indirect impacts arising from construction and operation of the proposal. This included the properties on which the solar farm will be constructed, as well as publicly accessible sections of two transmission line options. Also the 'subject land' as referenced in the BAM. A buffer of 1,500 metres has been used in desktop assessments in accordance with the BAM.
TEC	Threatened ecological community
Threatened biota	Threatened species, populations or ecological communities listed under the BC Act, FM Act and/or the EPBC Act.

1.6 Scope and limitations

This BDAR has been prepared by GHD for ENGIE and may only be used and relied on by ENGIE and its related bodies corporate for the purpose agreed between GHD and ENGIE as set out in sections 1.3 and 1.4 of this report.

GHD otherwise disclaims responsibility to any person other than ENGIE arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

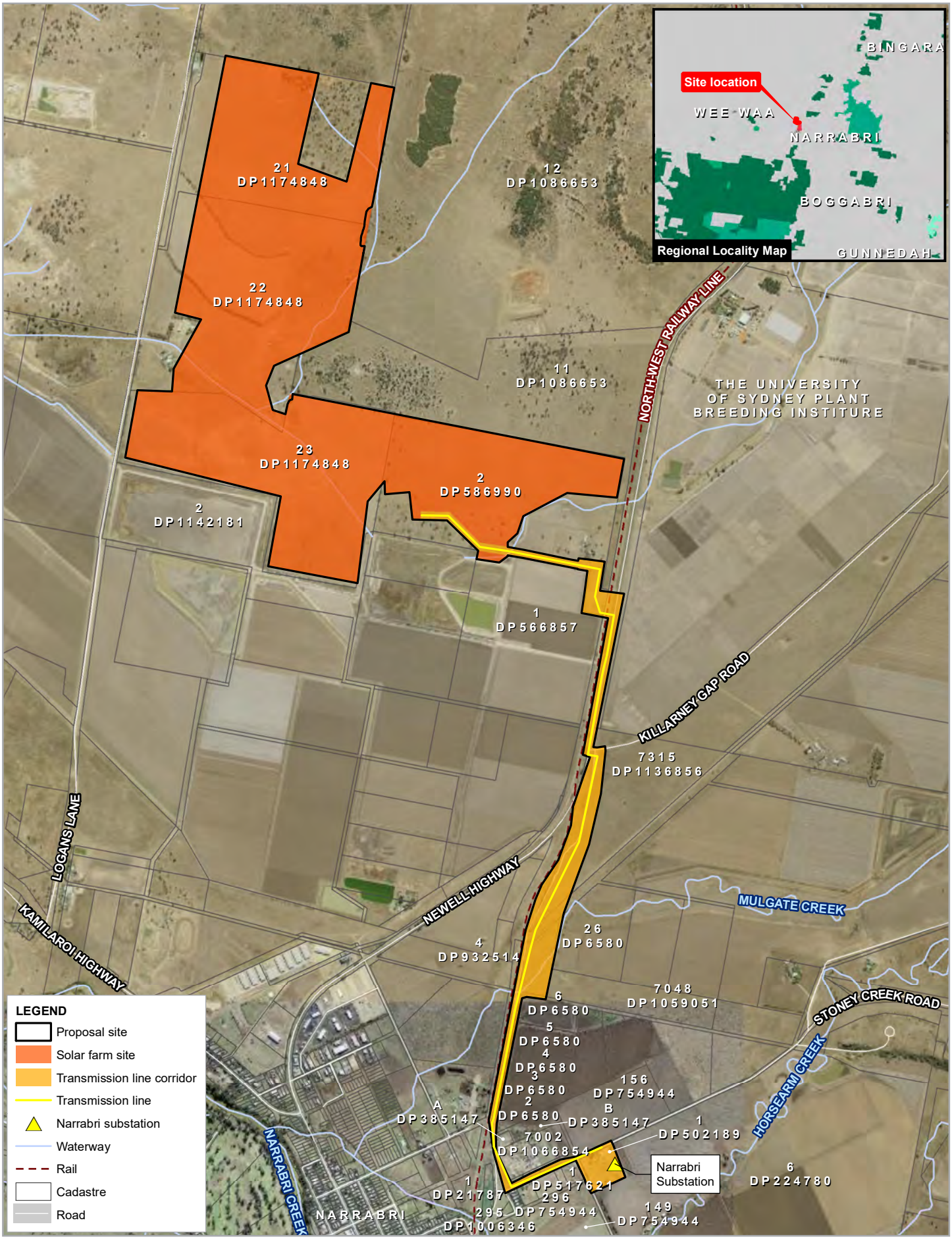
The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described throughout this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this BDAR on the basis of information provided by ENGIE and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, particular climatic conditions leading up to field surveys. As a result, not all relevant site features and conditions may have been identified in this report. Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Engie
Silverleaf Narrabri Solar Farm
Biodiversity Assessment

The proposal

Project No. 21-26998
Revision No. -
Date 02/05/2019

FIGURE 1-1

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Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Inset map - Geoscience Australia. Created by:jprice

2. Legislative context

2.1 Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) provides legal status for biota of conservation significance in NSW. The BC Act aims to, amongst other things, 'maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development'. It provides for the listing of threatened species and communities, establishes a framework to avoid, minimise and offset the impacts of proposed development (the Biodiversity Offsets Scheme), and establishes a scientific method for assessing the likely impacts on biodiversity values and calculating measures to offset those impacts (the Biodiversity Assessment Method, BAM). These are discussed further below.

2.1.1 Biodiversity Offset Scheme and Biodiversity Assessment Methodology

The BC Act, together with the *Biodiversity Conservation Regulations 2017*, provides a mechanism to address impacts on biodiversity from land clearing associated with development. Under this legislation, there are provisions for a Biodiversity Offsets Scheme (BOS), which includes a framework to avoid, minimise and offset impacts of development on biodiversity.

The aim of the BOS is to provide a transparent, consistent and scientifically based approach to biodiversity assessment and offsetting. It also allows for the establishment of biodiversity stewardship agreements, which are in-perpetuity agreements entered into by landholders, to secure offset sites and generate biodiversity credits, which can be used to offset impacts of development. The aim of the BOS is to ensure that the impacts of development, clearing or biodiversity certification will result in no net loss of biodiversity.

The Biodiversity Assessment Method (BAM) was established by OEH as a standard method to implement the aims of the BOS and to address the loss of biodiversity and threatened species. The scheme creates a market framework for the conservation of biodiversity values and the offsetting of development impacts. It also provides the mechanisms to offset impacts of development, clearing or biodiversity certification such that there is no loss of biodiversity values.

The BAM sets out how biodiversity values will be assessed, prescribes requirements to avoid and minimise impacts, establishes rules for calculating the number and class of credits required for unavoidable impacts, and determines the trading rules that will apply. The methodology includes a software package known as the Biodiversity Assessment Method Calculator (the BAM calculator) which processes site survey and assessment data. The BAM calculator specifies the type and extent of surveys required for a biodiversity assessment and then processes survey data to calculate the number and type of biodiversity credits that are either required at a development site or will be generated at a stewardship site. The BAM must be applied by a person accredited under the BC Act.

The Biodiversity Conservation Trust Fund (BCTF) ensures that landowners have the funds needed to carry out the management actions required each year and provides a financial incentive to landowners to carry out those actions. The scheme is administered by OEH and ensures accountability and compliance through legislation, regular reporting requirements and financial measures. Under certain circumstances a developer may make a payment directly into the BCTF to offset the impacts of a proposed development in lieu of purchasing and retiring biodiversity credits. The BCT must then use funds in the BCTF to purchase and retire appropriate biodiversity credits.

The BOS and BAM have been addressed in accordance with the project SEARs through the preparation of this BDAR by accredited assessors.

2.2 Fisheries Management Act 1994

The objects of the *Fisheries Management Act* 1994 (FM Act) are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. It provides for the listing of threatened species, populations and ecological communities, listing of 'Key Threatening Processes', and the requirements or otherwise for the preparation of a Species Impact Statement (SIS).

One of the objectives of the FM Act is to 'conserve key fish habitats ' which includes aquatic habitats that are important to the maintenance of fish populations generally and the survival and recovery of threatened aquatic species. To assist in the protection of key fish habitats, DPI has produced the Policy and guidelines for fish habitat conservation and management (DPI, 2013). This policy applies to the following developments, works or activities, each of which can impact on key fish habitat:

- Dredging or reclamation
- Impeding fish passage
- Damaging marine vegetation
- De-snagging

The FM Act has been considered in this assessment through:

- Desktop review to determine the threatened biota that are predicted to occur within the locality of the proposal and hence could occur, subject to the habitats present.
- Aquatic habitat assessment.
- Assessment of potential impacts on threatened biota and key fish habitat.
- Identification of suitable impact mitigation and environmental management measures for aquatic habitats, where required.

2.3 Biosecurity Act 2015

The *Biosecurity Act 2015* provides for risk-based management of biosecurity in NSW. It provides a statutory framework to protect the NSW economy, environment and community from the negative impact of pests, diseases and weeds.

The primary object of the Act is to provide a framework for the prevention, elimination and minimisation of biosecurity risks posed by biosecurity matter, dealing with biosecurity matter, carriers and potential carriers, and other activities that involve biosecurity matter, carriers or potential carriers.

In NSW, all plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.

One priority weed for the North West region was recorded in the proposal site. Legal requirements to minimise the potential for the introduction and/or spread of weeds as a result of the proposal are discussed in Section 5.1.

2.4 Environment Protection and Biodiversity Conservation Act 1999

The purpose of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is to ensure that actions likely to cause a significant impact on 'matters of national environmental significance' undergo an assessment and approval process. Under the EPBC Act, an action includes a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things. An action that 'has, will have or is likely to have a significant impact on a matter of national environmental significance (MNES)' is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Australian Minister for the Environment. MNES relevant to this report include threatened species and ecological communities and migratory species.

The EPBC Act has been considered in this assessment through:

- Desktop review to determine the listed biodiversity matters that are predicted to occur within the locality of the proposal and hence could occur, subject to the habitats present.
- Targeted field surveys for listed threatened biota and migratory species.
- Assessment of potential impacts on threatened and migratory biota, including assessments of significance in accordance with the EPBC Act Significant Impact Guidelines 3.1 (DotE, 2013).
- Identification of suitable impact mitigation and environmental management measures for threatened and migratory biota, where required.

2.5 Assessment guidelines and information

This report has been prepared in accordance with the Biodiversity Assessment Method (OEH 2017a) and with reference to the following guidelines:

- *NSW Guide to Surveying Threatened Plants* (OEH, 2016c)
- *'Species credit' threatened bats and their habitats. NSW survey guide for the Biodiversity Assessment Method* (OEH, 2018c).

3. Methods

3.1 Desktop assessment

3.1.1 Data review

A desktop database review was undertaken to identify threatened flora and fauna species, populations and ecological communities (threatened biota) listed under the BC Act and EPBC Act, that could be expected to occur in the locality, based on previous records, known distribution ranges, and habitats present. These were also used to obtain the necessary site data to perform BAM calculations.

A 10 km search radius from the proposal site was used to identify threatened species that were previously recorded in the locality. For flora species, the BioNet Atlas database (OEH, 2018a) yielded very few records and only one species within the standard 10 km search radius. This could reflect low or diffuse sampling efforts in the locality, rather than a low occurrence of threatened species. For this reason, the search radius for threatened flora was expanded to 20 km and included all valid records since 1980.

The threatened biota and migratory species identified in the desktop assessment are presented in Appendix A. Following collation of database records and threatened species and community profiles, a 'likelihood of occurrence' assessment was prepared for threatened biota and migratory species with reference to the broad vegetation types and habitats contained within the study area. This was further refined following field surveys and verification of vegetation types and identification and assessment of habitat present within the proposal site. A likelihood of occurrence ranking was attributed to these biota based on this information.

Information sources used in the preparation of this report include:

- Office of Environment and Heritage (OEH) NSW BioNet Atlas database for records of threatened species listed under the BC Act (OEH, 2018a)
- OEH Threatened biodiversity profile search online database for threatened ecological communities listed under the BC Act (OEH, 2018d)
- Department of the Environment and Energy (DEE) Protected Matters Online Search Tool for MNES listed under the EPBC Act and predicted to occur in the locality (DEE, 2018a)
- DEE online Species profiles and threats database (SPRAT) (DEE, 2018b)
- NSW BioNet Vegetation Classification (OEH, 2018b) to identify matching plant community types (PCTs) in the study area
- The list of species credit-type species and predicted species identified by the BAM calculator (OEH, 2019)

3.1.2 Background research

Background research was conducted to identify:

- Landscape-scale features of the study area in accordance with Section 4.2 of the BAM (OEH, 2017a).
- Site context of the study area that includes assessing vegetation cover and patch size as required under Subsections 4.3.2 and 5.3.2 of the BAM (OEH, 2017a).

- The likely distribution of native vegetation and threatened ecological communities, based on previous mapping and aerial photograph interpretation, for targeted field verification as required under Section 5 of the BAM (OEH, 2017a).
- A list of predicted and candidate threatened species and populations of flora and fauna to assess the habitat suitability and threatened biodiversity data collection as required under Section 6 of the BAM (OEH, 2017a).
- Evaluate baseline information to determine whether additional surveys, mapping and reporting is required to support project approval.

The background research included analysis of the following information sources:

- Aerial photographic imagery.
- NSW Mitchell Landscapes mapping and landscape descriptions (DECC, 2008b, a).
- Interim Biogeographic Regionalisation of Australia (IBRA version 7.0).
- Initial BAM credit calculations.
- Namoi CMA vegetation extant map, 2013 VIS-ID 4028, mapping and report prepared by EcoLogical for the Namoi Catchment Management Authority (EcoLogical, 2013).
- Mapping of the EPBC-listed “Natural Grasslands on the basalt and fine textured alluvial plains of northern NSW and southern Queensland” in the Namoi Catchment. VIS ID 3852 (EcoLogical, 2010).
- Namoi CMA Pre-European Vegetation Mapping, Namoi Catchment Management Authority (EcoLogical, 2009).
- Atlas of Groundwater Dependent Ecosystems (GDE) (BOM, 2018a).
- Directory of Important Wetlands of Australia (DIWA) (DEWHA, 2008).
- Aerial photographs and satellite imagery of the proposal site and buffer area.

3.2 Site survey

3.2.1 Survey overview

Staged surveys of the proposal site were conducted in accordance with the BAM and with reference to appropriate threatened species survey guidelines for targeted species. Site surveys included:

- Initial site stratification and vegetation mapping
- Sampling of vegetation integrity plot/transects
- Habitat assessments
- Targeted surveys for threatened flora
- Targeted surveys for threatened fauna

Survey effort was formally stratified across the proposal site in accordance with the BAM. Survey effort that has directly contributed to this BDAR is summarised in Table 3-1, mapped on Figure 3-1 and is described in detail below.

Table 3-1 Survey techniques and timing

Stage	Date	Survey Technique
BAM assessment survey	14-16 March 2018	Vegetation mapping Vegetation integrity plots Targeted flora searches Fauna survey Habitat assessment Spotlighting Call playback Anabats
Candidate species credit flora survey and additional plots	19-21 September 2018	Vegetation integrity plots Targeted flora searches Opportunistic fauna survey
Candidate species credit flora survey and additional plots	13 November 2018	Vegetation integrity plots Targeted flora searches Opportunistic fauna survey

Publicly accessible portions of the transmission line alignment were assessed through driven and walked transects, and where the transmission line crossed private properties, these were viewed from the nearest road. Vegetation along the transmission line was mapped based on the visual inspections and from aerial photography interpretation.

3.2.2 Vegetation and flora surveys

Vegetation mapping

Vegetation was assessed with reference to the BAM (OEH, 2017a). Regional vegetation mapping was ground-truthed in the field via driven and walked transects across the study area to verify community type and boundaries, floristic and structural homogeneity within patches and to update mapping as required. The proposed transmission alignment was inspected via vehicular traverses along roadsides and tracks.

Native vegetation communities in the study area were assigned to the closest equivalent Plant Community Type (PCT) held in the BioNet Vegetation Classification database (OEH, 2018b). The closest equivalent PCT for each vegetation community was determined through a comparison of the floristic descriptions of PCTs in the database with the plot / transect data collected from the site. In addition to floristic and structural similarity, the landscape position, soil type and other diagnostic features of the vegetation communities on the sites were also compared to the descriptions in the database in order to determine the most suitable PCT. Threatened ecological communities (TECs) as defined in NSW and Commonwealth legislation were also identified.

The native vegetation in the proposal site was then stratified into vegetation zones in accordance with Section 5.3.1 of the BAM (OEH, 2017a). A vegetation zone is defined in the BAM as a relatively homogenous area that is of the same vegetation type and broad condition. Each vegetation zone was assigned a patch size in accordance with Section 5.3.2 of the BAM (OEH, 2017a).

Vegetation integrity survey plots (assessing site condition)

Following the stratification of the proposal site into vegetation zones, plot surveys were conducted in accordance with Section 5.3.3 and Section 5.3.4 the BAM (OEH, 2017a) to obtain vegetation integrity data for the calculation of biodiversity credits. The field data sheets are provided in Appendix C.

Plots were located to comply with the minimum number of plots required by Table 4 in the BAM (OEH, 2017a). Due to refinements of the proposal site boundary during detailed design as part of efforts to reduce impacts on native vegetation, some plots used in the BAM calculations are located outside the final proposal site boundary. In total, 25 plots were sampled within the proposal site, with 15 plots located within the final proposal site and 10 plots outside of the proposal site. The location of survey plots is shown on Figure 3-1 and the minimum plot survey requirements are summarised in Table 3-2.

Table 3-2 Minimum plot survey requirements

PCT	Area in proposal site (ha)	Minimum number of plots required	Number of plots sampled	Comments
PCT 35 Brigalow - Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (EEC)	0.71	1	3	All plots located outside the final proposal site due to revisions in the proposal site boundary
PCT 35 Derived Native Grasslands	26.81	4	4	One plot located outside the final proposal site due to revisions in the proposal site boundary
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	0.69	1	3	All plots located outside the final proposal site due to revisions in the proposal site boundary
PCT 55 Derived Native Grasslands	121.96	6	6	-
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	1.15	1	3	All plots located outside the final proposal site due to revisions in the proposal site boundary
PCT 397 Derived Native Grasslands	32.69	4	4	-
Total	**184.0**	**17**	**23**	

Plots were located randomly within each of the vegetation zones by walking a random distance into the vegetation zone and then locating the plot on a randomly generated compass bearing, this was then repeated for subsequent plots within the vegetation zone. Plots were purposely not located near ecotones, tracks and their edges or other locally disturbed areas.

The site value was determined by assessing ten attributes used to assess function, composition and structure of vegetation within a 50 metre x 20 metre plot. These attributes were then assessed against benchmark values. Benchmarks are quantitative measures of the range of variability in condition in vegetation with relatively little evidence of alteration, disturbance or modification by humans since European settlement (DECC, 2009).

Attributes assessed within each plot are listed in Table 3-3. All flora species within a 20 metre by 20 metre quadrat nestled within the 50 m by 20 m plot were identified according to the nomenclature of the Royal Botanic Gardens and Domain Trust (RBGT, 2018). Each species identified was allocated a growth form group[1] and designated as either native, exotic or high threat exotic in accordance to the lists provided in the BAM calculator.

The overall condition of vegetation was assessed through general observation and comparison against the PCT condition benchmark data as well as using parameters such as species diversity, history of disturbance, weed invasion and canopy health.

Table 3-3 Site data collected within each plot

Attribute	Area assessed
Native plant species richness	20 X 20 metre plot
Percentage foliage cover for each species	20 X 20 metre plot
Estimated number of individuals for each species	20 X 20 metre plot
Number of large trees	50 X 20 metre plot
Tree regeneration (presence/absence)	50 X 20 metre plot
Tree stem size class	50 X 20 metre plot
Total length of fallen logs	50 X 20 metre plot
Litter cover	5 times 1 X 1 metre plot
High threat exotic vegetation cover	50 X 20 metre plot
Hollow bearing trees	50 X 20 metre plot

Threatened plant surveys

Potential candidate species credit entities for the proposal site were identified and assessed in accordance with Section 6.3 and steps 1 to 4 of Section 6.4 of the BAM (OEH, 2017a). All threatened plants are classified under the BAM as species credit entities as their occurrence cannot be reliably predicted based on vegetation type.

The suite of threatened plants with potential to occur in the proposal site was identified based on the desktop assessment results and the species credit entities identified by preliminary BAM Credit Calculations (see Appendix A). Habitat for these species was identified and assessed based on OEH threatened species profiles and the experience and judgement of GHD ecologists. The majority of the proposal site is highly modified and is dominated by exotic species, grazed, and can be readily discounted as supporting occurrences of threatened plant species.

[1] TG – tree, SG – shrub, GG – grass/grasslike, FG – forb, EG – fern, OG – other (Table 3 of the BAM, OEH 2017a)

A limited number of threatened species associated with alluvial clays or basaltic soils were considered to have marginal potential habitat within the Belah woodland types and associated derived native grassland areas of the proposal site. These were mainly woodland groundcover species, and include *Digitaria porrecta* (Finger Panic Grass), *Homopholis belsonii* (Belson's Panic) and *Swainsona murrayana* (Slender Darling Pea).

Noting that the above habitats at the time of survey were heavily grazed and relatively bare of ground vegetation, and considering the large areas of marginal potential habitat, searches were undertaken with due consideration of threatened species survey guidelines (DEC, 2004; OEH, 2016c), by utilising meandering traverses in marginal potential habitat within the proposal site, focussing on margins of woodland patches and along fence lines where grazing may be comparatively less intense.

3.2.3 Terrestrial fauna surveys

Fauna habitat assessment

Fauna habitat assessments were undertaken throughout the proposal site during all survey periods, including observation of potential shelter, basking, roosting, nesting and/or foraging sites. Specific habitat features and resources such as water bodies, food trees, the density of understorey vegetation, the composition of ground cover, the soil type, presence of hollow-bearing trees, leaf litter and ground debris were noted.

Indicative habitat criteria for targeted threatened species (i.e. those determined as having the potential to occur within the proposal site following the desktop review) were identified prior to fieldwork. Habitat criteria were based on information provided in OEH and DEE threatened species profiles, field guides, and the knowledge and experience of GHD field ecologists.

Habitat assessments included searches for resources of potential value to threatened fauna including:

- Trees with bird nests or other potential fauna roosts
- Rock outcrops or overhangs providing potential shelter sites for fauna
- Burrows, dens and warrens
- Distinctive scats or latrine sites, owl white wash and regurgitated pellets under roost sites
- Tracks or animal remains
- Evidence of activity such as feeding scars, scratches and diggings
- Specific food trees and evidence of foraging (chewed *Allocasuarina* cones)

The locations and quantitative descriptions of significant habitat features were captured with a handheld GPS unit and photographed where appropriate. The field survey effort included dawn and dusk observations of hollows for evidence of occupancy.

Opportunistic and incidental observations of fauna species were recorded at all times during field surveys. This included a conscious focus on suitable areas of habitat during flora surveys, for instance fallen timber was scanned and/or turned for reptiles and mature trees and stags were scanned for roosting birds.

Targeted surveys

Under the BAM, targeted surveys are not required for threatened fauna species that can be reliably predicted to occur at the proposal site based on habitat surrogates (predicted / ecosystem credit species). These species are assumed to be present within certain PCTs, given a certain patch size and condition. Nonetheless these species and their habitats were recorded along with fauna that are not listed as threatened, as a general guide to the condition and biodiversity value of the proposal site.

Targeted, seasonal surveys are required for candidate threatened species entities i.e. species credit species and specific habitat resources such as nesting or roosting habitat for dual credit species. Candidate species credit entities that have a moderate potential to occur at the proposal site (refer to Appendix A) were targeted during these surveys are listed in Table 3-4.

Targeted threatened fauna surveys were undertaken between 14-16 March 2018, with supplementary surveys in September and November 2018. Further detail regarding candidate fauna species targeted during surveys is provided in Section 6.1. No harp netting was conducted as there were no flyways, and candidate bat species would have breeding habitat such as caves (dual credit species) or suitable habitat (species credit only species) at the site.

Targeted fauna survey techniques and effort conducted in the proposal site are summarised in Table 3-5. Survey effort was stratified across the entire proposal site, noting that fauna species are mobile and may rely upon habitat resources in the proposal site even if not directly observed at the proposal site. All fauna observations were recorded on pro forma field data sheets.

Table 3-4 Candidate fauna species credit entities targeted during surveys

Common name	Scientific name	Appropriate survey period	Survey Method/Timing
Australian Bustard	*Ardeotis australis*	All year	Diurnal bird surveys (Mar, Sep, Nov)
Black-breasted Buzzard (breeding)	*Hamirostra melanosternum*	Sep-Nov	Habitat assessment – no breeding habitat present Diurnal bird surveys (March, Sep, Nov)
Koala	*Phascolarctos cinereus*	All year	Scat searches Opportunistic surveys Call playback (Mar, Sep, Nov)

Table 3-5 Targeted fauna survey techniques and effort

Survey technique	Survey effort
Daytime traverses Active reptile/ amphibian searches Active searches for scats and signs	Targeted searches of habitat for 12 person hours Included dedicated searches for any signs of fauna occupation. Included searching for evidence of feeding, foraging and signs of bird presence (such as pellets, whitewash, nests etc.) and other biota (scats, scratchings, diggings, nests etc.). Active searches of woody debris, under rocks and other ground litter were conducted throughout the proposal site targeting frogs and reptiles.
Spotlighting	Two consecutive nights of walked spotlighting transects on 14 and 15 March (3 x person hours each night) were conducted between the hours of 8 – 10 PM. Total effort = 6 person hours.
Call Playback	Two consecutive nights of call playback on 14 and 15 March targeting Koala, Barking Owl and Masked Owl.

Survey technique	Survey effort
Ultrasonic call recording	2 x Anabats positioned in different locations over two nights (12 hours each/per night from 14-16 March 2018). Total effort = 48 hours.
Diurnal bird surveys	4 person hours x 3 days. Total effort = 12 person hours.
Opportunistic fauna surveys	Fauna surveys in conjunction with plot/transects and flora searches on three days in September and one afternoon in November. 2 person hours x 4 days Total effort = 8 person hours.

3.2.4 Aquatic habitat assessment

A rapid aquatic habitat assessment was undertaken along the drainage line in the proposal site. The character and condition of the drainage line was noted.

An assessment of potential habitat for threatened aquatic species was based on the habitat assessments undertaken during the field survey and published habitat preferences of threatened biota. Key fish habitat maps for the area (DPI, 2007) were reviewed and key fish habitat was identified according to the following classifications as detailed in (DPI, 2013):

- Type 1 – highly sensitive fish habitat (includes freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or three metres in length, or native aquatic plants; known or expected protected or threatened fish habitat; and areas of critical habitat).
- Type 2 – moderately sensitive key fish habitat (freshwater habitats other than those defined in Type 1).
- Type 3 – minimally sensitive key fish habitat (ephemeral aquatic habitat not supporting native aquatic or wetland vegetation).
- Not key fish habitat (includes first and second order streams on gaining streams).

3.3 Survey conditions

The field surveys were undertaken between March and November in 2018. Bureau of Meteorology (BOM) records for the survey date are outlined in Table 3-6. These records were taken at Narrabri Airport weather station (054038) located approximately 3 kilometres from the proposal site (BOM, 2018b).

Surveys were undertaken during drought conditions, with much of the state experiencing drought impacts such as low soil moisture levels. The proposal site was very dry at the time of survey, as indicated by the absence of water from natural drainage lines, heavily grazed vegetation, bare sections of earth from vegetation dieback, and relatively low grassland flora species diversity.

Table 3-6 Daily weather observations during the survey period

Date	Minimum temp (Deg Celsius)	Max temp (Deg Celsius)	Rainfall (mm)
14 March 2018	17.4	32.5	0
15 March 2018	15.8	29.6	0
16 March 2018	18.6	35.7	0
19 September 2018	17.4	28.9	0
20 September 2018	8.2	21.3	0
21 September 2018	5.1	24.0	0

Date	Minimum temp (Deg Celsius)	Max temp (Deg Celsius)	Rainfall (mm)
13 November 2018	14.2	32.6	0

3.4 Geographical Information System (GIS) analysis

GIS was used to:

- Plot the proposal site on a high resolution aerial photo base and to map vegetation zones, survey effort, habitat resources and biodiversity values across the site.
- Calculate the extent of native vegetation to be impacted.
- Identify patch sizes relevant to the proposal site.
- Confirm the relevant IBRA bioregion, IBRA subregion and Mitchell Landscape for the site.

Additional GIS analysis was used to plot a 1,500 m buffer area surrounding the site in which site context components were calculated. Native vegetation cover, extent and connectivity were assessed using aerial photography. Air photo interpretation was used to identify and record distinct vegetation patches, determine the broad condition state of vegetation types and the location and extent of vegetated habitat corridors. Aerial photography was examined at scales between 1:2000 and 1:4000.

The buffer area and GIS area calculations were used to enter information about landscape value and to determine the change in Landscape Value score by assessing the impact of the proposal on native vegetation cover and connectivity as well as the patch size.

3.5 BAM calculations

The proposal was assessed according to the methodology presented in the BAM (OEH, 2017a), and the *Biodiversity Assessment Methods Calculator Users Guide* (OEH, 2017b). The BAM credit calculator is a software application that is used to apply the BAM. Data is entered into the BAM credit calculator based on information collected in the desktop assessment, site surveys and from using GIS mapping software.

The BAM credit calculations were performed by Cecilia Phu using credit calculator version 1.2.6.00 (OEH, 2019). Data entered into the BAM calculator is provided in Appendix D. The biodiversity credit report is included in Appendix F.

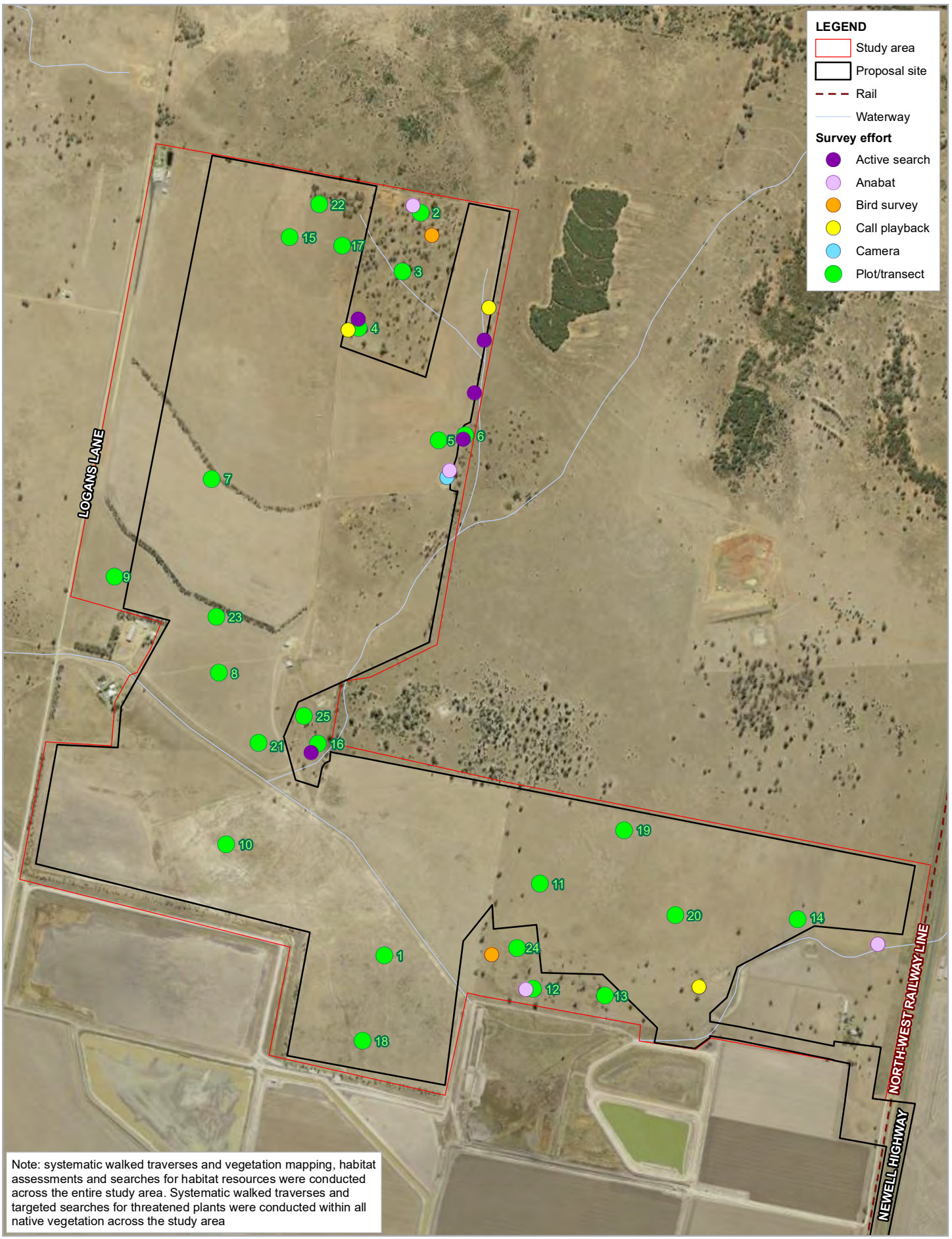
3.6 Staff qualifications

This BDAR was prepared by Kirsten Crosby (accredited assessor number BAAS17011) and Cecilia Phu (accredited assessor number BAAS17058) in accordance with the BAM. A technical review of the report and credit calculations was undertaken by Ben Harrington (accredited assessor number BAAS17023). Staff qualifications are presented in Table 3-7.

Table 3-7 GHD ecology staff and qualifications

Name	Position / Project Role	Qualifications	Relevant Experience
Kirsten Crosby	Senior Ecologist (fauna) Desktop assessment, site surveys, reporting	BSc (Zoology), PhD Accredited BAM Assessor	13+ years
Cecilia Phu	Senior Ecologist (flora) Site surveys, reporting	BSc (Honours) Accredited BAM Assessor	11+ years
Arien Quin	Senior Ecologist (flora) Site surveys	BA, BSc Accredited BAM Assessor	11+ years

Name	Position / Project Role	Qualifications	Relevant Experience
Philippa Fagan	Ecologist Site surveys	BBiod&Cons, MEnv&Bus Mgt Accredited BAM Assessor	4+ years
Bridie Halse	Ecologist Site surveys	BEnvs	2+ years
Ben Harrington	Technical Director – Technical review	BSc, MSc Accredited BAM Assessor	15+ years



Note: systematic walked traverses and vegetation mapping, habitat assessments and searches for habitat resources were conducted across the entire study area. Systematic walked traverses and targeted searches for threatened plants were conducted within all native vegetation across the study area

Paper Size ISO A4

0 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Engie
Silverleaf Narrabri Solar Farm
Biodiversity Assessment

Survey effort

Project No. 21-26998
Revision No. -
Date 02/05/2019

FIGURE 3-1

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Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

4. Landscape context

The BAM requires the assessment of landscape features to help describe the biodiversity values of the proposal site and assess the impacts of the proposal. Landscape features relevant to the BAM calculations are shown on Figure 4-1, discussed below and summarised in Table 4-1.

4.1 Location

The proposal site is located about four kilometres north-west of Narrabri, within the Narrabri Shire Council local government area. The proposal site consists of two rural properties located between Newell Highway in the east and Logans Lane in the west. The proposal site is predominantly located within the following lots:

- 330 Logans Lane – Lots 21 to 23 of DP 1174848 (referred to as the Logans Lane property in the EIS).
- 12461 Newell Highway – Lot 2 DP 586990 (referred to as the Newell Highway property in the EIS).

The proposal site also includes the corridor for a transmission line between the eastern side of the solar farm site and the substation located about 3.7 kilometres to the south on Stoney Creek Road.

4.2 Existing land uses

The proposal site has an area of approximately 450 hectares and is currently used for agricultural purposes, with the primary use being grazing with some cropping. The site contains three residential dwellings with two located on the Logan's Lane property and one on the Newell Highway property. Existing property access points are available adjacent to each of the dwellings from either Logans Lane or the Newell Highway. The Logans Lane property also has a number of sheds, some are positioned around the dwellings and some located east of the dwellings.

A low voltage transmission line runs through the southern part of the Logans Lane property and provides power to the dwellings on this property and also to the private airstrip (as discussed below). The alignment of this transmission line is shown in Figure 1-1.

A small private airstrip is located adjacent to the north-west corner of the solar farm site and is used by small crop dusting aircraft. This air strip is located on a separate property and does not form part of the properties on which the proposal is to be constructed.

4.3 Climate

In Narrabri, the climate is warm and temperate. About 658 mm of precipitation falls annually, with lowest rainfall in September and highest in January. January is also the warmest month with an average of 26.4 °C and maximum of 33.8 °C, while July is the coldest month of the year with an average of 10.6 °C and minimum of 3.8 °C.

4.4 Landscape features

The study area is in the Brigalow Belt South IBRA bioregion and occurs within the Liverpool Plains IBRA subregion (IBRA version 7.0). Landscape features within the study area as prescribed in Section 4 of the BAM are summarised in Table 4-1 and shown in Figure 4-1.

Table 4-1 Landscape features

Landscape feature	Study area
IBRA bioregions and subregions	Brigalow Belt South Bioregion / Liverpool Plains subregion
NSW landscape regions (Mitchell landscapes)	Kaputar Slopes and Liverpool Alluvial Plains (see section 4.4.1 below).
Local Government Area (LGA)	Narrabri
Rivers and streams	A predominantly 2nd order stream runs across the site. This channel runs through the site from Logans Lane to the property to the south where gates are located to control water flow. This drainage line is not mapped as key fish habitat (DPI, 2007).
Important and local wetlands	No wetlands occur at the proposal site, on adjacent lands or downstream.
Connectivity features	Vegetation at the site provides limited connectivity with areas outside the site.
Areas of geological significance and soil hazard features	There are no karst, caves, crevices, cliffs or other areas of geological significance located within the proposal site or buffer area surrounding the site.
Areas of outstanding biodiversity value	No declared areas of outstanding biodiversity value occur in or near the proposal site
Landscape features listed in the SEARs	No additional landscape features are listed in the SEARs

4.4.1 Mitchell landscape

The proposal site is located within two Mitchell soil landscapes: (1) Kaputar Slopes, and (2) Liverpool Alluvial Plains. The descriptions for these soil landscapes are reproduced below from DECC (2008a):

> **Kaputar Slopes**: *Lower slopes of the Kaputar volcanic complex with radiating finger-like ridges capped by basalt over lower Permian and Triassic quartz sandstone, lithic sandstone, silty sandstone, conglomerate and thin coal measures. General elevation 300 to 500m, local relief 80m. Shallow stony red-brown loam and clay loam in uniform profiles on basalt, yellow and yellow-brown texture-contrast profile on sandstone, deep black earths in lowest valleys. Kurrajong (*Brachychiton populneus*), yellow box (*Eucalyptus melliodora*), white box (Eucalyptus albens), rough-barked apple (*Angophora floribunda*) and Blakely's red gum (*Eucalyptus blakelyii*) on lower slopes and valleys.*
>
> **Liverpool Alluvial Plains**: *Quaternary alluvial plains and outwash fans derived from Tertiary basalts. Permian and Triassic quartz sandstones with minor basalt caps. Undulating hills and sloping plains with alluvial channels and floodplains. General elevation 300 to 350m, local relief <10m. Extensive black earths on low angle slopes. Deep black and brown cracking clays, alluvial soils and red or brown texture-contrast soils on slopes below sandstone. Open grasslands of plains grass (*Austrostipa aristiglumis*),* Panicum *sp., windmill grass (*Chloris truncata*) and blue grass (*Dichanthium sericeum*) on black earths with occasional myall (*Acacia pendula*), white box (*Eucalyptus albens*), yellow box (*Eucalyptus melliodora*), bimble box (*Eucalyptus populnea*) and wilga (*Geijera parviflora*). River red gum (*Eucalyptus camaldulensis*) along streams.*

The soils, vegetation and landform across the majority of the proposal site is well-matched to the Liverpool Alluvial Plains soil landscape. It is characterised by alluvial and basalt derived soils on a relatively flat landscape and supports vegetation containing *Eucalyptus populnea* (Poplar Box, also referred to as Bimble Box), *Geijera parviflora* (Wilga) and *Casuarina cristata* (Belah), which are all species typical of heavier, dark soils such as alluvial clays and basalts.

4.5 Determining site context

To determine site context as required under Section 4.3 of the BAM, an assessment of native vegetation cover and patch size has been undertaken and is outlined below.

4.5.1 Native vegetation cover

Native vegetation cover (woody and non-woody) was assessed on the proposal site and within a 1,500 metre buffer area surrounding the outside edge of the boundary of the proposal site. Aerial photography was examined at scales between 1:2000 and 1:4000. The percent native vegetation cover within the 1,500 metre buffer area was assessed to be 8.6% and includes:

- Native vegetation types
- Regrowth native vegetation

Areas that were excluded include:

- Derived or modified native grasslands
- Cleared areas
- Non-native cropping land
- Dams, ponds and other waterbodies
- Buildings

The identification of native vegetation (including derived native grasslands) in the 1,500 m buffer area was based on review of the Namoi CMA vegetation extant map, 2013 VIS-ID 4028 (EcoLogical, 2013), in combination with aerial photograph interpretation and ground-truthing during field surveys.

Table 4-2 Native vegetation cover

Native vegetation cover	Values
Total assessment area (1,500 m buffer area)	4,063 (nearest whole hectare)
Area of native vegetation cover (woody and non-woody)	349 (nearest whole hectare)
% native vegetation cover	8.6%
Cover class	0-10%

4.5.2 Patch size

Patch size is defined under the BAM (OEH, 2017a) as an area of intact native vegetation that:

- Occurs on the development site (i.e. proposal site).
- Includes native vegetation that has a gap of less than 100 m from the next area of moderate to good native vegetation (or ≤ 30 m for non-woody ecosystems).

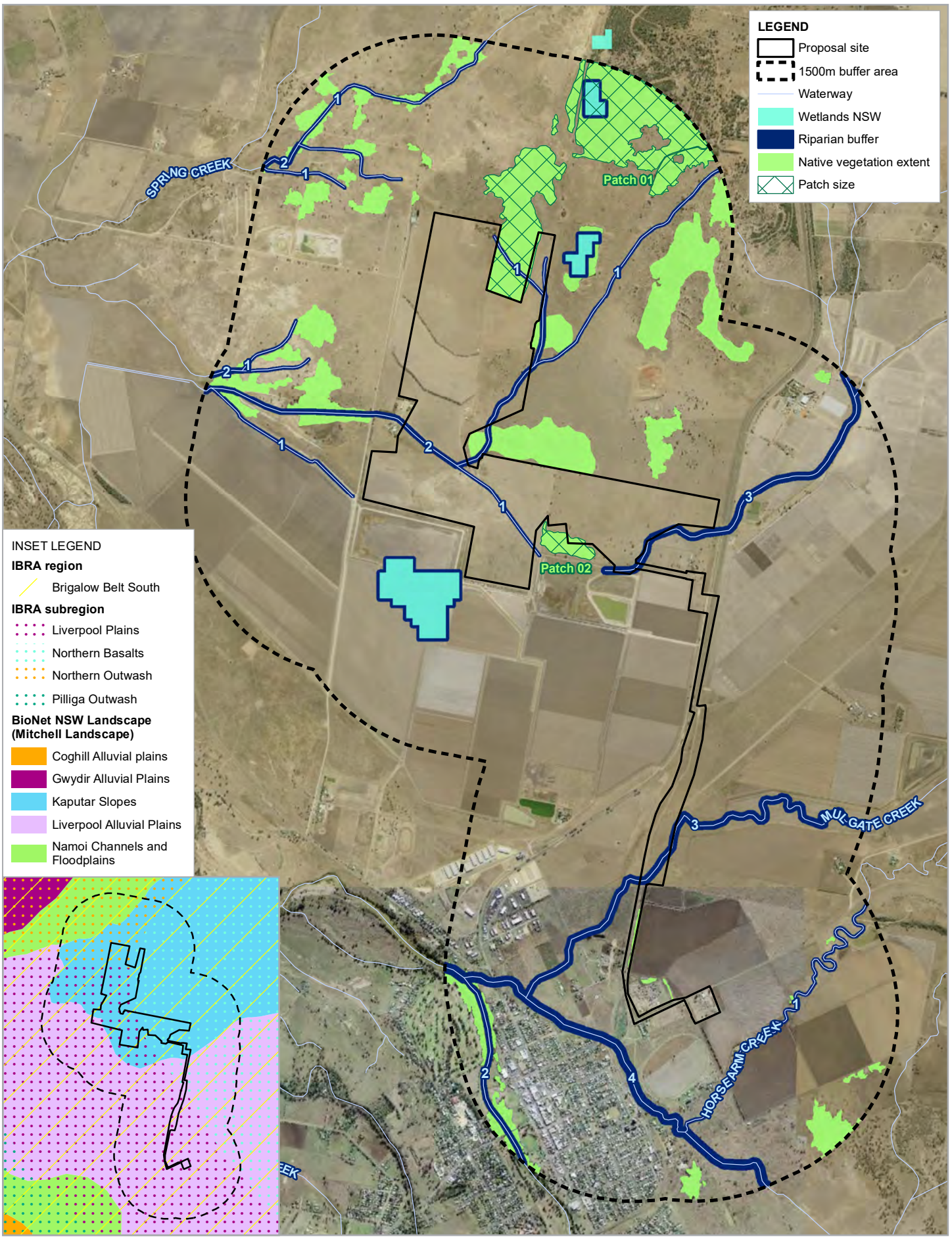
Intact native vegetation must contain all structural layers (strata) characteristic of the PCT.

Patch size may extend onto adjoining land that is not part of a development site or a stewardship site. Patch size area is assigned to each vegetation zone as a class, being < 5ha, 5-24 ha, 25-100 ha or ≥ 100 ha. For the purposes of the calculations in the BAM and for this assessment, the total patch size has not been calculated outside of the 1,500 m buffer area, given the highest class was already reached within the buffer area.

Two different patches were identified as occurring within the proposal site and extending beyond the proposal site (Table 4-3; see Figure 4-1). These patch size polygons are associated with vegetation zones in the proposal site that have a near-intact woodland structure representative of the intact form of the PCT. Derived native grassland vegetation zones in the proposal site have a patch size of 0 (see Table 5-2).

Table 4-3 Patch size

Patch	Size (nearest whole hectare)	Patch class
1	119	>100 ha
2	7	5-24 ha



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Engie
Silverleaf Narrabri Solar Farm
Biodiversity Assessment

Landscape features

Project No. 21-26998
Revision No. -
Date 02/05/2019

FIGURE 4-1

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Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Wetlands & inset data - OEH. Created by:jrprice

5. Vegetation

5.1 Flora species

A total of 143 species from 36 families were identified within the proposal site during the field survey, including 104 native species and 39 exotic species (Appendix B). The most species diverse families recorded were Poaceae (42 species, 30 native and 12 exotic), Asteraceae (14 species, eight native and six exotic), Chenopodiaceae (13 species all native) and Malvaceae (10 species, eight native and two exotic).

No threatened flora species were identified within the proposal during the field survey. The proposed transmission easement was inspected during vehicular and pedestrian traverses along roadsides. This inspection indicated that this land contains cleared cultivated lands and exotic grassland. No native vegetation would be impacted by the construction of the transmission line.

5.1.1 Priority and high threat species

One priority weed, *Lycium ferocissimum* (African Boxthorn) listed in the North West region (which includes the Narrabri local council area) was recorded within the proposal site during the field survey. The state and regional objective for this priority weed under the *Biosecurity Act 2015* is to protect priority assets. As such, the applicable mandatory measure for this species under Division 8, Clause 33 of the *Biosecurity Regulation 2017* is the restriction of sale or import of the species into the state (i.e. 'prohibition on dealings'). *Opuntia stricta* (Prickly Pear) is not a priority weed for the North West region but does carry a state objective of asset protection and so the same mandatory measure (i.e. prohibition on dealings) also applies to this species.

In addition, the general biosecurity duty also applies to all weed species, including African Boxthorn and Prickly Pear. The recommended measures to demonstrate compliance with the general biosecurity duty are (NWLLS, 2017):

- Land managers should mitigate the risk of new weeds being introduced to their land.
- Land managers should prevent seed and propagules spreading from their land.
- Land managers reduce the impacts of the plant on priority assets.

Lycium ferocissimum (African Boxthorn) and *Opuntia stricta* (Prickly Pear) are also Weeds of National Significance declared under the National Weed Strategy, which recommends that their spread should be minimised to protect priority assets.

The following exotic species recorded in the proposal site are classified as high threat weeds for the purposes of the BAM:

- *Carthamus lanatus* (Saffron Thistle)
- *Vachellia farnesiana* (Mimosa Bush)
- *Chloris gayana* (Rhodes Grass)
- *Paspalum dilatatum* (Paspalum)
- *Paspalum urvillei* (Vasey Grass)
- *Lycium ferocissimum* (African Boxthorn)

5.2 Vegetation in the region

The Narrabri region is located on the Liverpool Plains, a broad Quaternary alluvial plain bounded by volcanic ranges (Nandewar Ranges and Mt Kaputar to the east and the Warrumbungles to the west). Located at the confluence of several subregions within the Brigalow Belt South (including Liverpool Plains, Northern Outwash, and Northern Basalt sub-bioregions), the geology of the region features Tertiary and Quaternary alluvial fans and basalt outwashes. Soils are characterised by brown clays, red loams, and red or brown texture contrast soils on slopes below sandstone (OEH, 2015). Low angle slopes feature rich black earths (OEH, 2015).

The region supports a variety of vegetation types, from semi-arid woodlands to grassy woodlands and grasslands, to dry open forests (OEH, 2016a). Typical species on the fertile basalt and alluvial flats include *Eucalyptus populnea* (Poplar Box), *E, pilligaensis* (Pilliga Box), *E. moluccana* (Grey Box), *Casuarina luehmannii* (Bulloak), *C. cristata* (Belah), *Acacia harpophylla* (Brigalow), and *Callitris glaucophylla* (White Cypress Pine), with *Eucalyptus camaldulensis* (River Red Gum) along creeks and streams (OEH, 2016a). Shrub species commonly found on the heavier alluvial clays and basalts include *Geijera parviflora* (Wilga), *Eremophila mitchellii* (Budda), *Alectryon oleifolius* (Rosewood) and *Atalaya hemiglauca* (Whitewood) (OEH, 2016a). Native grasslands are commonly dominated by *Austrostipa aristiglumis* (Plains Grass), *Panicum* species, *Chloris* species and *Dichanthium* species on black earths (OEH, 2016a). Sandy soils (such as sandy outwash areas to the south of Narrabri) and skeletal sandy ridgetops support ironbark and *Callitris* open forests (OEH, 2016a).

Narrabri is broadly situated on the floodplains of the Namoi River and has a long agricultural history, with agricultural settlement of the broader Liverpool Plains taking place in the late 1820s (OEH, 2016b). From pastoral farming to crop farming, Narrabri is a recognised agricultural centre supporting industries such as cotton, wheat, beef and lamb (Lawrence Consulting, 2012). As such, much of the original vegetation in the region has been cleared to support agriculture, with remaining intact or remnant woodland vegetation on the flats occurring as scattered, diffuse patches within a predominantly grassland landscape. Larger areas of intact remnant vegetation remain in less fertile areas, namely thin and sandy soils in the outwash and sandstone ridgetop landscapes.

5.3 Vegetation at the proposal site

5.3.1 Native vegetation extent

The majority of the proposal site has been cleared and used for agriculture (sheep and cattle grazing). The dominant vegetation is represented by native and exotic pastures. A large proportion of the northern part of the proposal site has been cultivated and is comprised of improved pasture dominated by exotic species. The southern portion of the proposal site has been cleared but supports derived native grasslands dominated by a few native grass species. A number of windbreaks have been planted in the proposal site and are comprised of species that are not indigenous to the Narrabri region.

The extent of native vegetation mapped within the proposal site is approximately 262 ha and comprises remnant native woodland patches and derived native grassland (see Table 5-1). There is approximately 237 ha of non-native vegetation in the proposal site comprising cropping, exotic pastures or exotic grassland, and planted windbreaks.

5.3.2 Plant community types

Several small patches of remnant woodland are present in the proposal site; these patches have been highly modified as a result of agricultural activities, with much of the understorey affected by grazing activities. These remnant woodland patches have been mapped and described in the proposal site in accordance with the BAM. The remnant woodland patches correspond to three PCTs:

- PCT 35 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion.
- PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions.
- PCT 397 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion.

The surrounding derived native grasslands that occur at the proposal site are continuous with the understories of the remnant woodland patches and are considered to be derived from the clearing of the original woodland PCT. For this reason, different areas of derived native grassland have been assigned to the woodland PCTs that would have originally occurred. In determining the original woodland PCT that would have occurred at a location, consideration was given to nearby woodland patches (within and outside of the proposal site) and any scattered paddock trees present.

One of the PCTs identified within the proposal site (PCT 35 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion) comprises a local occurrence of the endangered ecological community (EEC) listed under the BC Act as Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions. It is also commensurate with the EEC listed under the EPBC Act as Brigalow (*Acacia harpophylla*) dominant and co-dominant (see Figure 6-1). The proposal site has been redesigned to avoid the areas of this community in moderate condition.

The vegetation types (including PCTs, derived grassland and non-native or non-indigenous vegetation) mapped within the study area are summarised in Table 5-1. Within the study area, the vegetation zones identified within the proposal site are detailed in Table 5-2 and shown on Figure 5-1.

Table 5-1 Vegetation types in the study area

Vegetation type	BC Act status	EPBC Act status	Extent in study area (ha)
PCT 35 Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions - endangered ecological community	Brigalow (*Acacia harpophylla* dominant and co-dominant) - endangered ecological community	3.94
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	Not listed	Not listed	6.83
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	Not listed	Not listed	18.52

Vegetation type	BC Act status	EPBC Act status	Extent in study area (ha)
PCT 35 Derived Native Grasslands	Does not conform to endangered ecological community final determination	Does not meet the key diagnostic characteristics in the listing advice	36.14
PCT 55 Derived Native Grasslands	Not listed	Not listed	159.78
PCT 397 Derived Native Grasslands	Not listed	Not listed	36.98
Planted vegetation	Not listed	Not listed	10.95
Cropped/predominantly exotic grassland	Not listed	Not listed	226.13

Table 5-2 Vegetation zones within the proposal site

Vegetation zone	Plant community type (OEH, 2018c)	PCT ID	Condition	Area (ha)	Patch size (ha)	BC Act Status	EPBC Act Status	Notes
n/a	Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion	35	Moderate	0	9	EEC/SAII	EEC	Proposal site boundary was revised to avoid this zone and hence impacts on SAII
n/a	Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion	35	Moderate	0	31	EEC/SAII	EEC	Proposal site boundary was revised to avoid this zone and hence impacts on SAII
1	Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion	35	Derived grassland	26.81	0	Does not meet EEC condition criteria	Does not meet EEC condition criteria	-
2	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	55	Moderate	0.69	7	Not listed	Not listed	-
3	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	55	Derived grassland	121.96	0	Not listed	Not listed	-
4	Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	397	Moderate	1.15	119	Not listed	Not listed	-
5	Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	397	Derived grassland	32.69	0	Not listed	Not listed	-

5.3.3 Vegetation profiles

Description profiles of the PCTs present in the study area are provided in Table 5-3, Table 5-4 and Table 5-5. Non-native vegetation is described in Table 5-6.

Table 5-3 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion

Attribute	Description
Vegetation Formation	Semi-arid Woodlands (grassy sub-formation)
Vegetation Class	Brigalow Clay Plain Woodlands
PCT ID	35
PCT % Cleared	90%
Plots sampled	6, 16, 25 (woodland form, vegetation zone 1 and 2) 8, 9, 21, 23 (derived native grassland form, vegetation zone 3)
Floristic description	This community is a low open woodland dominated by *Acacia harpophylla* (Brigalow) with a sparse understorey characterised by low abundances of saltbush species and native grasses. The canopy layer includes occasional occurrences of *Eucalyptus populnea* (Poplar Box) and *E. pilligaensis* (Pilliga Box). The low shrub layer is characterised by *Enchylaena tomentosa* (Ruby Saltbush), *Sclerolaena birchii* (Galvanised Burr), *S. muricata* (Black Rolypoly), *Dysphania pumilio* (Small Crumbweed), *Rhagodia spinescens* (Thorny Saltbush), *Einadia* spp. and *Portulaca oleracea* (Pigweed). The ground layer was very sparse at the time of survey but the dominant species included *Enteropogon acicularis* (Curly Windmill Grass), *Urochloa panicoides** (Urochloa Grass), *Tribulus terrestris** (Caltrop) and *Boerhavia dominii* (Tarvine).
Justification for PCT selection	Although the occurrence of this PCT within the study area is highly degraded and exhibits low native species diversity, it is generally consistent with the attributes described for this PCT in the BioNet Vegetation Classification database (landform position, dominant canopy, soil types, location).
Conservation significance	Woodland occurrences of this community within the study area are consistent with the final determination for the EEC *Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains* (BC Act). The woodland occurrences are also consistent with the EEC *Brigalow (*Acacia harpophylla *dominant and co-dominant)* (EPBC Act). The derived native grassland occurrences of this PCT are not consistent with the EECs listed under the BC Act and EPBC Act.
Photograph	

Attribute	Description
	Photograph 1 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion (remnant woodland)  Photograph 2 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion (derived native grassland)

Table 5-4 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions

Attribute	Description
Vegetation Formation	Semi-arid Woodlands (grassy sub-formation)
Vegetation Class	North-west Floodplain Woodlands
PCT ID	55
PCT % Cleared	83%
Plots sampled	12, 13, 24 (woodland form, vegetation zone 4) 1, 10, 11, 14, 18, 20 (derived native grassland form, vegetation zone 5)
Floristic description	This community is a tall woodland dominated by *Casuarina cristata* (Belah) and *Eucalyptus pilligaensis* (Pilliga Box) with a sparse understorey characterised by low abundances of saltbush species and native grasses. Although it is similar to PCT 35, it differs from PCT 35 in that it does not support any occurrences (regrowth or otherwise) of *Acacia harpophylla* (Brigalow). The low shrub layer is characterised by *Sclerolaena muricata* (Black Rolypoly), *Solanum esuriale* (Quena), *Sclerolaena birchii* (Galvanised Burr), *Sclerolaena divaricata* (Tangled Copperburr), *Salsola australis* and *Alectryon diversifolius* (Scrub Boonaree). The groundcover is very sparse and is characterised by low covers of native and exotic grasses and forbs, including *Enteropogon acicularis* (Curly Windmill Grass), *Chloris truncata* (Windmill Grass), *Hordeum leporinum** (Barley Grass), *Rapistrum rugosum** (Turnip Weed), *Medicago minima** (Woolly Burr Medic), *Urochloa panicoides* (Urochloa Grass), *Austrostipa aristiglumis* (Plains Grass), *Panicum effusum* (Hairy Panic) and *Sporobolus caroli* (Fairy Grass).

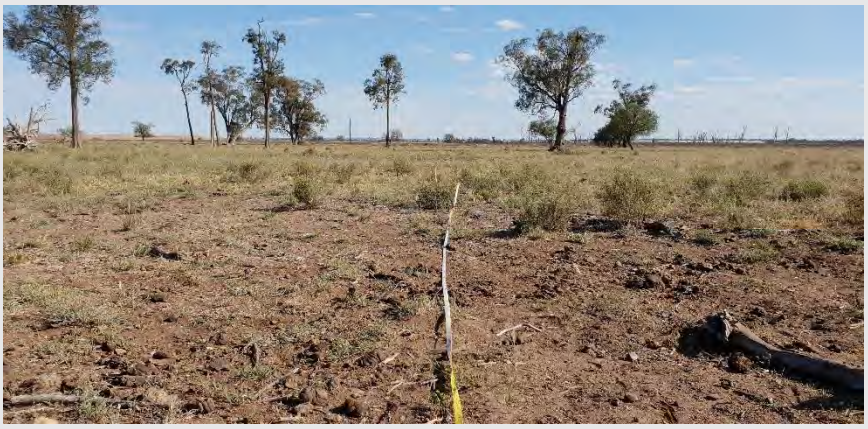
Attribute	Description
Justification for PCT selection	Although the occurrence of this PCT within the proposal site is highly degraded and exhibits low native species diversity, it is generally consistent with the attributes described for this PCT in the BioNet Vegetation Classification database (landform position, dominant canopy, soil types, location).
Conservation significance	Not listed as a threatened ecological community under BC Act and EPBC Act.
Photograph	 Photograph 3 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (remnant woodland)  Photograph 4 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (derived native grassland)

Table 5-5 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion

Attribute	Description
Vegetation Formation	Dry Sclerophyll Forests (Shrub/grass sub-formation)
Vegetation Class	Pilliga Outwash Dry Sclerophyll Forests
PCT ID	397
PCT % Cleared	45%
Plots sampled	2, 3, 4 (woodland form, vegetation zone 6) 15, 17, 19, 22 (derived native grassland form, vegetation zone 7)

Attribute	Description
Floristic description	This community is a tall woodland dominated by an open ironbark and box canopy with a sparse shrub layer and a grassy ground layer. The canopy is dominated by *Eucalyptus melanophloia* (Silver-leaved Ironbark) and *E. populnea* (Poplar Box). The shrub layer includes *Alectryon oleifolius* (Western Rosewood), *Myoporum acuminatum* (Boobialla), *Eremophila mitchelli* (Budda) and *Geijera parviflora* (Wilga), with a low shrub layer characterised by *Dysphania pumilio* (Small Crumbweed), *Sclerolaena birchii* (Galvanised Burr), *Sclerolaena muricata* (Black Rolypoly), *Abutilon leucopetalum*, *A. oxycarpum* (Straggly Lantern-bush) and *Maireana microphylla* (Small-leaf Bluebush). The ground layer is dominated by mixed grasses and forb in low abundances: *Enteropogon acicularis* (Curly Windmill Grass), *Paspalidium constrictum* (Knottybutt Grass), *P. jubiflorum* (Warrego Grass), *Aristida ramosa* (Purple Wiregrass), *Chloris truncata* (Windmill Grass), *Austrostipa aristiglumis* (Plains Grass), *A. ramosissima* (Stout Bamboo Grass), *Boerhavia dominii* (Tarvine), *Gomphrena celosioides** (Gomphrena Weed), *Chrysocephalum semipapposum* (Clustered Everlasting), *Solanum esuriale* (Quena), *Vittadinia cuneata* (Fuzzweed), *Calotis cuneifolia* (Purple Burr-daisy), *Einadia nutans* (Climbing Saltbush), *E. hastata* (Berry Saltbush), *Sida corrugata* (Corrugated Sida), *Carex inversa* and *Portulaca oleracea* (Pigweed).
Justification for PCT selection	Although the occurrence of this PCT within the proposal site is highly degraded and exhibits low native species diversity, it is generally consistent with the attributes described for this PCT in the BioNet Vegetation Classification database (landform position, dominant canopy, soil types, location).
Conservation significance	Native vegetation. Does not comprise an occurrence of a threatened ecological community.
Photograph	 Photograph 5 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion (remnant woodland)

Attribute	Description
	 Photograph 6 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion (derived native grassland)

Table 5-6 Non-native vegetation

Attribute	Description
Vegetation Formation	n/a
Vegetation Class	n/a
PCT ID	n/a
PCT % Cleared	n/a
Plots sampled	5, 7
Floristic description	Non-native vegetation in the study area is dominated by exotic grasslands comprising pastures or cropping for pasture, and roadside or trackside grassy swales. The dominant grass species recorded within exotic grassland was *Urochloa panicoides* (Urochloa Grass). Along roadsides, other common exotic species include *Paspalum dilatatum* (Paspalum), *Plantago lanceolata* (Lamb's Tongue) and *Modiola caroliniana* (Red-flowered Mallow). Other frequently recorded species within exotic grassland also comprised exotic plants and included *Polygonum aviculare* (Wireweed), *Conyza bonariensis* (Flaxleaf Fleabane), *Sida rhombifolia* (Paddy's Lucerne), *Centaurea solstitialis* (St Barnaby's Thistle) and *Tribulus terrestris* (Cat-head).
Justification for PCT selection	n/a
Conservation significance	Non-native vegetation. Does not comprise an occurrence of a threatened ecological community.

Attribute	Description
Photograph	 Photograph 7 Non-native vegetation (cropped/ predominantly exotic grassland)

5.3.4 Groundwater dependent ecosystems

The *NSW State Groundwater Dependent Ecosystems Policy* defines groundwater dependent ecosystems (GDEs) as ecosystems which have their species composition, and their natural ecological processes determined by groundwater (DLWC, 2002). Ecosystems vary dramatically in the degree of dependency of groundwater, from having no apparent dependence through to being entirely dependent on it (DLWC, 2002).

Dependence (or interaction) of the vegetation communities identified within the proposal site on groundwater was determined by searching the Atlas of GDEs (BOM, 2018a). This Atlas predicts the occurrence of groundwater dependent ecosystems and ecosystems that potentially use groundwater. It shows ecosystems that interact with the subsurface expression of groundwater (including vegetation ecosystems) or the surface expression of groundwater (such as rivers and wetlands. The Atlas also shows the likelihood that landscapes are accessing water in addition to rainfall, such as soil water, surface water or groundwater.

Native vegetation within the proposal site is mapped as having a low potential for being reliant on the subsurface presence of groundwater (BOM, 2018a). No aquatic GDEs are present.

5.4 Fauna habitat resources

5.4.1 Fauna species

A total of 50 species of fauna were recorded during the field survey. These included 30 bird species (including three introduced species), 15 mammal species (including three introduced species and 11 microbat species), three reptile species and two frog species (see Appendix B).

5.4.2 Fauna habitats

Fauna habitats comprise small patches of highly modified woodland and large areas of derived grassland or cropped land. There are no caves or culverts, cliff lines, substantial rock outcrops, wetlands or waterbodies in the proposal site. Fauna habitats present at the site are detail in Table 5-7 to Table 5-9.

Table 5-7 Fauna habitats: grassland with scattered trees

Grassland with scattered paddock trees	
Description	Dominated by exotic crop species (e.g. Oats) or derived native grassland. Occasional isolated paddock trees or small groups of paddock trees are present (see Photograph 8). Paddock tree species comprise Narrow-leaved Grey Box (*Eucalyptus pilligaensis*) and occasional White Cypress Pine (*Callitris glaucophylla*). Many of the Narrow-leaved Grey Box were hollow-bearing.
Fauna recorded	A number of bird species typically associated with open grazing country were recorded. Galahs (*Eolophus rosiecapillus*), Red-rumped Parrot (*Psephotus haematonotus*) and Eastern Rosella (*Platycercus eximius*) were recorded, often near hollows. The introduced Common Myna (*Sturnus tristis*) and Common Starling (*Sturnus vulgaris*) are likely to compete with native bird species for hollows. Small flocks of the Noisy Miner (*Manorina melanocephala*) were observed. Occasional ravens (*Corvus* spp.) and Pied Butcherbirds (*Cracticus nigrogularis*) were seen perching on fences and powerlines. Flocks of Welcome Swallows (*Hirundo neoxena*) were seen foraging above and in the pasture and grassland. Whistling Kites (*Haliastur sphenurus*) were observed at a nest in a paddock tree. The introduced Brown Hare (*Lepus capensis*) and Fox (*Vulpes vulpes*), and Eastern Grey Kangaroo (*Macropus giganteus*) were observed in open paddocks. A range of microbats were recorded and would forage over the proposal site. Potential roosting habitat is present in hollow trees. South-eastern Morethia Skinks (*Morethia boulengeri*) and Ragged Snake-eyed Skinks (*Cryptoblepharus pannosus*) were seen basking on fallen timber, and Tree Dtellas (*Gehyra variegata*) were observed on paddock trees while spotlighting.
Threatened species	A Black Falcon (*Falco subniger*) was observed roosting in a leafy paddock tree.

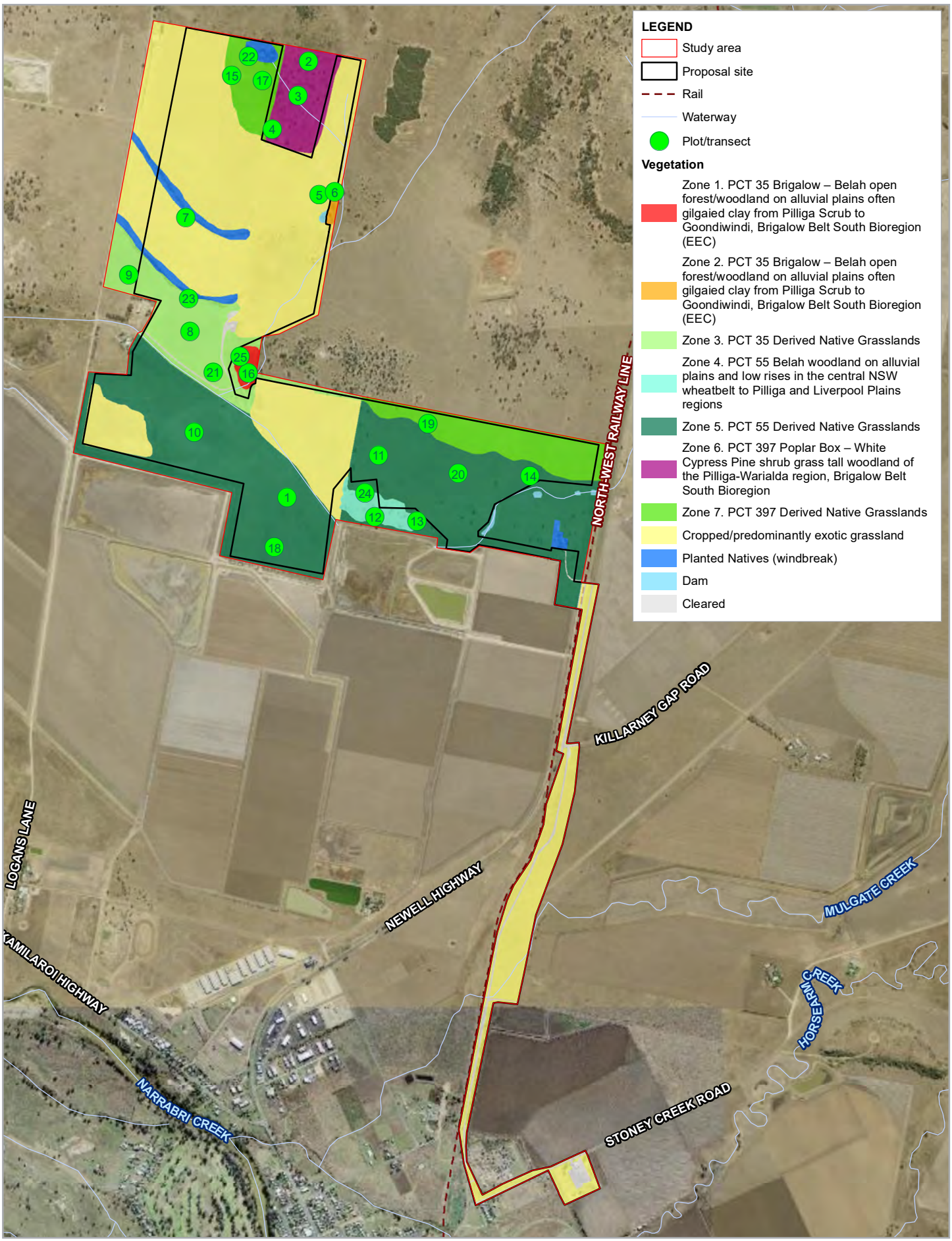
Grassland with scattered paddock trees	
	
	Photograph 8 Predominantly cleared paddock with occasional paddock trees and fallen timber

Table 5-8 Fauna habitats: woodland patches

Roadside vegetation	
Description	Woodland vegetation is present in small patches within the study area. This vegetation comprises a canopy of eucalypts and Cypress Pine, with a sparse understory and grassy ground layer. A higher density of leaf litter and fallen timber is present in these areas. Hollow-bearing trees are also present. These are not considered breeding habitat for large owls and cockatoos as they are not located along riparian corridors. There is some connectivity to larger patches of vegetation in adjacent properties, however vegetation is generally fragmented.
Fauna recorded	A number of woodland bird species were recorded in these areas but not in adjacent paddocks. These included the Apostlebird (*Struthidea cinerea*), Pied Butcherbird (*Cracticus torquatus*) and White-winged Chough (*Corcorax melanorhamphos*). A Barn Owl (*Tyto javanica*) was observed flying into woodland. Many of the bird species recorded in the cleared agricultural land were also observed in the woodland patches.
Threatened species	The Grey-crowned Babbler was recorded in the patch of Poplar Box – White Cypress Pine woodland in the northern portion of the site. A number of nests were also recorded in this area. The Little Pied Bat (*Chalinolobus picatus*) and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) were recorded in small woodland patches using Anabat analysis. These species could roost and breed in hollow-bearing trees at the site. The woodland patches constitute potential Koala (*Phascolarctos cinereus*) habitat , however this habitat is unlikely to be important habitat for the species. Local records are concentrated around the Pilliga, with none near the proposal site. Koalas may occur on rare occasions, but would be unlikely to breed at the site. No evidence of the Koala was recorded during surveys.
	
	Photograph 9 Native woodland

Table 5-9 Fauna habitats: farm dams and waterbodies

Farm dams	
Description	Two farm dams are present in the proposal site. These had limited emergent vegetation and are used as watering points by sheep (see Photograph 10 and Photograph 11). Small, undefined drainage lines are also present, leading to and from these dams. These tended to be depressions in the grassland, with occasional sedges present. No defined channel, standing water or pools are present. No woody debris or snags are present. A number of tanks with pumps are also present.
Fauna recorded	Common frogs such as the Spotted Grass Frog (*Limnodynastes tasmaniensis*) and Broad-palmed Frog (*Litoria latopalmata*) were observed at the dams. Tadpoles were observed in puddles adjacent to the tank. Apostlebirds and Magpie-larks were recorded at the dams. The dams and tanks would provide a source of water for other birds, microbats and macropods. Microbats are also likely to forage for insects above the dams, and a variety of microbats were recorded at these locations.
Threatened species	The Eastern Freetail Bat (*Mormopterus norfolkensis*), Little Pied Bat (*Chalinolobus picatus*) and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) were recorded at dams in paddocks using Anabat call analysis. These species could roost and breed in paddock trees at the site.
	
	Photograph 10 Farm dam
	
	Photograph 11 Tank



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Engie
Silverleaf Narrabri Solar Farm
Biodiversity Assessment

Vegetation

Project No. 21-26998
Revision No. -
Date 02/05/2019

FIGURE 5-1

N:\AU\Orange\Projects\21\26998\GIS\Maps\Deliverables\Biodiversity\21_26998_Z012_Biodiversity_Vegetation.mxd

Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

6. Conservation significance

6.1 Identification of threatened species under the BAM

6.1.1 Predicted threatened species (ecosystem credit entities)

Based on the bioregional context for the assessment and the PCTs, patch size, vegetation cover and habitat resources present at the proposal site, the BAM calculator generates a list of threatened fauna species that are predicted to utilise the proposal site (i.e. potential 'predicted threatened species', or potential 'ecosystem credit entities'). The potential for these predicted threatened species to occur within the site were further refined based on the desktop assessment, habitat resources observed during field surveys and the knowledge and experience of the assessor.

The suite of 'confirmed' predicted threatened species associated with ecosystem credits required for the proposal site, and with relevant habitat resources present on the site, are listed in Table 6-1. For each confirmed predicted threatened species, the vegetation zone association is provided. Targeted surveys are not required under the BAM for these species as they are assumed to be present. It is noted that a number of these species were recorded in the study area during surveys.

It should be noted that several of these species would only occur in the woodland form of the PCTs present at the proposal site and are only associated with ecosystem credits generated for impacts to woodland vegetation zones. Notably many threatened species of woodland birds would only occur in vegetation with canopy vegetation, as part of relatively extensive patch and/or with habitat resources such as abundant fallen woody debris (see Appendix A for further detail and justification).

Table 6-1 Confirmed predicted threatened species

Common name	Scientific name	Vegetation zone association
Little Pied Bat	*Chalinolobus picatus*	35-Brigalow - Belah open forest / woodland 55 - Belah woodland on alluvial plains and low rises 397 - Poplar Box - White Cypress Pine shrub grass tall woodland
Brown Treecreeper	*Climacteris picumnus victoriae*	397 - Poplar Box - White Cypress Pine shrub grass tall woodland – woodland form
Speckled Warbler	*Chthonicola sagittata*	55 - Belah woodland on alluvial plains and low rises – woodland form 397 - Poplar Box - White Cypress Pine shrub grass tall woodland – woodland form
Grey Falcon	*Falco hypoleucos*	55 - Belah woodland on alluvial plains and low rises
Black Falcon	*Falco subniger*	55 - Belah woodland on alluvial plains and low rises – woodland form 397 - Poplar Box - White Cypress Pine shrub grass tall woodland – woodland form
Little Lorikeet	*Glossopsitta pusilla*	397 - Poplar Box - White Cypress Pine shrub grass tall woodland – woodland form
Black-breasted Buzzard	*Hamirostra melanosternon*	55 - Belah woodland on alluvial plains and low rises 397 - Poplar Box - White Cypress Pine shrub grass tall woodland

Common name	Scientific name	Vegetation zone association
Hooded Robin	*Melanodryas cucullata cucullata*	55 - Belah woodland on alluvial plains and low rises – woodland form 397 - Poplar Box - White Cypress Pine shrub grass tall woodland – woodland form
Eastern Freetail-bat	*Mormopterus norfolkensis*	35-Brigalow - Belah open forest / woodland 55 - Belah woodland on alluvial plains and low rises 397 - Poplar Box - White Cypress Pine shrub grass tall woodland
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	35-Brigalow - Belah open forest / woodland 55 - Belah woodland on alluvial plains and low rises 397 - Poplar Box - White Cypress Pine shrub grass tall woodland
Superb Parrot	*Polytelis swainsonii*	55 - Belah woodland on alluvial plains and low rises – woodland form 397 - Poplar Box - White Cypress Pine shrub grass tall woodland – woodland form
Grey-crowned Babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*	55 - Belah woodland on alluvial plains and low rises – woodland form 397 - Poplar Box - White Cypress Pine shrub grass tall woodland – woodland form
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	35-Brigalow - Belah open forest / woodland 55 - Belah woodland on alluvial plains and low rises 397 - Poplar Box - White Cypress Pine shrub grass tall woodland
Diamond Firetail	*Stagonopleura guttata*	55 - Belah woodland on alluvial plains and low rises – woodland form 397 - Poplar Box - White Cypress Pine shrub grass tall woodland – woodland form
Masked Owl (foraging habitat)	*Tyto novaehollandiae*	35-Brigalow - Belah open forest / woodland 55 - Belah woodland on alluvial plains and low rises 397 - Poplar Box - White Cypress Pine shrub grass tall woodland

Species indicated by **bold text** were recorded within the study area

The potential predicted threatened species listed in Table 6-2 were assessed as unlikely to occur and were excluded from the list of confirmed predicted threatened species.

Table 6-2 Excluded predicted threatened species

Common name	Scientific name	Justification
Glossy Black-Cockatoo (foraging)	*Calyptorhynchus lathami*	Due to land clearing, there are very few canopy trees remaining in remnant patches characterised by *Allocasuarina* and *Casuarina* species. The foraging resource is very low, even though associated PCTs are present in the study area.
Painted Honeyeater	*Grantiella picta*	Mistletoes not present in the study area at a density of greater than five mistletoes per hectare
White-bellied Sea-Eagle (foraging)	*Haliaeetus leucogaster*	Habitat constraint for this species includes foraging habitats within 1km of rivers, lakes, large dams or creeks, wetlands and coastlines. No foraging habitat for this species is present at the site.

Common name	Scientific name	Justification
Swift Parrot (foraging)	*Lathamus discolor*	No habitat constraint listed in the Threatened Biodiversity Data Collection. However, this species has a high energy requirement and its foraging patterns strongly influenced by presence of a high abundance of flowering resources. Due to land clearing, the foraging resource is very low, even though associated PCTs are present in the study area. No important foraging habitat is likely to occur at the site.
Black-striped Wallaby	*Macropus dorsalis*	No habitat constraint listed in the Threatened Biodiversity Data Collection. This species requires dense vegetation, and occurs in the Pilliga forests south of Narrabri. No suitable dense shrubby habitat is present at the site.
Pilliga Mouse	*Pseudomys pilligaensis*	No Pilliga scrub habitat in the study area.
Stripe-faced Dunnart	*Sminthopsis macroura*	No habitat constraint listed in the Threatened Biodiversity Data Collection. This species prefers ungrazed habitats with a diversity and healthy understory, particularly along drainage lines. No suitable habitat is present given the high grazing intensity at the site and lack of vegetated drainage lines.

6.1.2 Candidate threatened species (Species credit entities)

Threatened species that cannot reliably be predicted to occur on a development site based on PCT, distribution and habitat criteria are identified by the Threatened Biodiversity Data Collection as 'species credit' entities. In some circumstances, the particular habitat components of species assessed for ecosystem credit species, such as the breeding habitat of a cave roosting bat or forest owls, are also assessed for species credits. The credit calculator references geographic, vegetation and habitat data for the proposal site to generate a list of the species credit entities that are predicted to occur (i.e. the '*potential* candidate threatened species').

Searches of threatened species databases were also completed to identify any additional potential candidate threatened species (to those generated by the credit calculator) that are known or predicted to occur in the locality (refer to likelihood of occurrence table in Appendix A). The likelihood of occurrence of these additional potential candidate threatened species were reviewed, giving consideration to the habitats available in the study area.

Potential candidate threatened species that could occur in the study area based on the habitat resources observed during field surveys were confirmed as candidate threatened species. 'Confirmed' candidate threatened species require targeted survey in accordance with Section 6.4.1.17 of the BAM (OEH, 2017a). The list of confirmed candidate threatened species is presented in Table 6-3; these species were subjected to targeted survey. Surveys were conducted in the appropriate season for all confirmed candidate threatened species and so the targeted survey results can be considered a reliable indicator of their presence or absence at the proposal site (see Table 6-3).

Table 6-3 Confirmed candidate species credit species for which surveys were conducted

Common name	Scientific name	BioNet records in locality	Survey months	Presence	Justification
FAUNA					

Common name	Scientific name	BioNet records in locality	Survey months	Presence	Justification
Australian Bustard	*Ardeotis australis*	N	All year	No - surveyed	No evidence of the species was recorded in the study area in surveys in March, September and November. There are no local records.
Koala (breeding)	*Phascolarctos cinereus*	Y	All year	No - surveyed	No evidence of the species was recorded in the study area in surveys in March, September and November. Local records are associated with large expanses of intact native vegetation.
FLORA					
Bluegrass	*Dichanthium setosum*	N	Dec - May	No - surveyed	No evidence of the species was recorded at the site in surveys in March.
Finger Panic Grass	*Digitaria porrecta*	Y	Dec - May	No – surveyed	No evidence of the species was recorded at the site in surveys in March.
Belson's Panic	*Homopholis belsonii*	Y	Dec – Apr	No – surveyed	No evidence of the species was recorded at the site in surveys in March.
Spiny Peppercress	*Lepidium aschersonii*	Y	Sep - May	No - surveyed	No evidence of the species was recorded at the site in surveys in March, September and November.
Slender Darling Pea	*Swainsona murrayana*	N	Sep – Feb	No – surveyed	No evidence of the species was recorded at the site in surveys in September and November.

A number of species could be reliably discounted as occurring within the study area based on the habitat types present and/or the known distribution of the species. A number of dual credit fauna species have foraging habitat present but either no potential breeding habitat was identified during the field surveys, or the species does not breed in the area. These species are **not** 'confirmed candidate threatened species' for the purposes of this assessment and do not require further assessment. Detailed justification for the conclusion is provided in Table 6-4 and/or the 'habitat/constraints' fields in the credit calculator.

Table 6-4 Excluded candidate threatened species

Common name	Scientific name	Justification
FAUNA		
Rufous Bettong	*Aepyprymnus rufescens*	No suitable habitat
Bush Stone-curlew	*Burhinus grallarius*	No suitable habitat
Glossy Black-cockatoo (breeding habitat)	*Calyptorhynchus lathami*	No suitable breeding habitat
Eastern Pygmy-possum	*Cercartetus nanus*	No suitable habitat
Large-eared Pied-bat	*Chalinolobus dwyeri*	No suitable habitat
White-bellied Sea-Eagle (breeding habitat)	*Haliaeetus leucogaster*	No suitable breeding habitat
Black-breasted Buzzard	*Hamirostra melanosternon*	No suitable breeding habitat
Little Eagle (breeding)	*Hieraaetus morphnoides*	No suitable breeding habitat
Pale-headed Snake	*Hoplocephalus bitorquatus*	No suitable habitat
Swift Parrot (breeding habitat)	*Lathamus discolor*	Does not breed on mainland Australia. No important foraging habitat present.
Square-tailed Kite (breeding habitat)	*Lophoictinia isura*	No suitable breeding habitat
Barking Owl (breeding habitat)	*Ninox connivens*	No suitable breeding habitat
Squirrel Glider	*Petaurus norfolcensis*	No suitable habitat
Superb Parrot (breeding habitat)	*Polytelis swainsonii*	No suitable breeding habitat (does not breed in Narrabri area)
Masked Owl (breeding habitat)	*Tyto novaehollandiae*	No suitable breeding habitat
Border Thick-tailed Gecko	*Uvidicolus sphyrurus*	No suitable habitat
Eastern Cave Bat	*Vespadelus troughtoni*	No caves in the study area and the proposal site is not within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, crevices or boulder piles, or within two kilometres of old mines, tunnels, old buildings or sheds.
FLORA		
Coolabah Bertya	*Bertya opponens*	No suitable habitat is present. The PCTs in the study area are not associated with stony or gravelly mallee ridges or sandy gully habitats; these latter habitats are typically associated with sandy outwash areas such as those found in the Pilliga Outwash sub-region to the south of Narrabri (where Jacks SF is located).
Ooline, Scrub Myrtle	*Cadellia pentastylis*	No suitable habitat is present. The habitat in the study area is associated with higher fertility soils associated with the Namoi River floodplains rather than the low-medium nutrient sandy clays. Also the remnant woodland vegetation does not provide suitable sheltered microhabitats that would be found in larger and more intact remnant vegetation.
-	*Commersonia procumbens* (syn. *Androcalva procumbens*)	No suitable habitat is present. The habitats within the study area are not associated with sandy soils.

Common name	Scientific name	Justification
-	*Cyperus conicus*	No suitable habitat is present. The habitats within the study area are not associated with sandy soils. Suitable habitat would be associated with sandy gullies in sandstone outwash areas. Waterbodies in the form of farm dams are present but does not provide suitable habitat and there are no wetlands and wet run-on areas.
-	*Philotheca ericifolia*	No suitable habitat is present. No dry sclerophyll forests or woodlands on sandstone. No heathy understories in sandy flats and gullies. Lack of suitable microclimates across the study area.
Native Milkwort	*Polygala linariifolia*	No suitable habitat is present. No dry sclerophyll forests and woodlands on sandy soils. The habitats that this species is associated with is typical of vegetation found in the Pilliga Outwash sub-region to the south of Narrabri.
Scant Pomaderris	*Pomaderris queenslandica*	No suitable habitat is present. Habitats in the study area lack sheltered, shrubby understories.
Greenhood Orchid, Cobar Rustyhood	*Pterostylis cobarensis*	No suitable habitat is present. No shrublands on stony ridges are present in the study area, and soils are not shallow sandy loams.
-	*Tylophora linearis*	No suitable habitat is present. The woodlands within the study area are associated with alluvials and basalt outwashes. Dry woodland habitat on sedimentary flats and low rises do not occur in the study area.

6.2 Threatened species survey results

6.2.1 Threatened flora

No threatened flora species were recorded in the proposal site during field surveys conducted in March, September or November.

All potential threatened plant habitat associated with native vegetation in the solar farm site was traversed on foot, with no notable barriers to human movement or visibility encountered during the field survey. Field staff were able to traverse all areas of potential threatened flora habitat on foot, in a manner that reflected threatened species survey guidelines (OEH, 2016; Cropper, 1993). The candidate threatened flora species can be excluded from occurring at the proposal site, given they were not located by an experienced botanist familiar with each of the species.

6.2.2 Threatened fauna

Five threatened fauna species listed under the BC Act were recorded during surveys, all of which are ecosystem credit species (see Figure 6-1):

- Black Falcon (*Falco subniger*)
- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)
- Eastern Freetail-bat (*Mormopterus norfolkensis*)
- Little Pied Bat (*Chalinolobus picatus*)
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*).

There is broadly suitable habitat for two candidate threatened fauna species listed in Table 6-3, the Australasian Bustard and Koala. Targeted field surveys were undertaken at a suitable time of year to detect the Australasian Bustard if present at the proposal site; however there were no observations and also there are no local records of the species. The Australasian Bustard can be reliably discounted as occurring at the proposal site based on the survey effort employed. Similarly, there was no evidence of the Koala during surveys in March, September and November. Potential habitat at the site is poor quality, and separated from better areas of habitat by large expanses of cleared agricultural land. It is unlikely that the Koala would traverse the site. This habitat would not be critical breeding habitat for the species.

No breeding habitat for any of the other dual credit fauna species was recorded at the site, and thus no species credit habitat is considered present for these species.

The small, undefined drainage lines on the proposal site are ephemeral streams that do not provide habitat for any threatened species listed under the FM Act.

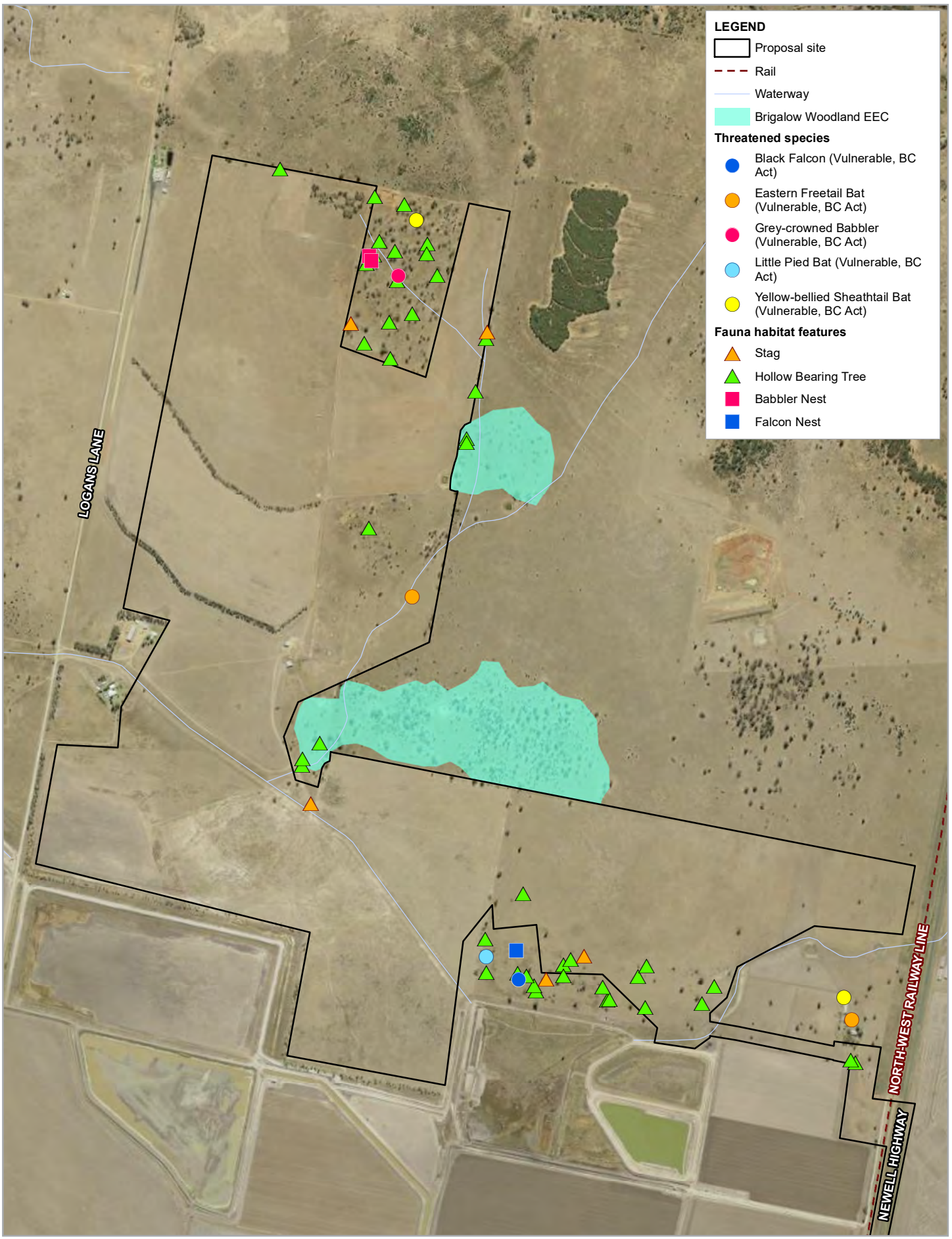
6.2.3 Threatened ecological communities

Moderate condition stands of Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion (PCT 35) within the study area are commensurate with the EEC listed under the BC Act as Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions, which is also identified as an SAII entity. It is also commensurate with the EEC listed under the EPBC Act as Brigalow (*Acacia harpophylla* dominant and co-dominant). The proposal site boundary has been redesigned to avoid clearing of these small patches (see Figure 6-1). The respective EECs listed under the BC Act and EPBC Act are hereafter collectively referred to as the 'Brigalow Woodland EEC'.

Based on the NSW Scientific Committee determination for the community, the derived grassland form of PCT 35 does not meet the condition criteria to comprise an occurrence of Brigalow Woodland EEC, and impacts on this area would not constitute impacts on an SAII entity. Similarly, based on the Commonwealth listing advice for the community, the derived grassland form of PCT 35 does not meet the condition criteria for the EEC.

The BioNet Vegetation Classification Database (OEH, 2018b) notes that PCT 397 is estimated to be 45 percent cleared.

The aquatic ecological community of the lowland Darling River is listed as an EEC under the FM Act. Farm dams are excluded from this listing. The small, undefined drainage channels in the proposal site do not contain any aquatic species or habitats and do not comprise an occurrence of the community.



Paper Size ISO A4

0 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Engie
Silverleaf Narrabri Solar Farm
Biodiversity Assessment

Threatened biota and habitat resources

Project No. 21-26998
Revision No. -
Date 02/05/2019

FIGURE 6-1

N:\AU\Orange\Projects\21\26998\GIS\Maps\Deliverables\Biodiversity\21_26998_Z014_Biodiversity_ThreatenedBiota.mxd

Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

7. Impact assessment

7.1 Measures to avoid and minimise impacts

7.1.1 Avoidance measures

During the development of the proposal, a number of alternate site layouts were investigated. These layouts were developed in response to ongoing environmental investigations and consultation with landowners (both on the subject properties or adjacent to the proposal site). The proposal was purposefully modified to avoid impacts to biodiversity values and especially threatened biota as follows:

- Avoidance of areas of threatened ecological communities, with a focus on high value vegetation, in particular areas of moderate condition Brigalow Woodland EEC.
- Avoidance of most other patches of woodland vegetation, to minimise impacts on fauna habitats and to retain better condition native vegetation.
- Retention of the existing drainage channel running through the southern part of the Logans Lane property.

The following additional changes to the proposal site layout were made to reduce social or other environmental impacts of the proposal and further reduced impacts to biodiversity values:

- Inclusion of a buffer around the existing airstrip located adjacent to the north-west corner of the proposal site to ensure that the operations of this business is not affected.
- Inclusions of buffer zones around residential dwellings to be left on site following consultation with landowners.
- Inclusion of buffers around the edge of the site to allow for potential plating of vegetation to provide visual screening.

7.1.2 Mitigation measures

A Construction Environmental Management Plan (CEMP) (or equivalent) would be required for the construction phase of the proposal, and would be prepared prior to issue of the Construction Certificate. The CEMP would include, as a minimum, industry-standard measures for the management of soil, surface water, weeds and pollutants, and planting of vegetated screens (see Section 8).

Planting of vegetated screens would occur along the boundary of the proposal site. These would include locally sourced species typical of the PCTs present on site. This would improve the condition of the retained vegetation in the long-term.

At the end of life, the solar farm will be disconnected from the electrical transmission network and all solar farm infrastructure would be removed (except for any cables which are underground to a depth of greater than 500 mm and solar farm access roads which need not be removed). ENGIE must also restore the surface of the solar farm land to a suitable condition for pastoral or other agricultural use (see Section 8.3).

7.2 Residual impacts

7.2.1 Direct impacts

Removal or modification of vegetation

The construction of the solar farm would predominantly comprise impacts on areas of derived native grassland and cropped land. In total, the proposal would remove or modify about 183 hectares of native remnant woodland and derived grassland as summarised in Table 7-1. There would be minimal impacts on native woodland vegetation (1.84 hectares out of the 397.8 hectare proposal site). Over storey vegetation would be completely removed in these areas to accommodate the proposed solar farm. Where trees are to be retained, appropriate buffers would be established around these trees.

Solar panels and other infrastructure would be constructed within 181.46 hectares of derived native grassland. All paddock trees would be removed in these areas and there would short term impacts across the entire area during the construction period associated with the movement of vehicles and equipment and installation of infrastructure.

Small areas of understorey vegetation would be removed and soil excavated within the immediate footprints of infrastructure such as solar panels and transmission line poles. There will be direct impacts associated with the installation of approximately 20,000 piles which would be driven or screwed into the ground, however groundcover will be retained under the panels. There would be temporary disturbance of groundcover during laying of cables, however trenches would be backfilled to the existing ground layer and groundcover would be able to regrow.

The majority of the native understorey vegetation, soil profiles and other habitat features in the proposal site would be retained in a similar condition to their current state throughout the operational phase of the proposal. These areas would be modified through shading by solar panels and periodic operational activities such as infrastructure maintenance and slashing to reduce fuel loads. This would comprise a substantially lower impact on biodiversity values than complete or permanent vegetation removal as reflected in the BAM credit calculations (see section 9.1.1).

Table 7-1 Direct impacts on native vegetation

Plant community type (PCT)	Threatened ecological community	Area impacted (ha)
Zone 3 – PCT 35 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion_Derived Grassland	Does not meet EEC condition criteria	26.81
Zone 4 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Moderate	Not listed	0.69
Zone 5 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Derived Grassland	Not listed	121.96
Zone 6 – PCT 397 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Moderate	Not listed	1.15
Zone 7 – PCT 397 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Derived Grassland	Not listed	32.69
Total native vegetation		**183.3**

Plant community type (PCT)	Threatened ecological community	Area impacted (ha)
Non-native vegetation (cropped land and exotic grassland, cleared land, planted windbreaks and dams)		206.1
Total proposal site		**397.8**

Removal of habitat and habitat resources

The vegetation that would be removed or modified provides habitat resources for native fauna species, including threatened species of fauna. The survey effort to date has been sufficient to exclude impacts on all candidate species credit species.

The clearing of approximately 1.84 hectares of woodland and scattered paddock trees within 181.46 hectares of derived native grassland would include the removal of mature trees and hollow-bearing trees. Mature trees have value for fauna populations as sources of foraging resources such as leaves, nectar, sap or seed and substrate for invertebrate prey. In the context of the areas of remaining native woodland and forest vegetation surrounding the proposal site, the proposal would remove a small proportion of available foraging resources for local populations of native fauna.

Fauna injury and mortality

As described above, the proposal site provides a variety of habitat resources for native fauna species, including foraging, roosting and shelter resources for threatened species as well as common native fauna. Groundcover vegetation, leaf litter and woody debris would provide shelter and foraging substrate for reptiles, frogs and invertebrates. Construction is likely to result in the injury or mortality of some individuals of these less mobile fauna species and other small terrestrial fauna that may be sheltering in vegetation within the proposal site during clearing activities. There is a potential risk of injury or mortality to any species which may be using hollows, such as microbats, arboreal mammals or hollow-nesting birds. The potential for impacts on fauna utilising hollows would be reduced through pre-clearance surveys of habitat trees and protocols for less-impact felling of habitat trees (see Table 8-1). More mobile native fauna such as native birds, bats, terrestrial and arboreal mammals that may be sheltering in vegetation in the proposal site are likely to evade injury during construction activities.

The proposal would involve the removal of a small number of hollow-bearing trees or stags. Hollows are a limiting resource, relied on by many native fauna for shelter and breeding. Galahs, Eastern Rosellas and Red-rumped Parrots were observed during surveys at these hollows. The removal of these hollows would reduce the extent of potential breeding habitat for native species in the area, and could potentially remove breeding habitat for threatened species such as the Yellow-bellied Sheathtail-bat, Little Pied Bat and Eastern Freetail-bat, which were recorded during surveys.

Recommendations have been made in Section 7.1.2 above to minimise the risk of vegetation clearing activities resulting in the injury or mortality of resident fauna.

Fragmentation or isolation of habitat

The proposal site is located in already cleared land. The majority of the proposal site is derived grassland and would already comprise a gap in habitat for less mobile or shelter dependent native fauna. No patches of intact native vegetation would be completely removed or isolated by the proposal and no connecting links would be severed. The proposal would remove small areas of woodland at the edge of patches resulting in a minor increase in the degree of fragmentation of habitat in the locality. The proposal would also remove clumps of paddock trees which may provide 'stepping stones' of connectivity between roadside vegetation to the east and west for mobile species such Galahs and other birds.

7.2.2 Indirect impacts

Indirect impacts that may occur as a result of the proposal are described in Table 7-2. Mitigation measures proposed to minimise the risk of these impacts are detailed in Section 7.1.2 and Section 8.

Table 7-2 Indirect impacts

Impact	Description
Reflected light and heat generated by solar panels	Reflected heat and light from the solar panel would increase the temperature of the microclimate around the infrastructure. This may alter the species composition and richness. It may also affect growth of plants. These impacts may then affect habitat for small fauna such as lizards that may occur in these areas.
Weed invasion and edge effects	'Edge effects' refer to increased noise and light or erosion and sedimentation at the interface of intact vegetation and cleared areas. Edge effects may result in impacts such as changes to vegetation type and structure, increased growth of exotic plants, increased predation of native fauna or avoidance of habitat by native fauna. Altered environmental conditions along new edges can allow invasion by pest animals specialising in edge habitats and/or change the behaviour of resident animals. Edge effects would result from construction activities and then continue to affect vegetation and habitats adjoining the proposal site. The proposal site and adjoining land has been extensively cleared for agricultural purposes. Small patches of woodland vegetation occur at scattered locations. Various weeds and exotic pasture species are present throughout the site. Construction of the proposal would result in new edges along already fragmented woodland patches, and has the potential to introduce or spread weeds. Given the existing degree of vegetation clearing in the study area this would comprise a very minor increase in the degree of edge effects.
Pests and pathogens	Construction activities, in general, have the potential to introduce or spread pathogens such as Phytophthora (*Phytophthora cinnamomi*), Myrtle Rust (*Uredo rangelii*) and Chytrid fungus (*Batrachochytrium dendrobatidis*) into native vegetation. The potential for impacts associated with these pathogens is low, given the disturbed nature of much of the study area, lack of permanent flowing water on site, and the environmental safeguards that would be implemented during the construction process.

Impact	Description
Noise, light and vibration	Construction of the proposal would require the use of additional vehicles and plant in the site. Fauna that occupy habitats within the proposal site and adjacent areas are likely to be accustomed to some existing noise and vibration originating from vehicles, agricultural machinery and light aircraft. There is limited light spill currently at the site. Noise and vibration disturbance during construction could disturb resident fauna. While there would be localised increases in noise, vibration and light that would temporarily create substantial disturbance, increases above existing background levels during construction are unlikely to result in a significant impact on fauna that occur in the study area.
Sedimentation and erosion	Construction of the proposal has the potential to result in sedimentation and erosion within the proposal site and adjoining native vegetation and aquatic habitats, through soil disturbance and construction activities. Sediment laden runoff to waterways can alter water quality and adversely affect aquatic life. Given the modified nature of drainage lines in adjacent areas and limited native vegetation, the potential for impacts is negligible.
Aquatic disturbance and pollution	Construction of the proposal has the potential to result in the mobilisation of contaminated sediments into waterways, or chemical spills from vehicles or plant. The introduction of pollutants from the proposal into the surrounding environment, if uncontrolled, could potentially impact on water quality further downstream. Given the modified nature of drainage lines in adjacent areas and limited native vegetation, the potential for impacts is negligible.

7.3 Assessment of serious and irreversible impacts

Under the BC Act, a determination of whether an impact is serious and irreversible must be made in accordance with the principles set up in Section 6.7 of the BC Regulation.

The principles are aimed at capturing impacts which are likely to contribute significantly to the risk of extinction of a threatened species or ecological community in New South Wales. These include impacts that will:

- Cause a further decline of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to be in a rapid rate of decline, or
- Further reduce the population size of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very small population size, or
- Impact on the habitat of a species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very limited geographic distribution, or
- Impact on a species or ecological community that is unlikely to respond to measures to improve habitat and vegetation integrity and is therefore irreplaceable.

The decision-maker must determine whether or not an impact on biodiversity values is likely to be a serious and irreversible impact (SAII). The framework allows for decision-makers to take into account the scale of an impact and the potential for avoidance and mitigation. These factors are weighed against the status and vulnerabilities of the potential SAII entity to ultimately determine if a proposal will indeed have a serious and irreversible impact (OEH, 2017c). If there is a serious and irreversible impact for a Part 4 development, the development must be refused.

Woodland form patches of PCT 35 within the study area are commensurate with the EEC listed under the BC Act as Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions, which is an identified SAII entity. Currently there is no threshold of impact for Brigalow EEC/SAII (OEH, 2017c) and so the default threshold of any direct impact would comprise a SAII.

The proposal site boundary has been redesigned to avoid remnant woodland patches of the EEC and therefore the proposal avoids impacts on SAII entities. No detailed assessment of this SAII entity is considered necessary.

7.4 Prescribed impacts

Prescribed impacts relevant to the proposal are described below. Given the scale and context of the proposal there are unlikely to be any substantial impacts on threatened species and their habitats beyond those associated with the removal of vegetation and habitat in the proposal site.

7.4.1 Areas of geological significance or rocks

No areas of geological significance are present. No caves for breeding of bats are present.

7.4.2 Human-made structures

No buildings, culverts, bridges or similar human-made structures of particular relevance to fauna would be removed for the proposal. The removal of dams and water points is discussed below.

7.4.3 Non-native vegetation

The proposal would remove or modify up to 198.2 hectares of non-native vegetation associated with cropped land and exotic grassland, cleared land, planted windbreaks and dams.

Non-native vegetation provides minimal habitat for most threatened species. Raptors may hunt over non-native grassland on occasion. Similarly, microchiropteran bats would forage above the non-native grassland. Small bird species that forage in woodland areas may also forage in the adjacent non-native grassland on occasion. No fauna species would rely on these areas for their survival in the locality, but may use these areas on occasion as part of a much larger home range.

As described above for areas of derived native vegetation, minimal areas of exotic vegetation would be removed and soil excavated within the immediate footprints of infrastructure. The majority of the non-native vegetation in the proposal site would be retained in a similar condition to its current state throughout the operational phase of the proposal. These areas would be modified through shading by solar panels and periodic operational activities. This would comprise a substantially lower impact on biodiversity values than complete or permanent vegetation removal.

7.4.4 Connectivity

Habitat fragmentation through the clearing of vegetation can increase the isolation of remnant vegetation and create barriers to the movements of small and sedentary fauna such as ground dwelling mammals, reptiles and amphibians. Furthermore, habitat fragmentation can create barriers to the movement of pollinator vectors, such as insects, or seed vectors, such as birds, and consequently affect the life cycle of both common and threatened flora.

The proposal site provides limited connectivity for fauna given the predominantly cleared native of the proposal site. Clearing of most woodland areas will been avoided for the proposal. Vegetation and scattered hollow-bearing trees in the proposal site comprises scattered fragments that together with woodland patches in adjacent areas provide 'stepping stones' of habitat between larger areas of vegetation for mobile species such as bats and birds. Removal of these patches and trees would reduce the availability of these stepping stones to a small degree. Species that require larger tracts of connected vegetation would not occur in these small, fragmented patches. Poles and wires associated with the transmission corridor would not impact movement of any fauna species.

Connectivity for small ground-dwelling fauna such as lizards and kangaroos would be retained in the proposal site, as these species can move under and between the solar panels.

7.4.5 Hydrology

Two farm dams may be removed for the proposal. This would reduce the number of watering points in the wider area by a small degree. Threatened species that may use these (such as the Grey-crowned Babbler and microchiropteran bats) would likely use a number of similar farm dams throughout their home range.

There would be limited direct impacts on the small, undefined drainage lines that occur on the proposal site. Given their ephemeral nature, these drainage lines provide negligible habitat for threatened species.

There would be minor if any impacts on aquatic habitat downstream of the proposal site and there is no evidence that aquatic habitat in the vicinity of the proposal site would be occupied by any threatened biota (see Section 7.5).

7.4.6 Vehicle strike

The proposal site currently has low levels of vehicle activity typically associated with farming. Occasional movements of cars, utility vehicles, trucks and farming equipment would occur throughout the proposal site. The movements of vehicles and machinery would increase during construction, but would be limited to occasional maintenance visits during operation.

The potential risk of vehicle strike is most relevant to common species such as kangaroos, and few threatened species are likely to be at risk. Birds such as the Grey-crowned Babbler would move away from vehicles and the risk of injury and mortality is low.

7.5 Impacts on aquatic habitats

Two farm dams may be removed for the proposal. There would be limited direct impacts on the small, undefined drainage lines that occur on the proposal site. The proposal would not remove these drainage lines. Any upgrades to tracks would include pipes or culverts to ensure drainage is not blocked. Given the low stream order this is in line with (DPI, 2013) fish crossing requirements.

None of the aquatic habitats in the proposal site or study area are classified as Key Fish Habitat and would not provide potential habitat for threatened fish (see Appendix A). Aquatic habitats may provide limited breeding and shelter resources for common frog and reptile species. Any tracks that may be constructed would include appropriate pipes or culverts to allow flow during rain events.

No habitat for threatened biota listed under the FM Act would be directly impacted. Indirect impacts could include sedimentation and erosion during construction. Given the generally dry nature of these drainage lines, the risk of indirect impacts is low. There would be no blockage of fish passage or removal of snags as a result of the proposal.

7.6 Consideration of MNES

The proposal has been designed to avoid direct impacts on Brigalow (*Acacia harpophylla* dominant and co-dominant) EEC listed under the EPBC Act. Given the close proximity of stands of this EEC to the proposal, an assessment of significance has been prepared in accordance with the '*Matters of National Environmental Significance Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999'* (DotE, 2013). This assessment is provided in Appendix E.

Given the avoidance of direct impacts, and limited potential for indirect impacts, the proposal is unlikely to constitute a significant impact, and no further assessment or approval of the proposal under the EPBC Act is likely to be required.

8. Recommended mitigation measures

8.1 Overview

The mitigation of adverse effects arising from the proposal has been presented according to the hierarchy of avoidance, mitigation and offsetting of impacts. The proposal has been located and designed to avoid impacts on biodiversity values as far as possible as discussed in Section 7.1.1. The proposal would result in minimal direct impacts on native biota and their habitats within the proposal site. There is limited potential for impacts on habitat in the study area during the longer-term operational phase of the proposal. Specific mitigation measures are recommended in section 8.2 to minimise impacts on the natural environment and biodiversity values.

8.2 Mitigation of impacts

In order to address the potential impacts of the proposal on biodiversity, the mitigation measures outlined in Table 8-1 should be incorporated into the Construction Environment Management Plan (CEMP).

Table 8-1 Mitigation measures

Timing	Mitigation measures	Responsible party
Pre-construction/ clearing	A fauna management plan should be prepared prior to construction. This would detail fauna management protocols including management of tree hollows and fauna handling.	Site ecologist
	Ensure all workers are provided with an environmental induction prior to starting work on site. This would include information on the ecological values of the site and protection measures to be implemented to protect biodiversity.	Construction contractor/ Site ecologist
	Use of and regular inspection and maintenance of erosion and sediment control measures.	Construction contractor
	Fence off or mark trees and areas of native vegetation to be retained, to avoid additional impacts on vegetation. Fencing should protect the entire Tree Protection Zone (i.e. 10 times the diameter of the trunk at breast height).	Construction contractor/ Site ecologist
	Appropriate buffers would be established around trees that are to be retained. Work would avoid damage to the structural root zones (SRZ) of the trees	Construction contractor/ Site ecologist
Construction/ clearing	Restrict stockpiles of construction materials, fill or vegetation to existing cleared areas and not within areas of adjoining native vegetation	Construction contractor
	Water should be applied to stockpile areas during windy conditions	Construction contractor
	Any hollow-bearing trees to be felled should be marked prior to clearing of vegetation. The removal of hollow bearing trees is to be undertaken in accordance with a tree hollow management protocol set out in the CEMP, and would involve the presence of a qualified ecologist or wildlife specialist experienced in the rescue of fauna.	Site ecologist

Timing	Mitigation measures	Responsible party
	Any trees with raptor nests should be felled outside the breeding season	Site ecologist
	Habitat features such as hollow trunks and limbs within the proposal site should be salvaged and replaced within areas proposed for screening vegetation as far as is practicable.	Site ecologist
Post construction/ clearing	Reinstatement of stabilised surfaces as quickly as practicable after construction	Site ecologist
	Planting of locally endemic tree species and groundcover in areas proposed for vegetated screens. Species would be drawn from the list of species typical in the PCTs present on site.	Site ecologist

8.3 Decommissioning of the solar farm

At the end of life, the solar farm will be disconnected from the electrical transmission network. This entails disconnecting and removing solar panels for recycling, recycling the steel associated with the single-axis tracking system, removing the containerised inverter and transformer systems, and associated cabling and any conduit. Under the proposed lease agreements with landowners, ENGIE must remove the solar farm infrastructure except for any cables which are underground to a depth of greater than 500 mm and solar farm access roads which need not be removed. ENGIE must also restore the surface of the solar farm land to a suitable condition for pastoral or other agricultural use and leave the land electrically safe and otherwise in a safe condition

9. Offsetting

9.1 BC Act offset requirements

9.1.1 Impacts requiring offset

Impacts associated with the proposal that require offsetting include the removal of 183 ha of native vegetation, and associated habitat for threatened biota. Impacts within the proposal site that require biodiversity offsets are shown on Figure 9-1.

Ecosystem credits

The data from the fieldwork and mapping was entered into version 1.2.6.00 of the BAM credit calculator as a 'Development Assessment' to determine the number and type of biodiversity credits that would be required to offset impacts of the proposal. The Biodiversity credit report is included in Appendix E and summarised below.

There are 183 hectares of native vegetation (remnant woodland and derived grassland) at the proposal site that would be impacted by construction of the solar farm. It is assumed that the construction and operation of a solar project will not necessitate the removal of all vegetation layers and so the 'future vegetation integrity score' for the various vegetation zones was not entered as 0.

As described in Section 1.2, the solar panels will sit about four metres above the ground, and the mounting system would be placed with rows of panels approximately six metres apart. There will be direct impacts associated with the installation of approximately 20,000 piles which would be driven or screwed into the ground, however groundcover will be retained under the panels. There would be temporary disturbance of groundcover during laying of cables, however trenches would be backfilled to the existing ground layer and groundcover would be able to regrow. The height and spacing of the solar panels will provide some shading throughout the day, however sunlight and rain will enable continued growth of the groundcover.

In order to reflect the quantum of impact associated with the proposal, the future vegetation integrity score of all vegetation zones entered into the BAM calculator was based on the following (these are also summarised in a table in Appendix D):

- Total removal of canopy and shrub layers, i.e. zero values for compositional, structural and canopy-related functional attributes, including:
  - No. large trees
  - Stem size class
  - Regeneration
- Removal of all woody debris, i.e. zero values for fallen logs.
- 10% reduction in the species richness of the groundcover due to predicted shading effects of the solar panels. Most groundcover species recorded during survey are considered to be relatively resilient species, withstanding grazing and drought conditions. A 10% reduction in the compositional scores for GG, FG, OG and EG attributes from the observed means was used.
- 50% reduction in the percentage cover of the groundcover due to predicted shading effects of the solar panels. A 50% reduction in the structural scores for GG, FG, OG and EG attributes from the observed means was used.

- No change in the percentage cover of high threat weeds from the observed means. The majority of high threat weeds are represented by exotic grasses and thistles, which are predicted to remain relatively unchanged by shading effects of the solar panels. *Lycium ferocissimum* (African Boxthorn) is the only high threat weed that is also a priority weed for the North West region. The regional and state objectives for this priority weed is asset protection, which carries a mandatory requirement to minimise the spread of the weed offsite (rather than to eradicate). African Boxthorn occurs in the proposal site in very low numbers and is unlikely to affect the high threat attribute for future vegetation integrity scores even if it were to be physically removed to accommodate the solar panels or as part of control activities. Note that Prickly Pear is not a high threat weed, even though it is a state priority weed.
- No change in litter values from the observed means. Due to the paucity of groundcover vegetation at the time of survey, most vegetation zones recorded relatively low functional litter cover. The functional litter cover is predicted to remain relatively unchanged by shading effects of the solar panels.

Ecosystem credits that would be required to offset the impacts of the proposal are shown in Table 9-1.

Table 9-1 Ecosystem credits required to offset impacts of the proposal

Vegetation zone / PCT	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	BC Act status	Ecosystem credits required
Zone 1 – PCT 35 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion_Derived Grassland	26.81	12	11.2	Does not meet EEC condition criteria	0*
Zone 2 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Moderate	0.69	45.3	25.6	Not listed	7
Zone 3 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Derived Grassland	121.96	28.4	21.9	Not listed	395
Zone 4 – PCT 397 Poplar Box-White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Moderate	1.15	52.6	17.5	Not listed	15
Zone 5 – PCT 397 Poplar Box-White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Derived Grassland	32.69	15.1	9.6	Not listed	0*

Note: * no offset is required because the current vegetation integrity score is less than 17.

9.1.2 Impacts not requiring offset

A biodiversity offset is not required if the vegetation integrity score of the impacted vegetation zone that comprises threatened species habitat is <17 (Sections 10.3.1.1 and 10.3.2.1 of the BAM). In this regard, an ecosystem credit obligation of zero was found for the derived grassland forms of PCT 35 and PCT 397 (Zone 1 and 5).

Offsets are not required for impacts on non-native vegetation. No credits were calculated for 'exotic/cleared land'.

Species credits

No species credit species were recorded. No species credit habitat for dual credit species (i.e. breeding habitat) was recorded. No polygons have been prepared and no species credits have been calculated.

The Black Falcon, Grey-crowned Babbler, Eastern Freetail Bat, Little Pied Bat and Yellow-bellied Sheathtail Bat were recorded within the proposal site during field surveys and are confirmed predicted threatened species for this assessment. The ecosystem credits listed above would offset the removal of foraging and breeding habitat for these species. None of these threatened fauna species are dual credit species.

9.1.3 Options to meet offset obligations / approach to delivering offsets

In accordance with the offset rules established by the *Biodiversity Conservation Regulation 2017* there are various means by which offset obligations described in Section 9.1 can be met. These include:

- Retiring the appropriate credits from an established stewardship site.
- Monetary payment directly into the Biodiversity Conservation Trust Fund, or
- Funding an approved biodiversity action. Funding a biodiversity action may be available as a last resort, subject to consultation with approval authorities, if all other options are determined to be unsuitable.

Existing biodiversity credits

The preferred approach to offset the residual impacts of the proposal is to secure and retire appropriate credits from stewardship site/s that fit within the trading rules of the BOS in accordance with the 'like for like' report generated by the credit calculator. The like for like trading rules for the ecosystem credits required for the proposal are summarised in Table 9-2. If such credits are unavailable, credits would be sourced in accordance with the 'variation report' generated by the BAM calculator.

Table 9-2 **'Like for like'** eecosystem credits required to offset impacts of the proposal

Credit Class	Any PCT in the below class	And in any of below trading groups	Containing hollow-bearing trees	In the below IBRA subregions
Credit classes for PCT 55	North-west Floodplain Woodlands (including PCT 55)	North-west Floodplain Woodlands - ≥ 70% - <90% cleared group (including Tier 4 or higher).	Yes	Liverpool Plains, Castlereagh-Barwon, Kaputar, Liverpool Range, Northern Basalts, Northern Outwash, Peel, Pilliga and Pilliga Outwash. or Any IBRA subregion that is within 100 kilometres of the outer edge of the impacted site.
Credit classes for PCT 397	Pilliga Outwash Dry Sclerophyll Forests (including PCT's 88, 141, 148, 397, 411, 702, 1090, 1384)	Pilliga Outwash Dry Sclerophyll Forests - < 50% cleared group (including Tier 7 or higher).	Yes	Liverpool Plains, Castlereagh-Barwon, Kaputar, Liverpool Range, Northern Basalts, Northern Outwash, Peel, Pilliga and Pilliga Outwash. or Any IBRA subregion that is within 100 kilometres of the outer edge of the impacted site.

Payment into the Biodiversity Conservation Fund

A payment to the Biodiversity Conservation Trust (BCT) could be considered if a suitable number and type of biodiversity credits could not be secured from third parties.

It should be noted that payment for offsets are subject to change and that credit payment prices are reviewed by the BCT quarterly. The payment amounts presented within this report were calculated and valid as of 19 March 2019.

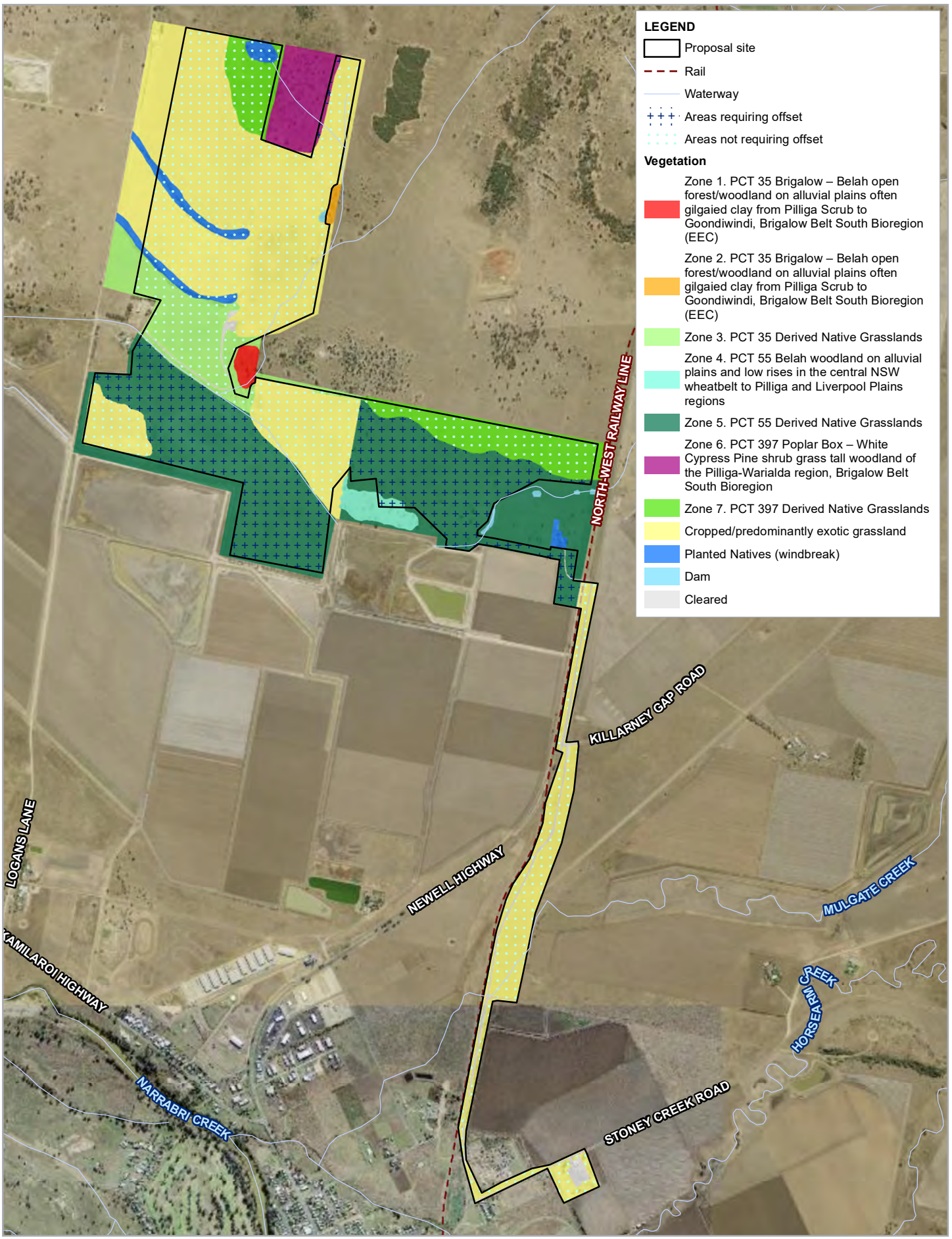
Table 9-3 Estimated biodiversity offset credit payment price

Credit class	Price per credit	Number of credits required	Final credit price
55 - Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions.	$2,017.01	402	$810,837.21
397 - Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	$2,017.01	15	$30,255.12
Subtotal (excl. GST)			$841,092.33
GST			$84,109.23
Total			$925,201.56

9.1 Offsets for impacts on MNES

Offsets are required for any significant residual impacts on MNES, according to the requirements of the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy October 2012* (EPBC Act Offsets Policy) (DSEWPaC, 2012).

The proposal has been redesigned to avoid moderate condition Brigalow near the boundary of the proposal site. The derived native grassland form of this PCT does not meet the condition criteria for the Brigalow (*Acacia harpophylla* dominant and co-dominant) EEC. The assessments of significance prepared for this EEC indicated that the proposal is unlikely to have a significant impact on this MNES, and thus the proposal would not be a controlled action and no offsets would be required under the EPBC Act.



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Engie
Silverleaf Narrabri Solar Farm
Biodiversity Assessment

Areas requiring offsets

Project No. 21-26998
Revision No. -
Date 02/05/2019

FIGURE 9-1

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Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

10. Conclusion

ENGIE proposes to construct and operate a 120 megawatt (MW) solar farm about four kilometres north-west of Narrabri between the Newell Highway in the east and Logans Lane in the west.

The majority of the study area has been cleared and used for agriculture (sheep and cattle grazing). The dominant vegetation is represented by native and exotic pasture. Several small patches of remnant woodland are present in the study area; these patches have been highly modified as a result of agricultural activities, with much of the understorey affected by grazing activities. The southern portion of the study area has been cleared but supports derived native grassland.

PCT 35 Brigalow-Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi Brigalow Belt South Bioregion in the study area comprises a local occurrence of the endangered ecological community (EEC) listed under the BC Act as *Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions*. Moderate condition forms of this community are an SAII entity and are commensurate with the EEC listed under the EPBC Act as *Brigalow (Acacia harpophylla) dominant and co-dominant*. The proposal site has been redesigned to avoid the areas of this community in moderate condition. There would be no direct impacts on the SAII entity.

Five threatened fauna species listed under the BC Act were recorded during surveys, all of which are ecosystem credit species. No threatened flora or other species credit -entities were recorded.

The proposal was purposefully modified to avoid impacts to biodiversity values and especially threatened biota. Areas of high value vegetation commensurate with Brigalow Woodland EEC were avoided, and most other patches of woodland vegetation were also avoided to minimise impacts on fauna habitats and to retain better condition native vegetation. The existing drainage channel would also be retained through the southern part of the Logans Lane property. A range of mitigation measures are also proposed, including planting of vegetated screens, fauna habitat management and rescue protocols, and protection of vegetation to be retained.

Residual impacts

Credits that would be required to offset the residual impacts of the proposal comprise:

- 7 credits for Zone 2 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Moderate.
- 395 ecosystem credits for Zone 3 – PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions_Derived Grassland.
- 15 ecosystem credits for Zone 4 – PCT 397 Poplar Box- White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion_Moderate.

No species credits are required for the proposal.

A biodiversity offset is not required if the vegetation integrity score of the impacted vegetation zone is <17 (Sections 10.3.1.1 and 10.3.2.1 of the BAM). In this regard, an ecosystem credit obligation of zero was found for the derived grassland forms of PCT 35 and PCT 397.

No credits were calculated for ‘exotic/cleared land’ as offsets are not required for impacts on non-native vegetation that does not provide habitat for threatened species.

There would be no direct impacts on *Brigalow (*Acacia harpophylla*) dominant and co-dominant* EEC listed under the EPBC Act. No further assessment, approval or provision of biodiversity offsets is required under the EPBC Act.

Aquatic habitat is limited to small, ephemeral 1st order drainage lines. These do not constitute key fish habitat, and do not contain any aquatic habitat within the Darling River EEC listed under the FM Act. There would be no impacts on habitat for threatened fish. Any construction of tracks would include suitable pipes or culverts to allow water flow during rain events.

A CEMP (or equivalent) would be required for the construction phase of the proposal, and would be prepared prior to issue of the Construction Certificate. The CEMP would include, as a minimum, industry-standard measures for the management of soil, surface water, weeds and pollutants, and planting of vegetated screens around the boundary of the solar farm.

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Appendices

Appendix A – Likelihood of occurrence of threatened and migratory biota

Likelihood of occurrence of threatened flora species at the site

Family	Scientific name	Common name	BC Status	EPBC Status	Number of records within 20km	Most recent record	Bionet atlas records (20km)	Protected Matters search report (10km)	Predicted by BAM Calculator	Species Habitat	SAII entity?	SAII threshold	Likelihood of Occurrence	Justification	Confirmed Candidate Species requiring further assessment (i.e. targeted survey)	Recommended survey times (from BAMC)	Survey undertaken	To be assessed as SAII entity?
Euphorbiaceae	*Bertya opponens*	Coolabah Bertya	V	V	84	2018	Recorded within 20km since 1980	-	No	Known from three scattered sites in NSW: near Coolabah in western NSW, and two locations south of Narrabri. A fourth population near Cobar is considered possibly extinct. Most recent records found 20km south of Narrabri in Jacks Creek SF; there are no records within 10km of the site. Occurs in a range of habtiats including stony/gravelly mallee ridges and cypress pine forest on red soils, or sandy gullies. Associated species at Jacks Creek SF (largest population) include Dirty Gum, White Cypress Pine and Red Ironbark.	No	n/a	Unlikely	No suitable habitat is present. The PCTs in the study area are not associated with stony or gravelly mallee ridges or sandy gully habitats; these latter habitats are typically associated with sandy outwash areas such as those found in the Pilliga Outwash sub-region to the south of Narrabri (where Jacks SF is located).	No	n/a	n/a	n/a
Surianaceae	*Cadellia pentastylis*	Ooline, Scrub Myrtle	V	V	22	2008	Recorded within 20km since 1980	Species or species habitat likely to occur within area	No	Relic rainforest species. Occurs from north of Gunnedah to west of Tenterfield. Forms a closed or open canopy mixing with eucalypt and cypress pine species. Presence appears to be strongly correlated with low-medium nutrient soils of sandy clay or clay consistency. All records within 20km are from intact forest approximately 20km to the east of the site, near the Deriah Community Conservation Area (Zone 2) Aboriginal Area.	No	n/a	Unlikely	No suitable habitat is present. The habitat in the study area is associated with higher fertility soils associated with the Namoi River floodplains. Also the remnant woodland vegetation does not provide suitable sheltered microhabitats that would be found in larger and more intact remnant vegetation.	No	n/a	n/a	n/a
Malvaceae	*Commersonia procumbens* (syn. *Androcalva procumbens*)	-	V	V	0	n/a	-	Species or species habitat likely to occur within area	No	Mainly confined to the Dubbo-Mendooran-Gilgandra region, but also in the Pilliga and Nymagee areas and recent collections from the Upper Hunter. Grows on sandy soils, often on roadsides. Has been recorded in Tumbledown Red Gum and Mugga Ironbark communities, Broombush scrub, under mallee eucalypts with a Common Fringe-myrtle understorey, and in a recently burnt Ironbark and Callitris area. Also in *Eucalyptus fibrosa subsp. nubila*, Tumbledown Red Gum, White Box and White Cypress Pine woodlands north of Dubbo.	No	n/a	Unlikely	No suitable habitat is present. The habitats within the study area are not associated with sandy soils.	No	n/a	n/a	n/a
Cyperaceae	*Cyperus conicus*	-	E	Not listed	1	2006	Recorded within 20km since 1980	-	Yes	Occurs rarely in the Pilliga area of NSW. Grows in open woodland in sandy soil. Recorded from Callitris forest in the Pilliga area, growing in sandy soil with Slender Flat-sedge, Bearded Flat-sedge and Sticky Sedge. Usually occurs with other sedge species and in sandy or silty and damp to wet soils. One record approximately 15km to the NE of Narrabri was recorded in deep sandy soil over sandstone, in a moist area near a shallow drainage line. The vegetation type was Dirty Gum-Black Cypress Pine forest.	No	n/a	Unlikely	No suitable habitat is present. The habitats within the study area are not associated with sandy soils. Suitable habitat would be associated with sandy gullies in sandstone outwash areas. Waterbodies in the form of farm dams are present but does not provide suitable habitat and there are no wetlands and wet run-on areas.	No	n/a	n/a	n/a
Poaceae	*Dichanthium setosum*	Bluegrass	V	V	0	n/a	-	Species or species habitat likely to occur within area	Yes	Occurs on the New England Tablelands, North-west Slopes and Plains and the Central-west Slopes. Associated with heavy basaltic black soils and red-brown loams with clay subsoil. Often found in moderately disturbed areas cleared woodland, grassy roadside remnants and highly disturbed pasture. Appears to have wide environmental tolerances. Associated species include White Box, Yellow Box, Silver-leaved Ironbark, Ribbon Gum, Winter Apple, Purple Wiregrass, Kangaroo Grass, Snowgrass, Redleg Grass.	No	n/a	Low - Moderate	Marginal habitat present in areas of native woodland and derived native grasslands; grazing and drought conditions has reduced the suitability of habitat.	Yes	December - May	March, September, November	n/a
Poaceae	*Digitaria porrecta*	Finger Panic Grass	E	Not listed	10	2017	Recorded within 20km since 1980	-	Yes	In NSW found on the North West Slopes and Plains, from near Moree south to Tambar Springs and from Tamworth to Coonabarabran. Inhabits native grasslands, woodland and open forests with grassy understorey on richer soils. Often found along roadsides and travelling stock routes where there is light grazing and occasional fire, and the understorey retains a reasonable level of species diversity. Associated species include White Box, Weeping Myall, Plains Grass, *Enteropogon acicularis*, Downs Nutgrass, Flower-of-an-Hour and Native Sensitive Plant.	No	n/a	Low - Moderate	Marginal habitat present in areas of native woodland and derived native grasslands; grazing and drought conditions has reduced the suitability of habitat.	Yes	December - May	March, September, November	n/a
Poaceae	*Homopholis belsonii*	Belson's Panic	E	V	5	2017	Recorded within 20km since 1980	Species or species habitat may occur within area	Yes	Occurs on northwest slopes and plains, north of Warialda between Wee Waa, Goondiwindi and Glen Innes. Grows in dry woodland (e.g. Belah), often on poor soils though also found in basalt-enriched sites and alluvial clay soils. Habitat and ecology poorly known. Grows under shrubs and trees and can be easily overlooked. Tends to prefer slightly modified environments.	No	n/a	Low - Moderate	Marginal habitat present in areas of native woodland. The woodland areas are highly modified and the understorey sparse due to previous clearing and ongoing grazing. This has reduced the suitability of habitat.	Yes	December - April	March, September, November	n/a
Brassicaceae	*Lepidium aschersonii*	Spiny Peppercress	V	V	3	2007	Recorded within 20km since 1980	-	Yes	Found on ridges of gilgai clays dominated by Brigalow, Belah, Bulloak and Grey Box. Often the understorey is dominated by introduced plants. The species grows as a component of the ground flora, in grey loamy clays. Vegetation structure varies from open to dense, with sparse grassy understorey and occasional heavy litter.	No	n/a	Low - Moderate	No suitable gilgai habitat present although small areas of highly modified Belah woodland is present as very marginal habitat; grazing impacts and drought conditions has reduced the suitability of habitat.	Yes	September - May	March, September, November	n/a
Rutaceae	*Philotheca ericifolia*	-	Not listed	V	0	n/a	-	Species or species habitat likely to occur within area	No	This species occurs in drainage areas in dry sclerophyll open forest or woodland on sandstone and in heath on damp sandy flats and gullies. Specific microclimates include damp sandy flats, alluvial deposits of coarse gravel in dry creek beds and along a spur receiving soakage from high ground. Associated species include Narrow-leaved Ironbark, Pinkwood and *Philotheca australis*.	No	n/a	Unlikely	No suitable habitat is present. No dry sclerophyll forests or woodlands on sandstone. No heathy understories in sandy flats and gullies. Lack of suitable microclimates across the study area.	No	n/a	n/a	n/a
Polygalaceae	*Polygala linariifolia*	Native Milkwort	E	Not listed	2	2006	Recorded within 20km since 1980	-	Yes	In NSW known from three locations: an isolated population west of Hungerford; north from Warialda and Copeton Dam; and on the north coast near Casino and Kyogle. Grows in sandy soils in dry eucalypt forest and woodland with a sparse understorey. In the Pilliga area has been recorded in Fuzzy Box woodland, White Cypress Pine - Bulloke - Ironbark woodland, Rough-barked Apple riparian forb-grass open forest, and Ironbark - Brown Bloodwood shrubby woodland	No	n/a	Unlikely	No suitable habitat is present. No dry sclerophyll forests and woodlands on sandy soils. The habitats that this species is associated with is typical of vegetation found in the Pilliga Outwash sub-region to the south of Narrabri.	No	n/a	n/a	n/a
Rutaceae	*Pomaderris queenslandica*	Scant Pomaderris	E	Not listed	0	n/a	-	-	Yes	Widespread but uncommon in northeast NSW and in Queensland. Known only from a few locations on the New England Tablelands and northwest slopes, including near Torrington and Coolatai, and from the NSW north coast. Inhabits moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks.	No	n/a	Unlikely	No suitable habitat is present. Habitats in the study area lack sheltered, shrubby understories.	No	n/a	n/a	n/a
Orchidaceae	*Pterostylis cobarensis*	Greenhood Orchid, Cobar Rustyhood	V	Not listed	3	2011	Recorded within 20km since 1980	-	No	Recorded from Bourke, Nyngan, Cobar, Nymagee, Warren, Gilgandra, Narrabri and Coonabarabran districts. Grows in eucalypt woodlands, open mallee shrubland or Callitris shrublands on low stony ridges in skeletal sandy loam soils. Associated species include Grey Mallee, Green Mallee, Gum Coolibah,*Eucalyptus vicina*, White Cypress Pine, Wilga, Belah, Currawang, *Senna* spp. and *Eremophila* spp.	No	n/a	Unlikely	No suitable habitat is present. No shrublands on stony ridges are present in the study area, and soils are not shallow sandy loams.	No	n/a	n/a	n/a
Fabaceae - Faboideae	*Swainsona murrayana*	Slender Darling Pea	V	V	0	n/a	-	-	Yes	Appears to prefer clay-based soils, ranging from grey, red and brown cracking clays to red-brown earths and loams, and appears in association with bladder saltbush, black box and grassland communities on level plains, floodplains and depressions and is often found with *Maireana* species. Plants have been found in remnant native grasslands or grassy woodlands that have been intermittently grazed or cultivated. The species may require some disturbance and has been known to occur in paddocks that have been moderately grazed or occasionally cultivated	No	n/a	Low - Moderate	Marginal habitat present in areas of native woodland and derived native grasslands; grazing impacts and drought conditions has reduced the suitability of habitat.	Yes	September - February	March, September, November	n/a
Apocynaceae	*Tylophora linearis*	-	V	E	0	n/a	-	Species or species habitat likely to occur within area	Yes	Found in the Barraba, Mendooran, Temora and West Wyalong districts in the northern and central western slopes of NSW. Grows in dry scrub and open forest. Recorded from low-altitude sedimentary flats in dry woodlands of Red Ironbark, Mugga Ironbark, White Box, Black Cypress Pine, White Cypress Pine and Bulloak.	No	n/a	Unlikely	No suitable habitat is present. The woodlands within the study area are associated with alluvials and basalt outwashes. Dry woodland habitat on sedimentary flats and low rises do not occur in the study area.	No	n/a	n/a	n/a

Key:
V - vulnerable
E - endangered

Likelihood of occurrence of threatened fauna species at the site

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Australian Brush-turkey population in the Nandewar and Brigalow Belt South Bioregions *Alectura lathami*	E		S	35 records (OEH 2018a)	Endangered population occurs in the Nandewar and Brigalow Belt South bioregions from north-east of Warialda to Narrabri. Majority of records are from Mount Kaputar National Park and Deriah State Forest, with some records from Severn State Forest. Preferred inland habitat is a dry rainforest community within the Semi-evergreen Vine Thicket EEC. Birds build nesting mounds in dense vegetation, while tall trees such as Eucalypts are used for nocturnal and diurnal roosting.	Nil. No suitable habitat present.
Australian Bustard *Ardeotis australis*	E		Species	Credit calculator	Occurs in inland Australia. In NSW mainly found in the north-west corner, less often in the lower western and central west plains regions, with occasional vagrants east to the western slopes and riverine plain. Breeding confined to the north-west region. Mainly inhabits tussock and hummock grasslands, also occurs in low shrublands and low open grassy woodlands. Breeds on bare ground on low sandy ridges or stony rises in ecotones between grassland and shrubland cover. Travels long distances, presumably in response to habitat and climatic conditions.	Possible. Not observed during surveys.
Australian Painted Snipe *Rostratula australis*	E	E	Ecosystem	2 records, last recorded 2007 (OEH 2018a); Species or species' habitat likely to occur within 10km (DotE 2018a)	Normally found in permanent or ephemeral shallow inland wetlands, either freshwater or brackish. Nests on the ground amongst tall reed-like vegetation near water. Feeds on mudflats and the water's edge taking insects, worm and seeds. Prefers fringes of swamps, dams and nearby marshy areas with cover of grasses, lignum, low scrub or open timber.	Nil. No suitable wetland habitat present. Very small farm dams unlikely to provide suitable habitat for this species.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Barking Owl *Ninox connivens*	V		Species (breeding)	74 records (OEH 2018a)	Occurs from coast to inland slopes and plains, though is rare in dense, wet forests east of the Great Dividing Range and sparse in higher parts of the tablelands and in the arid zone. Inhabits eucalypt woodlands, open forest, swamp woodlands, and, especially in inland areas, timber along watercourses. Roosts along creek lines in dense, tall understorey foliage (e.g. in Acacia and Casuarina), or dense eucalypt canopy. Nests in hollows of large, old eucalypts including *Eucalyptus camaldulensis, Eucalyptus albens, Eucalyptus polyanthemos* and *Eucalyptus blakelyi*. Birds and mammals important prey during breeding. Territories range from 30 to 200 hectares.	Possible. Could forage on site. Breeding unlikely as no timbered watercourse present.
Black Falcon *Falco subniger*	V		Ecosystem	2 records (OEH 2018a)	The Black Falcon is widely, but sparsely, distributed in New South Wales, mostly occurring in inland regions. Occurs in plains, grasslands, foothills, timbered watercourses, wetland environs, crops, and occasionally over towns and cities. Breeding occurs along timbered waterways in inland areas.	Present. Recorded roosting in dense canopy of a paddock tree.
Black-breasted Buzzard *Hamirostra melanosternon*	V		Ecosystem / Species	Credit calculator	Sparsely distributed in areas of less than 500mm rainfall, north from north-western NSW. Inhabits a range of inland habitats, especially along timbered watercourses which is the preferred breeding habitat. Also hunts over grasslands and sparsely timbered woodlands. Breeds from August to October near water in a tall tree.	Unlikely. Could forage on occasion at the site. No suitable waterways with very large raptor nests present.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Black-chinned Honeyeater (eastern subspecies) *Melithreptus gularis gularis*	V		Ecosystem	5 records (OEH 2018a)	Widespread in NSW, but rarely recorded east of Great Dividing Range except in Richmond and Clarence River areas and scattered sites in the Hunter, Central Coast and Illawarra regions. Mostly in upper levels of drier open forests /woodlands dominated by box and ironbark eucalypts, or less commonly smooth-barked gums, stringybarks and tea-treas. Forage over home range of >5 ha. Tend to occur within largest woodland patches in the landscape. They forage for insects, nectar and honeydew. The nest is hidden by foliage high in the crown of a tree.	Unlikely. Poor quality woodland habitat unlikely to support foraging of this species.
Brolga *Grus rubicunda*	V		Ecosystem	1 record, last recorded 2003 (OEH 2018a)	In NSW occurs west of the Great Dividing Range and on the north coast. Dependent on wetlands, especially shallow swamps. Often feed in dry grassland, ploughed paddocks or desert claypans.	Unlikely. No wetland habitat present. Could forage in paddocks on rare occasions.
Brown Treecreeper (eastern subspecies) *Climacteris picumnus victoriae*	V		Ecosystem	136 records (OEH 2018a)	Occurs from Corowa, Wagga Wagga, Temora, Forbes, Dubbo and Inverell to the east coast, in areas such as the Snowy River Valley, Cumberland Plain, Hunter Valley and parts of the Richmond and Clarence Valleys. Most common on the inland slopes and plains. Inhabits eucalypt woodlands and dry open forest, usually dominated by stringybarks or rough-barked species with open grassy understorey. Fallen timber is important foraging habitat. Nests in hollows in standing trees or stumps.	Unlikely. No large patches of woodland present. Limited fallen timber present.
Bush Stone-curlew *Burhinus grallarius*	E		Species	4 records (OEH 2018a)	Scattered distribution across NSW. Inhabits lowland grassy woodland and open forest and, in coastal areas, Casuarina and Melaleuca woodlands, saltmarsh and mangroves. Requires a low, sparse groundcover, some fallen timber and leaf litter, and a general lack of a shrubby understory (DEC 2006).	Unlikely. No large patches of woodland present. Limited fallen timber present.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Diamond Firetail *Stagonopleura guttata*	V		Ecosystem	34 records (OEH 2018a)	Typically found west of the Great Dividing Range, but populations also occur in drier coastal areas including W Sydney, Hunter, Clarence and Snowy River valleys. Occurs in grassy eucalypt woodlands including Box Gum and Snow Gum communities, as well as open forest, mallee and natural and derived grasslands. Often found in riparian areas and occasionally in lightly wooded farmland. Nests in shrubby understorey or higher up under nests of other species.	Possible. Could forage and breed at the site.
Dusky Woodswallow *Artamus cyanopterus*	V		Ecosystem	52 records (OEH 2018a)	The Dusky Woodswallow is widespread from the coast to inland, including the western slopes of the Great Dividing Range and farther west. It is often recorded in woodlands and dry open sclerophyll forests, and has also been recorded in shrublands, heathlands regenerating forests and very occasionally in moist forests or rainforests. The understorey is typically open with sparse eucalypt saplings, acacias and other shrubs, often with coarse woody debris. It is also recorded in farmland, usually at the edges of forest or woodland or in roadside remnants or wind breaks with dead timber. The nest is an open shallow untidy cup frequently built in an open hollow, crevice or stump. Although Dusky Woodswallows have large home ranges, individuals may spend most of their time in about a 2 ha range and defend an area about 50 m around the nest. Dusky Woodswallows prefer larger remnants over smaller remnants. Competitive exclusion by Noisy Miners (Manorina melanocephala) is a significant threat to this species.	Unlikely. Poor quality fragmented woodland habitat unlikely to support foraging of this species.
Flame Robin *Petroica phoenicea*	V		Ecosystem	1 record (OEH 2018a)	Breeds in upland moist eucalypt forests and woodlands, often on ridges and slopes, in areas of open understorey. Migrates in winter to more open lowland habitats such as grassland with scattered trees and open woodland on the	Likely. Could forage on occasion at the site. No breeding habitat present.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
					inland slopes and plains. Forages from low perches, feeding on invertebrates taken from the ground, tree trunks, logs and other coarse woody debris. Fallen logs and coarse woody debris are important habitat components. Open cup nest of plant fibres and cobweb is often built near the ground in a sheltered niche, ledge or shallow cavity in a tree, stump or bank.	
Freckled Duck *Stictonetta naevosa*	V		Ecosystem	3 records (OEH 2018a)	Breeds in large, ephemeral swamps in the Murray-Darling, particularly along the Paroo and Lachlan Rivers and other Riverina rivers. In drier times moves to more permanent waters. Disperses during extensive inland droughts and may be found in coastal areas during such times. Prefers freshwater swamps/ccreeks with dense Cumbungi, Lignum or tea-tree. Nests in dense vegetation at or near water level.	Nil. No wetland habitat present.
Glossy Black-Cockatoo *Calyptorhynchus lathami*	V		Ecosystem/ Species	98 records (OEH 2018a)	Widespread but uncommon from coast to southern tablelands and central western plains. Feeds almost exclusively on the seeds of Allocasuarina species. Prefers woodland and open forests, rarely away from Allocasuarina. Roost in leafy canopy trees, preferably eucalypts, usually <1km from feeding site. Nests in large (approx. 20cm) hollows in trees, stumps or limbs, usually in Eucalypts.	Unlikely. No suitable foraging habitat. Lack of water and limited leafy eucalypts present.
Grey Falcon *Falco hypoleucos*	E		Ecosystem	Credit calculator	Inhabits shrubland, grassland and wooded watercourses of arid and semi-arid regions, and occasionally open woodlands throughout the Murray-Darling Basin, with the occasional vagrant east of the Great Dividing Range. Breeding only occurs within arid areas of the Great Dividing Range. Its diet consists of other birds, especially parrots and pigeons, reptiles and small mammals. Nesting occurs in disused nests of other birds of prey and ravens, high in a	Possible. Could forage on occasion at the site. Unlikely to breed in the area.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
					living eucalypt near water or a watercourse. Breeding occurs in late winter and early spring.	
Grey-crowned Babbler (eastern subspecies) *Pomatostomus temporalis temporalis*	V		Ecosystem	398 records (OEH 2018a)	Occurs on western slopes and plains , as well as in the Hunter Valley and several locations on the north coast. Inhabits open Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands on alluvial plains. Family groups have territories between 1-50 (generally around 10) hectares. Nests typically built in shrubs or sapling eucalypts.	Present. Foraging and nests observed on site.
Hooded Robin (south-eastern form) *Melanodryas cucullata cucullata*	V		Ecosystem	32 records (OEH 2018a)	Considered a sedentary species, but local seasonal movements are possible. Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Occurrence is positively associated with patch size, and with components of habitat complexity including canopy cover, shrub cover, ground cover, logs, fallen branches and litter. Nests on low, live or dead forks or branches of trees or stumps, or occasionally on fallen trees or limbs.	Unlikely. Poor quality fragmented woodland habitat unlikely to support foraging of this species.
Little Eagle *Hieraaetus morphnoides*	V		Ecosystem/ Species	19 records (OEH 2018a)	Occurs throughout NSW except most densely forested parts of the Dividing Range escarpment. Occupies habitats rich in prey within open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used. For nest sites it requires a tall living tree within a remnant patch, where pairs build a large stick nest in winter and lay in early spring.	Possible. Could forage at the site. No large raptor nests observed other than an active Whistling Kite and possible falcon nest.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Little Lorikeet *Glossopsitta pusilla*	V		Ecosystem	76 records (OEH 2018a)	Occurs from coast to western slopes of the Great Dividing Range. Inhabits dry, open eucalypt forests and woodlands. Occurrence is positively associated with patch size, and with components of habitat complexity including canopy cover, shrub cover, ground cover, logs, fallen branches and litter. Feed primarily on profusely-flowering eucalypts and a variety of other species including melaleucas and mistletoes. On the western slopes and tablelands Eucalyptus albens and E. melliodora are particularly important food sources for pollen and nectar respectively. Mostly nests in small (opening approx. 3cm) hollows in living, smooth-barked eucalypts, especially Eucalyptus viminalis, E. blakelyi and E. dealbata. Most breeding records are from the western slopes.	Likely. Could forage on occasion at the site. Potential breeding habitat present.
Magpie Goose *Anseranas semipalmata*	V		Ecosystem	4 records (OEH 2018a)	Occurs in the tropics, increasing numbers in central and northern NSW and vagrants to south-east NSW. Inhabits shallow wetlands containing dense rushes or sedges, and nearby dry land used for grazing. It feeds on grasses, bulbs and rhizomes and roosts in tall vegetation within wetland areas. Breeding is occurs predominately in monsoonal areas and is unlikely in SE NSW. Nests are formed in trees over deep water.	Nil. No suitable wetland habitat present.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Malleefowl *Leipoa ocellata*	E	V	Ecosystem	1 record, last recorded 1999 (OEH 2018a); Species or species' habitat liekly to occur within 10km (DotE 2018a)	Occurs in semi-arid to arid mallee country in the south-west of NSW. Occasional records exist from the Pilliga. Inhabits predominately mallee communities, apparently preferring areas of sandy soil, abundant leaf litter, dense canopy and an abundance of food shrubs and herbs (especially legumes). Less frequently found in other eucalypt woodlands such as *Eucalyptus microcarpa*, Ironbark and *E. populnea* woodlands with thick understorey, and Mulga and native Cypress Pine communities.	Nil. No suitable habitat present.
Masked Owl *Tyto novaehollandiae*	V		Ecosystem/ Species	8 records (OEH 2018a)	Occurs across NSW except NW corner. Most common on the coast. Inhabits dry eucalypt woodlands from sea level to 1100 m. Roosts and breeds in large (>40cm) hollows and sometime caves in moist eucalypt forested gullies. Hunts along the edges of forests and roadsides. Home range between 500 ha and 1000 ha. Prey mostly terrestrial mammals but arboreal species may also be taken.	Possible. May forage on occasion at the site. No breeding habitat present.
Painted Honeyeater *Grantiella picta*	V	V	Ecosystem	23 records (OEH 2018a); Species or species' habitat known to occur within 10km (DotE 2018a)	Nomadic, occurring in low densities across most of NSW. Highest concentrations and almost all breeding occur on inland slopes of the Great Dividing Range. Inhabits Boree, Brigalow and Box Gum woodlands and Box-Ironbark forests. Specialist forager on the fruits of mistletoes, preferably of the Amyema genus. Nests in outer tree canopy.	Unlikely. Poor quality fragmented woodland habitat unlikely to support foraging of this species. Few mistletoes observed.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Regent Honeyeater *Anthochaera phrygia*	CE	CE	Ecosystem/ Species	4 records (OEH 2018a); Foraging, feeding or related behaviour may occur within 10km (DotE 2018a)	In NSW confined to two known breeding areas: the Capertee Valley and Bundarra-Barraba region. Non-breeding flocks occasionally seen in coastal areas foraging in flowering Spotted Gum and Swamp Mahogany forests, presumably in response to drought. Inhabits dry open forest and woodlands, particularly Box-Ironbark woodland and riparian forests of River Sheoak, with an abundance of mature trees, high canopy cover and abundance of mistletoes. The species is a dual credit species, with the species credit component mapped as an important area. These mapped areas do NOT require survey as it is presumed that the species is present. Any impact from development could potentially be serious and irreversible. Ecosystem credit areas are unlikely to have potential serious and irreversible impacts.	Unlikely. Poor quality woodland habitat unlikely to support foraging of this species. No important foraging habitat present. Does not breed in the area.
Scarlet Robin *Petroica boodang*	V		Ecosystem	9 records (OEH 2018a)	In NSW occurs from coast to inland slopes. Breeds in drier eucalypt forests and temperate woodlands, often on ridges and slopes, within open understorey of shrubs and grasses and sometimes in open areas. In autumn and winter it migrates to more open habitats such as grassy open woodland or paddocks with scattered trees. Abundant logs and coarse woody debris are important habitat components.	Unlikely. Poor quality woodland habitat unlikely to support foraging of this species.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Speckled Warbler *Chthonicola sagittata*	V		Ecosystem	255 records (OEH 2018a)	Within NSW most frequently reported from the hills and tablelands of the Great Dividing Range, rarely from the coast. Inhabits a wide range of Eucalyptus-dominated communities with a grassy understorey, a sparse shrub layer, often on rocky ridges or in gullies. Sedentary and requires large, relatively undisturbed remnants to persist in an area. Forages on the ground for seeds and insects, and nests in a slight hollow in the ground or at the base of a low dense plant.	Unlikely. Poor quality woodland habitat unlikely to support foraging of this species.
Spotted Harrier *Circus assimilis*	V		Ecosystem	14 records (OEH 2018a)	Occurs throughout Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. Inhabits grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe (e.g. chenopods). Most commonly in native grassland, but also in agricultural land, foraging over open habitats including edges of inland wetlands. Builds a stick nest in a tree and lays eggs in spring (or sometimes autumn).	Possible. Could forage at the site. No large raptor nests observed other than an active Whistling Kite and possible falcon nest.
Square-tailed Kite *Lophoictinia isura*	V		Ecosystem/ Species	5 records (OEH 2018a)	Occurs across NSW, resident in North, northeast and along west-flowing rivers. Summer breeding migrant to southeast of state. Inhabits a variety of habitats including woodlands and open forests, with preference for timbered watercourses. Favours productive forests on the coastal plain, box-ironbark-gum woodlands on the inland slopes, and Coolibah/River Red Gum on the inland plains. In Sydney area nests in mature living trees within 100m of ephemeral/permanent watercourse. Large home range > 100 km^2.	Possible. Could forage at the site however no timbered watercourses present. No large raptor nests observed other than Whistling Kite and possible falcon nest.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Superb Parrot *Polytelis swainsonii*	V	V	Ecosystem/ Species	18 records (OEH 2018a); Species or species' habitat may occur within 10km (DotE 2018a)	Occurs as a single population in the South-west Slopes and Riverina bioregions. Two core breeding areas: between Cowra and Yass – Grenfell, Cootamundra and Coolac in the SW Slopes, and along the Murray, Edward and Murrumbidgee Rivers in the Riverina. Birds breeding in the SW slopes migrate north to the Namoi/Gwydir Rivers for winter. Inhabits Box Gum, Box – Cypress Pine and Boree woodlands and River Red Gum Forest. Nest in hollow trees, in tall riparian River Red Gum communities (Riverina area) or open Box Gum woodland or isolated paddock trees (SW Slopes). Mainly forages in grassy box woodlands, up to 10km from breeding sites.	Unlikely. Could forage on occasion at the site. Breeding does not occur in the Narrabri area.
Swift Parrot *Lathamus discolor*	E	CE	Ecosystem/ Species	Credit calculator	Migratory, travelling to the mainland from March to October. Breeds in Tasmania from September to January. On the mainland, it mostly occurs in the southeast foraging on winter flowering eucalypts and lerps, with records of the species between Adelaide and Brisbane. Principal over-winter habitat is box-ironbark communities on the inland slopes and plains. The species is a dual credit species, with the species credit component mapped as an important area. These mapped areas do NOT require survey as it is presumed that the species is present. Any impact from development could potentially be serious and irreversible. Ecosystem credit areas are unlikely to have potential serious and irreversible impacts.	Unlikely. Poor quality woodland habitat unlikely to support foraging of this species.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Turquoise Parrot *Neophema pulchella*	V		Ecosystem	140 records (OEH 2018a)	Occurs from coast to inland slopes. In coastal area, most common between Hunter and Northern Rivers, and further south in S Coast. Inhabits open eucalypt woodlands and forests, typically with a grassy understorey. Favours edges of woodlands adjoining grasslands or timbered creek lines and ridges. Feeds on the seeds of native and introduced grasses and other herbs. Grasslands and open areas provide important foraging habitat for this species while woodlands provide important roosting and breeding habitat. Nests in tree hollows, logs or posts from August to December.	Likely. Could forage on occasion at the site. Potential breeding habitat present.
Varied Sittella *Daphoenositta chrysoptera*	V		Ecosystem	64 records (OEH 2018a)	Sedentary, occurs across NSW from the coast to the far west. Inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. Sensitive to habitat isolation and loss of structural complexity, and adversely affected by dominance of Noisy Miners. Cleared agricultural land is potentially a barrier to movement. Builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years.	Possible. Could forage on occasion at the site.
White-bellied Sea-Eagle *Haliaeetus leucogaster*	V	C	Ecosystem/ Species	4 records (OEH 2018a)	Primarily coastal but may extend inland over major river systems. Breeds close to water, mainly in tall open forest/woodland but also in dense forest, rainforest, closed scrub or remnant trees. Usually forages over large expanses of open water, but also over open terrestrial habitats (e.g. grasslands).	Nil. No suitable foraging habitat present. No large raptor nests observed other than Whistling Kite and possible falcon nest.
Curlew Sandpiper *Calidris ferruginea*	E	M (C,J,K)	Ecosystem/ Species	Species or species' habitat may occur within 10km (DotE 2018a)	Breeds in northern hemisphere. In Australia generally occupies littoral and estuarine habitats. In NSW mainly found in intertidal mudflats on sheltered coasts. Roosts on beaches, spits or islands on the coast/in wetlands, or in saltmarsh on rocky shores.	Nil. No wetland habitat present. Very small farm dams present unlikely to provide suitable foraging habitat.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Black-striped Wallaby *Macropus dorsalis*	E		Ecosystem	623 records (OEH 2018a)	Occurs on the far north coast and western slopes of NSW. On the north-west slopes occurs in Brigalow remnants to south of Narrabri. Preferred habitats characterised by dense low (up to 3m) woody or shrubby vegetation, near open grassy foraging areas. On the north-west slopes associated with dense vegetation including brigalow, ooline and vine-thickets. On the north-coast closely associated with dry rainforest but also recorded from moist eucalypt forest with dense understorey.	Nil. No suitable shrubby vegetation present.
Brush-tailed Rock-wallaby *Petrogale penicillata*	E	V	Species	9 records (OEH 2018a)	Occurs from the Shoalhaven north to the Queensland border. Now mostly extinct west of the Great Dividing Range, except in the Warrumbungles and Mt Kaputar. Occurs on rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north. Diet consists of vegetation in adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	Nil. No suitable rocky habitat present. No targeted surveys conducted.
Corben's Long-eared Bat *Nyctophilus corbeni*	V	V	Ecosystem	49 records (OEH 2018a); Species or species' habitat likely to occur within 10km (DotE 2018a)	Little known about the biology or social structure of these bats - rarely recorded and scattered distribution. Limited distribution that is retricted to the Murray-Darling Basin and western slopes in south-eastern Australia. Occur in a wide range of habitats including River Red Gum, Black Box, Allocasuarina, Belah, Mallee, open woodlands and savannahs, but are most common in box, ironbark and cypress open forests and buloke woodlands of inland northern NSW (Churchill 2008). In SA known to roost in tree hollows less than 3m above the ground with multiple small entrances, elsewhere they roost in fissures in branches and under exfoliating bark. Tree hollows used as maternity sites.	Possible. Could forage and breed at the site.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*	V		Ecosystem/ Species	15 records (OEH 2018a)	Generally occurs east of the Great Dividing Range along NSW coast. Inhabits various habitats from open grasslands to woodlands, wet and dry sclerophyll forests and rainforest. Essentially a cave bat but may also roost in road culverts, stormwater tunnels and other man-made structures. Only 4 known maternity caves in NSW, near Wee Jasper, Bungonia, Kempsey and Texas. Females may travel hundreds of kilometres to the nearest maternal colony.	Likely. Could forage on occasion oat the site. No breeding habitat present.
Eastern Cave Bat *Vespadelus troughtoni*	V		Species	28 records (OEH 2018a)	Occurs in NE NSW south to Kempsey and west to the Warrumbungles. Inhabits rainforest margins, wet and dry sclerophyll forests through to drier forests and woodlands in semi-arid environments. All records are within close proximity to sandstone or volcanic escarpments. Roosts in overhangs and caves, mines, boulder piles, abandoned Fairy Martin nests and occasionally in buildings, and regularly switches between alternate roost colonies. Forages over a small area, but are capable of flying 500m over clear paddocks.	Unlikely. Not recorded during anabat surveys. No volcanic escarpments in close proximity. Records in the region are centred around the Pilliga and forests of the Boggabri area.
Eastern Freetail-bat *Mormopterus norfolkensis*	V		Ecosystem	2 records (OEH 2018a)	Occurs in dry sclerophyll forest and woodland east of the Great Dividing Range. Forages in natural and artificial openings in vegetation, typically within a few kilometres of its roost. Roosts primarily in tree hollows but also recorded from man-made structures or under bark.	Present (probable record based on Anabat analysis). May forage, roost and breed at the site.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Eastern Pygmy-possum *Cercartetus nanus*	V		Species	7 records (OEH 2018a)	Occurs along the east coast of NSW, and inland to the Pillaga, Dubbo, Parkes and Wagga Wagga. Inhabits range of habitats from coastal heath and woodland though open and closed forests, subalpine heath and rainforest. Inhabits rainforest, sclerophyll forests and heath. Banksia spp. and myrtaceous shrubs and trees are favoured food sources and nesting proposal sites in drier habitats. Diet mostly pollen and nectar from Banksia, Eucalyptus, and Callistemon species, and insects. Nests in hollows in trees, under the bark of Eucalypts, forks of tea-trees, abandoned bird nests and *Xanthorrhoea* bases.	Nil. No suitable forested habitat present.
Greater Glider *Petauroides volans*		V	Species	27 records (OEH 2018a); Species or species' habitat may occur within 10km (DotE 2018a)	The greater glider is restricted to eastern Australia, occurring from the Windsor Tableland in north Queensland through to central Victoria, from sea level to 1200 m above sea level. It prefers taller montane, moist eucalypt forest with relatively old trees and abundant hollows.	Nil. No suitable moist forest habitat present. Nearest records are from Mt Kaputar National Park. No records from the Pilliga.
Grey-headed Flying-fox *Pteropus poliocephalus*	V	V	Ecosystem/ Species	Foraging, feeding or related behaviour may occur within 10km (DotE 2018a)	Roosts in camps within 20 km of a regular food source, typically in gullies, close to water and in vegetation with a dense canopy. Forages in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths, swamps and street trees, particularly in eucalypts, melaleucas and banksias. Highly mobile with movements largely determined by food availability. Will also forage in urban gardens and cultivated fruit crops.	Unlikely. No local records. No breeding camp present.
Koala *Phascolarctos cinereus*	V	V	Ecosystem/ Species	107 records (OEH 2018a); Species or species' habitat known to occur within 10km (DotE 2018a)	Occurs from coast to inland slopes and plains. Restricted to areas of preferred feed trees in eucalypt woodlands and forests. Home range varies depending on habitat quality, from < 2 to several hundred hectares. Important' habitat (species credit habitat) is defined by the density	Unlikely. Limited connectivity with better quality patches of vegetation. Site would not constitute core or important

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
					of koalas and quality of habitat determined by on-site survey.	habitat. No evidence during surveys.
Large-eared Pied Bat *Chalinolobus dwyeri*	V	V	Species	39 records (OEH 2018a); Species or species' habitat likely to occur within 10km (DotE 2018a)	Occurs from the coast to the western slopes of the divide. Largest numbers of records from sandstone escarpment country in the Sydney Basin and Hunter Valley. Roosts in caves and mines and most commonly recorded from dry sclerophyll forests and woodlands. An insectivorous species that flies over the canopy or along creek.	Unlikely. Limited connectivity with better quality patches of vegetation. No vegetated creek lines or rocky outcrops present. Records in the region are from Mt Kaputar National Park and the Pilliga.
Little Pied Bat *Chalinolobus picatus*	V		Ecosystem	24 records (OEH 2018a)	Found in caves, rock outcrops, mine shafts, tunnels, tree hollows and buildings in dry open forest and woodland, mulga woodlands, chenopod shrublands, cypress-pine forest, mallee, and Bimble box communities. They feed on moths and other flying invertebrates.	Present (probable record based on Anabat analysis). May forage, roost and breed at the site.
Pilliga Mouse *Pseudomys pilligaensis*	V	V	Ecosystem	67 records (OEH 2018a); Species or species' habitat may occur within 10km (DotE 2018a)	Mainly confined to low-nutrient deep sands of the Pilliga region, though an individual was also recorded from the Warrumbungles following major fires in 2013. Appears to prefer areas with sparse groundcover. Occur in highest numbers in: recently burnt moist gullies; areas dominated by Broombush; and areas with Bloodwood overstorey and *Acacia burrowii* understorey.	Nil. No suitable forested habitat present.
Spotted-tailed Quoll *Dasyurus maculatus*	V	E	Ecosystem	2 records (OEH 2018a)	Inhabits a range of environments including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Den sites are in hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces. Females occupy home ranges of up to 750 ha and males up to 3,500 ha, usually traversed along densely vegetated creek lines.	Unlikely. Limited connectivity with better quality patches of vegetation. No vegetated creek lines present.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Squirrel Glider *Petaurus norfolcensis*	V		Species	28 records (OEH 2018a)	Occurs along the drier inland slopes as well as coastal habitats. Inhabits woodland and open forest with a Eucalyptus, Corymbia or Angophora overstorey and a shrubby understorey of Acacia or Banksia. Key habitat components include reliable winter and early-spring flowering Eucalypts, Banksia or other nectar sources, and hollow-bearing trees for roost and nest sites, with social groups moving between multiple hollows.	Unlikely. Suitable woodland habitat with flowering understory species not present.
Stripe-faced Dunnart *Sminthopsis macroura*	V		Species	No local records	Occurs throughout much of inland central and northern Australia, extending into central and northern NSW. Prefers relatively ungrazed habitats with greater diversity and healthier understorey vegetation. Occurs in native dry grasslands and low dry shrublands, often along drainage lines where food and shelter resources tend to be better.	Unlikely. Site is highly grazed and has no drainage lines with suitable habitat. No local records.
Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris*	V		Ecosystem	193 records (OEH 2018a)	Migrates from tropics to SE Aus in summer. Forages across a range of habitats including those with and without trees, from wet and dry sclerophyll forest, open woodland, Acacia shrubland, mallee, grasslands and desert. Roosts communally in large tree hollows and buildings (Churchill 2008).	Present (definite record based on Anabat analysis). May forage, roost and breed at the site.
Pink-tailed Worm-lizard *Aprasia parapulchella*	V	V	Ecosystem	Species or species' habitat may occur within 10km (DotE 2018a)	Populations occur in the Queanbeyan/Canberra district, Cooma, Yass, Bathurst, Albury and West Wyalong areas. Inhabits grassland and open woodland with substantial embedded rock cover in sunny situations. Recorded in both native and non-native grasslands. Usually recorded under small rocks (150 - 600 mm basal area) shallowly embedded in the soil (2 - 5 cm, and use ant burrows under these rocks.	Nil. No suitable rocky habitat present. No targeted surveys conducted.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Border Thick-tailed Gecko *Uvidicolus sphyrurus*	V	V	Species	1 record, last recorded 2000 (OEH 2018a)	The Border Thick-tailed Gecko occurs in the New England Tableland, Nandewar and Brigalow Belt South Bioregions in northern NSW and in south-east Queensland. It is a nocturnal species that shelters by day and is most commonly found in undisturbed habitat remnants on rocky outcrops and stony hills within eucalypt and cypress-pine open forest or woodland between 500-1100 m elevation.	Nil. No suitable rocky habitat in undisturbed remnants present.
Five-clawed Worm-skink *Anomalopus mackayi*	E	V	Ecosystem	3 records (OEH 2018a); Species or species' habitat may occur within 10km (DotE 2018a)	Patchily distributed on the north-west slopes and plains of NSW between Ashford, Mungindi and Walgett and north into Queensland. Inhabits deep burrows and soil cracks in grassy White Box woodland on moist black soils and River Red Gum - Coolibah - Bimble Box woodland on cracking clays. Has also been recorded in grassland areas and open paddocks with scattered trees.	Possible. Could occur in better quality woodland patches as well as grazed paddocks.
Pale-headed Snake *Hoplocephalus bitorquatus*	V		Species	28 records (OEH 2018a)	Occurs north from Tuggerah along the coast and to the western side of the Great Divide, historically recorded as far west as Mungindi and Quambone. Inhabits dry eucalypt forests and woodlands, cypress woodland and occasionally in rainforest or moist eucalypt forest. West of the Great Dividing Range in NSW the species, has been recently recorded in sites dominated by Narrow-leaved Ironbark, Black Box and Silver-leaf Ironbark woodland and Coolabah. Favours streamside areas, particularly in drier habitats. Shelter during the day between loose bark and tree-trunks, or in hollow trunks and limbs of dead trees.	Unlikely. No suitable woodland along streams present at the site.

Name	BC Status	EPBC Status	Credit type	Source	Habitat Association	Likelihood of Occurrence
Eel Trailed Catfish *Tandanus tandanus*	E (FM Act)		NA	(DPI 2018a)	In NSW is currently only regularly observed in the Macquarie catchment upstream of Warren, the Castlereagh catchment upstream of Mendooran, the Namoi catchment upstream of Wee Waa, the Gwydir catchment upstream of Moree and the Border Rivers catchment upstream of Goondiwindi. Present in a range of riverine and lake habitats, preferring sluggish or still waters. Found in both clear and turbid waters, in areas ranging from mud to gravel to rock substrates. Now rare in riverine habitats in inland NSW and Queensland but can be found in farm dams.	Nil. No riverine habitat present.
Murray Cod *Maccullochella peelii*		V	NA	Species or species' habitat may occur within 10km (DotE 2018a)	Occurs throughout the Murray-Darling Basin. Can live in a wide range of habitats, from clear, rocky streams in the upper western slopes regions of New South Wales to the slow flowing, turbid rivers and billabongs of the western plains. Generally, they are found in waters up to 5m deep and in sheltered areas with cover from rocks, timber or overhanging banks. The presence of wood debris has been shown to be the primary factor determining Murray cod presence.	Nil. No riverine habitat present.
Purple Spotted Gudgeon *Mogurnda adspersa*	E (FM Act)		NA	(DPI 2018a)	Occured in inland drainages of the Murray-Darling basin as well as coastal drainages of northern NSW and Queensland. Now extremely rare in inland NSW, having been recorded from this area only once since 1983. Found in slow-moving or still waters of rivers, creeks and billabongs, often amongst weeds, rocks or large woody debris (snags).	Nil. No suitable creek or billabong habitat present.

Key: CE – critically endangered, E – endangered, EP – endangered population, V – vulnerable.

Appendix B – Survey results

Flora species recorded

Family	Scientific Name	Common Name	Exotic	BC Status	EPBC Status
Acanthaceae	*Brunoniella australis*	Blue Trumpet	-	-	-
Aizoaceae	*Tetragonia moorei*	-	-	-	-
Aizoaceae	*Tetragonia tetragonioides*	New Zealand Spinach	-	-	-
Amaranthaceae	*Alternanthera nodiflora*	Common Joyweed	-	-	-
Amaranthaceae	*Gomphrena celosioides*	Gomphrena Weed	*	-	-
Asteraceae	*Arctotheca calendula*	Capeweed	*	-	-
Asteraceae	*Calotis cuneifolia*	Purple Burr-Daisy	-	-	-
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy	-	-	-
Asteraceae	*Calotis* spp.	A Burr-daisy	-	-	-
Asteraceae	*Carthamus lanatus*	Saffron Thistle	*	-	-
Asteraceae	*Centaurea solstitialis*	St Barnabys Thistle	*	-	-
Asteraceae	*Chrysocephalum apiculatum*	Common Everlasting	-	-	-
Asteraceae	*Chrysocephalum semipapposum*	Clustered Everlasting	-	-	-
Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	*	-	-
Asteraceae	*Helianthus annuus*	Common Sunflower	*	-	-
Asteraceae	*Taraxacum officinale*	Dandelion	*	-	-
Asteraceae	*Vittadinia cuneata*	A Fuzzweed	-	-	-
Asteraceae	*Vittadinia spp.*	Fuzzweed	-	-	-
Asteraceae	*Xerochrysum bracteatum*	Golden Everlasting	-	-	-
Boraginaceae	*Cynoglossum australe*	-	-	-	-
Boraginaceae	*Echium plantagineum*	Paterson's Curse	*	-	-
Brassicaceae	*Lepidium africanum*	Common Peppercress	*	-	-
Brassicaceae	*Lepidium bonariense*	Argentine Peppercress	*	-	-
Brassicaceae	*Lepidium pseudohyssopifolium*	Peppercress	-	-	-
Brassicaceae	*Lepidium* spp.	A Peppercress	*	-	-
Brassicaceae	*Rapistrum rugosum*	Turnip Weed	*	-	-
Cactaceae	*Opuntia stricta*	Common Prickly Pear	*	-	-
Campanulaceae	*Wahlenbergia gracilis*	Sprawling Bluebell	-	-	-
Campanulaceae	*Wahlenbergia stricta*	Australian Bluebell	-	-	-
Caryophyllaceae	*Cerastium glomeratum*	Mouse-ear Chickweed	*	-	-
Casuarinaceae	*Casuarina cristata*	Belah	-	-	-
Chenopodiaceae	*Atriplex leptocarpa*	Slender-fruit Saltbush	-	-	-
Chenopodiaceae	*Chenopodium desertorum*	Desert Goosefoot	-	-	-

Family	Scientific Name	Common Name	Exotic	BC Status	EPBC Status
Chenopodiaceae	*Dysphania pumilio*	Small Crumbweed	-	-	-
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	-	-	-
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush	-	-	-
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush	-	-	-
Chenopodiaceae	*Maireana microphylla*	Small-leaf Bluebush	-	-	-
Chenopodiaceae	*Rhagodia spinescens*	Spiny Saltbush	-	-	-
Chenopodiaceae	*Salsola australis*	-	-	-	-
Chenopodiaceae	*Sclerolaena birchii*	Galvanized Burr	-	-	-
Chenopodiaceae	*Sclerolaena divaricata*	Tangled Copperburr	-	-	-
Chenopodiaceae	*Sclerolaena muricata*	Black Rolypoly	-	-	-
Chenopodiaceae	*Sclerolaena tetracuspis*	Brigalow Burr	-	-	-
Convolvulaceae	*Convolvulus angustissimus*	-	-	-	-
Convolvulaceae	*Convolvulus erubescens*	Blushing Bindweed	-	-	-
Convolvulaceae	*Evolvulus alsinoides*	Bindweed	-	-	-
Cucurbitaceae	*Cucumis myriocarpus subsp. leptodermis*	Paddy Melon	*	-	-
Cyperaceae	*Carex inversa*	Knob Sedge	-	-	-
Euphorbiaceae	*Euphorbia drummondii*	Caustic Weed	-	-	-
Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine	-	-	-
Fabaceae (Faboideae)	*Glycine microphylla*	Small-leaf Glycine	-	-	-
Fabaceae (Faboideae)	*Medicago polymorpha*	Burr Medic	*	-	-
Fabaceae (Mimosoideae)	*Acacia harpophylla*	Brigalow	-	-	-
Fabaceae (Mimosoideae)	*Acacia stenophylla*	River Cooba	-	-	-
Fabaceae (Mimosoideae)	*Neptunia gracilis* f. *gracilis*	Sensitive Plant	-	-	-
Fabaceae (Mimosoideae)	*Vachellia farnesiana*	Mimosa Bush	-	-	-
Haloragaceae	*Haloragis aspera*	Rough Raspwort	-	-	-
Lamiaceae	*Lamium amplexicaule*	Henbit	*	-	-
Malvaceae	*Abutilon cryptopetalum*	-	-	-	-
Malvaceae	*Abutilon leucopetalum*	-	-	-	-
Malvaceae	*Abutilon macrum*	-	-	-	-
Malvaceae	*Abutilon oxycarpum*	Straggly Lantern-bush	-	-	-
Malvaceae	*Sida ammophila*	Sand Sida	-	-	-
Malvaceae	*Sida corrugata*	Corrugated Sida	-	-	-

Family	Scientific Name	Common Name	Exotic	BC Status	EPBC Status
Malvaceae	*Sida cunninghamii*	Ridged Sida	-	-	-
Malvaceae	*Sida fibulifera*	Pin Sida	-	-	-
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	*	-	-
Malvaceae	*Sida* spp.	-	*	-	-
Myoporaceae	*Eremophila debilis*	Winter Apple	-	-	-
Myoporaceae	*Eremophila mitchellii*	Budda	-	-	-
Myrtaceae	*Corymbia maculata*	Spotted Gum	-	-	-
Myrtaceae	*Corymbia tessellaris*	Carbeen	-	-	-
Myrtaceae	*Eucalyptus chloroclada*	Dirty Gum	-	-	-
Myrtaceae	*Eucalyptus conica*	Fuzzy Box	-	-	-
Myrtaceae	*Eucalyptus dealbata*	Tumbledown Red Gum	-	-	-
Myrtaceae	*Eucalyptus melanophloia*	Silver-leaved Ironbark	-	-	-
Myrtaceae	*Eucalyptus pilligaensis*	Narrow-leaved Grey Box	-	-	-
Myrtaceae	*Eucalyptus populnea subsp. bimbil*	Bimble Box	-	-	-
Nyctaginaceae	*Boerhavia dominii*	Tarvine	-	-	-
Oxalidaceae	*Oxalis corniculata*	-	*	-	-
Oxalidaceae	*Oxalis perennans*	-	-	-	-
Oxalidaceae	*Oxalis* spp.	-	-	-	-
Pittosporaceae	*Rhytidosporum* spp.	-	-	-	-
Plantaginaceae	*Plantago gaudichaudii*	Narrow Plantain	-	-	-
Poaceae	*Aristida leptopoda*	White Speargrass	-	-	-
Poaceae	*Aristida ramosa*	Purple Wiregrass	-	-	-
Poaceae	*Aristida* spp.	A Wiregrass	-	-	-
Poaceae	*Austrostipa aristiglumis*	Plains Grass	-	-	-
Poaceae	*Austrostipa nodosa*	-	-	-	-
Poaceae	*Austrostipa ramosissima*	Stout Bamboo Grass	-	-	-
Poaceae	*Austrostipa verticillata*	Slender Bamboo Grass	-	-	-
Poaceae	*Bothriochloa decipiens* var. *decipiens*	Pitted Bluegrass	-	-	-
Poaceae	*Bothriochloa erianthoides*	Satintop Grass	-	-	-
Poaceae	*Bothriochloa ewartiana*	Desert Bluegrass	-	-	-
Poaceae	*Bothriochloa macra*	Red Grass	-	-	-
Poaceae	*Cenchrus setaceous*	Fountain Grass	*	-	-
Poaceae	*Chloris gayana*	Rhodes Grass	*	-	-
Poaceae	*Chloris truncata*	Windmill Grass	-	-	-
Poaceae	*Chloris ventricosa*	Plump Windmill Grass	-	-	-
Poaceae	*Cynodon dactylon*	Couch	-	-	-

Family	Scientific Name	Common Name	Exotic	BC Status	EPBC Status
Poaceae	*Dactylis glomerata*	Cocksfoot	*	-	-
Poaceae	*Dactyloctenium radulans*	Button Grass	-	-	-
Poaceae	*Digitaria diffusa*	Open Summer-grass	-	-	-
Poaceae	*Digitaria divaricatissima*	Umbrella Grass	-	-	-
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass	-	-	-
Poaceae	*Ehrharta longiflora*	Annual Veldtgrass	*	-	-
Poaceae	*Enteropogon acicularis*	Curly Windmill Grass	-	-	-
Poaceae	*Enteropogon* spp.	Windmill Grass	-	-	-
Poaceae	*Eragrostis leptostachya*	Paddock Lovegrass	-	-	-
Poaceae	*Eragrostis trachycarpa*	-	-	-	-
Poaceae	*Hordeum leporinum*	Barley Grass	*	-	-
Poaceae	*Lachnagrostis filiformis*	-	-	-	-
Poaceae	*Leptochloa divaricatissima*	-	-	-	-
Poaceae	*Lolium perenne*	Perennial Ryegrass	*	-	-
Poaceae	*Lolium spp.*	A Ryegrass	*	-	-
Poaceae	*Megathyrsus maximus* var. *maximus*	-	*	-	-
Poaceae	*Panicum effusum*	Hairy Panic	-	-	-
Poaceae	*Paspalidium constrictum*	Knottybutt Grass	-	-	-
Poaceae	*Paspalidium jubiflorum*	Warrego Grass	-	-	-
Poaceae	*Paspalum dilatatum*	Paspalum	*	-	-
Poaceae	*Paspalum urvillei*	Vasey Grass	*	-	-
Poaceae	*Rytidosperma* spp.	-	-	-	-
Poaceae	*Sorghum bicolor*	Cultivated Sorghums	*	-	-
Poaceae	*Sporobolus caroli*	Fairy Grass	-	-	-
Poaceae	*Thyridolepis mitchelliana*	Mulga Mitchell Grass	-	-	-
Poaceae	*Urochloa panicoides*	Urochloa Grass	*	-	-
Polygonaceae	*Persicaria decipiens*	Slender Knotweed	-	-	-
Polygonaceae	*Polygonum aviculare*	Wireweed	*	-	-
Polygonaceae	*Rumex brownii*	Swamp Dock	-	-	-
Polygonaceae	*Rumex crispus*	Curled Dock	*	-	-
Polygonaceae	*Rumex* spp.	-	*	-	-
Portulacaceae	*Portulaca oleracea*	Pigweed	-	-	-
Pteridaceae	*Cheilanthes sieberi*	Rock Fern	-	-	-
Rutaceae	*Geijera parviflora*	Wilga	-	-	-
Sapindaceae	*Alectryon diversifolius*	Scrub Boonaree	-	-	-

Family	Scientific Name	Common Name	Exotic	BC Status	EPBC Status
Scrophulariaceae	*Myoporum acuminatum*	Boobialla	-	-	-
Solanaceae	*Lycium ferocissimum*	African Boxthorn	*	-	-
Solanaceae	*Nicotiana megalosiphon* subsp. *megalosiphon*	-	-	-	-
Solanaceae	*Solanum esuriale*	Quena	-	-	-
Verbenaceae	*Glandularia aristigera*	Mayne's Pest	*	-	-
Verbenaceae	*Verbena officinalis*	Common Verbena	*	-	-
Zygophyllaceae	*Tribulus terrestris*	Caltrop	*	-	-

Fauna species recorded during surveys

Common Name	Scientific Name	Exotic	NSW Status	EPBC Status	Observation Type
BIRDS					
Apostlebird	*Struthidea cinerea*				O
Australian Magpie	*Cracticus tibicen*				O
Australian Owlet-nightjar	*Aegotheles cristatus*				W
Australian Raven	*Corvus coronoides*				O
Australian Ringneck	*Barnardius zonarius*				O
Black Falcon	*Falco subniger*		V		O
Black Kite	*Milvus migrans*				O
Black-shouldered Kite	*Elanus axillaris*				O
Brown Falcon	*Falco berigora*				O
Cockatiel	*Nymphicus hollandicus*				O
Common Myna	*Sturnus tristis*	*			O
Common Starling	*Sturnus vulgaris*	*			O
Crested Pigeon	*Ocyphaps lophotes*				O
Eastern Barn Owl	*Tyto javanica*				O
Eastern Rosella	*Platycercus eximius*				O
Galah	*Eolophus roseicapillus*				O
Grey Butcherbird	*Cracticus torquatus*				O
Grey-crowned Babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*		V		O
Magpie-lark	*Grallina cyanoleuca*				O
Nankeen Kestrel	*Falco cenchroides*				O
Noisy Miner	*Manorina melanocephala*				O
Pied Butcherbird	*Cracticus nigrogularis*				O
Red-rumped Parrot	*Psephotus haematonotus*				O
Rock Dove	*Columba livia*	*			O
Sulphur-crested Cockatoo	*Cacatua galerita*				O
Tawny Frogmouth	*Podargus strigoides*				O
Whistling Kite	*Haliastur sphenurus*				O
White-winged Chough	*Corcorax melanorhamphos*				O
Willie Wagtail	*Rhipidura leucophrys*				O
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*				W
MAMMALS					
Brown Hare	*Lepus capensis*	*			O

Common Name	Scientific Name	Exotic	NSW Status	EPBC Status	Observation Type
Eastern Grey Kangaroo	*Macropus giganteus*				O
Fox	*Vulpes vulpes*	*			O
House Mouse	*Mus musculus*	*			K
Chocolate Wattled Bat	*Chalinolobus morio*				D
Eastern Freetail-bat	*Mormopterus norfolkensis*		V		Pr
Ride's Freetail-bat	*Mormopterus ozimops ridei*				D
Gould's Wattled Bat	*Chalinolobus gouldii*				D
Inland Broad-nosed Bat	*Scotorepens balstoni*				Pr
Little Broad-nosed Bat	*Scotorepens greyii*				D
Little Forest Bat	*Vespadelus vulturnus*				D
Little Pied Bat	*Chalinolobus picatus*		V		Pr
long-eared bat	*Nyctophilus sp.*				D
White-striped Freetail-bat	*Tadarida australis*				D
Yellow-bellied Sheathtail-Bat	*Saccolaimus flaviventris*		V		D
REPTILES					
Ragged Snake-eyed Skink	*Cryptoblepharus pannosus*				O
South-eastern Morethia Skink	*Morethia boulengeri*				O
Tree Dtella	*Gehyra variegata*				O
FROGS					
Broad-palmed Frog	*Litoria latopalmata*				O
Spotted Grass Frog	*Limnodynastes tasmaniensis*				O

Key: * - exotic, V – vulnerable, D – definite record (Anabat analysis), K – dead, O – observed,

Pr - probable record (Anabat analysis), W – heard.

Appendix C – Field data sheets

BAM Plot – Field Survey Form

Site Sheet no: 1 of 1

Date		Survey Name	Plot Identifier	Recorders
13 Fe		Narrabri SF	P1	AQ + KC.

Zone	Datum	IBRA region		Photo #	Zone ID
__				AQ phone	

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
_ _ _ _ _ _	_ _ _ _ _ _ _	20 x 20	135 Magnetic

Likely Vegetation Class	Confidence: H M L
Derived Grassland.	

Plant Community Type	EEC:	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	N, 1	Non Euc	
50 – 79 cm	N, 1		
30 – 49 cm	N, 1		Hollows 20cm+
20 – 29 cm	N, 1		
10 – 19 cm	N, 1		
5 – 9 cm	N, 1		
< 5 cm	N, 1		This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	0		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	40	15	15	35	10	30	60	50	40	65	a	b	c	d	e	a	b	c	d	e
Average of the 5 subplots	23																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour	Grey	Soil Depth	
Slope	Flat	Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal	2	
Grazing (identify native/stock)	3	
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

45 → 35 → 25 → 15 → 5 → 5m

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date	14 3 18	Narrabri SF	P1	AR + KC

GF Code	*Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.*	N, E or HTE	Cover	Abund	stratum	voucher
/	Aristida leptopoda		50	20	G	
/	Lycium ferocissimum	HTE	0.1	5	S	
	~~Hibiscus~~ Urochloa praetervisa ✓		0.1	30	G	
	Sporobolus creber		15	100	G	
	Eulalopogon aciculatus		5	100	G	
	Sclerolaena 'long spike' ? tetrazenpa		1	50	G	✓
	Chamaesyce drummondii		0.1	80	G	
	Austrostipa aristiglumis		15	150	G	
	Panicum decompositum effusum		5	200	G	
	Medicago polymorpha		0.2	50	G	
	Saltbush small leaf = Atriplex leptocarpa		0.1	1	G	✓
	Opuntia stricta		0.1	2	G	
	Vittadinia cuneata		0.1	1	G	
	Cartonia cuneata		0.1	1	G	
	Lepidium oblongum pinnatifidum		0.1	5	G	
	Solanum esuriale		0.1	5	G	
	Sida cunninghamii		0.1	3	G	✓

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of 1

Survey Name	Plot Identifier	Recorders
Narrabri SF	P2	AQ + KC

Date	Zone	Datum	IBRA region	Photo #	Zone ID
15/3/18	__				

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
_____	_____	20 x 50	154° Magnetic

		Confidence: H M L
Likely Vegetation Class		
Plant Community Type	PCT 397 - Poplar box - White cypress Pine	EEC: N; Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot) dbh	Euc*	Non Euc	Stem Classes and Hollows: Hollows†
80 + cm	Euc	Non Euc	1
50 – 79 cm	1111		
30 – 49 cm	✓		Hollows 20cm+
20 – 29 cm			
10 – 19 cm			
5 – 9 cm			
< 5 cm			This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	0 Tally space		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)	Bare ground cover (%)	Cryptogam cover (%)	Rock cover (%)
Subplot score (% in each)	5 20 5 5 25	40 25 5 70 e	a b c d e	a b c d e
Average of the 5 subplots	10%			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture	Sandy	Soil Colour	red/brown	Soil Depth	
Slope	3°	Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)	3	
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

Free Text Section for brief site description

- Incidentals 4 in 50m plot.
Callitris glaucophylla
Tripodium terrestris

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 15 3 18	Narrabri SF	P2	AQ

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	1 Euc sp melanophloia		10	2	T	
	2 Austrostipa ~~virgata~~ ramosissima		0.7	20	G	
	3 Lysimachia ferrocinus		0.1	3	S	
	4 ~~Poaceae~~ (c) = Myoporum acuminatum		0.5	3	S	✓
	5 Austrostipa aristiglumis.		1	30	G	
	6 Aristida ramosa		20	400	G	
	7 Chloris truncata		5	160	G	
	8 Glycine clandestina		0.1	30	G	
	9 Euphorbia (c) drummondii		0.5	50	G	
	10 Lepidium africanum.		0.1	20	G	
	11 Chrysocephalum semipapposum		0.1	40	G	
	12 Evolvulus alsinoides		0.1	40	G	
Bauhinia	Purple trumpet flower (c) - Brunoniella australis		1	50	G	
Sulveolens	13 Vittadinia cuneata		0.1	20	G	
Brunoniella	14 Sida (c) ~~corrugata~~ cunninghamii		0.1	5	G	
australis	15 Pointy leaf grass (c) Paspalidium constrictum		1	50	G	
	16 Eragrostis ~~leptostachya~~		10	500	G	
	17 Convolvulus angustissimus		0.1	2	G	
	18 Abutilon oxycarpum		0.1	10	G	
	19 Rhytidosporum sp (non fertile)		0.1	20	G	
	20 Bothriochloa macra ewartiana		5	200	G	
	21 Bothriochloa decipiens		0.1	5	G	
	22 Opuntia Stricta		0.1	1	G	
	23 Succulent whorled (c)		0.1	5	G	
	24 Chrysocephalum apiculatum		0.1	30	G	
	25 Stemmi cervaria ?		0.1	20	G	
	26 Portulaca oleracea		1	30	G	
	27 Eriochloa pseudoacrotricha		0.1	5	G	
	28 Sclerolaena birchii		0.1	4	G	
	29 Chelanthes sieberi		0.1	10	G	
	30 Enchylaena tomentosa		0.1	5	G	
	31 Large mickey leaves (c) Digitaria diffusa		0.5	50	G	
	32 Einadia hastata		0.1	2	G	
	33 Abutilon oblongum (c) oxycarpum		0.1	5	G	
	34 Entodopogon ~~rupestris~~ acicularis		1	30	G	
	35 Eragrostis ~~spec panicoid~~ (c) leptostachya		2	50	G	
Gomphrena	36 Alternanthera ~~celosioides~~		0.1	1	G	
	37 Xerochrysum bracteatum		0.1	2	G	
	38 St barnabys thistle		0.1	1	G	
	39 Glycine microphylla		0.1	1	G	
	40 Digitaria parviflora		0.1	1	G	
	41 Maireana microphylla		0.1	1	G	
	42 ~~Myoporum acuminatum~~					
Alternanthera	43 Salsola tragus		0.1	1	G	

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of 2

Survey Name	Plot Identifier	Recorders
Narrabri Solar	P3	AQ, KC

Date	Zone	Datum	IBRA region	Photo #	Zone ID
15/3/18	__			Collector	

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
_____	_____	20x20 in 20x50	105° Magnetic °

		Confidence: H M L
Likely Vegetation Class		
Plant Community Type	PCT 397 - Poplar box - White cypress pine	EEC: N — Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)		Stem Classes and Hollows	
dbh	Euc*	Non Euc	Hollows†
80 + cm	Euc	Non Euc	III
50 – 79 cm	IIII		
30 – 49 cm	✓		Hollows 20cm+
20 – 29 cm	✓		I
10 – 19 cm			
5 – 9 cm			
< 5 cm			This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	IIII Tally space		total 4

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
Subplot score (% in each)	15	5	10	15	50	40	65	50	30	20										
Average of the 5 subplots	19					45														

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)	Cattle	
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

Free Text Section for brief site description

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 15 3 18	Narrabri SF	P3	AQ + KC

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	1 Euc melanophloia.	N	15	2	GT	
	2 Lycium ferrocissum	E	2	17	S	
	3 Austrostipa ramosissima		10	200	G	
	4 Chloris truncata.		10	200		
	5 Brunoniella australis		1	100		
	6 Bothriochloa macra.		10	400		
	7 Oxalis perennans.		0.1	5		
	8 Medicago polymorpha.		0.1	10		
	9 Enteropogon acicularis		5	200		
	10 Tetragonia tetragonoides.		0.1	3		
	11 Abutilon oxycarpum		0.1	20		
	12 Lepidium spp.		0.1	20		
	13 Euphorbia drummondii		0.5	80		
	14 Enicdia hastata.		0.5	40		
	15 Cocksfoot (E) ~~Urochloa panicoides~~.		0.1	5		
	16 Borhavia dominii.		0.1	20		
	17 Portulaca oleracea		1	50		
	18 Sclerolaena birchii		05	10		
	19 Vittadenia cuneata.		0.1	80		
	20 Tribulus terrestris		0.1	10		
	21 Enadia nutans		0.1	5		
	22 Glycine clandestina.		0.1	10		
	23 Maireana microphylla		0.1	3		
	24 ~~Abutilon fraseri~~ leucopetalum		0.1	10		
	25 Eragrostis 'closed panicle P2' leptostachya		5	100		
	26 Sclerolaena muricata		0.1	2		
	27 Abutilon ~~oxycarpum~~ leucopetalum		0.1	10		
	28 Aristida ramosa		05	200		
	29 Xerochrysum bracteatum		0.1	5		
	30 Paspalidium constrictum		1	30		
	31 ~~Enteropogon~~					
	32 Wahlenbergia stricta		0.1	10		
	33 Eremophila michellii		0.1	3	S	
	34 Sida (E) cunninghamii		0.1	10	G	
	35 Dysphyma pulmile		0.1	3		
	36 Solanum esuriale.		0.1	20		
	37 ~~Unknown~~ Broad leaf paspalum Urochloa panicoides		0.1	5		
	38 ~~Cymbopogon~~ ~~Stake~~ Sorghum leiocladum		0.1	10		
	39 Eremophila debilis		0.1	1		
	40 ~~Enteropogon~~					

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of 2

Survey Name	Plot Identifier	Recorders
Narrabri Solar	PA	AQ, KC

Date	Zone	Datum	IBRA region	Photo #	Zone ID
15 3 18	__			Collector	

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
_____	_____	20x20 in 20x50	90 Magnetic

		Confidence: H M L
Likely Vegetation Class		
Plant Community Type	PCT 397 - Poplar Box - White Cypress Pine **EEC:** N	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	1		
50 – 79 cm	1		
30 – 49 cm	✓		Hollows 20cm+
20 – 29 cm			1
10 – 19 cm			
5 – 9 cm			
< 5 cm			This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	IIII Tally space		5 total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	15	50	20	10	40	65	15	30	70	20	a	b	c	d	e	a	b	c	d	e
Average of the 5 subplots	27					40														

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)	Cattle 3	
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

Euc melaleuca also in 50m.

400 m² plot: Sheet _ of _

Survey Name	Plot Identifier	Recorders
Narvaon St	P4	AR + KC.

Date: 15 3 18

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	Euc populnea		15	2	T	
	Lycium ferrocissum		5	40	S	
	Austrostipa ramosissima.		5	30	G	
	Chloris truncata.		25	500		
	Paspalidium broadleaf. Urochloa panicoides		2	20		
	Abutilon oxycarpum		0.1	10		
	Enchylaena tomentosa		0.1	10		
	Convolvulus angustissimus		0.1	3		
	Tetragonia tetragonioides moorei		0.3	20		
	Sclerolaena muricata		0.1	2		
	Lepidium oxytrichum africanum		0.1	20		
	Paspalidium constrictum jubiflorum		5	100		
	Dysphania pumilio		0.3	40		
	Calotis cuneata		0.1	10		
	Chenopodium desctorum		0.1	10		
	Euphorbia drummondii		0.1	20		
	Eragrostis leptostachys		2	100		
	Enteropogon acicularis		5	100		
	Abutilon oxycarpum.		0.1	20		
	Enicia nutans		0.1	10		
	Carex (c) inversa		0.1	1		
	Button grass.		0.1	5		
	Xerochrysum bracteatum		0.1	1		
	Tribulus terrestris		0.1	10		
	Portulaca oleracea.		0.5	20		
	Alternanthera (c) nodiflora		0.1	20		
	Bothriochloa ewartiana		3	50		
	Marrana macrophylla		0.1	2		
	Salsola tragus (australis)		0.1	5		
	Cucumis/melo (c) Cucumis myriocarpus		0.1	1		
Nicotiana = megalosiphon	White trumpet flower (c)		0.1	5		
	Enteropogon acicularis		1	20		
	Eragrostis PZ.		~~0.1~~	30		
	Chrysocephalum semipapposum		0.2	20		
	Abutilon ~~oxycarpum~~ Sida ~~corrugata~~ fibulifera		0.1	10		
	Gigiera parviflora		0.1	1		
	Oxalis perennis.		0.1	3		
	Calotis spp lappulacea		0.1	2		
	Solanum esuriale		0.1	3		
	Sida macrii Abutilon macrum		0.1	10		

St Barnabys thistle

GF Code: see Growth Form definitions in BAM Appendix 1. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

opuntia stricta 0.1/1 Sida corrugata 0.1/5

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

Hakea salicifolia 0.1/5 Bothriochloa 0.1/5 Cucumis myriocarpus

BAM Plot – Field Survey Form

Site Sheet no: 1 of 1

Survey Name	Plot Identifier	Recorders
Narrabri SF	P5	AQ

Date	Zone	Datum	Easting	Northing
15/3/18	__		_____	_____

IBRA region		Photo #		Zone ID	
Plot Dimensions (e.g. 20 x 20 in 20 x 50)	20 x 50	Orientation of midline from the 0 m point.	250° Magnetic		

Likely Vegetation Class		Confidence: H M L
Plant Community Type	Nil Cultivated - Predominantly exotic EEC:	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	Nil	Non Euc	
50 – 79 cm	Nil		
30 – 49 cm	Nil		Hollows 20cm+
20 – 29 cm	Nil		
10 – 19 cm	Nil		
5 – 9 cm	Nil		
< 5 cm	Nil		This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	Nil Tally space		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	10	15	15	10	5	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
Average of the 5 subplots	11%					25%														

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour	Brown/Red	Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)	3	
Cultivation (inc. pasture)	2	
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)	3	
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Cultivated
→ Evidence of ripping

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date			

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	Chrysocephalum apiculatum					
	Dysphania pumilio (goosefoot)					
	Echinochloa colona					
	Lachnagrostis filiformis					
	Panicum effusum					
	Schoenus triumpus					
	~~Acacia~~ harpophylla					
	Eragrostis elongata					
	Solanum esuriale					
	Enchylaena sphaericus					
	Eucalyptus chloroclada					
	Evolvulus alsinoides var decumbens					
	Austrostipa verticillata					
	Lomandra multi					
	Senna artemisioides zygophylla.					
	SPECIES LIST (PS) ↓					
	Paspalum like broad leaf = Urochloa	E	75	1000+		
	Conyza bonariensis panicoides	E	2	100		
	Sida ? rhombifolia	N	0.5	50		
	~~Acacia spp~~ - Thyridolepis mitchelliana	E	0.1	5		
	Pentaloca aberrans	N	0.1	3		
	St Bernabys Thistle	E	0.1	2		
	Digitaria long = Leptochloa divaricatissima	E	0.1	10		
	A. cretostoloides		0.1	1		
	Wahlenbergia gracilis		0.1	15		
	tribulus terrestris		0.1	3		

Incidentals:
- Euc melanophloia
- Acacia harpophylla
- Euc populnea
- Brachychiton populneus
- Bclark

Windbreak - Corymbia tessalono - Euc sideroxylon

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

Paspalidium constrictum 1-2 50

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

oxalis perennis 0.1 2

BAM Plot – Field Survey Form

Site Sheet no: 1 of 2

Survey Name	Plot Identifier	Recorders
Narrabri Solar	PG	AQ, KC

Date	Zone	Datum	Easting	Northing	IBRA region	Photo #	Zone ID
15 3 18	__		_____	_____			

Plot Dimensions (e.g. 20 x 20 in 20 x 50): 20x20 in 20x50

Orientation of midline from the 0 m point.: 177 Magnetic °

		Confidence
Likely Vegetation Class	Brigalow / Poplar Box.	H M L
Plant Community Type	PCT 35 PCT ~~390~~ 35 **EEC:**	H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm			III
50 – 79 cm			
30 – 49 cm	✓		Hollows 20cm+
20 – 29 cm	✓		
10 – 19 cm	✓		
5 – 9 cm	✓		
< 5 cm			This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 II (Tally space)		total 52

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
Subplot score (% in each)	30	50	80	70	70	30	5	5	10	5										
Average of the 5 subplots	60																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance

	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)		
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 15 3 18	Narrabri SF	P6	AQ + KC

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	1 Acacia harpophylla		20	16	T	
	2 Euc populnea,		5	2	T	
	3 Sclerolaena birchii		~~10~~ 9	~~20~~ 1	S	
	4 Sporobolus caroli		5	100	G	
	5 Enteropogon acicularis		~~20~~ 15	200	G	
	6 Salsola australis		15	50	S	
	7 Enchylaena tomentosa		0.1	10	G	
	8 Dysphania pumilio		0.1	10		
	9 Chloris truncata	S	~~20~~ 15	100		
	10 Bothriochloa ewartiana	20	~~15~~ 10	500		
	11 Portulaca oleracea		1	20		
	12 Sida corrugata		0.1	10		
	13 Enchylaena nutans		1	3	↓	
	14 Leysera ferociana,		0.1	1	S	
	15 "Pappus broadleaf" Urochloa praticola		0.1	10	G	
	16 Tribulus terrestris,		2	50	G	
	17 Aeschynomene denfolius		0.5	1	G	
	18 St barnabys thistle.		0.1	3	G	
	19 ~~Sclerolaena~~ Salsola cuneifolia		0.1	1	G	
	20					
	21					
	22					
	23					
	24					
	25					
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34					
	35					
	36					
	37					
	38					
	39					
	40					

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of 1

Survey Name	Plot Identifier	Recorders
Narrabri SF	P7	AO

Date	Zone	Datum	Easting	Northing
15/3/18	__		_ _ _ _ _ _	_ _ _ _ _ _ _

IBRA region		Photo #		Zone ID	
Plot Dimensions (e.g. 20 x 20 in 20 x 50)	in	**Orientation of midline from the 0 m point.**	263 ° Magnetic °		

Likely Vegetation Class	Cultivated Paddock	Confidence: H M L
Plant Community Type	**EEC:**	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	**Trees**	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	**Trees**	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	0		
50 – 79 cm	Nil		
30 – 49 cm	Nil		Hollows 20cm+
20 – 29 cm	Nil		
10 – 19 cm	Nil		
5 – 9 cm	Nil		
< 5 cm	Nil		This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	0 Tally space		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	20	10	15	5	10	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
Average of the 5 subplots	12																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)		
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 15 8 18	Narrabri 5F	P7	AQ

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	~~Broadleaf paspalum~~ Urochloa panicoides		10	700	G	
	Polygonum aviculare		5	100	E	
	Chloris truncata		1	20	G	
	Sclerolaena muricata		0.3	2	G	
	Enneapogon nutans		0.1	5	G	
	Portulaca oleracea		0.1	3	G	
	~ 60% bare ground 40%					
	Rocky clay soils					

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of

Survey Name	Plot Identifier	Recorders
Narrabri SF	P8	AQ

Date	Zone	Datum	IBRA region	Photo #	Zone ID
15/8/18					

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
		20 x 50	165° Magnetic

Likely Vegetation Class	Confidence: H M L
Derived Grassland	

Plant Community Type	EEC:	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	Nil	Non Euc	
50 – 79 cm	Nil		
30 – 49 cm	Nil		Hollows 20cm+
20 – 29 cm	Nil		
10 – 19 cm	Nil		
5 – 9 cm	Nil		
< 5 cm	Nil		This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	Nil Tally space		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
Subplot score (% in each)	25	15	10	20	15															
Average of the 5 subplots	17																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture	clay/sand	Soil Colour	Grey	Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance

	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)	3	
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

Free Text Section for brief site description

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 15 3 18	Narrabri SF	P8	AQ + KC.

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	Aristida leptopoda		30	~~5~~00		
	Austrostipa aristiglumis		25	~~5~~00		
	Solanum esuriale		0.1	5		
	Vittadinia spp.		0.1	1		
	Sida spp cunninghamii		0.1	1		
	Sida ammophila		0.1	2		
	Rhyticlospema sp (non fertile		0.1	~~1~~0		
	Chrysocephalum apiculatum		0.1	1		

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of

Survey Name	Plot Identifier	Recorders
Narrabri SF	P9	AD + KC

Date	Zone	Datum	Easting	Northing
15/3/18				

IBRA region		Photo #		Zone ID	

Plot Dimensions (e.g. 20 x 20 in 20 x 50)	20x50	Orientation of midline from the 0 m point.	350° Magnetic

Likely Vegetation Class		Confidence: H M L
Plant Community Type	Derived Grassland	EEC: / Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	Nil		Nil
50 – 79 cm	Nil		
30 – 49 cm	Nil		Hollows 20cm+
20 – 29 cm	Nil		Nil
10 – 19 cm	Nil		
5 – 9 cm	Nil		
< 5 cm	Nil		This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	Nil Tally space		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
Subplot score (% in each)	15	10	10	15	25															
Average of the 5 subplots	15																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture	Sand/clay	Soil Colour	Grey	Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance

	Severity code	Age code
Clearing (inc. logging)	3	
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)	3	
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 15 3 18	Narrabri SF	P9	AO + KC

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	1 Aristida Leopoldia		40	600	G	
	2 ~~Austrostipa~~ Austrostipa aristiglumis	2	~~100~~	~~1000~~ 500	G	
	3 Chloris truncata		5	50	G	
	4 Bothriochloa ewartiana		10	200	G	
	5 Wahlenbergia gracilis		0.1	2	G	
	6 Sida spp		0.1	5	G	
	7 Vittadinia spp		0.1	2	G	
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					
	17					
	18					
	19					
	20					
	21					
	22					
	23					
	24					
	25					
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34					
	35					
	36					
	37					
	38					
	39					
	40					

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no:

Survey Name	Plot Identifier	Recorders
Narrabri SF	P10	AQ + KC

Date: 15/3/18	Zone:	Datum:	IBRA region:	Photo #:	Zone ID:
Easting:	Northing:	Plot Dimensions (e.g. 20 x 20 in 20 x 50): 20 x 50	Orientation of midline from the 0 m point.: 135°		

Likely Vegetation Class	Derived Grassland ?	Confidence: H M L
Plant Community Type	EEC:	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot) dbh	Euc*	Non Euc	Stem Classes and Hollows: Hollows†
80 + cm	Nil		Nil
50 – 79 cm	Nil		
30 – 49 cm	Nil		Hollows 20cm+
20 – 29 cm	Nil		Nil
10 – 19 cm	Nil		
5 – 9 cm	Nil		
< 5 cm	Nil		This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	Nil		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)	Bare ground cover (%)	Cryptogam cover (%)	Rock cover (%)
Subplot score (% in each)	25, 30, 10, 20, 25			
Average of the 5 subplots	22			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)	3	
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)	3	
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _

Survey Name	Plot Identifier	Recorders
Narrabri SF	P10	AQ + KC.

Date: 15 03 18

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	Bothriochloa ewartiana		20	400	G	
	Cenchrus truncatus		15	200	G	
	Portulaca oleracea.		0.7	30	G	
	Panicum effusum	circular	5	50	G	
	Sclerolaena succedens (E)		~~0.5~~	10	S	
	Sporobolus caroli		2	50	G	
	Vittadinia cuneata		0.1	5	G	
	Sida ammophila		0.1	1	G	
	Austrostipa aristiglumis		1	20	G	
	Opuntia stricta		2	9	S	
	Tall pannicl grass (E) Urochloa decumbens		2	50	G	
	Conyza bon	Urochloa decumbens	0.1	20	G	
	Calotis cuneata		0.1	1	G	
	Sclerolaena muricata		0.2	10	S	
	Tiny purple flower (helichrysum like)		0.1	3	G	
	Salsola tragus		0.1	2	G	
	Lachnagrostis filiformis		0.5	10	G	
	Euphorbia drummondii		0.1	5	G	
	Polygonum aviculare		0.1	2	G	
	Bothriochloa macra		1	30	G	
	Urochloa panicoides		0.1	5	G	
	Cynoglossum australe					

GF Code: see Growth Form definitions in BAM Appendix 1. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.
Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*
Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of

Survey Name	Plot Identifier	Recorders
Narrabri SF	P11	AQ + KC

Date	Zone	Datum	IBRA region	Photo #	Zone ID
15/3/18	__				

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
_ _ _ _ _ _	_ _ _ _ _ _ _	20x50	221° Magnetic

		Confidence: H M L
Likely Vegetation Class	Derived Grasslands	
Plant Community Type	**EEC:**	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	**Trees**	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	**Trees**	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	Nil	Non Euc	Nil
50 – 79 cm	Nil		
30 – 49 cm	Nil		Hollows 20cm+
20 – 29 cm	Nil		Nil
10 – 19 cm	Nil		
5 – 9 cm	Nil		
< 5 cm	Nil		This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	Nil Totally space		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	25	20	20	25	15	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
Average of the 5 subplots	21																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)		
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 15 3 18	Narrabri SF	P11	AA + KC

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	Chloris truncata		~~40~~	860		
	Austrostipa aristiglumis		3	30		
	Solanum esuriale		1	150		
	Portulaca oleracea		0.1	5		
	Bothriochloa ewartiana		10	50		
	Sida ammophila		0.1	10		
	tall annual grass (P10) = Leptochloa		5	100		
	Vittadinia sp (non astive) divaricata		0.1	30		
	Abutilon oxycarpum		0.1	30		
	Enidia nutans		0.1	2		
	Chrysocephalum apiculatum		0.5	20		
	Sclerolaena muricata		0.2	5		
	Calotis (yellow daisy)		0.1	5		
	Euphorbia drummondii		0.1	3		
	~ 40 bare ground.					

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of 2

Survey Name	Plot Identifier	Recorders
Narrabri Solar	P12	AR, KC

Date	Zone	Datum	IBRA region	Photo #	Zone ID
15/3/18	__			Collector	

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
_____	_____	20x20 20x50	75

		Confidence: H M L
Likely Vegetation Class	Belah Woodland	
Plant Community Type	PCT 85 PCT 379	EEC: / Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	1	1	1
50 – 79 cm	11	1	
30 – 49 cm			Hollows 20cm+
20 – 29 cm			11
10 – 19 cm			
5 – 9 cm			
< 5 cm			This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	𝍸 11		total 12

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)	Bare ground cover (%)	Cryptogam cover (%)	Rock cover (%)
Subplot score (% in each)	15 50 30 80 30	50 30 25 5 30		
Average of the 5 subplots	41			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)		
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date	15 3 18	Narrabri SF	P12	AQ + KC

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	1 Casuarina cristata		45	2	T	
	2 Sida ~~filiformis~~ cunninghamii		2	50	G	
	3 Sclerolaena muricata		5	80	S	
	4 Sclerolaena 'Succulent' = diacantha		3	100	S	
	5 Euphorbia drummondii		0.1	5	G	
	6 Lepidium pseudohyssopifolium		2	20	S	
	7 Salsola tragus		1	50	S	
	8 Austrostipa aristiglumis.		6	50	G	
	9 Lepidium sp.		0.1	10	G	
	10 Panicum effusum.		5	50	G	
	11 Eucalyptus pilligaensis		10	1	T	
	12 Enneapogon nigricans.		0.1	10	G	
	13 Bothriochloa decipiens		0.1	20	G	
	14 Portulaca oleracea		0.1	20	G	
	15 Oxalis perennans (brownii)		0.1	5	G	
	16 Digitaria (C) divaricatissima		1	30	G	
	17 Lepidium africanum		0.1	5	G	
	18 Cynodon dactylon		5	100	G	
	19 Bothriochloa decipiens		15	200	G	
	20 Enneapogon aciculatus		10	200	G	
	21 Chloris truncata		10	200	G	
	22 Opuntia stricta		0.1	3	G	
	23 Tribulus terrestris		0.1	10	G	
	24 Sida corrugata.		0.5	30	G	
	25 Austrostipa ramosissima		3	50	G	
	26 Sporobolus creber		0.1	2	G	
	27 Carex spp inter G		0.1	20	G	
	28					
	29					
	30					
	31					
	32					
	33					
	34					
	35					
	36					
	37					
	38					
	39 Rocky cracking grey clay.					
	40					

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 2 of 2

Survey Name	Plot Identifier	Recorders
Narrabri Solar	P13	AQ, KL

Date	Zone	Datum	IBRA region	Photo #	Zone ID
15/3/18	__				

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
_ _ _ _ _ _	_ _ _ _ _ _ _	20x20 in 20x50	98° Magnetic

		Confidence: H M L
Likely Vegetation Class	Box Woodland	
Plant Community Type	PCT 825 PCT 397	**EEC:** Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	1		1
50 – 79 cm			
30 – 49 cm	1		Hollows 20cm+
20 – 29 cm			1
10 – 19 cm			
5 – 9 cm			
< 5 cm			This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	1/1 Tally space		3 total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	30	5	15	40	10	30	95	50	20	30	a	b	c	d	e	a	b	c	d	e
Average of the 5 subplots	22																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)		
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 15 3 18	Narrabeen SF	P13	AA + CE

	GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
1		Eucalyptus pilligaras (now haplana)		20	1	T	
2		Alectryon oleifolius ~~subcinereus~~?		10	1	T	
3		Scleroteca muricata		10	50	S	
4		African box thorn.		1	5	S	
5		Austrostipa aristiglumis.		10	200	G	
6		Enicia nutans.		0.1	10	G	
7		Portulaca oleracea		0.1	10	G	
8		Tribulus terrestris.		0.1	10	G	
9		Chloris truncata.		10	500	G	
10		Paspalidium [illegible]		5	50	G	
11		Sporobolus caroli		3	50	G	
12		Scleroteca 'succulent' = S. diversicata		1	20	S	
13		Entropogon acicularis		5	500	G	
14		Solanum esuriale		0.1	10	G	
15							
16							
17							
18							
19							
20							
21							
22		Bare ground ~ 40%.					
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of 1

Date	Survey Name	Plot Identifier	Recorders
16/3/18	Narrabri SF	P14	AQ

Zone	Datum	IBRA region		Photo #		Zone ID	

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
		20 x 50	282 Magnetic °

Likely Vegetation Class	Derived Grassland	Confidence: H M L
Plant Community Type	**EEC:**	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	**Trees**	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	**Trees**	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	Nil	Nil	
50 – 79 cm	Nil		Nil
30 – 49 cm	Nil		Hollows 20cm+
20 – 29 cm	Nil		Nil
10 – 19 cm	Nil		
5 – 9 cm	Nil		
< 5 cm	Nil		This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	Tally space Nil		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	5	10	5	5	10	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
Average of the 5 subplots	7																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture	Cracking clay	Soil Colour	Brown/grey	Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)	3	
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date	16 3 18	Narrabri SF	P14	AO

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	1 Austrostipa aristiglumis		7	10	G	
	2 Chloris truncata		10	700	G	
	3 Urochloa panicoides		60	3000	G	
	4 Boerhavia dominii		0.1	50	G	
	5 Sclerolaena muricata		5	50	S	
	6 Oxalis perennans		0.3	100	G	
	7 Enchylaena tomentosa		0.3	100	G	
	8 Sclerolaena divaricata		0.1	5	S	
	9 Euphorbia drummondii		0.4	100	G	
	10 Aristida spp Wagara		0.1	5	G	
	11 Solanum esuriale		0.2	30	G	
	12 St barnaby thistle		0.1	1	G	
	13 Purple heliotrope like*		0.1	2	G	
	14 Sensitive plant ⊙ Neptunia gracilis		0.1	10	G	
	15 Conyza bonariensis		0.1	20	G	
	16		0.1	2	G	
	17 = Cynoglossum australe.					
	18					
	19					
	20					
	21					
	22					
	23					
	24					
	25					
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34					
	35					
	36					
	37					
	38					
	39					
	40					

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of 1

Survey Name	Plot Identifier	Recorders
Narrabri SF	P15	AQ + KC

Date	Zone	Datum	IBRA region	Photo #	Zone ID
16/3/18	__				

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
_____	_____	20 x 50	210° Magnetic

		Confidence: H M L
Likely Vegetation Class		
Plant Community Type	Derived Grassland (from 397) PCT	**EEC:** Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	**Trees**	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	**Trees**	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot) dbh	Euc*	Non Euc	Stem Classes and Hollows: Hollows†
80 + cm	Nil	Non Euc	Nil
50 – 79 cm	Nil		
30 – 49 cm	Nil		Hollows 20cm+
20 – 29 cm	Nil		Nil
10 – 19 cm	Nil		
5 – 9 cm	Nil		
< 5 cm	Nil		This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	Nil Tally space		total

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
Subplot score (% in each)	5	5	10	15	5															
Average of the 5 subplots	10%																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)		
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 16 3 18	Narrabri SF	P15	AQ + KC

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	1 Aristida ramosa		25	500		
	2 Bothriochloa erianthoides		5	200		
	3 St barnabys thistle		3	100		
	4 Sclerolaena birchii		0.3	4		
	5 Urochloa panicoides		15	500		
	6 African. box thorn		0.1	5		
	7 Opuntia stricta.		1	6		
	8 Paspalidium distans		0.1	30		
	9 Tribulus terrestris.		0.1	10		
	10 Cullen tenuifolium		0.1	10		
	11 Abutilon oxycarpum		0.1	5		
	12 Enneapogon nigricans leptostachyus		0.1	20		
	13 & Eragrostis spp.		2	50		
	14 Evolvulus alsinoides		0.1	5		
	15 Convolvulus angustissimus.		0.1	1		
	16 Vittadinia cuneata		0.1	1		
	17 Centrolepis drummondiana		1	30		
	18 Pentameris thuarii		0.1	1		
	19 Cynodon dactylon		5	400		
	20 Maireana pentagona Glandulosa enchylaena		0.1	2		
	21 Sida corrugata cunninghamii		0.1	20		
	22 Eremophila debilis		0.1	3		
	23					
	24					
	25					
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34					
	35					
	36					
	37					
	38					
	39					
	40					

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, …, 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, …, 10, 20, 30, … 100, 200, …, 1000, …

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Plot – Field Survey Form

Site Sheet no: 1 of 2

Survey Name	Plot Identifier	Recorders
Narrabri Solar	P16	AG, KC

Date	Zone	Datum	IBRA region	Photo #	Zone ID
16/3/18	__			Collector	

Easting	Northing	Plot Dimensions (e.g. 20 x 20 in 20 x 50)	Orientation of midline from the 0 m point.
_ _ _ _ _ _	_ _ _ _ _ _ _	20x20 in 20x50	165 Magnetic °

Likely Vegetation Class	Brigalow / Poplar Box	Confidence: H M L
Plant Community Type	PCT 35 39735	EEC: Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover %		

This table may be completed after entering data into available tools. It is not required while in the field.

BAM Attribute (20 x 50 m plot)	Stem Classes and Hollows		
dbh	Euc*	Non Euc	Hollows†
80 + cm	1		
50 – 79 cm			
30 – 49 cm			Hollows 20cm+
20 – 29 cm	✓		1
10 – 19 cm	✓		
5 – 9 cm	✓		
< 5 cm			This size class records tree regeneration
Length of logs (m) (≥10 cm diameter, >50 cm in length)	Tally space		total 0

Record **living** eucalypt* (Euc*) and **living native** non-eucalypt (Non Euc) stems separately

Data needed is presence only (tick) unless a 'large tree' for that veg class.

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† For **hollows** count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

Each size class is noted as present by the **living tree stems** only. Depending on the Vegetation Class, DBH values and counts may be needed for a size class. For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate if it is required by the large tree category for that vegetation class.

Hollows at least 20cm across are recorded for the purposes of habitat of some threatened species.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	10	40	5	15	30	90	20	90	85	60	a	b	c	d	e	a	b	c	d	e
Average of the 5 subplots	20%																			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture	cracking clays	Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance

	Severity code	Age code
Clearing (inc. logging)		
Cultivation (inc. pasture)		
Soil erosion		
Firewood / CWD removal		
Grazing (identify native/stock)		
Fire damage		
Storm damage		
Weediness		
Other		

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Free Text Section for brief site description

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 16 3 18	Narrabri SF	P16	AQ + ICC.

GF Code	Full species name mandatory, or a unique means of identifying separate taxa within a survey. Data from here will be used to assign growth form counts and covers.	N, E or HTE	Cover	Abund	stratum	voucher
	Acacia harpophylla		35	21	T	
	Wilga (Geijera parviflora)		3	2	S	
	Sclerolaena diacantha		0.1	1	S	
	Enneapogon nutans		0.1	3	G	
	Euc. pilligaensis.		5	1	T	
	Lycium ferocissimum		~~0.2~~ 3	~~3~~ 3	S	
	Solanum esuriale		0.1	~~4~~ 4	G	
	Rumex spp - brownii		0.1	~~2~~ 5		
	Chloris truncata ? (Forrest)		15	500		
	Boerhavia dominii		0.1	~~8~~ 10		
	Austrostipa ondrafolia		2	~~3~~ 20		
	Tribulus terrestris		0.1	10		
	Euphorbia drummondii		0.1	5		
	Enneapogon sp		0.5	20.		
	Urochloa paniculata		0.3	15		
	- Euc populnea recovery					
	- Heavily grazed.					
	- Bare ground ~ 75% of plot.					

GF Code: see Growth Form definitions in BAM Appendix 4. Identify top 3 dominants in the veg zone. **N:** native, **E:** exotic, **HTE:** high threat exotic.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

Print more copies of this sheet to allow for higher species counts at a plot. All species at a plot need to be recorded.

BAM Site – Field Survey Form

Site Sheet no: 1 of

		Survey Name	Zone ID	Recorders			
Date	20/09/18	Narrabri SF		BH, CP			
Zone / Datum	COLLECTOR Q17	Plot ID	Q17	Plot dimensions	20x50	Photo #	
Easting	Northing	IBRA region		Midline bearing from 0 m	195°S		
Vegetation Class						Confidence: H M L	
Plant Community Type	~~NOR~~ DNG			EEC:		Confidence: H M L	

Record easting and northing at 0 m on midline. Dimensions (Shape) of 0.04 ha base plot.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (1000 m² plot)		
DBH	# Tree Stems Count	# Stems with Hollows
80 + cm		
50 – 79 cm		
30 – 49 cm		
20 – 29 cm		
10 – 19 cm		
5 – 9 cm		
< 5 cm		n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)		

Counts apply when the **number of tree stems** within a size class is ≤ 10. Estimates can be used when > 10 (eg. 10, 20, 30 . . 100, 200, 300 . .). For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate. **Tree stems must be living.**

For **hollows**, count only the presence of a stem containing hollows. For a **multi-stemmed tree**, only the largest stem is included in the count/estimate. **Stems may be dead and may be shrubs.**

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	30	15	35	30	35															
Average of the 5 subplots																				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots centred at 5, 15, 25, 35, 45 m along the plot midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Assessors may also record the cover of rock, bare ground and cryptogams.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence:
Clearing (inc. logging)			
Cultivation (inc. pasture)			
Soil erosion			
Firewood / CWD removal			
Grazing (identify native/stock)			
Fire damage			
Storm damage			
Weediness			
Other			

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date	20 09 2018	Silverleaf Sdcr	Q17	C. Phu / B. Halse

GF Code	*Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
	Aristida ramosa		25	300		1
	Opuntia stricta		0.1	6		
	Cheilanthes sieberi		0.1	4		
	Rytidosperma sp		0.1	1		2
	Urochloa panicoides		0.1	50		
	Eragrostis leptostachya		0.1	20		
	Glandularia aristigera		0.1	20		3
	Medicago polymorpha		0.1	10		
	Chrysocephalum apiculatum		0.1	5		
	Glycine clandestina		0.1	10		
	~~Acacia pulchella / Vadellia lomasiana~~		0.1	1		4
	Taraxacum officionale		0.1	10		
	Echium plantagineum		0.1	20		5
	Centaurea solstit-		0.1	2		

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code** if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

BAM Site – Field Survey Form

Site Sheet no: 1 of

		Survey Name	Zone ID	Recorders			
Date	20 9 18	Narrabri SF	Q18 2	BH, CP			
Zone	Datum	Plot ID		Plot dimensions	20x50	Photo #	
Easting	Northing	IBRA region		Midline bearing from 0 m	90°E		
COLLECTOR Q18							
Vegetation Class						Confidence: H M L	
Plant Community Type		DNG		EEC:		Confidence: H M L	

Record easting and northing at 0 m on midline. Dimensions (Shape) of 0.04 ha base plot.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (1000 m² plot)		
DBH	# Tree Stems Count	# Stems with Hollows
80 + cm		
50 – 79 cm		
30 – 49 cm		
20 – 29 cm		
10 – 19 cm		
5 – 9 cm		
< 5 cm		n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)		

Counts apply when the **number of tree stems** within a size class is ≤ 10. Estimates can be used when > 10 (eg. 10, 20, 30 . . , 100, 200, 300 .) For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate. **Tree stems must be living.**

For **hollows**, count only the presence of a stem containing hollows. For a **multi-stemmed tree**, only the largest stem is included in the count/estimate. **Stems may be dead and may be shrubs.**

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	80	80	30	30	35															
Average of the 5 subplots																				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots centred at 5, 15, 25, 35, 45 m along the plot midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Assessors may also record the cover of rock, bare ground and cryptogams.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence:
Clearing (inc. logging)			
Cultivation (inc. pasture)			
Soil erosion			
Firewood / CWD removal			
Grazing (identify native/stock)			
Fire damage			
Storm damage			
Weediness			
Other			

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date	20 09 2018	Silverleaf Soler	Q18	B. Hulse / C. Plum

GF Code	*Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
	Enteropogon acicularis		10	50		
	Urochloa panicoides		0.1	20		
	Chrysocephalum apiculatum		0.1	3		
	Sorrel?		0.1	10		1
	Cynodon dactylon		0.1	10		
	Medicago polymorpha		0.1	10		
	Echium plantigeu ?		0.1	50		2

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code** if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

BAM Site – Field Survey Form

Site Sheet no: 1 of

		Survey Name	Zone ID	Recorders			
Date	20 9 18	NarrabriSF		BH, CP			
Zone ~~WAYPOINT~~ 4	Datum GPS 2019	Plot ID	Q19	Plot dimensions	20x50	Photo #	
Easting COLLECTOR	Northing Q19	IBRA region		Midline bearing from 0 m	165° S		
Vegetation Class		DNG				Confidence: H M L	
Plant Community Type				EEC:		Confidence: H M L	

Record easting and northing at 0 m on midline. Dimensions (Shape) of 0.04 ha base plot.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (1000 m² plot)		
DBH	# Tree Stems Count	# Stems with Hollows
80 + cm		
50 – 79 cm		
30 – 49 cm		
20 – 29 cm		
10 – 19 cm		
5 – 9 cm		
< 5 cm		n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)		

Counts apply when the **number of tree stems** within a size class is ≤ 10. Estimates can be used when > 10 (eg. 10, 20, 30..., 100, 200, 300...). For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate. **Tree stems must be living.**

For **hollows**, count only the presence of a stem containing hollows. For a **multi-stemmed tree**, only the largest stem is included in the count/estimate. **Stems may be dead and may be shrubs.**

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	~~40~~	35	25	15	20															
Average of the 5 subplots																				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots centred at 5, 15, 25, 35, 45 m along the plot midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Assessors may also record the cover of rock, bare ground and cryptogams.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence:
Clearing (inc. logging)			
Cultivation (inc. pasture)			
Soil erosion			
Firewood / CWD removal			
Grazing (identify native/stock)			
Fire damage			
Storm damage			
Weediness			
Other			

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date: 20 09 2018	Silverleaf Scar	Q19	CPhu / B. Hulse.

GF Code	*Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
	Chrysocephalum apiculatum		0.1	7		
	Sclerolaena diacantha		0.1	1		
	Lolium sp.		0.1	50		
	Medicago polym.		0.1	50		
	Urochloa panicoides		0.1	100		
	~~Aristida~~ Austrost. aristiglumis		10	250		
	Echium plantagineum		0.1	30		
	Solanum esuriale		0.1	10		
	Enteroop. acicularis		0.1	10		

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code** if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

BAM Site – Field Survey Form

Site Sheet no: 1 of

		Survey Name	Zone ID	Recorders			
Date	20 9 18	Narrabri SF		CP, BH			
Zone	Datum	Plot ID	Q20	Plot dimensions	20 x 50	Photo #	
Easting	Northing	IBRA region		Midline bearing from 0 m	30°NE		
COLLECTOR Q20							
Vegetation Class		DNG				Confidence: H M L	
Plant Community Type				EEC:		Confidence: H M L	

Record easting and northing at 0 m on midline. Dimensions (Shape) of 0.04 ha base plot.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (1000 m² plot)		
DBH	# Tree Stems Count	# Stems with Hollows
80 + cm		
50 – 79 cm		
30 – 49 cm		
20 – 29 cm		
10 – 19 cm		
5 – 9 cm		
< 5 cm		n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)		

Counts apply when the **number of tree stems** within a size class is ≤ 10. Estimates can be used when > 10 (eg. 10, 20, 30 .., 100, 200, 300 ..). For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate. **Tree stems must be living.**

For **hollows**, count only the presence of a stem containing hollows. For a **multi-stemmed tree**, only the largest stem is included in the count/estimate. **Stems may be dead and may be shrubs.**

BAM Attribute (1 x 1 m plots)	Litter cover (%)	Bare ground cover (%)	Cryptogam cover (%)	Rock cover (%)
Subplot score (% in each)	25 25 35 15 20			
Average of the 5 subplots				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots centred at 5, 15, 25, 35, 45 m along the plot midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Assessors may also record the cover of rock, bare ground and cryptogams.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence:
Clearing (inc. logging)			
Cultivation (inc. pasture)			
Soil erosion			
Firewood / CWD removal			
Grazing (identify native/stock)			
Fire damage			
Storm damage			
Weediness			
Other			

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date	20 09 2018	Silverleaf Star	D20	C. Phu / B. Hatse.

GF Code	*Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
	Solanum [redacted] esuriale		0.1	30		
	Medicago polymorpha		0.1	50		
	Chloris truncata		0.2	50		
	Sclerolaena birchii		0.3	19		
	Sida ~~corrugata~~ ✓		0.1	2		
	Chrysocephalum apiculatum		0.1	10		
	Enteropogon acicularis		10	100		
	Plantago gaudichaudii		0.1	3		
	Portulaca oleracea ssp.		0.1	3		
	Sclerolaena diacantha		0.1	1		
	Taraxacum officinale		0.1	5		
	Paspalidium constrictum		0.1	1		
	Chaemaegyce drummondii		0.1	1		
	Panicum effusum		0.1	10		
	Sporobolus caroli		0.1	1		

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code** if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

BAM Site – Field Survey Form

Site Sheet no: 1 of

		Survey Name	Zone ID	Recorders			
Date	21 09 18	Narrabri SK		BH, CP			
Zone	Datum	Plot ID	Q21	Plot dimensions	20x50	Photo #	
Easting	Northing	IBRA region		Midline bearing from 0 m	45° NE		
COLLECTOR	Q21						
Vegetation Class		DNG				Confidence: H M L	
Plant Community Type				EEC:		Confidence: H M L	

Record easting and northing at 0 m on midline. Dimensions (Shape) of 0.04 ha base plot.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (1000 m² plot)		
DBH	# Tree Stems Count	# Stems with Hollows
80 + cm		
50 – 79 cm		
30 – 49 cm		
20 – 29 cm		
10 – 19 cm		
5 – 9 cm		
< 5 cm		n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)		

Counts apply when the **number of tree stems** within a size class is ≤ 10. Estimates can be used when > 10 (eg. 10, 20, 30. . , 100, 200, 300. .). For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate. **Tree stems must be living.**

For **hollows**, count only the presence of a stem containing hollows. For a **multi-stemmed tree**, only the largest stem is included in the count/estimate. **Stems may be dead and may be shrubs.**

BAM Attribute (1 x 1 m plots)	Litter cover (%)	Bare ground cover (%)	Cryptogam cover (%)	Rock cover (%)
Subplot score (% in each)	25 20 15 10 10			
Average of the 5 subplots				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots centred at 5, 15, 25, 35, 45 m along the plot midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Assessors may also record the cover of rock, bare ground and cryptogams.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence:
Clearing (inc. logging)			
Cultivation (inc. pasture)			
Soil erosion			
Firewood / CWD removal			
Grazing (identify native/stock)			
Fire damage			
Storm damage			
Weediness			
Other			

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date	21 09 2018	Silverleaf Soils	Q21	CAHL. B.HALSE

GF Code	*Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
	MEDICAGO POLYMORPHA.		0.1	50		
	SOLANUM ESURIALE		0.1	20		
	CYNODON DACTYLON		1	50		
	~~ARISTIDA~~ Austrost. ARISTIDULUMES		1	50		
	ENTEROPOGON ACICULARIS		10	100		
	CHLORIS TRUNCATA		0.5	30		
	SPOROBOLUS CAROLI		0.1	10		
	UROCHLOA PANICOIDES		0.1	50		
	OXALIS SP.		0.1	10		
	LOMANDRA SP.		0.5	100		
	SCHEROLAENIA DIVERICATA		0.1	1		

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code** if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

BAM Site – Field Survey Form

Site Sheet no: 1 of

		Survey Name	Zone ID	Recorders			
Date	21 09 18	Narrabri SF		CP, BH			
Zone	Datum	Plot ID	Q22	Plot dimensions	20x50	Photo #	
Easting	Northing	IBRA region		Midline bearing from 0 m	180°S		
COLLECTOR Q22							
Vegetation Class						Confidence: H M L	
Plant Community Type		DNG		EEC:		Confidence: H M L	

Record easting and northing at 0 m on midline. Dimensions (Shape) of 0.04 ha base plot.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (1000 m² plot)		
DBH	# Tree Stems Count	# Stems with Hollows
80 + cm		
50 – 79 cm		
30 – 49 cm		
20 – 29 cm		
10 – 19 cm		
5 – 9 cm		
< 5 cm		n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)		

Counts apply when the **number of tree stems** within a size class is ≤ 10. Estimates can be used when > 10 (eg. 10, 20, 30 ... 100, 200, 300 ...) For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate. **Tree stems must be living.**

For **hollows**, count only the presence of a stem containing hollows. For a **multi-stemmed tree**, only the largest stem is included in the count/estimate. **Stems may be dead and may be shrubs.**

BAM Attribute (1 x 1 m plots)	Litter cover (%)	Bare ground cover (%)	Cryptogam cover (%)	Rock cover (%)
Subplot score (% in each)	5 15 10 10 25			
Average of the 5 subplots				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots centred at 5, 15, 25, 35, 45 m along the plot midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Assessors may also record the cover of rock, bare ground and cryptogams.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence
Clearing (inc. logging)			
Cultivation (inc. pasture)			
Soil erosion			
Firewood / CWD removal			
Grazing (identify native/stock)			
Fire damage			
Storm damage			
Weediness			
Other			

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date	21 09 18	Silverleaf Soar	922	CPHU. B.HANSE

GF Code	*Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
	Bothr. sp. (decipiens)		1	100		
	Calotis lepp.		0.1	10		
	Urochloa pascoides		0.5	200		
	Enterop. acic.		0.1	20		
	Cadom. lanatus.		0.1	5		
	Medicago polymo		0.1	10		
	Austrostip verticillata		5	100		
	Eragrostis leptost		0.5	30		
	Lycium ferocciss.		0.1	3		
	Panic. reimo		0.5	30		
	Sclerolaena birchii		0.2	20		
	Portulacca oler.		0.1	10		
	Chloris ventricosa		0.1	10		
	Glandularia		0.1	10		
	Opuntia stricta		0.1	2		
	Gomphrena celosioides		0.1	20		
	Arctoth. calendula		0.2	50		
	Neptunia gracilis f. gracilis		0.1	1		
	Cynoglossum australe.		0.2	50		
	Abutilon fruco.		0.1	2		
	Chrysocephalum apiculatum		0.1	10		
	Vittadinia cuneata		0.1	2		
	Cymod. dactylon		0.5	50		
	Wahl. stricta		0.1	1		
	Calotis cuneif		0.1	10		
	Rumex sp.		0.1	1		

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code** if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

BAM Site – Field Survey Form

Site Sheet no: 1 of

		Survey Name	Zone ID	Recorders			
Date	21 09 18	Narrabri SF		BH, CP			
Zone	Datum	Plot ID	Q23	Plot dimensions		Photo #	
Easting	Northing	IBRA region		Midline bearing from 0 m	275°W	Magnetic	
COLLECTOR Q23							
Vegetation Class						Confidence: H M L	
Plant Community Type		DNG		EEC:		Confidence: H M L	

Record easting and northing at 0 m on midline. Dimensions (Shape) of 0.04 ha base plot.

BAM Attribute (400 m² plot)		Sum values
Count of **Native Richness**	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of **Cover** of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (1000 m² plot)		
DBH	# Tree Stems Count	# Stems with Hollows
80 + cm		
50 – 79 cm		
30 – 49 cm		
20 – 29 cm		
10 – 19 cm		
5 – 9 cm		
< 5 cm		n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)		

Counts apply when the **number of tree stems** within a size class is ≤ 10. Estimates can be used when > 10 (eg. 10, 20, 30 . , 100, 200, 300 . .) For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate. **Tree stems must be living.**

For **hollows**, count only the presence of a stem containing hollows. For a **multi-stemmed tree**, only the largest stem is included in the count/estimate. **Stems may be dead and may be shrubs.**

BAM Attribute (1 x 1 m plots)	Litter cover (%)	Bare ground cover (%)	Cryptogam cover (%)	Rock cover (%)
Subplot score (% in each)	5 15 5 25 10			
Average of the 5 subplots				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots centred at 5, 15, 25, 35, 45 m along the plot midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Assessors may also record the cover of rock, bare ground and cryptogams.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence:
Clearing (inc. logging)			
Cultivation (inc. pasture)			
Soil erosion			
Firewood / CWD removal			
Grazing (identify native/stock)			
Fire damage			
Storm damage			
Weediness			
Other			

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date: 21 09 18	Silverleaf Star	Q23	B. HALSE OPHU

GF Code	*Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
	Cynodon dactylon		0.5	100		
	Kincadia mutans.		0.1	5		
	Medicago polymorpha		0.5	200		
	Enteropogs acicularis		1	200		
	Sideroxylon divaricate		0.1	20		
	Lycium ferocissi		0.1	1		
	Oxalis sp.		0.1	10		
	Urochloa panicoides		0.2	100		
	Paspalum effusum		0.1	10		
	Sporob. caroli		0.1	2		
	Solanum esuriale		0.1	2		

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code** if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

Transect Start: Lat -30.28143105°, Long: 149.78373368°
Transect End Lat -30.28191238, Long 149.78400291

BAM Site – Field Survey Form

Site Sheet no: 1 of

		Survey Name	Zone ID	Recorders			
Date	13 11 18	Silverleaf Sdal		PF + LD			
Zone	Datum	Plot ID	Q24	Plot dimensions		Photo #	
Easting	Northing	IBRA region		Midline bearing from 0 m	181°		
Vegetation Class						Confidence: H M L	
Plant Community Type				EEC:		Confidence: H M L	

Record easting and northing at 0 m on midline. Dimensions (Shape) of 0.04 ha base plot.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (1000 m² plot)		
DBH	# Tree Stems Count	# Stems with Hollows
80 + cm		
50 – 79 cm		
30 – 49 cm		
20 – 29 cm		
10 – 19 cm		
5 – 9 cm		
< 5 cm		n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)	1m	

Counts apply when the **number of tree stems** within a size class is ≤ 10. Estimates can be used when > 10 (eg. 10, 20, 30 ... 100, 200, 300 ...). For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate. **Tree stems must be living.**

For **hollows**, count only the presence of a stem containing hollows. For a **multi-stemmed tree**, only the largest stem is included in the count/estimate. **Stems may be dead and may be shrubs.**

BAM Attribute (1 x 1 m plots)	Litter cover (%)	Bare ground cover (%)	Cryptogam cover (%)	Rock cover (%)
Subplot score (% in each)	1, 15, 5, 10, 10			
Average of the 5 subplots	8.2			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots centred at 5, 15, 25, 35, 45 m along the plot midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Assessors may also record the cover of rock, bare ground and cryptogams

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence:
Clearing (inc. logging)			
Cultivation (inc. pasture)			
Soil erosion			
Firewood / CWD removal			
Grazing (identify native/stock)			
Fire damage			
Storm damage			
Weediness			
Other			

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

PCT 55

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date	13 11 2018	Silverleaf Solar	Q24	CP + PF

GF Code	*Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
	Eucalyptus fibrigaensis		0.5	1		
	Enteropogon acicularis		35	1000		
	Mustard weed		0.1	30		
	Sclerolaena birchii		0.1	20		
	Portulacca oleracens		0.1	10		
	Urochloa piscoides		0.1	30		
	Sclerolaena muricata		15	60		✓
	Chenopodium album? desertorum		0.1	10		✓
	~~Paspalidium sp~~ Rhrhacta longi?		0.1	10		✓
	Hordeum sp. leporinum		0.5	100		
	Solanum esuriale		0.1	50		
	Einadia trastata		0.1	10		
	Medicago polymorpha		1	100		
	Sida sp ~~subspicata~~ cunning		0.1	5		✓
	Dira → sporobo carbi		0.1	1		
	Lycium ferocissimum		0.1	1		
	Einadia nutans		0.1	10		
	Lepidium Dow		0.1	1		✓

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code** if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

Start lat -30.27444234°, Long 149.77597355° / end lat -30.27475117°, long 149.77610439°

BAM Site – Field Survey Form

Site Sheet no: 1 of

		Survey Name	Zone ID	Recorders			
Date	14 11 18	Silverleaf Solar		PF + CP			
Zone	Datum	Plot ID	Q25	Plot dimensions		Photo #	
Easting	Northing	IBRA region		Midline bearing from 0 m	153°		
Vegetation Class						Confidence: H M L	
Plant Community Type	Bigalow			EEC:		Confidence: H M L	

Record easting and northing at 0 m on midline. Dimensions (Shape) of 0.04 ha base plot.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (1000 m² plot)		
DBH	# Tree Stems Count	# Stems with Hollows
80 + cm	All Bigalow ✓ Tree with shrub	
50 – 79 cm	✓	
30 – 49 cm	✓	
20 – 29 cm		
10 – 19 cm		
5 – 9 cm		
< 5 cm		n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)	5, 10.5, 33 = 48.5 m	

LIT

Counts apply when the **number of tree stems** within a size class is ≤ 10. Estimates can be used when ≥ 10 (eg. 10, 20, 30 ... 100, 200, 300 ...) For a **multi-stemmed tree**, only the largest living stem is included in the count/estimate. **Tree stems must be living.**

For **hollows**, count only the presence of a stem containing hollows. For a **multi-stemmed tree**, only the largest stem is included in the count/estimate. **Stems may be dead and may be shrubs.**

BAM Attribute (1 x 1 m plots)	Litter cover (%)	Bare ground cover (%)	Cryptogam cover (%)	Rock cover (%)
Subplot score (% in each)	5 | 20 | 2 | 40 | 5			
Average of the 5 subplots	14.4			

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots centred at 5, 15, 25, 35, 45 m along the plot midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Assessors may also record the cover of rock, bare ground and cryptogams.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element	Flat	Landform Pattern		Microrelief	
Lithology		Soil Surface Texture	Very dry sandy loam	Soil Colour	grey	Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence:
Clearing (inc. logging)			✓ heavy
Cultivation (inc. pasture)			
Soil erosion			
Firewood / CWD removal			
Grazing (identify native/stock)			
Fire damage			
Storm damage			
Weediness			
Other			

Severity: 0=no evidence, 1=light, 2=moderate, 3=severe

Age: R=recent (<3yrs), NR=not recent (3-10yrs), O=old (>10yrs)

PC 35

400 m² plot: Sheet _ of _		Survey Name	Plot Identifier	Recorders
Date		Silverleaf	Q25	CP + PF

GF Code	*Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
	Acacia harpophylla		0.2	1		
	~~Bauhinia sp. Mitchell (purple flowers)~~		~~1~~	~~1~~		✓
	Enteropogon acicularis		.1	200		
	~~Sida trapezica~~ Abutilon cryptopetalum		0.1	10		✓
	Urochloa piercaides		0.1	20		
	Boerhavia dominii		0.1	30		
	~~Mustard weed~~ Rapistrum rugosum		0.2	100		
	Sensitive plant (Neptunia gracilis)		0.1	20		
	Sida corrugata.		0.1	30		
	Atriplex ~~sp.~~ leptocarpa		0.1	10		✓
	Solanum esuriale		0.1	50		
	Rytidosperma sp.		0.1	30		✓
	Austrostipa sp. anstiglumis		0.1	10		✓
	Verbena officinale.		0.1	1		
	Opuntia stricta		0.1	1		
	Aristida ramosa.		0.1	10		
	Austrostipa 2 (taller)		0.1	20		✓
	Chrysocephalum apiculatum		0.1	1		
	Convolvulus erubescens.		0.1	1		
	~~Paspalidium~~ Paspalidium constrictum		0.1	20		✓
	Enchylaena tomentosa		0.1	30		
	Solanum ferrense.		0.1	10		
	Oxalis corniculata		0.1	5		
	~~Notelaea microcarpa~~ Geijera parv.		0.1	4		
	Rhagodia spinescens		1	6		

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code** if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

Abundance: 1, 2, 3, ..., 10, 20, 30, ... 100, 200, ..., 1000, ...

Appendix D – BAM Calculator data

BAM calculator input data

VegZone	Location relative to footprint	plot	pct	area	patchsize	conditionclass	zone	easting	northing	bearing	compTree	compShrub	compGrass	compForbs	compFerns	compOther	strucTree	strucShrub	strucGrass	strucForbs	strucFerns	strucOther	funLargeTrees	funHollowtrees	funLitterCover	funLenFallenLogs	funTreeStem5to10	funTreeStem10to20	funTreeStem20to30	funTreeStem30to50	funTreeStem50to80	funTreeRegen	funHighThreatExotic
		Text[Maximum 10 charactors]	Number	Number with 2 decimal point	Number	Text[Letters, numbers, underscores and hyphans] Please fill condition-class name in all plots	[54 or 55 or 56]			Range in [0-359]	Number	Number	Number	Number	Number	Number	Number with 1 decimal point	Number with 1 decimal point	Number with 1 decimal point	Number with 1 decimal point	Number with 1 decimal point	Number with 1 decimal point	Number	Number	Number with 1 decimal point	Number with 1 decimal point	[0,1]	[0,1]	[0,1]	[0,1]	[0,1]	Number	Number with 1 decimal point
1	in	8	35	26.81	0	Derived_grassland	55	766757	6647688	165	0	1	2	5	0	0	0.0	0.1	55.0	0.5	0.0	0.0	0	0	17.0	0.0	0	0	0	0	0	0	0.0
1	out	9	35	26.81	0	Derived_grassland	55	766400	6648017	350	0	0	4	3	0	0	0.0	0.0	57.0	0.3	0.0	0.0	0	0	15.0	0.0	0	0	0	0	0	0	0.0
1	in	21	35	26.81	0	Derived_grassland	55	766892	6647450	45	0	1	6	2	0	0	0	0.1	13.1	0.2	0.0	0.0	0	0	16.0	0	0	0	0	0	0	0	0.0
1	in	23	35	26.81	0	Derived_grassland	55	766748	6647880	275	0	1	4	3	0	0	0	0.1	1.7	0.3	0.0	0.0	0	0	12.0	0	0	0	0	0	0	0	0.1
2	out	12	55	0.69	7	Moderate	55	767831	6646608	75	2	3	11	7	0	0	15	9	54.3	3	0	0	3	3	41.0	12.0	0	0	0	0	1	0	2.0
2	out	13	55	0.69	7	Moderate	55	768077	6646584	98	1	3	5	3	0	0	20.0	21.0	33.0	0.3	0.0	0.0	1	2	22.0	3.0	0	0	0	1	0	0	1.0
2	out	24	55	0.69	7	Moderate	55	767776	6646747	181	1	3	2	5	0	0	0.5	15.2	35.1	0.5	0.0	0.0	0	0	8.2	1	0	0	0	0	0	0	0.1
3	in	1	55	121.96	0	Derived_grassland	55	767322	6646721	135	0	2	5	6	0	0	0.0	1.1	40.5	0.6	0.0	0.0	0	0	23.0	0.0	0	0	0	0	0	0	0.1
3	in	10	55	121.96	0	Derived_grassland	55	766782	6647102	135	0	3	8	5	0	0	0.0	1.3	46.5	1.1	0.0	0.0	0	0	22.0	0.0	0	0	0	0	0	0	0.1
3	in	11	55	121.96	0	Derived_grassland	55	767853	6646967	221	0	2	4	8	0	0	0.0	0.3	58.0	2.1	0.0	0.0	0	0	21.0	0.0	0	0	0	0	0	0	0.0
3	in	14	55	121.96	0	Derived_grassland	55	768735	6646845	282	0	2	3	7	0	0	0.0	5.1	11.1	1.5	0.0	0.0	0	0	7.0	0.0	0	0	0	0	0	0	0.0
3	in	18	55	121.96	0	Derived_grassland	55	767247	6646430	90	0	0	2	1	0	0	0	0.0	10.1	0.1	0.0	0.0	0	0	45.0	0	0	0	0	0	0	0	0.0
3	in	20	55	121.96	0	Derived_grassland	55	768317	6646860	30	0	2	5	6	0	0	0	0.4	10.5	0.6	0.0	0.0	0	0	24.0	0	0	0	0	0	0	0	0.0
4	out	2	397	1.15	119	Moderate	55	767446	6649262	154	1	8	11	14	1	3	10.0	1.3	29.2	9.4	0.1	10.2	4	1	10.0	0.0	0	0	0	0	1	0	0.1
4	out	3	397	1.15	119	Moderate	55	767385	6649060	105	1	8	8	16	0	1	15.0	2.6	30.3	14.5	0.0	0.1	4	4	19.0	4.0	0	0	1	1	1	0	2.1
4	out	4	397	1.15	119	Moderate	55	767235	6648868	90	1	8	12	16	0	1	15	1.2	43.5	7.2	0.0	0.1	3	1	27.0	5	0	0	0	1	1	0	5.0
5	in	15	397	32.69	0	Derived_grassland	55	766999	6649178	210	0	3	5	6	0	1	0.0	0.5	38.0	0.6	0.0	0.1	0	0	10.0	0.0	0	0	0	0	0	0	0.2
5	in	17	397	32.69	0	Derived_grassland	55	767178	6649150	195	0	0	3	1	1	1	0	0.0	25.2	0.1	0.1	0.1	0	0	29.0	0	0	0	0	0	0	0	0.1
5	in	19	397	32.69	0	Derived_grassland	55	768142	6647150	165	0	1	3	2	0	0	0	0.1	0.3	0.2	0.0	0.0	0	0	27.0	0	0	0	0	0	0	0	0.0
5	in	22	397	32.69	0	Derived_grassland	55	767099	6649290	180	0	2	7	9	0	0	0	0.3	7.7	1.0	0.0	0.0	0	0	13.0	0	0	0	0	0	0	0	0.2
0	*in*	*5*				*Non-native*	*55*	*767508*	*6648483*	*250*	*0*	*0*	*3*	*3*	*0*	*0*	*0.0*	*0.0*	*1.4*	*0.3*	*0.0*	*0.0*	*0*	*0*	*11.0*	*0.0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.1*
0	*in*	*7*				*Non-native*	*55*	*766733*	*6648351*	*263*	*0*	*1*	*1*	*2*	*0*	*0*	*0.0*	*0.3*	*1.0*	*0.2*	*0.0*	*0.0*	*0*	*0*	*12.0*	*0.0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.0*
0	*out*	*16*	*35*	*0.08*	*9*	*Moderate*	*55*	*767095*	*6647446*	*165*	*2*	*2*	*3*	*5*	*0*	*0*	*40.0*	*3.1*	*17.5*	*0.5*	*0.0*	*0.0*	*1*	*1*	*20.0*	*0.0*	*1*	*1*	*1*	*0*	*0*	*0*	*0.2*
0	*out*	*25*	*35*	*0.08*	*9*	*Moderate*	*55*	*767048*	*6647541*	*153*	*1*	*5*	*6*	*5*	*0*	*1*	*0.2*	*1.4*	*1.5*	*0.5*	*0.0*	*0.1*	*4*	*0*	*14.4*	*49*	*0*	*0*	*0*	*1*	*1*	*0*	*0.0*
0	*out*	*6*	*35*	*0.63*	*31*	*Moderate*	*55*	*767599*	*6648500*	*177*	*2*	*4*	*4*	*5*	*0*	*0*	*25.0*	*11.6*	*45.0*	*2.3*	*0.0*	*0.0*	*0*	*3*	*60.0*	*52.0*	*1*	*1*	*1*	*1*	*0*	*0*	*0.1*

Site attribute values used to calculate the future vegetation integrity score for each vegetation zone

Attribute component	Site attribute	Future value	Justification
Composition	Tree (TG)	0	Assumes that there will be a total removal of canopy layers
	Shrub (SG)	0	Assumes that there will be a total removal of shrub layers
	Grass/Grasslike (GG)	-10% from observed means for each respective vegetation zone	A 10% reduction in the species richness value from the observed mean was used due to predicted shading effects of the solar panels. Most groundcover species recorded during survey are considered to be relatively resilient species, withstanding grazing and drought conditions.
	Forb (FG)	-10% from observed means for each respective vegetation zone	
	Fern (EG)	-10% from observed means for each respective vegetation zone	
	Other (OG)	-10% from observed means for each respective vegetation zone	
Structure	Tree (TG)	0	Assumes that there will be a total removal of canopy layers
	Shrub (SG)	0	Assumes that there will be a total removal of shrub layers
	Grass/Grasslike (GG)	-50% from observed means for each respective vegetation zone	A 50% reduction in the percentage cover from the observed mean was used due to predicted shading effects of the solar panels. Most groundcover species recorded during survey are considered to be relatively resilient species, withstanding grazing and drought conditions.
	Forb (FG)	-50% from observed means for each respective vegetation zone	
	Fern (EG)	-50% from observed means for each respective vegetation zone	
	Other (OG)	-50% from observed means for each respective vegetation zone	
Function	No. large trees	0	Assumes that there will be a total removal of canopy and shrub layers
	Litter	No change from observed means	Due to the paucity of groundcover vegetation at the time of survey, most vegetation zones recorded relatively low functional litter cover. The functional litter cover is predicted to remain relatively unchanged by shading effects of the solar panels.
	Fallen logs	0	Assumes that there will be a removal of all woody debris
	Stem size class	absent	Assumes that there will be a total removal of canopy and shrub layers
	Regen	absent	
	High threat weeds (HT)	No change from observed means	The majority of high threat weeds are represented by exotic grasses and thistles, which are predicted to remain relatively unchanged by shading effects of the solar panels. *Lycium ferocissimum* (African Boxthorn) is the only high threat weed that is also a priority weed for the North West region. The regional and state objectives for this priority weed is asset protection, which carries a mandatory requirement to minimise the spread of the weed offsite (rather than to eradicate). African Boxthorn occurs in the proposal site in very low numbers and is unlikely to affect the high threat attribute for future vegetation integrity scores even if it were to be physically removed to accommodate the solar panels or as part of control activities. Note that Prickly Pear is not a high threat weed, even though it is a state priority weed

Appendix E – EPBC Act assessments of significance

Introduction

This assessment of significance has been prepared to assess the significance of potential impacts on the 'Brigalow (*Acacia harpophylla* dominant and co-dominant' which is listed as an endangered ecological community (EEC) under the EPBC Act (hereafter referred to as 'Brigalow Woodland EEC').

This community occurs in the study area as two remnant patches on the eastern boundary of the Logans Lane property (i.e. the northern lot). The remnant patches extend outside of the study area (i.e. outside of the Logans Lane property).

The occurrence of Brigalow Woodland EEC within the study area has been affected by previous and ongoing agricultural use of the land, such as land clearing, grazing and livestock trampling. As such, the condition of the community is highly modified from its likely pre-European condition. Many extant examples of this community typically have a sparse ground later. The occurrences of this community within the study area still meet the key diagnostic characteristics and condition thresholds to be included as part of the EEC, namely:

- The canopy is dominated by *Acacia harpophylla* (Brigalow) trees (including regrowth)
- The overall patch size is greater than 0.5 ha
- Exotic perennial plants comprise less than 50% of the total vegetation cover of the patch.

Therefore, the occurrences of this community within the study area are in sufficiently good condition to be assessed as the EEC.

Regional and local extent

The Brigalow Woodland EEC occurs over a substantial geographic area in semi-arid eastern Australia, in QLD and NSW. The distribution of Brigalow woodlands extends from Townsville in Qld to Narrabri in NSW, in a broad band east of Blackall (Qld), Cunnamulla (Qld) and Bourke (NSW).

The original extent of the Brigalow Woodland EEC is not known but potential habitat in NSW is estimated to be approximately 115,300 hectares, based on mapping of "Brigalow soils" in the early 1960s. Recent vegetation mapping of the northern wheatbelt has found that only 13,500 hectares remains of this community and that it is severely fragmented. In NSW, remnants of the listed ecological community mostly occur north of Bourke, west of Narrabri and north of Moree.

Surviving remnants of Brigalow Woodland EEC are often small linear patches along roadsides and the edges of paddocks where threats include ongoing logging for fence posts; road widening and invasion by weeds.

Key threats

The key threat to the Brigalow Woodland EEC is land clearing. Other important threats and risks include inappropriate fire regimes, weeds, feral animals and inappropriate grazing. Climate change is also a threat that needs consideration in management.

Nature of impact

The proposal site has been redesigned to avoid direct impacts on this community. Therefore, the following assessment evaluates the potential indirect impacts of the proposal on the community, with reference to the significance impact criteria for critically endangered and endangered ecological communities (DotE, 2013).

Significant impact criteria

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:

- **Reduce the extent of an ecological community**

The proposal will not directly reduce the extent of the ecological community. The proposal site boundary has been redesigned to avoid (i.e. exclude from the direct impact area) the ecological community.

- **Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines**

The proposal will not fragment or increase fragmentation of the ecological community. The proposal site has been purposefully designed to avoid the ecological community. The entirety of the two patches now are located outside the proposal site boundary.

- **Adversely affect habitat critical to the survival of an ecological community**

The listing advice for the Brigalow Woodland EEC states that areas considered critical to the survival of the ecological community include all patches that meet the key diagnostic characteristics and condition thresholds for the ecological community, as well as buffer zones around these patches, particularly where the buffer zones include native vegetation. The purpose of the buffer zones is to minimise risk of damage to extant patches by limiting activities, or exercising care when undertaking activities around patches, such as cropping, ploughing, grazing or spraying.

The proposal will not include agricultural activities such as cropping, ploughing, grazing or spraying and is unlikely to indirectly impact the ecological community during its operational life. However, inadvertent damage may be cause during the construction and decommission of the proposal.

As part of the proposal, planting of vegetated screens would occur along the boundary of the proposal site. These would include locally sourced species typical of the vegetation communities present on site, including the Brigalow Woodland EEC. This would improve the condition of the retained vegetation in the long-term and protect the extant patches of the ecological community within the study area during construction and decommission of the proposal.

In addition to the above, prior to the construction of the proposal, trees and native vegetation patches that will be retained would be delineated to avoid additional impacts on vegetation including the Brigalow ecological community, through fencing or other means of demarcation. Fencing would be established at a distance from the trees and/or vegetation patches to protect the entire Tree Protection Zone (i.e. 10 times the diameter of the trunk at breast height).

With the implementation of these measures, the proposal would be unlikely to adversely affect habitat critical to the survival of this ecological community.

- **Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns**

The ecological community is mapped as having a low potential for being reliant on the subsurface presence of groundwater (BOM 2019a). Regardless, the proposal is unlikely to affect groundwater levels or substantially alter surface water drainage patterns. No works affecting soil nutrients is associated with the proposal. In addition, a Construction Environmental Management Plan (CEMP) (or equivalent) would be required for the construction phase of the proposal, and would be prepared prior to issue of the Construction Certificate. The CEMP would include, as a minimum, industry-standard measures for the management of soil, surface water, weeds and pollutants. No pollutants would be generated during the operational phase of the proposal.

- **Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including but not limited to:**
  - **Assisting invasive species, that are harmful to the listed ecological community, to become established, or**

A CEMP (or equivalent) would be required for the construction phase of the proposal, and would include, as a minimum, industry-standard measures for the management of soil, surface water, weeds and pollutants. An operation management plan would also include measures to minimise invasive species.

  - **Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or**

The proposal is not associated with the regular use of fertilisers, herbicides or other chemicals and would be unlikely to cause the mobilisation of such chemicals and pollutants into the ecological community.

- **Interfere with the recovery of an ecological community.**

The proposal avoids clearance of, and would protect remnant areas of the ecological community in the study area. The proposal would establish buffer zones through perimeter planting and demarcation measures during construction. The proposal would include responsible management of weeds under the CEMP and in consideration of the responsibilities of the general biosecurity duty under the *Biosecurity Act 2015*. As such the proposal is unlikely to interfere with the recovery of the ecological community.

Conclusion

Considering the above, the proposal is considered unlikely to have a significant impact on the Brigalow Woodland EEC. No further assessment, approval or provision of biodiversity offsets is required under the EPBC Act and associated policy.

Appendix F – Biodiversity credit report

BAM Biodiversity Credit Report (Like for like)

Proposal Details

Assessment Id
00011577/BAAS17011/19/00011578

Proposal Name
Silverleaf Solar Farm Narrabri

BAM data last updated *
04/01/2019

Assessor Name
Ben Harrington

Assessor Number
BAAS17023

BAM Data version *
6

Proponent Names

Report Created
19/03/2019

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Candidate Serious and Irreversible Impacts

PCT	TEC
35-Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions

Nil

Additional Information for Approval

PCTs With Customized Benchmarks

No Changes

BAM Biodiversity Credit Report (Like for like)

Predicted Threatened Species Not On Site

Name
Calyptorhynchus lathami / Glossy Black-Cockatoo
Lathamus discolor / Swift Parrot
Phascolarctos cinereus / Koala
Pseudomys pilligaensis / Pilliga Mouse
Petroica boodang / Scarlet Robin
Haliaeetus leucogaster / White-bellied Sea-Eagle

Ecosystem Credit Summary

PCT	TEC	Area	Credits
35-Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions	26.8	0.00
55-Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions.	Not a TEC	122.7	402.00
397-Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	Not a TEC	33.8	15.00

Credit classes for 35	**Like-for-like options**		
	Any PCT with the below TEC	Containing HBT	In the below IBRA subregions

	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions (including PCT's 35, 56, 87, 101, 244, 445, 629)	No	Liverpool Plains,Castlereagh-Barwon, Kaputar, Liverpool Range, Northern Basalts, Northern Outwash, Peel, Pilliga and Pilliga Outwash. or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.	

Credit classes for 55	**Like-for-like options**			
	Any PCT in the below Class	And in any of below trading groups	Containing HBT	In the below IBRA subregions
	North-west Floodplain Woodlands (including PCT's 55)	North-west Floodplain Woodlands - ≥ 70% - <90% cleared group (including Tier 4 or higher).	Yes	Liverpool Plains,Castlereagh-Barwon, Kaputar, Liverpool Range, Northern Basalts, Northern Outwash, Peel, Pilliga and Pilliga Outwash. or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.

BAM Biodiversity Credit Report (Like for like)

Credit classes for 55				
Credit classes for 397	**Like-for-like options**			
	Any PCT in the below Class	And in any of below trading groups	Containing HBT	In the below IBRA subregions
	Pilliga Outwash Dry Sclerophyll Forests (including PCT's 88, 141, 148, 397, 411, 702, 1090, 1384)	Pilliga Outwash Dry Sclerophyll Forests - < 50% cleared group (including Tier 7 or higher).	Yes	Liverpool Plains,Castlereagh-Barwon, Kaputar, Liverpool Range, Northern Basalts, Northern Outwash, Peel, Pilliga and Pilliga Outwash. or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.

Species Credit Summary

No Species Credit Data

GHD

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GHDDocId/https://projects.ghd.com/oc/Sydney/narrabrisolarfarmapp/Delivery/Documents/Final Draft Specialist Reports/Biodiversity/2126998_REP_Silverleaf BDAR.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	K. Crosby C. Phu	D. Mees		D Mees		06/05/2019

www.ghd.com

Appendix C – Aboriginal heritage

View south along eastern boundary of study area.

ABORIGINAL AND HISTORIC ARCHAEOLOGICAL IMPACT ASSESSMENT

Silverleaf Solar Farm

Narrabri LGA

April 2019

Report Prepared by

OzArk Environmental & Heritage Management Pty Ltd

for GHD on behalf of ENGIE Energy

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		Dr Alyce Cameron	
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Acknowledgement

OzArk acknowledge Traditional Owners of the area on which this assessment took place and pay respect to their beliefs, cultural heritage and continuing connection with the land. We also acknowledge and pay respect to the post-contact experiences of Aboriginal people with attachment to the area and to the elders, past and present, as the next generation of role models and vessels for memories, traditions, culture and hopes of local Aboriginal people.

EXECUTIVE SUMMARY

OzArk Environmental & Heritage Management (OzArk) has been engaged by GHD (the client), on behalf of ENGIE (the proponent) to complete an Aboriginal and historic archaeological impact assessment for the Silverleaf Solar Farm. This report examines proposed works associated with the Silverleaf Solar Farm north of Narrabri (the proposal). The proposal is situated within the Narrabri Local Government Area (LGA).

The study area consists of two sections, the solar farm and the electricity line easement. The proposed solar farm covers an area of 450 hectares between Logans Lane and the Newell Highway, approximately five kilometres north of Narrabri. The associated transmission line easement consists primarily of existing road corridors or electricity easements.

A pedestrian survey of the study area was undertaken by OzArk archaeologists Dr Alyce Cameron and Stephanie Rusden on Tuesday 23 to Thursday 25 October 2018. Representatives of the Narrabri Local Aboriginal Land Council and Gomeroi Native Title Claim Group were present during the survey. During the pedestrian survey, two Aboriginal sites were recorded: Silverleaf IF-1 (#19-3-0163) and Silverleaf IF-2 (#19-3-0164). No historic sites were recorded during the survey.

Should the management recommendations in this report be followed, there will be no impact to Aboriginal or historic sites arising from the proposal.

Recommendations

Impacts to Aboriginal cultural heritage sites within the study area will be managed as follows:

1) All management recommendations set out in **Section 6.1.2** should be followed.
2) There are no other Aboriginal cultural heritage constraints to the proposal; however, the following precautions should be taken:
    a. All land-disturbing activities must be confined to within the assessed study area. Should the parameters of the proposed work extend beyond the assessed area, then further archaeological assessment may be required.
    b. Construction staff involved in the proposed work should be made aware of the legislative protection requirements for all Aboriginal sites and objects.
3) This assessment has concluded that there is a low likelihood that the proposal will adversely harm Aboriginal cultural heritage items or sites. Following development consent of the proposal, Aboriginal heritage should be managed through an *Aboriginal Cultural Heritage Management Plan* (ACHMP) which is to be agreed to by the proponent, Aboriginal community and DP&E. The archaeological management recommendations within this report would normally be incorporated into the ACHMP that is usually formulated following development consent. The ACHMP should also include:

c. The long term management of any artefacts.
d. An *Unanticipated Finds Protocol* which can be followed and referred to during works, if Aboriginal artefacts or skeletal material are noted (see **Appendix 3** for example).
e. Construction staff should undergo cultural heritage induction to ensure they recognise Aboriginal artefacts (see **Appendix 4**) and are aware of the legislative protection of Aboriginal objects under the NPW Act and the contents of the *Unanticipated Finds Protocol*.

The historical assessment resulted in the conclusion that the proposed works will have an impact on the ground surface, however, no historic objects or intact archaeological deposits will be harmed by the proposal.

To ensure the greatest possible protection to the area's historical heritage values, the following recommendations are made:

4) This assessment has concluded that there is low likelihood that the proposed work will harm historic heritage objects, sites or potential archaeological deposits; as such, the proposed work can proceed without further archaeological investigation.
5) To avoid the potential for harm to historic objects on unassessed adjacent landforms, all ground surface disturbing activities must be confined to the assessed study area.
6) Care should be taken along Old Cemetery Road and Stoney Creek Road to avoid any impact to the adjacent cemetery which is listed on the Narrabri LEP 2012 (I018).
7) If any previously unknown significant subsurface historic deposit is observed during works, the Unanticipated Finds Protocol (**Appendix 5**) should be followed.

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

1.1 BRIEF DESCRIPTION OF THE PROPOSAL

OzArk Environmental & Heritage Management (OzArk) has been engaged by GHD (the client), on behalf of ENGIE Energy (the proponent) to complete an Aboriginal and historic archaeological impact assessment for the Silverleaf Solar Farm. This report examines proposed works associated with the Silverleaf Solar Farm north of Narrabri (the proposal). The proposal is situated within the Narrabri Local Government Area (LGA) (**Figure 1-1**).

1.2 BACKGROUND

ENGIE Renewables Australia received updated SEARs for an EIS in June 2018.

The SEARs identified that the EIS must include an assessment of the likely Aboriginal and historic heritage (cultural and archaeological) impacts of the development, including adequate consultation with the local Aboriginal community.

GHD consulted with the Office of Environment & Heritage (OEH) and confirmed that an Aboriginal Cultural Heritage Assessment Report (ACHAR) was not necessary for the Silverleaf Solar Farm EIS as the proposal will be avoiding all Aboriginal and historic sites and the pedestrian survey was conducted to the standard outlined in the Code of Practice for Archaeological Investigations. Furthermore, informal consultation was undertaken with two groups from the Aboriginal Community for the area (Narrabri Local Aboriginal Land Council and the Gomeroi Native Title Claim Group). **Appendix 2** provides the details of the Aboriginal Community consultation.

1.3 PROPOSED WORK

The proposal would consist of the following components:

- Solar arrays consisting of about 440,000 single-axis tracking panels four metres in height, supported by about 5,150 tracker units
- Construction of a transmission corridor, supporting 66 or 132 kV power lines, connecting the proposal site to the existing TransGrid substation located on Stoney Creek Road
- Inverter and transformer stations evenly distributed across the site, with onsite cabling and electrical connections between solar arrays and panel inverters
- A step-up substation to increase the voltage to 132 kV to allow connection to TransGrid substation (final step-up voltage to be confirmed during further consultation with TransGrid)
- Cables and trenches
- Internal access tracks
- Operational and maintenance office, including staff amenities block and car parking areas

- Perimeter security fencing
- Landscaping around the perimeter of the site where required.

1.4 STUDY AREA

The study area consists of two sections, the solar farm and the electricity line easement.

The study area for the solar farm is located about 5 kilometres north-west of Narrabri. The solar farm site consists of two rural properties located between Newell Highway in the east and Logans Lane in the west and covers an area of 450 hectares. The proposal site consists of the following lots:

- 330 Logans Lane – Lots 21 to 23 of DP 1174848
- 12461 Newell Highway – Lot 2 DP 586990

This area is private land and has been used extensively for agricultural cropping and grazing.

The proposed transmission line corridor is approximately 5 kilometres in length, running east from the proposed substation at the solar farm to the Newell Highway. It would then follow the highway alignment south to a point near the intersection with Killarney Gap Road. The route would diverge from the highway and continue south parallel to the railway line and Old Cemetery Road. It would then turn east at Stoney Creek Road to its connection point with the existing TransGrid Narrabri substation. **Figure 1-2** illustrates the entire study area.

1.5 ASSESSMENT APPROACH

The report and field inspection follow the standards outlined in the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b) and the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in New South Wales* (OEH 2011).

1.6 OZARK INVOLVEMENT

1.6.1 Field Assessment

The fieldwork component of this assessment was undertaken by OzArk on Tuesday 23 to Thursday 25 October 2018 by:

- Archaeologist: Dr Alyce Cameron (OzArk Project Archaeologist, BA [Hons] and PhD [Archaeology & palaeoanthropology] Australian National University).
- Archaeologist: Stephanie Rusden (OzArk Project Archaeologist, BS University of Wollongong, BA University of New England)

1.6.2 Reporting

The reporting component of the archaeological (Aboriginal and historic) assessment was undertaken by:

- Report Author: Dr Alyce Cameron;
- Reviewer: Ben Churcher (OzArk Principal Archaeologist; BA [Hons], Dip Ed).

Figure 1-1. Location of the Proposal.

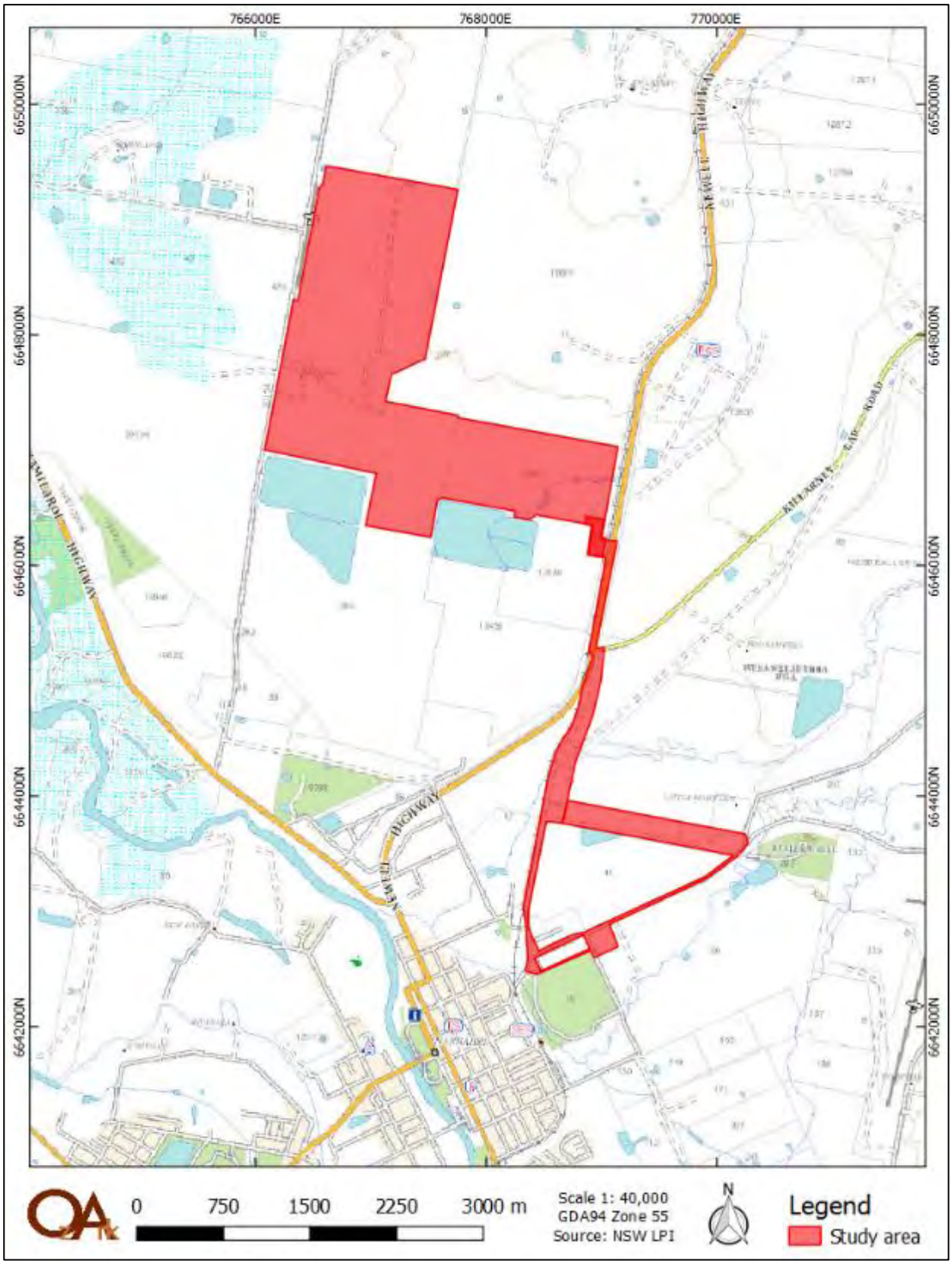


Figure 1-2: Aerial showing the study area.

2 LANDSCAPE CONTEXT

An understanding of the environmental contexts of a study area is requisite in any Aboriginal archaeological investigation (DECCW 2010). It is a particularly important consideration in the development and implementation of survey strategies for the detection of archaeological sites. In addition, natural geomorphic processes of erosion and/or deposition, as well as humanly activated landscape processes, influence the degree to which these material cultural remains are retained in the landscape as archaeological sites; and the degree to which they are preserved, revealed and/or conserved in present environmental settings.

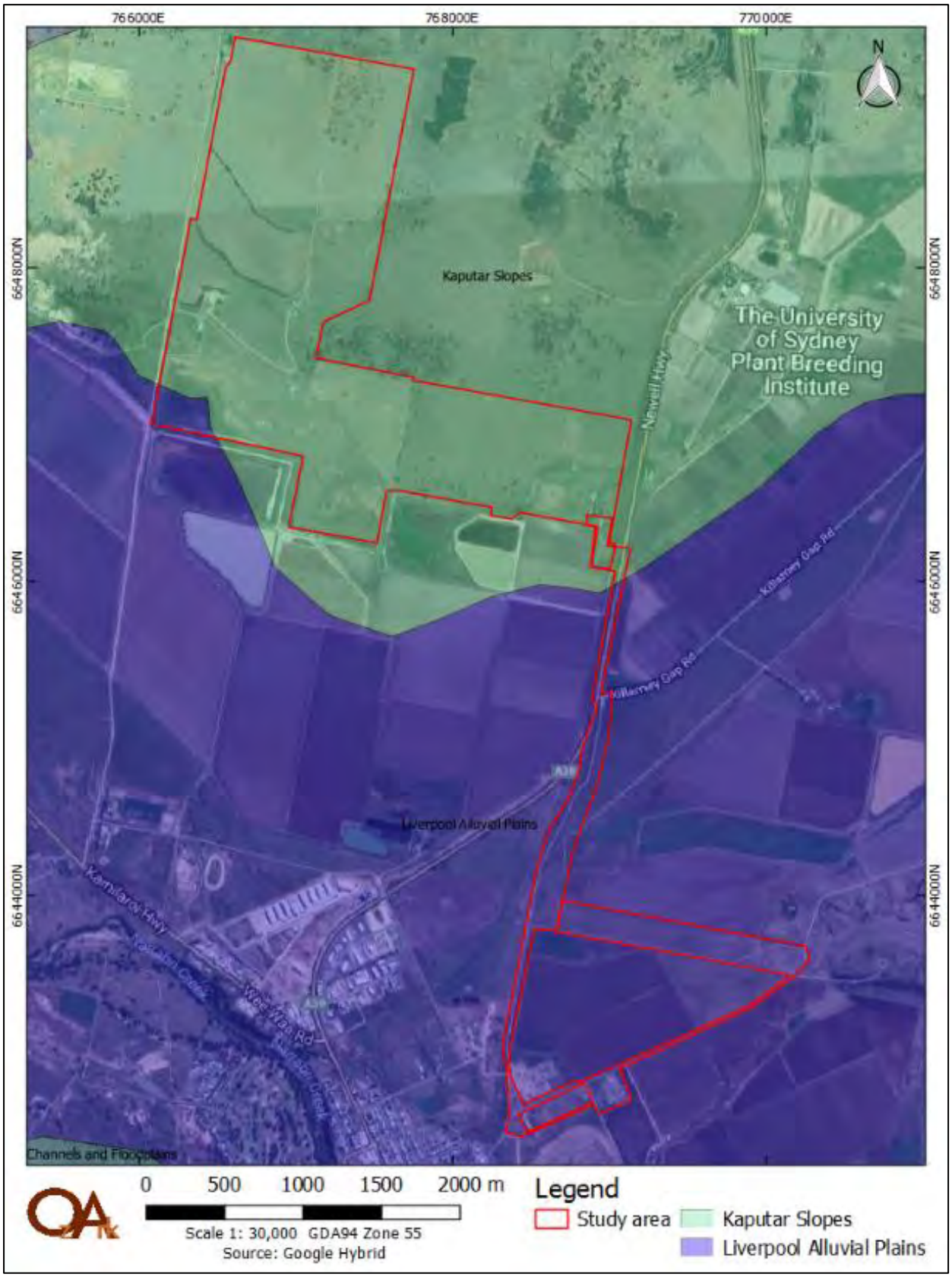
2.1 TOPOGRAPHY

The study area is situated in two landforms: the Kaputar Slopes and the Liverpool Alluvium Plains (Mitchell 2002; see **Figure 2-1**). The Kaputar Slopes is characterised by a general elevation of 300 to 500 metres and covers the lower slopes of the Kaputar volcanic complex (Mitchell 2002). The Liverpool Alluvial Plains are characterised by undulating hills and sloping plains with alluvial channels and floodplains. This landform has a general elevation of 300 to 350 metres (Mitchell 2002).

The study area is situated in the Brigalow Belt South bioregion, and in the Liverpool Plains, Northern Outwash and Northern Basalts subregions, though is mostly in the Liverpool Plains and Northern Basalts subregions. The Brigalow Belt South bioregion extends from Dubbo, north through New South Wales and into Queensland.

The topography of the study area itself varies. The northern section consisted of a gentle slope declining north to south, until evening into flat pastures. There is a large artificial drainage line beginning near the existing houses and farm buildings southeast through the southern section of the study area (**Plate 1)**. The southern section of the study area was flat, including the transmission line easement.

Figure 2-1: Mitchell's landscapes (2002) in relation to the study area



2.2 GEOLOGY AND SOILS

The soils of the Kaputar volcanic complex tend to be quartz sandstone, lithic sandstone, silty sandstone, conglomerate and thin coal (Mitchell 2002). The soils of the Liverpool Alluvial Plains tend to be deep black and brown cracking clays, alluvial soils and red/brown texture-contrast soils (Mitchell 2002).

On a regional scale, the Brigalow Belt South bioregion consists of extensive basalt flows and quartz sandstone, and has variable soils and vegetation depending on the rock type or sediment source (NPWS 2003).

2.3 HYDROLOGY

The closest watercourse to the study area is Doctors Creek, 800 metres east of the southern corner of the transmission line corridor for the solar farm. All other watercourses, including Narrabri Creek, Mulgate Creek, Horse Arm Creek and the Namoi River, are over one kilometre from any section of the study area (**Figure 2-2**).

Figure 2-2: The study area and closest hydrology

2.4 VEGETATION

The vegetation in the study area is a mix of non-native grasslands, native grasses, Western Slopes Dry Sclerophyll forests and Pilliga Outwash Dry Sclerophyll forests. These are characterised by poplar box, white cypress pine, narrow-leaved Ironbark, and Belah woodland.

2.5 CLIMATE

The climate of the Brigalow Belt South bioregion is subhumid with no dry season and a hot summer. The mean annual temperature ranges 10–19 degrees Celsius with a mean annual rainfall of 449–1015 millimetres.

For Narrabri, the hottest month is January with a mean maximum temperature of 37.4 degrees Celsius and the coldest month is July is with a mean minimum temperature of 4 degrees Celsius. Rainfall in Narrabri is highest in November with a mean rainfall of 71.8 millilitres and lowest in May with a mean rainfall of 23.6 millilitres (BOM 2018).

2.6 LAND-USE HISTORY AND EXISTING LEVELS OF DISTURBANCE

The study area is predominantly ploughed and grazed paddocks which have been cleared of vegetation. There is also farm buildings, fences and stockyards present in the main section of the study area. The transmission line section of the study area is made up of existing electricity easements and road reserves.

2.7 CONCLUSION

The landforms in the study area would not have been an impediment to movement or occupation (camping) in the past. However, occupation of this area in antiquity by Aboriginal people would most likely have been limited to transient inhabitation resulting from movement across the landscape to other areas which provide more stable resources such as water provided by Narrabri Creek or the Namoi River.

Based on the topography and geology of the study area, it is unlikely there will be suitable outcropping rock present, and therefore no sources of stone procurement for tool manufacture will be identified. The soils that characterise the study area are relatively stable, though repeated ground surface disturbance by ploughing, grazing and vegetation clearing will have allowed soil to be become more susceptible to erosion. The mature, native species within the study area would have provided resources for Aboriginal people in the past, however, resources likely to have supported a large population of people would have been present closer to the banks of more permanent water sources in the region. Given the presence of mature native vegetation, it is possible that some site types such as culturally modified trees may existing within the study area, however, the broad-scale vegetation clearance, reduce the likelihood that any culturally modified trees will remain present.

Disturbances arising from past land use have resulted in localised, significant changes to the landscape. The majority of the study area has been subject to extensive levels of disturbance from continued ploughing and cultivation. In other sections of the study area, these activities have resulted in less modification to the landscape although vegetation clearing, the construction of a homestead and associated farm infrastructure would have exacerbated soil movement leading to the dispersal or covering of stone artefact sites. As noted above, initial vegetation clearing would also have removed culturally modified trees, had they existed in the area. Unobtrusive sites such as open artefact scatters and isolated finds have a greater ability to withstand disturbances and persist within the landscape, however where present, such sites are likely to be disturbed.

3 ABORIGINAL CULTURAL HERITAGE IMPACT ASSESSMENT

3.1 RELEVANT LEGISLATION

Cultural heritage is managed by a number of state and national Acts. Baseline principles for the conservation of heritage places and relics can be found in the *Burra Charter* (Australia ICOMOS 2013). The *Burra Charter* has become the standard of best practice in the conservation of heritage places in Australia, and heritage organisations and local government authorities have incorporated the inherent principles and logic into guidelines and other conservation planning documents. The *Burra Charter* generally advocates a cautious approach to changing places of heritage significance. This conservative notion embodies the basic premise behind legislation designed to protect our heritage, which operates primarily at a state level.

A number of Acts of parliament provide for the protection of heritage at various levels of government.

3.1.1 State Legislation

Environmental Planning and Assessment Act 1979 (EP&A Act)

This Act established requirements relating to land use and planning. The framework governing environmental and heritage assessment in NSW is contained within the following parts of the EP&A Act:

- **Part 4:** Local government development assessments, including heritage. May include schedules of heritage items;
    - **Division 4.1:** Approvals process for State Significant Development;
- **Part 5:** Environmental impact assessment on any heritage items which may be impacted by activities undertaken by a state government authority or a local government acting as a self-determining authority; and
- **Part 5.1:** Approvals process for state significant infrastructure.

Under Part 4 of EP&A Act, approved projects do not require approval under the NPW Act to impact Aboriginal sites and such impacts, should they occur, are managed under an approved *Aboriginal Cultural Heritage Management Plan* (ACHMP).

National Parks and Wildlife Act 1974 (NPW Act)

Amended during 2010, the NPW Act provides for the protection of Aboriginal objects (sites, objects and cultural material) and Aboriginal places. Under the Act (Part 6), an Aboriginal object is defined as: any deposit, object or material evidence (not being a handicraft for sale) relating to indigenous and non-European habitation of the area that comprises NSW, being habitation both prior to and concurrent with the occupation of that area by persons of European extraction, and includes Aboriginal remains.

An Aboriginal place is defined under the NPW Act as an area which has been declared by the Minister administering the Act as a place of special significance for Aboriginal culture. It may or may not contain physical Aboriginal objects.

As of 1 October 2010, it is an offence under Section 86 of the NPW Act to 'harm or desecrate an object the person knows is an Aboriginal object'. It is also a strict liability offence to 'harm an Aboriginal object' or to 'harm or desecrate an Aboriginal place', whether knowingly or unknowingly. Section 87 of the Act provides a series of defences against the offences listed in Section 86, such as:

- The harm was authorised by and conducted in accordance with the requirements of an Aboriginal Heritage Impact Permit (AHIP) under Section 90 of the Act;
- The defendant exercised 'due diligence' to determine whether the action would harm an Aboriginal object; or
- The harm to the Aboriginal object occurred during the undertaking of a 'low impact activity' (as defined in the regulations).

Under Section 89A of the Act, it is a requirement to notify the Director-General of the Office of Environment and Heritage (OEH) of the location of an Aboriginal object. Identified Aboriginal items and sites are registered on Aboriginal Heritage Information Management System (AHIMS).

3.1.2 Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

Matters of National Environmental Significance listed under the EPBC Act include the National Heritage List and the Commonwealth Heritage List, both administered by the Commonwealth Department of the Environment and Energy. Ministerial approval is required under the EPBC Act for proposals involving significant impacts to National/Commonwealth heritage places.

3.1.3 Applicability to the Proposal

The proposal will be assessed under Division 4.7 of the EP&A Act.

Any Aboriginal sites within the study area are afforded legislative protection under the NPW Act.

It is noted there are no Commonwealth or National heritage listed places within the study area, and as such, the heritage provisions of the EPBC Act do not apply.

3.2 PURPOSE AND OBJECTIVES

The purpose of the Aboriginal and historic archaeological impact assessment is to identify and assess heritage constraints relevant to the proposed works and to provide recommendations to avoid and/or manage potential impacts.

3.2.1 Aboriginal Archaeological Assessment Objectives

The current assessment will apply the Code of Practice (to the completion of an Aboriginal archaeological assessment) in order to meet the following objectives:

Objective One: Undertake background research on the Assessment Boundary to formulate a predicative model for site location within the Assessment Boundary;

Objective Two: Identify and record objects or sites of Aboriginal heritage significance within the Assessment Boundary, as well as any landforms likely to contain further archaeological deposits; and

Objective Three: Assess the likely impacts of the proposed work to Aboriginal cultural heritage and provide management recommendations.

3.3 DATE OF ARCHAEOLOGICAL ASSESSMENT

The fieldwork component of this assessment was undertaken by Alyce Cameron and Stephanie Rusden of OzArk on Tuesday 23 to Thursday 25 October 2018.

3.4 ABORIGINAL COMMUNITY INVOLVEMENT

Two groups representing the Aboriginal community were invited to be involved with the archaeological assessment: the Narrabri Local Aboriginal Land Council and the Gomeroi Native Title Claim Group. **Appendix 2** details the informal consultation with the two community groups.

4 ABORIGINAL ARCHAEOLOGY BACKGROUND

4.1 ETHNO-HISTORIC SOURCES OF REGIONAL ABORIGINAL CULTURE

According to Tindale (1974), the current study area falls within the limits of the lands occupied by the Kamilaroi tribe. The name Narrabri is derived from an Aboriginal word, meaning 'Forked Waters'. The Kamilaroi tribal area extends from Walgett, NSW to Nindigully, QLD and included areas near Talwood and Garah at Moree, Mungindi, Mogil Mogil, Narrabri, Pilliga, Gunnedah, Bingara, Tamworth, Quirindi, Bundella, Barraba, Gwabegar and Come-by-Chance; on headwaters of the Hunter River (Tindale 1974). The current study area is located within the centre of the Kamilaroi tribal territory.

Prior to European settlement, the Kamilaroi people practiced a hunting, gathering and fishing economy with the Naomi River and the Gwydir River providing an abundance of resources. The Traditional Owners caught a variety of freshwater species including fish, eels, crayfish, yabbies, turtles and mussels using fishing lines and nets made from reed fibres. Watercraft was manufactured from large slabs of bark cut from the native River Red Gum trees. Away from the freshwater sources, the Kamilaroi people hunted kangaroos, wallabies, koalas, possums, echidnas, emus, lizards, snakes and frogs. Plant foods included grass seeds, wild orange, emu apple, melons, tubers, yams and roots. It is highly probable that the vegetation structure which existed prior to European occupation was a result of Aboriginal land management practices such as controlled burning (Appleton 2009).

Following Oxley's European 'discovery'[1] of the Liverpool Plains in 1817, a runaway convict George Clarke ("The Barber") began the first European settlement of the Boggabri area (c.1828 to his capture in 1831). According to historical reports Clarke made first contact with local Aboriginal people and was adopted into the Aboriginal community (Dunlop *et al.* 1957 as cited in Hamm 2005).

In 1831 Mitchell's exploring party, following Clarke's route, came across the Leard Forest. Their native guide "Mr Brown" noticed axe marking called "Mogo" on a number of trees which he described as a sign 'to keep away' (O'Rourke 1995). For further information Michael O'Rourke details an account of Mitchell's crossing in *Raw Possum and Salted Port: Major Mitchell and the Kamilaroi* (O'Rourke 1995).

The early 1830s saw the expansion of European settlement into northern New South Wales including Narrabri and its close surroundings with the first squatting settlement run 'Nurrabry' taken up in 1834 (Hunt 1998). Continued settlement in the region lead to violent interactions between the Europeans and the Kamilaroi. Aboriginal people were shot, poisoned and displaced

[1] '*discovery*' to NSW government knowledge.

from their land by pastoral settlers and, in retaliation, cattle, sheep, stockmen and shepherds were speared. Historical sources record a rapid decline in Kamilaroi numbers associated with the dispossession of land and the subsequent destruction of native habitats and social networks. Overall, European settlement of the region caused immense disruption and change to Aboriginal social and economic life and relationships to country.

4.2 REGIONAL ARCHAEOLOGICAL CONTEXT

On a broader perspective (Liverpool Plains District) the available data indicates variable use of the local landforms, with known sites indicating ephemeral, casual or limited use, and other sites showing more intensive or repeated use. The most frequent site type recorded in the broader region is the small open camp site, which is most often found on level, well drained terrain close to permanent water. Artefacts on these sites usually number less than 50, although the site size appears to be greatly affected by ground surface visibility conditions at the time of recording. Some sites are associated with grinding grooves and/or modified trees. Relevant studies within the broader region will be briefly reviewed below.

Silcox and Bowdler (1982) completed a survey for the proposed 132kV Transmission Line Route from Walgett to Narrabri. The survey area was approximately 180 kilometres in length with a 45 metre easement along the entire route. A total of 15 sites were recorded during the survey including seven isolated finds, four scarred trees, two open campsites and two possible hearths. Stone artefacts identified as isolated finds and within the open campsites included flakes, blades, backed blades, cores, a grinding stone containing two grooves and a possible scraper. These artefacts were largely comprised of chert (yellow, brown, pink and mottled yellow/orange), quartz, silcrete, ironstone and basalt. Silcox and Bowdler returned to the survey area later in 1982 to conduct excavations and surface collection of one of the recorded open campsites, WN6. They noted upon return to the site the amount and density of material had significantly decreased due to natural and made-made disturbances.

In 2007 Australian Archaeological Survey Consultants (AASC) completed a survey for Narrabri Coal Operations for extensions to the Narrabri Coal Project located approximately 20 kilometres south of Narrabri. The survey was concentrated on the areas known as the Pit Top Survey Area and the Ventilation Shaft Survey Area. A total of seven sites were recorded during the survey consisting of two isolated finds, two artefact scatters, two scarred trees and one resource site exhibiting a native food resource: Wild Orange Tree. A majority of the newly recorded sites were located within close proximity to Kurrajong Creek which bisects the north eastern quarter of the Pit Top Survey Area. The banks of Kurrajong Creek were noted as being the least disturbed by intensive agricultural activity and therefore sites recorded along the creek retained some of its archaeological integrity and context.

Appleton (2008) returned to the area to conduct salvage operations at Rocglen Coal Mine, following his 2002 survey of the site of the proposed Belmont Coal Mine. The salvage area consisted of three locations situated 25 kilometres north of Gunnedah, between Vickery State Forest and Wean Road. Appleton (2002) had previously noted artefacts, including a silcrete core at Site "B1", a micro-debitage scatter of eight small silcrete flakes at Site "B2", and an extended artefact scatter (over 40 artefacts consisting of three cores, with the remainder flaked pieces and flakes) at Site "B3". The salvage operation noted significant disturbance between 2002 and 2008 caused by agricultural activity or storms and slope-wash. Additional artefacts were recovered at "B1" (eight stone artefacts, no cores), at "B2" (13 stone artefacts), and at "B3" (67 artefacts, including three cores). Appleton interpreted the 'Rocglen Assemblage' as a camping area to which various groups returned over an extended period of time.

Appleton (2009) completed a survey for the Narrabri Coal Operations "Longwall Project" located about 30 kilometres south east of Narrabri, nearby the Kamilaroi Highway. The assessment entailed a survey over four main areas comprising the impact zones. A total of 121 sites were identified across all four survey areas located on a variety of landforms. Forty-three sites were recorded in the first survey area, 69 sites recorded in the second, nine recorded in the third and no sites recorded within the fourth survey area. Overall, most sites comprised low density artefact scatters with only four per cent of artefact scatters containing more than 20 artefacts. A scarred tree and a hearth were also identified within the first survey area. Higher density artefact scatters, the scarred tree and hearth were all recorded along ephemeral and permanent watercourses, including Pine Creek and Kurrajong Creek.

More recently in 2016, OzArk was engaged by the Central West Local Land Services (CWLLS) to formulate and test a predictive model for Aboriginal site location within Travelling Stock Reserves (TSRs) across the CWLLS area. In formulating a predictive model for site location, Mitchell (2002) landscapes were used to understand the underlying landform type. The resolution of the Mitchell landscape units was too fine to be of use and OzArk (2016) used a higher-level classification within the Mitchell landscape units to describe the landscapes within the CWLLS area. Landscapes were divided into the following types:

- Channels and floodplains;
- Alluvial plains;
- Slopes;
- Uplands; and
- Downs.

Previously recorded AHIMS sites were plotted against these landscape types and the following observations made:

- A high number of sites (n=876) were located within slopes landscapes, however, this result could be due to the fact that Dubbo is located within a slopes landscape and the highest number of sites in the CWLLS area is recorded in and around Dubbo;
- The highest density of sites is within channels and floodplains landscapes (n=927);
- Alluvial plains landscapes have the third highest density of sites (n=770);
- Relatively small numbers of sites are recorded in uplands (n=5) and plateau (n=34) landscapes; and
- A moderate number of sites are recorded in downs landscapes (n=255). Three or four clusters of sites exist in downs landscapes, which may have skewed the data. If the veracity of all site recordings in this category could be verified, it is suspected that the actual number of sites in downs landscapes would be lower.

OzArk (2016) divided the CWLLS area into two stream orders—major watercourses (normally named rivers) and minor watercourses (normally named creeks and their larger tributaries)—and buffers were established for each watercourse type as follows:

- **Drainage 1 buffer:** 200m either side of a major watercourse; and
- **Drainage 2 buffer:** 100m either side of a minor watercourse.

As such, the OzArk (2016) CWLLS predictive model made predictions based on the landscape type and distance to watercourses. The predictive model was tested by assessing 32 TSRs within the CWLLS area located in a variety of landscape types with variable distances to water. As a result of the assessment, 59 sites were recorded. Twenty six (44%) of the recorded sites were modified trees, 22 (37%) were artefact scatters and 11 (19%) were isolated finds. The majority of recorded sites were located in channels and floodplains landscapes (35 sites or 59% of all sites), followed by 10 in slopes landscapes, four in alluvial plains landscapes and one in a downs landscape. No sites were recorded in uplands or plateau landscapes.

Table 4-1 demonstrates that the most archaeologically sensitive landscape in the CWLLS area is channels and floodplains, followed by slopes landscapes. Other landscape types have a low representation but demonstrate that low densities of sites exist in other landscape types.

Table 4-1: Association of all recorded sites to landscape units (OzArk 2016).

Landscape unit	Number of sites	Percentage of total (n=59)
Channels and floodplains	36	61
Alluvial plains	6	10
Slopes	14	23
Downs	1	2
Uplands	2	4
Plateau	0	0

Site types associated with the landscapes most-frequently recording sites (channels and floodplains and slopes) show that channels and floodplains landscapes are more likely to contain

modified trees and that slopes landscapes are more likely to contain artefact scatters and isolated finds (**Table 4-2**).

Table 4-2: Frequency of site types in association with landscape types (OzArk 2016).

Site type	Channels and floodplains	Slopes	Alluvial Plains
Artefact scatter	11 (30.5%)	7 (50%)	3 (50%)
Isolated finds	4 (11%)	3 (21%)	3 (50%)
Modified trees	21 (58.5%)	4 (29%)	0 (0%)

In terms of drainage buffers, OzArk (2016) found that 27 sites (or 46% of all sites) were recorded with the Drainage 1 buffer and 10 sites (or 17% of all sites) were recorded within the Drainage 2 buffer. Therefore, more than 63% of all sites were recorded within the two drainage buffers, with a clear bias toward Drainage 1 buffers.

4.3 LOCAL ARCHAEOLOGICAL CONTEXT

4.3.1 Desktop Database Searches Conducted

A desktop search was conducted on the following databases to identify any potential previously-recorded heritage within the study area. The results of this search are summarised in **Table 4-3**.

Table 4-3: Desktop database search results.

Name of Database Searched	Date of Search	Type of Search	Comment
Commonwealth Heritage Listings	14/11/18	Narrabri LGA	One place listed on the Commonwealth Heritage List: Narrabri Post Office and former Telegraph Office. 5.5 kilometres south of study area
National Native Title Claims Search	14/11/18	NSW	The Gomeroi People (Tribunal File No. NC2011/006) have an active claim over the study area
OEH AHIMS	4/10/18	Easting 757488–779112 Northing 6633883–6658196 No buffer.	No sites are within the study area. 29 sites recorded in the 21.6 x 24.3 kilometre search area.
Local Environment Plan (LEP)	14/11/18	Narrabri LEP of 2012	There are no Aboriginal Places listed.

As per **Table 4-3**, it is noted that the study area includes land currently subject to Native Title Claim (The Gomeroi People, Tribunal File No. NC2011/006, Federal Court No. NSD2308/2011).

A search of the Aboriginal Heritage Information Management System database (AHIMS) resulted in 29 Aboriginal sites being located within 10 kilometres of the study area. There are no sites recorded within the study area itself (**Figure 4-1**). **Table 4-4** shows that the majority of sites are artefact scatters (34%), followed by scarred/carved trees (31%). Burials, grinding grooves and isolated artefacts are all equally represented (7%), with a limited number of other site types also being present (3% each). The closest AHIMS sites to the study area are AHIMS #19-3-0133 and

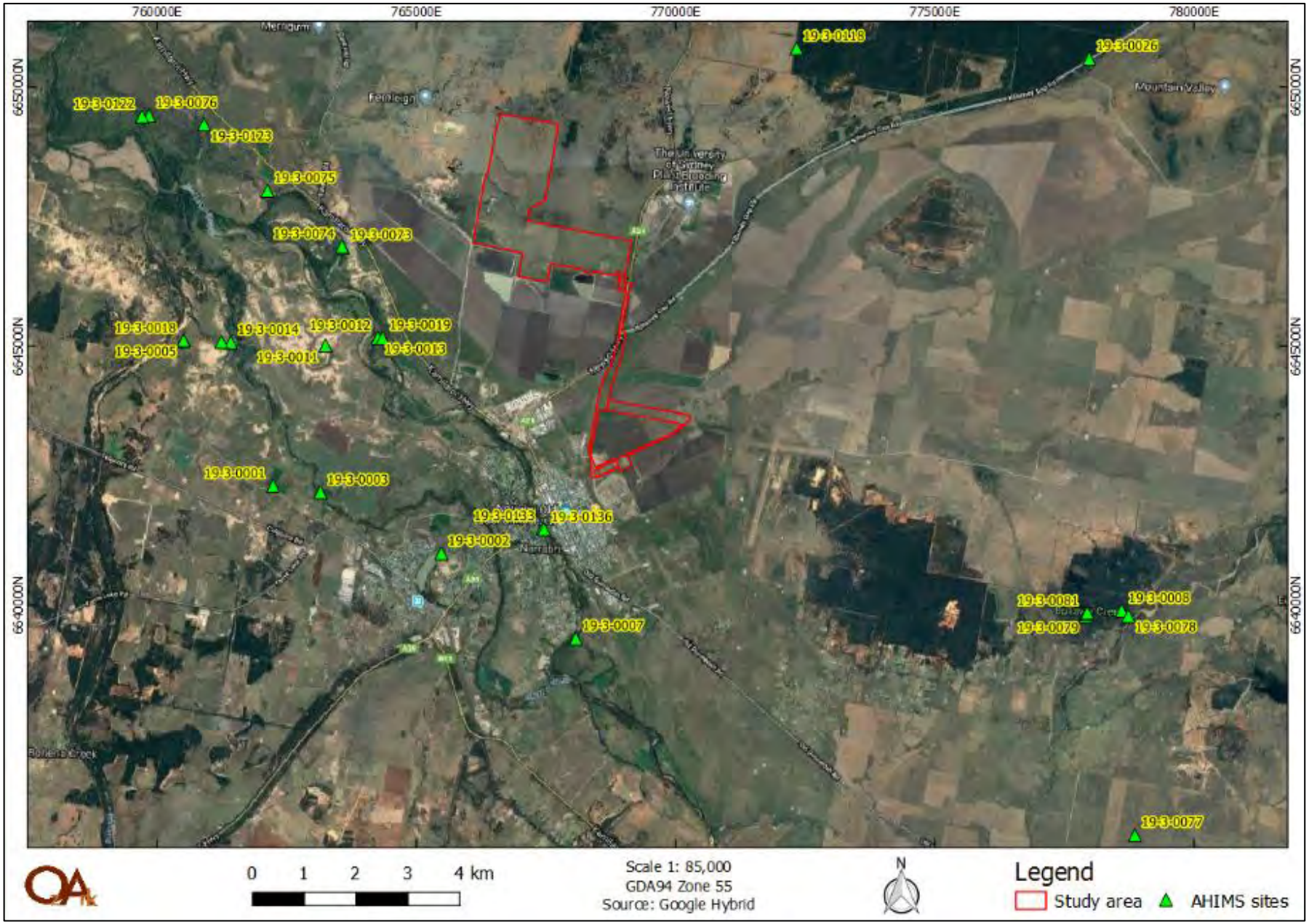
#19-3-0136 located approximately 1.4 kilometres southwest from the proposed transmission line easement. The extensive AHIMS search results are available in **Appendix 1**.

Table 4-4: AHIMS site types and frequencies.

Site Type	Number	% Frequency
Artefact scatter	10	34
Modified tree	9	31
Burial	2	7
Grinding grooves	2	7
Isolated artefact	2	7
Artefact scatter & modified tree	1	3
Habitation structure	1	3
Ochre Quarry	1	3
Stone Quarry	1	3
Total	**29**	**100**

Artefact sites and modified trees are the most commonly recorded Aboriginal sites in the 10 kilometre radius of the study area. These types of sites are often located in the vicinity of watercourses and large areas of native vegetation (as illustrated in **Figure 4-1**). It is unlikely that large campsites or modified trees will be located within the study area, due to the study area's distance from permanent or semi-permanent watercourses and the lack of large areas of native vegetation. It is possible that low density artefact scatters or isolated artefacts will be present within the study area.

Figure 4-1: The study area in relation to previously recorded sites.



4.4 PREDICTIVE MODEL FOR SITE LOCATION

Across Australia, numerous archaeological studies in widely varying environmental zones and contexts have demonstrated a high correlation between the permanence of a water source and the permanence and/or complexity of Aboriginal occupation. Site location is also affected by the availability of and/or accessibility to a range of other natural resources including plant and animal foods; stone and ochre resources and rock shelters; as well as by their general proximity to other sites/places of cultural/mythological significance. Consequently, sites tend to be found along permanent and ephemeral water sources, along access or trade routes or in areas that have good flora/fauna resources and appropriate shelter.

In formulating a predictive model for Aboriginal archaeological site location within any landscape it is also necessary to consider post-depositional influences on Aboriginal material culture. In all but the best preservation conditions, very little of the organic material culture remains of ancestral Aboriginal communities survives to the present. Generally, it is the more durable materials such as stone artefacts, stone hearths, shell, and some bones that remain preserved in the current landscape. Even these however may not be found in their original depositional context since these may be subject to either (a) the effects of wind and water erosion/transport - both over short and long time scales or (b) the historical impacts associated with the introduction of European farming practices including: grazing and cropping; land degradation associated with exotic pests such as goats and rabbits and the installation of farm related infrastructure including water-storage, utilities, roads, fences, stockyards and residential quarters. Scarred trees may survive for up to several hundred years but rarely beyond.

Knowledge of the environmental contexts of the study area and a desktop review of the known local and regional archaeological record (**Section 4.2** and **Section 4.3**), the following predictions are made concerning the probability of those site types being recorded within the study area:

- Isolated finds may be indicative of random loss or deliberate discard of a single artefact, the remnant of a now dispersed and disturbed artefact scatter, or an otherwise obscured or sub-surface artefact scatter. They may occur anywhere within the landscape but are more likely to occur in topographies where open artefact scatters typically occur.
    - As isolated finds can occur anywhere, particularly within disturbed contexts, it is predicted that this site type could be recorded within the study area.
- Open artefact scatters are defined as two or more artefacts, not located within a rock shelter, and located no more than 50m away from any other constituent artefact. This site type may occur almost anywhere that Aboriginal people have travelled and may be associated with hunting and gathering activities, short or long term camps, and the manufacture and maintenance of stone tools. Artefact scatters typically consist of surface scatters or sub-surface distributions of flaked stone discarded during the manufacture of tools, but may also include other artefactual rock types such as hearth and anvil stones. Less commonly, artefact scatters may include archaeological stratigraphic features such as hearths and artefact concentrations which relate to activity areas. Artefact density can

vary considerably between and across individual sites. Small ground exposures revealing low density scatters may be indicative of background scatter rather than a spatially or temporally distinct artefact assemblage. These sites are classed as 'open', that is, occurring on the land surface unprotected by rock overhangs, and are sometimes referred to as 'open camp sites'.

Artefact scatters are most likely to occur on level or low gradient contexts, along the crests of ridgelines and spurs, and elevated areas fringing watercourses or wetlands. Larger sites may be expected in association with permanent water sources.

Topographies which afford effective through-access across, and relative to, the surrounding landscape, such as the open basal valley slopes and the valleys of creeks, will tend to contain more and larger sites, mostly camp sites evidenced by open artefact scatters.

  - Artefact scatters, as well as isolated stone artefacts, are the predominant site types occurring in the region. The expected location of artefact scatters is on eroded exposures most commonly adjacent to drainage lines along flat and lower slope landforms. This site type is likely to be in a secondary context from disturbances such as erosion and ploughing. It is likely that any sites associated with such landforms are likely to have a low artefact density and a low complexity of tool types as the sites are either one-off events or only infrequently used due to the lack of a permanent or semi-permanent water source and the undifferentiated landforms present. Artefacts are most likely to be manufactured from a variety of materials including silcrete, volcanic, quartz and fine-grained siliceous materials

- Aboriginal scarred trees contain evidence of the removal of bark (and sometimes wood) in the past by Aboriginal people, in the form of a scar. Bark was removed from trees for a wide range of reasons. It was a raw material used in the manufacture of various tools, vessels and commodities such as string, water containers, roofing for shelters, shields and canoes. Bark was also removed as a consequence of gathering food, such as collecting wood boring grubs or creating footholds to climb a tree for possum hunting or bark removal. Due to the multiplicity of uses and the continuous process of occlusion (or healing) following removal, it is difficult to accurately determine the intended purpose for any particular example of bark removal. Scarred trees may occur anywhere old growth trees survive. The identification of scars as Aboriginal cultural heritage items can be problematical because some forms of natural trauma and European bark extraction create similar scars. Many remaining scarred trees probably date to the historic period when bark was removed by Aboriginal people for both their own purposes and for roofing on early European houses. Consequently, the distinction between European and Aboriginal scarred trees may not be clear.

  - Vegetation within the study area includes remnant native species. These stands of native vegetation include trees of a type, age and size well suited to scar-producing activities. This site type therefore may be encountered and it is also noted that this site type has been recorded locally although high levels of vegetation clearing reduce the likelihood of recording this site type. While the likelihood of recording this site type increases with proximity to water, Kelton (1996) found that modified trees can be found within all landforms.

- Hearths/ovens are often used by Aboriginal people for the preparation of food and would generally be located in the vicinity of available resources, such as water sources to procure fish and shellfish, and on elevated ground to avoid impact from environmental threats.
    - This site type is considered possible in areas where A-Horizon soils are relatively undisturbed. However, given the high levels of disturbance across the study area, the likelihood of identifying this site type is significantly reduced.
- Quarry sites and stone procurement sites typically consist of exposures of stone material where evidence for human collection, extraction and/or preliminary processing has survived. Typically, these involve the extraction of siliceous or fine grained igneous and meta-sedimentary rock types for the manufacture of artefacts. The presence of quarry/extraction sites is dependent on the availability of suitable rock formations.
    - This site type is not considered likely to be recorded within the study area.
- Burials are generally found in soft sediments such as aeolian sand, alluvial silts and rock shelter deposits. In valley floor and plains contexts, burials may occur in locally elevated topographies rather than poorly drained sedimentary contexts. Burials are also known to have occurred on rocky hilltops in some limited areas. Burials are generally only visible where there has been some disturbance of sub-surface sediments or where some erosional process has exposed them.
    - Generally found in elevated sandy contexts or in association with rivers and major creeks. No such features exist with the study area and therefore burials are unlikely to occur.

5 RESULTS OF ABORIGINAL ARCHAEOLOGICAL ASSESSMENT

5.1 SAMPLING STRATEGY AND FIELD METHODS

The archaeological methods utilised in the Aboriginal archaeological assessment followed the Code of Practice and the proposed methodology (**Appendix 2**). Standard archaeological field survey and recording methods were employed in this study (Burke & Smith 2004).

The fieldwork component of this assessment was undertaken by OzArk on Tuesday 23 to Thursday 25 October 2018 by:

- Archaeologist: Dr Alyce Cameron (OzArk Project Archaeologist, BA [Hons] and PhD [Archaeology & palaeoanthropology] Australian National University).
- Archaeologist: Stephanie Rusden (OzArk Project Archaeologist, BS University of Wollongong, BA University of New England)

The following representatives of Aboriginal community groups participated in the fieldwork program:

- Natalie Mason (Narrabri Local Aboriginal Land Council): 23–25 October 2018
- David Trindall (Narrabri Local Aboriginal Land Council): 23–24 October 2018
- Darren Mason (Narrabri Local Aboriginal Land Council): 25 October 2018
- Donald Craigie (Gomeroi Native Title Claim Group): 25 October 2018

The entirety of the study area was assessed by pedestrian transects, excluding the areas surrounding existing houses, farm infrastructure and the TransGrid substation, which will not be impacted by the proposal. The surveyors were spaced approximately 30–50 metres apart. All mature, native trees within the study area and with the potential to contain Aboriginal scarring were inspected.

Sites were recorded with digital photography and by GPS units loaded with Mobile Mapper software and were described on field recording sheets. General notes pertaining to the survey and ground covered by the archaeologist was kept as well.

Figure 5-1 illustrates the pedestrian coverage of the study area. It should be noted that this figure only displays the track log of one to two surveyors, though there were an additional two to three surveyors each day.

5.2 PROJECT CONSTRAINTS

There were no significant constraints in completing the archaeological assessment of the study area. Ground surface visibility (GSV) posed the greatest constraint during field inspection, however, not to the extent that the efficacy of the survey was unduly diminished.

5.3 EFFECTIVE SURVEY COVERAGE

Two of the key factors influencing the effectiveness of archaeological survey are GSV and ground surface exposure (GSE). These factors are quantified in order to ensure that the survey data provides adequate evidence for the evaluation of the archaeological materials across the landscape. For the purposes of the current assessment, these terms are used in accordance with the definitions provided in the *Code of Practice* (DECCW 2010).

GSV is defined as:

> *… the amount of bare ground (or visibility) on the exposures which might reveal artefacts or other archaeological materials. It is important to note that visibility, on its own, is not a reliable indicator of the detectability of buried archaeological material. Things like vegetation, plant or leaf litter, loose sand, stone ground or introduced materials will affect the visibility. Put another way, visibility refers to 'what conceals'* (DECCW 2010: 39).

GSE is defined as:

> *… different to visibility because it estimates the area with a likelihood of revealing buried artefacts or deposits rather than just being an observation of the amount of bare ground. It is the percentage of land for which erosion and exposure was sufficient to reveal archaeological evidence on the surface of the ground. Put another way, exposure refers to 'what reveals'* (DECCW 2010: 37).

The study area can be differentiated into three different types of survey units based on landform or land use. The majority of the study area consists of paddocks, used for long-term agricultural cultivation and grazing (**Plate 2**). These can be divided by those paddocks with a gentle slope and those which are flat. The transmission line corridor consists of road reserves or existing electricity line easements (**Plate 3**, **Plate 4** and **Plate 5**). The differing survey units within the study area are illustrated in **Figure 5-2**. **Table 5-1** and **Table 5-2** outline the survey coverage achieved for each unit. Overall, the gentle slopes paddocks had a GSV of 40% and GSE of 60%, resulting in 24% effective coverage of this survey unit. The flat paddocks had a GSV of 40% and GSE of 50% with a 20% effective coverage. The road reserves and electricity easements generally had low GSV (30%) and higher GSE (50%) resulting in 15% of this survey unit being effectively covered. The sealed roads (such as the Newell Highway) are included in the overall area for this survey unit, and only the edges of the road corridors were surveyed in these instances.

Details of the two Aboriginal sites recorded during the field assessment are provided in **Section 5.4**.

Figure 5-1: Survey coverage within the study area.

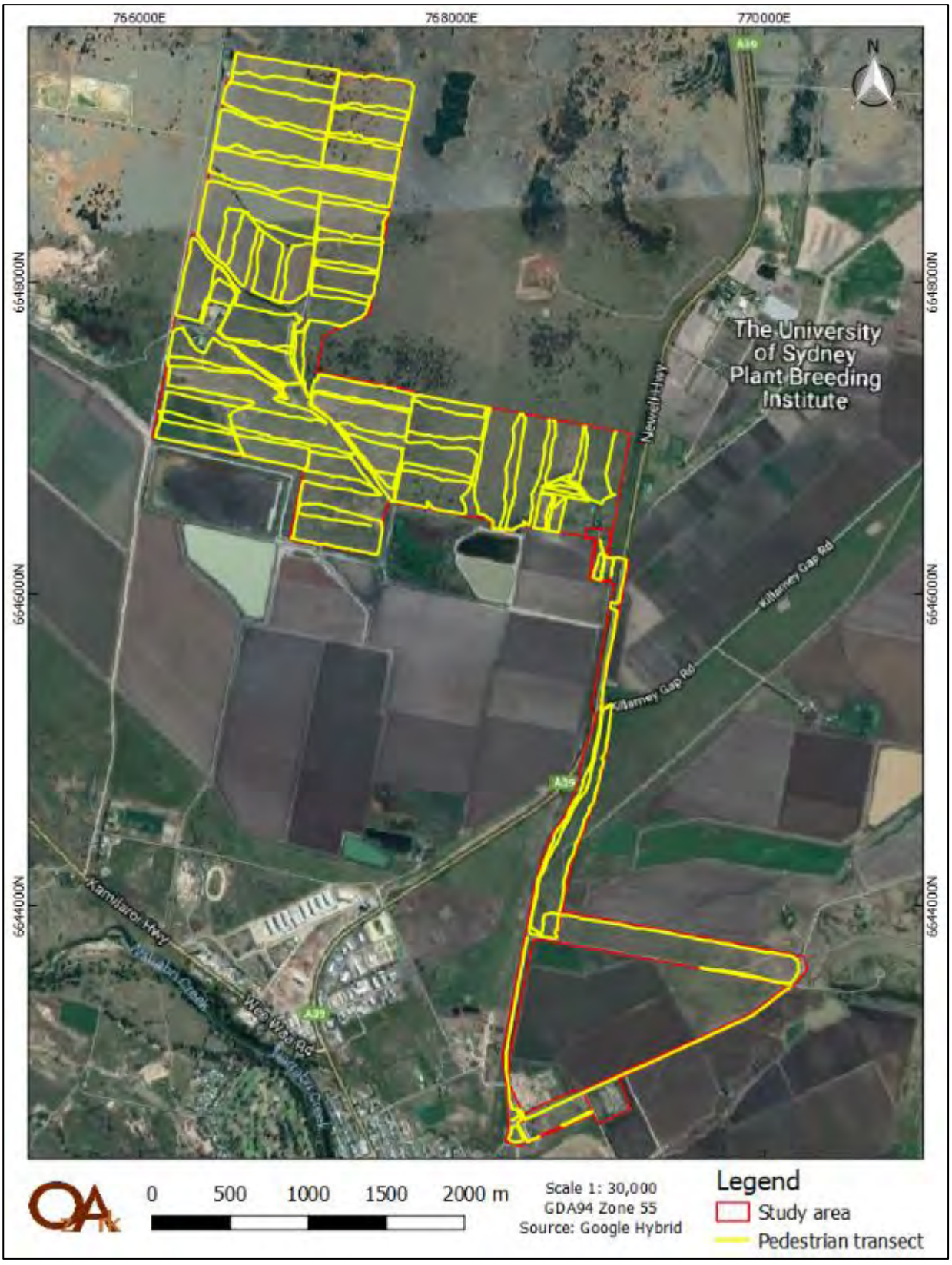


Figure 5-2: Survey units within the study area.

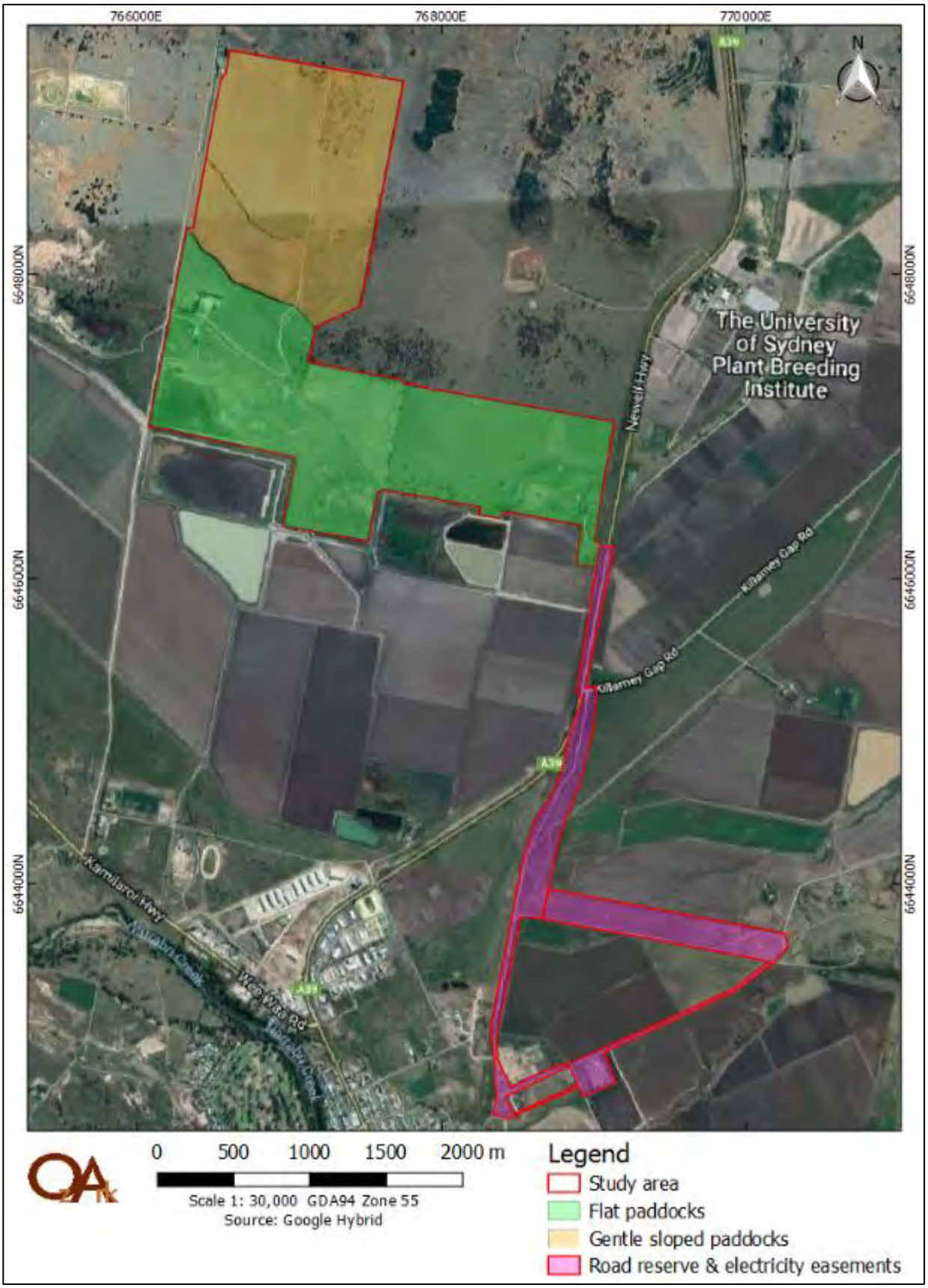


Table 5-1: Survey coverage data.

Survey Unit	Landform	Survey Unit Area (sq. m)	Visibility %	Exposure %	Effective Coverage Area (sq. m) (= Survey Unit Area x Visibility % x Exposure %)	Effective Coverage % (= Effective Coverage Area / Survey Unit Area x 100)
1	Gentle sloped paddocks	1,790,000	40	60	429600	24
2	Flat paddocks	2,720,000	40	50	544000	20
3	Road reserve & electricity easements	834,710	30	50	125206.5	15

Table 5-2: Landform summary—sampled areas.

Landform	Landform area (sq. m)	Area Effectively Surveyed (sq. m) (= Effective Coverage Area)	% of Landform Effectively Surveyed (= Area Effectively Surveyed / Landform x 100)	Number of Sites	Number of Artefacts or Features
Gentle sloped paddocks	1,790,000	429600	24	0	0
Flat paddocks	2,720,000	544000	20	2	2
Road reserve & electricity easements	834,710	125206.5	15	0	0

5.4 ABORIGINAL HERITAGE SITES RECORDED

Two previously unrecorded Aboriginal sites were identified during the pedestrian survey: Silverleaf IF-1 and Silverleaf IF-2 (**Table 5-3** and **Figure 5-3**).

Table 5-3: Aboriginal site features.

Site Name	Coordinates (GDA) (Centre point)	Site type	Artefact Count	Site Dimensions (m)
Silverleaf IF-1 (#19-3-0163)	766916E / 6647274N	Isolated artefact	1	1 x 1
Silverleaf IF-2 (#19-3-0164)	767094E / 6647233N	Isolated artefact	1	1 x 1

Figure 5-3: Location of Aboriginal sites

Silverleaf IF-1 (#19-3-0163)

Site Type: Isolated artefact

GPS Coordinates: 766916E / 6647274N

Location of Site: The site is located in Oakville agricultural property, 780 metres east of Logans Lane and 5.5 kilometres north of Narrabri. The site is located south of a large artificial water drainage channel. Narrabri Creek is the closest watercourse and is located three kilometres southwest of the site.

Description of Site: The site situated within a large patch of erosion 16 metres east of a gate and fence line in a paddock used for grazing (**Figure 5-4**). The bank of the artificial water channel is 22 metres northeast from the site location. The site consists of a single, silcrete proximal flake fragment at a tertiary stage of reduction. The flake is 3 centimetres in length, 2 cm in width and 1 cm in thickness. The site extent covers a one metre radius around the artefact location.

There were no additional artefacts located at the site and the site is assessed as having limited potential for *in situ* sub-surface deposits.

Figure 5-4: Silverleaf IF-1 (#19-3-0163). View of site.

1. View east of Silverleaf IF-1.

Silverleaf IF-2 (#19-3-0164)

Site Type: Isolated artefact

GPS Coordinates: 767094E / 6647233N

Location of Site: The site is located in Oakville agricultural property, 970 metres east of Logans Lane and 5.5 kilometres north of Narrabri. The site is located north of a large artificial water drainage channel. Narrabri Creek is the closest watercourse and is located 3.3 kilometres southwest of the site.

Description of Site: The site is located in a paddock used for currently for grazing, but that has also been ploughed and cropped. The site consists of a single, quartzite proximal flake fragment at a tertiary stage of reduction (**Figure 5-5**). The flake is 1.5 centimetres in length, 1 cm in width and 0.5 centimetres in thickness. The site is situated eight metres east side of a fence line and approximately 15 metres north of a dirt track. The artefact was in a patch of erosion.

There were no additional artefacts located at the site and the site is assessed as having limited potential for *in situ* sub-surface deposits.

Figure 5-5: Silverleaf IF-2 (#19-3-0164). View of site and located artefact.

1. View southeast of Silverleaf IF-2.

2. Artefact located at Silverleaf IF-2.

5.5 DISCUSSION

Two Aboriginal sites were recorded during the pedestrian survey: Silverleaf IF-1 (#19-3-0163) and Silverleaf IF-2 (#19-3-0164) (see **Section 5.4** for details). Both are isolated artefacts located in disturbed contexts without associated subsurface deposits.

There is low potential for further sites or *in situ* subsurface archaeological deposits being present within the remainder of the study area.

The results of the assessment confirm to the predictive model in **Section 4.4**. There are no archaeologically sensitive landforms or watercourses within the study area, meaning large complex sites (such as camp sites) are unlikely. While the presence of the two isolated artefact sites is not uncommon in such landforms, they can be described as a 'background' scatter, indicating there were Aboriginal people in the area, but not providing any further scientific information.

5.6 ASSESSMENT OF SIGNIFICANCE

The appropriate management of cultural heritage items is usually determined on the basis of their assessed significance as well as the likely impacts of any proposed developments. Scientific,

cultural and public significance are identified as baseline elements of significance assessment, and it is through the combination of these elements that the overall cultural heritage values of a site, place or area are resolved.

Social or cultural value

This area of assessment concerns the importance of a site or features to the relevant cultural group: in this case, the Aboriginal community. Aspects of social value include assessment of sites, items, and landscapes that are traditionally significant or that have contemporary importance to the Aboriginal community. This importance involves both traditional links with specific areas, as well as an overall concern by Aboriginal people for their sites generally and the continued protection of these. This type of value may not be in accord with interpretations made by the archaeologist: a site may have low archaeological value but high social value, or vice versa.

Archaeological/scientific value

Assessing a site in this context involves placing it into a broader regional framework, as well as assessing the site's individual merits in view of current archaeological discourse. This type of value relates to the ability of a site to answer current research questions and is also based on a site's condition (integrity), content and representativeness.

The overriding aim of cultural heritage management is to preserve a representative sample of the archaeological resource. This will ensure that future research within the discipline can be based on a valid sample of the past. Establishing whether or not a site can contribute to current research also involves defining 'research potential' and 'representativeness'. Questions regularly asked when determining significance are: can this site contribute information that no other site can? Is this site representative of other sites in the region?

Aesthetic value

This refers to the sensory, scenic, architectural and creative aspects of the place. It is often closely linked with the social values. It may consider form, scale, colour, texture and material of the fabric or landscape, and the smell and sounds associated with the place and its use (Australia ICOMOS 2013).

Historic value

Historic value refers to the associations of a place with a historically important person, event, phase or activity in an Aboriginal community. Historic places do not always have physical evidence of their historical importance (such as structures, planted vegetation or landscape modifications). They may have ‘shared’ historic values with other (non-Aboriginal) communities.

Places of post-contact Aboriginal history have generally been poorly recognised in investigations of Aboriginal heritage. Consequently, the Aboriginal involvement and contribution to important

regional historical themes is often missing from accepted historical narratives. This means it is often necessary to collect oral histories along with archival or documentary research to gain a sufficient understanding of historic values.

5.6.1 Assessed significance of the recorded sites

Social or cultural value

The social value of Aboriginal sites is generally determined through consultation with Aboriginal people. Aboriginal sites have significance to the local Aboriginal community in the Narrabri region, providing tangible links to the occupation of the land by their ancestors. As noted in **Section 3.4** and **Section 5.1,** members of the Aboriginal community did accompany the survey. Silverleaf IF-1 and Silverleaf IF-2 have been provisionally assigned **high social/cultural value** based on comments by the Aboriginal community members who participated in the survey.

Archaeological/scientific value

The scientific significance of Silverleaf IF-1 and Silverleaf IF-2 are assessed as low as all sites represent isolated artefacts in secondary contexts. These sites are assessed as having **low scientific/archaeological values** based on the following:

- Low density of artefacts
- No formal tool types
- Widespread past and current disturbance through the creation of the artificial drainage line and use of the property for cropping and grazing.

Aesthetic value

The aesthetic value of a site is derived from its relationship to and position within the surrounding landscape. Silverleaf IF-1 and Silverleaf IF-2 have been assessed as having **low aesthetic values**, as all sites are within a road corridor which has undergone various disturbances.

Historic value

There are no known historical associations for Silverleaf IF-1 and Silverleaf IF-2.

Table 5-4 summaries the significance assessment for Silverleaf IF-1 and Silverleaf IF-2.

Table 5-4: Significance assessment for recorded artefacts.

Site Name (number)	Social or Cultural Value	Archaeological / Scientific Value	Aesthetic Value	Historic Value
Silverleaf IF-1 (#19-3-0163)	High	Low	Low	None
Silverleaf IF-2 (#19-3-0164)	High	Low	Low	None

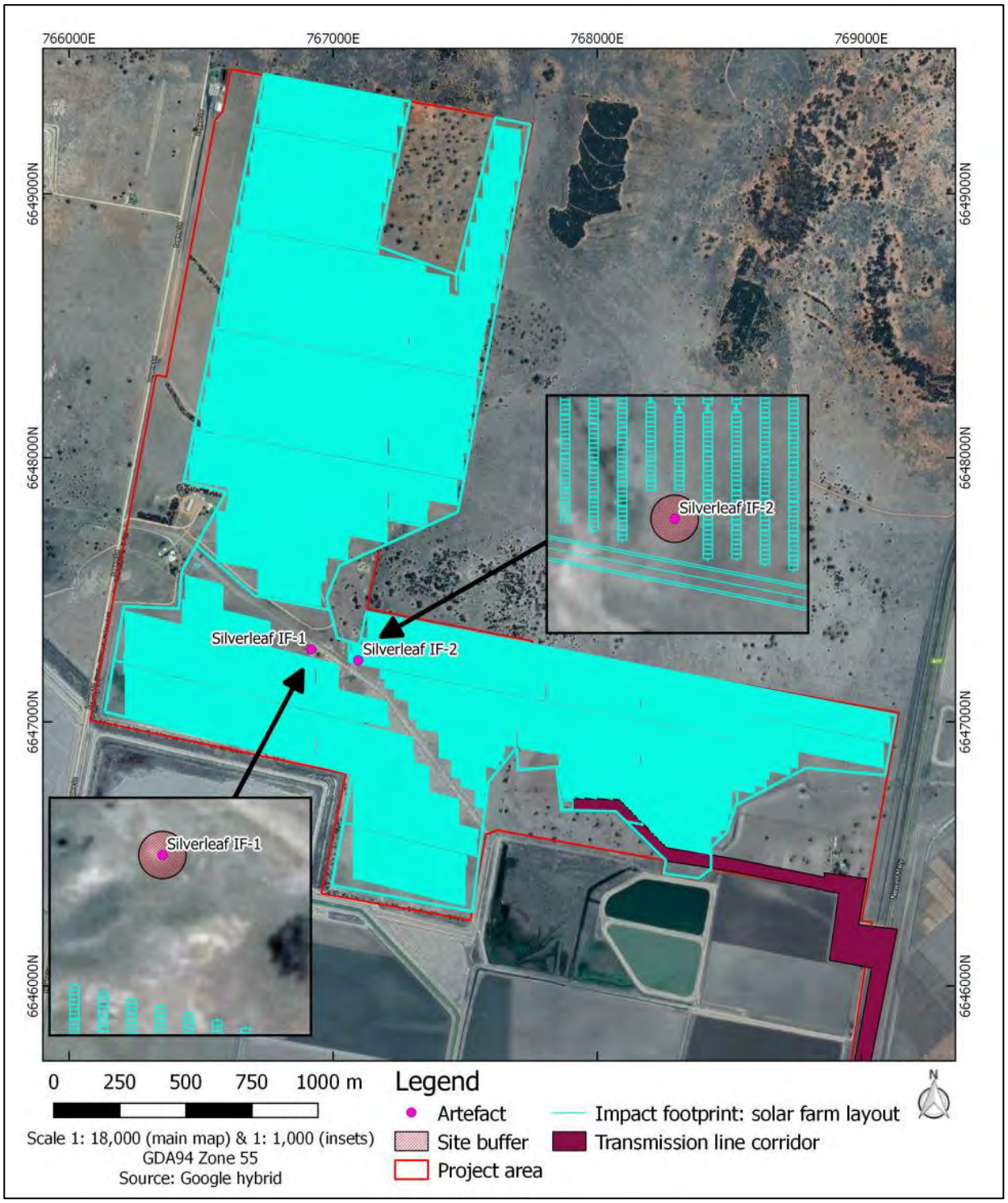
5.7 LIKELY IMPACTS TO ABORIGINAL HERITAGE FROM THE PROPOSAL

The impact footprint of the proposed works associated with the proposal will cover the majority of the study area. As part of the mitigation and management concerning Aboriginal sites, the proponent has confirmed that the impact footprint of the solar farm will avoid the two sites and a 5 m wide buffer will be implemented to avoid disturbance. As such, the sites will not be impacted by the proposal (**Table 5-5**). The finalised impact footprint is shown in **Figure 5-6**.

Table 5-5: Impact assessment of Aboriginal sites.

Site Name	Type of Harm (Direct/Indirect / None)	Degree of Harm (Total/Partial / None)	Consequence of Harm (Total/Partial/No Loss of Value)
Silverleaf IF-1 (#19-3-0163)	None	None	No loss of value
Silverleaf IF-2 (#19-3-0164)	None	None	No loss of value

Figure 5-6: Impact footprint in relation to study area and Aboriginal sites



6 MANAGEMENT AND MITIGATION: ABORIGINAL CULTURAL HERITAGE

6.1.1 General principles for the management of Aboriginal sites

Appropriate management of cultural heritage items is primarily determined on the basis of their assessed significance as well as the likely impacts of the proposed development. **Section 5.6** and **Section 5.7** describe, respectively, the significance / potential of the recorded sites and the likely impacts of the proposal. The following management options are general principles, in terms of best practice and desired outcomes, rather than mitigation measures against individual site disturbance.

- Avoid impact by altering the development proposal or in this case by avoiding impact to a recorded Aboriginal site. If this can be done, then a suitable curtilage around the site must be provided to ensure its protection both during the short-term construction phase of development and in the long-term use of the area. If plans are altered, care must be taken to ensure that impacts do not occur to areas not previously assessed. The ongoing management of sites will be covered in an *Aboriginal Cultural Heritage Management Plan* (ACHMP). The ACHMP should include measures for site conservation, as well providing protocols for unanticipated finds. The management will depend on many factors including the assessed significance of the sites (**Section 5.6**). In certain instances, a site may have low archaeological, aesthetic, and historic values but high cultural value. In these cases, management is aimed to mitigate the loss of the cultural heritage values, rather than the loss of the scientific values. Sites of low scientific significance, such as an isolated find, could, from an archaeological perspective, be removed/destroyed with no further archaeological management being required. However, given the site's cultural value and that the proposal is avoiding them, further management in respect to these sites is recommended. The ACHMP will be developed in consultation between the proponent, the Aboriginal community and DP&E.
- If impact is unavoidable then it will be necessary to undertake further assessment in the form of an *Aboriginal Cultural Heritage Assessment Report* (ACHAR) and Aboriginal community consultation will also need to occur following the OEH ACHCRs.

6.1.2 Management and mitigation of recorded Aboriginal sites

If the two Aboriginal sites recorded within the study area are able to be avoided, then management of the sites will include:

1) The creation of a five metre buffer zone around the artefact location at Silverleaf IF-1 (#19-3-0163) and Silverleaf IF-2 (#19-3-0164) will ensure that the sites are avoided by the proposal. Permanent, high-visibility fencing should be used around the buffer extent of the sites (**Figure 6-1**).

2) Ongoing and long term management of the sites will be detailed in an ACHMP agreed upon by the proponent, Aboriginal community and DP&E.
3) All construction crew members should be made aware of the location of the sites and inductions should be provided to workers on the proposal explaining the locations of the sites, the required management of the sites, and the sites' legislative protection under the NPW Act.

Figure 6-1: Buffer zone for Silverleaf IF-1 and Silverleaf IF-2

HISTORIC HERITAGE IMPACT ASSESSMENT REPORT

7 HISTORIC HERITAGE ASSESSMENT: BACKGROUND

7.1 BRIEF DESCRIPTION OF THE PROPOSAL

Please refer to **Section 1** for a description of the proposal and study area.

7.2 RELEVANT LEGISLATION

7.2.1 State Legislation

Environmental Planning and Assessment Act 1979 (EP&A Act)

The EP&A Act is described in **Section 3.1.1**.

Heritage Act 1977 (Heritage Act)

The *Heritage Act 1977* (Heritage Act) is applicable to the current assessment. This Act established the Heritage Council of NSW. The Heritage Council's role is to advise the government on the protection of heritage assets, make listing recommendations to the Minister in relation to the State Heritage Register, and assess/approve/decline proposals involving modification to heritage items or places listed on the Register. Most proposals involving modification of a listed heritage item are assessed under Section 60 of the Heritage Act.

Automatic protection is afforded to 'relics', defined as 'any deposit or material evidence relating to the settlement of the area that comprised New South Wales, not being Aboriginal settlement, and which holds state or local significance' (note: formerly the Act protected any 'relic' that was more than 50 years old. Now the age determination has been dropped from the Act and relics are protected according to their heritage significance assessment by a qualified archaeologist rather than purely on their age). Excavation of land on which it is known or where there is reasonable cause to suspect that 'relics' will be exposed, moved, destroyed, discovered or damaged is prohibited unless ordered under an excavation permit.

7.2.2 Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is described in **Section 3.1.2**.

7.3 HISTORIC HERITAGE ASSESSMENT OBJECTIVES

The current assessment will apply the Heritage Council *Historical Archaeology Code of Practice* (Heritage Council 2006) in the completion of a historical heritage assessment, including field investigations, in order to meet the following objectives:

Objective One: To identify whether or not historical heritage items or places are, or are likely to be, present within the Assessment Boundary;

Objective Two: To assess the significance of any recorded historical heritage items or places;

Objective Three: Determine whether the activities of the Modification are likely to cause harm to recorded historical heritage items or places; and

Objective Four: Provide management recommendations and options for mitigating impacts.

7.4 DATE OF HISTORIC HERITAGE ASSESSMENT

The fieldwork component of this assessment was undertaken by Dr Alyce Cameron and Stephanie Rusden of OzArk on Tuesday 23 to Thursday 25 October 2018 concurrently with the Aboriginal archaeological assessment.

7.5 LANDSCAPE CONTEXT

Please refer to **Section 2** for a description of the landscape context of the study area.

8 HISTORIC HERITAGE ASSESSMENT: BACKGROUND

8.1 BRIEF HISTORY OF NARRABRI

Aboriginal people have occupied north central NSW for tens of thousands of years. European colonisation of north-central NSW occurred relatively late, as the expansion had halted at Wellington Valley during the 1820s. Land was taken up around Dubbo in the early 1830s and subsequent colonisation beyond Wellington was rapid, tending to follow the major river courses (Heritage Concepts 2009: 49). The Moree plains area between Narrabri and Moree began to be occupied by pastoralists shortly after Mitchell passed through the area in 1831 and Coxen in 1835, each reporting good pastoral land (NSW HO and DUAP 1996: 80-81). Mitchell's route passed through country around Narrabri, crossing the Gwydir River near Moree and continuing as far north as Mungindi (Heritage Concepts 2009: 49).

By the late 1830s, many prime grazing sites along the Namoi River and Gwydir River had been taken up by European pastoralists, including James Cox at Moree, Thomas Simpson Hall at Wee Bella Bolla and John Fleming at Mundi Bundie (Elder 2003: 75). Many more cattle runs were established than sheep stations in the Namoi and Gwydir pastoral districts. Runs tended to be owned by absentee landholders living in the Hunter Valley, Cumberland or Bathurst areas, and were attended to by ex-convict or convict stock keepers and shepherds living in huts. As a result, few early substantial houses built. More owners came to live in the region with the security of land tenure that emerged after 1847 when more substantial houses were built.

Conflict between Aboriginal people and European pastoralists probably occurred initially over competition for food and water resources. Access to creeks and rivers was often denied to Aboriginal people, which lead to the poaching of sheep and cattle, with subsequent reprisals and attacks from both sites. Conflict between Aboriginal people and European colonists was particularly violent in the Gwydir and Macintyre Valleys, with reports made by the Commissioner of Crown Lands, Alexander Paterson, as early as 1837 (Heritage Concepts 2009: 50–51). This report lead to the Waterloo Creek Massacre and subsequent rampages perpetrated by Mounted Police under Commander Major James Nunn in 1838 (Elder 2003: 79–82). A number of massacres occurred throughout the region, including the Myall Creek Massacre of 1838 perpetrated by 12 stockmen who massacred 28 Aboriginal men, women and children. Eleven of the 12 were tried for their crimes and seven were eventually found guilty of murder and hung in December 1838 at Sydney Goal (Elder 2003: 83–94). Throughout the 1840s the conflict between Aboriginal people and European colonists continued unabated as the Kamiloroi resisted European incursions (Heritage Concepts 2009: 54–56). It was not until 1850 that the region was eventually 'pacified' under violence from the Native Police Force (Heritage Concepts 2009: 49).

By 1861, most of north central NSW was occupied by Europeans (Heritage Concepts 2009: 49). Urban development prior to 1850 was very limited. Travellers' accounts indicate that isolated inns

were scattered across the landscape, catering to travellers and local recreation. Some of these inns developed into towns like Narrabri, while others were eventually abandoned or burned (NSW HO and DUAP 1996: 81).

In 1834, Pat Quinn and Andrew Doyle claimed an area which became known as Narrabry Run (Hunt 1998). At this time, Narrabry was the furthermost run on the Namoi River, though other settlers soon followed. There were various spellings of Narrabry including Narribry, Narrabri and Nunnabry. The Narrabry Run extended from the Namoi River to the top of Nandewars, while other runs such as Baan Baa were 107,500 acres and South Wee Waa was 96,000 acres in size. These runs were primarily used for grazing, as opposed to agriculture (Hunt 1998).

A nearby early pastoral settlement was established at Wee Waa. In 1880, the larger town of Narrabri was established on a water reserve on Narrabri Creek, a tributary of the Namoi River, at an important crossing place on the droving route south. By 1871, Narrabri's population was 350 and the town included stores, inns, a bank and school. The railway reached the town in 1882 and Narrabri became an official municipality the following year, when a courthouse was also built (NSW HO and DUAP 1996: 84).

8.2 LOCAL CONTEXT

8.2.1 Desktop database searches conducted

A desktop search was conducted on the following databases to identify any potential previously-recorded heritage within the study area. The results of this search are summarised in **Table 8-1**.

Table 8-1: Historic heritage: desktop-database search results.

Name of Database Searched	Date of Search	Type of Search	Comment
National and Commonwealth Heritage Listings	14/11/2018	Narrabri LGA	The Narrabri Post Office and former Telegraph Office (Place ID 105495): located 930 metres southwest of the study area.
NSW State Heritage Register (SHR)	14/11/2018	Narrabri LGA	The Narrabri Goal and Residence (SHR 00344): located one kilometre southwest of the study area.
Local Environment Plan (LEP) 2012	14/11/2018	Narrabri LGA	Cemetery (I018): located adjacent to the study area (transmission corridor) at the corner of Stoney Creek Road and Old Cemetery Road.

A search of the Heritage Council of NSW administered heritage databases and the Narrabri LEP returned three records for historical heritage sites within the designated search areas (**Figure 8-1**). The Narrabri Post Office and former Telegraph Office is listed on the Commonwealth Heritage List and located at the corner of the intersection of Maitland and Doyle Street in Narrabri. The Narrabri Goal and Residence is listed on the NSW State Heritage Register (SHR 00344).

A number of buildings within the precinct of Narrabri are also listed on the Narrabri Local Environment Plan 2012. These include Narrabri Public School (I022), St Cyprians Anglican Church (I023) and the Narrabri Railway Station (I024). The cemetery (I018) is the only LEP listing which is in close proximity to the study area, being located directly northeast of where the study area covers Stoney Creek Road and Old Cemetery Road.

Figure 8-1: Historic heritage listed in the vicinity of study area

8.3 SURVEY METHODOLOGY

Standard archaeological field survey and recording methods were employed (Burke and Smith 2004) during the visual assessment. The historic heritage field survey was completed concurrently with the Aboriginal heritage field assessment. The assessment was undertaken using pedestrian transects of four to five surveyors. GPS data was captured via a handheld GPS device equipped with GIS software.

The assessment was undertaken by OzArk Project Archaeologists, Dr Alyce Cameron and Stephanie Rusden, on Tuesday 23 to Thursday 25 October 2018. Representatives from the Narrabri LALC and Gomeroi Native Title Claim Group assisted in the assessment. **Section 2.3.6** details the survey methodology and pedestrian transects of the field assessment.

No historical sites were recorded during the pedestrian survey.

8.4 PROJECT CONSTRAINTS

Ground surface visibility was the main project constraint. In respect to historical heritage, the buildings within the study area, in particular the three private houses and associated farm infrastructure, are not of historical age or interest.

8.5 HISTORIC HERITAGE CONSTRAINTS

The pedestrian survey identified no historical heritage items in the study area. There is one heritage item, the cemetery (I018) listed on the Narrabri LEP 2012, which is adjacent to part of the study area. As the proposed works will be confined to within the study area, and the study area adjacent to the cemetery is part of the transmission line easement, there will be no impact on the cemetery itself.

9 RESULTS OF HISTORIC HERITAGE IMPACT ASSESSMENT

9.1 HISTORIC HERITAGE SITES

There are no historic sites recorded within the study area. As such, there will be no impact to any historic sites during the proposed works.

9.2 ASSESSMENT OF HISTORIC HERITAGE SIGNIFICANCE

9.2.1 Assessment of significance-general principles

The current assessment will evaluate the heritage significance of the historic heritage sites identified within the study area in accordance with the NSW Heritage Office guidelines for *Assessing Heritage Significance* (Heritage Office 2001). A historic heritage site must satisfy at minimum one of the following criterion to be assessed as having heritage significance:

Criterion (a): *An item is important in the course, or pattern, of NSW's cultural or natural history (or the cultural or natural history of the local area).*

Criterion (b): *An item has a strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local area).*

Criterion (c): *An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area).*

Criterion (d): *An item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons.*

Criterion (e): *An item has potential to yield information that will contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area).*

Criterion (f): *An item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or the cultural or natural history of the local area).*

Criterion (g): *An item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places; or cultural or natural environments (or a class of the local area's cultural or natural places; or cultural or natural environments).*

Significance assessments are carried out on the basis that decisions about the future of heritage items must be informed by an understanding of these items' heritage values. The *Australia ICOMOS Burra Charter* (Australia ICOMOS 2013) recognises four categories of heritage value: historic, aesthetic, scientific, and social significance

Items are categorised as having local or state level, or no significance. The level of significance is assessed in accordance with the geographical extent of the item's value. An item of state significance is one that is important to the people of NSW whilst an item of local significance is one that is principally important to the people of a specific LGA.

9.2.2 Assessment of significance of historic items

There are no historic sites within the study area. As such, there will be no impact to any historic sites during the proposed works.

9.3 LIKELY IMPACTS TO HISTORIC HERITAGE FROM THE PROJECT

No historic heritage items, which may hold constraints for undertaking the proposal, were identified in the study area. As such, there are no likely impacts to historic heritage from the activities of the proposal.

10 MANAGEMENT AND MITIGATION: HISTORIC HERITAGE

10.1 GENERAL PRINCIPLES FOR THE MANAGEMENT OF HISTORIC SITES

Appropriate management of heritage items is primarily determined on the basis of their assessed significance as well as the likely impacts of the proposal.

In terms of best practice and desired outcomes, avoiding impact to any historical item is a preferred outcome, however, where a historical site has been assessed as having no heritage value, impacts to these items does not require any legislated mitigation.

10.2 MANAGEMENT AND MITIGATION OF RECORDED HISTORIC SITES

No items or sites of historic heritage significance were identified in the study area. Should any items of historic heritage significance be uncovered then the *Historic Heritage Unanticipated Finds Protocol* (**Appendix 5**), will need to be enacted. This protocol stipulates the processes to follow should likely historic objects become uncovered through the activities of the proposal.

11 RECOMMENDATIONS

Should the management recommendations in this report be followed, there will be no impact to Aboriginal or historic sites arising from the proposal.

11.1 ABORIGINAL HERITAGE

Under Section 89A of the NPW Act it is mandatory that all newly-recorded Aboriginal sites be registered with OEH AHIMS. As a professional in the field of cultural heritage management it is the responsibility of OzArk to ensure this process is undertaken.

The undertaking of the assessment resulted in **two Aboriginal sites** being recorded during the pedestrian survey: Silverleaf IF-1 (AHIMS# 19-3-0163) and Silverleaf IF-2 (AHIMS# 19-3-0164) (**Section 3**). The management strategies outlined in **Section 6.1.2** are designed to ensure the newly recorded Aboriginal sites will not be impacted by the proposal.

As sites were located within the study area, but can be avoided, this moves the proposal to the following outcomes:

1) All management recommendations set out in **Section 6.1.2** should be followed.
2) There are no other Aboriginal cultural heritage constraints to the proposal; however, the following precautions should be taken:
    a. All land-disturbing activities must be confined to within the assessed study area. Should the parameters of the proposed work extend beyond the assessed area, then further archaeological assessment may be required.
    b. Construction staff involved in the proposed work should be made aware of the legislative protection requirements for all Aboriginal sites and objects.
3) This assessment has concluded that there is a low likelihood that the proposal will adversely harm Aboriginal cultural heritage items or sites. Following development consent of the proposal, Aboriginal heritage should be managed through an *Aboriginal Cultural Heritage Management Plan* (ACHMP) which is to be agreed to by the proponent, Aboriginal community and DP&E. The archaeological management recommendations within this report would be incorporated into the ACHMP. The ACHMP should also include:
    c. The long term management of any artefacts.
    d. An *Unanticipated Finds Protocol* which can be followed and referred to during works if Aboriginal artefacts or skeletal material are found (see **Appendix 3** for example).
    e. Construction staff should undergo cultural heritage induction to ensure they recognise Aboriginal artefacts (see **Appendix 4**) and are aware of the legislative

protection of Aboriginal objects under the NPW Act and the contents of the Unanticipated Finds Protocol.

11.2 HISTORIC HERITAGE

The undertaking of the due diligence process resulted in the conclusion that the proposed works will have an impact on the ground surface, however, no historic objects or intact archaeological deposits will be harmed by the proposal.

To ensure the greatest possible protection to the area's historical heritage values, the following recommendations are made:

4) This assessment has concluded that there is low likelihood that the proposed work will harm historic heritage objects, sites or potential archaeological deposits; as such, the proposed work can proceed without further archaeological investigation.
5) To avoid the potential for harm to historic objects on unassessed adjacent landforms, all ground surface disturbing activities must be confined to the assessed study area.
6) Care should be taken along Old Cemetery Road and Stoney Creek Road to avoid any impact to the adjacent cemetery which is listed on the Narrabri LEP 2012 (I018).
7) If any previously unknown significant subsurface historic deposit is observed during works, the *Historic Heritage: Unanticipated Finds Protocol* (**Appendix 5**) should be followed.

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PLATES

Plate 1: Artificial drainage channel, view southwest.

Plate 2: View north along paddock in western section of study area.

Plate 3: Road reserve along eastern side of Newell Highway, view north.

Plate 4: View southwest along east side of Stoney Creek Road reserve.

Plate 5: View east along existing electricity line easement.

APPENDIX 1: AHIMS SEARCH RESULTS

Office of Environment & Heritage NSW

AHIMS Web Services (AWS)
Extensive search - Site list report

Your Ref/PO Number : Silverleaf
Client Service ID : 374154

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
19-3-0002	Daugar Village Narrabri	AGD	55	765359	6640819	Open site	Valid	Burial : -	Burial/s	
	Contact	Recorders	Harry Creamer					Permits		
19-3-0026	Killarney ST1	AGD	55	777870	6650150	Open site	Valid	Modified Tree (Carved or Scarred) : 1		98770
	Contact	Recorders	Phil Purcell					Permits	1774	
19-3-0013	WN23 Narrabri	AGD	55	764133	6644061	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	84
	Contact	Recorders	Rex Silcox					Permits		
19-3-0001	Tarabie Narrabri	AGD	55	762110	6642225	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	J Auld					Permits		
19-3-0003	Daugar Village Old Mission Cemetery	AGD	55	763121	6642000	Open site	Valid	Burial : - Aboriginal Ceremony and Dreaming : -		
	Contact	Recorders	Ray Kelly,Mr.Terry Donovan,Bill Trindal					Permits		
19-3-0005	Bohena Creek;Brigalow Creek	AGD	55	760379	6641910	Open site	Valid	Ceremonial Ring (Stone or Earth) : -, Modified Tree (Carved or Scarred) : -	Bora/Ceremonial,Carved Tree	65
	Contact	Recorders	Isabel McBryde					Permits		
19-3-0007	Narrabri Junction;Namoi Farm	AGD	55	767155	6637171	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Brown					Permits		
19-3-0008	Kelvin	AGD	55	778159	6639714	Open site	Valid	Stone Quarry : -, Artefact : -	Quarry	
	Contact	Recorders	Brown					Permits		
19-3-0011	Narrabri Creek	AGD	55	763121	6641833	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	J Auld					Permits		
19-3-0012	WN24 Narrabri	AGD	55	764133	6644901	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	84
	Contact	Recorders	Rex Silcox					Permits		
19-3-0014	WN22 Narrabri	AGD	55	761753	6644890	Open site	Valid	Artefact : -	Open Camp Site	84
	Contact	Recorders	Rex Silcox					Permits		
19-3-0015	WN21 Narrabri	AGD	55	762110	6644904	Open site	Valid	Artefact : -	Open Camp Site	84
	Contact	Recorders	Rex Silcox					Permits		
19-3-0018	WN20 Narrabri	AGD	55	760379	6641930	Open site	Valid	Artefact : -	Open Camp Site	84

Report generated by AHIMS Web Service on 04/10/2018 for Alyce Cameron for the following area at Datum :GDA, Zone : 55, Eastings : 757488 - 779112, Northings : 6633883 - 6658196 with a Buffer of 0 meters. Additional Info : Background. Number of Aboriginal sites and Aboriginal objects found is 29

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Office of Environment & Heritage NSW

AHIMS Web Services (AWS)
Extensive search - Site list report

Your Ref/PO Number : Silverleaf
Client Service ID : 374154

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
	Contact	Recorders	Rex Silcox					Permits		
19-3-0019	WN25 Narrabri	AGD	55	764724	6644978	Open site	Valid	Artefact : -	Open Camp Site	84
	Contact	Recorders	Rex Silcox					Permits		
19-3-0077	Glen Iron (GH-OS4 with PAD) same as 36-6-0727	GDA	55	778866	6635558	Open site	Deleted	Artefact : -		
	Contact	Recorders	Warwick Peckham,Doctor.Jodie Benton,Ms.Wendy Lewis,Mr.Phillip Cameron					Permits		
19-3-0078	Bullawa Creek SCA 1	GDA	55	778240	6638794	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Craig Trindall					Permits		
19-3-0079	Bullawa Creek SCA site 2 grinding grooves	GDA	55	777910	6639732	Open site	Valid	Grinding Groove : 4		
	Contact	Recorders	Mr.Craig Trindall					Permits		
19-3-0080	Bullawa Creek SCA 3 Grinding Grooves	GDA	55	777920	6639845	Open site	Valid	Grinding Groove : 2		
	Contact	Recorders	Mr.Craig Trindall					Permits		
19-3-0081	Bullawa Creek SCA site 4 ochre	GDA	55	777921	6639845	Open site	Valid	Ochre Quarry : 2		
	Contact	Recorders	Mr.Craig Trindall					Permits		
19-3-0082	Bullawa Creek SCA site 5 Grinding Dish	GDA	55	777948	6639853	Open site	Valid	Artefact : 3		
	Contact	Recorders	Mr.Craig Trindall					Permits		
19-3-0122	MOLLEE TSR ST 1	GDA	55	759681	6649121	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact: Narrabri Local Aboriginal Land	Recorders	Mr.Patrick Gaynor					Permits		
19-3-0123	MOLLEE TSR ST 2	AGD	55	760775	6649004	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	Recorders	Mr.Patrick Gaynor					Permits		
19-3-0073	TRINDALL'S TSR - CORE	AGD	55	763460	6646717	Open site	Valid	Artefact : 1		
	Contact: Searle	Recorders	Mr.B Trindall					Permits		
19-3-0074	ST-TRINDALL'S TSR	AGD	55	763440	6646750	Open site	Valid	Modified Tree (Carved or Scarred) :		
	Contact: Searle	Recorders	Mr.B Trindall					Permits		
19-3-0076	Tree with two scars near Mollie Weir	AGD	55	759714	6649251	Open site	Valid	Modified Tree (Carved or Scarred) :		
	Contact: Searle	Recorders	Mr.Shawn Smith					Permits		
19-3-0075	Narrabri Reserve	AGD	55	762000	6647900	Open site	Valid	Habitation Structure : 1		
	Contact: T Russell	Recorders	Unknown Author					Permits		

Report generated by AHIMS Web Service on 04/10/2018 for Alyce Cameron for the following area at Datum :GDA, Zone : 55, Eastings : 757488 - 779112, Northings : 6633883 - 6658196 with a Buffer of 0 meters. Additional Info : Background. Number of Aboriginal sites and Aboriginal objects found is 29

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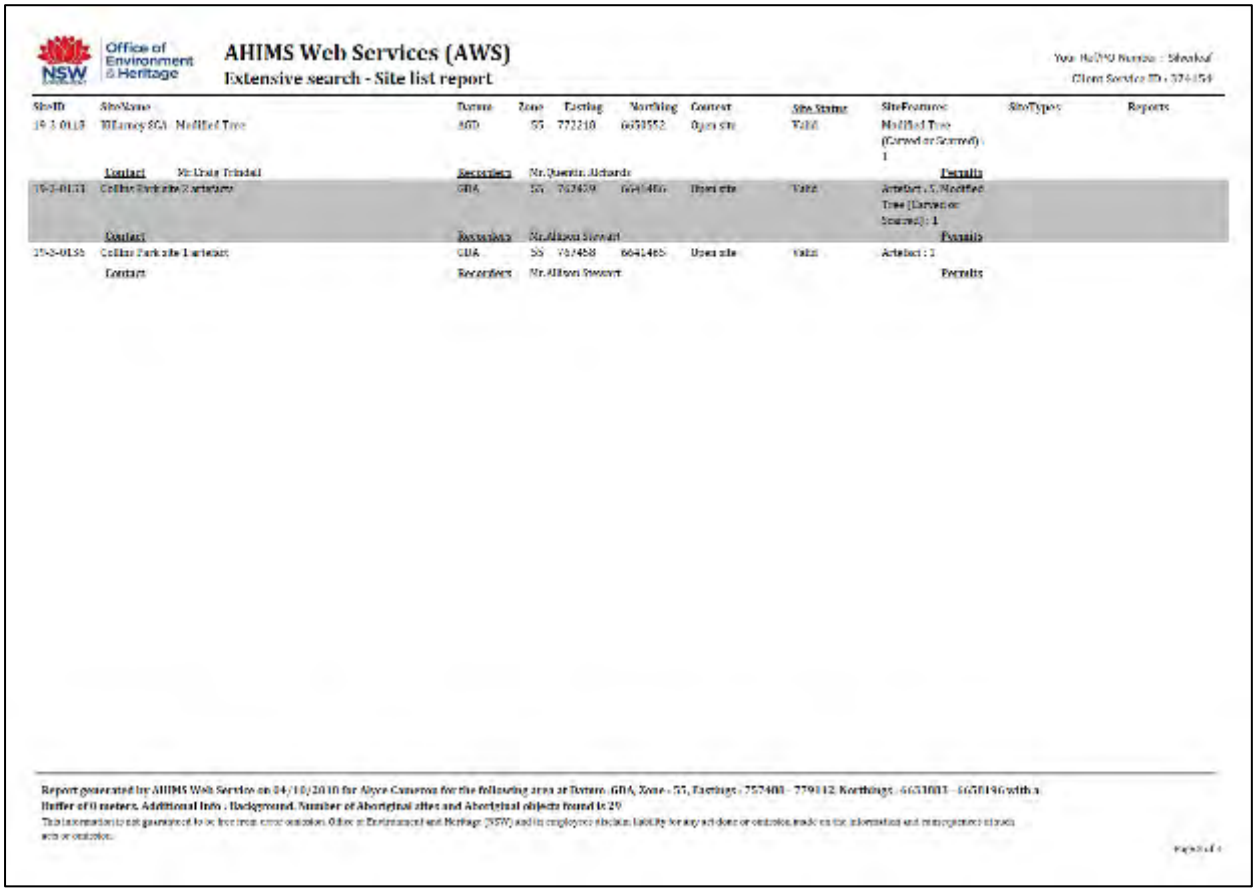


Office of Environment & Heritage

NSW

AHIMS Web Services (AWS)

Extensive search - Site list report

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
19-3-0113	Bilarney SCA - Modified Tree	AGD	55	772210	6650552	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact: Mr Dean Trindall	Recorders: Mr.Quentin Richards						Permits:		
19-3-0133	Collins Park site 2 artefact	GDA	55	767459	6641465	Open site	Valid	Artefact : 2, Modified Tree (Carved or Scarred) : 1		
	Contact:	Recorders: Mr.Allison Stewart						Permits:		
19-3-0134	Collins Park site 1 artefact	GDA	55	767458	6641465	Open site	Valid	Artefact : 1		
	Contact:	Recorders: Mr.Allison Stewart						Permits:		

Report generated by AHIMS Web Service on 04/10/2010 for Alyce Cameron for the following area at Datum :GDA, Zone : 55, Eastings : 757400 - 779112, Northings : 6653003 - 6670196 with a Buffer of 0 meters. Additional Info : Background. Number of Aboriginal sites and Aboriginal objects found is 29

This information is not guaranteed to be free from error or omission. Office of Environment and Heritage (OEH) and its employees disclaim liability for any act done or omission made on the information and consequences of such acts or omissions.

APPENDIX 2: ABORIGINAL COMMUNITY CONSULTATION

Consultation log

Aboriginal Consultation Log – Silverleaf Solar Farm			
Date	**Organisation**	**Comment**	**Method**
10.10.18	Narrabri Local Aboriginal Land Council	Rebecca Hardman (RH) sent invitation to fieldwork, RSVP 16th Oct 2018	Email
10.10.18	Gomeroi Native Title Group	Sheridan Baker (SB) rang and spoke to Dylan (NTSCORP) requesting details on who is currently doing the fieldwork for the Gomeroi group. Dylan informed that it would have to be sent to the group to decide. SB discussed that they would require workers comp and that we needed to give as much notice as possible. Dylan said that there was going to be a meeting on the 19.10.18. SB said that this would not give enough notice to the worker and could he please chase. SB said she was happy to call Steve Talbott, as he is the one that normally attends and Dylan informed that it had to be sent to the group to nominate.	Email
10.10.18	Gomeroi Native Title Group	RH sent invitation to fieldwork, RSVP 16th Oct	Email
16.10.18	Narrabri Local Aboriginal Land Council	RH phoned and was advised they did not receive email. Asked to resend. Should have 1 site officer available, possibly 2	Phone
16.10.18	Narrabri Local Aboriginal Land Council	RH re sent invitation to fieldwork	Email
16.10.18	Gomeroi Native Title Group	RH phoned, Dylan was on lunch. Will call back later	Phone
16.10.18	Gomeroi Native Title Group	RH phoned, Dylan to call back after speaking to colleague	Phone
16.10.18	Narrabri Local Aboriginal Land Council	RH phoned, N/A	Phone
17.10.18	Narrabri Local Aboriginal Land Council	RH phoned, confirmed will be sending 2 site officers but do not know who yet. Requested copy of workers comp	Phone
17.10.18	Gomeroi Native Title Group	RH phoned, leave message for Dylan to call back. Was told he is unavailable and no one else I can talk to	Phone
17.10.18	Gomeroi Native Title Group	RH sent follow up email requesting urgent response	Email
17.10.18	Gomeroi Native Title Group	RH received email advising NTSCORP will be having a meeting with the Gomeroi applicant on Friday19th and will advise us by COB that day if attending and who	Email

19.10.18	Narrabri Local Aboriginal Land Council	RH phoned to request workers comp	Phone
19.10.18	Narrabri Local Aboriginal Land Council	RH received copy of workers comp	Email
22.10.18	Gomeroi Native Title Group	SB rang and got message bank - not open until 9am	Phone
22.10.18	Gomeroi Native Title Group	SB emailed Anjeline and Dylan requesting urgent contact regarding who their nominee was and the supply of a worker's compensation certificate	Email
22.10.18	Gomeroi Native Title Group	SB rang and spoke to Lachlan. Lachlan said that Anjeline and Dylan were not quite in the office yet and he would ask them to contact SB. SB informed that it was urgent	Email
22.10.18	Gomeroi Native Title Group	SB rang and spoke to the receptionist. Dylan won't be in today - he is on country, Anjeline is out, Grace Manning Davis does not work there any more, Frank Russo is on leave. The receptionist will leave a message for Miska the principal solicitor to call back.	Phone
22.10.18	Gomeroi Native Title Group	SB rang to speak to Steve Talbott. Automated response saying unable to take call, please call again later	Phone
	Gomeroi Native Title Group	SB received an email from Anjeline saying that they are working on who is attending.	Email
22.10.18	Gomeroi Native Title Group	Philippa Sokol (PS) received a call from Anjeline for SB to call back	Phone
22.10.18	Gomeroi Native Title Group	SB received email from Anjeline Antont saying that they are trying to sort out site officers and to call her back on her mobile	Phone
22.10.18	Gomeroi Native Title Group	SB rang back Anjeline on her mobile and left a voicemail message	Phone
22.10.18	Gomeroi Native Title Group	SB rang Anjeline on the office number and left a message to return her call with the receptionist	Phone
22.10.18	Gomeroi Native Title Group	SB received a call back from Anjeline - SB confirmed prefer one site officer for the period so as to ensure continuity of standard. Anjeline will discuss with her senior and confirm who site officer is. SB confirmed she has current insurances for Stephen Talbott	Phone
22.10.18	Gomeroi Native Title Group	SB received a call from Angeline saying that they would like to take 2 site officers for the same $$ value. Stephen Talbott and Donald Craigie. Donald Craigie also needs to start at 10 tomorrow. SB said she would discuss and call back	Phone
22.10.18	Gomeroi Native Title Group	SB called Anjeline and confirmed that Stephen was approved to work as we have current valid workers comp. Donald would not be able to start late tomorrow and would not be approved to work until workers comp insurance has been approved. SB also confirmed that at this stage work is not confirmed for Donald as we physically do not have enough places for him in the vehicle. SB to call Stephen and Donald direct and confirm discussions with Anjeline tomorrow.	Phone

22.10.18	Gomeroi Native Title Group	SB called and left a message for Steve to call back	Phone
22.10.18	Gomeroi Native Title Group	SB called Donald Craigie. Informed him that there is no promise of work at this stage, explained about workers comp insurance and that he needs to send through asap tomorrow morning for consideration, also that if the insurance is valid there is still no guarantee as we need to see if we can fit in vehicle and if not, how this can work. Donald said he would email workers comp in the morning through to SB and SB said she would work out after that and come back to him. Work will not be approved for Donald on Tuesday, but considered for Wed, Thurs, Frid	Phone
22.10.18	Gomeroi Native Title Group	SB called and left a message for Steve to call back	Phone
22.10.18	Gomeroi Native Title Group	SB called 6:30pm ish to discuss work tomorrow. Left a message	Phone
22.10.18	Gomeroi Native Title Group	SB texted work details through to Steve and asked for a call back	Phone
23.10.18	Gomeroi Native Title Group	Stephanie Rusden (SR) called Steve and left a message	Phone
23.10.18	Gomeroi Native Title Group	SB received a call from Dylan, apologising for the delay from their side, but they are still trying to set up structures with the group to ensure fairness and transparency. Dylan advised that Stephen Talbott is on sorry business and will not be available this week. Dylan will contact Donald and get him to send through accident cover/ workers comp insurance	Phone
23.10.18	Gomeroi Native Title Group	SB received another call from Dylan asking if there was additional funds for travel and accommodation for Donald. SB informed that Donald will need to cover costs. SB explained that there is a third party employer (Getset) that he could go through however they take a fee for the service from Donald. Dylan is going to try and assist Donald to get injury/ accident cover, and will advise accordingly. SB said that there are enough seats in the vehicle now that Stephen is not available. Dylan will also look at a backup plan if Donald can't get sorted.	Phone
23.10.18	Gomeroi Native Title Group	SB sent through to Dylan Frank from Getset's contact details.	Phone
23.10.18	Gomeroi Native Title Group	SB received email from Dylan confirming that Donald will be going through a Getset, expected start Wednesday	Phone
23.10.18	Gomeroi Native Title Group	SB rang and left a message for Dylan to return call	Phone
23.10.18	Gomeroi Native Title Group	SB rang Getset and confirmed that Donald is approved for 3 days work, Getset will email SB once they receive the paperwork and when he is covered by them. Expected start Wednesday	Phone
23.10.18	Gomeroi Native Title Group	SB received a call from Dylan. SB confirmed work will commence at 7 am due to heat. Dylan confirmed that paperwork will not be done in time and are currently aiming for Thursday	Phone

23.10.18	Gomeroi Native Title Group	SB rang GetSet an informed Frank - paperwork through tomorrow and commence will probably be Thursday	Phone
23.10.18	Narrabri LALC	Two field officers participated in survey	In person
24.10.18	Gomeroi Native Title Group	SB sent email to Dylan asking him to pass on to Donald that the archs are anticipating finishing work on Thursday afternoon or maybe a couple of hours early Friday morning, therefore the offer is now Thursday and possibly Friday.	Phone
24.10.18	Gomeroi Native Title Group	SB received a call from Dylan confirming that Donald was going to go with Get set and was going to send the paperwork through today to Getset. SB confirmed that she will wait for confirmation from Frank (Getset) that Donald will be covered.	Phone
24.10.18	Narrabri LALC	Two field officers participated in survey. Two sites (isolated finds) were recorded. Field officers were happy if sites could be avoided by works with an appropriate buffer.	In person
25.10.18	Narrabri LALC	Two field officers participated in survey.	In person
25.10.18	Gomeroi Native Title Group	One field officer (Donald Craige) participated in survey.	In person
01.02.19	Narrabri LALC	Alyce Cameron (AC) rang LALC to check spelling of a representative's name who participated in survey.	Phone

Invitation to participate in survey

10th October 2018

[redacted]

Dear Members,

Aboriginal Cultural Heritage Assessment for the proposed Silverleaf Solar Project, Narrabri LGA.

ENGIE Renewables Australia Pty Ltd is proposing the development of the Silverleaf Solar Farm (the Project) to be located about five kilometres north of Narrabri in north eastern NSW. The Project comprises the construction of a photovoltaic (PV) solar plant to be developed over approximately 450 hectares of land located between Logans Lane and the Newell Highway, approximately five kilometres to the north of Narrabri. The Project also include a transmission line corridor connecting to the existing Narrabri Substation located to the south-east. The area identified as the Project site is shown in Figure 1.

The archaeological assessment will be undertaken in accordance with the NSW Office of Environment and Heritage (OEH) *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010; code of practice) and the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011). Pedestrian transects with participants approximately 50 metres apart will be traversed over the full project area, with transects of 20–30 metres used in areas determined as being of higher sensitivity.

OzArk would like to invite you to provide two (2) Site Officers to participate in four (4) days of field assessment.

We do not currently have a copy of your current workers compensation certificate; please submit a current copy to OzArk to confirm your interest in the fieldwork.

Field Work Date:	Tuesday 23 October to Friday 26 October 2018
Time to Meet:	8:00 am
Location to Meet:	Narrabri Shire Visitor Centre (Figure 2)
Duration:	Four full days
Fee offer:	The fee offered is $[redacted] for the full day of participation in the fieldwork for the experienced Site Officer (excl. GST). This fee is all inclusive of travel, travel time, fuel, accommodation, meal expenses and participation in the field work. Breaks are not paid.

Invoices: Invoices are to be addressed to:

ENGIE Renewables Australia Pty Ltd
ACN 615 753 574
C/- Marcus Dowling
marcus.dowling@engie.com
Level 33 Rialto South Tower,
525 Collins Street,
Melbourne VIC 3000

You must ensure that you or your representative has enough water and snacks / lunch for the duration of the fieldwork.

Personal Protective Equipment (PPE) – your Site Officer will need:

- Long pants and long sleeve shirt;
- High visibility safety shirt / vest;
- Enclosed, sturdy footwear;
- Water / Sunscreen / Hat.

You or your representative must be physically fit and will need to identify if you have any medical conditions / allergies that should be known to other people participating in the fieldwork in the event of an emergency. The OzArk field director will send home anyone who they determine to be 'unfit for work' or who may pose a WH&S risk to themselves or others.

Please note, if you are a sending a representative who has any underlying medical conditions or severe allergies, it is important that they have on their person appropriate treatment such as asthma inhalers or EpiPens and notify us accordingly.

As previously noted due to NSW WH&S legislation we need to have on record current Workers Compensation insurances before going into the field. Unfortunately we will **NOT** be able to allow participation in the fieldwork without seeing your **current Workers Compensation Certificate of Currency.** These can be emailed through to sheridan@ozarkehm.com.au. Please note that if you are unable to send a representative from your organisation, we will proceed with the fieldwork with the OzArk archaeologist only.

Please respond by **Tuesday 16th October 2018** as to whether you are able to provide a site officer for the duration of the survey

If you have any feedback or relevant cultural heritage knowledge that you would like to offer, please discuss with the archaeologist during the fieldwork or contact our office.

Should you have any queries in relation to the enclosed information please do not hesitate to contact our office.

Kind regards,

Sheridan Baker
Consultation Officer

Figure 1: Map showing an overview and satellite imagery of the project site (bounded in red) and transmission line options (yellow and orange lines).

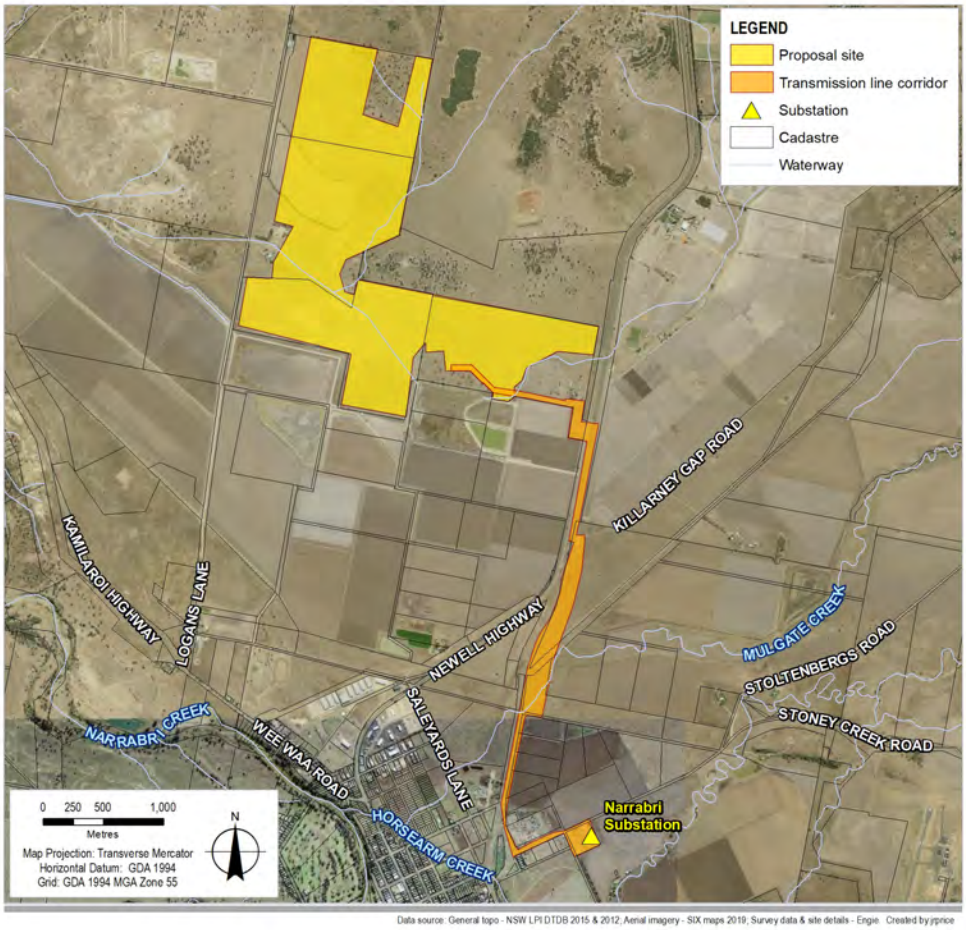


Figure 2: Proposed meeting location: Narrabri Shire Visitors Centre (circled in red)

APPENDIX 3: ABORIGINAL HERITAGE: UNANTICIPATED FINDS PROTOCOL

An Aboriginal artefact is anything which is the result of past Aboriginal activity. This includes stone (artefacts, rock engravings etc.), plant (culturally scarred trees) and animal (if showing signs of modification; i.e. smoothing, use). Human bone (skeletal) remains may also be uncovered while onsite.

Cultural heritage significance is assessed by the Aboriginal community and is typically based on traditional and contemporary lore, spiritual values, and oral history, and may also take into account scientific and educational value.

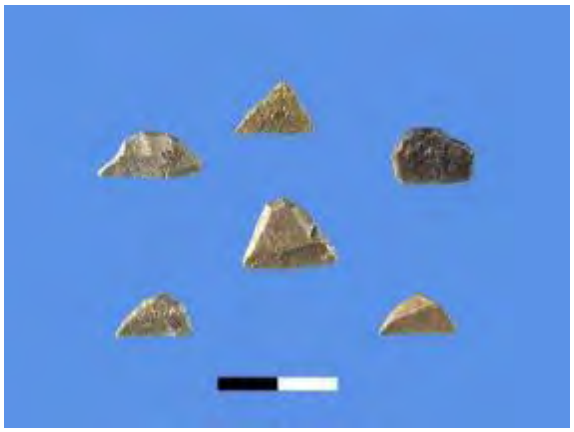
Protocol to be followed in the event that previously unrecorded or unanticipated Aboriginal object(s) are encountered:

1. If any Aboriginal object is discovered and/or harmed in, or under the land, while undertaking the proposed development activities, the proponent must:
    a. Not further harm the object;
    b. Immediately cease all work at the particular location;
    c. Secure the area so as to avoid further harm to the Aboriginal object;
    d. Notify OEH as soon as practical on 131 555, providing any details of the Aboriginal object and its location; and
    e. Not recommence any work at the particular location unless authorised in writing by OEH.
2. In the event that Aboriginal burials are unexpectedly encountered during the activity, work must stop immediately, the area secured to prevent unauthorised access and NSW Police and OEH contacted.
3. Cooperate with the appropriate authorities and relevant Aboriginal community representatives to facilitate:
    a. The recording and assessment of the find(s);
    b. The fulfilment of any legal constraints arising from the find(s), including complying with OEH directions; and
    c. The development and implementation of appropriate management strategies, including consultation with stakeholders and the assessment of the significance of the find(s).
4. Where the find(s) are determined to be Aboriginal object(s), recommencement of work in the area of the find(s) can only occur in accordance with any consequential legal requirements and after gaining written approval from OEH (normally an Aboriginal Heritage Impact Permit).

APPENDIX 4: ABORIGINAL HERITAGE: ARTEFACT IDENTIFICATION

Retouched blades (scale = 1cm)

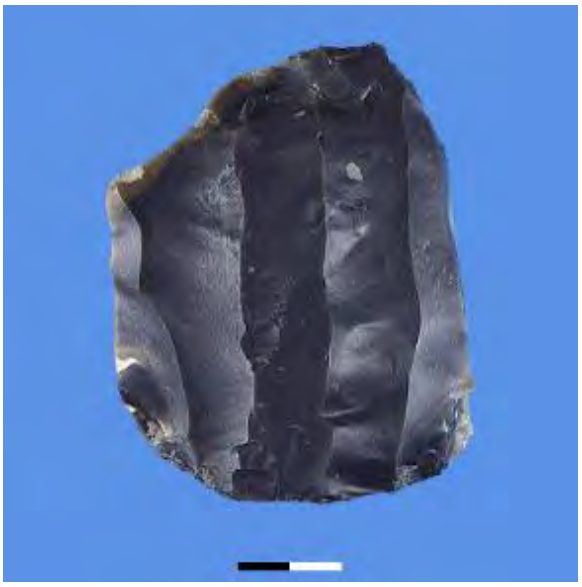
Flakes



Microliths (scale = 1cm)

Scraper (scale = 1cm)

Flake characteristics (scale = 1cm)



Core from which flakes have been removed (scale = 1cm)

APPENDIX 5: HISTORIC HERITAGE: UNANTICIPATED FINDS PROTOCOL

A historic artefact is anything which is the result of past activity not related to the Aboriginal occupation of the area. This includes pottery, wood, glass and metal objects as well as the built remains of structures, sometimes heavily ruined.

Heritage significance is assessed by suitably qualified archaeologists who place the item or site in context and determine its role in aiding the community's understanding of the local area, or their wider role in being an exemplar of State or even National historic themes.

Protocol to be followed in the event that previously unrecorded or unanticipated historic object(s) are encountered:

1. All ground surface disturbance in the area of the finds should cease immediately the finds are uncovered.
    a) The discoverer of the find(s) will notify machinery operators in the immediate vicinity of the find(s) so that work can be halted; and
    b) The site supervisor will be informed of the find(s).
2. If finds are suspected to be human skeletal remains, then NSW Police must be contacted as a matter of priority.
3. If there is substantial doubt regarding the historic significance for the finds, then gain a qualified opinion from an archaeologist as soon as possible. This can circumvent proceeding further along the protocol for items which turn out not to be significant. If a quick opinion cannot be gained, or the identification is that the item is likely to be significant, then proceed to the next step.
4. Immediately notify OEH (Heritage Branch) of the discovery:
5. Facilitate, in co-operation with the appropriate authorities:
    a) The recording and assessment of the finds;
    b) Fulfilling any legal constraints arising from the find(s). This will include complying with OEH directions; and
    c) The development and conduct of appropriate management strategies. Strategies will depend on consultation with stakeholders and the assessment of the significance of the find(s).
6. Where the find(s) are determined to be significant historic items, any re-commencement of construction related ground surface disturbance may only resume in the area of the find(s) following compliance with any consequential legal requirements and gaining written approval from OEH (normally a Section 60 excavation permit).

Appendix D – Noise and vibration assessment

Silverleaf Solar Farm Pty Ltd

Narrabri 120 MW Solar Farm

Noise and Vibration Impact Assessment

August 2019

Executive summary

GHD Pty Ltd has been engaged by ENGIE Renewables Australia Pty Ltd to conduct a noise and vibration impact assessment for the proposed Narrabri Solar Farm (the proposal).

This assessment is based on the available information at this stage of the design. The exact location and layout of operational noise sources within the proposal site are yet to be specified and assumptions made in this report have been outlined within Section 5.

The potential noise and vibration impacts associated with the proposal have been assessed with consideration of the following documents:

- *Interim Construction Noise Guideline* (ICNG) (DECC 2009)
- NSW *Road Noise Policy* (RNP) (DECCW 2011)
- NSW *Noise Policy for Industry* (NPI) (EPA 2017)

The results of the construction noise impact assessment indicate that the construction of the proposal is predicted to exceed the construction noise management levels at two residential receivers and one commercial location during the noisiest construction works, being impact pile driving. General noise mitigation measures have been provided to reduce construction noise levels to these receivers. No adverse vibration impacts are anticipated at any sensitive receivers during construction of the proposal.

It is typical for construction projects to exceed the construction noise and vibration management levels. Any impacts due to construction works are temporary in nature and would not represent a permanent impact on the community and surrounding environment. The predicted noise and vibration levels are conservative and would only be experienced for limited periods during construction when the distance between the construction works and the sensitive receiver is the closest. For the majority of the time, the predicted construction noise levels will be below the construction noise management levels at nearby receivers. Impacts may be reduced through the introduction of feasible and reasonable mitigation measures which have been recommended within this report.

The results of the operational noise impact assessment indicate that the operation of the proposal will comply with the relevant operational project noise trigger levels (PNTLs) and is not predicted to adversely impact the acoustic amenity of the surrounding sensitive receivers.

The results of the traffic noise assessment indicate that the construction and operation of the proposal will comply with the requirements of the Road Noise Policy.

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Glossary

Term	Description
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} descriptor.
dB	Decibel is the unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics.
dBA	Decibel expressed with the frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at low and high frequencies.
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
EPA	Environment Protection Authority
ICNG	*Interim Construction Noise Guideline* (DECC, 2009)
NPI	*Noise Policy for Industry* (EPA, 2017)
$L_{A90(period)}$	The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise e.g. $L_{A90(15\ min)}$.
$L_{Aeq(period)}$	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{Amax(period)}$	The maximum sound pressure level over a specified period of time.
Mitigation	Reduction in severity.
Noise sensitive receiver	An area or place potentially affected by noise which includes: • a residential dwelling • an educational institution, library, childcare centre or kindergarten • a hospital, surgery or other medical institution • an active (e.g. sports field, golf course) or passive (e.g. national park) recreational area • commercial or industrial premises • a place of worship
Rating Background Level	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period. This is the level used for assessment purposes.

1. Introduction

1.1 Overview

ENGIE Renewables Australia Pty Ltd (ENGIE) proposes to construct and operate a 120 megawatt (MW) solar farm about five kilometres north-west of Narrabri between the Newell Highway in the east and Logans Lane in the east (referred to as the 'proposal').

ENGIE has engaged GHD Pty Ltd (GHD) to prepare an Environmental Impact Statement (EIS) for the proposal. The EIS identifies and assesses the environmental issues associated with the proposed solar farm.

The proposal requires development consent from the Minister for Planning under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This Environmental Impact Statement (EIS) has been prepared to support the development application and identifies and assesses the environmental issues associated with the proposal.

The EIS addresses the requirements of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) and Section 4.15 of the EP&A Act and the Secretary's Environmental Assessment Requirements (SEARs) which were provided on 22 June 2018 by the Department of Planning and Environment.

This noise assessment has been prepared in support of the EIS. It considers construction and operational noise and vibration impacts associated with the proposal, including road traffic noise.

1.2 Secretary's Environmental Assessment Requirements and agency requirements

The Secretary's Environmental Assessment Requirements (SEARs), and agency requirements that relate to noise and are addressed in this report are summarised in Table 1-1.

Table 1-1 Secretary's Environmental Assessment Requirements and agency requirements

Assessment requirements	Where addressed in report
Assessment of construction, upgrading and decommissioning noise impacts of the development in accordance with the *Interim Construction Noise Guideline (*ICNG)	Section 4 (criteria) Section 5 (construction impact assessment)
Assessment of operational noise impacts in accordance with the *NSW Noise Policy for Industry* (NPI) and NSW *Road Noise Policy* (RNP)	Section 4 (criteria) Section 6 (operation impact assessment)
Description of measures (as part of a draft noise management plan) that would be implemented to mitigate any impacts if the assessment shows construction, upgrading or decommissioning noise is likely to exceed applicable criteria.	Section 7
Agency requirements	
NSW EPA	
Identify potential impacts and mitigation strategies to be incorporated during operation to minimise noise and comply with NSW policies and legislation on noise control.	Section 4 (criteria) Section 5 (construction impact assessment) Section 6 (operational impact assessment) Section 7 (mitigation)

1.3 Scope and structure of the report

1.3.1 Scope of report

This report assesses the potential noise and vibration impacts of the proposal. The assessment has been undertaken to address the SEARs and other agency requirements detailed in Section 1.2.

1.3.2 Structure of report

- **Chapter 1 – Introduction** – This chapter introduces the proposal.
- **Chapter 2** – **Proposal description** – This chapter outlines the details of the proposal.
- **Chapter 2 – Existing environment** – This chapter describes the proposal location, existing noise environment and sensitive receivers in the proposal area.
- **Chapter 3 – Noise criteria** – This chapter identifies the criteria for assessment.
- **Chapter 4 – Construction noise and vibration impact assessment** – This chapter examines the potential noise and vibration impacts associated with construction of the proposal.
- **Chapter 5 – Operational noise impact assessment** – This chapter examines the potential noise impacts associated with operation of the proposal.
- **Chapter 6 – Noise mitigation** – This chapter identifies mitigation measures relating to noise.
- **Chapter 7 – Conclusions** – This chapter summarises the assessment conclusions.
- **Chapter 8 – References** – This chapter provides a reference list.

1.4 Limitations

This report: has been prepared by GHD for ENGIE Renewables Australia Pty Ltd and *may only be used and relied on by ENGIE Renewables Australia Pty Ltd and its related bodies corporate for the purpose agreed between GHD and the ENGIE Renewables Australia Pty Ltd as set out in section 1.2 of this report.*

GHD otherwise disclaims responsibility to any person other than ENGIE Renewables Australia Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by ENGIE Renewables Australia Pty Ltd and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Proposal description

2.1 Location of the proposal site

2.1.1 Solar farm site

ENGIE proposes to construct, operate and eventually decommission or recondition a 120 megawatt (MW) AC solar farm located about five kilometres north-west of Narrabri and is within the Narrabri Shire Council local government area. The proposal site consists of two rural properties located between Newell Highway in the east and Logans Lane in the west and includes the following lots:

- 330 Logans Lane – Lots 21 to 23 of DP 1174848 (property referred to as the Logans Lane property in this EIS)
- 12461 Newell Highway – Lot 2 DP 586990 (property referred to as the Newell Highway property in this EIS)

The location and extent of the proposal site is shown in Figure 2-1.

2.1.2 Transmissions line corridor

The proposal includes constructing a transmission line between the proposal site and the TransGrid substation located about five kilometres to the south on Stoney Creek Road. The alignment of this transmission line corridor is shown in Figure 3-1.

2.2 Elements of the proposal

The proposal would consist of the following components:

- Solar arrays consisting of about 440,000 solar panels four (4) metres in height.
- The panels would be single-axis tracking panels, which would consist of about 5,150 tracker units.
- The arrays would be supported by approximately 20,000 piles, driven or screwed into the ground to support the solar array's mounting system.
- Construction of a transmission corridor, supporting a 132 kV (kilovolt) power lines, connecting the proposal to the existing TransGrid substation located on Stoney Creek Road.
- Inverter and transformer stations evenly distributed across the site, with onsite cabling and electrical connections between solar arrays and panel inverters.
- A step-up substation to increase the voltage to 66kV or to 132 kV.
- Cables and trenches.
- Internal access tracks.
- Operational and maintenance office including staff amenities block.
- Site storage and maintenance shed.
- Perimeter security fencing.
- Landscaping around the perimeter of the site where required.

Construction of the proposal is expected to take 12 months. The proposed solar arrays and associated components have an estimated operational life of 35 years. At the end of its operational life, the proposal would be either reconditioned or decommissioned.

Reconditioning would involve replacing original components with new components that reflect technology that is available at that time. Decommissioning would involve removing all above ground infrastructure and rehabilitating the site to allow it to be used for other purposes such as agriculture.

2.3 Key features of the proposal

2.3.1 Site layout

The site layout is shown in Figure 2-1. The following areas would not be used for the installation of solar panels:

- Buffer area around the private airstrip located adjacent to the north-west corner of the proposal site.
- Existing dwellings on the Logans Lane property including the near sheds and other support buildings.
- Existing dwelling on the Newell Highway property.
- Existing drainage channel traversing the southern component of the Logans Lane property.
- Footprints of the proposed access track network, proposed substation, operational and maintenance office building.
- A buffer around the perimeter fencing, allowing vegetation to be planted as a visual buffer.
- Buffer areas around two site of Aboriginal heritage significance (refer to Section 6.3 of the EIS).

The extent of the land to be excluded from development for the proposal is shown in Figure 2-1.

2.3.2 Solar array layout

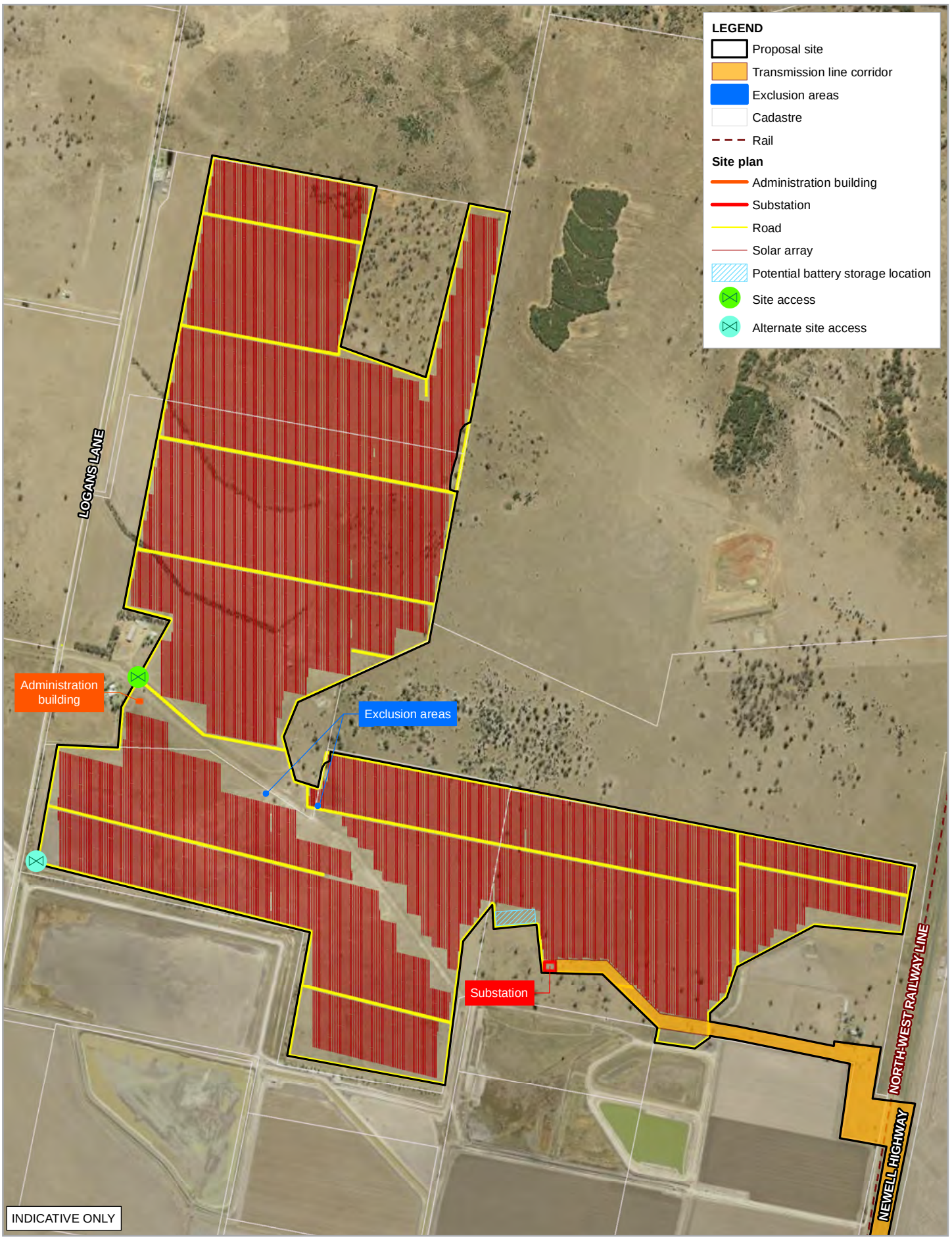
The panels convert sunlight into electric current (direct current or DC). The inverters convert the variable direct current (DC) output of the photovoltaic solar panels into an alternating current (AC) that can be fed into the electricity grid. More details on the inverters are provided in Section 2.3.4.

The detailed design will confirm the final layout, quantity and type of panel to be installed. The concept layout for the solar arrays and their position in relation to the solar farm boundary are shown in Figure 2-1.

The panels would likely consist of 72 cell polycrystalline solar photovoltaic panels. ENGIE is currently investigating the use of bi-facial photovoltaic panels on a South American solar farm. Should this technology prove to be beneficial, this technology would be considered for the proposal.

The panels would be mounted on single-axis tracking structures. In total there would be about 5,150 tracking units on site, each controlling 85 panels.

The selected panels and mounting system would be installed on approximately 20,000 piles which would be driven or screwed into the ground. The mounting system would be placed with rows of panels approximately six metres apart. Racks would then be installed on the poles to allow solar panels to be installed. Examples of the mounting system with and without panels are shown in Figure 2-2 and Figure 2-3 respectively.



Paper Size ISO A4

0 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Engie
Silverleaf Narrabri Solar Farm

The proposal

Project No. 21-26998
Revision No. -
Date 02/05/2019

FIGURE 2-1

N:\AU\Orange\Projects\21\26998\GIS\Maps\Deliverables\Noise\21_26998_Z017_Noise_TheProposal.mxd

Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct. Created by:jrprice

Figure 2-2 Example of single-axis mounting system before panel installation

Figure 2-3 Example of single-axis mounting system after panel installation

2.3.3 Transmission corridor

The 66 or 132 kV transmission lines would be installed overhead and extend approximately five kilometres from the proposed substation at the proposal site to TransGrid's substation located on Stoney Creek Road (refer to Figure 2-1). The lines would be installed on steel poles, between 20 and 30 metres high and spaced at intervals of around 50 metres. Stays would be required at locations where the transmission line changes direction.

The transmission line would cross from the west to the east of the Newell Highway just south of the existing Newell Highway property access point. At this location it would also cross the North-West Railway Line which runs parallel to the Newell Highway. RMS and the Australian Rail Track Corporation (ARTC) have been consulted regarding the crossing point design and further consultation will be undertaken during detailed design to confirm that it meets both RMS and ARTC design standards. The transmission lines will cross properties owned by Narrabri Shire Council and RMS. ENGIE has consulted with these landowners.

An indicative width of 90 metres has been identified for the transmission corridor to allow for design flexibility. An easement will be required for the transmission line. The width of the final easement would be significantly reduced once the detailed design has been completed and it is anticipated to be between 30 and 45 metres wide depending on detailed design and final arrangement of the transmission line.

2.3.4 Inverters and transformers

The proposal may either use centralised inverters or string (decentralised) inverters. The preferred option would be selected during detailed design. The inverters convert the variable direct current (DC) output of the photovoltaic solar panels into an alternating current (AC) that can be fed into the electricity grid.

Between 25 and 30 inverter and transformer stations would be installed across the site. Each of the stations would contain a centralised inverter and a transformer (either 11 kV, 22 kV or 33 kV). The overall voltage would be matched to the operating input voltage range of the inverters.

Centralised inverters have a higher capacity than de-centralised inverters which enables them to be connected to a larger number of solar arrays. String inverters have a lower capacity and connect to a single solar array string. These inverters would be installed directly onto the mounting structures. If string inverters are implemented, the centralised inverter in or on each of the boxes or skids would not be required.

These module interconnections would be as short as possible to reduce the length of the cabling loops. This would minimise the potential for adverse impacts from events such as lightning strikes.

The indicative dimensions of the station are 11 metres long by 2.5 metres wide and 2.5 metres high. The dimensions would depend on the type of station selected and this would be determined during detailed design. Examples of an inverter and transformer station is shown in Figure 2-4.

Figure 2-4 Example of an inverter and transformer station

This station would be positioned within the infrastructure corridor shown in Figure 2-1 along the existing transmission line corridor. The exact location would be confirmed during detailed design. It is likely that the delivery station would be combined with the substation.

2.3.5 Site cabling

Direct current cabling would run from the back of the panels, along the mounting structure in cable trays, to a combiner box. The combiner box would have a consolidated run of direct current cabling to connect with the main transformer and inverter station. The cable run from the combiner box to the inverter and transformer would be buried in trenches.

Alternating current cables would connect the inverters and transformers with the on-site substation. The on-site alternating current voltage would be determined at the detailed design stage, but is likely to be 33 kV. Alternating current cables would have diameters between 70 mm and 300 mm and be buried in trenches. All junctions and turning points would be clearly marked with cable warning markers.

Site cable trenches

The final depth of the cable trenches would be determined at the detailed design stage, but is likely that trenches would be up 0.9 metres deep. Sand would be used to backfill the trenches around the cables, with excavated spoil placed over the sand. Trenches would be backfilled to match existing surface levels.

Underground cabling on site would be designed to comply with Australian and international standards. This would take into account the temperature of the ambient environment in which the cables and ancillaries would operate, and the allowable currents compatible with an acceptable warming-up as stated in the standards and the manufacturers' recommendations.

Trenches would accommodate and protect the cables and would contain:

- Power cables to export the production from the solar arrays to the combiner boxes
- Power ducts to export the production from the combiner boxes to the inverter and transformer stations
- Copper wire for equipotentiality (earthing)
- Medium voltage power cables to connect the inverter and transformer stations and the substation
- Fibre optic connection
- Communication cables

2.3.6 Substation

A 33 kV to 132 kV step-up substation would be constructed within the proposal site. The potential substation location is shown in Figure 2-1.

The substation would convert power generated by the solar farm to 66 kV or 132 kV to allow transfer to the network. The transfer will be via a new 66 kV or 132 kV transmission line to the TransGrid substation as described in section 2.3.3.

The substation would contain the following infrastructure:

- 33 kV switchgear
- 33 kV or 132 kV transformer
- Three-way mesh circuit breakers for the connection of the 132 kV transmission line
- Anti-lightning poles, 21 metres high

The substation would be constructed on a concrete pad with dimensions of about 55 metres long by 40 metres wide.

Figure 2-5 provides an example of a 132 kV substation.

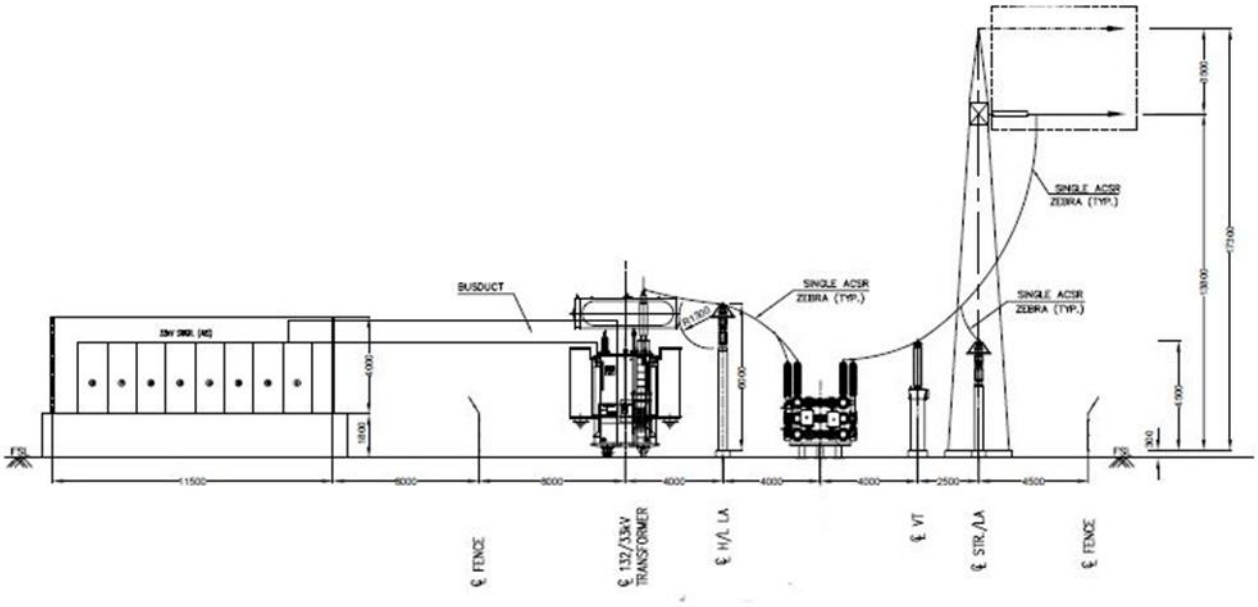


Figure 2-5 Example of substation to be located on site

2.3.7 Operation and maintenance office

The proposal would require a site office which would be used by maintenance personnel during operation. ENGIE is investigating the use of the farm manager's residence on the Logans Lane property as a potential site office. Discussions with the landowner will determine if this residence is suitable.

If this residence is not suitable for any reason, a site office would be developed. This may either be a prefabricated structure that is imported to site, or constructed at site.

If a new building is required to house the office it would have dimensions of 20 metres long by 10.5 metres wide and about 6.75 metres high. The indicative office location of a new site office is shown in Figure 2-1. The layout of a typical administration building is shown in Figure 2-6.

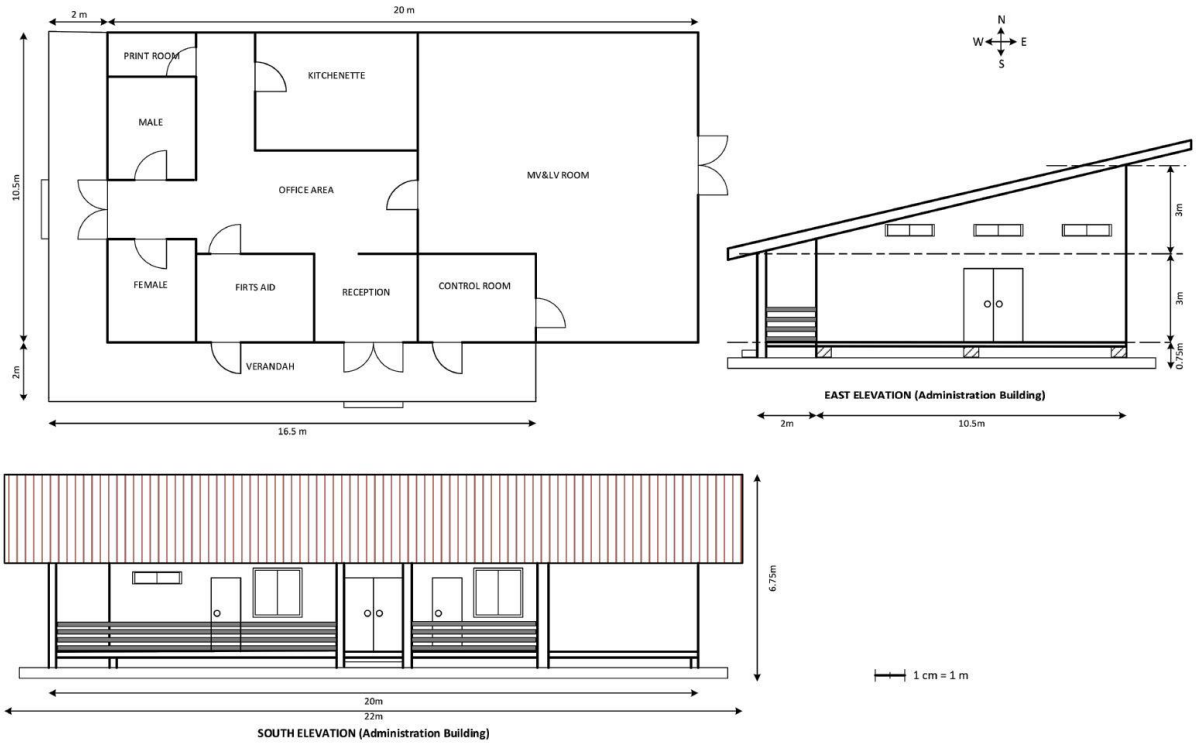


Figure 2-6 Administration building

2.3.8 Storage building

A storage building would be required to house maintenance equipment, spare parts and other operational needs. The storage building would have dimensions of 40 metres long, 20 metres wide and nine metres high. The location of the storage building is shown in Figure 2-1. The layout of a typical storage building is shown in Figure 2-7.

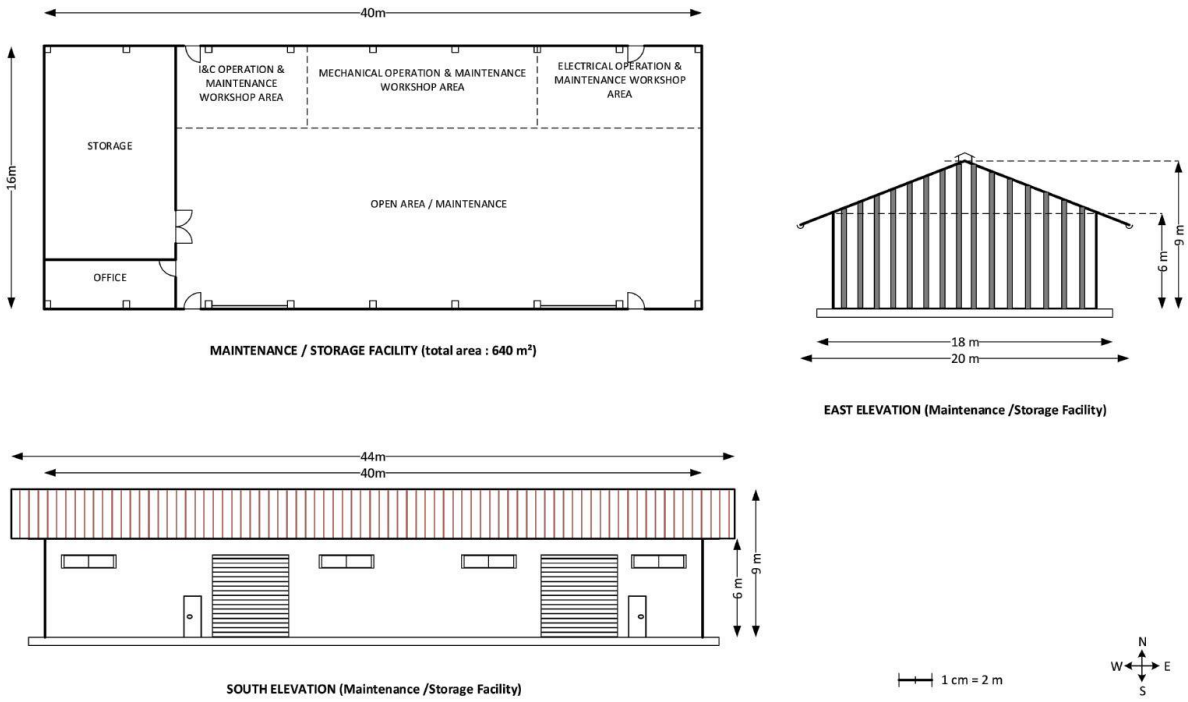


Figure 2-7 Storage building

2.3.9 Battery storage

The site layout includes the allowance for a battery storage system to be installed in the future (refer to Figure 2-1). The design of this area, including the type of batteries and the size of the storage facility, would be undertaken as a subsequent phase of work if ENGIE decides to proceed with installing battery storage. Further environmental assessment would be considered at a later stage once the nature of this storage facility is known.

2.3.10 Site access and access tracks

Site access

Vehicular access would be either from a new driveway along the property frontage near the southern boundary of the site, or via the existing Logans Lane property access points. The location of the driveway would be determined during detailed design. Its location would be sited to avoid the need to clear native vegetation located along Logans Lane or within the site. This access would be constructed to comply with Narrabri Shire Council's standards. The potential access locations are shown in Figure 2-1.

Upgrade to Logans Lane

If required, Logans Lane would be upgraded prior to construction to accommodate large trucks required for deliveries and construction equipment. Logans Lane would be re-graded to remove ruts and uneven surfaces. A layer of compacted gravel, certified as being free of contamination, would be installed.

The intersection of Logans Lane and the Kamilaroi Highway will be upgraded to meet safety standards and accommodate the movement of large trucks. Consultation with Narrabri Council and RMS would be completed as part of the detailed design to confirm the intersection design. Section 6.7 in the EIS describes the road network in the proposal area.

Internal tracks

Internal access tracks would be provided to all site facilities including the office building and substation. A car park would also be provided on site near the office. An internal network of tracks, including a perimeter track around the entire boundary fence, would provide access to the solar arrays and site equipment. Access tracks would be located in order to minimise any vegetation clearance. The design of access tracks would be dependent on the final site layout and would be confirmed during detailed design.

All tracks would consist of a compacted gravel layer. The gravel would be clean material that is certified as being free of contamination. If required, geotextile would be laid between the soil and the gravel.

2.4 Construction activities

2.4.1 Indicative timeline

Construction of the proposal is expected to take about 12 months and is planned to commence in the first half of 2020.

2.4.2 Indicative work methodology

The main construction activities would include:

- Site establishment and preparation including:
  - Establishing site access
  - Removing any existing infrastructure on site (e.g. haysheds, water tanks) which are not to be retained
  - Adjustment of existing low voltage transmission line traversing the site, the alignment of this transmission line is to be confirmed during detailed design
  - Removing existing internal fences (if required)
  - Establishing compound area and laydown areas
  - Installing environmental controls
- Construction of internal access tracks and any drainage infrastructure
- Installing the steel post foundation system for the solar panels, followed by mounting system and then panels
- Installing underground cabling (trenching), invertor and transformer station and delivery station, and connecting communications equipment
- Constructing the substation and associated transmission line
- Landscaping works as required
- Fencing works as required
- Construction of the operations and maintenance office and storage building
- Removing temporary construction facilities and rehabilitation of disturbed areas

2.4.3 Construction hours

Construction would be in accordance with the *Interim Construction Noise Guideline* (DECC 2009) (ICNG) which defines the standard construction working hours as follows:

- Monday to Friday: 7:00 am to 6:00 pm
- Saturday: 8:00 am to 1:00 pm
- Sundays and public holidays: no work

Works outside of these hours is unlikely to be required. Should works outside these hours be required nearby residents would be notified. This would involve justifying why works are required outside the standard hours and outlining the timing, duration and potentially expected noise levels.

2.4.4 Plant and equipment

Equipment used during construction would include earth-moving equipment for civil works, diesel generators, trucks and cranes. Noise outputs are similar to farm machinery such as tractors. Pile driving of the solar panel foundations would be undertaken using a machine which screws or hammers poles into the ground.

Construction of the proposed transmission line would use equipment such as excavators, cranes, jinker trailers (for delivery of poles), elevated work platforms, brake and winch trucks. Equipment listed above is indicative and would be confirmed during detailed design and construction planning.

2.4.5 Earthworks

The proposal would involve minimal earthworks because the poles supporting the solar array's mounting system would be driven or screwed into the ground. The proposal would not result in any substantial earthworks to level the ground as the array can be positioned on land with a 5 to 10 per cent slope. Minor localised earthworks may be required to areas where there is a sharp change in the slope that exceeds 10 per cent, although this is not anticipated as part of the proposal.

Earthworks would be required in the northern part of the proposal site in order to level the ground in the location of an existing borrow pit used by the landowner. Some earthworks would also potentially be required to fill any existing dams on site that are not to be retained.

The majority of ground disturbance would be in relation to levelling ground for ancillary structures such the substation, and inverter and transformer stations. Some minor earthworks would be required to construct the internal access tracks and to excavate trenches for the cables. The trenches would be backfilled to match the adjacent land surface.

2.4.6 Construction compounds and laydown areas

A temporary construction compound would be established on site. The temporary compound would include a site office and amenities. The location of the compound would be determined during the detailed design phase and would be positioned in an area which is not required for the final site layout. The construction office and staff amenities building would include the following facilities:

- Bathroom facilities
- Changing rooms
- Dining room

- Administrative office
- Undercover storage area

The use of the existing residential dwellings on site for use as a potential construction site office is to be investigated further during detailed design. In the event these dwellings are not suitable for use as an office, a prefabricated structure would be installed. This temporary structure would be delivered to site by truck and removed from site when required. Parking areas would also be provided in the vicinity of the amenities building.

Designated laydown areas would be developed on site for the delivery and storage of materials. Temporary hardstand areas, consisting of compacted gravel or similar, would be constructed and then progressively rehabilitated when no longer required. The location would be determined during detailed design and construction planning. All laydown areas would be located within the proposal site.

2.4.7 Construction workforce

It is anticipated that a maximum of 120 construction personnel (including labourers, construction supervisors and technicians) would be required during the peak construction periods. Outside of these peak periods a workforce of about 50 is expected to be on site.

2.4.8 Construction traffic and access

Construction traffic numbers

Preliminary construction planning indicates that a peak of about 120 heavy vehicle movements (i.e. to and from site is two movements) would be required to site per week throughout the construction period. This number could be lower if B-doubles are used rather than semi-trailers. The peak vehicle movements would likely occur during the installation of the panels as trucks would be delivering panels, and mounting structures to site during this phase.

A maximum of 240 light vehicle movements per day would be required during peak periods of construction. Consideration would be given to using buses to transfer workers from Narrabri to site, however this would be confirmed during detailed design and would be outlined in the traffic management plan to be developed for the proposal.

Vehicle movements generally occur during standard construction hours just before and after to allow workers to enter and leave site).

Oversized vehicles may be required to access the site after hours in line with any RMS, Narrabri Shire Council or NSW Police requirements. Oversized vehicles would potentially be required to deliver large plant and components such as the transformer for the substation. Oversized vehicles such as a 50 tonne crane may also need to access the site to place the infrastructure such as the substation components. Details on construction traffic and transport management are provided in Section 6.7 of the EIS.

Construction parking

All vehicles used by construction workers would be parked in designated car parking areas on site. These areas would be determined during detailed design and construction planning, and would be identified in the traffic management plan to be prepared for the proposal.

Construction access

Construction access to the site would be via Logans Lane. Logans Lane is accessible off the Kamilaroi Highway which is located to the south of the proposal site. Access to the Kamilaroi Highway from Narrabri would be via the Newell Highway.

Transmission line traffic and access

Access to the proposed transmission line corridor would be from the nearest available public road. Where possible, the number of access points to the corridor would be limited and existing access points along the corridor would be used where possible. Access to the corridor would be determined following further consultation with all relevant stakeholders and landowners.

2.4.9 Construction materials

Approximate volumes of the following materials would be required for construction:

- 8,000 m^3 of gravel for access tracks and preparation of sites for all ancillary infrastructure
- 10,000 tonnes of steel for the piles to support the panel array mounting systems
- 900 m^3 of concrete for foundations for any structure such as the operation and maintenance office
- 10,000 m^3 of sand to backfill cable trenches

Water would be required during construction primarily for dust suppression, but also for other activities such as vehicle washing. It is estimated that about 100 mega litres of water would be required during construction.

Where possible this would be sourced from rain water tanks already on site or those to be installed on any temporary structures on site. If water from tanks is not available water would be sourced from a Council water filling station or a similar alternative location and trucked to the site. The source of water would be determined during detailed design and construction planning.

2.5 Commissioning of the proposal

Commissioning is expected to take up to two months and would commence following the completion of construction. The commissioning phase would involve the testing all aspects of the proposal and would include the connection of the proposal to the electricity network.

2.6 Operation of the proposal

2.6.1 Hours of operation

Daily operations and maintenance by site staff would be undertaken during standard working hours:

- Monday – Friday 7:00 am to 6:00 pm
- Saturday 8:00 am to 1:00 pm

Operation and maintenance work may be occasionally extend beyond standard working hours. Outside of maintenance activities or emergencies, night works or work on Sundays or public holidays are unlikely to be required. The solar farm would generate electricity during daylight hours which means that during summer months when days are longer, it would operate prior to 7:00 am and after 6:00 pm.

2.6.2 Workforce

The proposal would employ up to three full time workers. The workforce requirements would be confirmed at the commencement of operations. These workers would work on site Monday to Friday. The site would also be remotely operated (particularly during the weekends when full time staff are not working).

The number of site workers would potentially increase when maintenance activities are required. The number of people on site would further increase during any major outages for the solar farm. These events are likely to be rare and short-term in nature.

2.6.3 Maintenance activities

Once operational, daily activities would include operations and maintenance tasks such as:

- Visual inspection of the solar arrays and other infrastructure including the use of drones.
- General maintenance of infrastructure including cleaning activities.
- Management of vegetation on the site including both landscaping and the grass located below the arrays. This would include a monitoring program to manage any bare areas to minimise erosion.
- Response to security breaches.
- Response to major outage events.
- Replacement of equipment and infrastructure, as required.

Overall it is expected that the majority of maintenance activities would be undertaken by the full time staff employed for the site. During normal operation, the number of vehicles present on the site would be limited to staff vehicles. During periods of increase maintenance activities the number of vehicles on site would increase. Operational activities such as maintenance would be undertaken primarily during standard work hours.

Major outage works would potentially be required outside the standard hours; however these would be infrequent. During major outages, 20 to 30 vehicles may be present at any one time, including some larger vehicles such as trucks.

2.6.4 Water use during operation

Water would be required during the operation to clean the panels during maintenance works. It is estimated that about 2.5 mega litres of water would be required per year. Water would be source from onsite rainwater tanks where possible, however the use of town water (which would be trucked to site) may also be required.

2.7 Decommissioning or reconditioning of the proposal

At the end of its operational life (about 35 years), the proposal site would be either reconditioned or decommissioned.

2.7.1 Reconditioning

Towards the end of the proposal's operational life, there is potential for the infrastructure to be upgraded to extend the life of the plant by replacing components with technology that is current at the time.

It is likely that the reconditioned proposal would operate in a similar manner to the proposal described in this EIS. A review of the operations would be undertaken to confirm whether the operation of the reconditioned plant is consistent with the project approval for which this EIS has been prepared. Should further land be required as part of the reconditioning works, further assessment and environmental approvals may be required.

2.7.2 Decommissioning

In the event that reconditioning of the proposal is not feasible, the proposal would be decommissioned. It would be disconnected from the electrical transmission network and all above ground infrastructure would be removed from site. Decommissioning would take approximately six months to complete.

The solar panels would be removed for recycling, together with the steel associated with the single-axis tracking system, the inverter and transformer systems. Associated cabling and conduits would be removed where possible.

Under the proposed lease agreements with the landowners, ENGIE must remove the solar farm infrastructure except for any cables which are over 50 centimetres underground. Internal access roads may remain if the landowner can make use of them, otherwise these would be removal with the land rehabilitated.

Key elements of proposal decommissioning would include:

- The solar farm's generator would be disconnected from the metering point.
- The solar arrays would be removed, including the foundation poles, with the materials to be reused or recycled where possible.
- All site amenities and equipment would be removed and materials recycled or reused, wherever possible.
- Poles and cabling would be removed and recycled (some infrastructure 50 centimetres below ground may be left in place).
- Fencing would be removed unless it is requested by the landowner to remain.
- Rehabilitation of the site would comply with requirements that will be agreed during consultation with the landholder.

ENGIE would also restore the ground surface to a suitable condition for pastoral or other agricultural use and leave the land in a safe condition. ENGIE intends for wire, transformers, and switchgear to be recycled in accordance with all national and international regulations through a local third party. ENGIE would seek out decommissioning and recycling partners that hold R2 Certification (for electronics) or are members of the Australian Metal Recycling Industry Association (for bulk metals).

Traffic generated during decommissioning would be similar in type but of shorter duration than that required for the construction phase.

3. Existing environment

3.1 Proposal location and existing environment

The proposal site is approximately five kilometres north of the Narrabri town centre to the east of Logans Lane and to the west of the Newell Highway. The proposal site is within the Narrabri Shire Council local government area in an area zoned RU1 – Primary Production. The location of the site, the nearest sensitive receivers, the transmission line corridor options and the surrounding planning zones are shown on Figure 3-1.

3.2 Sensitive receivers

Noise sensitive receivers are defined based on the type of occupancy and the activities performed in the land use. Sensitive noise receivers could include residences, educational institutes, hospitals, place of worship, recreational areas and commercial/industrial premises.

Seventeen isolated residential receivers, homesteads on agricultural properties, have been identified as being potentially impacted by construction and/or operational noise associated with the proposal. Three commercial receivers that may be potentially affected by construction noise have been identified.

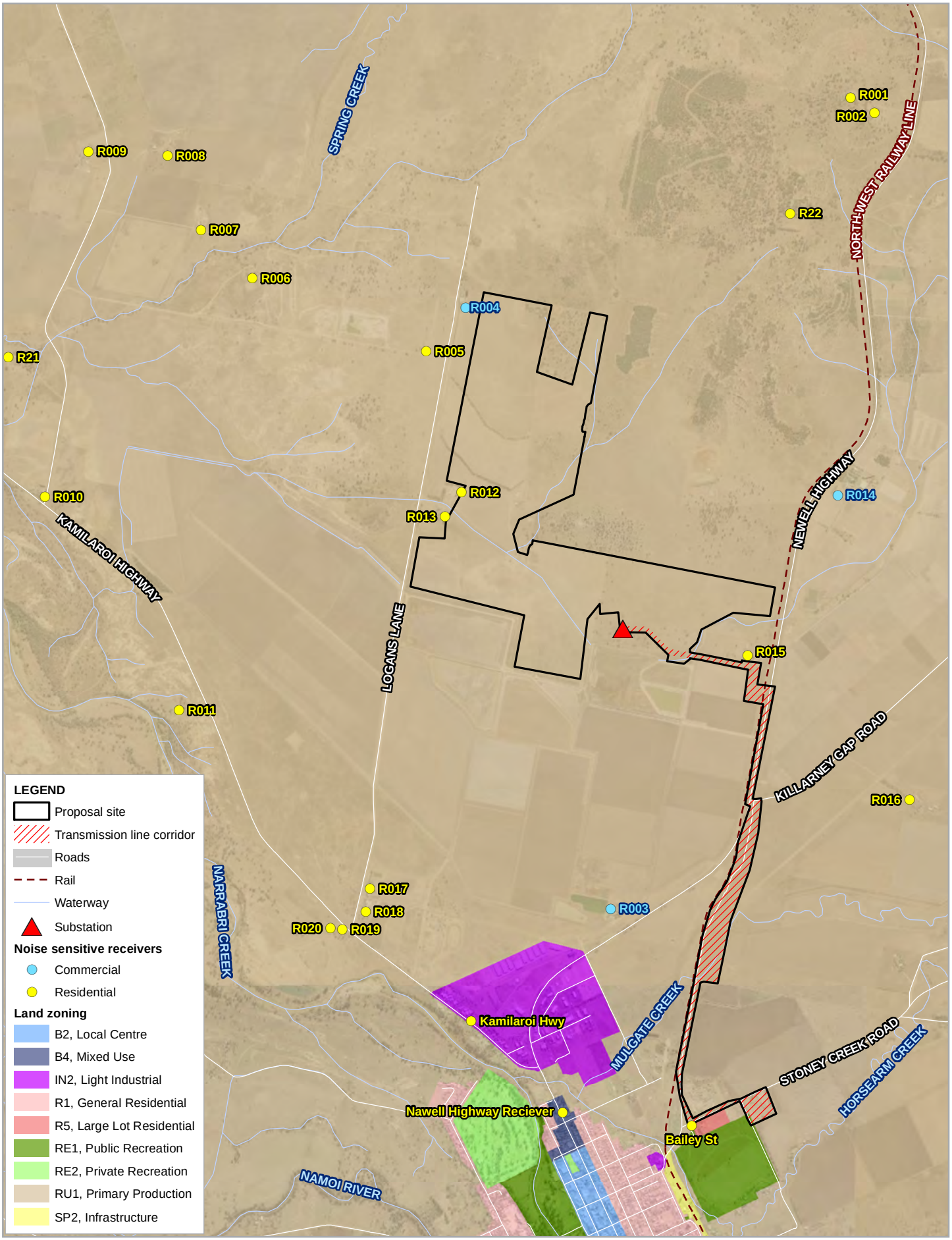
Two residential receivers (identified as R12 and R13 within this report) have commercial agreements with ENGIE and as such, the assessment of potential noise impacts have not been assessed against the Interim Construction Noise Guideline (ICNG) (DECC 2009) or the Noise Policy for Industry (NPI 2017). However, noise levels have been predicted to these residential receivers for reference.

The results of the noise assessment for these receivers are considered applicable for other nearby residences that have not been included in the assessment. In addition, three (3) commercial receivers have been identified within the study area of the proposal. The residential and commercial sensitive receivers within the study area are tabulated in Table 3-1 and are shown on Figure 3-1.

Table 3-1 Identified noise sensitive receivers – construction and operational

Rec. ID	Receiver Type	Planning zone	Direction from main proposal site	Distance to nearest solar farm boundary (metres)
R01	Residential	RU1 – Primary Production	North-east	2700
R02	Residential	RU1 – Primary Production	North-east	2750
R03	Commercial	RU1 – Primary Production	South	1930
R04	Commercial	RU1 – Primary Production	West	124
R05	Residential	RU1 – Primary Production	West	370
R06	Residential	RU1 – Primary Production	West	1900
R07	Residential	RU1 – Primary Production	West	2420
R08	Residential	RU1 – Primary Production	North-west	2850
R09	Residential	RU1 – Primary Production	North-west	3500
R10	Residential	RU1 – Primary Production	West	3100
R11	Residential	RU1 – Primary Production	South-west	2200
R12	Residential	RU1 – Primary Production	West	10
R13	Residential	RU1 – Primary Production	West	33
R14	Commercial	RU1 – Primary Production	East	940
R15	Residential	RU1 – Primary Production	East	340
R16	Residential	RU1 – Primary Production	South-east	1890

Rec. ID	Receiver Type	Planning zone	Direction from main proposal site	Distance to nearest solar farm boundary (metres)
R17	Residential	RU1 – Primary Production	South	2210
R18	Residential	RU1 – Primary Production	South	2330
R19	Residential	RU1 – Primary Production	South	2570
R20	Residential	RU1 – Primary Production	South	2570
R21	Residential	RU1 – Primary Production	West	3500
R22	Residential	RU1 – Primary Production	North-east	1700



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Engie
Silverleaf Narrabri Solar Farm

Site location, transmission line corridor, planning zones, noise sensitive receivers

Project No. 21-26998
Revision No. -
Date 08/08/2019

FIGURE 3-1

N:\AU\Orange\Projects\21\26998\GIS\Maps\Deliverables\Noise\21_26998_Z018_Noise_ReceiversAndZoning.mxd

Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Land use zoning - NSW DPE 2018. Created by:jrprice

4. Noise criteria

4.1 Construction noise criteria

The *Interim Construction Noise Guideline* (ICNG) (DECC 2009) is used to assess noise impacts associated with construction works. The guideline recommends standard hours for construction activities as Monday to Friday: 7:00 am to 6:00 pm, Saturday: 8:00 am to 1:00 pm and no work on Sundays or public holidays.

The ICNG acknowledges that the following activities have justification to be undertaken outside the recommended standard construction hours assuming all reasonable and feasible mitigation measures are implemented to minimise the impacts to surrounding sensitive land uses:

- The delivery of oversized plant or structures that police or other authorities require special arrangements to transport along public roads.
- Emergency work to avoid the loss of life or damage to property, or to prevent environmental harm.
- Works where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours.
- Works which maintain noise levels at receivers to below the noise management levels outside of the recommended standard construction hours.

Table 4-1 details the ICNG construction noise management levels at residential receivers in the study area. For commercial noise receivers within the study area, the noise management level is 70 dBA.

Table 4-1 Construction noise management levels at residences

Time of day	Management level[1] $L_{Aeq(15min)}$	How to apply
Recommended standard hours: • Monday to Friday 7:00 am to 6:00 pm • Saturday 8:00 am to 1:00 pm • No work on Sundays or public holidays	**45 dBA** Noise affected Rating background level + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise: • Where the predicted or measured $L_{Aeq(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	75 dBA Highly noise affected	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
OOHW1 - Outside recommended standard hours – weekends (Saturdays 1:00 pm to 6:00 pm, Sundays 8:00 am to 6:00 pm)	**40 dBA** Noise affected Rating background level + 5 dBA	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.
OOHW2 - Outside recommended standard hours – evenings/nights (Sunday to Thursday 6:00 pm to 7:00 am, Fridays and Saturdays 6:00 pm to 8:00 am)	**35 dBA** Noise affected Rating background level + 5 dBA	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

1 Table 2 of the ICNG. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.

4.2 Project noise trigger levels

The Noise Policy for Industry 2017 (NPI) has been developed by the NSW EPA to provide guidance on the assessment of operational noise impacts. The guideline includes both intrusiveness and project amenity noise levels that are designed to protect receivers from noise significantly louder than the background level, and to limit the total noise level from industry near a receiver.

The NPI project noise trigger levels provide an objective for assessing a proposal and are not mandatory limits required by legislation. The project noise trigger levels assist the regulatory authorities to establish licensing conditions. Where project noise trigger levels are predicted to be exceeded, feasible and reasonable noise mitigation strategies should be considered. In circumstances where noise criteria cannot be achieved, residual noise impacts are used to assess noise impacts and manage noise from the site in negotiation between the regulatory authority and community. The regulatory authority then sets statutory compliance levels that reflect the achievable and agreed noise limits from the development.

The intrusiveness noise level controls the relative audibility of operational noise compared to the background level at residential receivers. The amenity noise level limit the total level of extraneous noise for all receiver types. Both levels are calculated and the lower of the two in each time period is set as the project noise trigger level. The intrusiveness noise level is assessed over a 15 minute period however the amenity noise level is assessed over the day, evening or night time period. For the purposes of assessment to standardise the approach the NPI recommends that the $L_{Aeq(15min)} = L_{Aeq(period)} + 3$ dBA unless an alternative approach can be justified.

4.2.1 Intrusiveness noise level

The intrusiveness noise level is determined by a 5 dB addition to the measured or adopted background noise level. A minimum intrusiveness noise level of 35 dBA is adopted for the evening and night period, and 40 dBA for the day period. The NPI recognises that in rural locations the background noise levels may be the same for day, evening and night. It recognises that noise generating activities during the day would have a different impact than they would during the evening or night during sleep or relaxation time. The intrusiveness noise levels are only applicable to residential receivers.

4.2.2 Project amenity noise level

The recommended amenity noise level applies to all industrial noise in the area, which when combined, should remain below the recommended amenity noise level. The recommended amenity noise level represents the total industrial noise at a receiver location and a Project Amenity Noise Level is set at 5 dBA below the recommended amenity noise level. Project amenity noise levels are set by combining all noise from industrial sources, and subtracting 5 dBA to minimise disruption to speech, community annoyance or some sleep disturbance.

For residential receivers, the noise trigger levels are provided in Table 4-2. The noise trigger levels reflect the most stringent noise level requirements derived from the intrusiveness and project amenity noise levels. Noise trigger levels at the sensitive receivers have been determined based on the minimum background noise level thresholds, as no background noise monitoring has been undertaken.

Residential receiver areas are characterised into 'urban', 'suburban', 'rural' or other categories based on land uses, and include the existing level of noise from industry and road traffic. With consideration to the NPI 'noise amenity area' classification, the residential receivers identified for this assessment should be classified as 'Rural Residential' and all other nearby industrial sites are classified as 'Industrial premises'.

4.3 Summary of project noise trigger levels

For residential receivers, the project noise trigger levels are provided in Table 4-2. The project noise trigger levels reflect the most stringent noise level requirements derived from the intrusiveness and project amenity noise levels. Daytime, evening and night-time project noise trigger levels should be achieved, as the solar farm will operate during these time periods. Project noise trigger levels at the sensitive receivers have been determined based on the minimum background noise level thresholds, as no background noise monitoring has been undertaken.

Table 4-2 Project noise trigger levels – residential noise receivers, dBA

Criteria $L_{Aeq(15min)}$	Residential Receivers		
	Day	Evening	Night
Intrusiveness noise level	40	35	35
Project amenity noise level (rural)	48	43	38
Project noise trigger levels	40	35	35

Notes:

- The NPI defines Day as 7:00 am to 6:00 pm Monday to Friday and 8:00 am to 6:00 pm Saturday, Sunday and Public Holidays, Evening 6:00 pm to 10:00 pm and Night as the remaining periods.
- In accordance with the NPI, the minimum assumed Rating Background Level (RBL) during the daytime is 35 dBA and 30 dBA for the evening and night periods (no background noise monitoring was undertaken as part of this assessment).
- Noise from the site is to be measured at the most affected point within the residential boundary, or at the most affected point within 30 metres of the dwelling where the dwelling is more than 30 metres from the boundary, to determine compliance with the project noise trigger levels, except where otherwise specified below.

For industrial receivers, the project noise trigger levels are provided in Table 4-3 below.

Table 4-3 Project noise trigger levels – commercial and industrial receivers

Receiver	Time of day	L_{Aeq}, dBA
Commercial premises	When in use	65

4.3.1 Hours of operation

It is understood that the operations of at the solar farm site will be limited to the hours presented in Table 4-4.

Table 4-4 Operating hours

Activity	Day of week	Time	Quietest assessment period
Trackers/modules	7 days a week	Daylight hours	Night
Substation/power stations		Daylight hours	Night
Operational and maintenance activities		Daylight hours	Night

4.3.2 Meteorological conditions

Noise propagation can be affected by particular wind conditions and temperature inversions. The NPI states:

"Where inversion conditions are predicted for at least 30% (or approximately 2 nights per week) of the total night time in winter, then inversion effects are considered to be significant and should be taken into account in the noise assessment.

Wind effects need to be assessed where wind is a feature of the area. Wind is considered to be a feature where source-to-receiver wind speeds (at 10 m height) of 3 m/s or below occur for 30 per cent of the time or more in any assessment period (day, evening, night) in any season."

Meteorological modelling has not been undertaken, however temperature inversions are likely to be a significant feature of the area. To simulate worst case meteorological conditions for noise propagation, Concawe F-Class meteorological conditions with 3.0 m/s winds in the worst-case direction from source to receiver have been used. Predictions are carried out assuming an average temperature of 10°C and average humidity of 70%.

4.3.3 Modifying factor adjustments

The NPI requires that modifying factor adjustments are applied if the noise sources contain tonal, intermittent or low frequency characteristics, which have the potential to increase annoyance. The modifying factor adjustments are detailed in Table 4-5.

Table 4-5 NPI modifying factor adjustments

Factor	Assessment/ measurement	When to apply	Correction[1,2]
Tonal noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is above 400 Hz • 8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive • 15 dB or more if the centre frequency of the band containing the tone is below 160 Hz	5 dBA[2]
Low frequency noise	Measurement of C-weighted and A-weighted level	Measure/assess C and A weighted $L_{eq,T}$ levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more and: • Where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2 dBA positive adjustment to measured/predicted A-weighted levels for the evening/night period. • Where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dBA and cannot be mitigated, a 5 dBA positive adjustment to measured/predicted A-weighted noise levels applies for the evening/night period and a dBA positive adjustment for the daytime period.	5 dBA[2]
Intermittent noise	Subjectively assessed	When the night-time noise level drops to that of the background noise level with a noticeable change in noise level of at least 5 dBA.	5 dBA
Impulsive noise	A-weighted fast response and impulse response	If the difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB.	Apply the difference in measured noise levels as the correction up to a maximum of 5 dBA

Factor	Assessment/ measurement	When to apply	Correction[1,2]
Note 1: Where two or more modifying factors are present the maximum correction is limited to 10 dBA. Note 2: Where a source emits a tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low frequency range.			

4.3.4 Sleep disturbance

The NPI recommends a detailed maximum noise level event assessment be undertaken where night-time noise levels from a development exceed the following levels when assessed externally at the nearest residential location:

- $L_{Aeq(15min)}$ 40 dBA or the prevailing RBL + 5 dBA (whichever is greater); and/or
- L_{AFmax} 52 dBA or the prevailing RBL + 15 dBA (whichever is greater)

Sleep disturbance is not anticipated from the operation of the solar farm as it is not expected to generate significant noise after 10:00 pm or before 7:00 am.

4.4 Road traffic noise criteria

The *Road Noise Policy* (RNP) (DECCW), 2011) provides traffic noise criteria for residential receivers in the vicinity of existing roads, as shown in Table 4-6. This criteria is applied to public roads without existing traffic counts for operational and construction traffic on roads to identify potential road traffic impacts and the requirement for reasonable and feasible mitigation measures.

Table 4-6 Road traffic noise criteria, $L_{Aeq(period)}$ dBA

Type of Development	Day 7:00 am to 10:00 pm	Night 10:00 pm to 7:00 am
Existing residence affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	60 $L_{eq(15hr)}$	55 $L_{eq(9hr)}$
Existing residence affected by additional traffic on existing local roads generated by land use developments	55 $L_{eq(15hr)}$	50 $L_{eq(9hr)}$

The Roads and Maritime Services' *Noise Criteria Guideline* (2015) defines sub-arterial, collector and local roads as shown in Table 4-7. Based on these definitions, Kamilaroi Highway and Newell Highway have been classified as sub-arterial roads which are assessed under the sub-arterial road criteria as outlined in Table 4-6. Logans Lane has been classified as a local road.

Table 4-7 Roads and Maritime road classification criteria

Road	Definition
Sub-arterial	Connects arterials to regions of development and carry traffic from one part of a region to another. Provide connection between arterial roads and local roads. May support arterial roads during peak periods. A road that collects local traffic leaving a locality and connects to another local road, sub-arterial or arterial. Note not all networks are large enough to have both sub-arterial and collector roads.

Road	Definition
Collector	Connects the sub-arterial roads to the local road system in developed areas. May support sub-arterial roads during peak periods. May have been designed as local streets but can serve major traffic-generating developments or support non-local traffic. Note not all networks are large enough to have both collector and sub-arterial roads. The Road Noise Policy does not provide separate noise criteria for collector roads. Roads and Maritime applies sub-arterial noise criteria to collector roads and still considers collector roads and sub-arterial roads to be different functional classes.
Local	Provide vehicular access to abutting property and surrounding streets. They are the subdivisional roads within a particular developed area.

For roads with existing traffic counts the RNP application notes state that *"for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level as a result of the development should be limited to 2 dB above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dB of or exceeds, the relevant day or night noise assessment criterion."*

If road traffic noise increases from the development are within 2 dBA of current levels then the objectives of the RNP are met and no specific mitigation measures are required.

5. Construction noise impact assessment

5.1 Construction noise sources

Equipment used during construction would include earth-moving equipment for civil works, diesel generators, trucks and cranes with similar noise outputs to farm machinery such as tractors. Pile driving for the solar panel foundations would be undertaken using a machine which screws or hammers poles into the ground, similar to that used for driving farm fence poles into the ground.

The typical construction equipment likely to be the main noise sources are shown in Table 5-1 with the corresponding noise level. The typical construction scenarios associated with the proposal, the relevant construction equipment, hours of construction and activity sound power levels are presented in Table 5-2.

Noise levels of construction equipment have been obtained from Australian Standard, *AS 2436 – 2010 "Guide to Noise Control on Construction, Maintenance and Demolition Sites"*, the Department for Environment Food and Rural Affairs (DEFRA) "*Noise Database for Construction Sites"* 2005 and the RMS *"Construction Noise and Vibration Guideline" 2016* (CNVG).

Table 5-1 Construction equipment sound power levels, dBA

Equipment	Sound power level (typical)	Source
4WD	105	AS2436
Bored piling rig	111	AS2436
Cable winch	96	DEFRA
Concrete mixer	110	AS2436
Concrete truck	110	AS2436
Crane	104	AS2436
Delivery truck	107	AS2436
Dozer	115	AS2436
Dump truck	110	CNVG
Excavator	107	AS2436
Forklift	98	CNVG
Generator	99	AS2436
Grader	110	AS2436
Hand tools	102	AS2436
Impact pile driver	121	AS2436
Roller	108	AS2436
Scissor lift	100	CNVG
Trenching machine	112	DEFRA
Water truck	107	AS2436
Welding machine	105	CNVG

To simulate the worst-case scenario and to calculate the activity sound power level, the two loudest items of mechanical plant have been modelled as point source. As the proposal site is very large, this is considered conservative as it is likely that there will be greater distances between the items of construction equipment during construction.

Table 5-2 provides details on the construction scenarios modelled for the proposal. The activity sound power level is calculated from the logarithmic sum of the two loudest construction equipment items to simulate the worst-case scenario. The sound power levels shown in Table 5-1 are modelled at the source. These levels do not account for sound dissipation over distance, or the blocking effect of topography or intervening obstacles.

Table 5-2 Construction scenarios associated with the proposal

CS	Scenario	Construction area location	Construction hours	Construction equipment		Activity sound power level, dBA
S1	Site establishment, preparation works and construction compound	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Grader	Water truck	116
				Dozer	Hand tools	
				Dump truck	Roller	
				Excavator	4WD	
S2	Installing steel post foundations	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Impact pile driver	Crane	122
				Hand tools	Bored piling rig (optional)	
S3	Installation of underground cabling, power station and delivery station	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Trenching machine	Water truck	114
				Excavator	Grader	
S4	Construction of the 33 / 132 kV substation	Substation area	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Generator	Concrete truck	116
				Forklift	Grader	
				Crane	Dozer	
				Concrete mixer	Hand tools	
S5	Landscaping works	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Excavator	Grader	113
				Dump truck	-	
S6	Removal of temporary construction facilities and rehabilitation of disturbed areas	Proposal site	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Excavator	Generator	112
				Welding machine	4WD	
				Dump truck	-	
S7	Construction of the transmission line	Potential transmission line corridor area	Standard (Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm)	Dump truck	Scissor lift	114
				Bored piling rig	Cable winch	

Note: 1) The activity sound power level is calculated from the logarithmic sum of the two loudest construction equipment items to simulate the worst-case scenario.

5.1.1 Construction assessment methodology

The noise emissions from construction activities have been assessed at the surrounding sensitive receivers. A quantitative assessment has been undertaken with consideration to the ICNG.

For each construction activity, the potential noise impacts on the surrounding sensitive receivers have been predicted. Noise modelling was undertaken using CadnaA 2018 which calculates environmental noise propagation according to the CONCAWE noise algorithm. The following assumptions and calculation parameters were used in the noise model:

- Land was modelled assuming a mixture of hard and soft ground with a ground absorption coefficient of 0.75. This has been considered representative of the grassy, agricultural land surrounding the site.
- The noise model was used to predict noise levels during a typical worst case 15 minute period of operation where all equipment is operating at full power.
- Meteorological conditions was based on Concawe D-class during the day period simulate worst-case meteorological conditions for noise propagation.
- Atmospheric absorption was based on an average temperature of 10 °C and an average humidity of 70%.

5.1.2 Predicted construction noise levels

A summary of the predicted noise levels of each construction scenario is provided in Appendix A along with the relevant noise management level (NML). The predicted noise levels for nearby receivers are provided as a range as the proposal extent is approximately three kilometres (north to south and east to west) and will significantly vary depending on the distance of the construction equipment to the sensitive receiver.

The range is calculated from the closest point from the receiver to the nearest and furthest point of the relevant construction equipment. The predicted noise levels for commercial receivers is a maximum noise level from the shortest distance from the receiver to the relevant construction equipment.

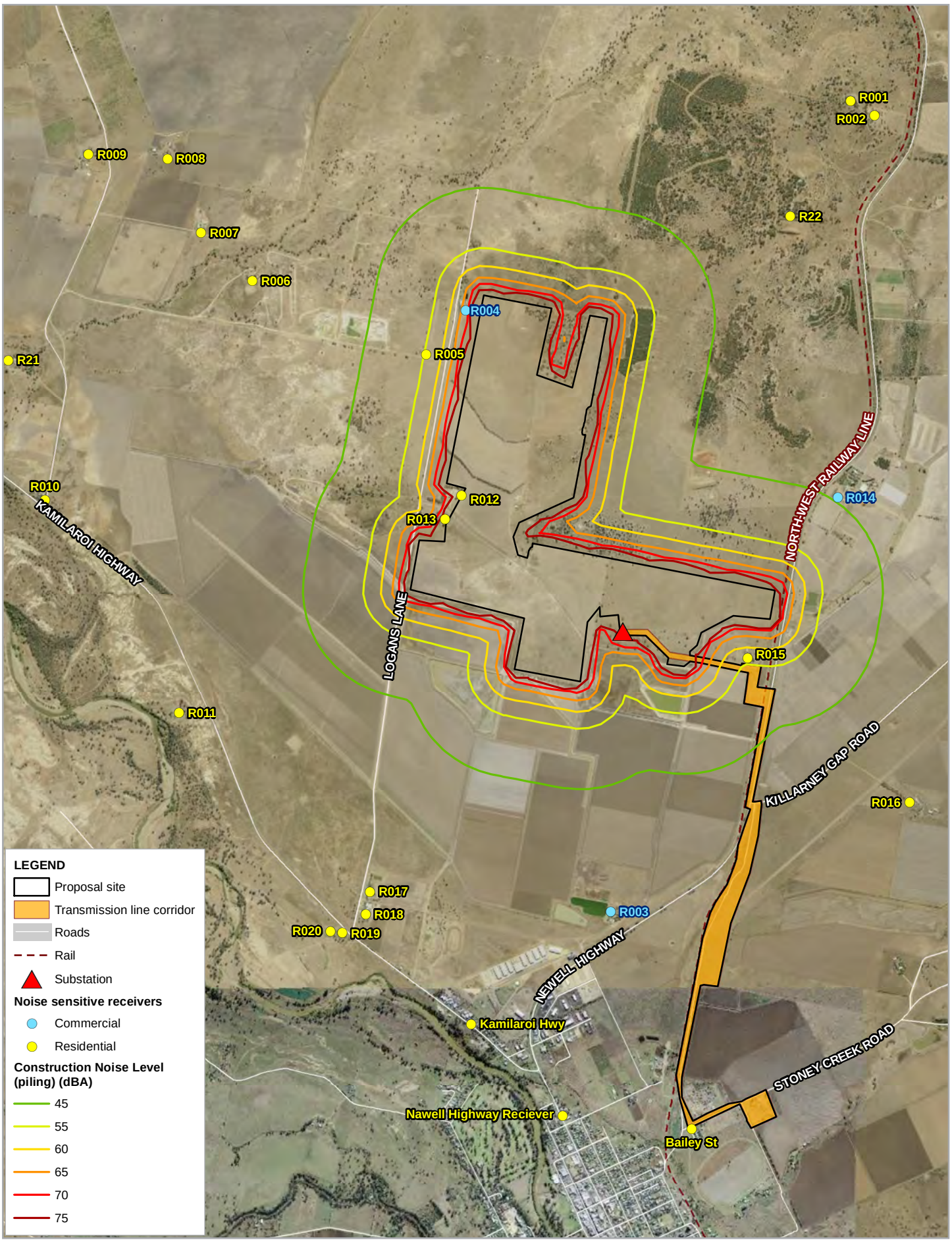
All exceedances of the noise management levels and the highly noise affected criteria at sensitive receivers are presented in Table 5-3.

Table 5-3 Exceedances of noise management levels

Construction Scenario	Exceedance NML, dB	Exceedances - Highly Noise Affected, 75 dBA
S1	R05 – 4 dB	None
	R15 – 6 dB	
S2	R04 – 2 dB	None
	R05 – 10 dB	
	R15 – 12 dB	
S3	R05 – 2 dB	None
	R15 – 4 dB	
S4	None	None
S5	R05 – 1 dB	None
	R15 - 3 dB	
S6	R15 – 2 dB	None

The worst case noise levels are predicted to exceed the noise affected construction noise management levels at the residential receivers R05 and R15 and the commercial receiver at R04. The highest exceedances are predicted to occur during impact piling works (construction scenario S2). These exceedances are expected to be short term in duration and would reduce as the plant and equipment moved further away from the sensitive receiver.

Construction noise contours for the noisiest scenario, being S2 (impact sheet piling), are shown in Figure 5-1.



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Engie
Silverleaf Narrabri Solar Farm

Predicted worst-case construction noise levels (piling), dBA

Project No. 21-26998
Revision No. -
Date 08/08/2019

FIGURE 5-1

N:\AU\Orange\Projects\21\26998\GIS\Maps\Deliverables\Noise\21_26998_Z019_Noise_Construction.mxd

Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Land use zoning - NSW DPE 2018. Created by:jrprice

5.2 Construction of transmission line (S7)

Buffer distances have been calculated to determine when the construction noise management level will be likely be exceeded during construction of the transmission line. The calculations are based on the following assumptions:

- The activity sound power level is 114 dBA (based on the construction equipment listed in Table 5-2).
- The use a of a ground absorption co-efficient of 0.75.
- Use of the ISO 9613 algorithm for noise propagation.
- No ground elevation difference between the source and receiver.
- Construction equipment is at 2.0 metres and the receiver height is 1.5 metres above the ground.

Based on the assumptions above, the calculations indicate the following:

- The construction noise management level of 45 dBA is predicted to be exceeded when the distance between construction works and a residential receiver is 440 metres or closer.
- The highly noise affected criteria of 75 dBA is predicted to be exceeded when works are within 39 metres of a residential receiver.
- The construction noise management level of 70 dBA is predicted to be exceeded when the distance between construction works and a commercial receiver is 44 metres or closer.

The maximum noise levels predictions are conservative and would only be experienced for limited periods during construction when the distance between the construction works and the sensitive receiver is the closest. A small section of transmission line construction would take place within 39 metres of a residence at 12 Bailey Street, which is situated on the corner of Stoney Creek Road and Bailey Street. As such, this receiver will experience noise levels that may exceed the highly affected noise criteria of 75 dB(A). All other receivers along Bailey Street are predicted to experience noise levels exceeding the construction noise management level of 45 dB(A), but below the highly affected noise criteria of 75 dB(A). Even though the construction noise levels in this area are anticipated to be elevated during the construction of the transmission line, the works are scheduled to occur no longer than two days duration.

Works in any location would not continue for longer than a week. For the majority of the time, the predicted construction noise levels will be below the construction noise management levels at nearby receivers.

5.3 Construction traffic noise impacts

5.3.1 Overview of applicable roads

Construction of the proposal would generate approximately 80 heavy vehicles movements per week (maximum of 2 movements per hour) and about 220 light vehicle movements (20 movements per hour) during the peak construction period. Movements would occur during the daytime period only, with access to the site occurring from Logan Lane via Kamilaroi Highway and Newell Highway.

5.3.2 Road traffic noise modelling

A separate model was created using the noise modelling software CadnaA 2018 in order to determine the effects of the additional light and heavy vehicle movements on residential receivers along Logans Lane, Kamilaroi Highway and Newell Highway. Road traffic noise propagation was calculated according to the *Calculation of Road Traffic Noise* (CoRTN) 1998 standard. The following modelling assumptions were used as shown in Table 5-4.

Table 5-4 Road traffic modelling assumptions

Input	Assumptions
Traffic speed limit –Logans Lane	50 km/hour
Traffic speed limit –Kamilaroi Highway	50 km/hour
Traffic speed limit –Newell Highway	110 km/hour (50 km/hr in residential zones)
Traffic volumes	Average traffic counts from 2008 were used as the base for calculations.
Existing Traffic – Logans Lane	Not known. Assumed to be negligible (zero)
Existing Traffic – Kamilaroi Highway	AADT = 4400 vehicles with 30% heavy vehicles (assumed)
	7 am to 10 pm (15 hour) = 3520[1] with 30% HV
	Hourly = 235 with 30% HV
Existing Traffic – Newell Highway	AADT = 6200 vehicles with 38% heavy vehicles
	7 am to 10 pm (15 hour) = 4960[1] with 38% HV
	Hourly = 330 with 38% HV
Traffic growth - day	An additional 220 light vehicle movements per day (20/hour) and additional 80 heavy vehicle movements per week (max 2/hour) to existing counts (peak period)
Road gradient	Taken into account based on existing topography
Road surface correction – Logans Lane (After upgrade – sealed)	+2.0 dBA for bitumen seal
Road surface correction – Kamilaroi Highway	+0.0 dBA for dense graded asphalt
Road surface correction – Newell Highway	+0.0 dBA for dense graded asphalt
Buildings	Buildings close to receivers were included in the model to account for reflection and wake effects
Receiver heights	1.5 metres above building ground level
Ground absorption	G = 0.75, where 0 is non-porous ground and 1 is porous ground such as that found in a rural setting comprising of mainly grass and vegetation
Ground topography	A digital terrain model with a 1 metre resolution has been used
Façade correction	+2.5 dBA to account for noise reflected from the façade (from Road Noise Policy – DECCW)
CoRTN factor (Adapted to Australian conditions through research undertaken by the Australian Road Research Board)	-1.7 dBA at the façade

Notes:

1) 15 hour volumes assumed to be 80% of AADT (Modelling, Measuring and Mitigating Road Traffic Noise, Austroads 2005)
2) HV% for Kamilaroi Highway is unknown, 30% HV has been assumed

Noise levels were predicted at the nearest residential buildings along Logans Lane, Kamilaroi Highway and Newell Highway was modelled using CadnaA as outlined above and are presented in Table 5-5 and Table 5-6.

Table 5-5 Predicted road traffic noise levels for roads without existing traffic counts

Road	Distance between road edge and nearest residential facade	Expected additional vehicles per hour	RNP criteria, dBA	Predicted level during construction, dBA	Compliance
Logans Lane	45 metres	22 light/4 heavy	$L_{Aeq(15hour)}$ 55	$L_{Aeq(15hour)}$ 47	Yes

Table 5-6 Predicted road traffic noise levels for roads with existing traffic counts

Road	Distance to nearest residential façade (m)	Existing hourly traffic	Existing noise level, dBA	Criteria, dBA (existing + 2 dBA)	Expected additional vehicles per hour	Predicted level during construction, dBA
Kamilaroi Highway	11 metres	164 light/ 71 heavy	$L_{Aeq(15hour)}$ 67	$L_{Aeq(15hour)}$ 69	22 light/ 4 heavy	$L_{Aeq(15hour)}$ 68
Newell Highway	12 metres	205 light/ 125 heavy	$L_{Aeq(15hour)}$ 68	$L_{Aeq(15hour)}$ 70	22 light/ 4 heavy	$L_{Aeq(15hour)}$ 68

The expected traffic along Logans lane, Kamilaroi highway and Newell Highway would not exceed the day time noise criteria of Road Noise Policy at any residential receiver locations along these roads. The expected additional traffic along Old Cemetery Road and Stoney Creek Road during the construction of the transmission line will not be significant enough to increase road traffic noise levels at the nearest residential buildings along these roads. As such, compliance with the Road Noise Policy is anticipated during the construction of the transmission line at the nearest residential buildings along Old Cemetery Road and Stoney Creek Road.

5.4 Vibration impacts

Safe working buffer distances to comply with the human comfort and cosmetic damage criteria were sourced from the Construction Noise and Vibration Guideline (CNVG). Calculations are presented in Table 5-7 for the equipment relevant to the proposal.

Table 5-7 Vibration safe working buffer distances, m

Activity	Human comfort, metres	Cosmetic damage to standard dwellings, metres
Vibratory Roller (> 18 tonnes)	100	25
Vibratory Roller (18 - 13 tonnes)	100	20
Pile boring	4	2
Impact sheet piling[1]	175	45

Note:

1) Based on GHD calculations to comply with the human comfort and cosmetic damage criteria within the CNVG

Solar farm construction area

Vibratory rolling, bored piling and impact sheet piling works have the potential to cause adverse human comfort and cosmetic vibration impacts at nearby receivers. Based on the buffer distances presented in Table 5-7 and a review of the location of sensitive receivers, the following has been identified:

- No vibratory rolling activities are expected within 100 metres of residential dwellings. As such no human comfort or cosmetic damage impacts are anticipated.
- No bored piling activities are expected within 4 metres of residential dwellings. As such no human comfort or cosmetic damage impacts are anticipated.
- Residential buildings within 175 metres of impact sheet piling works may experience adverse human comfort impacts during piling. These works are temporary and will decrease to within acceptable and compliant levels as the works move further away from the residential buildings. Mitigation measures have been provided in Section 7 to reduce potential vibration impacts during impact piling works.
- Residential buildings within 45 metres of impact sheet piling have the potential to have cosmetic damage during impact sheet piling works. Impact sheet piling works would not be undertaken within 175 metres of any off-site residences, and piles would be bored where feasible. Mitigation measures have been provided in Section 7 to reduce potential vibration impacts during impact piling works.

Transmission line

Bored piling works have the potential to cause adverse human comfort and cosmetic vibration impacts when the works are within 4 metres of residential buildings. No buildings have been identified within this 4 metres of the potential transmission line corridor and as such, no human comfort or cosmetic damage impacts are anticipated.

6. Operational noise impact assessment

6.1 Operational noise

6.1.1 Noise generating equipment

At maximum operation, noise generating equipment and activities on the proposal site will include:

- Single-axis tracking systems (including approximately 5,150 trackers) on which the photovoltaic modules (solar array panels) are installed.
- Twenty five (25) transformer/inverters stations (11 m x 2.5 m x 2.5 m) containing one (1) inverter and a single 33 kV transformer.
- A 33/132 kV substation, with one 140 MVA switchgear and transformer.

The tracking motors are to operate during the daylight hours and the substation and power stations are to operate on a 24-hour basis. To simulate the worst-case scenario, all noise sources have been assessed against the NPI amenity night criteria for rural residential receivers as the tracking motors may operate between 6:00 am and 7:00 am. It is uncertain when the nearby non-residential sites to the proposed solar farm are in use, so it has been assumed that these sites operate on a 24-hour basis a worst-case scenario. Noise from light vehicles during operation has not been assessed as the predicted noise level will be negligible at all nearby receiver locations.

For the purposes of the noise assessment, the single-axis tracking panel case has been conservatively considered. The operational noise sources and associated sound power levels are summarised in Table 6-1 below.

Noise levels for the single-axis tracking panels and photovoltaic boxes were sourced from manufacturer data provided in Appendix A of the *Moree solar farm Operational noise prediction report* (Blackett Acoustics, 2014) for similar equipment and time-adjusted to account for 1 minute operation within a 15 minute period. Noise levels for the 40 MVA transformer were sourced from *AS 2374.6 (1994) – Power transformers Park 6: Determination of transformer and reactor sound levels*. Noise levels for the transformer/inverter stations were provided from ENGIE.

The exact layout of the transformer/interceptor stations and the tracking motors would be confirmed during detailed design. Accordingly, they have been modelled as area sources across the entire solar farm with each point source sound power level distributed evenly across the area source.

The exact location of these point sources would have a negligible effect on the predicted noise levels at sensitive receivers, provided the tracking motors are evenly spread throughout the proposal area. For the purposes of the noise assessment, the single-axis tracking panel case has been conservatively considered.

The operational noise sources and associated sound power levels at the noise source are summarised in Table 6-1. The predicted noise levels at surrounding sensitive receivers from operation of the proposal at night time are shown in Table 6-2. The receivers R012 and R013 are subject to lease from Silverleaf Solar Farm and are therefore not considered sensitive receivers for night time operations. There would be no exceedances of the NPI from the operation of the proposal.

Table 6-1 Operational equipment sound power levels and sound transmission losses, dBA

Equipment	Number of units	Octave-band noise level (Frequency, Hz), dBA									Overall noise level, dBA	Source	Modifying factor Noise penalty	Adjusted sound power level $L_{Aeq,adj}$ dBA
		31.5	63	125	250	500	1k	2k	4k	8k				
Single-axis tracking panel motor	5,150	No octave-band data available (generic motor spectrum used)									SWL 66 (each)	Blackett Acoustic MSF report	None	66
Transformer/ Inverter station	25	17	41	62	72	84	84	81	85	65	SWL 89 (each)	ENGIE	+ 5 dBA (tonal)	94
40 MVA substation transformer	1	-	48	58	67	79	71	64	57	55	SWL 88	AS 60076-10:2009 (Transformer noise – max)	+ 5 dBA (tonal)	93

6.1.2 Modelling methodology

To assess compliance with the noise criteria, noise predictions were undertaken using CadnaA 2018 which calculates environmental noise propagation according to *ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors* and meteorological conditions according to CONCAWE algorithms. The following assumptions and calculation parameters were used in the noise model:

- Land was modelled assuming a mixture of hard and soft ground with a ground absorption coefficient of 0.75. This has been considered representative of the grassy, agricultural land surrounding the site.
- The single-axis tracking panel motor sound power levels were corrected to an operational time of one minute during a 15 minute period. All other equipment was modelled as operating continuously over the 15 minute period.
- Atmospheric absorption was based on an average temperature of 10 °C and an average humidity of 70%.
- All noise sources presented in Table 6-1 are modelled at maximum capacity during the night period (6 am to 7 am) as a worst-case scenario.
- Meteorological conditions was based on Concawe F-class with 3.0 m/s winds in the worst-case source to receiver direction during for the night period to simulate worst-case meteorological conditions for noise propagation.

6.1.3 Modifying factor adjustments

Based on past noise measurements of transformers, there is the potential for the 140 MVA transformer and the transformer/inverter power stations to have tonal noise characteristics.

A conservative +5 dB tonality factor adjustment has been applied to the contributions from the transformers to the received noise levels, in accordance with the NPI.

6.1.4 Predicted operational noise levels

The predicted noise levels for site operations are summarised in Table 6-2. Noise contour plots of the solar farm at maximum operation are shown in Figure 6-1.

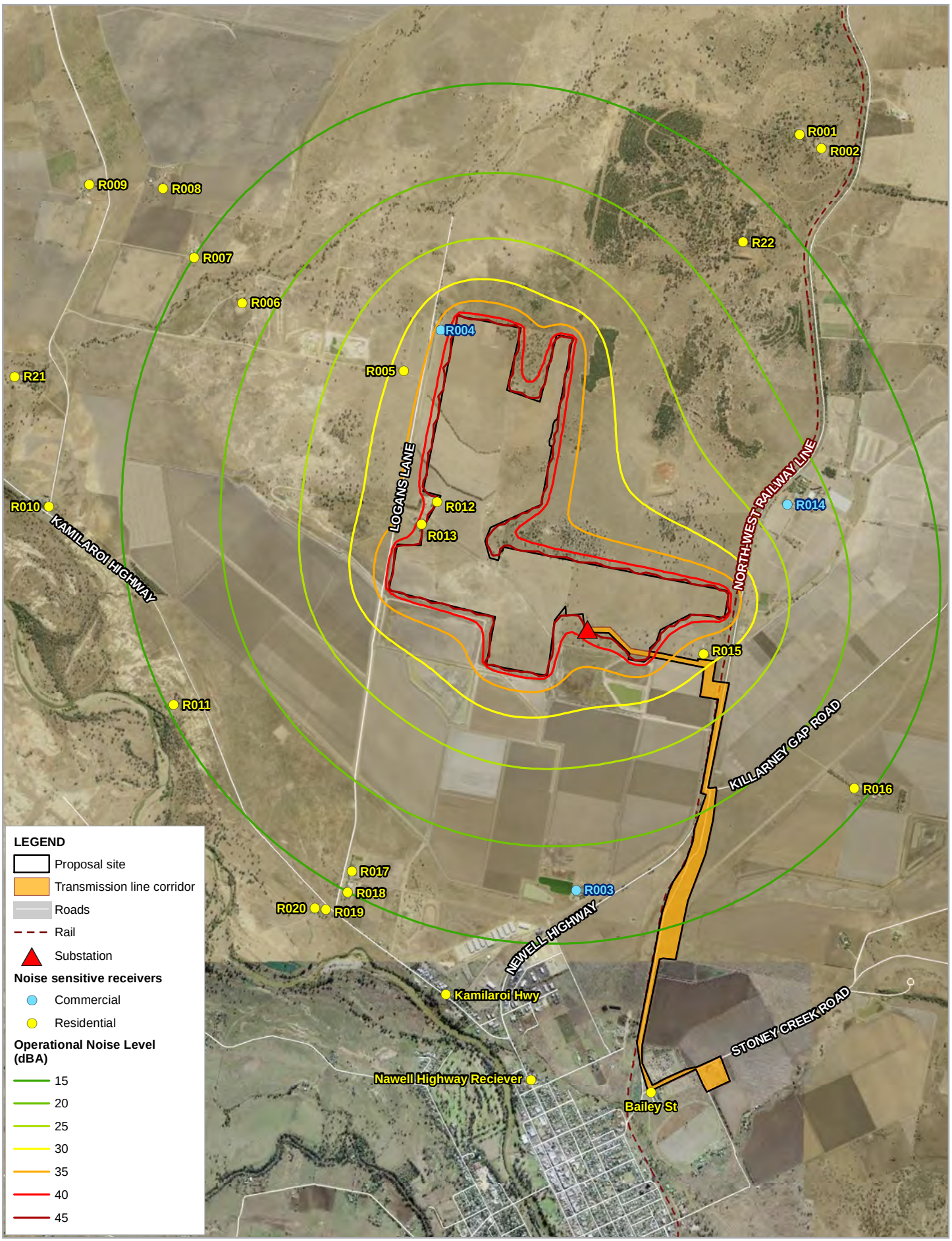
The noise levels are predicted to comply with the noise criteria during all assessment time periods. The noise predictions are considered conservative, as the predictions assume worst-case scenario meteorological conditions for noise propagation (Concawe F-Class) during the night period. Noise levels during the day time period and under calm conditions would generally be lower.

Table 6-2 Predicted noise levels at surrounding receivers

Receiver	Receiver Category	Assessment Period	Project noise trigger level	Predicted noise level, $L_{Aeq(15min)}$	Exceedances
R001	Residential	Night	35	12	No
R002	Residential	Night	35	11	No
R003	Commercial	Night	65	18	No
R004	Commercial	Night	65	37	No
R005	Residential	Night	35	32	No
R006	Residential	Night	35	18	No
R007	Residential	Night	35	15	No
R008	Residential	Night	35	12	No
R009	Residential	Night	35	9	No
R010	Residential	Night	35	12	No
R011	Residential	Night	35	15	No
R012	Residential	Night	35	45	N/A
R013	Residential	Night	35	42	N/A
R014	Commercial	Night	65	23	No
R015	Residential	Night	35	32	No
R016	Residential	Night	35	16	No
R017	Residential	Night	35	16	No
R018	Residential	Night	35	15	No
R019	Residential	Night	35	14	No
R020	Residential	Night	35	14	No
R021	Residential	Night	35	11	No
R022	Residential	Night	35	17	No

6.2 Operational road traffic noise

During operation, the proposal is considered unlikely to impact on the operation of the surrounding road network as vehicle numbers would be low and limited to those associated with infrequent maintenance activities. As such, compliance with the acoustic requirements of the Road Noise Policy would be achieved during the operation of the proposal.



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Engie
Silverleaf Narrabri Solar Farm

Predicted noise contours (operational), dBA

Project No. 21-26998
Revision No. -
Date 08/08/2019

FIGURE 6-1

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Data source: General topo - NSW LPI DTDB 2015 & 2012; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Land use zoning - NSW DPE 2018. Created by:jrprice

7. Noise mitigation

7.1 Construction noise

7.1.1 Construction measures

A noise management plan would be prepared and implemented as part of the construction environmental management plan.

The noise modelling results indicate that the construction noise management levels may be potentially exceeded when work is undertaken at the proposal site boundary closest to the sensitive receivers R05 and R15. The following general noise mitigation measures are recommended to mitigate construction noise impacts:

- All engine covers should be kept closed while equipment is operating.
- As far as possible, heights from which materials are dropped, into or out of trucks, should be minimised.
- Machines found to produce excessive noise compared to industry best practice should be removed from the site or stood down until repairs or modifications can be made.
- To reduce the annoyance associated with reversing alarms, broadband reversing alarms (audible movement alarms) would be used for all site equipment. Satisfactory compliance with occupational health and safety requirements would need to be achieved and a safety risk assessment may need to be undertaken to determine that safety is not compromised. Refer to Appendix C of the ICNG (2009) for more information.

Further to the above, the following project-specific noise mitigation measures are recommended to mitigate construction noise impacts at nearby sensitive receivers:

- If possible, bored piling (rather than impact sheet piling) should be considered as an alternative to install the steel post foundations.
- If impact sheet piling is required, no impact sheet piling should be undertaken within 45 metres of adjacent dwellings.

Table 7-1 presents noise control methods and expected noise reductions according to Australian Standard AS 2436 – 2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites.*

Table 7-1 Relative effectiveness of various forms of noise control, dBA

Noise control method	Typical noise reduction	Maximum noise reduction
Distance	Approximately 6 per doubling of distance	
Screening	5 to 10	15
Acoustic Enclosures	15 to 25	50
Engine Silencing	5 to 10	20

7.1.2 Work ethics

All site workers would be briefed on the potential for noise impacts on local residents and the requirement to implement practical and reasonable measures to minimise noise impacts during the course of their activities. This would include:

- Avoiding the use of loud radios.
- Avoiding shouting and slamming doors.

- Where practical, machines would be operated at low speed or power and switched off when not being used rather than left idling for prolonged periods.
- Keeping truck drivers informed of designated vehicle routes, parking locations and delivery hours.
- Minimising reversing.
- Avoiding dropping materials from height and avoiding metal to metal contact on material.
- Keeping engine covers closed while equipment is operating.

7.1.3 Community relations

Consultation and cooperation with the nearest sensitive receivers will assist in minimising uncertainty, misconceptions and adverse reactions to noise. The following community relation measures would be implemented:

- The construction contractor would establish contact with residents affected by construction noise and communicate the construction program and progress on a regular basis, particularly when noise generating activities are planned. Communication with the local community would be maintained throughout the construction period.
- The construction contractor would provide a community liaison phone number and permanent site contact so that noise complaints can be received and addressed in a timely manner.
- Upon receipt of a noise complaint, monitoring would be undertaken and reported as soon as possible. If exceedances are detected, the situation would be reviewed to identify means to attempt to reduce the impact to acceptable levels.

7.1.4 Selection of construction equipment

Once the selection of construction equipment has been confirmed, a review would be undertaken to confirm that the noise levels do not exceed the assumed levels in this assessment.

7.2 Operational noise

Based on the information provided in this assessment, specific operational mitigation measures are not required.

8. Conclusion

This report was prepared to assess potential noise impacts associated with construction and operation of the Silverleaf Solar Farm, north of Narrabri. Minimum background noise levels were adopted in accordance with the Noise Policy for Industry (NPI) (EPA 2017). Based on information provided by the client relating to construction and operation, computer noise modelling was undertaken to predict potential impacts on key sensitive receivers.

Some construction activities during recommended standard hours are predicted to exceed the noise affected construction noise management levels at nearby sensitive receivers. No exceedances of the highly noise affect criteria is predicted. Recommended noise mitigation measures would be implemented where feasible and reasonable to reduce the noise impacts. With the incorporation of mitigation measures, no adverse vibration impacts are anticipated from the construction and operation of the proposal.

Operational noise from the proposal is predicted to comply with the NPI at the surrounding sensitive receivers during all times of the day. The proposal would be acceptable from an acoustic perspective assuming the recommended mitigation measures are implemented.

9. References

AS 2374.6 – Power transformers Park 6: Determination of transformer and reactor sound levels, Australian Standards, 1994

AS 2436 Guide to noise and vibration control on construction, demolition and maintenance sites, Australian Standards, 2010

BS 5228.2 Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration, British Standards, 2009

Noise Policy for Industry, EPA, 2017

Interim Construction Noise Guideline, Department of Environment and Climate Change, July 2009

Construction Noise and Vibration Guideline, RMS, 2016

Moree solar farm Operational noise prediction report, Blackett Acoustics, 2014

Road Noise Policy, DECCW, 2011

Noise Guide for Local Government, EPA, 2013

Appendices

Appendix A – Construction noise levels at receivers

Construction Scenario	Construction Hours	Receiver ID	Receiver Type	NML	Predicted noise level, $L_{Aeq(15min)}$	Exceedances
S1	Standard (Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm)	R01	Residential	45	16 to 23	No
		R02	Residential	45	16 to 22	No
		R03	Commercial	65	20 to 28	No
		R04	Commercial	65	32 to 61	No
		R05	Residential	45	30 to 49	4 dB
		R06	Residential	45	20 to 28	No
		R07	Residential	45	17 to 25	No
		R08	Residential	45	15 to 22	No
		R09	Residential	45	13 to 19	No
		R10	Residential	45	15 to 20	No
		R11	Residential	45	19 to 26	No
		R12	Residential	45	39 to 88	N/A
		R13	Residential	45	36 to 75	N/A
		R14	Commercial	65	27 to 39	No
		R15	Residential	45	30 to 51	6 dB
		R16	Residential	45	19 to 28	No
		R17	Residential	45	19 to 26	No
		R18	Residential	45	18 to 25	No
		R19	Residential	45	17 to 23	No
		R20	Residential	45	16 to 23	No
		R21	Residential	45	10 to 17	No
		R22	Residential	45	21 to 30	No
S2	Standard (Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm)	R01	Residential	45	22 to 29	No
		R02	Residential	45	22 to 28	No
		R03	Commercial	65	26 to 34	No
		R04	Commercial	65	38 to 67	2 dB
		R05	Residential	45	36 to 55	10 dB
		R06	Residential	45	26 to 34	No
		R07	Residential	45	23 to 31	No
		R08	Residential	45	21 to 28	No
		R09	Residential	45	19 to 25	No
		R10	Residential	45	21 to 26	No
		R11	Residential	45	25 to 32	No
		R12	Residential	45	45 to 94	N/A
		R13	Residential	45	42 to 81	N/A
		R14	Commercial	65	33 to 45	No
		R15	Residential	45	36 to 57	12 dB
		R16	Residential	45	25 to 34	No
		R17	Residential	45	25 to 32	No
		R18	Residential	45	24 to 31	No
		R19	Residential	45	23 to 29	No
		R20	Residential	45	22 to 29	No
		R21	Residential	45	16 to 23	No
		R22	Residential	45	27 to 36	No
		R01	Residential	45	14 to 21	No

S3	Standard (Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm)	R02	Residential	45	14 to 20	No
		R03	Commercial	65	18 to 26	No
		R04	Commercial	65	30 to 59	No
		R05	Residential	45	28 to 47	2 dB
		R06	Residential	45	18 to 26	No
		R07	Residential	45	15 to 23	No
		R08	Residential	45	13 to 20	No
		R09	Residential	45	11 to 17	No
		R10	Residential	45	13 to 18	No
		R11	Residential	45	17 to 24	No
		R12	Residential	45	37 to 86	N/A
		R13	Residential	45	34 to 73	N/A
		R14	Commercial	65	25 to 37	No
		R15	Residential	45	28 to 49	4 dB
		R16	Residential	45	17 to 26	No
		R17	Residential	45	17 to 24	No
		R18	Residential	45	16 to 23	No
		R19	Residential	45	15 to 21	No
		R20	Residential	45	14 to 21	No
		R21	Residential	45	8 to 15	No
		R22	Residential	45	19 to 28	No
S4	Standard (Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm)	R01	Residential	45	3 to 10	No
		R02	Residential	45	4 to 10	No
		R03	Commercial	65	13 to 22	No
		R04	Commercial	65	0 to 17	No
		R05	Residential	45	0 to 18	No
		R06	Residential	45	3 to 11	No
		R07	Residential	45	2 to 9	No
		R08	Residential	45	0 to 0	No
		R09	Residential	45	0 to 0	No
		R10	Residential	45	0 to 0	No
		R11	Residential	45	6 to 13	No
		R12	Residential	45	0 to 26	N/A
		R13	Residential	45	0 to 26	N/A
		R14	Commercial	65	13 to 25	No
		R15	Residential	45	17 to 38	No
		R16	Residential	45	11 to 20	No
		R17	Residential	45	10 to 17	No
		R18	Residential	45	9 to 16	No
		R19	Residential	45	8 to 15	No
		R20	Residential	45	8 to 15	No
		R21	Residential	45	-7 to 0	No
		R22	Residential	45	6 to 14	No
		R01	Residential	45	13 to 20	No
		R02	Residential	45	13 to 19	No
		R03	Commercial	65	17 to 25	No
		R04	Commercial	65	29 to 58	No
		R05	Residential	45	27 to 46	1 dB

S5	Standard (Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm)	R06	Residential	45	17 to 25	No
		R07	Residential	45	14 to 22	No
		R08	Residential	45	12 to 19	No
		R09	Residential	45	10 to 16	No
		R10	Residential	45	12 to 17	No
		R11	Residential	45	16 to 23	No
		R12	Residential	45	36 to 85	N/A
		R13	Residential	45	33 to 72	N/A
		R14	Commercial	65	24 to 36	No
		R15	Residential	45	27 to 48	3 dB
		R16	Residential	45	16 to 25	No
		R17	Residential	45	16 to 23	No
		R18	Residential	45	15 to 22	No
		R19	Residential	45	14 to 20	No
		R20	Residential	45	13 to 20	No
		R21	Residential	45	7 to 14	No
		R22	Residential	45	18 to 27	No
S6	Standard (Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm)	R01	Residential	45	12 to 19	No
		R02	Residential	45	12 to 18	No
		R03	Commercial	65	16 to 24	No
		R04	Commercial	65	28 to 57	No
		R05	Residential	45	26 to 45	0 dB
		R06	Residential	45	16 to 24	No
		R07	Residential	45	13 to 21	No
		R08	Residential	45	11 to 18	No
		R09	Residential	45	9 to 15	No
		R10	Residential	45	11 to 16	No
		R11	Residential	45	15 to 22	No
		R12	Residential	45	35 to 84	N/A
		R13	Residential	45	32 to 71	N/A
		R14	Commercial	65	23 to 35	No
		R15	Residential	45	26 to 47	2 dB
		R16	Residential	45	15 to 24	No
		R17	Residential	45	15 to 22	No
		R18	Residential	45	14 to 21	No
		R19	Residential	45	13 to 19	No
		R20	Residential	45	12 to 19	No
		R21	Residential	45	6 to 13	No
		R22	Residential	45	17 to 26	No

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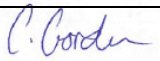
2126998-57731/https://projects.ghd.com/oc/Sydney/narrabrisolarfarmapp/Delivery/Documents/Final Draft Specialist Reports/Noise/2126998_REP_Silverleaf_Noise and vibration impact assessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	M.Velasco	C. Gordon	C. Gordon	D. Mees	D. Mees	06/05/2019
1	M. Velasco	C. Gordon		D. Mees		09/08/2019

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Appendix E – Rural lands study

Silverleaf Solar Farm Pty Ltd

Narrabri 120 MW Solar Farm

Rural Lands Study

May 2019

Executive summary

Silverleaf Solar Farm Pty Ltd (ENGIE) proposes to construct and operate a 120 megawatt (MW) solar farm, known as the Silverleaf Solar Farm. The site is four kilometres north-west of Narrabri between the Newell Highway in the east, and Logans Lane in the west ("the proposal").

The land that is the subject of the proposal has an area of approximately 450 hectares and is situated approximately four kilometres north of Narrabri in the Narrabri Local Government Area (LGA). The proposal site is zoned RU1 Primary production as defined in the Narrabri Local Environment Plan (LEP) 2012. This report is the Rural Lands Study for the proposed Silverleaf Solar Farm and is part of the Environmental Impact Statement (EIS) for the proposal.

The scope of this report has been informed by the revised Secretary's Environmental Assessment Requirements (SEARs), and addresses the specific issue concerning "Land" in the SEAR.

A desktop study was undertaken to examine the land capability and existing land use of the proposal site and broader region. The land use of the proposal site and broader region was also considered including the gross value of agricultural production. As the operation of the proposal is an activity that differs from the agricultural activities on surrounding properties, land use conflict risk assessment (LUCRA) was undertaken to ensure that the solar enterprise does not impact on the continuing ability of neighbouring properties to pursue agricultural production.

The Land Capability Classification of the proposal site is Class 3 (1%) and Class 5 (99%). As such, the majority of the land is not capable of being regularly cultivated but is suitable for grazing with occasional cultivation. As expected based on land capability, land use at the proposal site is split between cropping (54%) grazing (46%). It is estimated the proposal site represents 0.0003% of land use within the Narrabri LGA. To provide an indicative value of agriculture at the proposal site, an estimate of the value of agricultural production was derived. The gross annual value of production of the proposal site represents 0.07% of the total value of agricultural production in the Narrabri Local Government Area (LGA).

The LUCRA lists the potential sources of land use conflict from the proposal, assesses the risk based on a matrix, and suggests management strategies to reduce possible conflicts. Potential biosecurity risks and potential measures that may mitigate the risks were also identified as part of this specialist study.

The proposal site can also be rehabilitated to enable agricultural production to resume in the future, if the solar farm ceases to operate.

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1. Introduction

1.1 Overview

Silverleaf Solar Farm Pty Ltd (ENGIE) proposes to construct and operate a 120 megawatt (MW) solar farm about four kilometres north-west of Narrabri between the Newell Highway in the east and Logans Lane in the west (referred to as the 'proposal').

The proposal requires development consent from the Minister for Planning under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This Environmental Impact Statement (EIS) has been prepared to support the development application and identifies and assesses the environmental issues associated with the proposal.

The Secretary's Environmental Assessment Requirements (SEARs) which were provided on 22 June 2018 by the Department of Planning and Environment. Appendix A provides a copy of the SEARs and details of where each SEAR is address in this document.

The EIS addresses the assessment requirements of the *Biodiversity Conservation Act 2016* (BC Act) and the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This Rural Lands Study has been prepared in support of the EIS.

1.2 Description of the study area and planning context

The proposal is in the Narrabri local government area (LGA) on land that is zoned RU1 Primary Production under the Narrabri LEP. A locality map of the proposal site is shown in Figure 1 with more detail on the site included in later sections of this report.

1.3 Description of the proposal

1.3.1 Solar farm site

The proposal site is located about four kilometres north-west of Narrabri and is within the Narrabri Shire Council local government area. The proposal site consists of two rural properties located between Newell Highway in the east and Logans Lane in the west and includes the following lots:

- 330 Logans Lane – Lots 21 to 23 of DP 1174848 (property referred to as the Logans Lane property).
- 12461 Newell Highway – Lot 2 DP 586990 (property referred to as the Newell Highway property).

1.3.2 Transmission line corridor

The proposal includes constructing a transmission line between the proposal site and the Transgrid substation located about five kilometres to the south on Stoney Creek Road. The alignment of this transmission line corridor is shown in Figure 1.

1.4 Secretary's Environmental Assessment Requirements and agency requirements

This report is the Rural Lands Study for the proposed Narrabri Solar Farm and is part of the EIS for the proposed solar farm.

The scope of this report has been informed by the Secretary's Environmental Assessment Requirements (SEARs) dated 22 June 2018, and in particular addresses the specific issue concerning "Land" in the SEAR.

The SEARs listed seven reference documents that expand on the above requirements, namely:

- Primefact 1063: Infrastructure proposals on rural land (DPI).
- Establishing the social licence to operate large scale solar facilities in Australia: insights from social research for industry (ARENA).
- Local Land Services Act 2013.
- Australian Soil and Land Survey Handbook (CSIRO).
- Guidelines for Surveying Soil and Land Resources (CSIRO).
- The land and soil capability assessment scheme: second approximation (OEH).
- Land Use Conflict Risk Assessment Guide (Department of Industry – Land and Water).

In addition to the above, the Department of Industry also provided commentary on behalf of the Department of Primary Industries and Lands and Water which outlined additional issues to be addressed in this study. The Department of Industry's response and the location where the issues are addressed are summarised in Table 1.

Table 1 Additional requirements from NSW Department of Industry

Issue and desired outcome	Detail/Requirement	Where addressed
Site Suitable for development	• Complete a Land Use Conflict Risk Assessment (LUCRA) to identify potential landuse conflict, in particular relating to separation distances and management practices to minimise dust, noise and visual impacts from sensitive receptors. A LUCRA is described in the DPI Land Use Conflict Risk Assessment Guide. The development needs to consider itself as the encroaching development and consider if existing land management techniques surrounding the development will be impacted on in order to avoid land use conflict, hence the proposals potential to sterilise surrounding farmland. • Investigate that the site slopes and soil types have the capacity to sustain the development without causing land degradation resulting in a permanent loss of agricultural productivity. The proposal needs to highlight sensitive areas, limits, triggers, monitoring, management and mitigation measures to avoid land degradation.	LUCRA – section 4 Land and soil capability – Section 3

Issue and desired outcome	Detail/Requirement	Where addressed
Consideration of impacts to agricultural resources and land	• Describe the current and potential Important Agriculture Land on the proposed development site and surrounding locality including the land capability and agricultural productivity. • Demonstrate that all significant impacts on current and potential agricultural developments and resources can be reasonably avoided or adequately mitigated (explore the use of lower impact technologies such as the use of screw of driven piers over concrete and other innovative installation techniques). • Consider how infrastructure may be installed taking into consideration the needs of future rural activities (see Infrastructure Proposals on Rural Land guideline). • Consider possible cumulative effects to agricultural enterprises and landholders. • Detail the expected life span of the proposed development. • Outline strategies to avoid land use conflict around agricultural aerial spraying and fertilising in the area. • Outline details of potential landuse sharing with agriculture. How will land sharing be managed to avoid land degradation. • Detailed management of ground cover to protect soil from erosion. Include: – Appropriate expertise that are to be sought. – Pasture composition to be maintained. – Alternatives to be used to protect the soil if pasture establishment is not successful. – Management of beneficial grazing to maintain ground cover.	Current land use addressed in Section 3.1 Section 3 of the EIS LUCRA – Section 4
Suitable and secure water supply	• Estimated water demand and water availability should be clearly outlined in the proposal. • Outline any impacts to water use from agriculture and mitigation measures if required.	Section 6.8 of the EIS
Biosecurity Standards met	• Include a biosecurity (pests, weeds and livestock disease) risk assessment outlining the likely plant, animal and community risks as per guidelines in Attachment 2.	Section 4.3

Issue and desired outcome	Detail/Requirement	Where addressed
	• Consideration of a biosecurity response to deal with identified risks as well as contingency plans for any failures. Including monitoring and mitigation measures in weed, disease and pest management plans.	
Visual amenity achieved	• Amenity impacts are assessed and any necessary response to mitigate visual impacts is described and illustrated. In particular night lighting and glare from solar panels.	Section 6.4 of EIS
Land stewardship met	• Develop Rehabilitation and Decommissioning/Closure Management Plans that outlines the rehabilitation objectives and strategies. This includes, but is not limited to, describing the design criteria of the final landuse and landform, indicators to be used to guide the return of the land back to agricultural production, along with the expected timeline for the rehabilitation program. • Outline monitoring and mitigation measures to be adopted for rehabilitation remedial actions. • On any land with a cropping history or land with a capability for cropping, where it is justified that cables/pipes are not to be removed they will need to be buried at the maximum depth to allow the greatest opportunity for continued agricultural activities to continue over the top (including deep ripping and fencing), particularly for non-decommissioned cables/pipes once restoration is complete. Innovative installation solutions, above ground identification of buried cables and through removal of buried infrastructure needs to be investigated and justified. • In recognition of the importance of BSAL as a limited and highly valued resource to the state of NSW, that all below ground cabling and infrastructure on BSAL must be removed at the end of the project. • Trenching through sodic soils during construction must include soil amendment with Gypsum. Actual rates to be determined following soil testing (Clay content, ECEC and EC).	Section 3.6 of the EIS Section 5 for decommissioning
Adequate consultation with community	• Consult with relevant agencies such as on the design, construction and operation of the proposed infrastructure.	Section 4 of the EIS

Issue and desired outcome	Detail/Requirement	Where addressed
	• Consult with the owners / managers / lessee of affected and adjoining neighbours and agricultural operations in a timely and appropriate manner about; the proposal, the likely impacts and suitable mitigation measures or compensation. • Establish a complaints register that includes reporting and investigating procedures and timelines, and liaison with consent Authorities in relation to complaint issues.	

1.5 Methodology

GHD completed this report as a desktop study using a range of statistical and mapping data to address the SEARs, as well as written and verbal correspondence with NSW DPI as described above. All consultation with the community including adjacent landowners was completed by ENGIE.

1.6 Scope and limitations

This report: has been prepared by GHD for ENGIE and *may only be used and relied on by ENGIE for the purpose agreed between GHD and ENGIE as set out in section one of this report.*

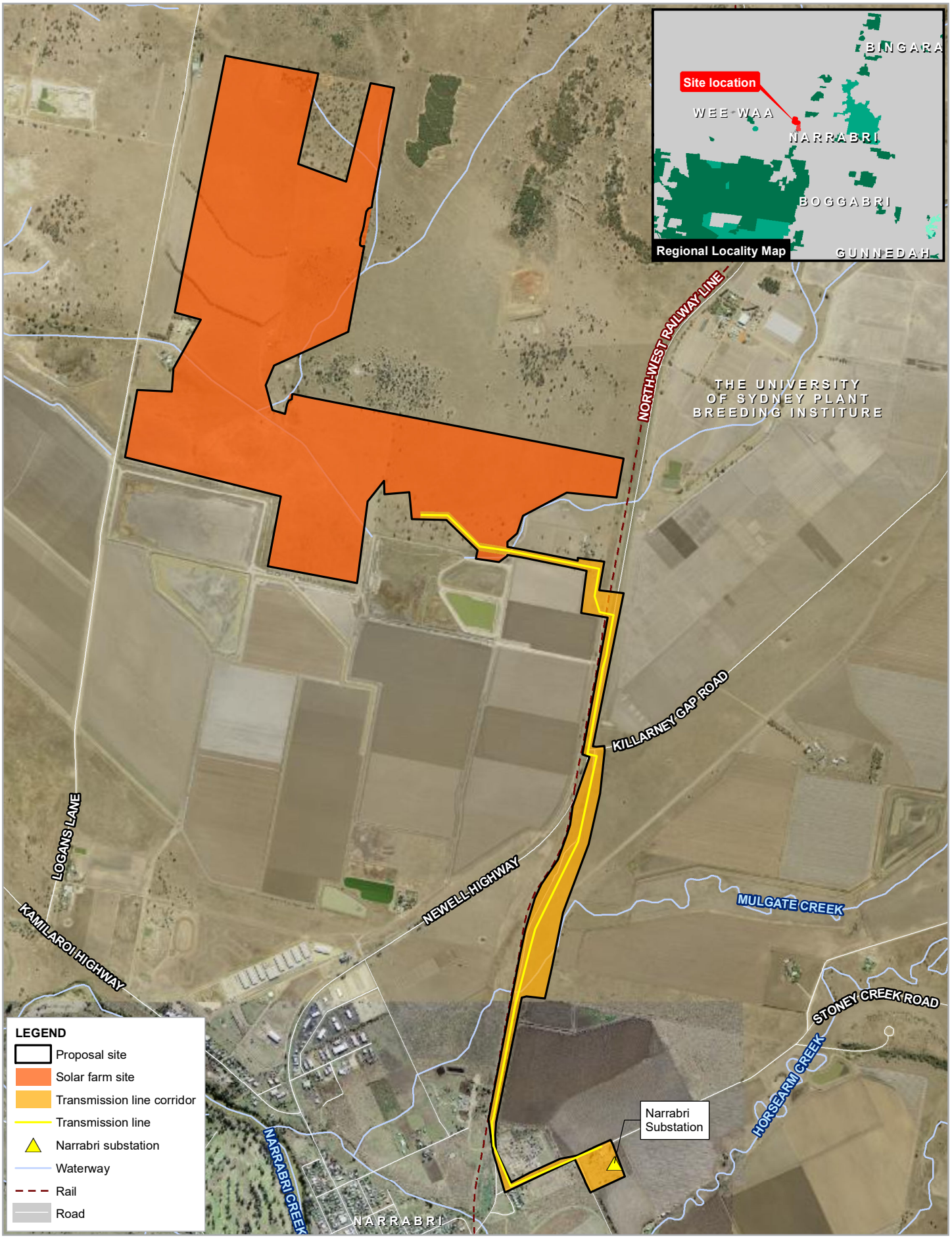
GHD otherwise disclaims responsibility to any person other than ENGIE arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by ENGIE and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.



Paper Size ISO A4

0 400 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Engie
Silverleaf Narrabri Solar Farm EIS

Project No. **21-26998**
Revision No. **A**
Date **21 Mar 2019**

Site location

FIGURE 1

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Data source: General topo - NSW LPI DTDB 2015 & 2015; Aerial imagery - SIX maps 2019 (); Survey data & site details - Engie & Solaire direct; Inset map - Geoscience Australia. Created by:jrprice

2. Land zoning

The land comprises of four allotments (Lot 2 DP 586990 and Lots 21-23 DP 1174848) of 449.3 hectares and is zoned RU1 Primary Production under the Narrabri LEP 2012. The objectives and land uses relevant for the RU1 Zone are show in Table 2 below.

Table 2 Zone RU1 Primary Production – Narrabri LGA 2012

Zone RU1 Primary Production	
1. Objectives of zone	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 allow for non-agricultural land uses that will not restrict the use of other land for agricultural purposes.
2. Permitted without consent	Building identification signs; Environmental protection works; Extensive agriculture; Farm buildings; Forestry; Home occupations; Intensive plant agriculture; Roads.
3. Permitted with consent	Air transport facilities; Airstrips; Animal boarding or training establishments; Aquaculture; Bed and breakfast accommodation; Boat launching ramps; Boat sheds; Camping grounds; Cellar door premises; Cemeteries; Community facilities; Depots; Dual occupancies; Dwelling houses; Environmental facilities; Extractive industries; Farm stay accommodation; Flood mitigation works; Freight transport facilities; Helipads; Home businesses; Home industries; Information and education facilities; Intensive livestock agriculture; Landscaping material supplies; Open cut mining; Plant nurseries; Recreation areas; Recreation facilities (major); Recreation facilities (outdoor); Research stations; Roadside stalls; Rural industries; Rural workers' dwellings; Signage; Turf farming; Water recreation structures; Water supply systems.
4. Prohibited	Any development not specified in item 2 or 3.

3. Land capability and existing land use

For the following sections on land capability and land use, GHD has relied on data obtained from public sources and aerial photographs of the study area and its surrounds, and general information regarding the study area known by GHD.

3.1 Land use at the proposal site

Solar farm site

The proposal site has an area of approximately 450 hectares and is currently used for agricultural purposes, with the primary use being grazing with some cropping. The site contains three residential dwellings with two located on the Logan's Lane property and one on the Newell Highway property. Existing property access points are available adjacent to each of the dwellings from either Logans Lane or the Newell Highway. The Logans lane property also has a number of sheds, some are positioned around the dwellings and some located east of the dwellings.

The proposal site is largely cleared of vegetation, however there are a number of areas of vegetation located along internal and boundary fence lines. Some isolated stands of vegetation are also located within the site, primarily in the northern part of the proposal site.

A low voltage transmission line runs through the southern part of the Logans Lane property and provides power to the dwellings on this property and also to the private airstrip. A drainage channel is also present on the southern part of the Logans Lane property. This channel runs through the site from Logans Lane to the property to the south where gates are located to control water flow. A number of small farm dams are also located across the site.

A small private airstrip is located adjacent to the north-west corner of the solar farm site and is used by small crop dusting aircraft. This air strip is located on a separate property and does not form part of the properties on which the proposal is to be constructed.

Transmission line site

The 132 kV transmission lines will cross properties owned by Narrabri Shire Council and Road and Maritime Services (RMS). An easement will be required for the transmission line. An indicative corridor width of 90 metres has been identified to allow for design flexibility. The width of the final easement would be significantly reduced once the detailed design has been completed and is anticipated to be around 30 to 45 metres wide depending on detailed design and final arrangement of the 132 kV transmission line.

The proposed transmission line corridor is approximately five kilometres long, running east from the proposed substation at the proposal site to the Newell Highway. It would follow the highway south to a point near the intersection with Killarney Gap Road. The route would diverge from the highway and continue south parallel to the railway line and Old Cemetery Road. It would then turn east at Stoney Creek Road to its connection point at Transgrid's Narrabri substation (refer to (refer to Figure 1).

3.2 Land and soil capability

Land in NSW is commonly classified according to the capability of land to remain stable under particular land uses. The 8-class classification is shown in Table 3 while Table 4 and Figure 2 are, respectively, the land areas and map of the land capability classifications at the site, including a comparison with land capability for the Narrabri LGA. Land within the study area comprises Class 3 (4.5 ha, 1%) and Class 5 (444.7 ha, 99%) land. As such, the majority of the land is not capable of being regularly cultivated but is suitable for grazing with occasional cultivation as per the definition in Table 3. The comparison of land capability with the whole of the Narrabri LGA in Table 4 shows that the site has a lower proportion of better quality land compared to the LGA as a whole.

Within the proposal site, there is an area of Class 3 land (4.5 ha) along the southern boundary that has been classed as Biophysical Strategic Agricultural Land and that will be retained for a buffer zone.

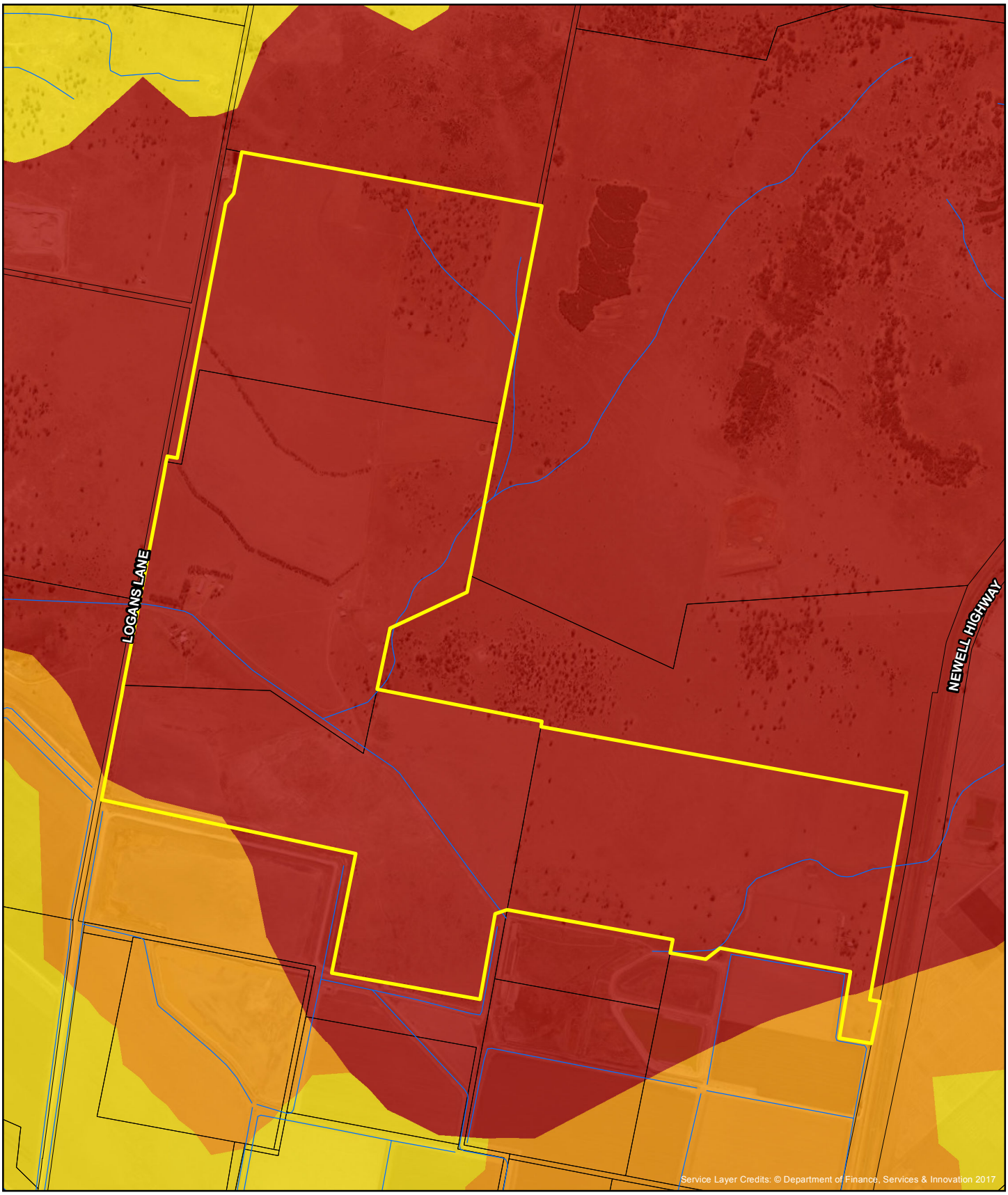
Table 3 Land and soil capability

Broad category	Class	Description
Land capable of being regularly cultivated (Slope < 10%)	Class 1	No special soil conservation works or practices necessary
	Class 2	Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotation.
	Class 3	Structural soil conservation works such as diversion banks, graded banks and waterways, together with soil conservation practices as in Class 2.
Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation (Slope 10% - 25%)	Class 4	Soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or reestablishment of permanent pastures.
	Class 5	Structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with the practices as in Class 4.
Land not capable of being cultivated but suitable for grazing (Slope > 25%)	Class 6	Soil conservation practices including limitation of stock, broadcasting of seed and fertiliser, prevention of fire and destruction of vermin. This class may require some structural works.
Other lands	Class 7	Land best protected by green timber
	Class 8	Cliffs, lakes or swamps and other land incapable of sustaining agricultural or pastoral production.

Source: Office of Environment and Heritage (2017), Land and Soil Capability Mapping for NSW, NSW Office of Environment and Heritage, Sydney

Table 4 Land and soil capability at the proposal site and Narrabri LGA

Land and soil capability class	Proposal site		Narrabri LGA	
	Area (Ha)	Percent	Area (Ha)	Percent
2	-	-	246,238.8	18.9%
3	4.5	1%	288,097.1	22.1%
4			255,493.3	17.3%
5	444.7	99%	446,231.0	34.3%
6	-	-	27,062.5	2.1%
7	-	-	63,625.6	4.9%
8			4,648.0	0.4%
Not defined			997.1	0.1%
Total	**449.3**	**100%**	**1,332,393**	**100%**



LEGEND

- Proposal site
- Cadastre
- Waterway

Soil and Land Capability

- 2
- 3
- 5

Paper Size A4

0 100 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

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Engie
Silverleaf Solar Farm
Agricultural Impact Assessment

Job Number	21-26998
Revision	A
Date	20 Jul 2018

Soil and Land Capability

Figure 2

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Data source: General topo - NSW LPI DTDB 2017, 2015 & 2012; Aerial imagery - SIX maps 2018; Survey data & site details - Engie. Created by:jrprice

3.3 Land use at the study area

Table 5 and Figure 4 show land use at the site and includes a comparison with the Narrabri LGA. As expected based on land capability, land use at the site is split between cropping (54%) and grazing (46%) and has a higher proportion of cropping and grazing compared to the Narrabri LGA. There is no mining or quarrying at the site. Figure 3 outlines the mineral and petroleum titles and applications within the North West Slopes and Plains region of NSW and shows that the site is subject to mineral or petroleum titles or applications, however these are not expected to impact on the proposed solar farm. The total land area of the site (449.3 hectares) represents 0.0003 per cent of the total land area of Narrabri LGA (1,302,438 hectares).

Based on land use and land capability information, the site is not considered to currently fit the classification of “Important Agriculture Land”. The lack of any foreseeable irrigation development combined with the generally lower land capability of the site also means it is unlikely to have the potential to be classified as “Important Agriculture Land” in the future. Land adjacent to the southern and eastern boundaries appears to be used for irrigated cropping and is on land with capability classes 2 and 3 and current agricultural practices on these adjoining properties will continue. Grazing of livestock may be considered on the site in the future in consultation with adjoining landholders and will also be used to reduce fuel loads.

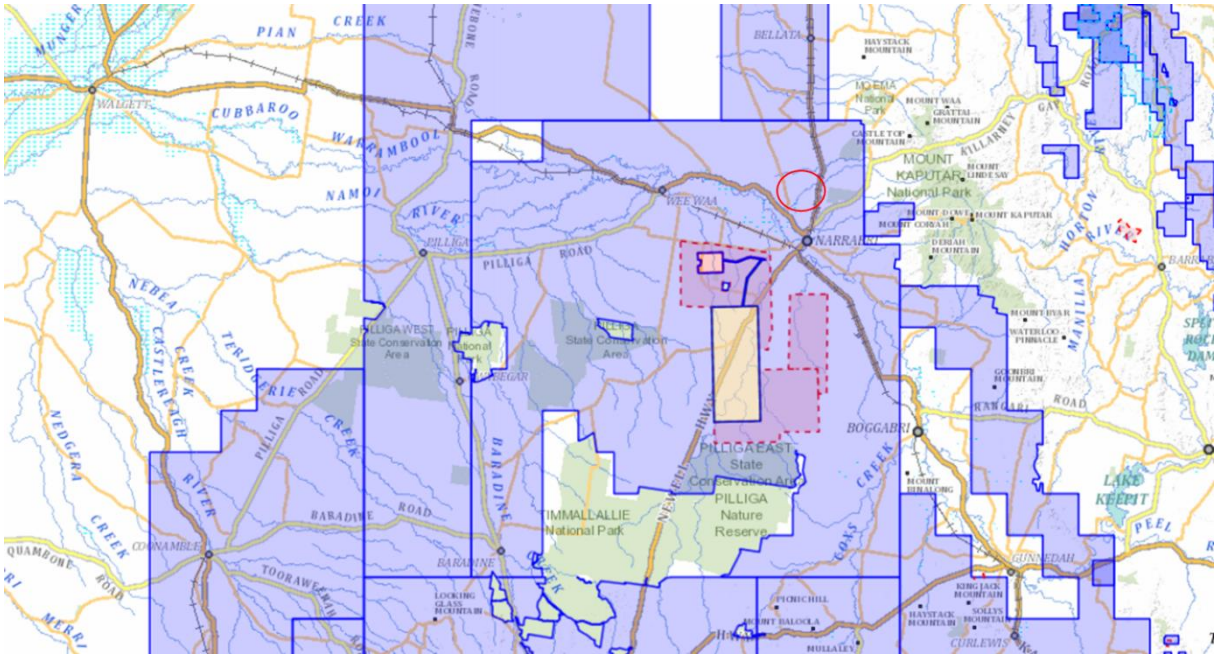


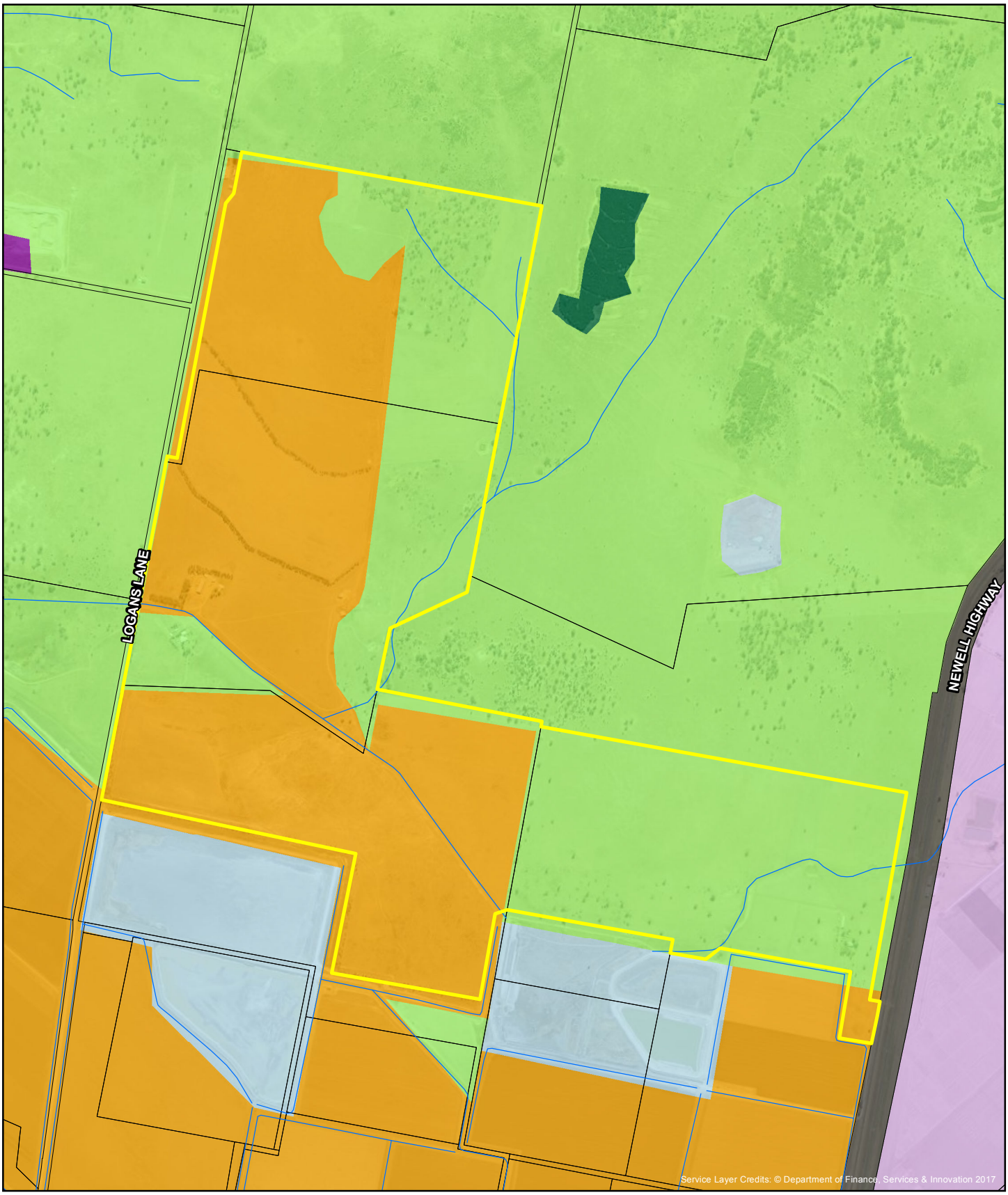
Figure 3 Mineral and petroleum titles within proximity to study area

Source: MinView – NSW Department of Planning & Environment (2018) Accessed 15 January 2018. Red circle denotes approximate location of proposal site.

Table 5 Land use – NSW OEH Data

Landuse	Proposal site		Narrabri LGA	
	Area (Ha)	Percent	Area (Ha)	Percent
Conservation Area	-	-	375,002.0	28.8%
Cropping	242.3	53.9%	339,558.9	26.1%
Grazing	206.9	46.1%	430,569.5	33.1%
Horticulture	-	-	197.6	0.0%
Intensive Animal Production	-	-	51.5	0.0%

Landuse	Proposal site		Narrabri LGA	
	Area (Ha)	Percent	Area (Ha)	Percent
Mining & Quarrying	-	-	1,055.0	0.1%
Power Generation			48.9	0.0%
River & Drainage System	-	-	19,820.8	1.5%
Special Category	-	-	5,109.7	0.4%
Transport & Other Corridors	0.1	0%	8,268.1	0.6%
Tree & Shrub Cover	-	-	104,211.1	8.0%
Urban	-	-	17,534.2	1.3%
Wetland	-	-	1,010.9	0.1%
Total	**449.3**	**100%**	**1,302,438.4**	**100.0%**



LEGEND

- Proposal site
- Cadastre
- Waterway

Landuse

- Conservation Area
- Cropping
- Grazing
- Mining & Quarrying
- River & Drainage System
- Transport & Other Corridors
- Tree & Shrub Cover
- Urban

Paper Size A4

0 100 200 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Silverleaf Solar Farm
Agricultural Impact Assessment

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Landuse of the site and surrounding area

Figure 4

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Data source: General topo - NSW LPI DTDB 2017, 2015 & 2012; Aerial imagery - SIX maps 2018; Survey data & site details - Engie. Created by:jrprice

Figure 5 View across proposal site from northern paddock (near existing dam) looking south

Figure 6 View across proposal site from southern boundary looking north

Figure 7 View across proposal site looking east from western boundary of Newell Highway property

3.4 Value of agricultural production

Agriculture is an important component of the economy of Narrabri LGA and accounts for $375 million per annum (ABS 2018). The majority of the value of production is from cropping with cotton and wheat contributing approximately $140.3 million and $78.9 million per annum respectively. Livestock slaughterings (mainly cattle and sheep) and livestock products (mainly wool) also make smaller contributions. Table 6 provides a breakdown of the value of agricultural production by commodity type.

More detail on livestock production in Narrabri LGA is provided in section 3.4.1 and Table 7 below.

Table 6 Gross value of agricultural production Narrabri LGA (2015-16)

Commodity	Narrabri ($m)
Total crops (including hay)	$331.9
Horticulture	$0.3
Livestock slaughtering – cattle	$32.6
Livestock slaughtering – sheep and lambs	$3.6
Livestock slaughtering - poultry	$1.6
Livestock slaughtering – other	$0.3
Livestock products – wool	$4.6
Total	$375 ($M)

Source: ABS (2018) Value of Agricultural Commodities Produced–New South Wales and Local Government Areas–2015-16, Cat. No. 7503.0 (Table 2), Statistics for Narrabri (A).

3.4.1 Agricultural production – livestock

In addition to winter cereal (mainly wheat) and cotton crops that are grown throughout Narrabri local government area, livestock enterprises are an important agricultural commodity in the region. Sheep and lambs are grazed for wool and meat production while a significant number of beef cattle are sold through the Narrabri Livestock Selling Centre.

Table 7 Livestock numbers Narrabri LGA (2015-16)

	Total Numbers	No. of establishments
Beef Cattle	63,290	250
Dairy Cattle	291	3
Sheep and lambs	126,641	115
Pigs	582	4
Poultry	68,220	0
Goats	112	2

Source: ABS (2018) Agriculture Commodities New South Wales and Local Government Areas–2015-16, Cat. No. 7121.0 (Table 2), Statistics for Narrabri (A).

3.4.2 Value of agricultural production at the proposal site

To provide an indicative value of agriculture at the site, an estimate of the value of production was derived using a combination of publically available data from the NSW Department of Primary Industries' (DPI) website and knowledge gained from undertaking similar agricultural assessments in the region.

Table 8 outlines the average gross income ($/ha/year) indicative of major agricultural enterprises in the proposal area. This data has been sourced from the NSW DPI website (http://www.dpi.nsw.gov.au/agriculture/farm-business/budgets)

Table 8 Estimated gross income per hectare for major enterprises within the project area

Enterprise	Gross income ($/ha/year)
Cropping	
Wheat Long Fallow, No Till (Winter)	$726
Average crop gross income ($/ha/year)	$726
Grazing	
Feeder steers	$52.00
1st Cross Ewes/Terminal meat rams	$70.34
Merino ewes (20 micron)	$60.98
Average gross income ($/DSE)	$61.11
Stocking rate (DSE/ha)	5.7
Average livestock gross income ($/ha/year)	$348.31

Source: NSW DPI 2017 for Livestock and NSW DPI 2012 Cropping adjusted for inflation.

DSE = Dry sheep equivalent

Using the above information on gross income per hectare and applying this to the land use areas (refer to Table 5), Table 11 Table 12 calculates the gross annual value of production of the proposal site at $247,974. This represents 0.07% of the total value of agriculture in the Narrabri LGA as described in Table 6. This is based on a long-term seasonal conditions and it is assumed the proposal site is being run as a single agricultural entity and able to take advantage of economies of scale.

Gross income from agricultural activities are not a measure of farm profitability as they do not include capital (machinery, land, buildings etc.) or fixed or variable costs (insurance, rates, taxes, variable costs incurred in agricultural enterprises). The Australian Bureau of Agricultural Economics (ABARES) publishes *Financial Performance: all broadacre industries for NSW, 2015-16 to 2017-18* which provides an estimate of farm performance. This average is across all of NSW and an assumption is made for the subject that (a) the area is half the average farm size for the survey sample and (b) assumes average seasonal conditions for the proposal site (noting that this has not been prevalent in recent years):

Table 9 Financial Performance: all broadacre industries for NSW, 2015-16 to 2017-18

Measure	Unit	2015-16	2016-17 (p)	2017-18 (y)	Subject Ave
Total Cash Receipts	$	509,580	547,900	518,000	262,580
Total Cash Costs	$	334,820	364,500	352,000	175,220
Farm Cash Income	$	174,760	183,400	166,000	87,360
Farm Business Profit	$	89,320	107,200	65,000	43,856

p=preliminary estimate y=provisional estimate

The farm business profit is calculated as the addition of farm cash income and change in trading stocks less depreciation and owner labour. This would result in an estimated average farm business profit of $43,856 for a property of similar size to the proposal site.

When looking at ABARES farm cash incomes of NSW broad acre farms by region the following analysis emerges, again assuming that the subject in aggregate represents half the size of the average ABARES farm size:

Table 10 Farm cash incomes: NW Slopes and Plains NSW

ABARES Region	Unit	5 Year Average to 2015-16	Subject
NW Slopes and Plains NSW	$	137,520	68,760

While development of the site would represent a continuing annual reduction in agricultural income over the life of the proposal, it is expected that this will be offset by the value of future solar energy sales. In addition, the proposal is expected to have a “light” impact on land capability such that when it is at the end of its operational life (estimated to be after 35 years), the site could be rehabilitated to a state that would allow agricultural production similar to its current status.

Table 11 Estimate of gross value of agricultural production at the site

Enterprise	Area	Gross income per hectare	Gross income per year
Cropping	242.3	$726	$175,909
Grazing	206.9	$348.31	$72,065
Total			**$247,974**

3.5 Agricultural employment

Table 12 below analyses employment for the Narrabri LGA. The agriculture, forestry and fishing industry accounts for the second largest proportion (17%) of those employed in the local economy after mining (19%). Narrabri is the main administrative centre for the broader LGA and supports a range of employment including retail trade, health care and social assistance, education and training, construction, and accommodation and food services.

Table 12 Employees by industry of occupation (2016)

	Total number	% of total
Agriculture, forestry and fishing	1,033	17%
Mining	1,124	19%
Manufacturing	160	3%
Electricity, gas, water and waste services	67	1%
Construction	269	4%
Wholesale trade	154	3%
Retail trade	498	8%
Accommodation and food services	370	6%
Transport, postal and warehousing	250	4%
Information media and telecommunications	30	0%
Financial and insurance services	59	1%
Rental, hiring and real estate services	46	1%
Professional, scientific and technical services	259	4%
Administrative and support services	161	3%
Public administration and safety	279	5%
Education and training	407	7%
Health care and social assistance	581	10%
Arts and recreation services	30	0%
Other services	249	4%

Source: Australian Bureau of Statistics (2016) 2016 Census of Population and Housing

4. Land use conflict risk assessment

As the operation of the proposal is an activity that differs from the agricultural activities on surrounding properties, it is important that impacts are minimised on the continuing ability of neighbouring properties to pursue agricultural production. A land use conflict risk assessment (LUCRA) is a tool that can assess the potential of any negative impacts on surrounding land use and provide options for mitigation of potential impacts. The Department of Industry (DoI) documents *Land Use Conflict Risk Assessment Guide* (DPI Guide 2011) and *Living and working in rural areas handbook* (DoI Handbook) were referenced for this risk assessment.

4.1 Land use conflict risk assessment matrix

The following risk assessment matrix has been adopted to assess potential land use conflict risks from the proposal.

Table 13 Land use matrix

Likely consequence from a dispute or conflict arising over the land use or activity		Likelihood of a dispute or conflict arising over the land use or activity		
		Very likely	Likely	Unlikely
	Major consequences and impacts likely	HIGH	HIGH	MEDIUM
	Modest or periodic consequences and impacts likely	HIGH	MEDIUM	LOW
	Minimal consequences and impacts likely	MEDIUM	LOW	LOW

Source: Living and Working in Rural Areas – A handbook for managing land use conflict issues on the NSW North Coast. DPI (2007)

4.2 Land use conflict risk assessment (LUCRA)

Table 14 lists the potential sources of land use conflict from the proposal, assesses the risk based on the above matrix, and suggests management strategies to reduce possible conflicts. The list is adapted from the DPI *Living and Working in Rural Areas handbook*. A number of issues listed in the DPI document are considered to pose a negligible risk for the proposal and have been assessed as not applicable (N/A).

The LUCRA assumes the separation distances as described in Figure 1 and also the following features:

- Adjoining properties along Logans Lane, Kamilaroi Highway and Newell Highway will continue to be actively used for agricultural purposes in the future.
- Future farming operations will be similar to current operations with no expected reduction in productivity or employment on the adjoining properties as a result of the proposal.
- The Newell Highway is adjacent to the eastern boundary of the proposal site.

Table 14 Land use conflict risk assessment

Issue	Assessment	Issue management
Agricultural aerial spraying	Low	The heights of infrastructure are similar to existing infrastructure on surrounding land. Glare from the infrastructure will be very low and vegetation screening will be provided where it is deemed necessary in consultation with adjacent land owners.
Airstrip	Low	A buffer has been provided around the existing airstrip located adjacent to the north-west corner of the proposal site to ensure that the operations of this business is not impacted. See EIS (section 6.6) for further details.
Catchment management	Low	The proposal is likely to have negligible impact on natural resource management of surrounding agricultural properties. The existing drainage channel running through the southern part of the Logans Lane property will be retained. Engie will be responsible for ensuring site plans (e.g. stormwater) meet guidelines for discharges into waterways. See Hydrology section in EIS for further detail on drainage and catchment management.
Dogs	N/A	
Dust	Low	While initial construction is expected to generate low levels of dust, once construction is completed there is likely to be minimal dust generation as result of vehicles accessing the site for maintenance purposes. In this respect, it is expected that dust generation would be similar to that occurring on adjacent agricultural land. Landscaping to be located on site (to be confirmed following consultation with nearby residents) would potentially reduce dust moving beyond the site boundary.
Dwellings	Low	Existing dwellings are present on the site and the continued use of these dwellings will be confirmed as part of the development of the lease arrangements with the landholders. As such these dwellings are not considered to be sensitive receivers as their continued use would be subject to the lease agreement. The other closest dwelling is about 240 metres to the west of the western boundary of the proposal site. A draft landscape plan has been developed and considers the positioning of additional screening vegetation on the proposal site to minimise visual impacts to nearby visually sensitive receivers. Adjoining landowners are being consulted on the draft landscape plan to confirm its likely effectiveness and acceptability.
Fencing	Low	Fences with adjoining agricultural land will need to be maintained in a condition to minimise the possibility of livestock straying onto the site from adjoining properties. The maintenance of shared boundary fencing is the responsibility of all land owners.
Fire	Low	A bushfire management plan will be prepared for the site with further detail available in section 6.10 of the EIS.
Lights	Low	Construction of the proposal would be limited to standard construction hours and therefore it is not proposed that any lighting would be required. During operation some lighting would be present on site, however this would be limited to the office building and would generally only be used when personnel are on site. This lighting is unlikely to impact on adjacent land use.

Issue	Assessment	Issue management
Noise	Low	The proposal is predicted to exceed construction noise management levels calculated in accordance with the Interim Construction Noise Guideline. This would be limited to the construction period and would have minimal impact on adjacent land use. Operation of the proposal is predicted to comply with noise criteria calculated in accordance with the Industrial Noise Policy and is unlikely to adversely impact on adjacent land use.
Odours	N/A	
Pesticides	Low	Pesticide use within the proposal site will be minimal such as for weed control, and any product are likely to be similar to those used by surrounding landholders
Roads	Low	There will be an increase in traffic numbers, particularly during construction, however these roads have unused capacity to accommodate the increased traffic volumes.. Construction traffic and access has been addressed in the EIS and is unlikely to impact on adjacent land uses..
Straying livestock	Low	See Fencing
Theft/vandalism	Low	The relative isolation and nature of the boundary fencing is expected to reduce the risk posed by theft/vandalism at the site and with adjacent holdings.
Visual amenity	Low	Section 6.4 of the EIS outlines an assessment of the likely visual impacts of the development (including any glare, reflectivity and night lighting) on surrounding residences, scenic or significant vistas, air traffic and road corridors in the public domain, including a draft landscaping plan for on-site perimeter planting. This has been developed in consultation with adjoining landowners.
Weeds and pests	Low	Weed and pest control, including for noxious weed and pests, will be subject to ongoing routine monitoring and management. See also biosecurity below.

4.3 Biosecurity impacts

The productivity and profitability of agricultural production depends in part on the management of pests and diseases, including the prevention of incursion of pests and diseases onto properties. Biosecurity is a term that is commonly used for such management and the set of measures adopted to protect a property from the entry and spread of pests, diseases and weeds.

Farms generally prepare an on-farm biosecurity plan based on industry guidelines such as those available on the website: farmbiosecurity.com.au. The guidelines include risk assessments and control option to minimise impacts. The major biosecurity risk from this proposal relate to the movement of people, vehicles and machinery, with the risks occurring at both construction and operation phases. Table 15 outlines the potential biosecurity risk and potential measures that may mitigate the risks.

Table 15 Biosecurity risks and mitigation options

Biosecurity risk	Potential mitigation measures
People	Limit entry points to the property All construction vehicles, equipment and boots should be cleaned upon entering the property in a wash-down bay Limit worker contact with livestock, crops or plant materials as much as possible and eliminate any unnecessary contact altogether Keep a visitor register.
Vehicles	Limit the number of entry and exit points (one is preferable) Clearly sign and lock restricted access areas Ensure construction vehicles are clean and are parked in a designated area away from livestock or crops. Establish a vehicle high pressure wash down facility well away from livestock and crops to clean vehicles and equipment which need to enter the property. Ensure construction vehicles remain on designated tracks
Equipment	Clean machinery and equipment from the top down and dismantle it as far as possible to gain access to internal spaces

Source: Adapted from farmbiosecurity.com.au website (accessed July 2018)

5. Rehabilitation

At the end of its operational life, proposed to be 35 years, the proposal site would be either reconditioned or decommissioned.

5.1 Decommissioning

At the end of the proposal's life where reconditioning is not feasible, the solar farm would be disconnected from the electrical transmission network. This would entail disconnecting and removing solar panels for recycling, recycling the steel associated with the single-axis tracking system, removing the inverters and transformer, associated cabling and any conduit.

Under the lease agreements with the project landowners, ENGIE must remove the solar farm infrastructure except for:

- Any cables which are underground to a depth of greater than 500 mm
- Solar farm access roads which need not be removed.

ENGIE must restore the surface of the solar farm land to a suitable condition for pastoral or other agricultural use and leave the land electrically safe and otherwise in a safe condition. ENGIE intends for wire, transformers, and switchgear to be recycled in accordance with all national and international regulations through a local third party. ENGIE would seek out decommissioning and recycling partners that hold R2 Certification (for electronics) or is a member of the Australian Metal Recycling Industry Association (for bulk metals). Final details regarding decommissioning and recycling would be confirmed following a review of technology that is available at that time.

6. Conclusion

The proposed conversion of agricultural land to a solar farm has been assessed for its impact on the preservation of agricultural land at the proposal site and surrounding LGA. This assessment considered the SEARs, and in particular addresses the additional requirements from NSW Department of Industry.

Using information combining land use, land capability, gross value of agricultural production and employment statistics, GHD analysed the impact the removal of this parcel of land would have on the broader agricultural economy within the Narrabri LGA.

Having regard to the information available, including the general knowledge of agriculture in the area, it is estimated that the proposal site represents 0.0003% of land use and 0.07% of the total value of agricultural production within the Narrabri LGA. Removal of the land from agricultural production would have minimal impact within the broader region.

A LUCRA was completed and determined that the likelihood of potential conflict was low. Current agricultural land use on surrounding land could continue with minimal impact. The proposal site can also be rehabilitated to enable agricultural production to resume in the future, if the solar farm ceases to operate.

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Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	P. Dellow	M. White		D. Mees		06/05/2019

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Appendix F – Geotechnical, Hydrological and Topographic Survey

REPORT

Narrabri Solar Farm

Geotechnical, Hydrological, and Topographic Survey

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Distribution List

1 electronic copy

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APPENDICES

1.0 INTRODUCTION

ENGIE Renewables Australia commissioned Golder Pty Ltd (Golder) to complete a geotechnical investigation, hydrological and hydrogeological assessment, and a topographic survey for the proposed Narrabri Solar farm. The proposed site is approximately 330 hectares and located 5 km north of Narrabri (lots 21, 22 and 23 of DP117848). The site investigation including borehole drilling, Cone Penetration Tests (CPTs), Wenner testing, topographic survey and hydrologic site walkover was undertaken between 27 February 2018 and 8 March 2018 and was based on the scope of work defined in our proposal (Golder document reference no. P1782350-001-P-Rev2 dated 19 January 2018).

2.0 PROJECT DETAILS

The proposed Narrabri Solar Farm construction is understood to include the following:

- Solar panels installed on single-axis tracking structures (PV structures, to be on piled or drilled shafts).
- Pad top hosting electrical equipment (i.e. switchgears).
- MV transformers and inverters (Switchyard and substation elements, to be on shallow spread footings and/or mat foundations).
- Connections through both overhead and underground electrical cables associated to combiner boxes.
- Transmission line approximately 5 km long from site to a nearby TransGrid substation (not included as part of the site investigation works).

The conceptual plan, provided to Golder as a google earth file, is presented as Appendix B of the Request for Quotation (RFQ) document ref: SPE-0007-A-EN_RFQ_GEOTECH_studies dated 05 December 2017.

3.0 FIELDWORK AND LABORATORY TESTING

The fieldwork consisted of the following:

- borehole drilling – 20
- CPTs – 15
- geophysical investigation - Electrical Resistivity Soundings (ERS)
- laboratory testing on selected samples
- hydrological site walkover
- topographic survey

Figure 1 presents the borehole, ERS and CPT locations.

3.1 Borehole Drilling

Twenty boreholes (designated GA-BH1 to GA-BH20) were undertaken by Soiltech with a utility mounted drilling rig using continuous solid flight auger techniques. Borehole termination criteria were to drill down to 5 m below ground level (bgl) or bit refusal. Boreholes reached between 4.5 m and 5.45 m bgl. A summary of the termination depths and remarks are presented in Table 1.

Standard Penetration Tests (SPTs) were performed and undisturbed samples (U50/U75) were collected with the initial tests starting at 0.5 m bgl followed at 1.5 m depth intervals to assist in assessing the density and consistency of the site materials and to provide samples for laboratory testing. Upon completion, the boreholes were backfilled (with the exception of GA-BH15 and GA-BH18) with the cuttings and surface plugged. Borehole locations were pegged and surveyed by a licensed surveyor (as part of the survey scope of work).

Two boreholes designated GA-BH15 and GA-BH18 had monitoring wells installed for groundwater readings. The monitoring wells were dry during installation and during a final check before departing site.

All boreholes were drilled under supervision of suitably qualified and experienced geotechnical personnel from Golder. Borehole logging was undertaken in accordance with AS 1726-2017 "*Geotechnical site investigations*" and AS 1289-2000 "*Method of testing soils for engineering purposes*".

Borehole and monitoring well reports are presented in Appendix A.

Table 1: Borehole Location and Subsurface Conditions Summary

Borehole ID	Coordinates (MGA 94 zone56)		Elevation RL (m AHD)	Depth of Hole (m bgl)	Alluvium (m bgl)	Residual Soil (m bgl)	Termination Comment
	Easting (m)	Northing (m)					
GA-BH01	766833.3	6649360.5	229.65	5.45	0.00-5.45	-	Target Depth
GA-BH02	766754.0	6648898.9	227.52	5.45	0.00-5.45	-	Target Depth
GA-BH03	766672.3	6648488.1	222.40	5.45	0.00-5.45	-	Target Depth
GA-BH04	766512.8	6647904.7	216.84	5.45	0.00-5.45	-	Target Depth
GA-BH05	766489.5	6647229.3	210.98	5.18	0.00-5.18	-	SPT Refusal
GA-BH06	767190.5	6649184.0	233.54	5.45	0.00-5.45	-	Target Depth
GA-BH07	766973.5	6648754.1	228.13	5.45	0.00-3.20	3.20-5.45	Target Depth
GA-BH08	767050.1	6648331.7	222.67	5.45	0.00-2.00	2.00-5.45	Target Depth
GA-BH09	766920.3	6647628.6	216.64	5.45	0.00-5.45	-	Target Depth
GA-BH10	766814.5	6647073.2	212.18	5.45	0.00-5.45	-	Target Depth
GA-BH11	767450.3	6647225.1	215.95	5.45	0.00-2.00	2.00-4.80[1]	Target Depth
GA-BH12	767232.3	6646787.7	213.05	5.45	0.00-5.45	-	Target Depth
GA-BH13	767676.8	6647014.2	216.50	5.45	0.00-5.45	-	Target Depth
GA-BH14	768182.4	6647032.4	216.77	5.27	0.00-5.27	-	SPT Refusal

Borehole ID	Coordinates (MGA 94 zone56)		Elevation RL (m AHD)	Depth of Hole (m bgl)	Alluvium (m bgl)	Residual Soil (m bgl)	Termination Comment
	Easting (m)	Northing (m)					
GA-BH15	766942.4	6646901.1	212.01	5.16	0.00-5.16	-	SPT Refusal
GA-BH16	767508.1	6646657.2	213.86	5.45	0.00-5.45	-	Target Depth
GA-BH17	768205.4	6646622.2	215.21	5.45	0.00-5.45	-	Target Depth
GA-BH18	768602.4	6646887.8	216.78	5.45	0.00-5.45	-	Target Depth
GA-BH19	767528.6	6648090.1	219.89	4.50	0.00-3.80	3.80-4.50	Drill Bit Refusal
GA-BH20	766345.9	6647001.5	210.36	5.45	0.00-5.45	-	Target Depth

Note: [1]Extremely Weathered Rock 4.80 – 5.45 (m bgl) in GA-BH11

3.2 CPTs

Fifteen CPTs with pore pressure measurements (using a compression cone) were performed using a truck mounted CPT rig. The CPT set-up and testing was carried out by Insitu Geotechnical Services Pty Ltd. Real time readings were observed and recorded at the surface with a dedicated laptop computer.

CPTs (designated GA-CPT1 to GA-CPT15) were terminated when the required push rate could not be maintained due to either hard/dense ground characteristics or obstructions up to a maximum depth of 6.0 m bgl. Tests were pushed to depths ranging from 2.05 m to 6.01 m bgl (with the exception of GA-CPT-07). The test at GA-CPT-07 was terminated at 1.23 m bgl, which was insufficient to inform on subsurface parameters. The rig was then shifted slightly offset from the original GA-CPT-07 location and designated as GA-CPT-07A which reached refusal at 0.81 m and the location was abandoned after reaching shallow refusal in two attempts. CPT reports are included in Appendix B.

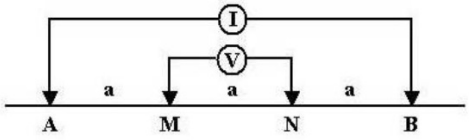
Table 2: CPT Location and Termination Summary

CPT ID	Coordinates (MGA 94 zone56)		Elevation RL (m AHD)	Depth of Test (m bgl)	Termination Comment
	Easting (m)	Northing (m)			
GA-CPT01	766179.4	6647013.9	210.48	6.01	Target Depth
GA-CPT02	768300.6	6646435.1	214.88	6.00	Target Depth
GA-CPT03	769122.1	6646903.9	218.01	5.61	Refusal
GA-CPT04	766813.1	6647076.2	212.20	6.00	Target Depth

CPT ID	Coordinates (MGA 94 zone56)		Elevation RL (m AHD)	Depth of Test (m bgl)	Termination Comment
	Easting (m)	Northing (m)			
GA-CPT05	767489.8	6646865.3	214.53	4.29	Refusal
GA-CPT06	767251.1	6646531.6	212.62	2.48	Refusal
GA-CPT07	767898.9	6646854.2	215.89	1.23	Refusal
GA-CPT07A*	767898.0	6646854.0	215.90	0.81	Refusal
GA-CPT08	766769.0	6647856.4	218.09	2.95	Refusal
GA-CPT09	767282.0	6647974.5	218.52	2.05	Refusal
GA-CPT10	767382.6	6648495.7	224.42	2.14	Refusal
GA-CPT11	766979.1	6648756.2	228.33	6.00	Target Depth
GA-CPT12	766988.0	6649114.1	234.10	5.78	Refusal
GA-CPT13	767389.0	6649056.3	230.55	3.30	Refusal
GA-CPT14	766776.7	6647386.0	213.33	6.02	Target Depth
GA-CPT15	767224.1	6647059.1	214.70	4.36	Refusal

3.2.1 Geophysical Investigation - Electrical Resistivity Soundings (ERS)

The Wenner array electrode configuration consists of four co-linear, equally spaced electrodes inserted into the ground in a straight line. Current is passed through the outer two electrodes whilst voltage (i.e. electrical potential) is measured between the two inner electrodes. The array spacing expands about the array midpoint while maintaining an equivalent spacing between each electrode as shown in **Inset 1,** with measurements of apparent resistivity (ρ_a) of the geological profile recorded during individual surveys.



Inset 1 – Wenner array electrode configuration and relationship for estimating apparent resistivity (ρA). 'A' and 'B' are current electrodes, 'M' and 'N' are potential measurement electrodes, and 'a' is the equi-distant separation between all electrodes.

$$\rho_A = 2\pi\ a \frac{V}{I}$$

A Megger earth resistance instrument (*DET5/3R*) was used to obtain earth resistance readings which by way of a simple mathematical formula were converted to apparent soil resistivity values based on the spacing of the four electrodes (pins). The Megger unit directly produces a resistance value (in ohms) that is converted to an apparent resistivity (in ohm.m).

Electrical Resistivity Soundings (ERS) were completed at a total of nine (9) locations designated as (Wenner 1 to Wenner 9). Where site conditions allowed, two orthogonal Wenner soundings were completed at each location to provide better control on survey results owing to likely anisotropy and heterogeneity of ground conditions. These are labelled as 'Sounding A' and 'Sounding B' in the results section.

Measurements were taken using different electrode "a" spacing of 0.6 m, 1.0 m, 2.0 m, 2.5 m, 5.0 m and 10 m. The conditions onsite limited the testing to be completed to the maximum array length of 10 m at one location (Wenner No 8).

In accordance with ASTM International publication G 57–95a (Reapproved in 2001) titled *Standard Test Method for Field Measurements of Soil Resistivity Using the Wenner Four-Electrode Method*, the electrode depths did not exceed 5% of the electrode spacing.

3.3 Topographic Survey

A topographic survey was carried out by Mitchel Hanlon Consulting between the 6 March and 15 March. The topographic survey maps are provided in Appendix C.

3.4 Laboratory Testing

Laboratory testing was undertaken on selected soil samples collected from the boreholes. Laboratory testing was performed by NATA accredited laboratories, including Soiltech, TriLab Brisbane and ALS Environmental and Golder's Melbourne Laboratory.

Laboratory tests were undertaken in accordance with relevant Australian Standard AS1289 "Methods of testing soils for engineering purposes".

- Moisture content (AS1289.2.1.1)
- Atterberg Limits (AS1289.3.1.2, AS1289.3.2.1, AS1289.3.3.1, AS1289.3.4.1)
- Particle Size Distribution (AS1289.3.6.1)
- Aggressivity suite (pH, Soluble Sulfate and Chloride)
- Thermal Resistivity

4.0 RESULTS OF INVESTIGATION

4.1 Regional Geology

Based on published geological information (i.e. Narrabri 1:250,000 Geological Map) the project site is located in the centre of the Gunnedah Basin (1:1,500,000 Structural Framework Map of NSW map) and comprises of quaternary alluvial deposits of gravel, sand, silt and clay. This overlies the Pilliga Formation (Jurassic) of quartz sandstone, conglomerate and claystone.

4.2 Subsurface Conditions

A summary of typical subsurface conditions encountered in the geotechnical investigation are as follows:

Alluvium: Layers of silty clay, sandy clay and clay, very stiff to hard, down to between 1.5 m to the depth of hole (generally 5.45 m bgl); overlying in places

Residual Soil/Extremely Weathered Rock: Sandstone weathered down and exhibiting clayey sand and sand soil properties. Relic rock structure becoming visible (GA-BH11).

Table 1 summaries the subsurface conditions between alluvium and residual soil/extremely weathered rock. Groundwater was not encountered in any of the boreholes.

4.3 Geophysical Results

A total of nine ERS tests using the Wenner array were completed at the proposed Narrabri Solar Farm site. Two orthogonal tests were conducted at selected intrusive test sites. A summary of the results is provided Table 3 and in the graph below (Plate 1).

The results generally indicate conductive (low resistivity) ground conditions at most sites, with values mostly in the range of 3 Ohm-m to 20 Ohm-m except for the smallest ‘a’ spacing at most locations. The highest apparent resistivity values were observed at GA-CPT11, and the lowest at GA-BH16. The results from the orthogonal tests generally show good agreement.

It should be noted that all results presented in this report are representative of the ground conditions at the time of the survey. The resistivity of the ground can vary due to seasonal factors, including changes in moisture content.

Table 3: Narrabri Wenner Resistivity Results

Test Reference	Test Location	Sounding	Apparent Resistivity (Ohm-m)					
			a-spacing (m)					
			0.6	1	2	2.5	5	10
Wenner 1	GA-CPT11	N-S	34.1	19.4	16.6	14.9	9.1	4.4
		E-W	44.2	22.1	19.0	15.2	10.1	4.0
Wenner 2	GA-CPT02	N-S	9.2	4.1	5.0	7.4	5.0	6.3
		E-W	21.9	7.8	5.5	5.8	5.0	4.4
Wenner 3	GA-CPT03	N-S	13.8	3.5	3.8	3.8	3.5	(Poor Reading)
		E-W	21.3	6.1	4.7	4.0	4.3	3.1

Wenner 4	**GA-BH09**	N-S	30.5	17.6	5.2	4.9	4.4	3.8
		E-W	37.7	16.2	6.4	5.8	4.7	4.0
Wenner 5	**GA-BH16**	N-S	3.5	2.3	1.8	1.5	2.5	3.8
		E-W	4.5	2.2	2.0	2.0	2.5	4.4
Wenner 6	**GA-BH14**	N-S	10.2	5.2	9.0	2.7	3.8	6.3
		E-W	5.1	6.2	2.9	2.8	3.8	5.7
Wenner 7	**GA-CPT04**	N-S	38.5	24.3	11.3	8.8	6.0	5.0
		E-W	35.1	17.3	8.3	7.2	4.7	4.4
Wenner 8	**GA-CPT01**	NE-SW	4.5	4.7	3.0	3.3	3.8	4.4
		NW-SE	11.8	4.6	3.1	3.3	4.1	*1
Wenner 9	**GA-BH18**	N-S	8.8	6.1	3.8	2.8	2.7	3.1
		E-W	16.4	6.2	3.5	3.3	2.5	3.8

*1 Not possible due to space constraints

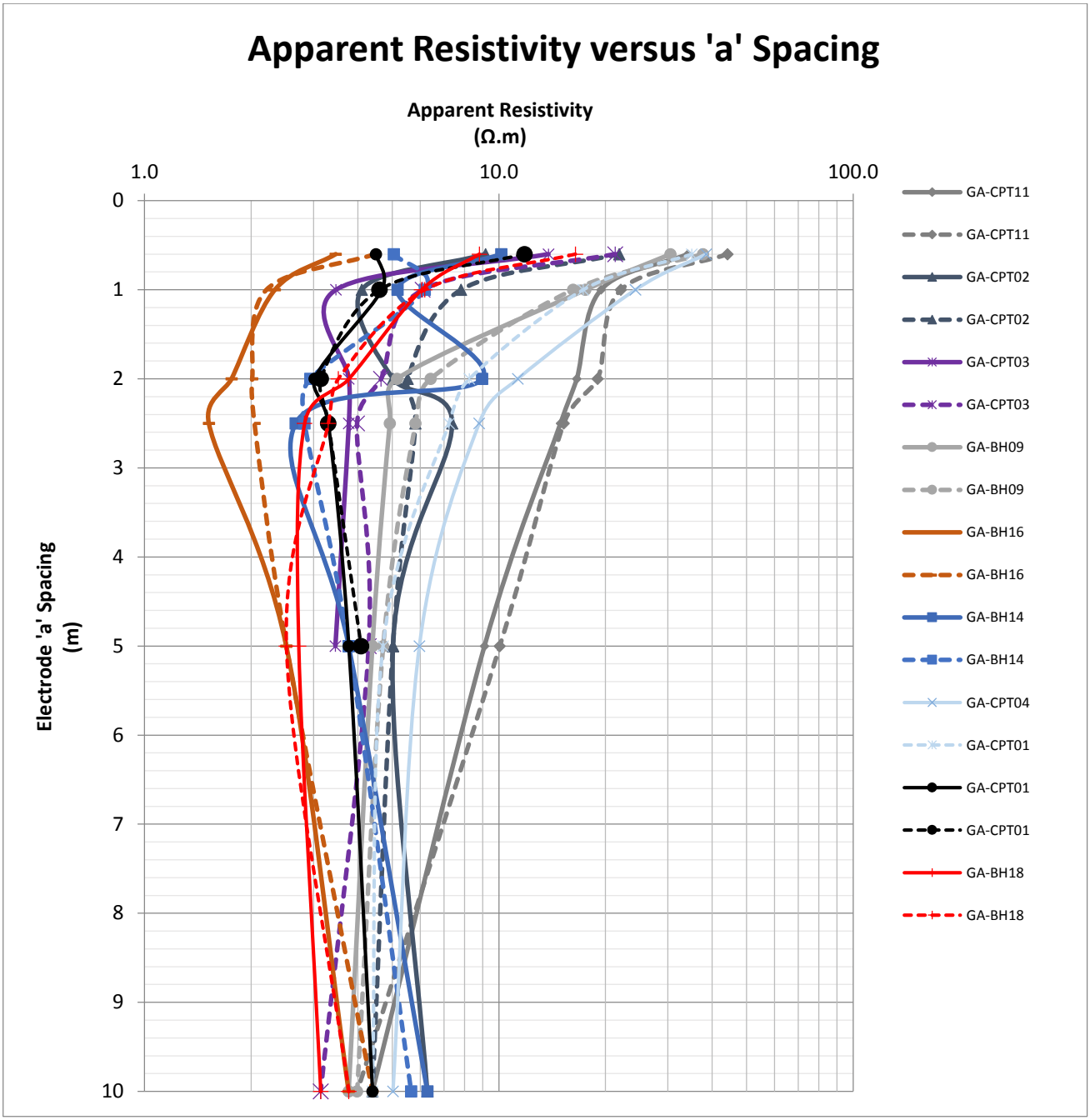


Plate 1: Apparent Resistivity versus 'a' Spacing

5.0 HYDROLOGICAL SETTING

5.1 Hydrometeorology

The climate of the study area is typical of that of the North West Slope and Plains of NSW: long summers, and short winters with infrequent frosts. Maximum temperatures in summer average 34°C; average winter minimum temperatures are as low as 4 to 5°C. Droughts are common.

Average annual rainfall in the Namoi river basin varies from more than 1100 mm/year in the east of the catchment, to about 600 mm/year near Gunnedah and less than 500 mm/year west of Walgett. Locally, average annual rainfall as measured at the Narrabri Airport about 5.7 km southeast of the site to the west of Narrabri is approximately 660 mm.

Rainfall is relatively evenly distributed throughout the year, with minor peaks in the monthly averages during the periods December to March. Average monthly rainfall in these periods can reach 70 to 80 mm, whereas in drier months average rainfall is approximately 40 to 50 mm. Table 4 presents a summary of average monthly rainfall and other relevant historical rainfall data, as measured at Narrabri Airport (BOM, 2018).

Table 4: Average monthly rainfall totals at Narrabri Airport (mm/month)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Mean	83	61	60	38	47	49	45	40	41	51	60	76	659
Lowest	0	0	0	0	0	0.2	0	0	0	0	0	3	298
5th %ile	6	7	0	0	0	5	3	0	1	6	4	12	378
10th %ile	10	9	3	0	1	13	6	4	3	10	8	18	466
Median	60	48	47	20	33	40	38	32	31	49	59	63	661
90th %ile	210	140	138	88	105	92	92	94	97	98	112	156	899
95th %ile	225	154	191	132	137	110	114	107	110	103	126	183	955
Highest	307	220	228	211	196	241	160	160	142	211	204	284	1012

Regionally, average Class A pan evaporation throughout the catchment varies significantly from 1200 mm/year east of Tamworth, to 1600 mm/year near Gunnedah, and 2100 mm/year west of Walgett. Average daily and monthly evaporation rates measured at Tamworth Airport, which is the closest weather station to the site with this data, is presented in Table 5 (BOM, 2018).

Table 5: Average daily and monthly potential evaporation rates Tamworth Airport (mm)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Daily	8.6	8.4	6.9	4.6	2.9	2.0	2.1	3.0	4.4	6.0	7.6	8.7	5.4
Monthly	262	256	210	140	88	61	64	95	134	183	232	265	165

Evaporation is expected to exceed rainfall throughout the year.

5.2 Regional Hydrological Setting

The site is situated in the Namoi River basin which is based around the Namoi, Peel and Manilla rivers. It is bounded by the Great Dividing Range in the east, the Liverpool and Warrumbungle ranges in the south and the Nandewar Range and Mount Kaputar in the north.

The main surface water resource of the Namoi River catchment is the Namoi River. The Namoi River basin drains an area of 42 000 km^2 flowing from east to west from its headwaters in the Great Dividing Range and is one of the Murray-Darling Basin's major sub-catchments in New South Wales.

The average annual flow in the Namoi River at Gunnedah (about 90 km southeast of Narrabri) between 1900 and 2011 was 669 GL. Two of the largest annual flows, 3305 and 3871 GL, were experienced in 1955 and 1956 respectively, both resulted in significant flooding throughout the region with the 1956 flood also resulting in the largest inundation area in the basin. Overall the river has developed an extensive floodplain with around a quarter of the basin prone to flooding.

Mawhinney (2011) states that basic water quality indicators such as electrical conductivity and turbidity were monitored on a monthly basis for the Namoi Water Quality Project study between 2002 and 2007. The study found that majority of sites had median electrical conductivity results that did not meet the Australian and New Zealand Environmental and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australian and New Zealand (ARMCANZ) default trigger values for the protection of aquatic ecosystems of south-eastern Australia of 30 – 350 μScm^{-1}. Despite not meeting the default trigger values of EC the water was still considered suitable for irrigation purposes for plants in this area based on ANZECC salinity tolerance values. The study also noted that the majority of suspended sediments in the Namoi River were derived from the Mooki River and Coxs Creek catchments (to the east of Narrabri) and caused by gully and channel bank erosion; these two catchments are the largest sources of suspended solids to the Namoi River (Commonwealth of Australia, 2018).

Plate 2 shows the flooding extent of the largest flood event in the Namoi river basin in 1956. This flood was attributed to two wetter years due to the La Niña events of 1955 and 1956, with these being the two strongest La Niña events recorded in Australia (Bureau of Meteorology, 2013). Annual total rainfalls for 1955 and 1956 were well above the annual long-term mean at several sites in the basin; for example, annual rainfalls in Narrabri for the two years were 872 and 850 mm respectively (compared to the long-term average of 649 mm/year). Although these are not among the highest rainfalls for the basin, O'Gorman (2010) considered the residual effects of a wetter year in 1955, coupled with the above-average rainfall in 1956, to be the most likely preludes which created the conditions that led to the 1956 flood.

The Namoi river basin also experienced much wetter years in 1963, 1964, 1977, 1978, 1988, 1991, 1999, 2004 and 2010. Flooding extents in these years however were less than that experienced in 1956, possibly due to the flood mitigation effects of Keepit Dam (completed in 1960), Split Rock Dam (completed in 1987) and Chaffey Dam (which was completed in 1979). Green et al., 2011 also state the increased numbers of farm dams capturing runoff and other diversions due to the growth in economic development in the basin (since 1956) may also have had moderating effects on these flood events in the basin.

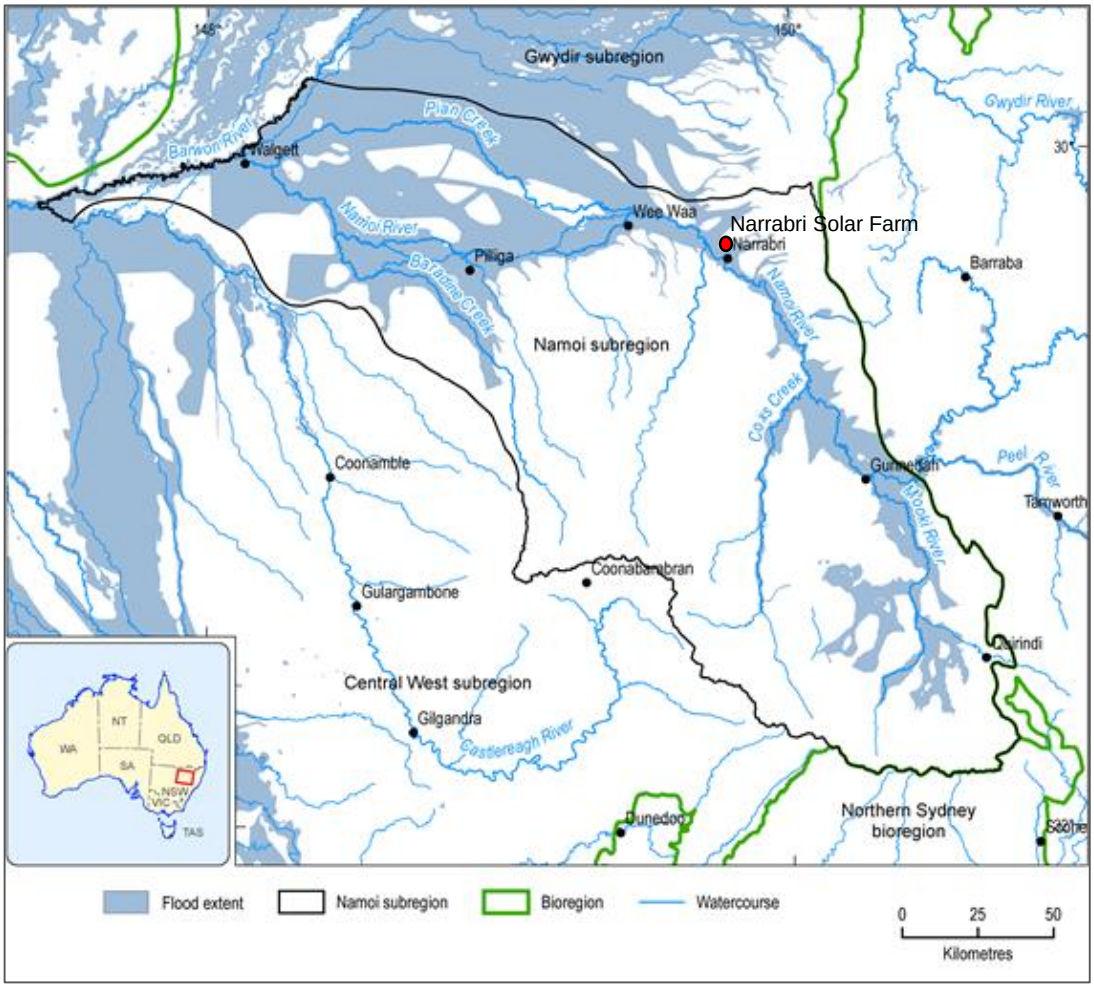


Plate 2: Extent of flooding in the Namoi river basin in 1956

5.3 Hydrological Site Setting

A site visit was undertaken to visually assess waterbodies, watercourses and natural drainage channels at the site. The setting of the site, with an emphasis on key hydrological features of the site, is summarised as follows:

- The site consists of two former grazing properties which consist mostly of broad-acre open grazing land; with the exception of boundary and internal fencing, internal dirt roads, a few dams, two windmills (situated near two registered groundwater abstraction bores) an irrigation channel, the site is essentially devoid of structures or any significant development.
- The highest point at the site is located at an elevation of about 236 m AHD midway along the northern boundary of the site.
- Slopes to the east, south and west of this are generally at about 2 degrees (º) or less and generally flatten to the towards the alluvial plains of the Namoi River floodplain, particularly to the south of the site.
- Surface soils across much of the site appear to be silt or clay dominant whilst ground cover generally consists of a variety of grasses suitable for the grazing of livestock (mostly cows and sheep). Occasional rows of trees are also located around the boundary of the site and along some internal fences whilst a semi-disturbed area of bushland (Pilliga scrub) is also located in the north-eastern corner of the property.
- Several swales have been graded into the central and northern portions of the site, presumably to help direct surface water runoff towards potential holding facilities and minimise potential surface erosion and/or

gullying. These are generally oriented northwest to southeast across these areas and direct surface water runoff roughly to the central portion of the property in these areas.

- Several small dams are located about the site. These are thought to be only a few metres deep at most and appear to be used to retain surface water or pumped groundwater for stock watering purposes.
- Gullying was not observed at the site, nor was any evidence of significant (or even marginal) sheet erosion or scalding associated with rising saline water tables.
- A surface water drainage culvert is situated roughly midway along the eastern boundary of the site (approximate GDA94 – MGA55 grid coordinates 769,160 mE, 6,646,805 mN). The culvert consists of twenty 0.6 m diameter circular drains and passes beneath both the north Northern Tablelands rail line and the Newell Highway.
- An open channel traverses from northwest to southeast across the southern portion of the property. It is about 2 m deep with graded berms on both embankments and appears to join the gated series of channels at the neighbouring property immediately to the south. Discussions with the current owner of the 'access' property indicate the neighbouring property to the south has been used to grow cotton with flood-irrigation the method of water application for these crops.
- A large water storage dam, presumably used to store water for irrigation at the neighbouring property, immediately bounds the western portion of the site's southern boundary.

Surface water features located on site have been presented in Figure 1.

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LEGEND

- Borehole Tests
- CPT Tests
- Wenner Tests
- Railroad
- Road
- Constructed Open Channels
- Constructed Irrigation Retention Ponds
- Site Area
- Cadastre

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994

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CLIENT
ENGIE RENEWABLES AUSTRALIA

CONSULTANT
GOLDER

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DESIGNED	AG
PREPARED	AG
REVIEWED	TS
APPROVED	FH

NOTE(S)

Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

REFERENCE(S)

Railroads: Spatial Services | Department of Finance, Services and Innovation
Roads: Spatial Services | Department of Finance, Services and Innovation
Site Area: © Engie Renewables Australia
Cadastre: Spatial Services | Department of Finance, Services and Innovation

PROJECT
NARRABRI SOLAR FARM

TITLE
SITE SURFACE WATER FEATURES

PROJECT NO.	CONTROL	REV.	FIGURE
1792350	001	1	1

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0 25mm

5.4 Surface Water Runoff Assessment

Hydrology uses design rainfalls to determine or simulate catchment runoff. A hydrologic study includes taking into consideration rainfall, topography, and catchment development to determine catchment runoff. A discrete hydrological model utilising the Laurenson Method was developed for the site using the program XPSTORM, taking into account the factors that contribute to catchment runoff which have been discussed in sections below.

5.4.1 Catchments

Catchments on the Narrabri Solar Farm site have been delineated based on the topographical survey conducted as part of this project and Shuttle Radar Topography Mission (SRTM) survey where site specific survey was not available.

XPSTORM models were developed for the hydrologic routing of catchments shown in Figure 2. The catchment properties applied within the XPSTORM models are provided in Table 6.

Table 6: Narrabri Solar Farm catchments - existing stormwater management

Catchment	Catchment area (ha)	Catchment slope (%)	Impervious (%)
Catchment 1 – reporting to open channel	462.1	0.06	0
Catchment 2 – reporting to discharge point into southern neighbour	1651.0	0.72	0

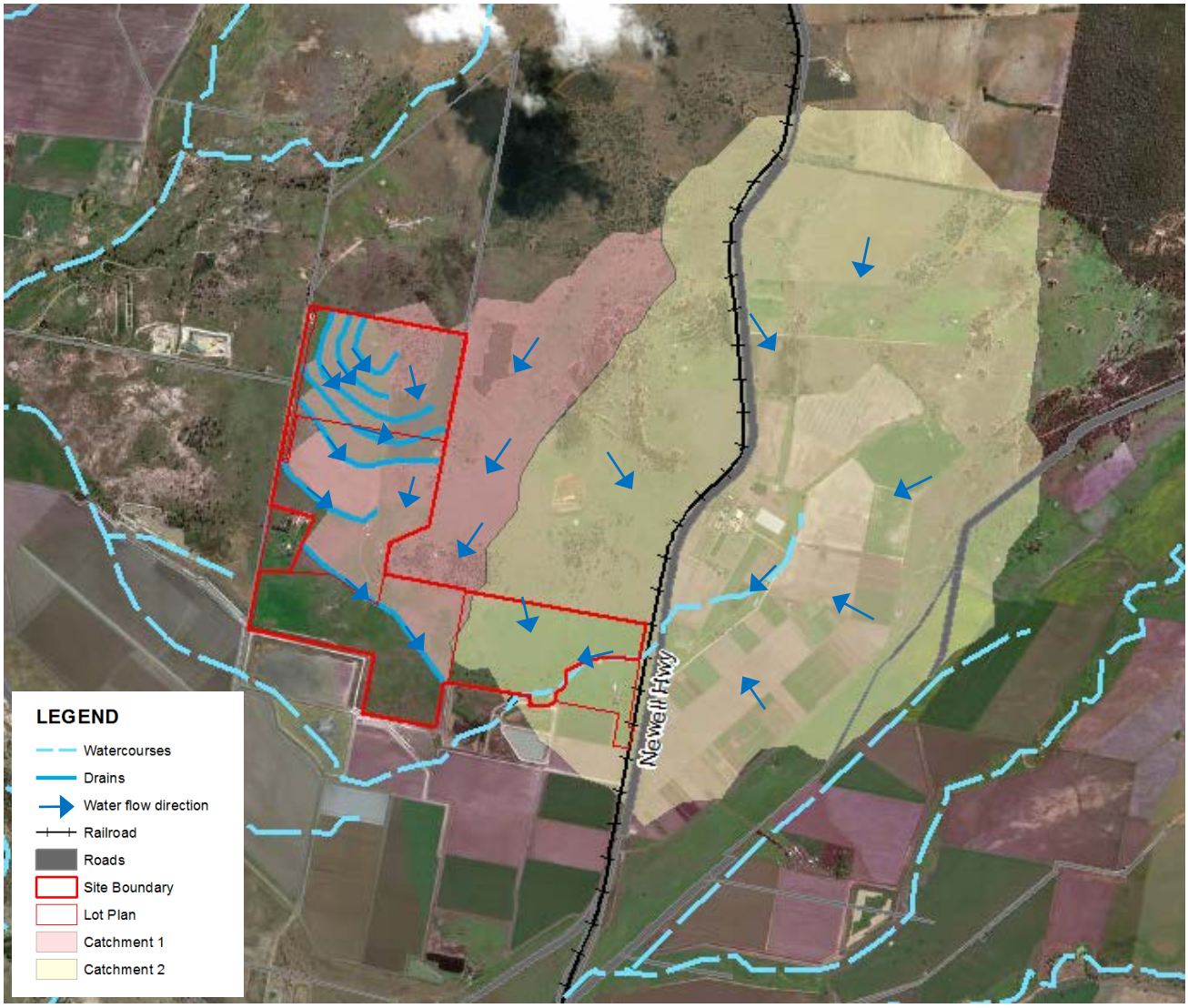


Figure 2: Catchment delineation

The adopted parameters associated with land cover type are presented in Table 7. The manning's roughness coefficients chosen for vegetated cover are typical of grassed cover. Infiltration rates chosen for vegetated cover have been estimated using values from the ARR Data Hub (Geoscience Australia, 2017) typical of the region. Conservatively, impervious areas have been assigned infiltration of 0 mm/hr.

Table 7: Land cover properties

Parameter	Cover Type:	
	Vegetated	Impervious
Manning's n	0.035	0.014
Initial Loss (mm)	43	0
Continuing Loss (mm/h)	0.2	0

5.4.2 Rainfall

Australian Rainfall and Runoff (ARR) (Geoscience Australia, 2016) provides guidance on the estimation of rainfall depths for a range of Annual Exceedance Probabilities (AEP). This estimation is completed for a range of durations and achieved through the development of a site-specific Intensity-Frequency-Duration (IFD) relationship. The Bureau of Meteorology's (BOM) online IFD system was used to derive the IFD relationship for the Narrabri Solar Farm site for 1%, 5%, 10%, and 20% AEP rainfall.

Temporal rainfall patterns represent the distribution of rainfall over a period of time. A wide range of temporal patterns can be observed in nature; the period of peak intensity can occur early, centrally, or late in the storm event. Understanding the variability in representative temporal patterns is important as temporal patterns can cause variation in peak flows between rainfall events of comparable magnitude.

In order to consider this variability, ARR (2016) have generated an ensemble of 10 temporal patterns for each AEP rage, duration, and region. These have been made available on the ARR Data Hub (2017) and the 'Central Slopes' temporal patterns have been incorporated into the hydrologic model.

5.4.3 Peak flows

Peak flow estimates have been modelled using the runoff routing hydrologic model XPSTORM using the Laurenson Method. The method computes storage delay coefficients of each catchment to develop non-linear runoff hydrographs.

ARR (2016) provides guidance about peak flow estimation. Flow representative of the median is determined for each storm duration ensemble. The storm duration associated with the highest median flow is considered the peak flow from the catchment. The hydrological modelling was conducted considering a rainfall events for 1%, 5%, 10%, and 20% AEP. Peak flows obtained from the hydrologic model have been presented in Table 8.

Table 8: Existing Condition Peak flows

Reporting point	Peak flows (m^3/s)			
	1% AEP	5% AEP	10% AEP	20% AEP
Open channel discharge point into southern neighbour	8.5	5.3	4.4	2.9
East catchment discharge point into southern neighbour	54.9	40.2	30.4	20.8

In lieu of infrastructure plans from Engie, a post development hydrological scenarios were run assuming percentage of impervious areas on the site area.

Table 9, Table 10, and Table 11 present peak flows expected for 25% impermeable, 50% impermeable, and 75% impermeable site areas respectively. It is evident that as the percentage of impermeable area increases, peak flows also increase. Increases in peak flows can result in increased erosive forces, overtopping of channels and water storages, and increased flood extents.

Table 9: 25% Impermeable Site Area - Peak flows

Reporting point	Peak flows (m^3/s)			
	1% AEP	5% AEP	10% AEP	20% AEP
Open channel discharge point into southern neighbour	13.9	9.6	7.3	5.6
East catchment discharge point into southern neighbour	56.8	42.7	33.1	21.7

Table 10: 50% Impermeable Site Area - Peak flows

Reporting point	Peak flows (m^3/s)			
	1% AEP	5% AEP	10% AEP	20% AEP
Open channel discharge point into southern neighbour	20.5	14.2	11.7	8.4
East catchment discharge point into southern neighbour	59.8	44.7	34.3	23.4

Table 11: 75% Impermeable Site Area - Peak flows

Reporting point	Peak flows (m^3/s)			
	1% AEP	5% AEP	10% AEP	20% AEP
Open channel discharge point into southern neighbour	26.0	18.7	13.9	12.1
East catchment discharge point into southern neighbour	63.6	46.2	35.6	24.6

5.4.4 Water quality

Sedimentation due to land disturbance is likely to be the most relevant water quality issue for the development of the PV plant. Soil losses expected from existing and expected site conditions have been calculated to give indication of the magnitude of potential water quality issues. The impact of soil losses and resulting sedimentation have been discussed in sections below.

5.4.4.1 Soil loss

The Revised Universal Soil Loss Equation (RUSLE) can be used to predict long-time average soil loss rates from sheet and rill flow.

RUSLE calculates annual erosion rates based on the following equation.

$$A = R.K.LS.C.P$$

Where:

A	=	annual soil loss due to erosion [t/ha/yr]
R	=	rainfall erosivity factor
K	=	soil erodibility factor
LS	=	topographic factor derived from slope length and slope gradient
C	=	cover and management factor
P	=	erosion control practice factor

A summary of RUSLE calculations for existing, during construction (vegetation cleared), and revegetated conditions have been presented in Table 12. Values in the table have been extracted and interpolated from reference tables within the *Best Practice Erosion and Sediment Control* Guideline by IECA (2008).

Table 12: RUSLE calculations

RUSLE factors	Existing (established vegetation)	Construction (cleared vegetation)	Revegetated (newly established vegetation)
R	1800	1800	1800
K	0.025	0.025	0.025
LS	0.24	0.24	0.24
C	0.04	-	0.10
P	-	-	-
A (t/ha/yr)	**0.44**	**10.80**	**1.08**

Assuming some clearing of surface cover vegetation for the construction of the PV plant, soil erosivity is expected to increase significantly compared to existing site conditions.

Under the assumption that vegetation will be re-established after the construction of the PV plant, soil losses will be lessened from the construction phase, however, soil losses greater than pre-construction conditions are to be expected until the vegetation is fully established.

5.4.4.2 Impacts on water quality

Soil losses in the catchment results in sedimentation in runoff. Sediment in runoff from disturbed lands is considered a major source of pollutants in NSW waterways (Landcom, 2004).

Sediment and other suspended solids can:

- affect the growth of aquatic plants,
- impact the suitability of habitats for some aquatic flora and fauna,
- reduce the aesthetic appeal of water,
- reduce the capacity of downstream channels and water bodies, worsening flood impacts,

5.4.4.3 Erosion and sediment control

To minimise the impact of the PV plant development on the environment, erosion and sediment control strategies should be implemented.

Erosion and sediment control principles relevant to this site include the following:

- Fit the project to the existing topography, soils vegetation;
- Minimise disturbance and retain natural vegetation;
- Schedule works to minimise soil exposure during rainy season;
- Vegetate and mulch denuded areas;
- Minimise slope steepness and slope length by using benches, terraces, contour furrows or diversion ditches;
- Utilise channel linings or temporary structures in drainage channels to slow runoff velocities;
- Keep sediment on-site by using sediment traps, or sediment barriers; and
- Monitor and inspect sites frequently and correct problems promptly.

6.0 HYDROGEOLOGICAL SETTING

The hydrogeological setting at and surrounding the site is described in this section. It has been based on information from a number of sources including (but not limited to):

- hydrological and hydrogeological descriptions on the Australian Government's Bioregional Assessments website
- maps and accompanying explanatory notes published by the Geological Survey of New South Wales, the Australian Geological Survey Organisation and the Water Resources Commission of New South Wales,
- Water Sharing Plans prepared by the New South Wales Office of Water
- geological and hydrogeological information presented on the borehole summary worksheets (BSWs) for a number of registered bores obtained from a search of the borehole database held by the New South Wales Department of Industry – Water (DI-W), and
- observations and measurements during a visual inspection of the site.

Where available information was scarce, interpretation has been based on general hydrogeological principles and professional judgement.

Copies of the borehole summary worksheets held by DI-W for all of the registered boreholes discussed in this section are presented in APPENDIX D whilst their locations are shown on Figure 2. Information presented on the worksheets includes the depth of boring in the area, geological formations encountered during drilling, depth to and the type(s) of water-bearing zones encountered, and general information relating to the quality of groundwater in the area.

6.1 Aquifers

The Namoi catchment in the vicinity of Narrabri can be divided into four broad hydrogeological units, two of which are of importance to the site and immediate surrounds. There are:

- The Pilliga Sandstone (which underlies the site and is a significant aquifer in the southern – i.e. New South Wales – portion of the GAB), and

- The alluvial sediments along the alignment of the Namoi palaeochannel which locally comprises the sands, silts, clays and gravels along the low lying river valleys and floodplains immediately to the south and further to the west of the site.

Descriptions of the aquifers in each of these geological units are provided below.

6.1.1 Pilliga Sandstone

The Pilliga Sandstone is a well-sorted coarse-grained sandstone which outcrops in the central part of the Namoi Catchment. It's highly porous and permeable and typically produces high yields of good quality groundwater which has made it an important (and often over-exploited) groundwater resource throughout the Namoi and surrounding catchments.

Three aquifers (or aquifer intervals) in those areas where the Pilliga Sandstone outcrops such as at the site. These are:

- a regionally significant and high yielding confined aquifer hosted within relatively fresh sandstone
- a localised unconfined (i.e. watertable) aquifer hosted within the uppermost weathered zone of the sandstone, and
- possible perched aquifers in those areas where clay-rich lenses may be present in the uppermost weathered zone and above the watertable.

Hydraulic conductivities of the confined aquifers of the Pilliga Sandstone typically range between about 0.1 and 1 m/day. Yields of these aquifers at the time of drilling (as reported in the BSWs) though vary greatly. Yields are typically between about 0.5 and 5 L/s however higher yields of up to about 20 L/s have been noted for some of the deeper bores in the area, one of which (namely GW901095) has been drilled to 162 m and a well installed to 125 m depth.

Little is known about yields in the unconfined aquifers hosted in the uppermost weathered zone of the Pilliga Sandstone. They are though are expected to typically range between about 0.5 and 5 L/s with higher yields in sand-dominant layers.

Yields of any perched aquifers are expected to be low and short-lived owing to the limited and often small volume of water comprising these aquifers.

6.1.2 Nearby Alluvial Aquifers

Alluvial sediments in the Namoi catchment are subdivided into three formations:

- the uppermost Narrabri Formation
- the Gunnedah Formation, and
- the Cubbaroo Formation (which is only present in the Lower Namoi area and not of importance for this assessment).

These formations consist mainly of sand, gravel and clay and their thickness is largely controlled by the bedrock topography.

The Narrabri Formation, which is present to the south and west of the site, is generally 30 to 40 m thick, but can be up to 70 m thick. It consists mostly of extensive clays with minor channel sands and gravel beds and forms an unconfined (i.e. watertable) aquifer which is generally low yielding and of low to medium salinity. The aquifer is highly stressed due to over-extraction and is known to be highly interactive with the Namoi and Mooki rivers.

Aquifers in the underling Gunnedah Formation are confined to semi-confined and comprise moderately to well-sorted sands and gravels with minor clay beds (Kelly et al., 2007; Ransley et al., 2012a). The Gunnedah Formation is the most extensive and productive aquifer throughout the area, yielding good quality water that is used for irrigation, meaning this aquifer has also been highly stressed due to over-extraction in the past. Although unproven, it is thought the Gunnedah Formation may be located closer to Narrabri rather than in close proximity to the site.

The Australian government bioregional assessments website for the Namoi Catchment states in some areas there is little no hydraulic separation between the unconsolidated alluvial formations and they act as a single aquifer (CSIRO, 2007). In other areas however analysis of groundwater hydrograph indicates only minimal connectivity between these aquifers (Kelly et al., 2007; Parsons Brinkerhoff, 2011).

Hydraulic characteristics of the Narrabri and Gunnedah formations are generally well documented. The hydraulic properties of the alluvial aquifers are highly variable, with hydraulic conductivity typically varying between about 0.01 and 30 m/day (Golder, 2010).

Owing to increased proportions of sand and gravels towards the base of the alluvial-infilled paleaochannel, hydraulic conductivity and yields generally increase with depth. This is shown somewhat by the yields quoted on the BSWs for bores GW902817 (situated about 1.5 km south of the site) and GW965355 (about 2.2 km southeast of the site), both of which were drilled about screened in sands and gravels at depths between 70 and 100 m and reported yields of 94 and 75 L/s respectively. In contrast however, yields for other bores drilled in the alluvial sediments to depths of between 20 and 40 m are much lower, typically varying between about 0.5 and 10 L/s regardless of depth.

When considering the above, Kelly et al. (2007) notes that the dominant sediments in these formations are sometimes reversed with clays dominant in the Gunnedah Formation at some locations and sand and gravel dominant in the Narrabri Formation at others.

6.2 Groundwater Management

Groundwater resources in the Namoi catchment are the most intensively developed in NSW and the subregion has one of the highest levels of groundwater extraction within the MDB (CSIRO, 2007). There are over 18,000 bores in the Namoi catchment which are licensed to provide over 343,000 ML of groundwater entitlement per year with aquifer licences covering a variety of purposes including irrigation, industrial, stock and domestic water.

Reference to Plate 3 indicates the site is situated within the Gunnedah-Oxley Basin groundwater management unit (GMU) as defined by the NSW government in accordance with the Murray–Darling Basin Plan for regulation and management purposes. This plate also shows that the alluvial sediments to the south of the site are situated in either the Upper Namoi Alluvium GMU (when upstream and to the east of Narrabri) or the Lower Namoi Alluvium GMU (when downstream and to the west of Narrabri).

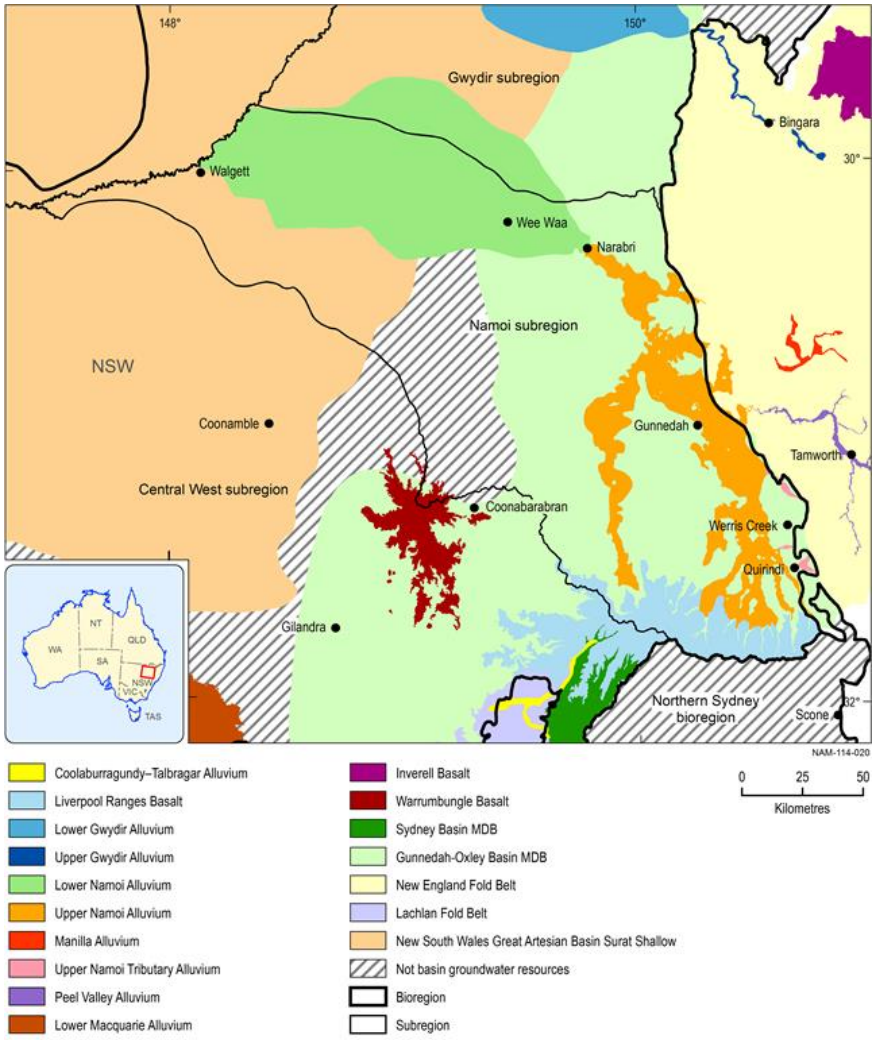


Plate 3: Groundwater Management Units in the Namoi Subregion (SWS, 2011)

Groundwater in the Pilliga Sandstone at the site is managed and regulated under the legislation of two water sharing plans. These are:

- the *NSW Great Artesian Basin Shallow Groundwater* Water Sharing Plan – for groundwater at depths less than 60 m, and
- the *NSW Great Artesian Basin Groundwater* Water Sharing Plan – for groundwater at depths greater than 60 m.

Groundwater in both the Upper and Lower Namoi Alluvium GMUs immediately to the south of the site is managed under two common water sharing plans, namely:

- the *Namoi Unregulated and Alluvial Sources* plan, and
- the *Upper and Lower Namoi Groundwater* plan.

6.3 Groundwater Levels, Flow Directions and Hydraulic Gradients

6.3.1 Pilliga Sandstone

Plate 4 which is modified from the regional potentiometric surface developed for the Surat Basin as part of the Great Artesian Basin Water Resource Assessment, shows that groundwater in the confined aquifers of the Pilliga Sandstone (which is the uppermost unit of the GAB at and in the vicinity of the site) generally flows from the recharge areas in the south-east of the Namoi catchment to the west and north-west. This mirrors the regional surface water flow direction in the Narrabri area as well as the orientation of the Namoi palaeochannel which passes through Narrabri about 2 km south of the site.

Shallow groundwater flow in any unconfined aquifers in the uppermost weathered zone of the Pilliga Sandstone at and in the vicinity of the site is expected to be heavily influenced by the local topography. As such groundwater in these water-bearing zones is likely to flow to the south, southwest and west of the site. It is then expected to discharge to the alluvial aquifers surrounding the Pilliga Sandstone provided there is suitable hydraulic connection (most importantly the absence of any significant clay-rich layers at the top of the sandstone) between these two aquifers.

Hydraulic gradients throughout the catchment vary between about 0.01 in the recharge areas to the east of the site and 5 x 10-4 beneath the alluvial flats to the west. In the vicinity of the site however the hydraulic gradient is estimated to be about 5 x 10-3 with groundwater likely flowing to the southwest or west.

Information provided on the BSWs for those boreholes drilled (and screened) in the confined aquifers within the Pilliga Sandstone both at and surrounding the site suggest confined groundwater-bearing zones are typically encountered at depths of between about 20 and 40 m. Some deeper water-bearing zones (typically about 50 m depth although as deep as 70 m) are also noted, particularly to the northeast of the site, although are not common.

Groundwater in those boreholes drilled and screened in the weathered profile of the Pilliga Sandstone has typically been encountered at depths of between 10 and 20 m; these water-bearing zones are often described as comprising sands, gravels, clays and varying mixtures of these lithologies highlighting the weathered nature of these water-bearing zones.

At the time Plate 4 was produced groundwater heads in the confined aquifers in the Pilliga Sandstone beneath the site were estimated to be at about 210 m AHD. Groundwater flow in these aquifers was estimated to be to the west or southwest in line with the structural orientation and topographic expression of the sandstone in this area. Some variation in the groundwater flow direction could be expected though should there be significant hydraulic connection between the confined aquifers in the Pilliga Sandstone with the alluvial sediments along the Namoi palaeochannel to the south of the site.

Barrett (2012) notes that regionally, groundwater heads in the Pilliga Sandstone are generally above those in the nearby alluvial aquifers.

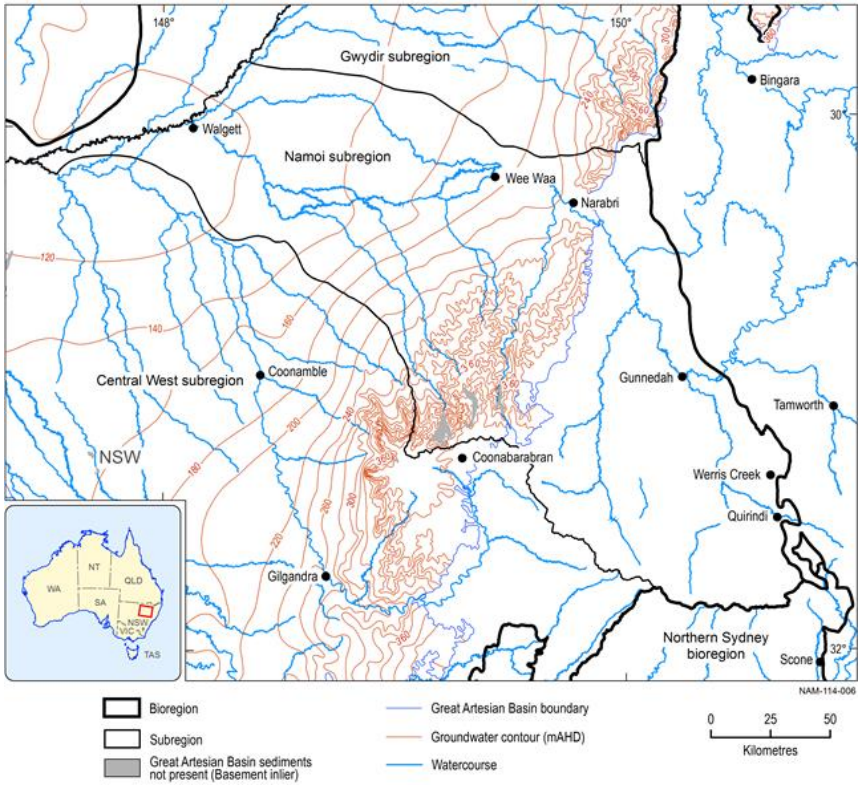


Plate 4: Potentiometric surface of groundwater in the uppermost Great Artesian Basin aquifer (CSIRO, 2012)

6.3.2 Nearby Alluvial Aquifers

Information provided on the BSWs for those bores screened in the alluvial aquifers situated between the site and the Namoi River suggest unconfined groundwater-bearing zones are typically encountered at depths of between about 5 and 10 m. Groundwater levels are typically encountered at similar depths.

Water-bearing zones in the alluvial sediments are often described as consisting of sands, gravels, sandy gravels and clayey gravels. Thicknesses though vary greatly highlighting the varied nature of palaeochannel thickness in the area.

To the south and west of the site groundwater in the alluvial plain aquifers is expected to flow to the southwest before then flowing to the west and northwest along the alignment of the Northern Namoi Palaeochannel.

Regionally, hydraulic gradients in these aquifers indicate groundwater flow is generally from the east in a north-westerly to westerly direction. Plate 5 shows groundwater flow in the Upper Namoi is generally south to north and drains into the Lower Namoi through a bedrock constriction north of Narrabri. Groundwater in the Lower Namoi generally flows from east to west.

At the time Plate 5 was produced groundwater levels in the unconfined alluvial aquifers to the west and south of the site were estimated to be between about 200 and 210 m AHD. As such groundwater heads in the Pilliga Sandstone beneath the site are above those in the nearby alluvial aquifers.

Hydraulic gradients in the alluvial aquifers at and in the vicinity of Narrabri were estimated to be between 1 x 10-3 and 2 x 10-3.

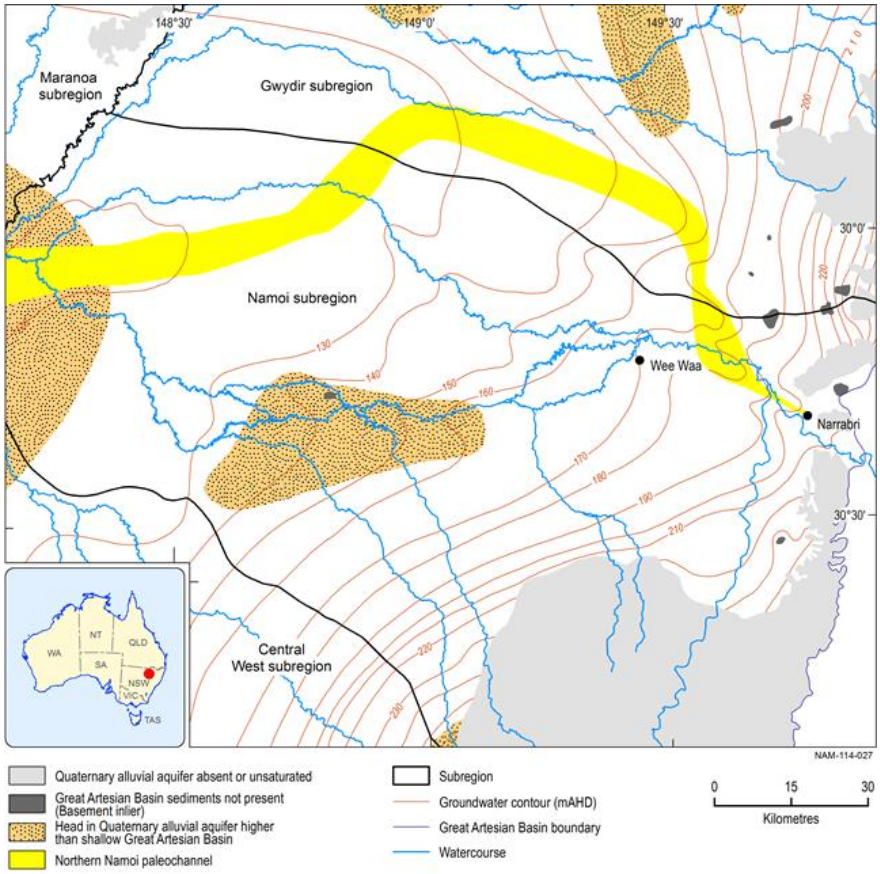


Plate 5: Watertable in the Narrabri Formation (SWS, 2011; Barrett, 2012)

In addition to the above regional studies by NSW Office of Water have shown significant vertical hydraulic gradients also exist in the alluvial sediments within the Namoi catchment. In the Upper Namoi Alluvium GMU to the east of Narrabri there is primarily downward flow of groundwater from the Narrabri to the Gunnedah formations, however vertical hydraulic gradients are reversed in the Lower Namoi Alluvium GMU to the west of Narrabri with these gradients and fluxes increasing with distance to the west.

6.4 Groundwater Recharge

Recharge of the confined aquifers in the Pilliga Sandstone occurs mostly along the south and eastern fringe of the Great Artesian Basin (GAB). It is derived from rainfall and streamflow and has been estimated by Kellett et al. (2012) to be less than two per cent of rainfall.

Recharge of the unconfined aquifers in the Pilliga Sandstone is likely to occur several mechanisms including:

- Infiltration of excess rainfall
- irrigation and other on-farm water losses, in particular when this water is drawn from the deeper confined aquifers in the Pilliga Sandstone or from the nearby alluvial aquifers to the west and south of the site, and
- upward leakage of groundwater from the underlying aquifers.

Recharge to the Narrabri Formation alluvial aquifers to the south and west of the site in the vicinity of Narrabri is likely to occur via:

- leakage from the Namoi River and its tributaries, particularly during major flooding events

- rainfall infiltration
- irrigation (and other on-farm water losses)
- through flow from surrounding aquifers and catchments, and
- upward leakage of groundwater from the underlying aquifers.

Irrigation is thought to constitute a significant component of recharge of the alluvial aquifers. In some areas it may be an important mechanism for rising groundwater and salinity, especially in those areas where cracking clay soils are present. This may be the case at the property immediately to the south of the access property which has been used for the cotton farming (including irrigated crops), however no signs of scalding were observed at the site or immediate surrounds during the site inspection.

6.5 Groundwater Discharge

The discharge of groundwater from the confined aquifers of the Pilliga Sandstone is expected to primarily occur in 'upwelling' areas along the western boundary of the GAB. Locally however some groundwater though may also discharge to the overlying alluvial aquifers to the south of the site via:

- vertical leakage over the surface area of the contact between these units, and
- lateral leakage where the alluvial sediments have infilled palaeochannels which have been eroded into the (underlying and regionally significant) Pilliga Sandstone.

Other discharges from these confined aquifers includes pumping for irrigation, commercial, stock and domestic purposes and evapotranspiration; as mentioned in Section 6.2 the confined water-bearing zones in the Pilliga Sandstone often produce high yields of good quality groundwater which has made it an important (and often over-exploited) groundwater resource throughout the Namoi catchment.

Groundwater in the unconfined aquifers of the Pilliga Sandstone is expected to primarily discharge to the alluvial sediments to the south and west of the site. Groundwater in these aquifers may also be abstracted for a range of uses however are unlikely to be used for irrigation purposes owing to the lower yields typical of these aquifers.

Groundwater in the alluvial sediments in the vicinity of the site are expected to discharge to either (i) the Namoi River, or (ii) deeper alluvial units within the Namoi Palaeochannel, most importantly the Gunnedah Formation.

Other discharges from both the alluvial aquifers includes pumping for irrigation, commercial, stock and domestic purposes and evapotranspiration.

No springs or 'soaks' were observed at or in the vicinity of the site. It is noted however that the assessment was carried out in a relatively dry period and no significant rain is thought to have fallen in the area for some time.

6.6 Aquifer Connectivity

6.6.1 Pilliga Sandstone (and Underlying GAB Aquifers)

Regionally the degree of connectivity of the confined aquifers of the Pilliga Sandstone with the overlying alluvial sediments is generally low owing to the presence of a well-developed saprolite layer at the top of the sandstone. There may though be significant hydraulic interaction between the Pilliga Sandstone and the alluvial aquifers where these sediments have infilled the Namoi palaeochannel(s) which have been eroded into the top of the Pilliga Sandstone (thereby removing the saprolite layer limiting groundwater fluxes between these units).

In stating the above it should be noted that groundwater pressures in the confined aquifers of the Pilliga Sandstone (and indeed in many of the aquifers within the GAB) have fallen significantly since it was first tapped for groundwater abstraction. As such upward fluxes of groundwater may increase should recent basin-wide

water management strategies implemented in the southern portion of the GAB result in increased groundwater resources and groundwater pressures in these aquifers.

A high degree of connectivity is expected between the unconfined aquifers in the uppermost weathered zone of Pilliga Sandstone and the alluvial sediments, particularly along the margins of the alluvial sediments where they overlie the Pilliga Sandstone.

6.6.2 Nearby Alluvial Aquifers

Interaction of the alluvial aquifers throughout the area is likely to be greatest via both horizontal and vertical connections within and between other alluvial aquifers; this is likely to be most notable between the Narrabri Formation and underlying Gunnedah Formation closer to the township of Narrabri.

As discussed above some interaction with the Pilliga Sandstone (and deeper GAB aquifers) is also expected along the margins of deep alluvial palaeochannels throughout the area.

6.7 Groundwater Quality

Plate 6 (Green et al., 2011 as shown on the Australian Government bioregional assessment website) shows the suitability of groundwater in the Namoi Catchment (based on salinity) for various uses. It suggests that groundwater at the site (i.e. within the Pilliga Sandstone) is likely to have total dissolved solids (TDS) contents of between 500 and 1,500 mg/L and therefore be suitable for a number of purposes including domestic, stock and some irrigation uses; groundwater in the alluvial sediments to the south and west of the site is likely to have TDS contents of less than 500 mg/L and therefore be suitable for stock, domestic, municipal supply and most irrigation purposes.

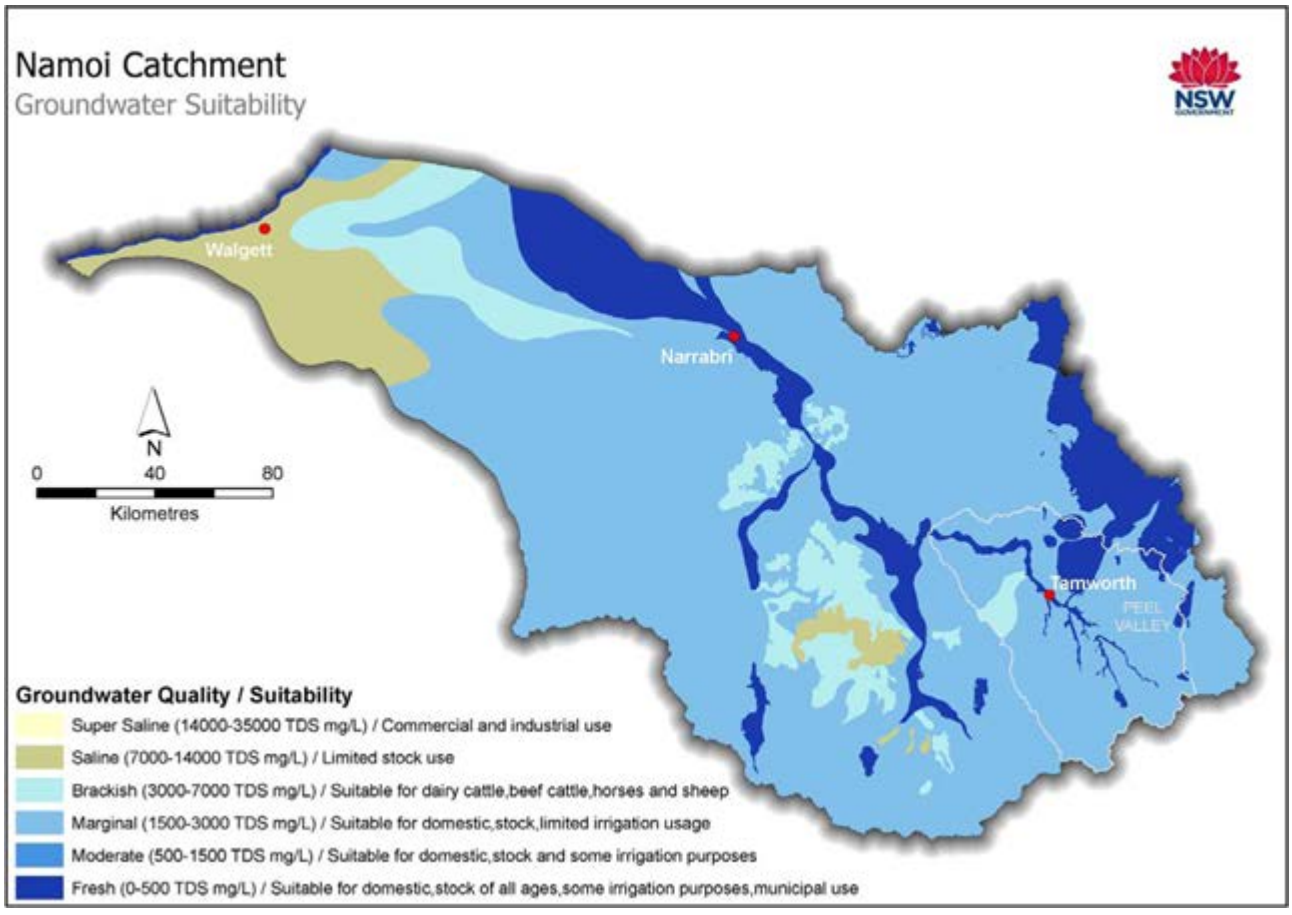


Plate 6: Alluvial groundwater quality and suitability in the Namoi area (Green et al., 2011).

The BSWs for those boreholes drilled within a 5 km radius of the site indicate that groundwater throughout the area is generally of 'good' quality with a few occurrences of 'fresh' groundwater also noted. Most of these boreholes were drilled and screened in the Pilliga Sandstone, whilst several of those boreholes located on the alluvial flats to the south of the site have also been drilled and screened in the (underlying) Pilliga Sandstone; this may be due to the presumably clay-rich nature of the alluvial sediments near the site and the well documented yields available from the Pilliga Sandstone.

Groundwater in Borehole GW012154, which was drilled in the northern portion of the site and screened across clay and sand water-bearing zones in the Pilliga Sandstone, reportedly encountered 'good' quality groundwater during drilling. This borehole was drilled to 76 m below ground level and the well installed to 57 m depth with water-bearing zones encountered between about 11 and 57 m below ground level. On completion of drilling groundwater was noted at about 7 m depth highlighting the confined nature of groundwater in the screened water-bearing zones.

BSWs indicated three bores located between 200 and 400 m to the south of the access property all encountered groundwater with TDS concentrations of about 500 mg/L. These bores were drilled to depths of between 78 and 95 m and screened in sandstones and gravels of the Pilliga Sandstone, in the case of Borehole GW012138 beneath the overlying alluvial sediments.

Only one registered borehole (namely GW071333) had a water quality descriptor of 'fair' on its BSW. This borehole was drilled in the Pilliga Sandstone about 3 kilometres northeast of the site and was screened between 24.5 and 36.5 m depth across upward-fining sand sequences thought to be weathered sandstone. The standing water level in this bore post drilling was about 15 m below ground level whilst the bore was reported to have a yield of about 3.7 L/s.]

No occurrences of brackish or saline water were noted on the BSWs for those bores drilled in a 5 km radius of the site.

Further abroad, Plate 6 shows that the salinity of groundwater to the east and upstream of Narrabri is generally less than 1500 microsiemens per centimetre (µS/cm). There are though some areas of brackish and saline groundwater about 100 km southeast of Narrabri. Parsons Brinckerhoff (2011) also states results of hydrogeochemical sampling of alluvial groundwater in the Upper Namoi indicate the following.

- Groundwater in the Narrabri Formation sodium and chloride dominant.
- Major ion chemistry of groundwater in the Gunnedah Formation is spatially variable suggesting this aquifer is laterally discontinuous with zones of differing salinity and major ion composition.
- Furthermore a change of major-ion chemistry has occurred in some of these bores, particularly those in which salinity is increasing
- Groundwater quality has deteriorated in some bores in the Narrabri Formation with these bores no longer suitable for stock purposes.
- Some bores in the Gunnedah Formation showed a long-term increasing trend in salinity which is attributed to either:
  - downward leakage of saline water where aquitards are thin or absent, and/or
  - leakage of saline water from clay aquitards as a result of depressurisation where persistent abstraction has occurred.

- Processes influencing the major ion composition of groundwater include mixing, ion exchange, weathering of silicate minerals and clays and dissolution and precipitation of minerals such as carbonates and gypsum.

Plate 6 also shows that groundwater salinity generally increases away from the main recharge areas in the east, ultimately becoming super-saline in and around the township of Walgett about 160 km west of Narrabri. Welsh et al. (2014), as noted on the Australian government Bioregional assessments website, also states the results of recent groundwater level and geochemical sampling of alluvial groundwater in the Lower Namoi catchment indicates the following.

- Groundwater levels downstream of Narrabri have declined between 1.5 to 4 m since the late 1970s
- Chloride and sodium are, and remain, the dominant anion and cation in all alluvial aquifers.
- The beneficial use of groundwater has deteriorated at some bores in the Narrabri Formation (now no longer suitable for stock), Gunnedah Formation (now no longer suitable for some crops including cotton) and Cubbaroo Formation (no longer suitable for some crops including cotton).
- Some Gunnedah Formation bores showed a long-term increasing trend in salinity which was attributed to:
  - vertical leakage of saline water from the upper aquifer, and
  - saline intrusion of pore waters.

6.8 Groundwater Utilisation

Groundwater in the area is predominantly used for a combination of domestic, stock and irrigation purposes; of the fifty-four bores located within a 3 km radius of the site, all but a handful are registered for such use.

Bores registered for irrigation purposes are primarily located to the northeast and south of the site. Yields at the time of drilling were reported to vary between about 0.2 and 20 L/s in those bores drilled in the Pilliga Sandstone, and 2 and 94 L/s for those bores drilled solely in the alluvial sediments to the south of the site. In general, yields appear to increase with bore depth with several of the bores licenced for irrigation purposes some of the deepest in the vicinity of the site.

No boreholes registered for municipal supply purposes were identified in the study area.

7.0 GROUNDWATER MONITORING

Both the NSW Office of Water (NOW) and NSW Department of Planning and Environment (DP&E) were contacted as to any groundwater monitoring requirements they may have for the planned development. Neither though could provide any comment or advice regarding whether the monitoring of groundwater quality or levels would be required prior to and/or during the life of the development. Both though stated that groundwater monitoring may be required once any environmental assessment documentation for the planned development is presented to these departments and reviewed.

In stating the above it is considered beneficial should some preliminary level of groundwater and rainfall monitoring may be beneficial in light of potential groundwater salinity issues that may arise at the site as a result of the storage of water in the dams immediately to the south of the site (which should they leak may cause waterlogging and possibly the salinisation of shallow groundwater and soils), as well as any future change in water policy in the Namoi Catchment.

Recommended groundwater and rainfall monitoring is summarised in the following sections.

7.1 Groundwater Levels

Groundwater levels should be measured and monitoring in four new groundwater monitoring wells to be installed along the southern boundary of the site. Recommended locations for groundwater monitoring wells is summarised in Table 13.

Table 13: Recommended groundwater monitoring well locations

Borehole ID	Easting (mE†)	Northing (mN††)	Depth (m)	Screened Interval (m bgl$^{\Psi}$)	Target Aquifer of the Pilliga Sandstone
ENG-GW-01$^{\varepsilon}$	766,145*	6,647,035*	10*$^{\Omega}$	5 - 10*$^{\Omega}$	Unconfined aquifer of the Pilliga Sandstone
ENG-GW-02$^{\varepsilon}$	767,060*	6,646,770*	10*$^{\Omega}$	5 - 10*$^{\Omega}$	Unconfined aquifer of the Pilliga Sandstone
ENG-GW-03$^{\varepsilon}$	767,140*	6,646,330*	10*$^{\Omega}$	5 - 10*$^{\Omega}$	Unconfined aquifer of the Pilliga Sandstone
ENG-GW-04$^{\varepsilon}$	768,300*	6,646,430*	10*$^{\Omega}$	5 - 10*$^{\Omega}$	Unconfined aquifer of the Pilliga Sandstone

Notes:† metres east (MGA94, Zone 56)

†† metres north (MGA94, Zone 56)

‡ metres Australian Height Datum

Ψ metres below ground level

* estimate only and should be verified in the field

Ω estimate only and should be revised based on the geological profile encountered during drilling

Groundwater level measurements should be collected:

- Weekly when daily rainfall totals is 5 mm or less, and
- Daily for one week following rainfall events where daily rainfall totals exceed 5 mm.
- Groundwater levels should be monitored weekly and could be monitored using:
- an electric water level ‘dip’ meter with an accuracy of 5 millimetres, and/or
- automatic water pressure transducers and data loggers.
- Should automated water pressure transducers and data loggers be used, these should be suspended from the well casing or a purpose-build suspension ring using stainless steel cable, and the loggers placed at the base of the wells. Vented units should be used, however should non-vented units be used then an accompanying atmospheric pressure transducer and data logger should also be installed in one of the wells and suspended above the water table.
- Groundwater levels, referenced to metres Australian Height Datum, should be plotted on a series of hydrographs

7.2 Groundwater Quality

Groundwater samples should be collected from each of the groundwater monitoring nominated in Section 7.1 every three months and be submitted for laboratory analysis for the following parameters.

- Fluid pH
- Total dissolved solids
- Major anions (sulphate, chloride, carbonate and bicarbonate)
- Major cations (sodium, potassium, calcium and magnesium)

- Fluoride, and
- Total anions and cations.
- Measurements of fluid pH, electrical conductivity, redox potential, dissolved oxygen and temperature should also be recorded during sample collection.

7.3 Rainfall

Total daily rainfall at the site should be recorded using a rain gauge.

Daily rainfall totals should be presented on the groundwater hydrographs for each groundwater monitoring well to help assess the likely influence of rainfall recharge on groundwater levels at the site.

8.0 LABORATORY TESTING

The laboratory test results are summarised in Appendix E and the laboratory report sheets are included in Appendix F.

9.0 GEOTECHNICAL ENGINEERING ASSESSMENT

9.1 Geotechnical Design Parameters

Geotechnical parameters relevant to each of the encountered soil types have been assessed based on borehole observations, in situ test results, and correlations based on previous experience, engineering judgment and published references. The assessed range of geotechnical parameters for each soil type is listed in Table 14.

Table 14: Geotechnical Soil Parameters for Narrabri Solar Farm

Material Type	Consistency/ Density/ Strength	Unit Weight (kN/m3)	Undrained		Drained	
			Cohesion (kPa)	Friction Angle (Degrees)	Effective Cohesion (kPa)	Effective Friction Angle (Degrees)
Clay (including Silty Clay, Sandy Clay and Gravelly Clay)	Very stiff	18-19	100-200	-	0-10	27-29
	Hard	19 – 21	200-400	-	0-15	27-30
Clayey Sand	Medium Dense	17-19	-	-	0-5	30-35
	Dense and Very Dense	18-20	-	-	0-5	35-40
Sand	Medium Dense	17-19	-	-	-	30-35
	Dense to Very Dense	18-21	-	-	-	35-40
Clayey Gravel	Dense	19-21	-	-	0-5	40-45

Material Type	Consistency/ Density/ Strength	Unit Weight (kN/m3)	Undrained		Drained	
			Cohesion (kPa)	Friction Angle (Degrees)	Effective Cohesion (kPa)	Effective Friction Angle (Degrees)
Gravel (including Sandy Gravel)	Dense	19-21	-	-	-	40-45

It should be noted that for the range of strength parameters provided in Table 14, the minimum value shown for each consistency/density classification should be adopted in assessing footing design parameters to account for the minimum strength value(s) which may be present or which could result due to natural moisture variation.

9.1.1 Young's Modulus and Poisson's Ratio

The Young's modulus and Poisson's ratio for the stratigraphy encountered is listed below:

Table 15: Young's (Elastic) Modulus and Poisson's Ratio

Material Type	Consistency/Density/ Strength	Elastic Modulus E'	Poisson's Ratio v'
Sand	Medium Dense	10-30	0.3
	Dense to Very Dense	25-100	
Gravel	Dense to Very Dense	100-200	0.3
Clay	Very Stiff	15-35	0.4
	Hard	30-60	0.40

9.1.2 Earth Pressures

Where fully drained retaining walls could permanently retain cuts at the site. Lateral pressures on walls that are not surcharged and retain horizontal backfill materials could be based on parameters outlined in Table 16. The 'at-rest' values should be adopted where walls are rigid and only limited movements can be tolerated. (i.e. rigid/propped retention).

Table 16: Earth Pressure Parameters

Material Type	Consistency/Density /Strength	Active Earth Pressure coefficient k_a^*	Passive Earth Pressure Coefficient k_p^*	At rest Lateral Earth Pressure Coefficient k_0^*
Clay (including Silty Clay, Sandy Clay and Gravelly Clay)	Very Stiff to Hard	0.34 – 0.38	2.7 – 2.9	0.9 – 1.0
Clayey Sand	Medium Dense	0.34 – 0.37	2.7 – 2.9	0.5 – 0.55

Material Type	Consistency/Density /Strength	Active Earth Pressure coefficient k_a*	Passive Earth Pressure Coefficient k_p*	At rest Lateral Earth Pressure Coefficient k_0*
	Dense to Very Dense	0.26 - 0.33	3.0 - 3.8	0.4 - 0.5
Sand	Medium Dense	0.34 – 0.37	2.7 – 2.9	0.5 – 0.55
	Dense to Very Dense	0.26 - 0.33	3.0 - 3.8	0.4 - 0.5
Clayey Gravel and Gravel	Dense	0.2-0.25	3.9 - 4.5	0.30-0.40

9.2 Earthquake Actions:

A review of the 'Earthquake action in Australia' (AS 1170.4 - 2007) indicates that the site has a very low probability of an earthquake occurring. Based on AS1170.0 (2002) the site has been classified as per its Table 3.1 as having an importance level 1 and as a Class Ce – shallow soil as per Clause 4.2.3. According to Table 4.1 in AS1170.4 this type of soil is not required to be designed for earthquake actions.

9.3 Liquefaction assessment

The site is generally composed of well consolidated materials (i.e. stiff to hard alluvial clays and medium dense to very dense alluvial clayey sands underlain by residual soils) which are not prone to liquefaction. In addition to this, these are not saturated soils (i.e. no groundwater table was encountered from the investigations) such that excess pore pressures cannot develop. Based on these information, liquefaction cannot take place within the bounds of the area investigated.

10.0 EARTHWORKS

10.1 Earthworks Preparation

In preparing the site for structures and pavement support the area is to be cleared, grubbed and proof rolled. This includes clearing tree roots, stripping and stockpiling of surficial soils and deleterious material prior to subgrade preparation. The unsuitable material is specified in AS3798-2007 clause 4.3 and may be utilised for landscape bunding.

The soils encountered onsite should be suitable for reuse as fill onsite as required once all unsuitable material has been removed. Special consideration should be given for the following:

- High plasticity clay requires strict moisture and density control,
- Over-wet materials (in the event of rainfall) will need to be removed if unable to be dried out during project construction.

Exposed subgrade should be proof-rolled using a 10 tonnes dual axis water truck (or similar) with moisture control to confirm the suitability of the subgrade. Soft unsuitable, over-wet and unsuitable material should be removed and replaced with suitable select fill placed and compacted to appropriate specifications. The minimum relative compaction for general fill should have a minimum density ratio or 95% for cohesive soils and a minimum density index of 70% for cohesionless soils. It is recommended that the layers be placed in 200 mm thickness in large open areas as the site generally contains high plasticity clayey material. It is not recommended to use high plasticity clay for road foundation construction purposes.

Reference should be made to AS3798-2007 (Earthworks for Residential and Commercial Developments) for guidelines in relation to earthworks procedures as well as geotechnical supervision and testing requirements. Earthworks should be carried out under Level 1 supervision as defined in AS3798.

10.1.1 Trenches

Excavation of trenches for service installation should consider lateral changes in ground conditions to surrounding undisturbed soil. It should be noted that cohesive soils can have a bulk up of 20-40%.

10.1.2 Excavation

The materials encountered onsite are considered to be suitable to be excavated using powered excavation plant. Should distinctly weathered rock be encountered high powered excavation plant with ripping tools may be required.

11.0 SOIL AGGRESSIVITY

Laboratory tests were carried out on representative samples to determine soil aggressivity towards concrete and steel. Results of the laboratory tests together with the exposure classification to AS2159-2009 (Table 6.4.2(C) and 6.5.2(C) is reported in Table 17 below. The soil conditions are B for all samples (soil above the groundwater table).

Table 17: Summary of Exposure Classification

Investigation Location	Depth	pH	Saturated Resistivity (ohm.cm)	Sulfate as So_4^{2-} (mg/kg)	Chloride (mg/kg)	Exposure classification	
						Concrete	Steel
GA-BH02	0.6-1.05	8.9	770	160	190	Non -aggressive	Moderate
GA-BH04	2.0-2.45	5.4	390	410	690	Mild	Moderate
GA-BH07	2.0-2.45	8.6	1480	110	20	Non -aggressive	Mild
GA-BH08	0.5-0.95	8.2	450	1040	150	Non -aggressive	Moderate
GA-BH09	0.5-0.67	9.0	1150	150	140	Non -aggressive	Mild
GA-BH10	2.0-2.36	9.7	700	100	60	Non -aggressive	Moderate
GA-BH14	3.5-3.95	9.7	310	520	910	Non -aggressive	Moderate
GA-BH17	5-5.45	10.0	360	70	330	Non -aggressive	Moderate

12.0 FOUNDATION RECOMMENDATION

12.1 Shrink-Swell Characteristics and Site Classification

According to the *Assignment of AS2870-2011 soil suction change profile parameters to TMI derived climatic zone for NSW* by Barnett and Kingland, the site is located within Climatic Zone 5 (semi arid) where the depth of suction change is estimated to be of the order of 4.0 m and the depth of cracking is 2.0 m. This indicates that significant ground movement can occur above this depth in medium or high plasticity soils due to seasonal moisture content changes which may occur.

Surface movement has been calculated using AS2870-2011 Residential Slabs and Footings based on shrink swell index and depth of seasonal moisture change and the profiles within the boreholes at this site. The characteristic surface movement has been estimated to range from 60 to 110 mm. Classes ‘H2-D’ to ‘E-D’ for

the Narrabri site have been assessed according to the level system within AS2870-2011. This classification is based on the six shrink swell index laboratory testing, and is considered our best estimate.

12.2 High Level Footings Parameters

High level footings may be required for equipment on site. To reduce differential movements resulting from soil reactivity, shallow footings will need to be adequately stiffened and integrated. Founding the shallow footing below the depth of seasonal moisture variation is not considered to be achievable in most places on site (which has been assessed as 4.0 m depth). Spread footings founded in clay soils above the assessed depth of seasonal moisture change, will potentially be subject to seasonal ground movements.

To reduce footing movements resulting from seasonal moisture effects, footings will need to be integrated as stiffened rafts; embedded to found in relatively moisture stable strata; or founded in and supported by a non-swelling structural fill platform. If granular fill is used in platform construction then the fill should contain adequate fines so that surface water does not collect within the fill platform. High level footing systems supported by the natural strata or fill platforms should be designed to accommodate the site classification discussed in Section 12.1.

Allowable (working stress) values for footings to be founded in the natural material or compacted fill platforms are given in Table 18 and based on a factor of safety of 2.5 for expected ultimate geotechnical capacities. These values assume that suitable base preparation has been carried out, and for granular material the square footings are 1 metre square with a depth of embedment of 0.5 m. The values provided for granular material will vary depending of the footing size and the embedment depth. The ground strength profile is assumed to be uniform through each layer (with no underlying lower strength material). The values provided in Table 18 are not valid for eccentric loads.

Table 18: Bearing Capacity for Shallow Footings

Material Type	Consistency / Density	Allowable Bearing Capacity (kPa)	Ultimate Bearing Capacity (kPa)
Clay (including Silty Clay, Sandy Clay and Gravelly Clay)	Very Stiff	200 – 400	500 – 1000
	Hard	400 - 600	1000 - 1500
Clayey Sand / Sand	Medium Dense	150-300	375-750
	Dense to Very Dense	300-400	750-1000
Clayey Gravel and Gravel	Dense	300-400	750-1000

Foundation excavations should be inspected by a suitably experienced geotechnical engineer or geotechnician prior to footing construction to confirm that the actual founding conditions are consistent with the design parameters. In wet-weather periods, surface water inflows or groundwater ingress should be controlled to prevent potential changes in moisture condition and associated shrink-swell effects and deterioration of the shallow founding strata at formation levels. Any structural elements supported by high level footings will need to be able to move relative to adjacent elements supported by bored piles and founded in moisture stable strata.

12.3 Pile Foundations Parameters

Allowable geotechnical strength values for end bearing capacity and shaft adhesion for bored pile design provided in Table 19 have been based on the basic geotechnical strength reduction factor (ϕ_{gb}) for low redundancy, very low to low risk applications which is specified in Table 4.3.2(C) of AS2159-2009. The basic geotechnical strength reduction factor applicable to this site can be considered to be 0.61 from ultimate values. The values presented in Table 19 are valid for piles with length to diameter ratio not less than 4.

Pile design recommendations and minimum depths will be largely dependent on the plasticity of soils in contact with the shaft. Potential shrinkage away from the pile shaft to the depth of seasonal moisture change (i.e. expected to be 4 m) should be allowed for in design. The minimum pile depth embedment will therefore be dependent on the geotechnical capacity requirements for the soil/rock strata below the seasonal moisture variation depth to support the design loadings.

Table 19: Bearing Capacity for Pile Foundations

Material type	Consistency / Density	Allowable		Ultimate	
		Skin friction (kPa)	End bearing (kPa)	Skin friction (kPa)	End bearing (kPa)
Clay (including Silty Clay, Sandy Clay and Gravelly Clay)	Very Stiff	20-30	350-700	50-70	900-1800
	Hard	30-60	700-1400	70-140	1800-3600
Clayey Sand / Sand	Medium Dense	2-4	200-800	5-10	500-2000
	Dense to Very Dense	4-8	800-1600	10-20	2000-4000
Clayey Gravel and Gravel	Dense				

12.4 Wind Load and Preliminary Pile Depth

AS1170.2-2011 is the Australian standard for wind action but does not specifically deal with solar farms. For the purpose of determining the design wind speed, we have anticipated that the solar panels would be up to 0.5 to 1.0 m above ground level and that the solar farm design life is 50 years. The design wind pressure, p [in Pa] is provided in Section 2.4.1 of AS1170.2-2011 and defined as

$$p = (0.5\ \rho_{air})\ [V_{des,\theta}]^2\ C_{fig}\ C_{dyn}$$

Where

- Design wind speed, $V_{des,\theta} = V_{sit,\beta} = V_R\ M_d\ (M_{z,cat}\ M_s\ M_t)$
- Air density, ρ_{air} = 1.2 kg/m^3
- Aerodynamic shape factor, C_{fig} = -0.8 to -2.2 — For tilt up to 30° based on Table D4A in Appendix D of AS1170.2-2011 where the area reduction factor (K_a) and local net pressure factor (K_l) is equal to unity.
- Dynamic response factor, C_{dyn} = 1.0 — Wind farms are considered to not be dynamically wind sensitive.
- Regional wind speed, $V_R = V_{50}$ = 39 m. s^{-1} — For a design life of 50 years and the site located in Wind Region A1 according to Figure 3.1(A) of AS1170.2-2011.

- Wind direction multiplier, Md = 1.0 — Based on Table 3.2 of AS1170.2-2011. The wind direction being unknown for the site and could come from any direction.
- Terrain/height multiplier, $M_{z,cat}$ = 0.88 — The site was classified as Terrain Category 2.5: *Terrain with a few trees or isolated obstructions* with multiplier averaged between TC2 and TC3 in Table 4.1 of AS1170.2-2011.
- Shielding multiplier, M_s = 1.0 — The shielding has been considered as nil according to Table 4.3 of AS1170.2-2011.
- Topographic multiplier, $M_t = M_h$ = 1.0 — For H/2Lu < 0.05 according to Table 4.4 of AS1170.2-2011.

Using the above assumptions, the design wind pressure, p (uplift) is estimated to range from 0.55 to 1.5 kPa for solar panel tilt up to 30°. This is equivalent to an uplift force ranging from 1 to 3 kN for solar panel dimension 1 m x 2 m wide.

The aerodynamic factor is not provided in AS1170.2 for solar panel tilt between 30° and 45°. As an initial estimate, it is assumed that the uplift force due to wind load could be up to double that of the 30° solar panel tilt which would result on an uplift force of 6 kN. It should be noted that the calculations presented are preliminary only and will need inputs from a structural engineer during detailed design stage.

12.5 Preliminary Pile Depth Design

We understand the piles such as a 50 UC23 H steel section are considered for the driven pile option.

The design geotechnical strength was determined using Section 4 of AS 2159-2009 using the geotechnical reduction factor as determined in section 12.3. An upper bound value for the geotechnical reduction factor could be adopted if pile testing is carried out on site prior to the main work which could modify the pile length.

Considering the typical compression, moment and uplift forces expected on the pile as well as cracked depth and expected seasonal movement, a depth range of 2.0 to 3.0 m is expected for H steel pile.

12.6 Footing Options Comparison

We understand that several pile options are currently considered by ENGIE. Table 20 presents the advantages, disadvantages and suitability for the Narrabri site of each of the footing system in consideration.

Table 20: Advantages and Disadvantages of Proposed Piling Options

Piling Method	Advantage	Disadvantage	Site Suitability
Bored Pile	Piles can be extended as need on site if ground conditions differs from the expected one.	Required full time supervision by a qualified geotechnical engineer. May require splicing and cutting steel reinforcement, increase time on site.	Suitable
Driven Pile	Installation at the Narrabri site should be reasonably quick due to expected ground conditions. Soil around pile shaft is somehow compressed when pile is driven for granular material up to medium dense,	May require preboring in places where hard layers are present. May require splicing and cutting steel reinforcement, increase time on site. Dense and very dense granular material can be loosened by driving piles.	Highly suitable

	resulting in greater skin friction than other pilling techniques.		
Screw Pile	Easy installation	Vertical and lateral capacity of the pile is more difficult to predict than driven or bored pile. Pile testing required to test pile loading capability.	Moderately suitable

12.7 Foundation Summary

Shallow footings shall take into consideration the site reactivity and expected seasonal surface movements. To reduce footing movements resulting from seasonal moisture effects, footings will need to be integrated as stiffened rafts; embedded to found in relatively moisture stable strata; or founded in and supported by a non-swelling structural fill platform.

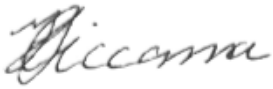
For the solar panels, driven piles (with or without the need of preboring) are considered to be the most suitable technique for this site. Pile depth will need to be finalised at the detailed design stage. Within the first 1.8 m, CPTs have indicated cone resistance typically ranging from 1.5 to 20 MPa at three locations reaching refusal before or close to 1.8 m depth. Preboring may be required in some areas.

13.0 IMPORTANT INFORMATION

Your attention is drawn to the document - “Important Information Relating to this Report”, which is included as an Appendix H of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the services provided for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Signature Page

Golder Associates Pty Ltd



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https://golderassociates.sharepoint.com/sites/1792350/shared documents/correspondence out/1792350-001-r-rev1-narrabri solar farm_reviewed.docx

APPENDIX A

Borehole Logs

REPORT OF BOREHOLE: GA-BH01

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 766833.3 m E 6649360.5 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 229.65 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: SJC DATE: 27/2/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L-M	Groundwater Not Encountered	0	0.15 229.80	BDS 0.15-0.30 m			CI CL	TOPSOIL: Silty CLAY medium plasticity, dark grey to dark brown, trace fine to medium grained sand, trace rootlets, appears hard			ALLUVIUM
					U75 0.50-0.65 m				Sandy CLAY low plasticity, dark grey to dark brown, fine to coarse grained sand			
				0.70 230.35					grey to dark brown, increased sand content, trace calcium carbonate lenses	M		
			1								H	
				1.50 231.15					brown and yellow brown			
				1.75 231.40					pale brown and yellow brown			
			2		SPT 2.00-2.45 m 10, 11, 13 N=24							
				2.50 232.15				SC	Clayey SAND fine to medium grained, yellow brown, medium plasticity clay, grading to sandy clay in places			
	H		3							D - M		
					SPT 3.50-3.73 m 16, 30/80mm						VD	
			4									
	M-H			5.00 234.65						M		
			5	5.15 234.80	SPT 5.00-5.45 m 11, 13, 15 N=28			CI-CH	Silty CLAY medium to high plasticity, red brown, pale grey and yellow brown, trace fine to medium grained sand, trace fine to coarse grained, sub-anular gravel		H	
				235.10					fine grained, angular quartz gravel layer at 5.15 m END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH02

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 766754.0 m E 6648898.9 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 227.52 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: SJC DATE: 27/2/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	M	Groundwater Not Encountered	0	0.10 227.62	U75 0.00-0.25 m PP = 500 kPa U50 0.50-0.60 m PP = 500 kPa SPT 0.60-1.05 m 9, 12, 12 N=24			CI CI	TOPSOIL: Silty CLAY medium plasticity, dark grey to dark brown, trace fine to medium grained sand, trace rootlets, appears very stiff Sandy CLAY medium plasticity, dark brown, trace fine to coarse grained sand, trace fine grained gravel			
			1	1.40 228.92					brown to yellow brown	M	H	
				1.70 229.22				CL-CI	Gravelly CLAY low to medium plasticity, brown, pale brown and yellow brown, fine to coarse grained gravel			
			2		SPT 2.00-2.45 m 4, 7, 9 N=16							
				2.70 230.22				SC	Clayey SAND fine to coarse grained, pale brown, yellow brown and orange brown, trace fine to coarse grained, sub-rounded gravel			
			3		SPT 3.50-3.95 m 8, 15, 18 N=33							
			4							D - M	D	
			5		SPT 5.00-5.45 m 7, 12, 19 N=31							
				232.97					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

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REPORT OF BOREHOLE: GA-BH03

SHEET: 1 OF 1

CLIENT: ENGIE Renewables Australia
COORDS: 766672.3 m E 6648488.1 m N MGA94 56
DRILL RIG: Ute Mounted

PROJECT: Narrabri Solar Farm
SURFACE RL: 222.40 m DATUM: AD
CONTRACTOR: Soiltech

LOCATION: Narrabri
INCLINATION: 90°
LOGGED: SJC DATE: 27/2/18

JOB NO: 1792350
HOLE DEPTH: 5.45 m
CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L-M	Groundwater Not Encountered	0	0.10 222.50				CI	TOPSOIL: Silty CLAY medium plasticity, dark grey to dark brown, trace fine to medium grained sand, trace rootlets, appears hard	D		ALLUVIUM
					U50 0.50-0.62 m			CI	Silty CLAY medium plasticity, dark grey to dark brown, trace fine to coarse grained sand, trace calcium carbonate	D		
			1								H	
				1.80 224.20				CI	Sandy CLAY medium plasticity, yellow brown to brown and pale grey, fine to medium grained sand	M		
			2		U50 2.00-2.10 m SPT 2.10-2.55 m 10, 16, 22 N=38							
	H			2.90 3.00				GP	GRAVEL coarse grained, sub-rounded, green grey, appears dense			
			3	225.40				CL-CI	Sandy CLAY low to medium plasticity, yellow brown, coarse grained sand, trace fine grained, sub-rounded gravel	D - M	H - Fb	
					SPT 3.50-3.77 m 26, 30/120mm							
	M-H		4	4.00 226.40				SC	Clayey SAND fine to coarse grained, medium plasticity, brown and yellow brown		D	
				4.90 227.30				SW	SAND fine to coarse grained, pale grey			
			5	5.20	SPT 5.00-5.45 m 12, 27, 18 N=45			GP	Sandy GRAVEL fine grained, yellow brown and orange brown, fine to coarse grained sand			
				5.35 227.85				SC	Clayey SAND fine to fine grained, yellow brown, with fine grained, sub-rounded gravel, trace timber fragments			
			6						END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH04

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 766512.8 m E 6647904.7 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 216.84 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: EJS DATE: 28/2/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT		Groundwater Not Encountered	0	0.15				CH	TOPSOIL: Silty CLAY			
				216.99				CI	high plasticity, dark brown, appears hard			ALLUVIUM
			1		U50 0.50-0.70 m PP = 500 kPa				Silty CLAY high plasticity, dark grey, trace fine grained sand, increased silt content			
				1.50								
	L			218.34				CH	CLAY high plasticity, grey	M		
				1.80								
				218.64				CH	Sandy CLAY high plasticity, grey, fine grained sand			
			2		SPT 2.00-2.45 m 7, 10, 14 N=24						H	
				3.00								
				3.10					increased sand content			
	H			219.94				CI-CH	Sandy CLAY medium to high plasticity, pale grey, fine to coarse grained sand, with fine to medium grained, sub-rounded gravel lense at 3.10 m			
			3		SPT 3.50-3.95 m 20, 24, 25 N=49							
			4							D - M		
	M			4.50								
				221.34				CH	Sandy CLAY high plasticity, brown, fine to coarse grained sand, with silt			
				5.00								
			5	221.84	SPT 5.00-5.45 m 12, 16, 20 N=36			CI-CH	Sandy CLAY medium to high plasticity, pale grey to pale brown, fine to coarse grained sand, trace fine grained, sub-angular gravel			
				5.25								
				222.09				SW	SAND fine to coarse grained, pale brown, with clay		D	
				222.29					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

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REPORT OF BOREHOLE: GA-BH05

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 766489.5 m E 6647229.3 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 210.98 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: EJS DATE: 28/2/18
JOB NO:	1792350	HOLE DEPTH: 5.18 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	0.15 / 211.13				CH	TOPSOIL: Silty CLAY high plasticity, dark grey, trace fine to coarse grained sand, trace fine grained, sub-rounded to sub-angular gravel			ALLUVIUM
					U75 0.50-0.61 m PP = 500 kPa			CH	Silty CLAY high plasticity, dark grey, with fine to medium grained, sub-rounded to sub-angular, pale grey gravel	D - M		
			1	1.30 / 212.28				CH	CLAY high plasticity, pale yellow brown, trace fine to medium grained, sub-rounded gravel, trace fine to coarse grained sand		H	
			2	2.00 / 212.98	U50 2.00-2.27 m PP = 450 kPa				with fine to medium grained, sub-rounded to sub-angular gravel			
				2.70 / 213.68				CH	Silty CLAY high plasticity, pale grey, trace fine to medium grained sand	M		
			3	3.50 / 214.48	SPT 3.50-3.95 m 5, 7, 9 N=16				grading to clayey silt in places, red brown staining		VSt - H	
			4	4.10 / 215.08					pale brown, trace fine grained, sub-rounded gravel			
			5		U50 5.00-5.18 m PP = 500 kPa							
				216.16					END OF BOREHOLE @ 5.18 m REFUSAL BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH06

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 767190.5 m E 6649184.0 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 233.54 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: SJC DATE: 27/2/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L-M	Groundwater Not Encountered	0	233.59				CI	TOPSOIL: Silty CLAY medium plasticity, dark grey to dark brown, trace fine to medium grained sand, trace rootlets, appears hard	M		ALLUVIUM
				0.50 234.04	U50 0.50-0.60 m PP = 500 kPa			CI	Sandy CLAY medium plasticity, dark brown, fine to coarse grained sand dark brown to red brown	D - M		
			1	0.90 234.44				CI-CH	Silty CLAY medium to high plasticity, red brown to dark brown, trace fine to coarse grained sand			
			2		SPT 2.00-2.45 m 20, 26, 26 N=52							
	H			2.70 236.24					red brown		H - Fb	
			3							D		
					SPT 3.50-3.73 m 12, 30/80mm							
			4									
			5		SPT 5.00-5.10 m 30/95mm							
				238.99					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

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REPORT OF BOREHOLE: GA-BH07

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 766973.5 m E 6648754.1 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 228.13 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: SJC DATE: 27/2/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L-M	Groundwater Not Encountered	0	0.10 228.23	BDS 0.10-0.30 m			CI CI	TOPSOIL: Silty CLAY medium plasticity, dark grey to dark brown, trace fine to medium grained sand, trace rootlets, appears hard			ALLUVIUM
					U75 0.50-0.60 m				Sandy CLAY medium plasticity, dark brown, trace calcium carbonate			
			1	1.50 229.63					with fine grained, sub-rounded gravel, brown and yellow brown	M	H	
				1.80 229.93					grey and red brown			
			2		SPT 2.00-2.45 m 5, 7, 9 N=16							
			3	3.20 231.33				CI	Sandy CLAY medium plasticity, pale brown and yellow brown, fine to coarse grained sand, trace coarse grained, sub-rounded gravel, grading to residual soil in places	D - M		RESIDUAL SOIL
				3.50 231.63	SPT 3.50-3.95 m 10, 13, 15 N=28				increased clay content, pale brown, yellow brown and dark brown			
	M		4							M	VSt - H	
			5	5.00 233.13	SPT 5.00-5.45 m 10, 15, 21 N=36			CI	Sandy CLAY medium plasticity, pale grey and yellow brown, fine to coarse grained sand		H	
				233.58					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

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GAP gINT FN. F01a
RL3

REPORT OF BOREHOLE: GA-BH08

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 767050.1 m E 6648331.7 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 222.67 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: SJC DATE: 27/2/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L-M	Groundwater Not Encountered	0	0.10 222.77				CI	TOPSOIL: Silty CLAY medium plasticity, dark grey to dark brown, trace fine to medium grained sand, trace rootlets, appears hard	M		ALLUVIUM
			1		SPT 0.50-0.95 m 8, 9, 9 N=18			CI	Silty CLAY medium plasticity, dark grey to dark brown, trace fine to coarse grained sand, trace calcium carbonate		H	
				1.50 224.17				CI-CH	Sandy CLAY medium to high plasticity, brown to red brown, fine to coarse grained sand			
			2	2.00 224.67	SPT 2.00-2.45 m 12, 12, 15 N=27			SC	Clayey SAND fine to coarse grained, pale brown to red brown, low plasticity clay, grading to residual soil	D - M		RESIDUAL SOIL
				2.80 225.47					yellow brown, with clay			
	H		3	3.30 225.97					fine grained, sub-anuglar quartz gravel lense			
				3.50 226.17	SPT 3.50-3.95 m 10, 11, 11 N=22				pale brown to red brown		MD - D	
	M		4									
				4.70 227.37					yellow brown, becoming clayey sand between 4.70 and 5.00 m			
			5		SPT 5.00-5.45 m 14, 16, 22 N=38					M		
				228.12					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

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REPORT OF BOREHOLE: GA-BH09

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 766920.3 m E 6647628.6 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 216.64 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: EJS DATE: 28/2/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	0.15 216.79	BDS 0.10-0.30 m			CH	TOPSOIL: Silty CLAY high plasticity, dark brown, appears very stiff			ALLUVIUM
					U75 0.50-0.67 m PP = 500 kPa			CH	Silty CLAY high plasticity, dark brown, with fine grained sand			
			1	1.20 217.84				CH	CLAY high plasticity, dark brown	M	H	
			2		U75 2.00-2.19 m PP = 480-550 kPa							
				2.50 219.14				SC	Clayey SAND fine to coarse grained, pale grey, high plasticity clay, with fine to medium grained, sub-rounded to sub-angular gravel			
				2.80 219.44				SC	Clayey SAND fine to coarse grained, yellow grey, medium plasticity clay, trace fine grained, sub-rounded to sub-angular gravel, grading to sandy clay in places	D - M	MD	
	M		3		SPT 3.50-3.95 m 11, 10, 11 N=21							
				3.80 220.44					with fine grained, sub-rounded to sub-angular gravel			
			4	4.00 220.64				CH	CLAY high plasticity, brown to yellow brown, trace fine grained sand	M	H	
				5.00 221.64	SPT 5.00-5.45 m 9, 12, 16 N=28			CH	Sandy CLAY high plasticity, yellow brown and grey, fine grained sand			
			5	222.09					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

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REPORT OF BOREHOLE: GA-BH10

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 766814.5 m E 6647073.2 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 212.18 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: EJS DATE: 1/3/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	0.15 212.33				CI	TOPSOIL: Silty CLAY medium plasticity, dark grey, with fine grained sand, appears hard			ALLUVIUM
					U 0.50-0.61 m PP = 500 kPa			CI-CH	Silty CLAY medium to high plasticity, dark grey, trace fine grained sand, trace fine grained, sub-angular to sub-rounded gravel			
			1	1.40 213.58				CI	Sandy CLAY medium plasticity, pale yellow brown, fine to medium grained sand	D - M	H	
	M		2		SPT 2.00-2.36 m 12, 26, 30/60mm							
			3	3.30 215.48				SC	Clayey SAND fine to coarse grained, yellow brown, medium plasticity clay			
				3.70 215.88	SPT 3.50-3.95 m 13, 17, 19 N=36				trace clay		D	
			4	4.20 216.38				CI-CH	Sandy CLAY medium to high plasticity, yellow brown, fine to coarse grained sand, with fine to coarse grained, sub-rounded gravel			
	H M			216.48					fine grained gravel		H	
			5	5.00 217.18	SPT 5.00-5.45 m 7, 11, 16 N=27				reduced sand content			
			6	217.63					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH11

SHEET: 1 OF 1

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767450.3 m E 6647225.1 m N MGA94 56
SURFACE RL: 215.95 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 5.45 m

DRILL RIG: Ute Mounted
CONTRACTOR: Soiltech
LOGGED: EJS DATE: 28/2/18
CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT		Groundwater Not Encountered	0	0.15 216.10				CH CI	TOPSOIL: Silty CLAY high plasticity, dark brown, trace fine grained sand, trace rootlets, appears hard			ALLUVIUM
					U50 0.50-0.69 m PP = 500 kPa				Silty CLAY medium plasticity, dark brown, trace fine grained sand	M	H	
	L		1	1.50								
				1.60				CI	medium plasticity, trace fine grained sand, trace fine grained, rounded gravel, increased sand content			
	H			1.70 217.65				CI				
				2.00				CH	Silty CLAY medium plasticity, pale brown, with fine to medium grained, sub-rounded gravel			
			2	217.95	SPT 2.00-2.45 m 10, 13, 26 N=39			SC				RESIDUAL SOIL
				2.50					Silty CLAY high plasticity, brown, with fine to coarse grained sand			
				218.45				SP	Clayey SAND fine to medium grained, yellow brown, medium plasticity clay			
			3						SAND fine to coarse grained, yellow brown			
	M				SPT 3.50-3.77 m 20, 30/115mm					D - M	D	
			4									
				4.80 220.75				SC	Clayey SAND fine to medium grained, pale grey, medium plasticity clay			
			5	5.10	SPT 5.00-5.45 m 13, 21, 30/145mm					M	H	
				221.10				CH SP	CLAY high plasticity, pale grey, with fine grained sand		VD	EXTREMELY WEATHERED ROCK
				221.40					SAND fine to medium grained, yellow brown and pale grey, with clay, relic rock structure			
			6						END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH12

SHEET: 1 OF 1

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767232.3 m E 6646787.7 m N MGA94 56
SURFACE RL: 213.05 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 5.45 m

DRILL RIG: Ute Mounted
CONTRACTOR: Soiltech
LOGGED: EJS DATE: 28/2/18
CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	0.15 213.20				CH	TOPSOIL: Silty CLAY high plasticity, grey, with fine grained sand, trace rootlets, appears very stiff to hard			ALLUVIUM
					U75 0.50-0.65 m PP = 370-410 kPa			CH	Silty CLAY high plasticity, grey	D - M	VSt - H	
			1	1.50 214.55				CH	CLAY high plasticity, grey	M		
				1.90 214.95				CI	Sandy CLAY medium plasticity, grey, fine grained sand			
			2		SPT 2.00-2.45 m 17, 16, 15 N=31					D		
			3							M		
				3.75 216.80	SPT 3.50-3.95 m 14, 19, 22 N=41				trace fine, subrounded to subangular gravel, increasing sand content		H	
	H		4							D - M		
			5		SPT 5.00-5.45 m 28, 29, 30/145mm							
				218.50					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH13

SHEET: 1 OF 1

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767676.8 m E 6647014.2 m N MGA94 56
SURFACE RL: 216.50 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 5.45 m

DRILL RIG: Ute Mounted
CONTRACTOR: Soiltech
LOGGED: EJS DATE: 28/2/18
CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	0.15 216.65				CH	TOPSOIL: Silty CLAY high plasticity, dark grey, with fine grained sand, trace rootlets, appears hard			ALLUVIUM
					U50 0.50-0.75 m PP = 500 kPa			CH	Silty CLAY high plasticity, dark grey to grey, trace fine grained sand, trace organics	D - M		
			1	1.50 218.00	U50 1.50-1.70 m PP = 500 kPa			CH	CLAY high plasticity, grey, trace fine to medium grained, sub-rounded gravel	M		
			2	2.00 218.50 2.20					reduced gravel content at 2.00 m			
	M			218.70	SPT 2.50-2.95 m 14, 19, 22 N=41			CH	Sandy CLAY high plasticity, grey to pale grey, fine to coarse grained sand, trace fine to medium grained, sub-rounded gravel	D - M	H	
			3	3.30 219.80	SPT 3.50-3.95 m 9, 12, 18 N=30			CI-CH	Gravelly CLAY medium to high plasticity, yellow brown, fine to medium grained, sub-rounded gravel	M		
			4	4.50 221.00				CI-CH	Sandy CLAY medium to high plasticity, red brown, fine to coarse grained sand, trace fine grained, sub-rounded gravel, increasing sand content in places, sand lenses in places	D - M M		
			5		SPT 5.00-5.45 m 10, 18, 14 N=32							
				221.95					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH14

SHEET: 1 OF 1

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 768182.4 m E 6647032.4 m N MGA94 56
SURFACE RL: 216.77 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 5.27 m

DRILL RIG: Ute Mounted
CONTRACTOR: Soiltech
LOGGED: EJS DATE: 1/3/18
CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	0.15 216.92	BDS 0.15-0.30 m			CH	TOPSOIL: Silty CLAY high plasticity, dark grey, trace fine to coarse grained sand, trace rootlets, appears hard			ALLUVIUM
					SPT 0.50-0.95 m 10, 10, 10 N=20			CH	Silty CLAY high plasticity, dark grey, trace fine to coarse grained sand, trace rootlets	D - M		
			1	1.40 218.17	U 1.50-1.70 m PP = 500 kPa			CH	CLAY high plasticity, dark grey, trace fine to medium grained sand	M		
	M		2	2.30 219.07	SPT 2.50-2.95 m 11, 11, 16 N=27			CI-CH	Sandy CLAY medium to high plasticity, pale grey to pale yellow brown, fine to coarse grained sand, trace fine to medium grained, sub-rounded gravel	D	H	
			3		SPT 3.50-3.95 m 8, 19, 22 N=41							
	H		4	4.00 220.77				CH	CLAY high plasticity, pale yellow brown, with fine to medium grained sand	D - M		
			5	5.00 221.77 5.15 221.92	SPT 5.00-5.27 m 13, 29/115mm				increasing sand content trace fine grained, sub-rounded to sub-angular gravel	D		
				222.04					END OF BOREHOLE @ 5.27 m REFUSAL BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

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GAP gINT FN. F01a
RL3

REPORT OF BOREHOLE: GA-BH15

SHEET: 1 OF 1

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 766942.4 m E 6646901.1 m N MGA94 56
SURFACE RL: 212.01 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 5.16 m

DRILL RIG: Ute Mounted
CONTRACTOR: Soiltech
LOGGED: EJS DATE: 28/2/18
CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	212.01 *0.20*				CH	TOPSOIL: Silty CLAY high plasticity, dark grey, with fine grained sand, appears hard			
				212.21 *0.50*				CH	Silty CLAY high plasticity, dark grey			ALLUVIUM
			1	212.51 *1.20*	SPT 0.50-0.95 m 7, 6, 8 N=14			CH	Sandy CLAY high plasticity, dark grey and pale grey, fine grained sand	D - M	H	
				213.21 *1.90*	U75 1.50-1.70 m PP = 480-500 kPa			CH	CLAY high plasticity, dark brown, trace fine to coarse grained sand, trace fine grained, sub-rounded gravel	M		
	M		2	213.91 *2.70*				GC	Clayey GRAVEL fine to medium grained, sub-rounded to sub-angular, grey, high plasticity clay, with fine to coarse grained sand	D - M	D	
				214.71 *3.00*				CH	Sandy CLAY high plasticity, pale yellow brown, fine to medium grained sand, trace fine to medium grained, sub-rounded gravel	M		
	H		3	215.01	SPT 3.00-3.45 m 11, 15, 16 N=31				increased sand and gravel content, fine to coarse grained sand	D - M		
			4									
			5		U50 5.00-5.16 m PP = 550 kPa					M		
				217.17					END OF BOREHOLE @ 5.16 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

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GAP gINT FN. F01a
RL3

REPORT OF BOREHOLE: GA-BH16

SHEET: 1 OF 1

CLIENT: ENGIE Renewables Australia
COORDS: 767508.1 m E 6646657.2 m N MGA94 56
DRILL RIG: Ute Mounted

PROJECT: Narrabri Solar Farm
SURFACE RL: 213.86 m DATUM: AD
CONTRACTOR: Soiltech

LOCATION: Narrabri
INCLINATION: 90°
LOGGED: EJS DATE: 28/2/18

JOB NO: 1792350
HOLE DEPTH: 5.45 m
CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	0.15 214.01	BDS 0.20-0.40 m			CH	TOPSOIL: Silty CLAY high plasticity, dark grey, trace rootlets, appears hard	D - M		ALLUVIUM
					U75 0.50-0.72 m PP = 310-320 kPa			CH	CLAY high plasticity, dark grey		VSt	
			1		U75 1.50-1.71 m PP = 360-370 kPa					M		
			2	2.50 216.36				CI	CLAY medium plasticity, grey, trace fine to medium grained, sub-rounded gravel			
				2.70 216.56				CH	CLAY high plasticity, grey, trace fine to medium grained, sub-rounded gravel, trace fine to medium grained sand			
	M		3		SPT 3.00-3.45 m 9, 14, 22 N=36						VSt - H	
			4	4.00 217.86				CI	Sandy CLAY medium plasticity, grey, fine to medium grained sand, trace fine to medium grained, sub-rounded gravel	D - M		
	M-H			4.80 218.66					decreasing gravel content			
			5		SPT 5.00-5.45 m 15, 21, 25 N=46							
				219.31					END OF BOREHOLE @ 5.45 m REFUSAL BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH17

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 768205.4 m E 6646622.2 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 215.21 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: EJS DATE: 1/3/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	215.21 *0.20* 215.41				CH	TOPSOIL: Silty CLAY high plasticity, dark grey, trace fine to coarse grained sand, trace rootlets, appears hard			ALLUVIUM
					U50 0.50-0.64 m PP = 500 kPa			CH	Silty CLAY high plasticity, dark grey, trace fine to coarse grained sand			
			1	*1.50* 216.71				CI-CH	CLAY medium to high plasticity, yellow brown, with silt, trace fine to coarse grained sand, trace fine to medium grained, sub-aungular gravel	D - M	H	
	M		2		SPT 2.00-2.45 m 8, 8, 13 N=21							
			3	*3.50* 218.71	SPT 3.50-3.95 m 9, 16, 17 N=33			CI-CH	Sandy CLAY medium to high plasticity, pale grey and pale yellow brown, fine grained sand			
			4	*3.85* 219.06 *4.20* 219.41				CI	CLAY medium plasticity, yellow brown, trace fine grained sand with fine to medium grained sand, trace fine grained, sub-rounded gravel			
	H		5	*5.00* 220.21	SPT 5.00-5.45 m 7, 13, 15 N=28				pale grey and yellow brown, increased sand content, becoming sandy clay in places	M		
			6	220.66					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			7									
			8									
			9									
			10									

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GAP gINT FN. F01a
RL3

REPORT OF BOREHOLE: GA-BH18

SHEET: 1 OF 1

CLIENT:	ENGIE Renewables Australia	COORDS: 768602.4 m E 6646887.8 m N MGA94 56	DRILL RIG: Ute Mounted
PROJECT:	Narrabri Solar Farm	SURFACE RL: 216.78 m DATUM: AD	CONTRACTOR: Soiltech
LOCATION:	Narrabri	INCLINATION: 90°	LOGGED: EJS DATE: 1/3/18
JOB NO:	1792350	HOLE DEPTH: 5.45 m	CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	0.15 216.93				CH	TOPSOIL: Silty CLAY high plasticity, dark grey, trace fine to coarse grained sand, trace rootlets, appears very stiff to hard			ALLUVIUM
					U75 0.50-0.59 m			CH	Silty CLAY high plasticity, dark grey, trace fine grained, sub-rounded gravel	D - M		
			1	1.80 218.58				CI-CH	Sandy CLAY medium to high plasticity, dark brown, fine to coarse grained sand	M		
			2		SPT 2.00-2.45 m 8, 10, 11 N=21							
				2.60 219.38					decreased sand content		H	
				2.80 219.58				CH	CLAY high plasticity, pale yellow brown, trace fine to medium grained sand			
	M		3		SPT 3.50-3.95 m 13, 16, 20 N=36							
				3.70 220.48				CH	Sandy CLAY high plasticity, pale grey and pale yellow brown, fine to coarse grained sand, trace fine to medium grained, sub-rounded gravel	D - M		
			4	4.40 221.18					yellow brown, decreased gravel content			
			5	5.10 221.88	SPT 5.00-5.45 m 13, 19, 20 N=39			SC	Clayey SAND fine to medium grained, yellow brown, high plasticity clay, trace clay		D	
				222.23					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH19

SHEET: 1 OF 1

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767528.6 m E 6648090.1 m N MGA94 56
SURFACE RL: 219.89 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 4.50 m

DRILL RIG: Ute Mounted
CONTRACTOR: Soiltech
LOGGED: SJC DATE: 27/2/18
CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	219.89				CH	Silty CLAY high plasticity, dark grey		H	ALLUVIUM
					U75 0.50-0.70 m PP = 500 kPa							
			1	*1.20*								
				221.09				CH	Sandy CLAY high plasticity, dark grey to dark brown, fine to coarse grained sand, with fine to coarse grained, rounded to sub-angular gravel			
				1.50								
				221.39				SC	Clayey SAND fine to coarse grained, yellow brown	M		
			2		SPT 2.00-2.45 m 6, 10, 12 N=22						MD	
			3	*3.30*								
				223.19				SW	SAND fine to coarse grained, pale brown, gravel lense at 3.30 m			
					SPT 3.50-3.88 m 19, 30, 30/80mm							
				3.80								
	M-H		4	223.69				SW	SAND fine to coarse grained, red brown, iron rich lenses of increased strength, grading to residual soil in places	D	VD	RESIDUAL SOIL
				224.39					END OF BOREHOLE @ 4.50 m REFUSAL BACKFILLED AND MARKER STAKE PLACED			
			5									
			6									
			7									
			8									
			9									
			10									

REPORT OF BOREHOLE: GA-BH20

SHEET: 1 OF 1

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 766345.9 m E 6647001.5 m N MGA94 56
SURFACE RL: 210.36 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 5.45 m

DRILL RIG: Ute Mounted
CONTRACTOR: Soiltech
LOGGED: EJS DATE: 28/2/18
CHECKED: FHH DATE: 28/3/18

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Groundwater Not Encountered	0	0.10 210.46	BDS 0.20-0.50 m			CH MH	TOPSOIL: Silty CLAY high plasticity, dark grey, trace fine to coarse grained sand, trace rootlets, appears very stiff			ALLUVIUM
					U75 0.50-0.67 m PP = 500 kPa				Clayey SILT high liquid limit, dark grey, trace fine to medium grained gravel, trace fine to coarse grained sand	D - M		
			1	1.30 211.66				CH	Sandy CLAY high plasticity, pale yellow brown, with fine to medium grained, sub-rounded to sub-angular gravel	M		
				1.80 212.16					pale grey		H	
			2		SPT 2.00-2.45 m 6, 11, 15 N=26							
	M		3		SPT 3.50-3.95 m 15, 20, 29 N=49					D - M		
			4	4.10 214.46				SC	Clayey SAND fine to coarse grained, pale grey with some dark grey, high plasticity clay, with fine to medium grained, sub-rounded to sub-angular gravel			
	H		5		SPT 5.00-5.45 m 9, 16, 16 N=32						D	
				215.81					END OF BOREHOLE @ 5.45 m TARGET DEPTH BACKFILLED AND MARKER STAKE PLACED			
			6									
			7									
			8									
			9									
			10									

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01a
RL3

APPENDIX B

CPT Logs

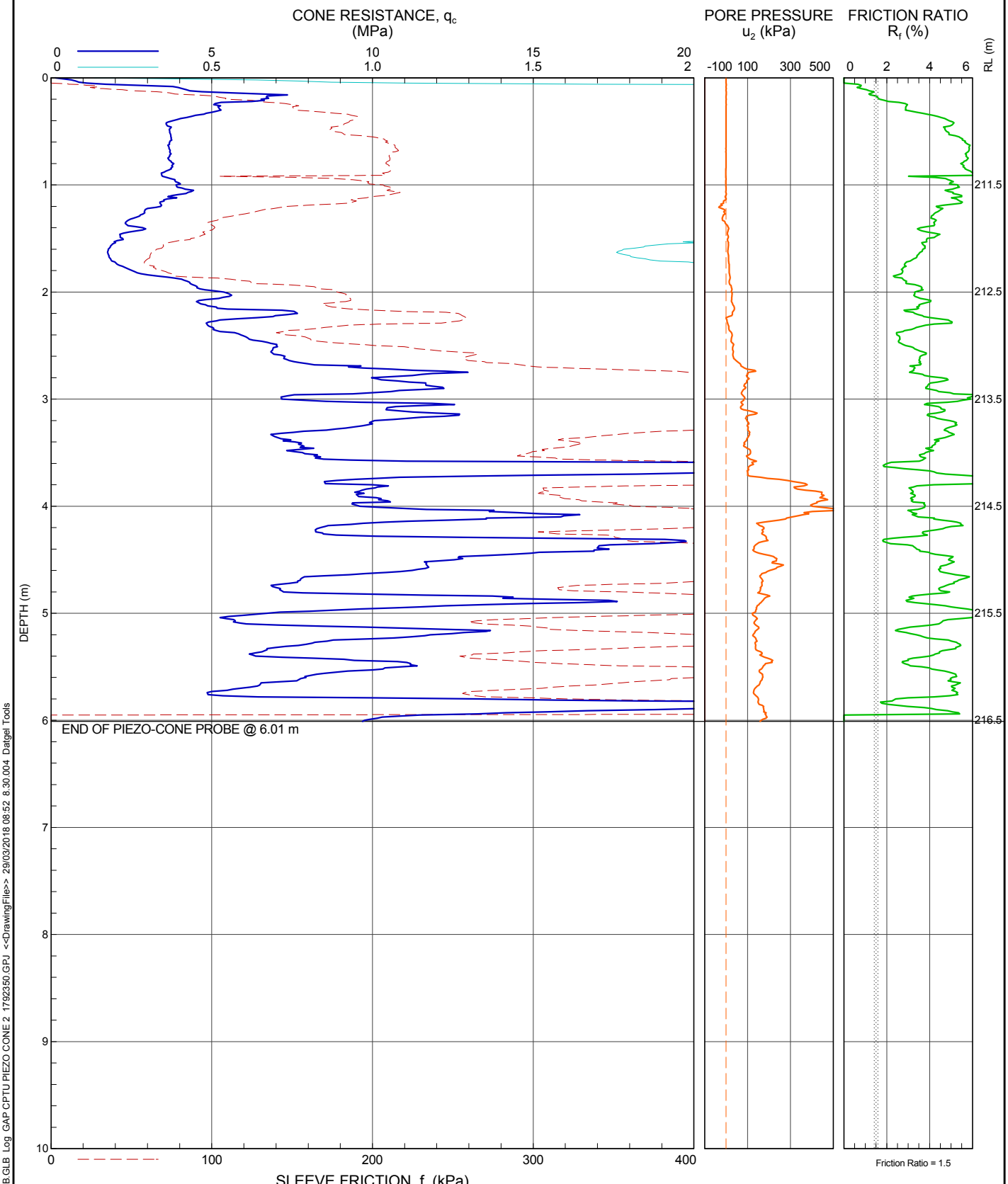
REPORT OF PIEZO-CONE PROBE: GA-CPT-01

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 766179.4 m E 6647013.9 m N MGA94 56
SURFACE RL: 210.48 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 6.01 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 7/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

This report of piezo-cone probe must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

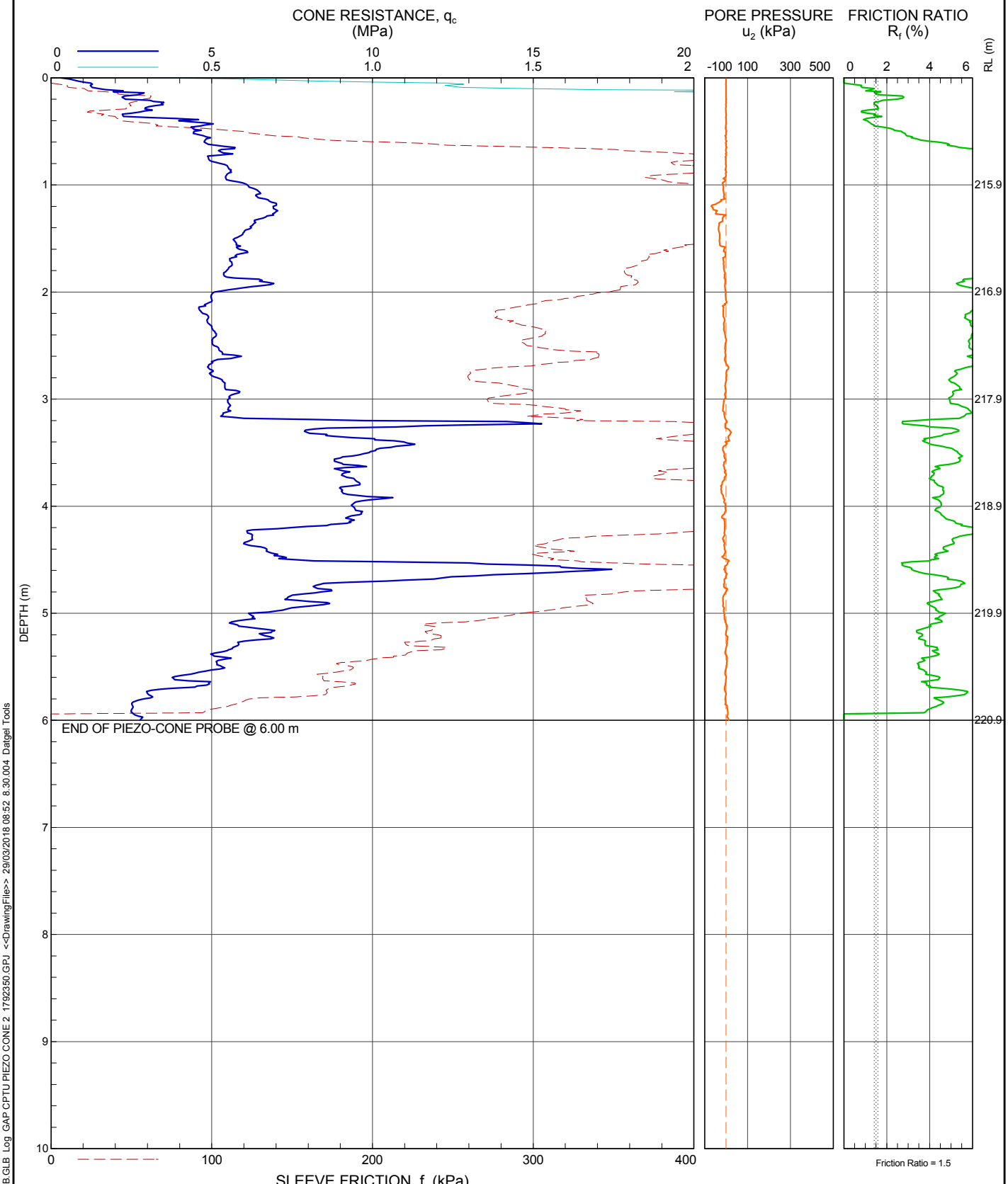
REPORT OF PIEZO-CONE PROBE: GA-CPT-02

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 768300.6 m E 6646435.1 m N MGA94 56
SURFACE RL: 214.88 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 6.00 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 8/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

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GAP gINT FN. F10 RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

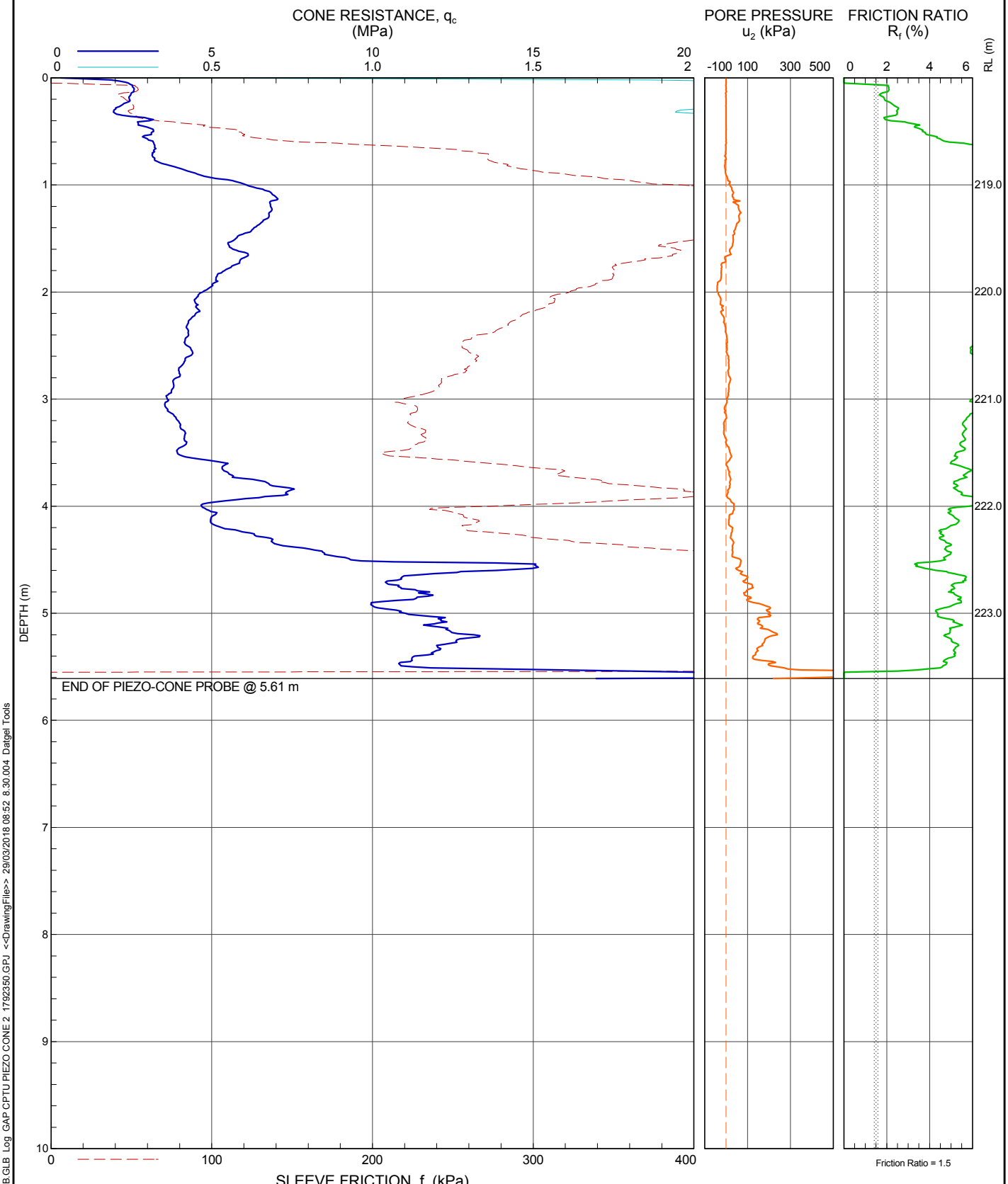
REPORT OF PIEZO-CONE PROBE: GA-CPT-03

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 769122.1 m E 6646903.9 m N MGA94 56
SURFACE RL: 218.01 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 5.61 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 8/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

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GAP gINT FN. F10
RL3

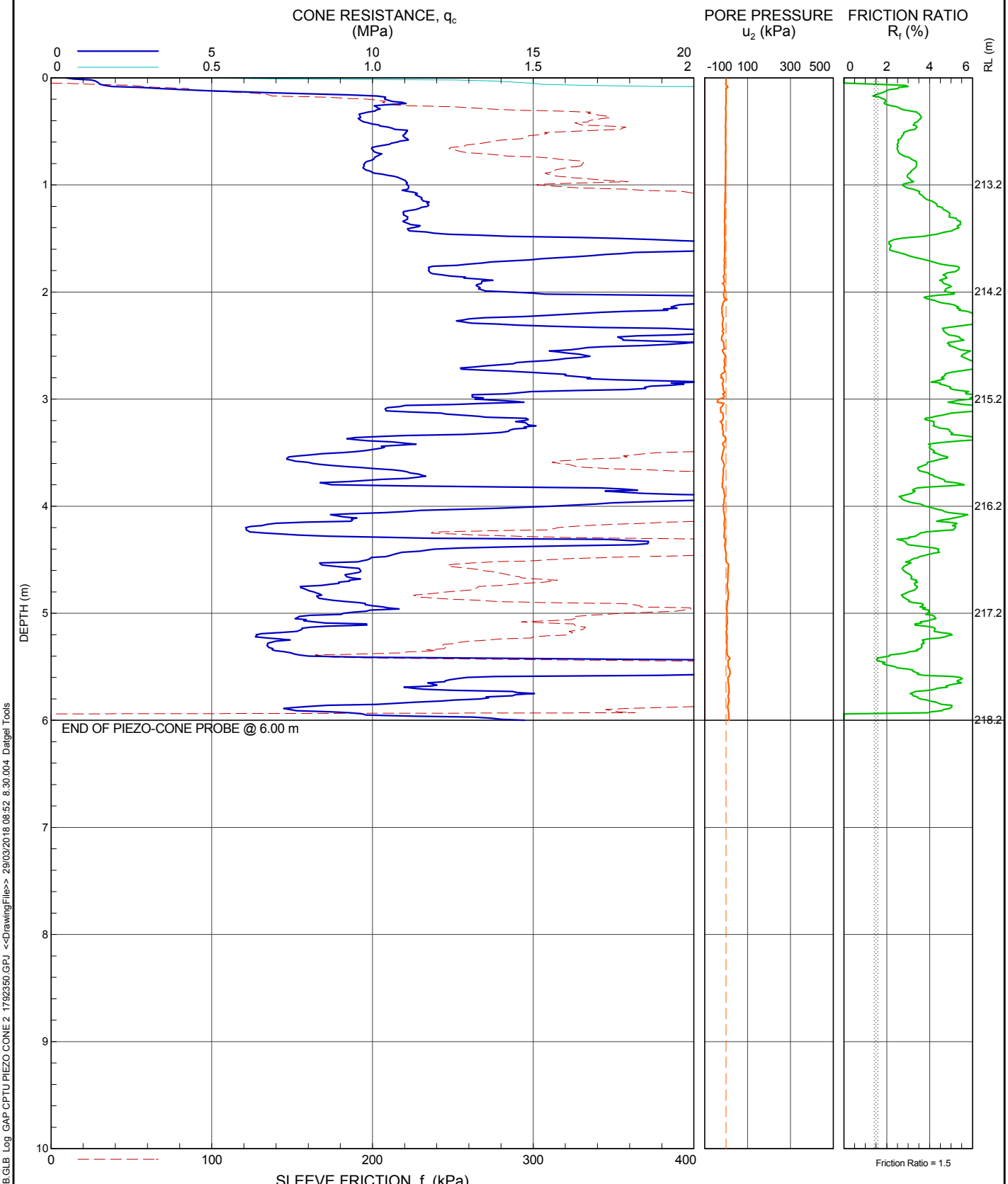
REPORT OF PIEZO-CONE PROBE: GA-CPT-04

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 766813.1 m E 6647076.2 m N MGA94 56
SURFACE RL: 212.20 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 6.00 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 7/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

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GAP gINT FN. F10 RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

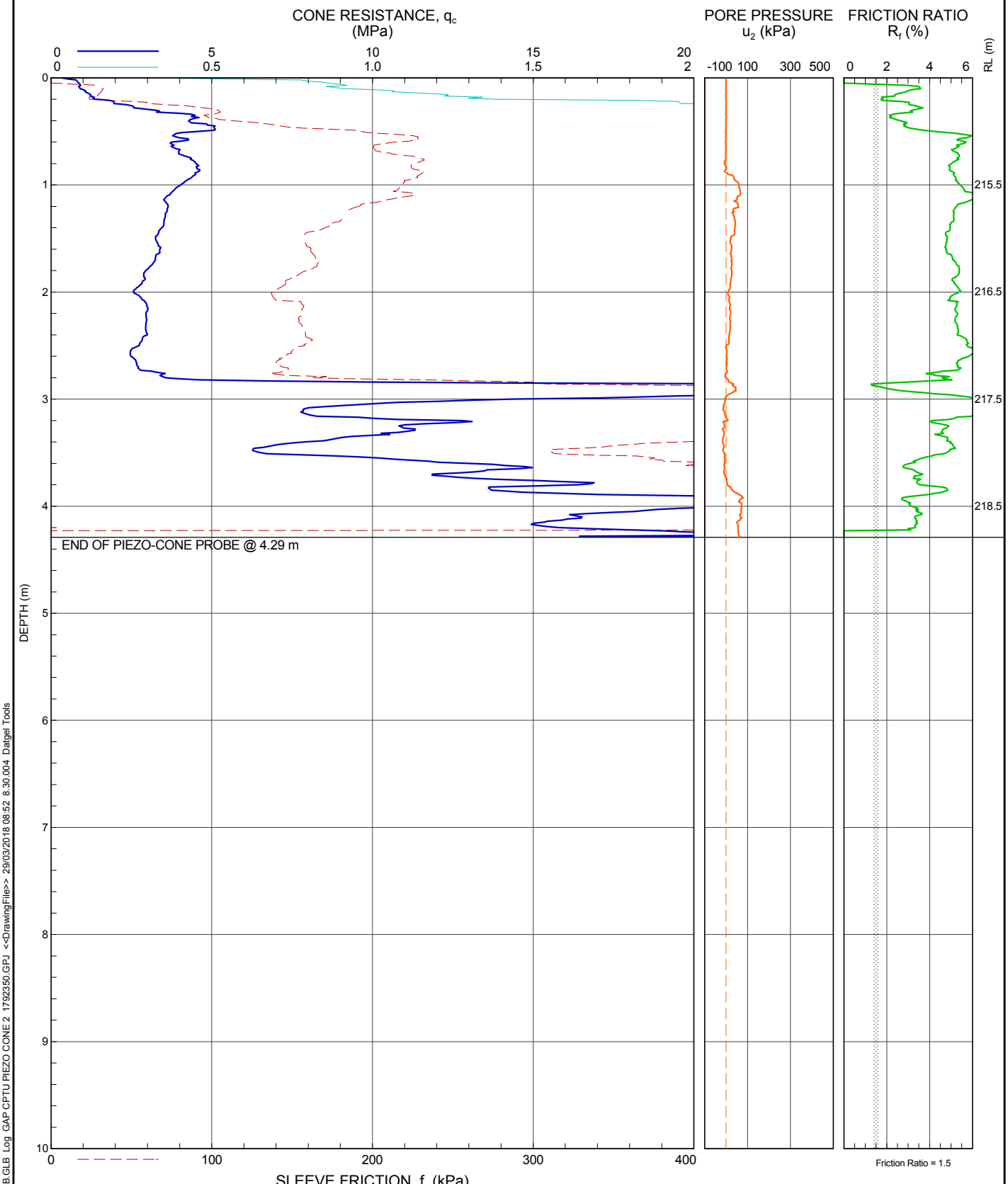
REPORT OF PIEZO-CONE PROBE: GA-CPT-05

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767489.8 m E 6646865.3 m N MGA94 56
SURFACE RL: 214.53 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 4.29 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 8/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

This report of piezo-cone probe must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

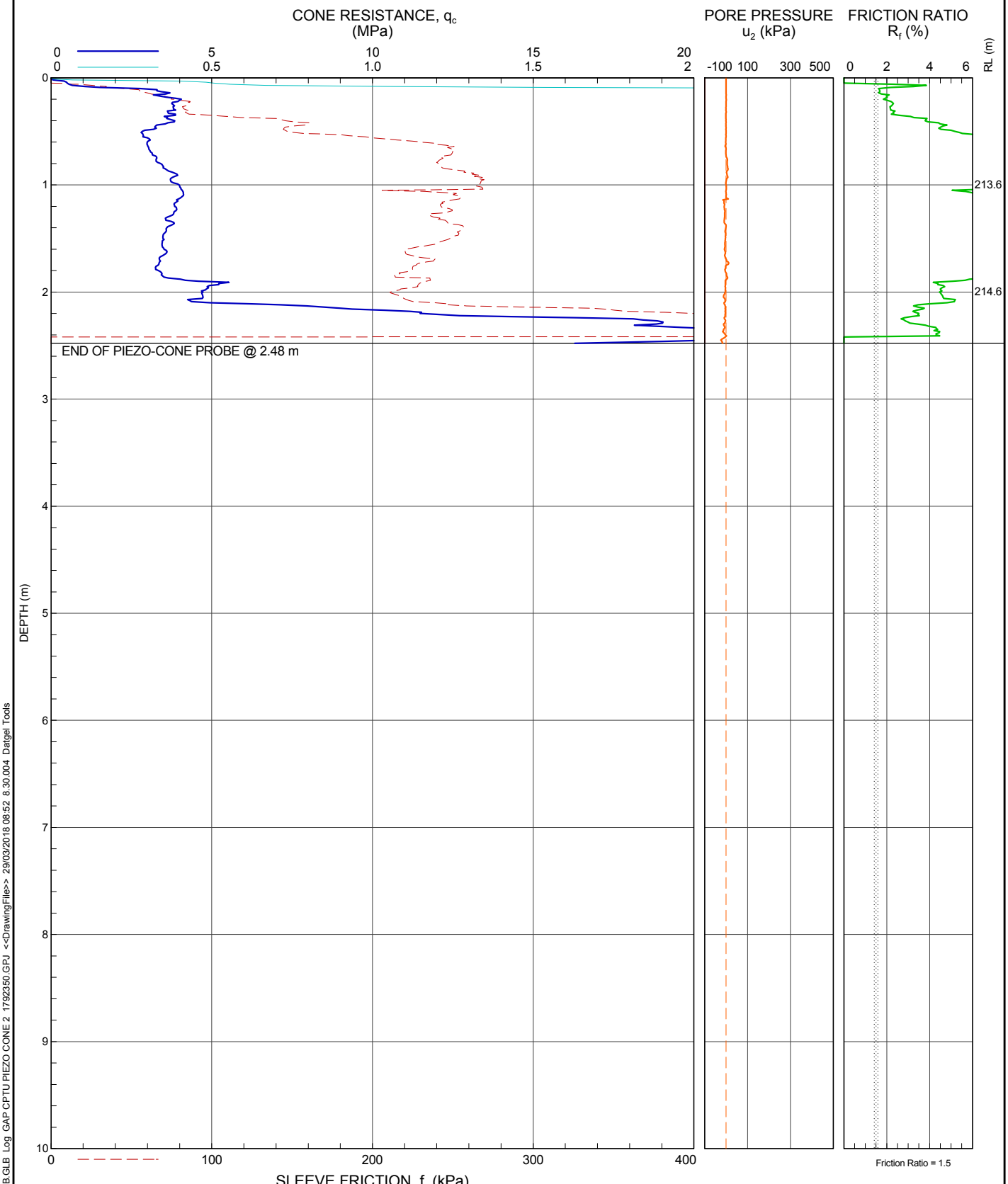
REPORT OF PIEZO-CONE PROBE: GA-CPT-06

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767251.1 m E 6646531.6 m N MGA94 56
SURFACE RL: 212.62 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 2.48 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 7/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

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GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

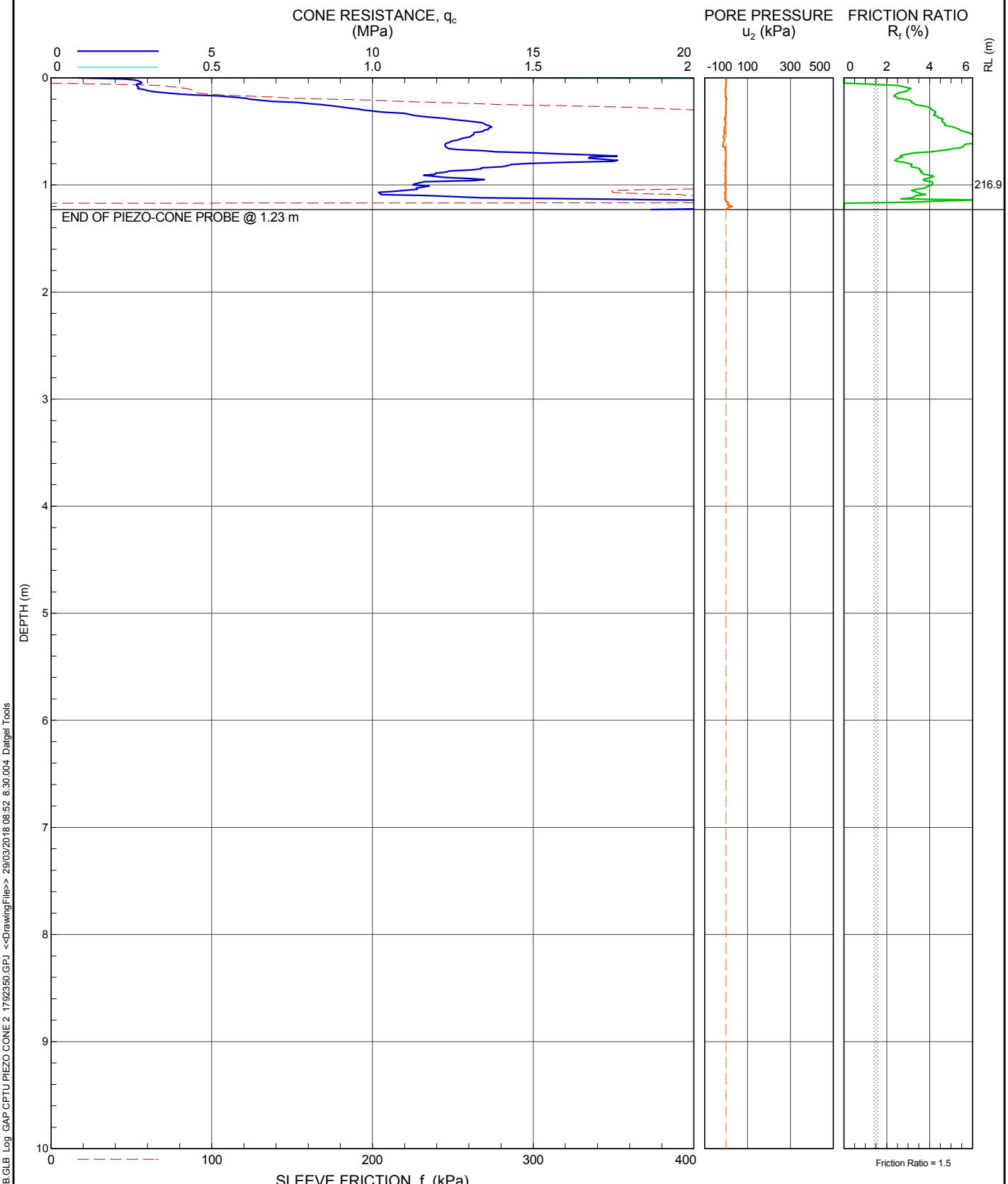
REPORT OF PIEZO-CONE PROBE: GA-CPT-07

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767898.9 m E 6646854.2 m N MGA94 56
SURFACE RL: 215.89 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 1.23 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 8/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

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GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

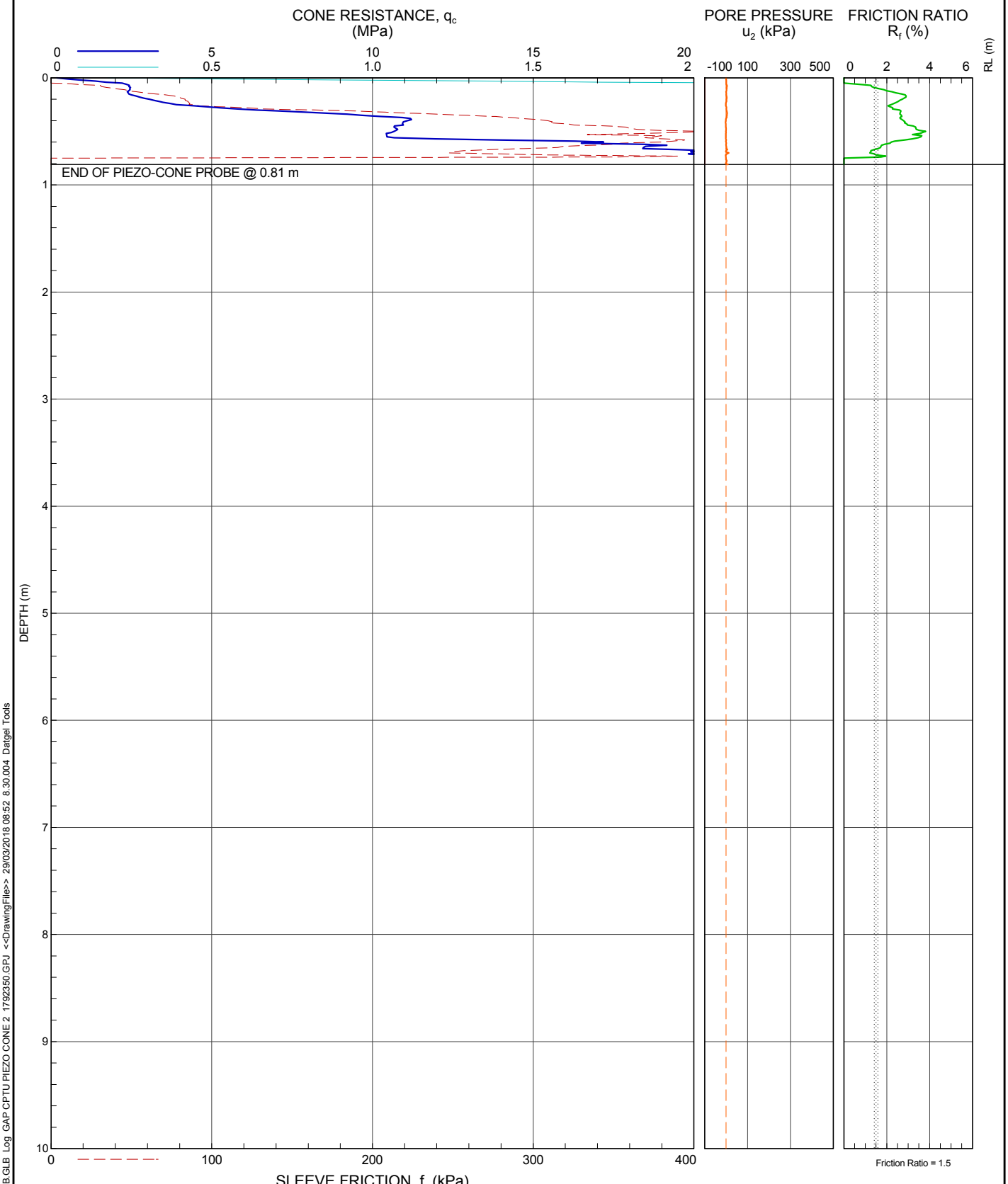
REPORT OF PIEZO-CONE PROBE: GA-CPT-07A

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767899 m E 6646854 m N MGA94 56
SURFACE RL: 215.90 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 0.81 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 8/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

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GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

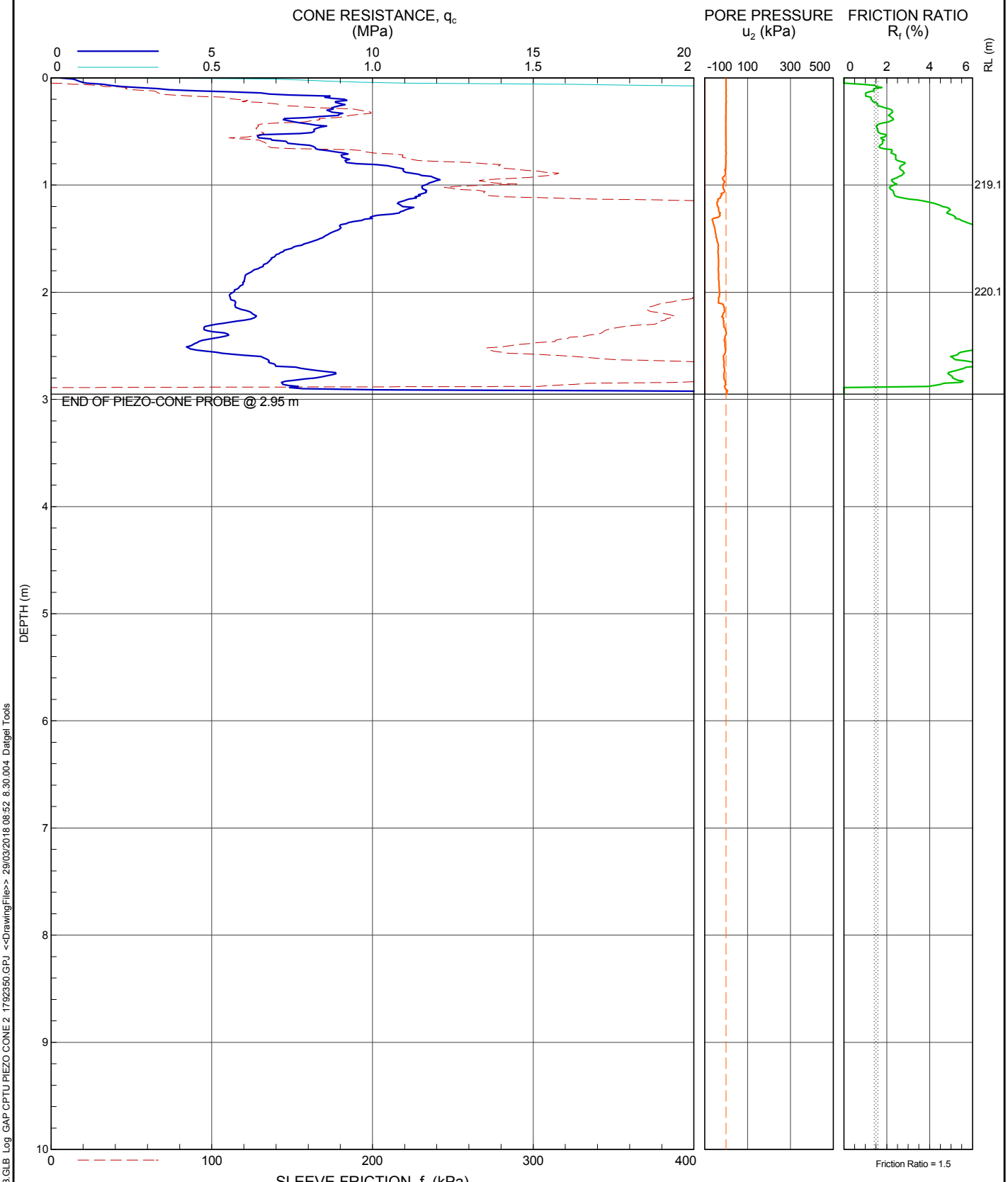
REPORT OF PIEZO-CONE PROBE: GA-CPT-08

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 766769.0 m E 6647856.4 m N MGA94 56
SURFACE RL: 218.09 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 2.95 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 6/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

This report of piezo-cone probe must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

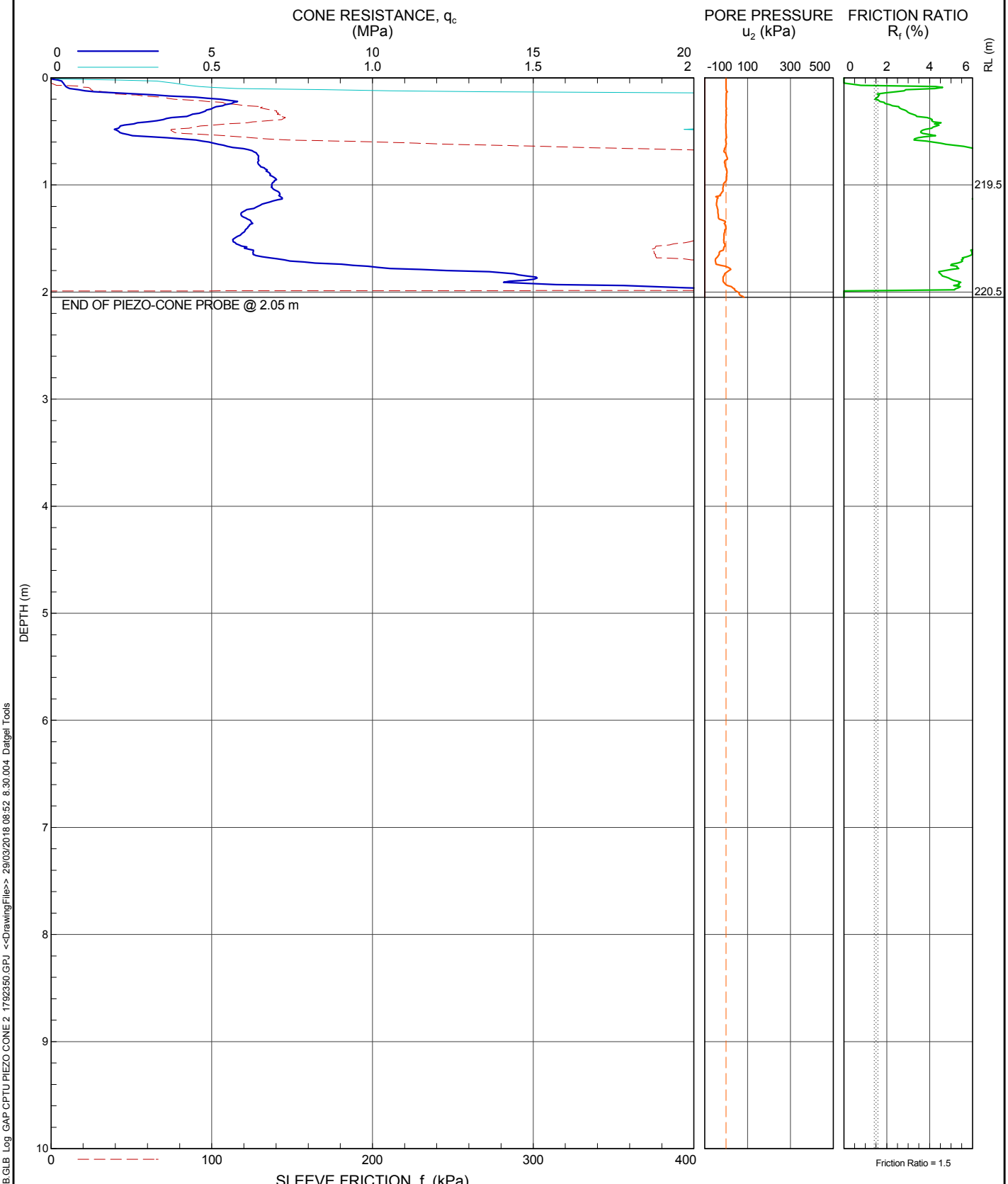
REPORT OF PIEZO-CONE PROBE: GA-CPT-09

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767282.0 m E 6647974.5 m N MGA94 56
SURFACE RL: 218.52 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 2.05 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 6/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

This report of piezo-cone probe must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

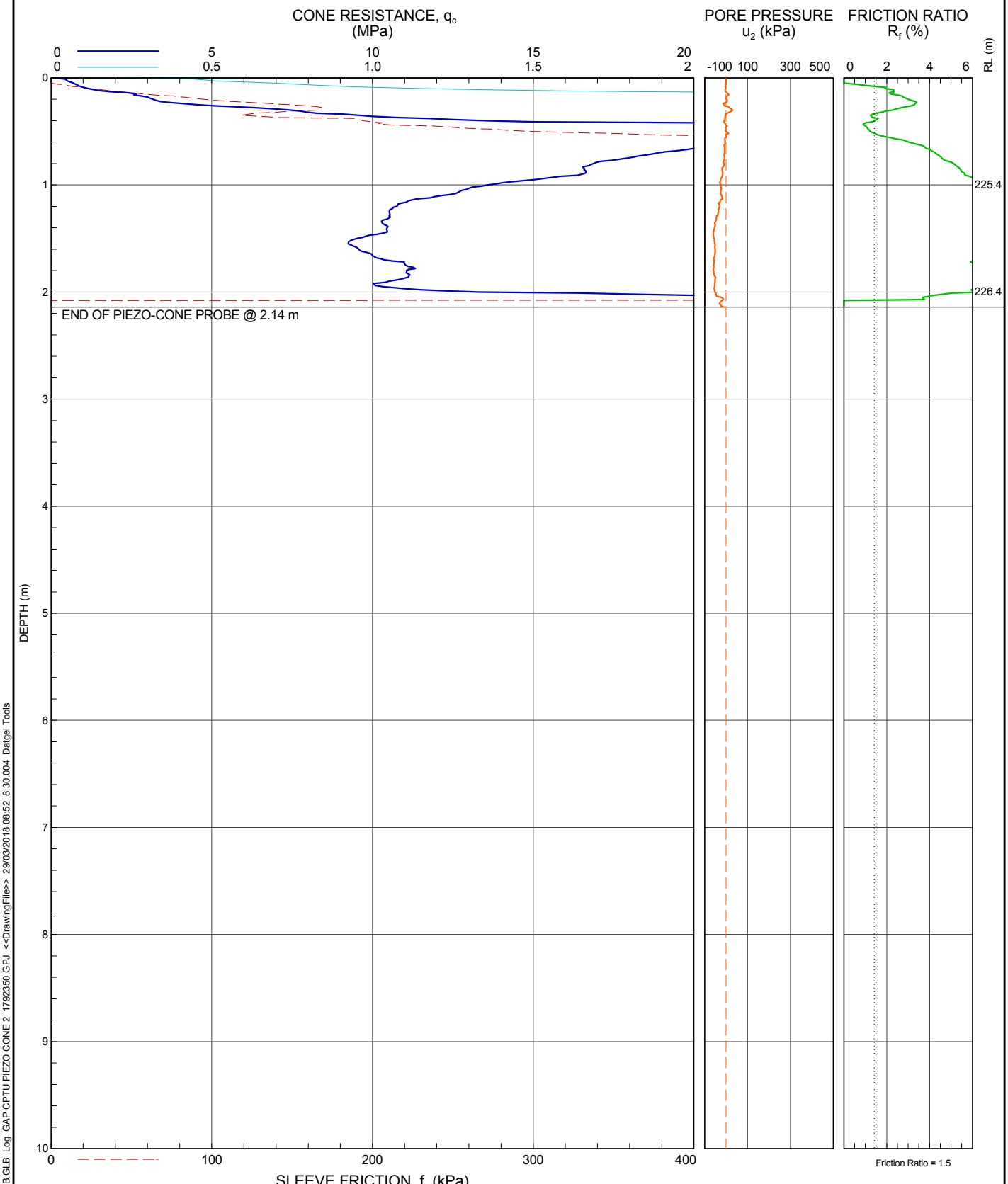
REPORT OF PIEZO-CONE PROBE: GA-CPT-10

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767382.6 m E 6648495.7 m N MGA94 56
SURFACE RL: 224.42 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 2.14 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 6/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

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GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

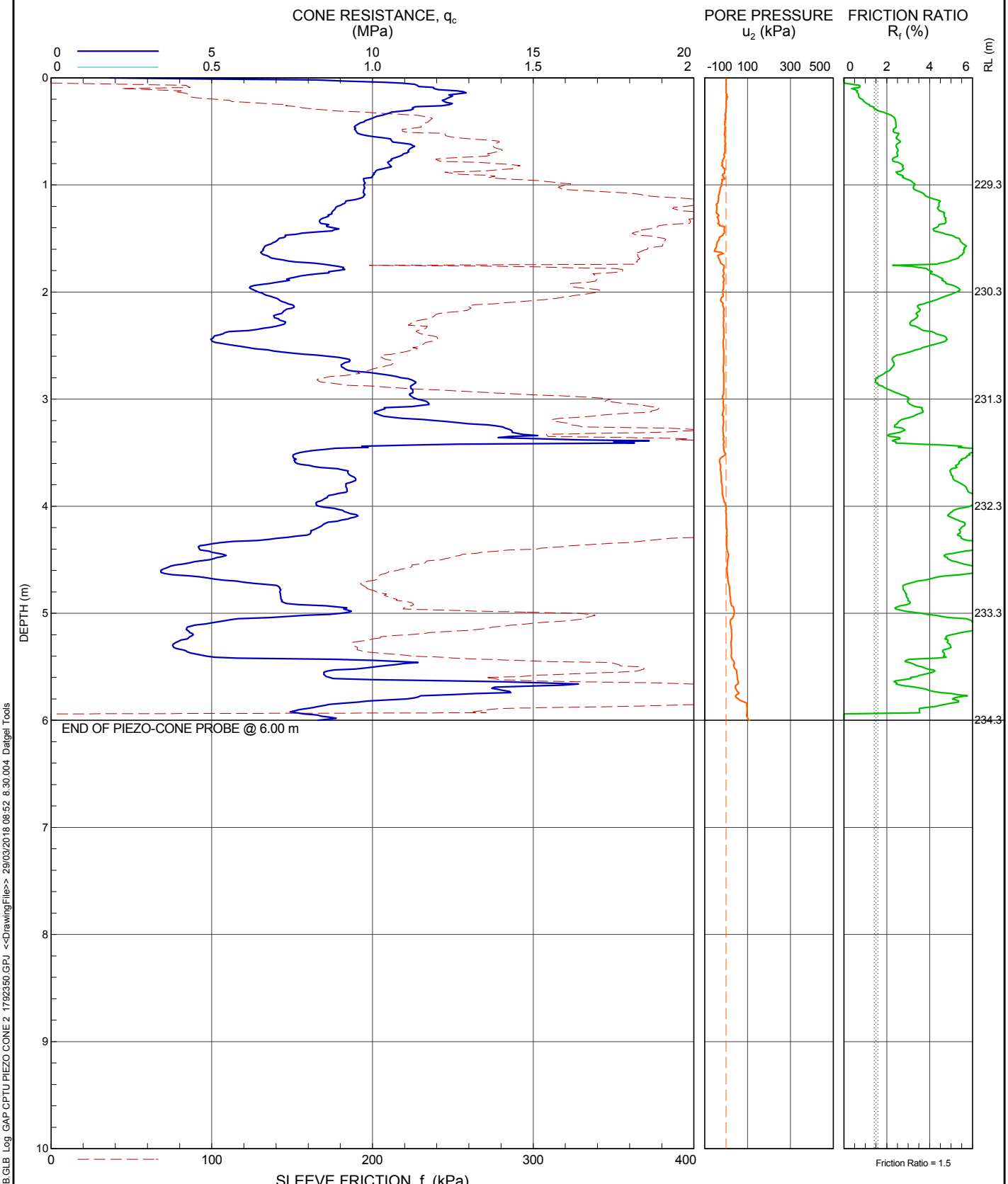
REPORT OF PIEZO-CONE PROBE: GA-CPT-11

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 766979.1 m E 6648756.2 m N MGA94 56
SURFACE RL: 228.33 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 6.00 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 6/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

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GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

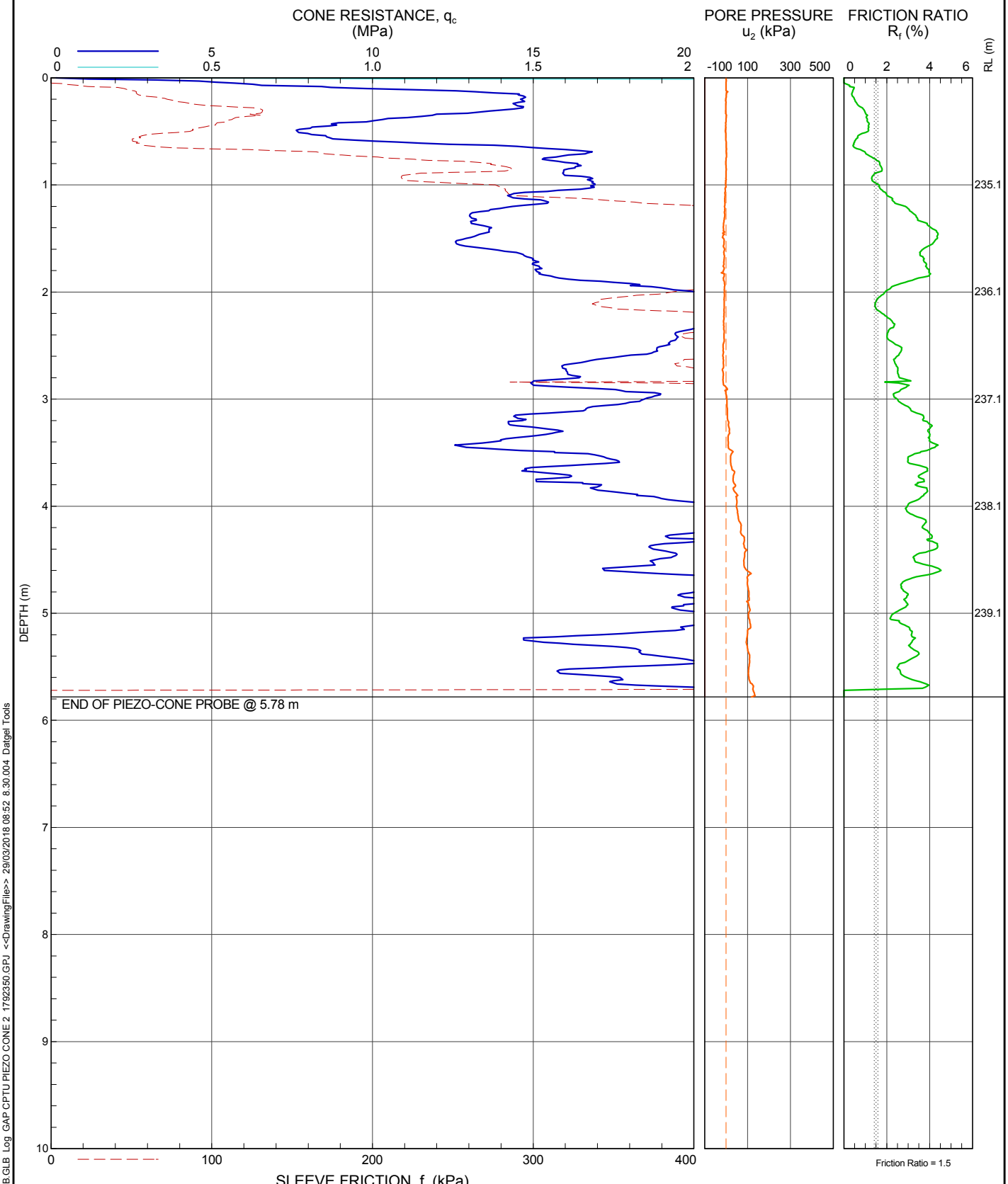
REPORT OF PIEZO-CONE PROBE: GA-CPT-12

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 766988.0 m E 6649114.1 m N MGA94 56
SURFACE RL: 234.10 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 5.78 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 5/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

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GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

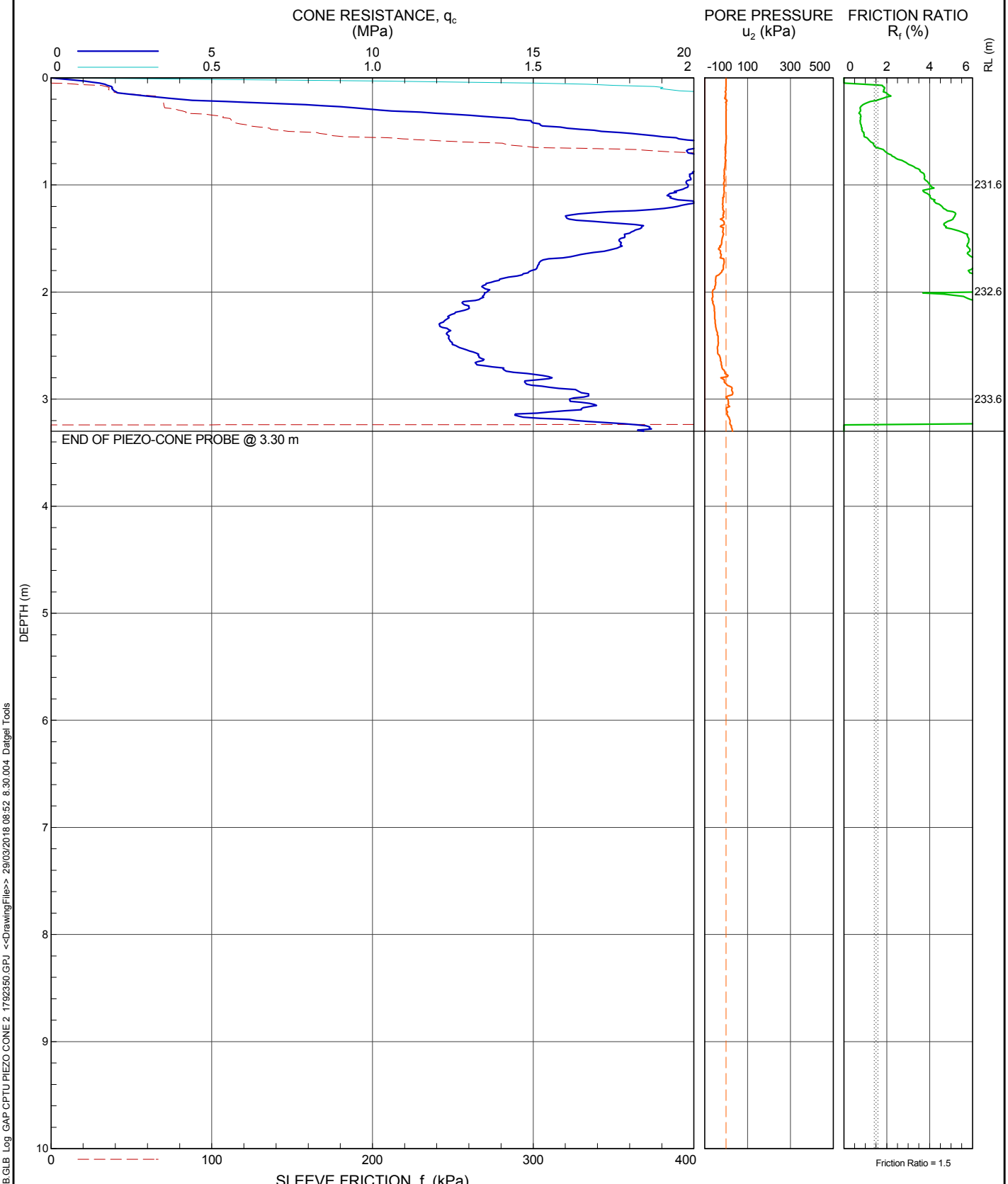
REPORT OF PIEZO-CONE PROBE: GA-CPT-13

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767389.0 m E 6649056.3 m N MGA94 56
SURFACE RL: 230.55 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 3.30 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 6/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

This report of piezo-cone probe must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F10
RL3

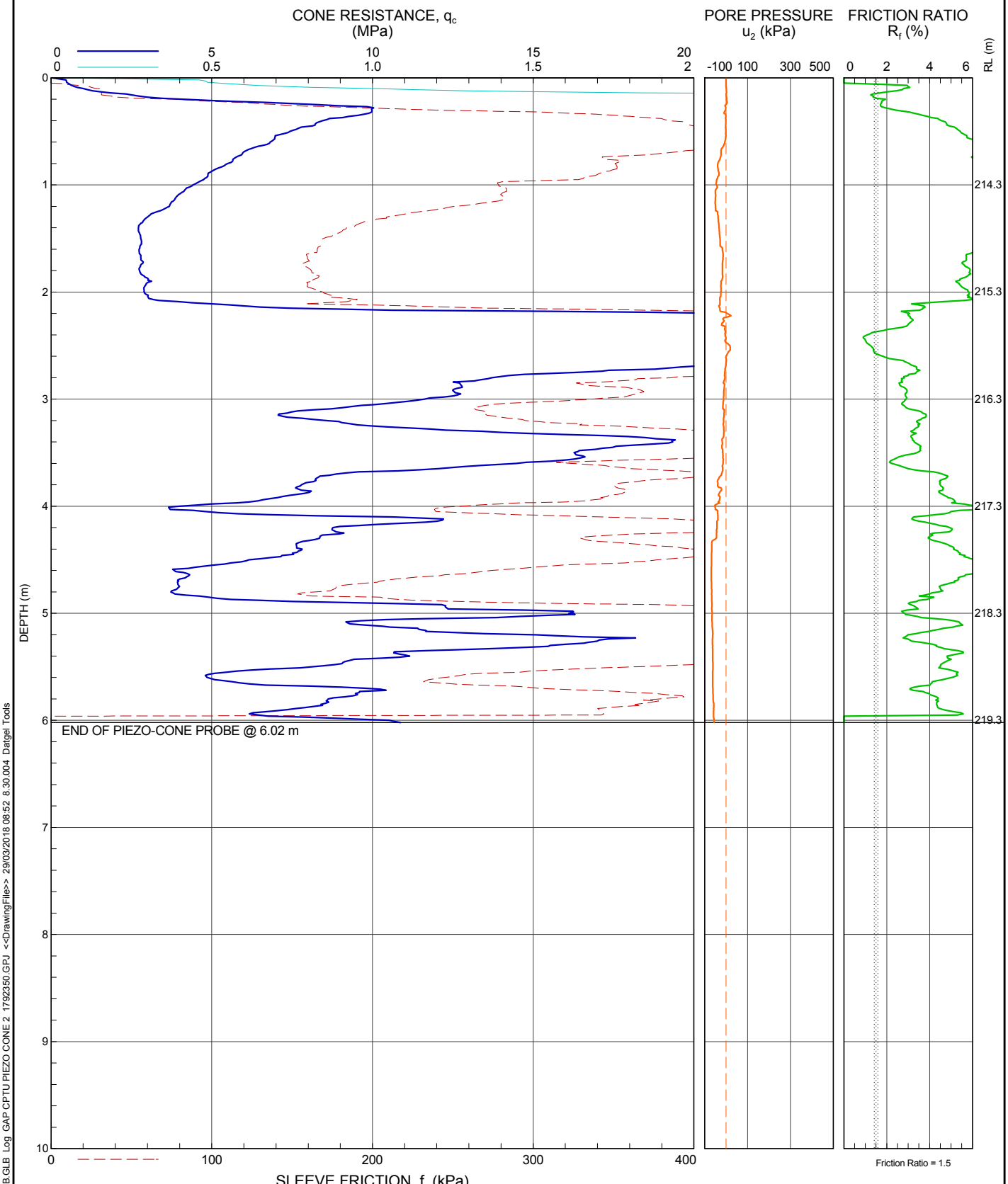
REPORT OF PIEZO-CONE PROBE: GA-CPT-14

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 766776.7 m E 6647386.0 m N MGA94 56
SURFACE RL: 213.33 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 6.02 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 6/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

This report of piezo-cone probe must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F10 RL3

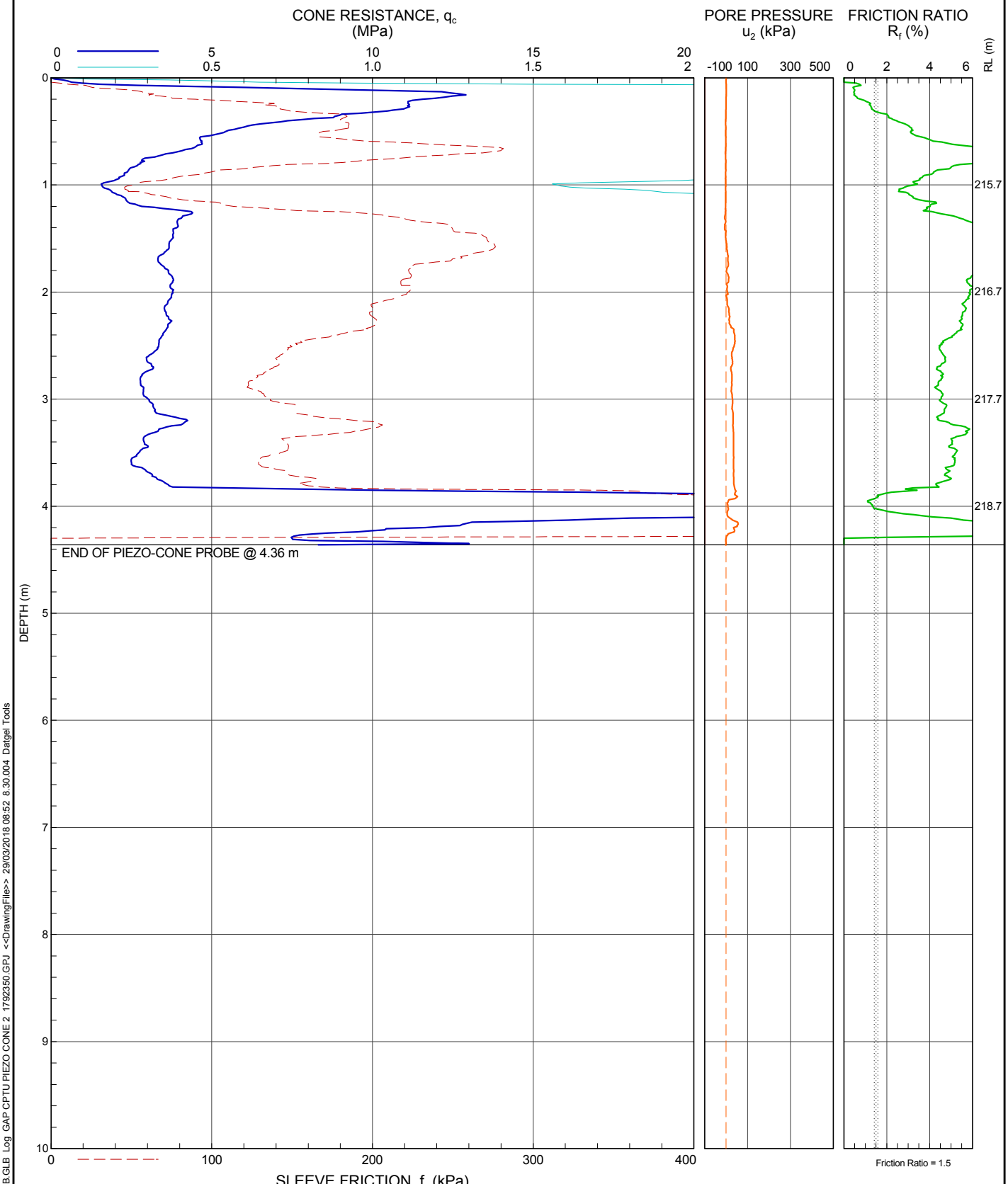
REPORT OF PIEZO-CONE PROBE: GA-CPT-15

SHEET: 1 OF 1
CONE No.: C10CFIIP.C17294

CLIENT: ENGIE Renewables Australia
PROJECT: Narrabri Solar Farm
LOCATION: Narrabri
JOB NO: 1792350

COORDS: 767224.1 m E 6647059.1 m N MGA94 56
SURFACE RL: 214.70 m DATUM: AD
INCLINATION: 90°
HOLE DEPTH: 4.36 m

RIG: Newtracks Crawler
CONTRACTOR: GeoMil Equipment B.V.
RECORDED: NB DATE: 7/3/18
CHECKED: FHH DATE: 28/3/18



COMMENT:
Dissipation Test

This report of piezo-cone probe must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F10
RL3

GAP 8_16.4 LIB.GLB Log GAP CPTU PIEZO CONE 2 1792350.GPJ <<DrawingFile>> 29/03/2018 08:52 8.30.004 Datgel Tools

APPENDIX C

Topographic Report

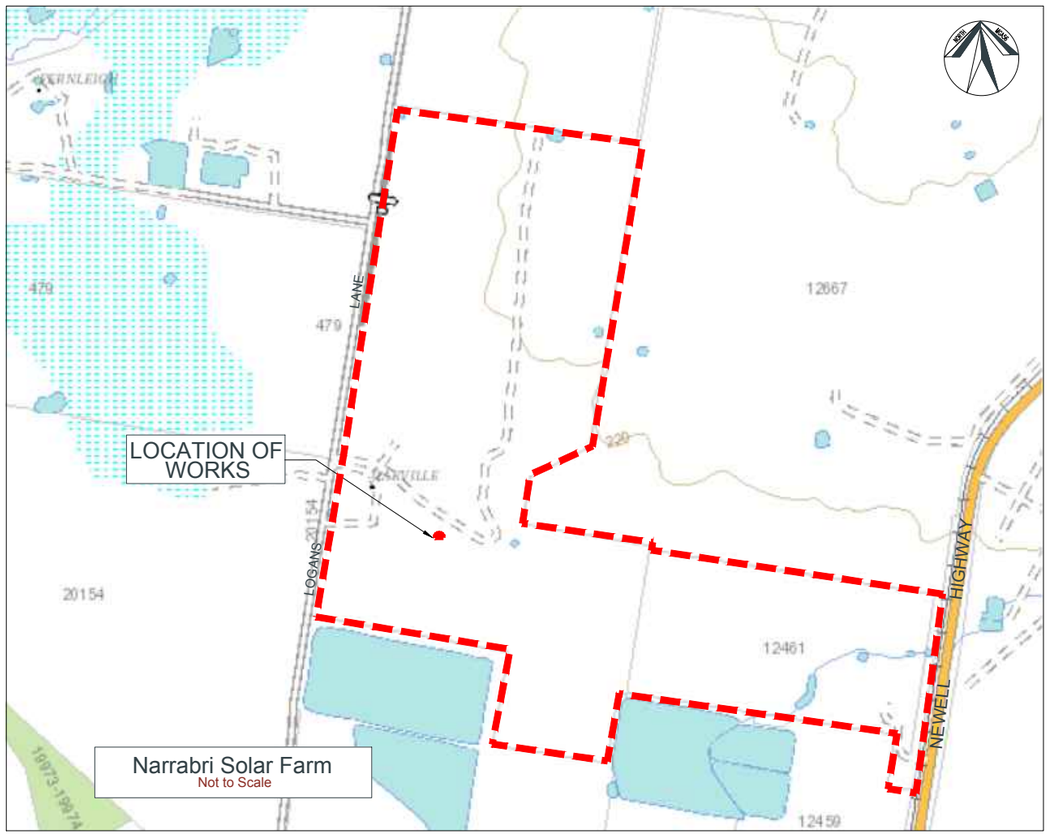
NARRABRI SOLAR FARM

GOLDER ASSOCIATES PTY LTD

DETAIL SURVEY

"OAKVILLE", LOGANS LANE, NARRABRI
LOT 21, LOT 22 AND LOT 23 IN DP1174848 & LOT 2 IN DP586990

SHEET INDEX



LOCALITY PLAN
Not to Scale

Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

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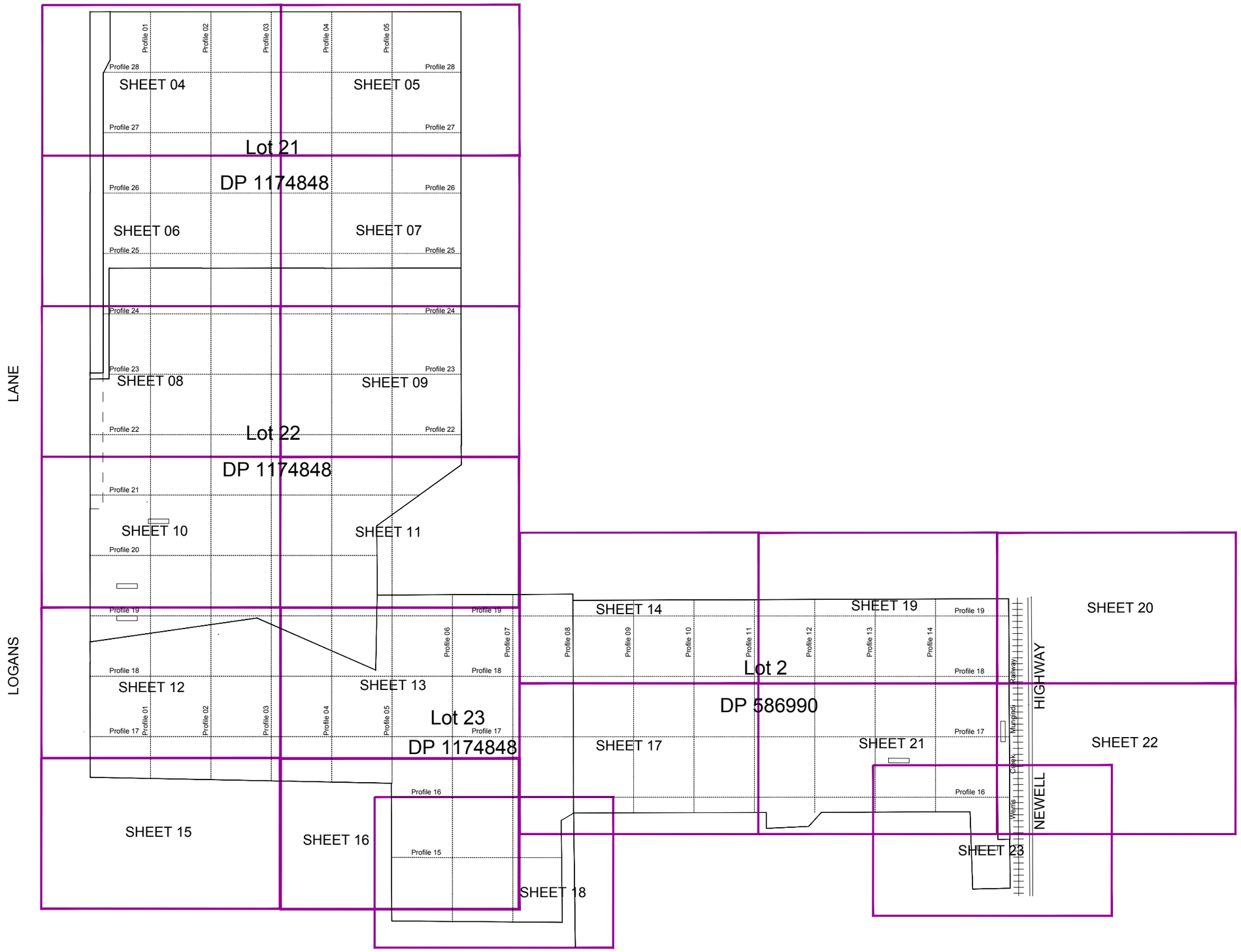
office@mitchelhanlon.com.au
www.mitchelhanlon.com.au
ABN 51 104 693 736
ACN 104 693 736
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Front Sheet

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN

DRAWING No.:	SHEET 1
REVISION	B
ORIGINAL SIZE	A1



Plot Date:

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10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

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www.mitchelhanlon.com.au

ISO9001:2008
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM

SHEET and PROFILE INDEX

A1 Original | Co-ordinate System: MGA Zone 56 | APPROVED: M.H.D. | Contour Interval: 0.2m | Scale: 1:1

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon

SHEET 2

B

A1

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IMPORTANT NOTES & CAUTIONS:-

1. Date of Survey: 26 February to 2 March 2018
2. Control: PM 77369 from NSW SCIM dated 24 Jan 2018.
   - E: 765,692.102, N: 6,644,244.147, Class 2A Order 0
   - H: 209.880, Class B, Order 2
3. Datum
   - Horizontal: MGA 56
   - Vertical: AHD
4. Contours shown depict the topography. Except at spot levels shown, they do not represent the exact level at any particular point. the spot levels are true for their location, and are intended to be useful to represent the general terrain. Care should be taken if extrapolating.
5. This detail survey is not a "land survey" as defined by the Surveying and Spatial Information Act, 2002. If any construction or design work which relies on critical setbacks from the street or boundaries is planned, it would be imperative to carry out further survey work to determine the boundary dimensions.
6. Boundaries have been identified in accordance with Clause 10 of the NSW Surveying and Spatial Information Regulation 2017.
7. Restrictions on the Use of Land apply to Lots 21 and 22 in DP 1174848. No structural improvements are permitted which will interfer with aviation activities on Lot 20 in DP 1174848.
8. Where shown, tree spread and trunk diameters shown are diagrammatic only & may not be symmetrical.
9. The existence and position of underground services has not been investigated. It is the responsibility of each contractor and/ or consultant to contact "Dial Before You Dig" (DBYD) (phone 1100 fax 1300 652 077) before commencing any excavation. Note that not all services providers are members of DBYD.
10. If position and depth of a service is critical to design or construction, the service must be exposed by "pot-holing" carried out by a person accredited by the relevant service provider. Services shown hereon have been determined by visual evidence only. Prior to any demolition, excavation or construction on the site, the relevant authority should be contacted to establish detailed location and depth. Note that not all services providers are members of DBYD. These warnings are for the protection of all parties involved in the development by minimising the chances that existing services are damaged.
11. It should be clearly pointed out that the above notes are an integral part of the plan and must be reproduced in any use, duplication or amendment of the plan. If this is not done Mitchel Hanlon Consulting Pty Ltd will not accept any responsibility and therefore Mitchel Hanlon Consulting Pty Ltd expressly disclaims all liability for errors or omissions of any kind whatsoever, or from any loss, damage or other consequences that may arise from any person relying on the locations of utilities determined by this survey. Such responsibility is transfered to the client who gave instructions for the survey i.e. owner, architect, etc.
12. Any permitted downloading, electronic storage, display, print, copy or reproduction of this survey should contain no alteration or addition to the survey.

THE TITLE BLOCK AND THESE NOTES ARE AN INTEGRAL PART OF THIS DRAWING AND ARE NOT TO BE REMOVED.

SUMMARY TABLE:-

1. Land area:
   - 100.9 ha in land parcel Lot 21 in DP 1174848
   - 134.1 ha in land parcel Lot 22 in DP 1174848
   - 112.1 ha in land parcel Lot 23 in DP 1174848
3. Buildings have not been located by the survey. They are indicated on the plans
   - Main dwelling house
   - Machinery shed
   - Stockyards
   - Woolshed/shearing shed and associated yards
4. Slope:
   - Minimum = 0% (Profiles 2, 6, 7, 20, 23, 24, 26, 28, 31 and 32)
   - Maximum = 1.9% (Profile 2)
5. Vegetation:
   - Trees are located groups as indicated.
   - Tree lines are located along contour banks as indicated with zero to 20m spacing between driplines
   - Tree areas are located on uncultivated areas as open woodland. Tree density varies.
6. Constraints:
   - Banks, drains, dams have been located as shown
   - Overhead powerlines have been located as shown.
   - A restriction on the erection of structures that may impede aircraft use exists south of the landing field. the extent of the restriction is shown on the plan
   - Isolated stock water points are located throughout the site as water troughs
   - Silos are located throughout the site
   - Fences and yards are located throughout the site

Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

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www.mitchelhanlon.com.au
ABN 51 104 693 736
ACN 104 693 736

ISO9001:2008 FS555072

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
Survey Notes and Summary Table

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smtih
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 3
REVISION: B
ORIGINAL SIZE: A1

Lot 12
DP 1086653

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LANE

LOGANS

AIRSTRIP

AIRSTRIP

Lot 20
DP 1174848
(5.57Ha)

Lot 21
DP 1174848
(100.9Ha)

BH01

CPT12

Water Tanks

Miscellaneous Post

Miscellaneous Post

Miscellaneous Post

Cattle Trough

SURVEYED

NOT

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

REDUCTION RATIO
A1: 1:1000
A3: 1:2000
A4: 1:3000

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Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
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ABN 51 104 693 736
ACN 104 693 736

ISO9001:2008
FS555072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
Lot 21 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 4
REVISION B
ORIGINAL SIZE A1

Lot 21
DP 1174848
(100.9Ha)

Lot 12
DP 1086653

BH06
CPT13
Creek
Water

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

Plot Date: 10 April 2018
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ACN 104 693 736

ISO9001:2008 FS550572

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
Lot 21 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 5
REVISION: B
ORIGINAL SIZE: A1

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LANE

LOGANS

AIRSTRIP

Lot 20
DP 1174848
(5.57Ha)

AIRSTRIP

NOT SURVEYED

Lot 21
DP 1174848
(100.9Ha)

Lot 22
DP 1174848
(134.1Ha)

BH02
BH07
CPT11
Cattle Trough
Electricity Box
Windmill

Contour
Bank

226.00
229.00
228.00
227.00
224.00
223.00
225.00
222.00
220.00

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

REDUCTION RATIO
A1: 1:1000
A3: 1:2000
A4: 1:3000

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Plot Date: 10 April 2018
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B	10-04-18	Profiles		
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A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

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ABN 51 104 693 736
ACN 104 693 736

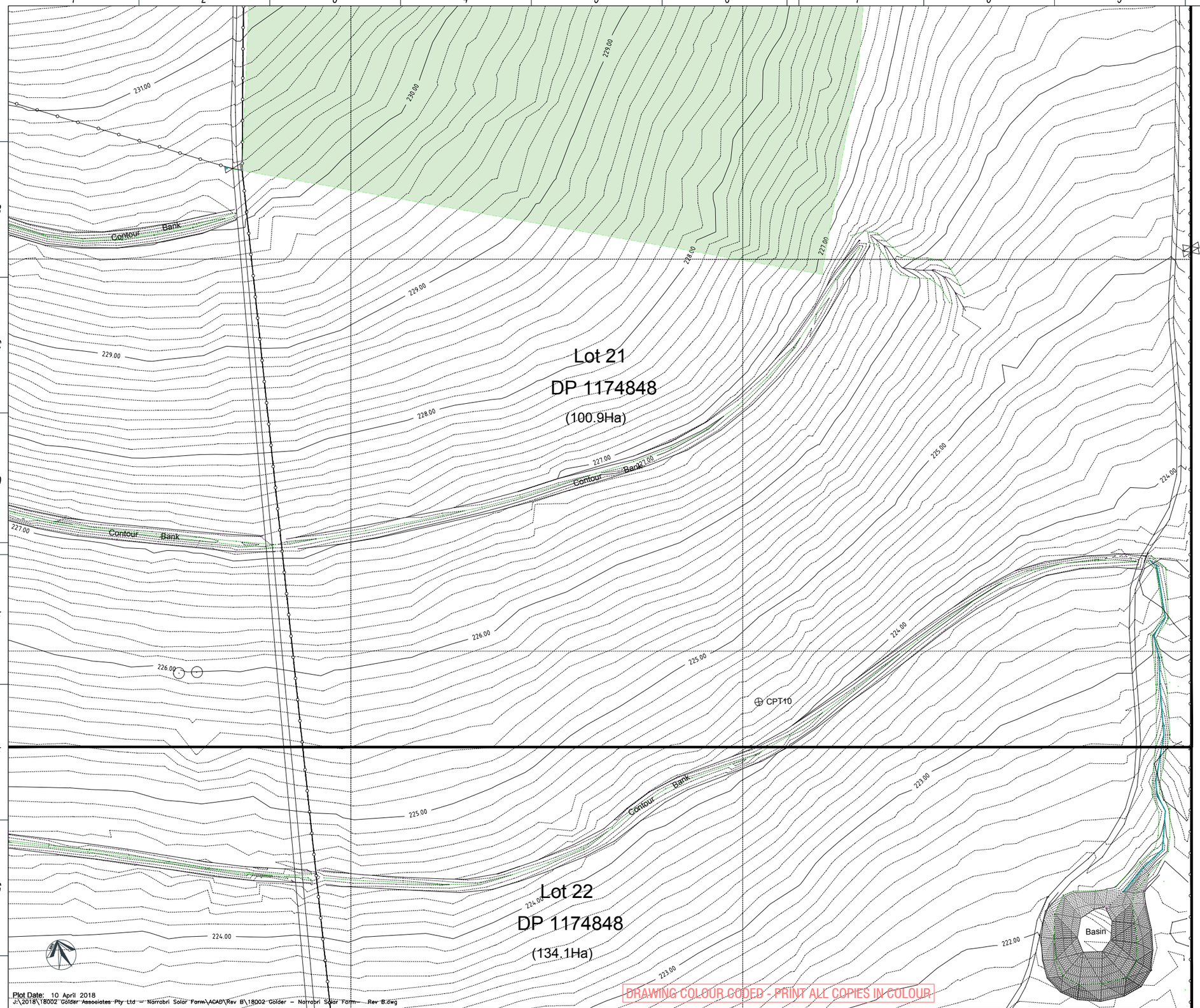
ISO9001:2008 FS555072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
LOT 21 AND LOT 22 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 6
REVISION: B
ORIGINAL SIZE: A1



Lot 12
DP 1086653

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SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POWER POLE WITH LIGHT
- STAY POLE
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- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

Plot Date: 10 April 2018
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A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

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ABN 51 104 693 736
ACN 104 693 736

ISO9001:2008 FS555072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
LOT 21 AND LOT 22 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 7
REVISION B
ORIGINAL SIZE A1

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LANE

AIRSTRIP

Lot 20
DP 1174848
(5.57Ha)

NOT SURVEYED

Lot 22
DP 1174848
(134.1Ha)

LOGANS

Contour Bank

Cattle Trough

223.00 222.00 221.00 220.00 219.00 217.00

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
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- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

(A) RESTRICTIONS ON THE USE OF LAND (AIRSTRIP) DP1174848

REDUCTION RATIO
A1: 1:1000
A3: 1:2000
A4: 1:3000

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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

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ABN 51 104 693 736
ACN 104 693 736

ISO9001:2008 FS555072

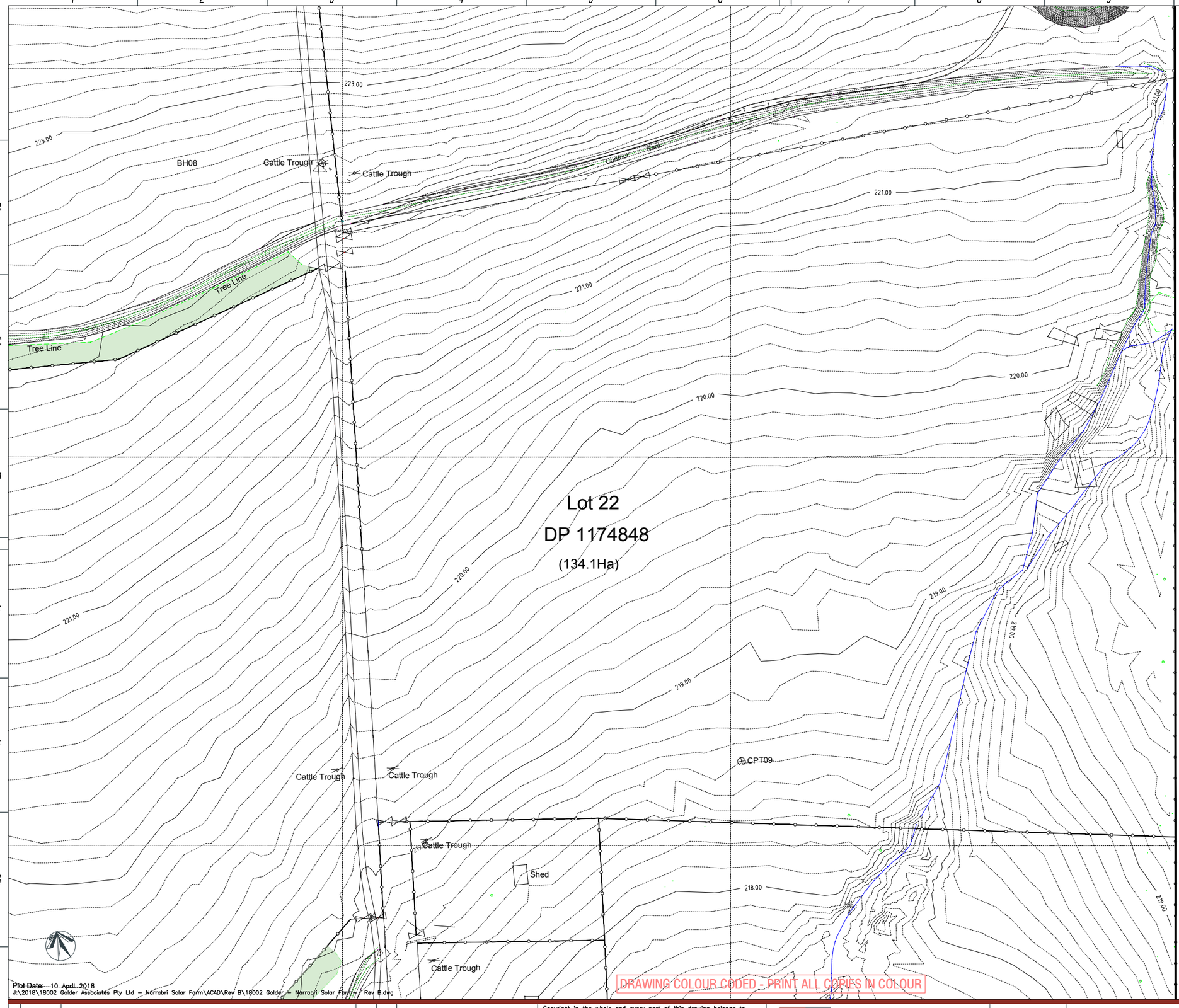
DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 22 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 8
REVISION: B
ORIGINAL SIZE: A1



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DIAL 1100 BEFORE YOU DIG

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT POINT
- POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

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ABN 51 104 693 736
ACN 104 693 736

ISO9001:2008 FS550072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
Lot 22 in DP1174848

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN

DRAWING No.: SHEET 9
REVISION: B
ORIGINAL SIZE: A1

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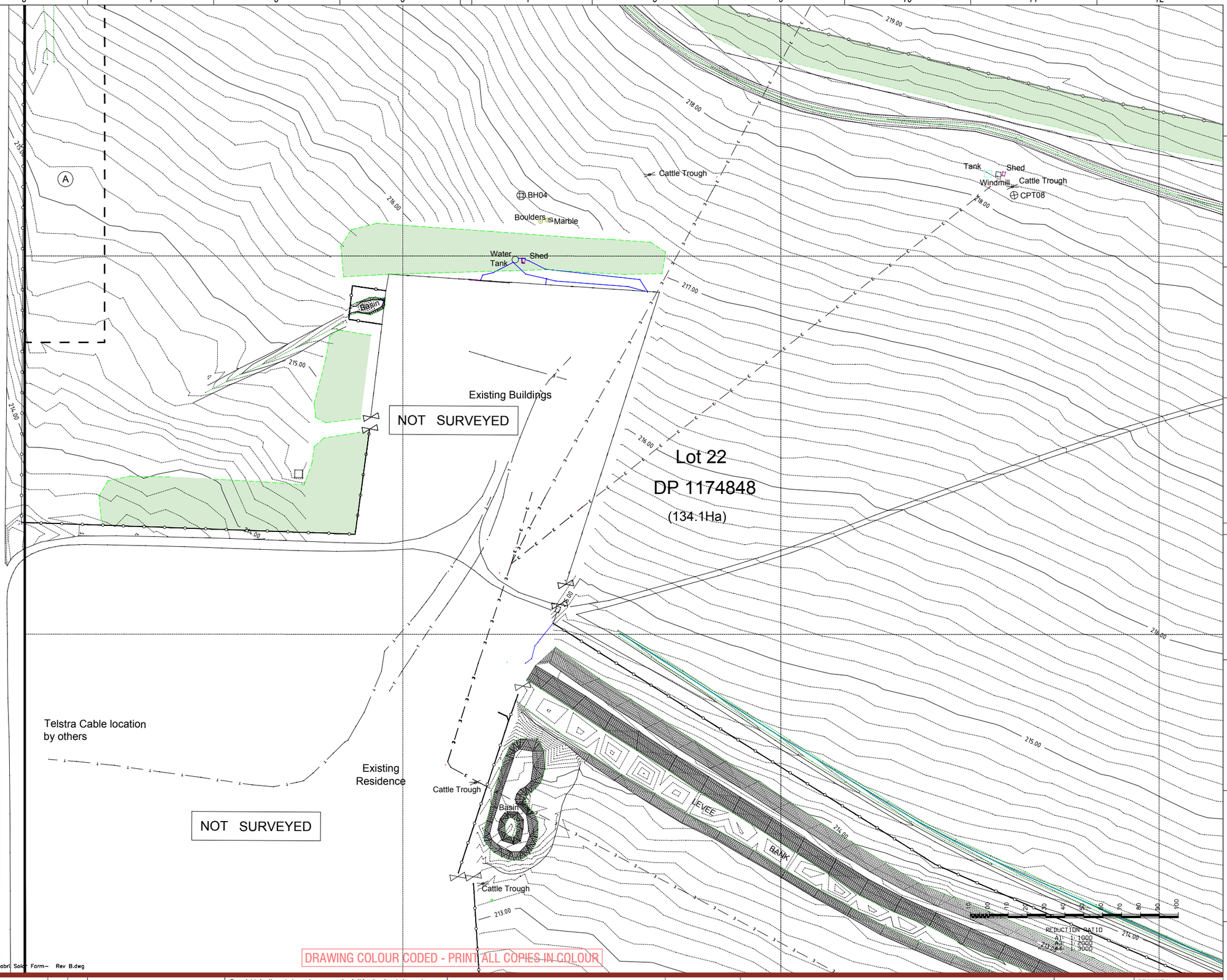
LANE

LOGANS



SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

(A) RESTRICTIONS ON THE USE OF LAND (AIRSTRIP) DP1174848

REDUCTION RATIO
A1 1:1000
A3 1:2000
A4 1:3000

Plot Date: 10 April 2018
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ISO9001:2008 FS555072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
Lot 21 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 10
REVISION B
ORIGINAL SIZE A1

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Shed
Cattle Trough
Shed
Cattle Trough
Shed
Cattle Trough
Existing Building
Water Tank
Wind Mill
Existing Wool Shed
Sheep Yard
Basin
Stock Pile
BH09

Lot 22
DP 1174848
(134.1Ha)

Lot 11
DP 1086653

Lot 23
DP 1174848
(112.1Ha)

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

REDUCTION RATIO
A1: 1:1000
A3: 1:2000
A4: 1:3000

Plot Date: 10 April 2018
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ISO9001:2008 FS555072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
LOT 22 and LOT 23 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 11
REVISION: B
ORIGINAL SIZE: A1

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NOT SURVEYED

Lot 22
DP 1174848
(134.1Ha)

Lot 23
DP 1174848
(112.1Ha)

LANE

LOGANS

Contour Bank

BH05

213.00 212.00 211.00 210.00

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT POINT
- POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

REDUCTION RATIO
A1: 1:1000
A3: 1:2000
A4: 1:3000

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Plot Date: 10 April 2018
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DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
LOT 22 and LOT 23 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 12
REVISION: B
ORIGINAL SIZE: A1

Lot 22
DP 1174848
(134.1Ha)

Lot 23
DP 1174848
(112.1Ha)

Lot 23
DP 1174848
(112.1Ha)

LEVEE BANK

LEVEE BANK

Contour Bank

BH11

CPT04

BH10

CPT05

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

REDUCTION RATIO
1:500
1:1000
1:2000
1:3000

Plot Date: 10 April 2018
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ISO9001:2008 FS555072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 23 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 13
REVISION: B
ORIGINAL SIZE: A1

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SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

Lot 11
DP 1086653

Lot 23
DP 1174848
(112.1Ha)

Lot 2
DP 586990
(102.6Ha)

BH13

BH14

218.00

217.00

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

Plot Date: 10 April 2018
J:\2018\18002_Golder_Associates_Pty_Ltd_-_Narrabri_Solar_Farm\ACAD\Rev_B\18002_Golder_-_Narrabri_Solar_Farm_-_Rev_B.dwg

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DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 23 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 14
REVISION: B
ORIGINAL SIZE: A1

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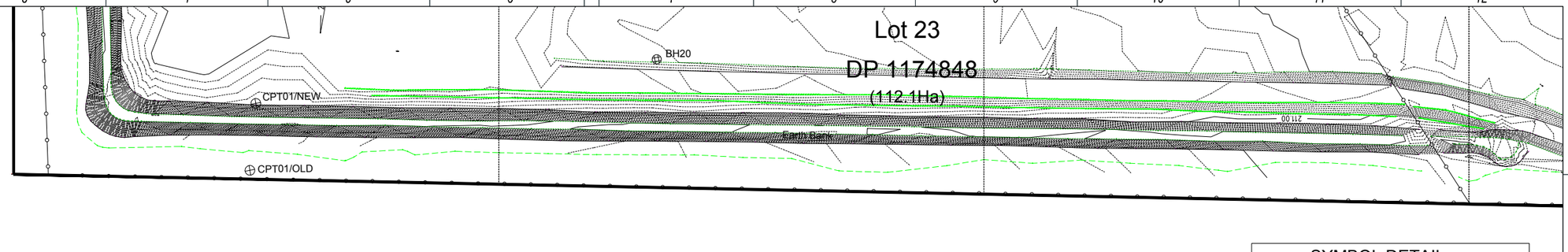

Lot 23
DP 1174848
(112.1Ha)

Lot 2
DP 1142181

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT POINT
- POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

Plot Date: 10 April 2018
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DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 23 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 15
REVISION: B
ORIGINAL SIZE: A1

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BH15
212.00
Earth Bank
Contour Bank
BH12
213.00
LEVEE BANK
Lot 2
DP 1142181
Lot 23
DP 1174848
(112.1Ha)
CPT06
212.00
213.00

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT POINT
- POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

Plot Date: 10 April 2018
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CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 23 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 16
REVISION: B
ORIGINAL SIZE: A1

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BH13

CPT07

BH16

BH17

216.00

215.00

214.00

Lot 23
DP 1174848
(112.1Ha)

Lot 2
DP 586990
(102.6Ha)

Lot 2
DP 1142181

Lot 373A
DP 186621

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
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- WATER METER
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- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

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ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 23 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 17
REVISION: B
ORIGINAL SIZE: A1

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT POINT
- POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
- LETTERBOX
- MAILBOX
- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

Plot Date: 10 April 2018
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B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

Mitchel Hanlon Consulting Pty Ltd
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office@mitchelhanlon.com.au
www.mitchelhanlon.com.au

ISO9001:2008 FS555072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
LOT 23 in DP1174848

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 18
REVISION: B
ORIGINAL SIZE: A1

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SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT POINT
- POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
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- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

Lot 11
DP 1086653

Lot 2
DP 586990
(102.6Ha)

217.00

BH18

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

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Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
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A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

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ISO9001:2008 FS555072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 2 in DP586990

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 19
REVISION: B
ORIGINAL SIZE: A1

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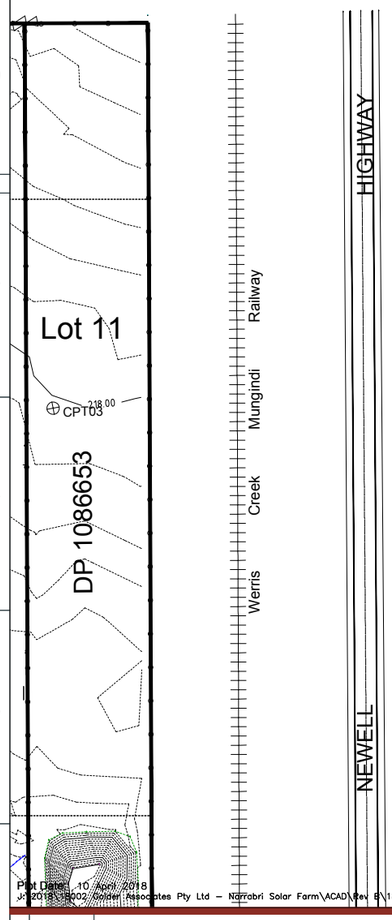

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
- POWER POLE & TRANSFORMER
- TELECOM CABLE MARKER
- TELECOM SINGLE CONC PIT
- TELEPHONE POLE
- TELECOM MAIN PIT
- TELECOM TWIN CONC PIT
- TELECOM DISTRIBUTION PILLAR
- DENSE TREE AREA
- HYDRANT
- WATER METER
- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
- BORE HOLE
- SIGN
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- TREE
- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

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Plot Date: 10 April 2018
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ACN 104 693 736

ISO9001:2008 FS550072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM
DETAIL SURVEY
LOT 2 in DP586990

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 20
REVISION: B
ORIGINAL SIZE: A1

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Lot 2
DP 586990
(102.6Ha)

NOT SURVEYED

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POWER POLE WITH LIGHT
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- SEWER MANHOLE
- CONE PENETRATING TEST (CTP)
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- FLAGPOLE FP
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- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

Plot Date: 10 April 2018
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ISO9001:2008 FS555072

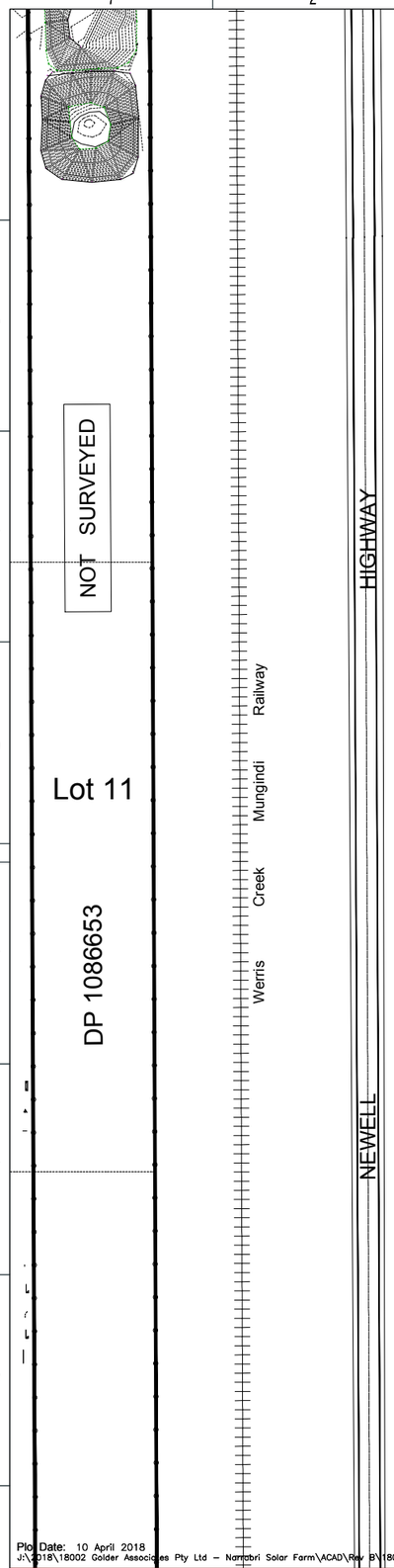
DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 2 in DP586990

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 21
REVISION B
ORIGINAL SIZE A1



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SYMBOL DETAIL

- STN - SSM, PM
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- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
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- FLAGPOLE FP
- GATE
- FENCE
- GAS LINE
- ELECTRICAL CABLE
- SEWER
- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1:1000
A3: 1:2000
A4: 1:3000

Plot Date: 10 April 2018
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ISO9001:2008 FS555072

DATUM: AHD
ORIGIN:PM 77369 RL:209.88
CONTOUR INTERVAL:0.1m

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 2 in DP586990

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 22
REVISION: B
ORIGINAL SIZE: A1

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Lot 2
DP 586990
(102.6Ha)

Lot 11
DP 1086653

NOT SURVEYED

Werris Creek Mungindi Railway

HIGHWAY

NEWELL

SYMBOL DETAIL

- STN - SSM, PM
- BOLT,NAIL,DPY,SPIKE
- LIGHT POLE
- POWER POLE
- STAY ANCHOR POINT
- POINT POWER POLE WITH LIGHT
- STAY POLE
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- WATER
- TELECOMMUNICATIONS CABLE
- IRRIGATION

10 00 10 20 30 40 50 60 70 80 90 100

REDUCTION RATIO
A1: 1: 1000
A3: 1: 2000
A4: 1: 3000

Plot Date: 10 April 2018
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ABN 51 104 693 736
ACN 104 693 736

ISO9001:2015
FS555072

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
LOT 2 in DP586990

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 23
REVISION: B
ORIGINAL SIZE: A1

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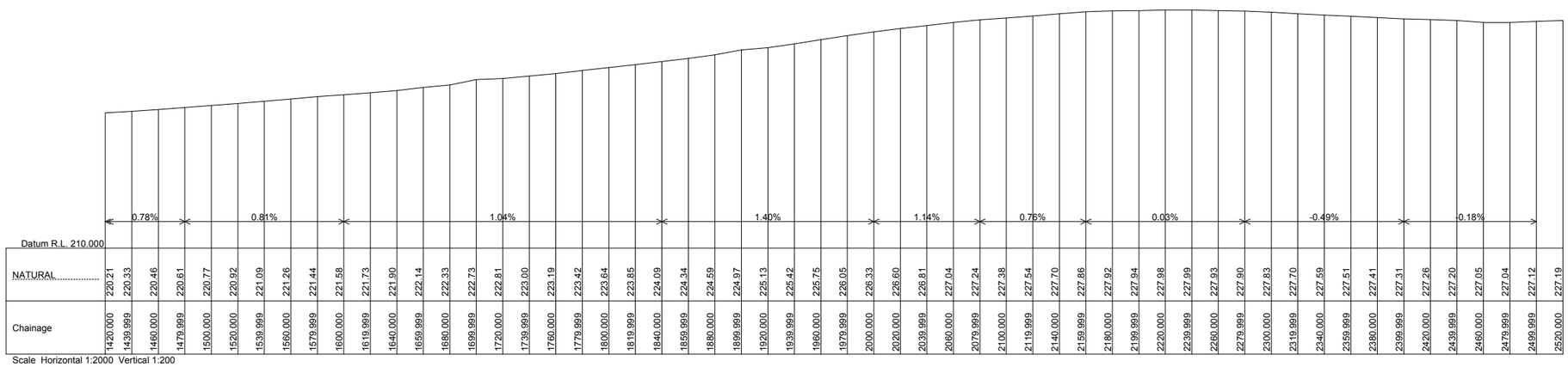
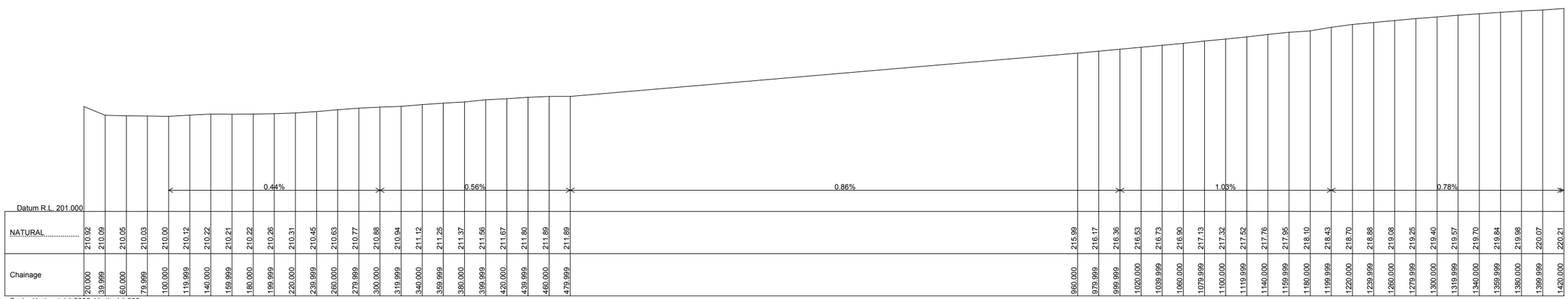


Scale Horizontal 1:2000 Vertical 1:200

Profile 01



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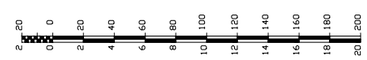
Profile 01



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ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profile No.01

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN

DRAWING No.: SHEET 24
REVISION: B
ORIGINAL SIZE: A1

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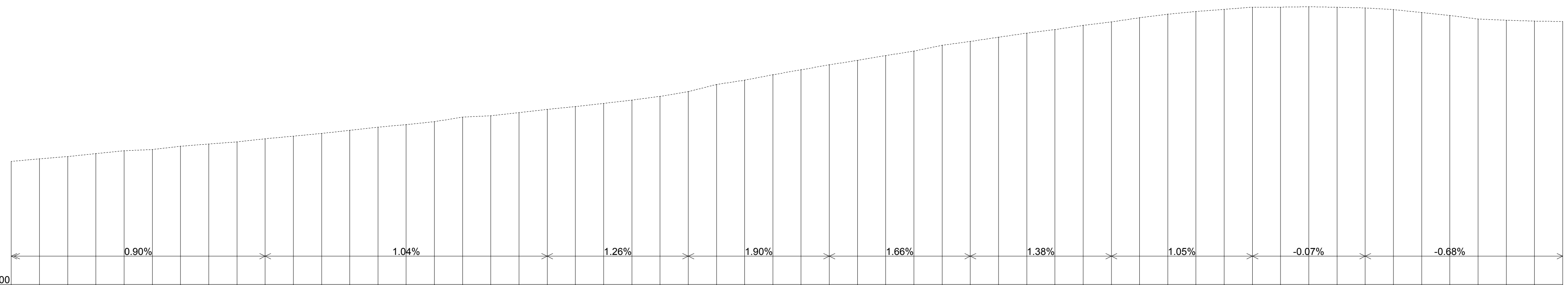
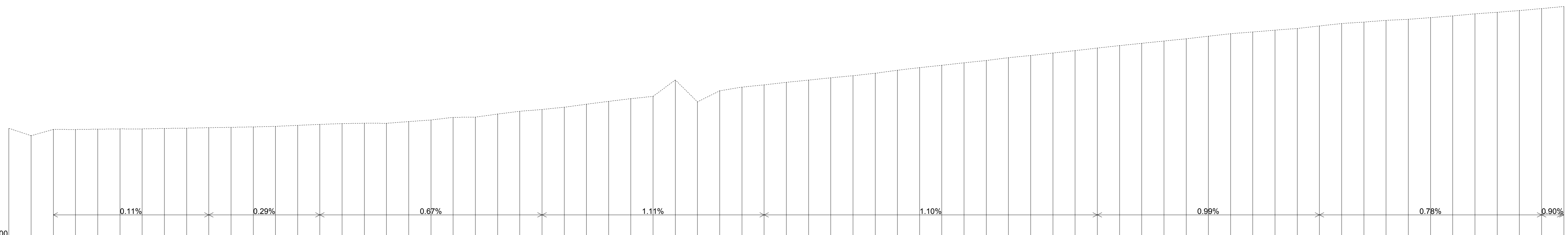


Datum R.L. 213.000

Chainage	NATURAL
1420.000	221.73
1439.999	221.91
1460.000	222.08
1479.999	222.28
1499.999	222.49
1520.000	222.57
1539.999	222.81
1560.000	222.97
1579.999	223.12
1600.000	223.34
1619.999	223.52
1640.000	223.72
1659.999	223.94
1680.000	224.16
1699.999	224.34
1720.000	224.55
1739.999	224.88
1760.000	224.97
1779.999	225.20
1800.000	225.42
1819.999	225.62
1840.000	225.85
1859.999	226.08
1880.000	226.35
1899.999	226.68
1920.000	227.19
1939.999	227.49
1960.000	227.88
1980.000	228.23
1999.999	228.59
2020.000	228.90
2039.999	229.24
2060.000	229.56
2079.999	229.97
2100.000	230.25
2119.999	230.54
2140.000	230.83
2159.999	231.09
2180.000	231.38
2199.999	231.63
2220.000	231.93
2239.999	232.18
2260.000	232.37
2279.999	232.52
2300.000	232.68
2319.999	232.68
2340.000	232.71
2359.999	232.67
2380.000	232.62
2399.999	232.50
2420.000	232.29
2439.999	232.09
2460.000	231.83
2480.000	231.75
2499.999	231.69
2520.000	231.66

Scale Horizontal 1:2000 Vertical 1:200

Profile 02



Datum R.L. 201.000

Chainage	NATURAL
20.000	210.78
39.999	210.12
60.000	210.68
79.999	210.68
100.000	210.71
119.999	210.73
140.000	210.73
159.999	210.78
180.000	210.80
199.999	210.84
220.000	210.87
239.999	210.91
260.000	210.96
279.999	211.05
300.000	211.14
319.999	211.21
340.000	211.24
359.999	211.24
380.000	211.39
399.999	211.53
420.000	211.77
439.999	211.79
460.000	212.07
479.999	212.31
499.999	212.48
520.000	212.68
539.999	212.95
560.000	213.21
579.999	213.45
600.000	213.66
619.999	215.13
640.000	213.16
659.999	214.16
680.000	214.48
699.999	214.69
720.000	214.92
739.999	215.12
760.000	215.33
779.999	215.51
800.000	215.73
819.999	216.00
840.000	216.24
859.999	216.45
880.000	216.67
899.999	216.88
920.000	217.13
939.999	217.33
960.000	217.55
979.999	217.77
999.999	218.00
1020.000	218.22
1039.999	218.42
1060.000	218.63
1079.999	218.83
1100.000	219.06
1119.999	219.29
1140.000	219.44
1159.999	219.61
1180.000	219.76
1199.999	219.98
1220.000	220.20
1239.999	220.33
1260.000	220.49
1279.999	220.58
1300.000	220.73
1319.999	220.89
1340.000	221.07
1359.999	221.21
1380.000	221.37
1399.999	221.54
1420.000	221.73

Scale Horizontal 1:2000 Vertical 1:200

Profile 02

REDUCTION RATIO
A1: H: 1:2000 V: 1:200
A3: H: 1:4000 V: 1:400
A4: H: 1:6000 V: 1:600

Plot Date: 10 April 2018
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www.mitchelhanlon.com.au

ISO9001:2015
FS555072

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
Profile No.02

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 25
REVISION B
ORIGINAL SIZE A1

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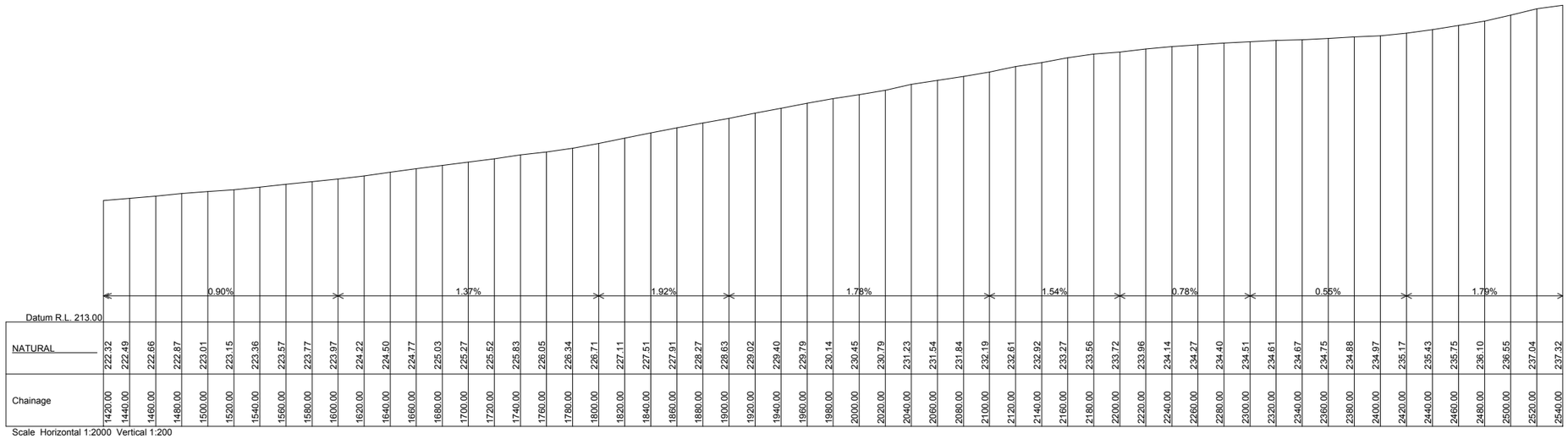
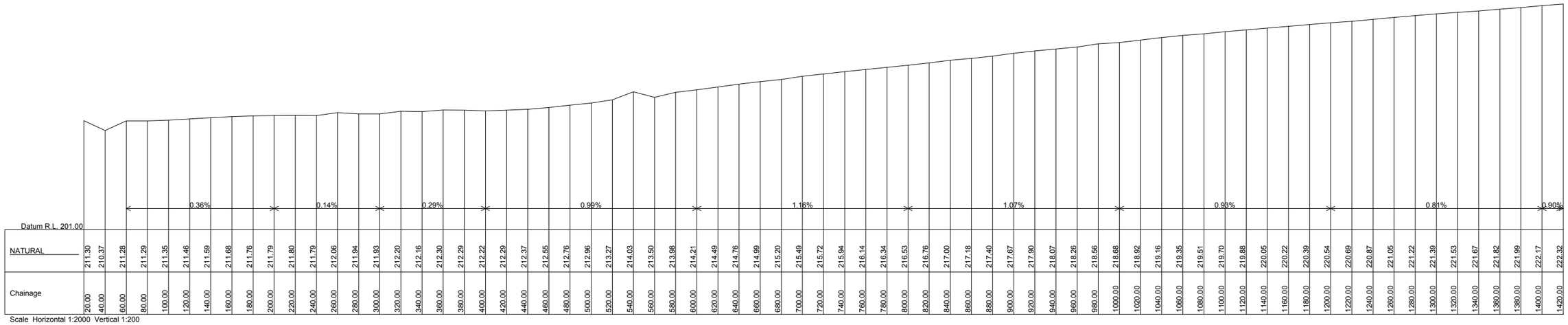


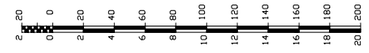
Scale Horizontal 1:2000 Vertical 1:200

Profile 03



Scale Horizontal 1:2000 Vertical 1:200

Profile 03



Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

Mitchel Hanlon Consulting Pty Ltd
ABN 51 104 693 736
ACN 104 693 736
121 Bridge Street
P.O. Box 1568
Tamworth, NSW, 2340
Telephone:02-6762 4411
Facsimile:02-6762 4412
office@mitchelhanlon.com.au
www.mitchelhanlon.com.au
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profile No.03

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN

DRAWING No.: SHEET 26
REVISION: B
ORIGINAL SIZE: A1

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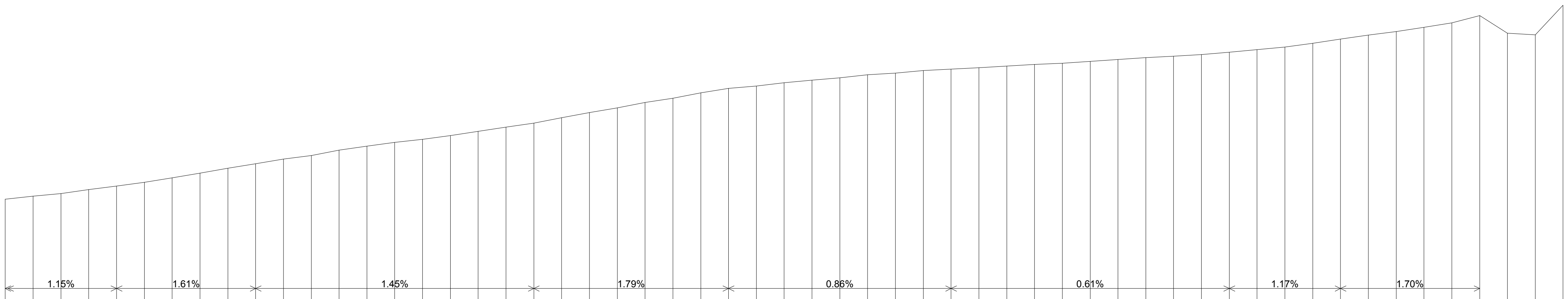


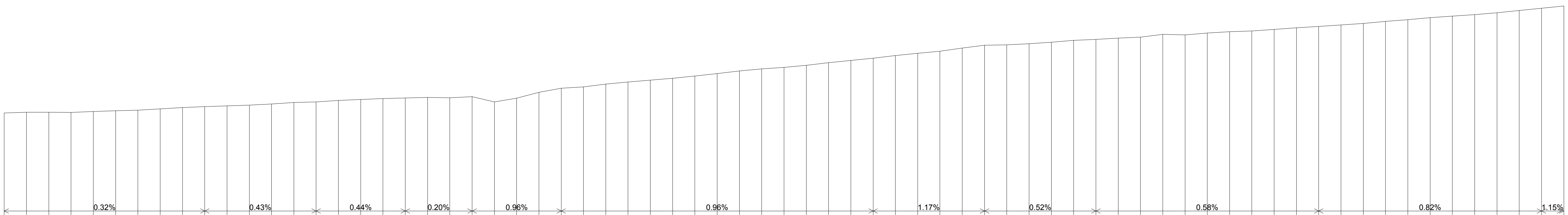
Grade	Chainage range
1.15%	1420.00 – 1500.00
1.61%	1500.00 – 1600.00
1.45%	1600.00 – 1800.00
1.79%	1800.00 – 1940.00
0.86%	1940.00 – 2100.00
0.61%	2100.00 – 2300.00
1.17%	2300.00 – 2380.00
1.70%	2380.00 – 2480.00

Datum R.L. 213.00

Chainage	NATURAL
1420.00	221.41
1440.00	221.62
1460.00	221.82
1480.00	222.10
1500.00	222.36
1520.00	222.62
1540.00	222.94
1560.00	223.29
1580.00	223.63
1600.00	223.96
1620.00	224.30
1640.00	224.55
1660.00	224.94
1680.00	225.22
1700.00	225.49
1720.00	225.72
1740.00	225.97
1760.00	226.28
1780.00	226.58
1800.00	226.87
1820.00	227.26
1840.00	227.63
1860.00	227.97
1880.00	228.37
1900.00	228.66
1920.00	229.05
1940.00	229.38
1960.00	229.55
1980.00	229.77
2000.00	229.96
2020.00	230.13
2040.00	230.34
2060.00	230.47
2080.00	230.64
2100.00	230.75
2120.00	230.85
2140.00	230.97
2160.00	231.09
2180.00	231.18
2200.00	231.31
2220.00	231.45
2240.00	231.58
2260.00	231.67
2280.00	231.79
2300.00	231.97
2320.00	232.15
2340.00	232.34
2360.00	232.60
2380.00	232.90
2400.00	233.19
2420.00	233.45
2440.00	233.76
2460.00	234.08
2480.00	234.60
2500.00	233.33
2520.00	233.21
2540.00	235.33

Scale Horizontal 1:2000 Vertical 1:200

Profile 04



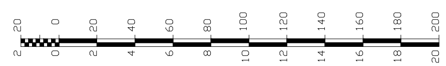
Grade	Chainage range
0.32%	20.00 – 200.00
0.43%	200.00 – 300.00
0.44%	300.00 – 380.00
0.20%	380.00 – 440.00
0.96%	440.00 – 520.00
0.96%	520.00 – 800.00
1.17%	800.00 – 900.00
0.52%	900.00 – 1000.00
0.58%	1000.00 – 1200.00
0.82%	1200.00 – 1400.00
1.15%	1400.00 – 1420.00

Datum R.L. 201.00

Chainage	NATURAL
20.00	211.80
40.00	211.87
60.00	211.86
80.00	211.85
100.00	211.93
120.00	212.01
140.00	212.06
160.00	212.17
180.00	212.29
200.00	212.38
220.00	212.44
240.00	212.51
260.00	212.61
280.00	212.74
300.00	212.80
320.00	212.93
340.00	213.02
360.00	213.09
380.00	213.15
400.00	213.21
420.00	213.17
440.00	213.27
460.00	212.80
480.00	213.14
500.00	213.65
520.00	214.03
540.00	214.15
560.00	214.39
580.00	214.58
600.00	214.75
620.00	214.93
640.00	215.12
660.00	215.34
680.00	215.58
700.00	215.77
720.00	215.91
740.00	216.08
760.00	216.32
780.00	216.52
800.00	216.72
820.00	216.95
840.00	217.16
860.00	217.35
880.00	217.63
900.00	217.88
920.00	217.92
940.00	218.02
960.00	218.15
980.00	218.32
1000.00	218.41
1020.00	218.53
1040.00	218.61
1060.00	218.86
1080.00	218.81
1100.00	218.98
1120.00	219.10
1140.00	219.17
1160.00	219.30
1180.00	219.45
1200.00	219.58
1220.00	219.70
1240.00	219.84
1260.00	220.02
1280.00	220.18
1300.00	220.36
1320.00	220.50
1340.00	220.63
1360.00	220.81
1380.00	221.00
1400.00	221.21
1420.00	221.41

Scale Horizontal 1:2000 Vertical 1:200

Profile 04



REDUCTION RATIO
A1: H: 1: 2000 V: 1: 200
A3: H: 1: 4000 V: 1: 400
A4: H: 1: 6000 V: 1: 600

Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

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ISO9001:2015
FS555072

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
Profile No.04

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 27
REVISION: B
ORIGINAL SIZE: A1

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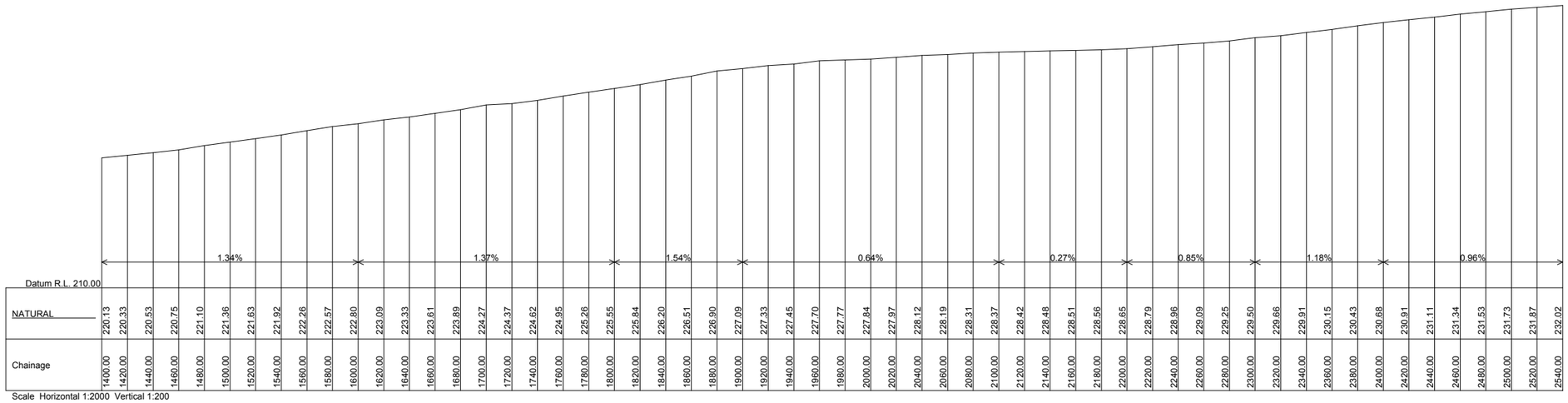
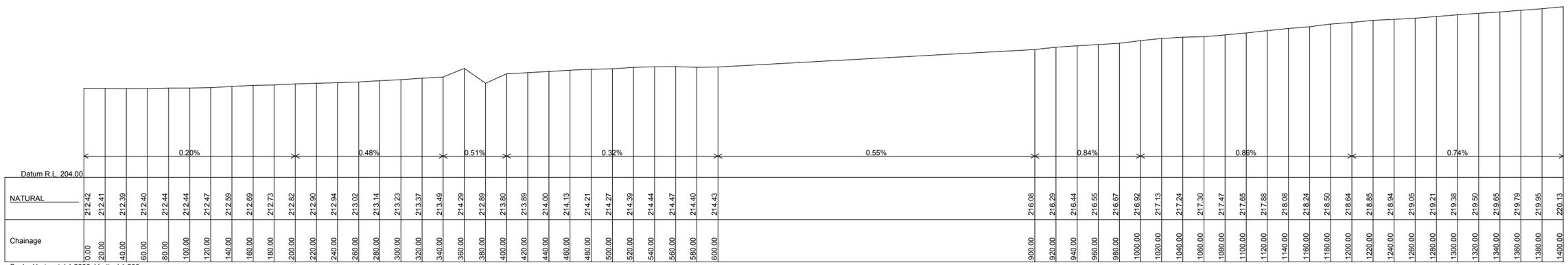


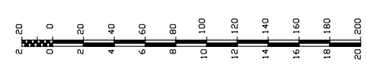
Scale Horizontal 1:2000 Vertical 1:200

Profile 05



Scale Horizontal 1:2000 Vertical 1:200

Profile 05



REDUCTION RATIO
A1: H: 1:2000 V: 1:200
A3: H: 1:4000 V: 1:400
A4: H: 1:6000 V: 1:600

Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

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Facsimile:02-6762 4412
office@mitchelhanlon.com.au
www.mitchelhanlon.com.au

ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profile No.05

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN

DRAWING No.: SHEET 28
REVISION: B
ORIGINAL SIZE: A1

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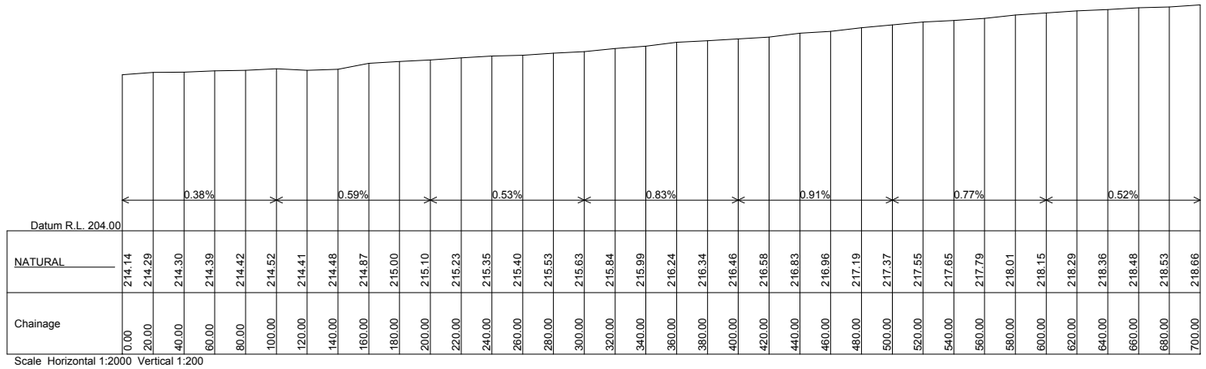
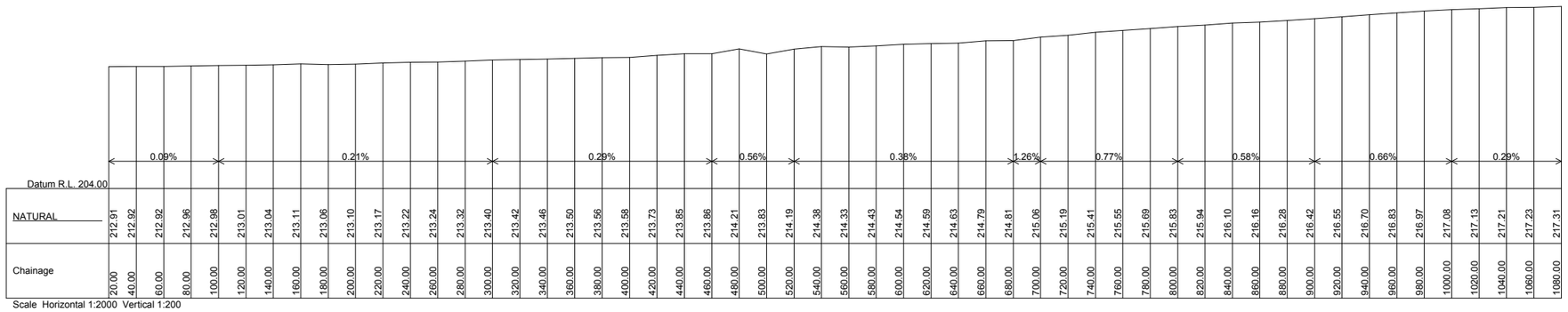


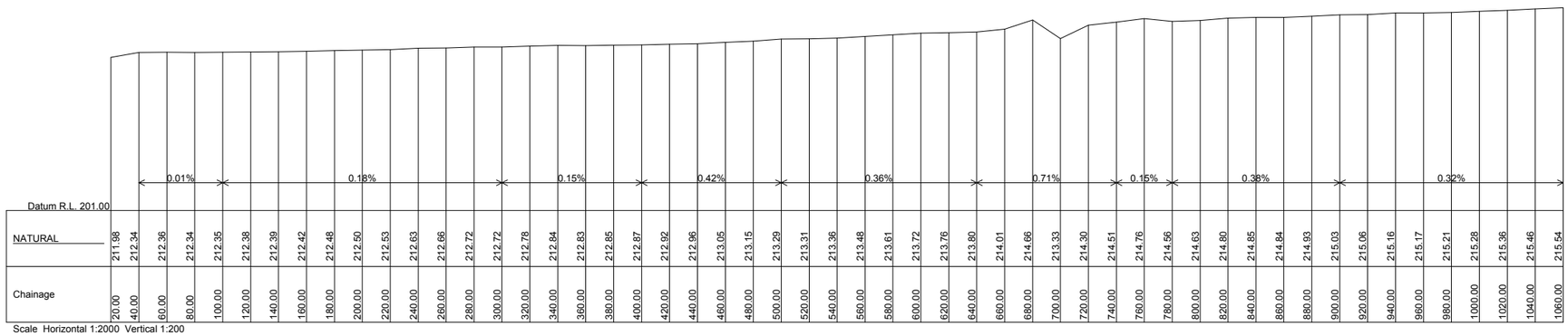
Scale Horizontal 1:2000 Vertical 1:200

Profile 08



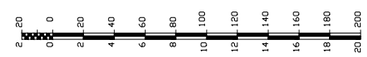
Scale Horizontal 1:2000 Vertical 1:200

Profile 07



Scale Horizontal 1:2000 Vertical 1:200

Profile 06



Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

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ACN 104 693 736
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Facsimile:02-6762 4412
office@mitchelhanlon.com.au
www.mitchelhanlon.com.au
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profiles No.06, 07 and 08

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN

DRAWING No.:	SHEET 29
REVISION	B
ORIGINAL SIZE	A1

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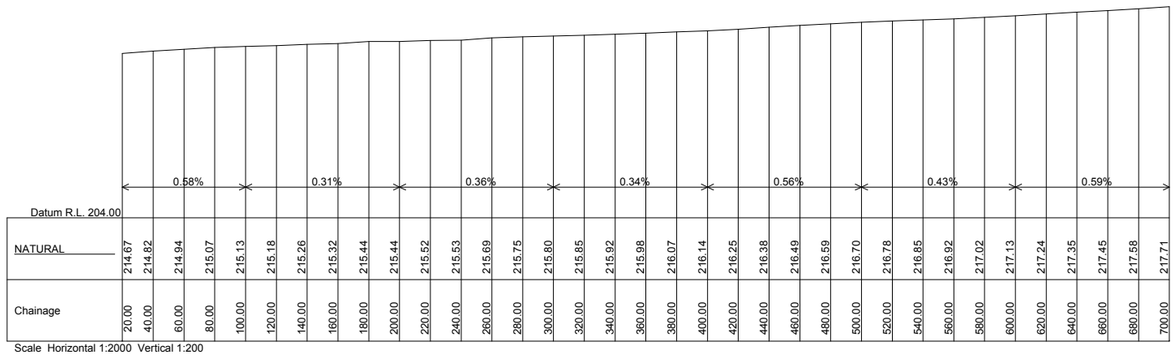
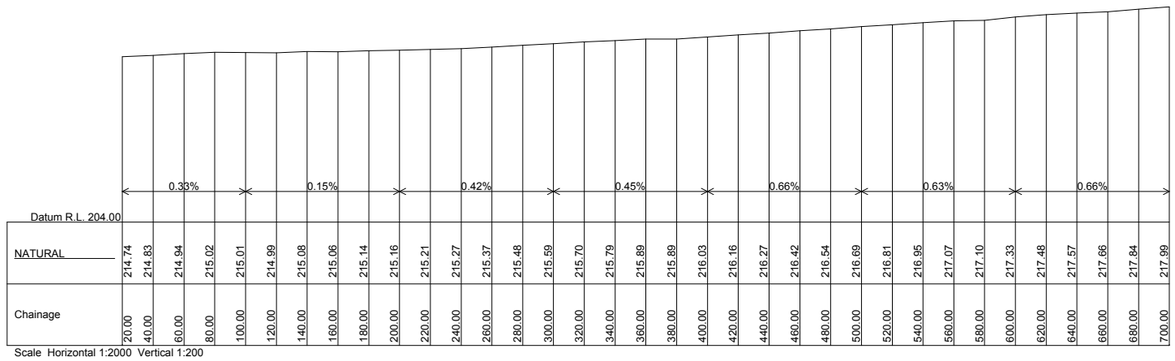


Datum R.L. 204.00																														
NATURAL	214.67	214.82	214.94	215.07	215.13	215.18	215.26	215.32	215.44	215.44	215.52	215.53	215.69	215.75	215.80	215.85	215.92	215.98	216.07	216.14	216.25	216.38	216.49	216.59	216.70	216.78	216.85	216.92	217.02	217.13	217.24	217.35	217.45	217.58	217.71
Chainage	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00

Scale Horizontal 1:2000 Vertical 1:200

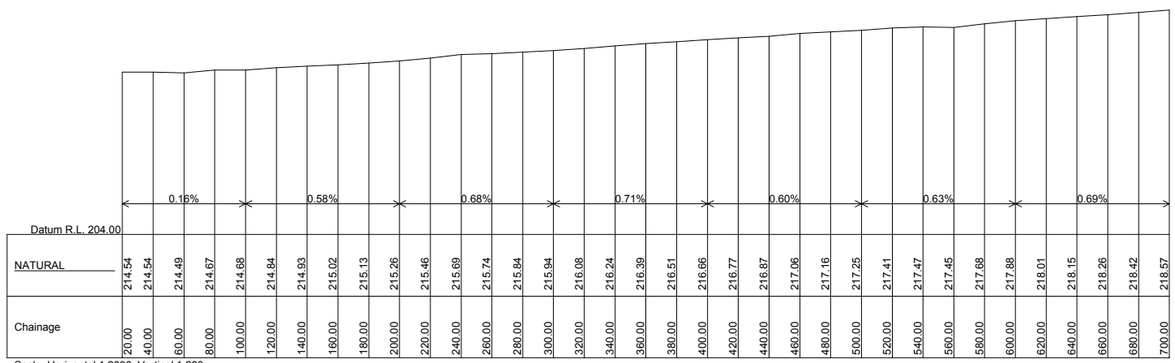
Profile 11



Datum R.L. 204.00																														
NATURAL	214.74	214.83	214.94	215.02	215.01	214.99	215.08	215.06	215.14	215.16	215.21	215.27	215.37	215.48	215.59	215.70	215.79	215.89	215.89	216.03	216.16	216.27	216.42	216.54	216.69	216.81	216.95	217.07	217.10	217.33	217.48	217.57	217.66	217.84	217.99
Chainage	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00

Scale Horizontal 1:2000 Vertical 1:200

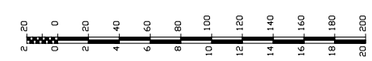
Profile 10



Datum R.L. 204.00																														
NATURAL	214.54	214.54	214.49	214.67	214.68	214.84	214.93	215.02	215.13	215.26	215.46	215.69	215.74	215.84	215.94	216.08	216.24	216.39	216.51	216.66	216.77	216.87	217.06	217.16	217.25	217.41	217.47	217.45	217.68	217.88	218.01	218.15	218.26	218.42	218.57
Chainage	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00

Scale Horizontal 1:2000 Vertical 1:200

Profile 09



Plot Date: 10 April 2018
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ACN 104 693 736
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profiles No.09, 10 and 11

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED: PROJ.MAN	

DRAWING No.: SHEET 30
REVISION: B
ORIGINAL SIZE: A1

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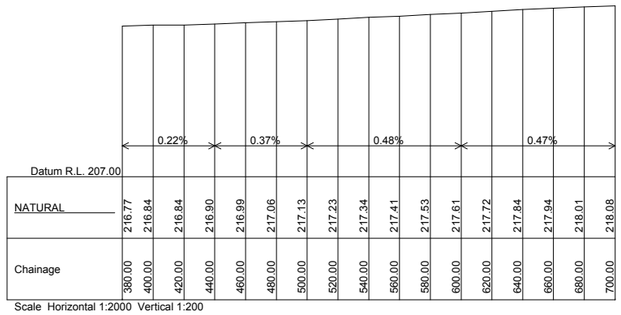
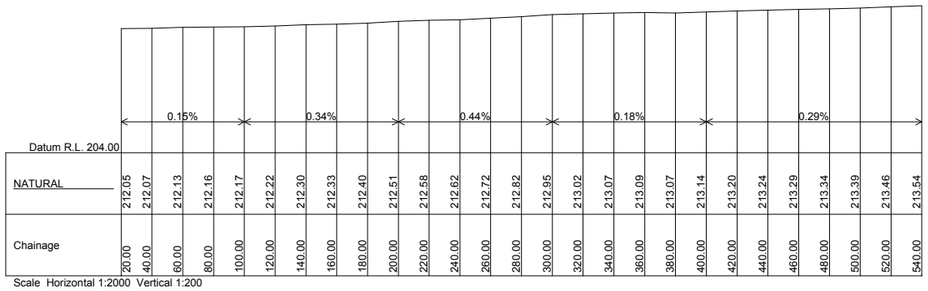


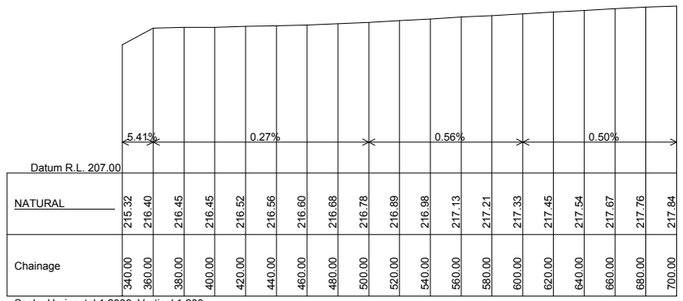
Scale Horizontal 1:2000 Vertical 1:200

Profile 14



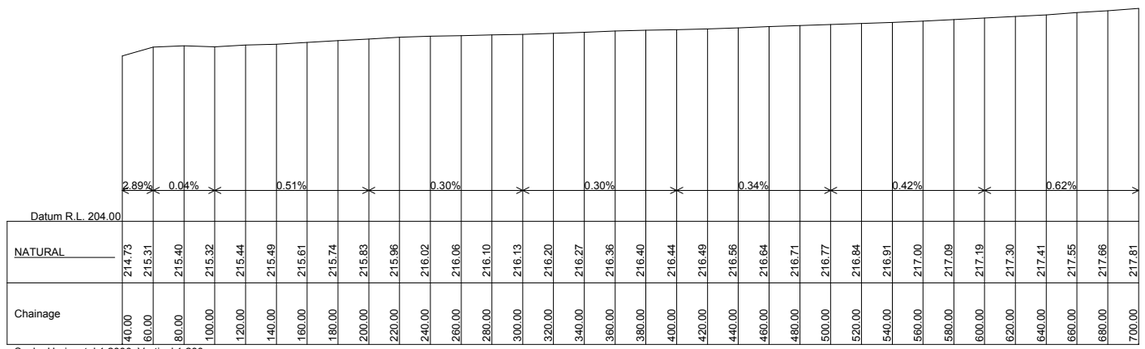
Scale Horizontal 1:2000 Vertical 1:200

Profile 15



Scale Horizontal 1:2000 Vertical 1:200

Profile 13



Scale Horizontal 1:2000 Vertical 1:200

Profile 12

REDUCTION RATIO
A1: H: 1:2000 V: 1:200
A3: H: 1:4000 V: 1:400
A4: H: 1:6000 V: 1:600

Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

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ABN 51 104 693 736
ACN 104 693 736
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profiles No.12, 13, 14 and 15

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED: PROJ.MAN	

DRAWING No.:	SHEET 31
REVISION	B
ORIGINAL SIZE	A1

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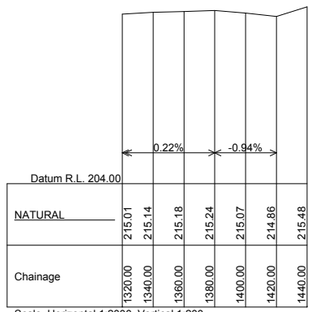
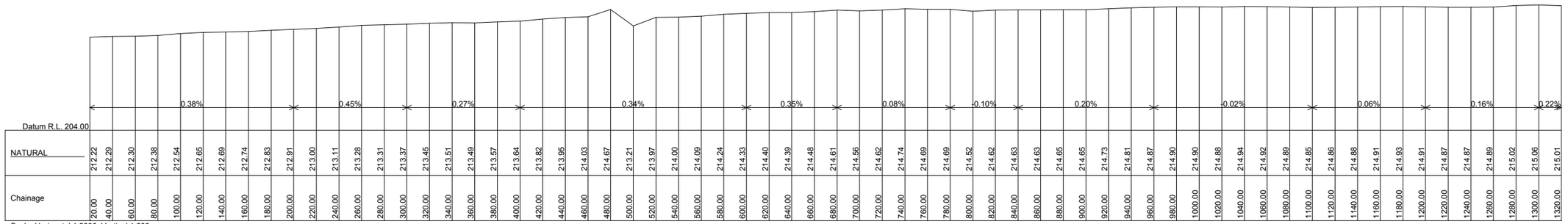


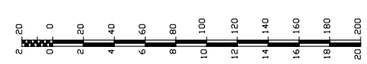
Scale Horizontal 1:2000 Vertical 1:200

Profile 16



Scale Horizontal 1:2000 Vertical 1:200

Profile 16



REDUCTION RATIO
A1: H: 1:2000 V: 1:200
A3: H: 1:4000 V: 1:400
A4: H: 1:6000 V: 1:600

Plot Date: 10 April 2018
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DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR

Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

Mitchel Hanlon Consulting Pty Ltd
ABN 51 104 693 736
ACN 104 693 736
121 Bridge Street
P.O. Box 1568
Tamworth, NSW, 2340
Telephone:02-6762 4411
Facsimile:02-6762 4412
office@mitchelhanlon.com.au
www.mitchelhanlon.com.au
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profile No.16

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN

DRAWING No.:	SHEET 32
REVISION	B
ORIGINAL SIZE	A1

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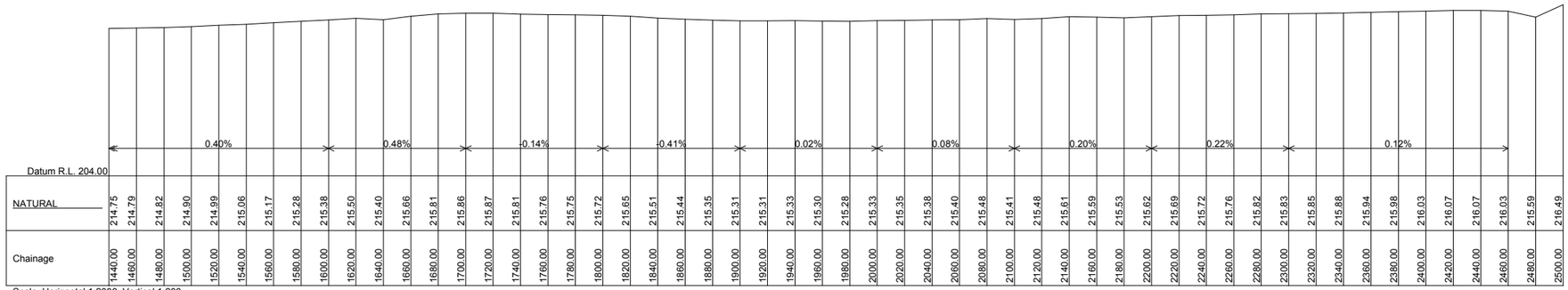
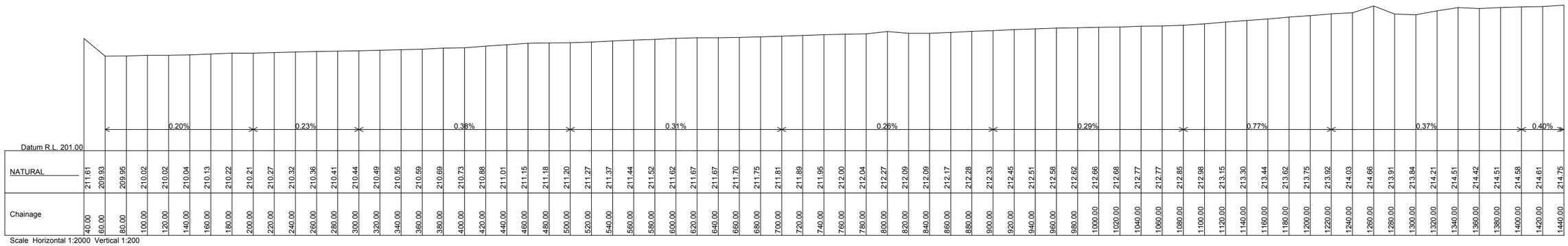


Datum R.L. 204.00

Chainage	NATURAL
1440.00	214.75
1460.00	214.79
1480.00	214.82
1500.00	214.90
1520.00	214.99
1540.00	215.06
1560.00	215.17
1580.00	215.28
1600.00	215.38
1620.00	215.50
1640.00	215.40
1660.00	215.66
1680.00	215.81
1700.00	215.86
1720.00	215.87
1740.00	215.81
1760.00	215.76
1780.00	215.75
1800.00	215.72
1820.00	215.65
1840.00	215.51
1860.00	215.44
1880.00	215.35
1900.00	215.31
1920.00	215.31
1940.00	215.33
1960.00	215.30
1980.00	215.28
2000.00	215.33
2020.00	215.35
2040.00	215.38
2060.00	215.40
2080.00	215.48
2100.00	215.41
2120.00	215.48
2140.00	215.61
2160.00	215.59
2180.00	215.53
2200.00	215.62
2220.00	215.69
2240.00	215.72
2260.00	215.76
2280.00	215.82
2300.00	215.83
2320.00	215.85
2340.00	215.88
2360.00	215.94
2380.00	215.98
2400.00	216.03
2420.00	216.07
2440.00	216.07
2460.00	216.03
2480.00	215.59
2500.00	216.49

Scale Horizontal 1:2000 Vertical 1:200

Profile 17

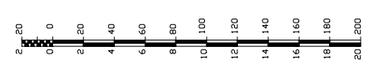


Datum R.L. 201.00

Chainage	NATURAL
40.00	211.61
60.00	209.93
80.00	209.95
100.00	210.02
120.00	210.02
140.00	210.04
160.00	210.13
180.00	210.22
200.00	210.21
220.00	210.27
240.00	210.32
260.00	210.36
280.00	210.41
300.00	210.44
320.00	210.49
340.00	210.55
360.00	210.59
380.00	210.69
400.00	210.73
420.00	210.88
440.00	211.01
460.00	211.15
480.00	211.18
500.00	211.20
520.00	211.27
540.00	211.37
560.00	211.44
580.00	211.52
600.00	211.62
620.00	211.67
640.00	211.67
660.00	211.70
680.00	211.75
700.00	211.81
720.00	211.89
740.00	211.95
760.00	212.00
780.00	212.04
800.00	212.27
820.00	212.09
840.00	212.09
860.00	212.17
880.00	212.28
900.00	212.33
920.00	212.45
940.00	212.51
960.00	212.58
980.00	212.62
1000.00	212.66
1020.00	212.68
1040.00	212.77
1060.00	212.77
1080.00	212.85
1100.00	212.98
1120.00	213.15
1140.00	213.30
1160.00	213.44
1180.00	213.62
1200.00	213.75
1220.00	213.92
1240.00	214.03
1260.00	214.66
1280.00	213.91
1300.00	213.84
1320.00	214.21
1340.00	214.51
1360.00	214.42
1380.00	214.51
1400.00	214.58
1420.00	214.61
1440.00	214.75

Scale Horizontal 1:2000 Vertical 1:200

Profile 17



REDUCTION RATIO
A1: H: 1:2000 V: 1:200
A3: H: 1:4000 V: 1:400
A4: H: 1:6000 V: 1:600

Plot Date: 10 April 2018
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DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR

Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

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www.mitchelhanlon.com.au
ABN 51 104 693 736
ACN 104 693 736
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profile No.17

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN

DRAWING No.: SHEET 33
REVISION: B
ORIGINAL SIZE: A1

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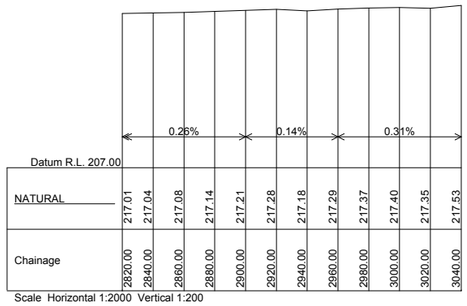
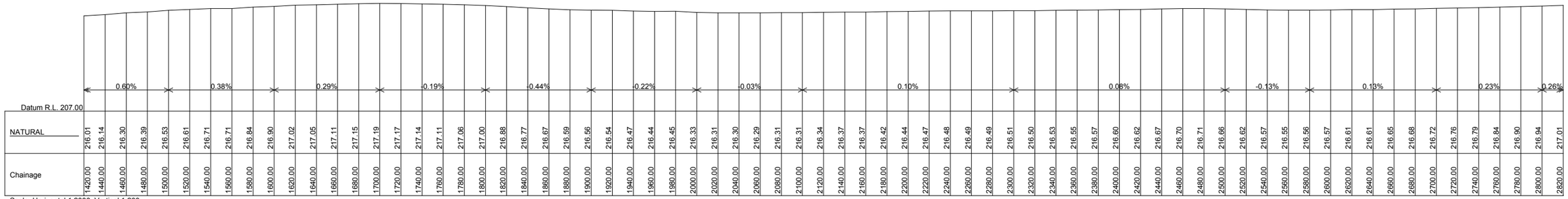


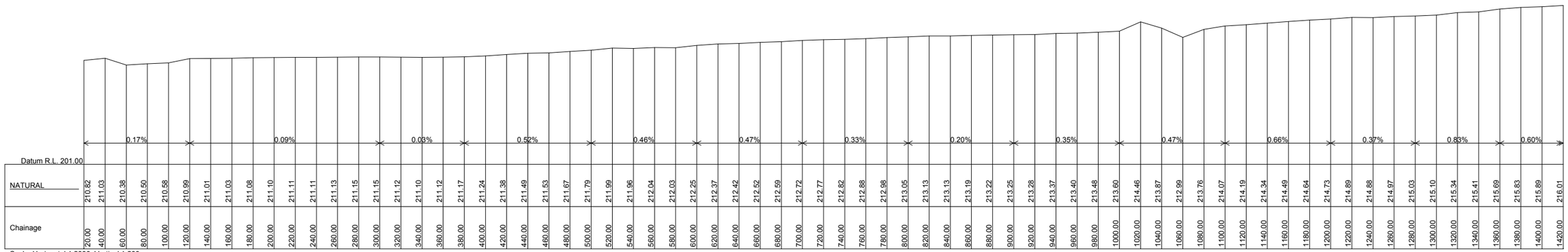
Scale Horizontal 1:2000 Vertical 1:200

Profile 18



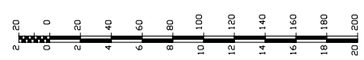
Scale Horizontal 1:2000 Vertical 1:200

Profile 18



Scale Horizontal 1:2000 Vertical 1:200

Profile 18



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Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

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www.mitchelhanlon.com.au
ABN 51 104 693 736
ACN 104 693 736
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profile No.18

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN

DRAWING No.:	SHEET 34
REVISION	B
ORIGINAL SIZE	A1

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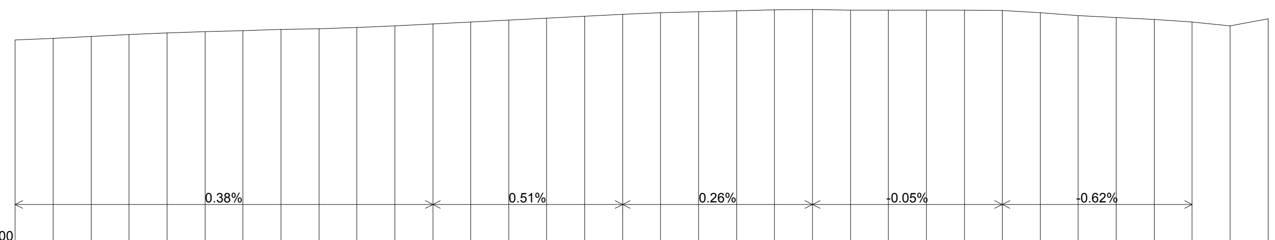
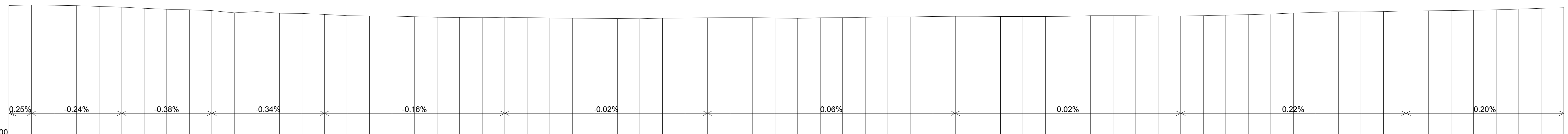


Datum R.L. 204.00

Chainage	NATURAL
280.00	214.65
300.00	214.73
320.00	214.83
340.00	214.93
360.00	215.01
380.00	215.08
400.00	215.14
420.00	215.20
440.00	215.24
460.00	215.30
480.00	215.38
500.00	215.49
520.00	215.60
540.00	215.70
560.00	215.80
580.00	215.89
600.00	216.00
620.00	216.08
640.00	216.14
660.00	216.19
680.00	216.23
700.00	216.25
720.00	216.22
740.00	216.21
760.00	216.21
780.00	216.22
800.00	216.20
820.00	216.08
840.00	215.93
860.00	215.83
880.00	215.72
900.00	215.59
920.00	215.39
940.00	215.76

Scale Horizontal 1:2000 Vertical 1:200

Profile 20

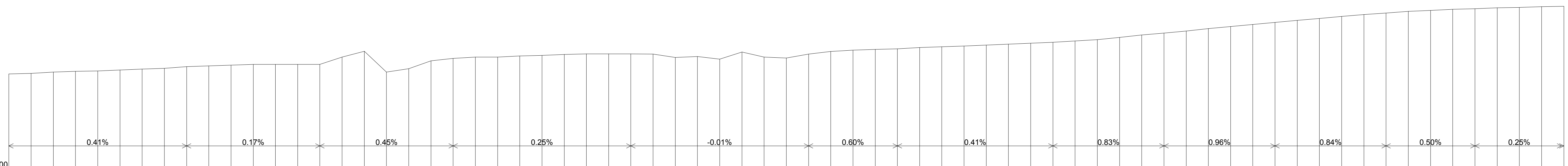


Datum R.L. 207.00

Chainage	NATURAL
1660.00	218.56
1680.00	218.60
1700.00	218.58
1720.00	218.54
1740.00	218.47
1760.00	218.41
1780.00	218.31
1800.00	218.21
1820.00	218.17
1840.00	218.10
1860.00	217.89
1880.00	218.02
1900.00	217.86
1920.00	217.86
1940.00	217.76
1960.00	217.66
1980.00	217.63
2000.00	217.61
2020.00	217.57
2040.00	217.52
2060.00	217.49
2080.00	217.49
2100.00	217.51
2120.00	217.48
2140.00	217.45
2160.00	217.43
2180.00	217.40
2200.00	217.39
2220.00	217.38
2240.00	217.42
2260.00	217.44
2280.00	217.46
2300.00	217.47
2320.00	217.48
2340.00	217.45
2360.00	217.42
2380.00	217.47
2400.00	217.48
2420.00	217.52
2440.00	217.54
2460.00	217.55
2480.00	217.58
2500.00	217.59
2520.00	217.60
2540.00	217.59
2560.00	217.59
2580.00	217.58
2600.00	217.59
2620.00	217.64
2640.00	217.65
2660.00	217.65
2680.00	217.63
2700.00	217.64
2720.00	217.65
2740.00	217.69
2760.00	217.74
2780.00	217.81
2800.00	217.88
2820.00	217.94
2840.00	218.00
2860.00	217.98
2880.00	218.01
2900.00	218.07
2920.00	218.09
2940.00	218.11
2960.00	218.13
2980.00	218.17
3000.00	218.25
3020.00	218.31
3040.00	218.35

Scale Horizontal 1:2000 Vertical 1:200

Profile 19



Datum R.L. 204.00

Chainage	NATURAL
260.00	212.48
280.00	212.52
300.00	212.64
320.00	212.71
340.00	212.74
360.00	212.82
380.00	212.91
400.00	212.98
420.00	213.14
440.00	213.21
460.00	213.27
480.00	213.33
500.00	213.34
520.00	213.34
540.00	213.34
560.00	213.99
580.00	214.51
600.00	212.64
620.00	212.94
640.00	213.65
660.00	213.88
680.00	214.00
700.00	214.00
720.00	214.10
740.00	214.14
760.00	214.22
780.00	214.27
800.00	214.27
820.00	214.28
840.00	214.27
860.00	213.96
880.00	214.04
900.00	213.81
920.00	214.44
940.00	213.99
960.00	213.90
980.00	214.27
1000.00	214.49
1020.00	214.62
1040.00	214.69
1060.00	214.74
1080.00	214.86
1100.00	214.92
1120.00	214.99
1140.00	215.07
1160.00	215.15
1180.00	215.24
1200.00	215.32
1220.00	215.45
1240.00	215.56
1260.00	215.76
1280.00	215.98
1300.00	216.15
1320.00	216.34
1340.00	216.56
1360.00	216.74
1380.00	216.92
1400.00	217.11
1420.00	217.30
1440.00	217.46
1460.00	217.65
1480.00	217.81
1500.00	217.95
1520.00	218.11
1540.00	218.18
1560.00	218.29
1580.00	218.35
1600.00	218.43
1620.00	218.47
1640.00	218.53
1660.00	218.56

Scale Horizontal 1:2000 Vertical 1:200

Profile 19

REDUCTION RATIO
A1: H: 1: 2000 V: 1: 200
A3: H: 1: 4000 V: 1: 400
A4: H: 1: 6000 V: 1: 600

Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original	Co-ordinate System: MGA Zone 56	Height Datum: A.H.D.	Contour Interval: 0.2m	Scale: 1:1,000

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ISO9001:2015
FS555072

CLIENT: GOLDER ASSOCIATES PTY LTD
PROJECT: NARRABRI SOLAR FARM

DETAIL SURVEY
Profile No.19 and 20

SURVEY: T Bolte
DESIGN: N/A
DRAWN: K Smith
CHECKED: M Hanlon
APPROVED: PROJ.MAN

DRAWING No.: SHEET 35
REVISION B
ORIGINAL SIZE A1

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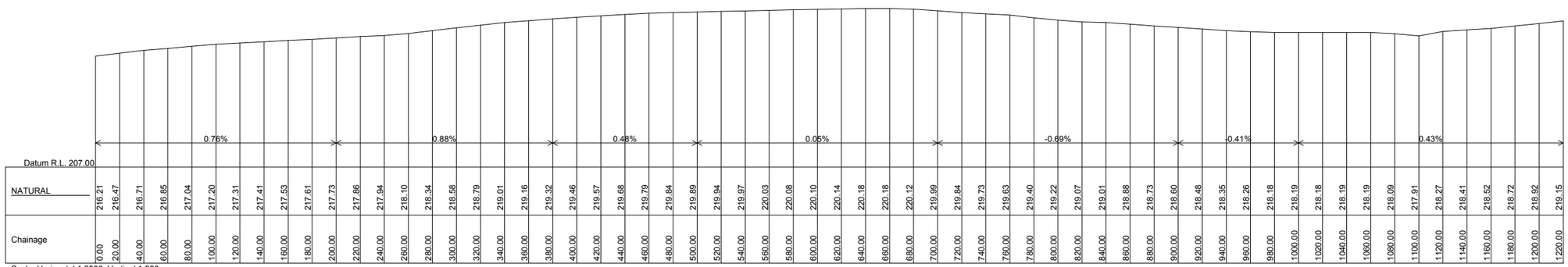
Datum R.L. 210.00

Chainage	0.00	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	900.00	920.00	940.00	960.00	980.00	1000.00	1020.00	1040.00	1060.00	1080.00	1100.00	1120.00	1140.00	1160.00
NATURAL	218.44	218.65	218.80	218.96	219.14	219.35	219.54	219.71	219.88	220.04	220.16	220.33	220.47	220.59	220.73	220.82	220.98	221.10	221.19	221.30	221.40	221.48	221.53	221.57	221.62	221.67	221.71	221.72	221.74	221.70	221.66	221.60	221.48	221.34	221.19	221.06	220.91	220.74	220.69	220.56	220.40	220.28	220.12	219.98	219.91	219.78	219.73	219.74	219.73	219.71	219.70	219.69	219.66	219.64	219.58	219.48	219.28	219.34	219.83

Scale Horizontal 1:2000 Vertical 1:200

Profile 23

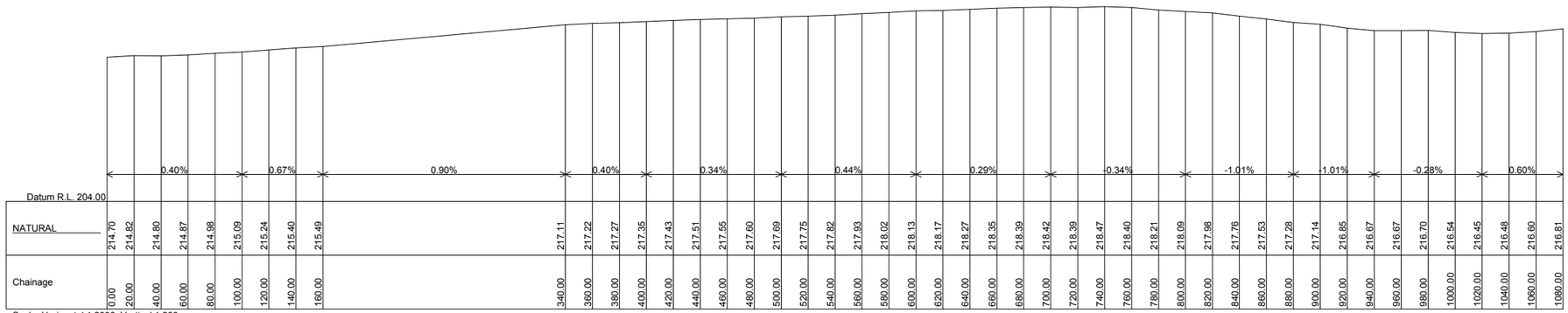


Datum R.L. 207.00

Chainage	0.00	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	900.00	920.00	940.00	960.00	980.00	1000.00	1020.00	1040.00	1060.00	1080.00	1100.00	1120.00	1140.00	1160.00	1180.00	1200.00	1220.00
NATURAL	216.21	216.47	216.71	216.85	217.04	217.20	217.31	217.41	217.53	217.61	217.73	217.86	217.94	218.10	218.34	218.58	218.79	219.01	219.16	219.32	219.46	219.57	219.68	219.79	219.84	219.89	219.94	219.97	220.03	220.08	220.10	220.14	220.18	220.18	220.12	219.99	219.84	219.73	219.63	219.40	219.22	219.07	219.01	218.88	218.73	218.60	218.48	218.35	218.26	218.18	218.19	218.18	218.19	218.19	218.09	217.91	218.27	218.41	218.52	218.72	218.92	219.15

Scale Horizontal 1:2000 Vertical 1:200

Profile 22

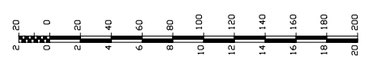


Datum R.L. 204.00

Chainage	0.00	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	900.00	920.00	940.00	960.00	980.00	1000.00	1020.00	1040.00	1060.00	1080.00
NATURAL	214.70	214.82	214.80	214.87	214.98	215.09	215.24	215.40	215.49	217.11	217.22	217.27	217.35	217.43	217.51	217.55	217.60	217.69	217.75	217.82	217.93	218.02	218.13	218.17	218.27	218.35	218.39	218.42	218.39	218.47	218.40	218.21	218.09	217.98	217.76	217.53	217.28	217.14	216.85	216.67	216.67	216.70	216.54	216.45	216.48	216.60	216.81

Scale Horizontal 1:2000 Vertical 1:200

Profile 21



Plot Date: 10 April 2018
J:\2018\18002 Golder Associates Pty Ltd – Narrabri Solar Farm\ACAD\Rev B\18002 Golder – Narrabri Solar Farm– Rev B.dwg

DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR

Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

Mitchel Hanlon Consulting Pty Ltd
121 Bridge Street
P.O. Box 1568
Tamworth, NSW, 2340
Telephone:02-6762 4411
Facsimile:02-6762 4412
office@mitchelhanlon.com.au
www.mitchelhanlon.com.au
ABN 51 104 693 736
ACN 104 693 736
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profiles No.21, 22 and 23

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED: PROJ.MAN	

DRAWING No.:	SHEET 36
REVISION	B
ORIGINAL SIZE	A1

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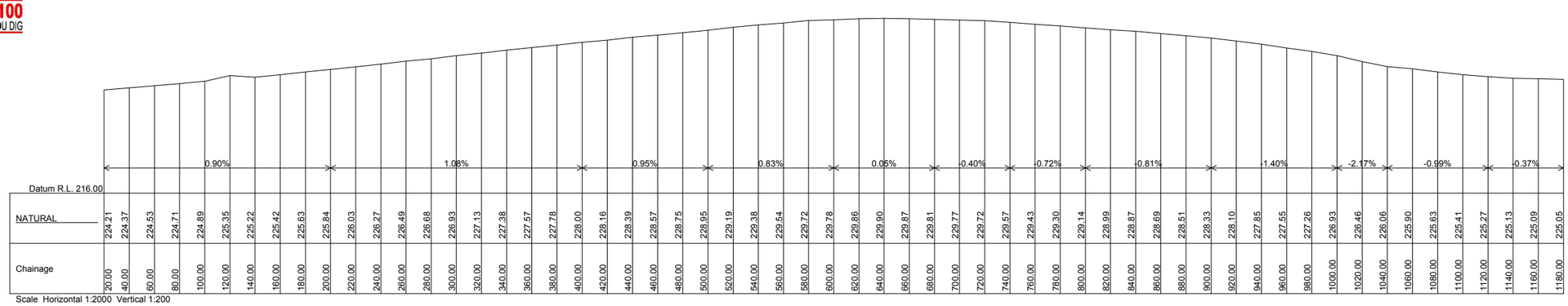
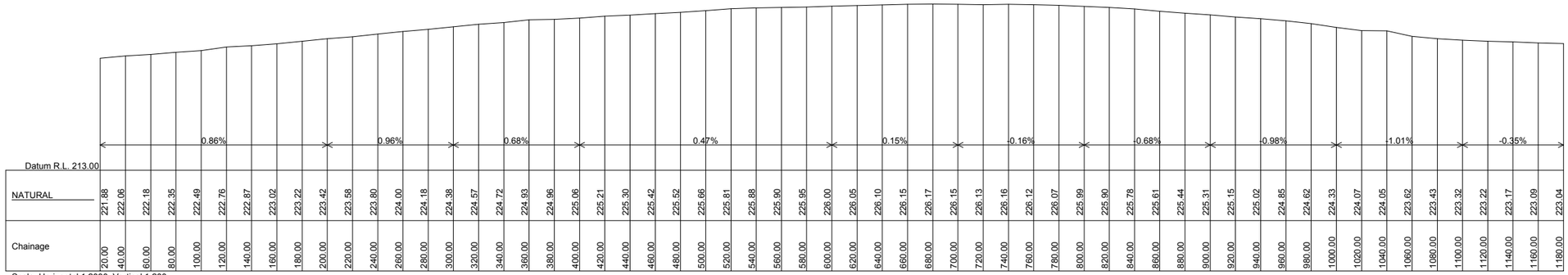


Datum R.L. 216.00

Chainage	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	900.00	920.00	940.00	960.00	980.00	1000.00	1020.00	1040.00	1060.00	1080.00	1100.00	1120.00	1140.00	1160.00	1180.00
NATURAL	224.21	224.37	224.53	224.71	224.89	225.35	225.22	225.42	225.63	225.84	226.03	226.27	226.49	226.68	226.93	227.13	227.38	227.57	227.78	228.00	228.16	228.39	228.57	228.75	228.95	229.19	229.38	229.54	229.72	229.78	229.86	229.90	229.87	229.81	229.77	229.72	229.57	229.43	229.30	229.14	228.99	228.87	228.69	228.51	228.33	228.10	227.85	227.55	227.26	226.93	226.46	226.06	225.90	225.63	225.41	225.27	225.13	225.09	225.05

Scale Horizontal 1:2000 Vertical 1:200

Profile 26

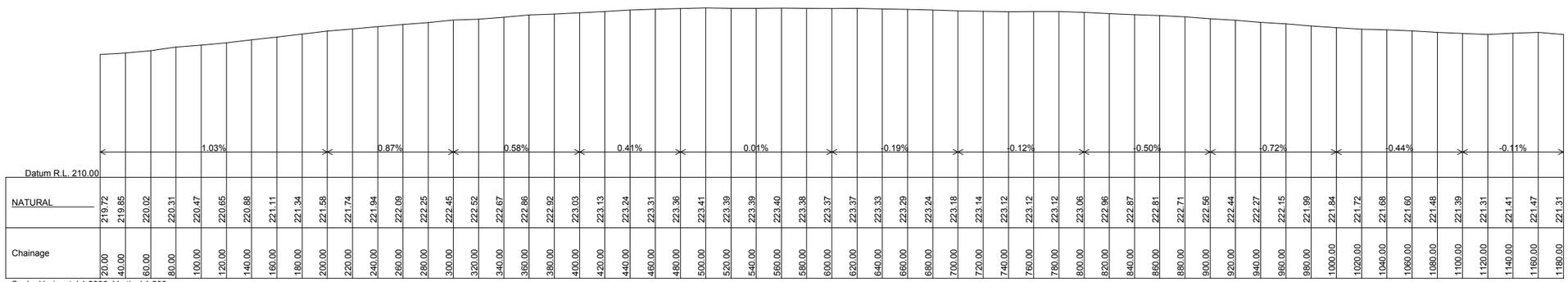


Datum R.L. 213.00

Chainage	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	900.00	920.00	940.00	960.00	980.00	1000.00	1020.00	1040.00	1060.00	1080.00	1100.00	1120.00	1140.00	1160.00	1180.00
NATURAL	221.88	222.06	222.18	222.35	222.49	222.76	222.87	223.02	223.22	223.42	223.58	223.80	224.00	224.18	224.38	224.57	224.72	224.93	224.96	225.06	225.21	225.30	225.42	225.52	225.66	225.81	225.88	225.90	225.95	226.00	226.05	226.10	226.15	226.17	226.15	226.13	226.16	226.12	226.07	225.99	225.90	225.78	225.61	225.44	225.31	225.15	225.02	224.85	224.62	224.33	224.07	224.05	223.62	223.43	223.32	223.22	223.17	223.09	223.04

Scale Horizontal 1:2000 Vertical 1:200

Profile 25

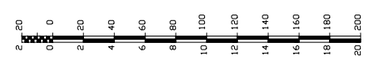


Datum R.L. 210.00

Chainage	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	900.00	920.00	940.00	960.00	980.00	1000.00	1020.00	1040.00	1060.00	1080.00	1100.00	1120.00	1140.00	1160.00	1180.00
NATURAL	219.72	219.85	220.02	220.31	220.47	220.65	220.88	221.11	221.34	221.58	221.74	221.94	222.09	222.25	222.45	222.52	222.67	222.86	222.92	223.03	223.13	223.24	223.31	223.36	223.41	223.39	223.39	223.40	223.38	223.37	223.37	223.33	223.29	223.24	223.18	223.14	223.12	223.12	223.12	223.06	222.96	222.87	222.81	222.71	222.56	222.44	222.27	222.15	221.99	221.84	221.72	221.68	221.60	221.48	221.39	221.31	221.41	221.47	221.31

Scale Horizontal 1:2000 Vertical 1:200

Profile 24



REDUCTION RATIO
A1: H: 1: 2000 V: 1: 200
A3: H: 1: 4000 V: 1: 400
A4: H: 1: 6000 V: 1: 600

Plot Date: 10 April 2018
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Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

GOLDER

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ABN 51 104 693 736
ACN 104 693 736
ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profiles No.24, 25 and 26

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED: PROJ.MAN	

DRAWING No.:	SHEET 37
REVISION	B
ORIGINAL SIZE	A1

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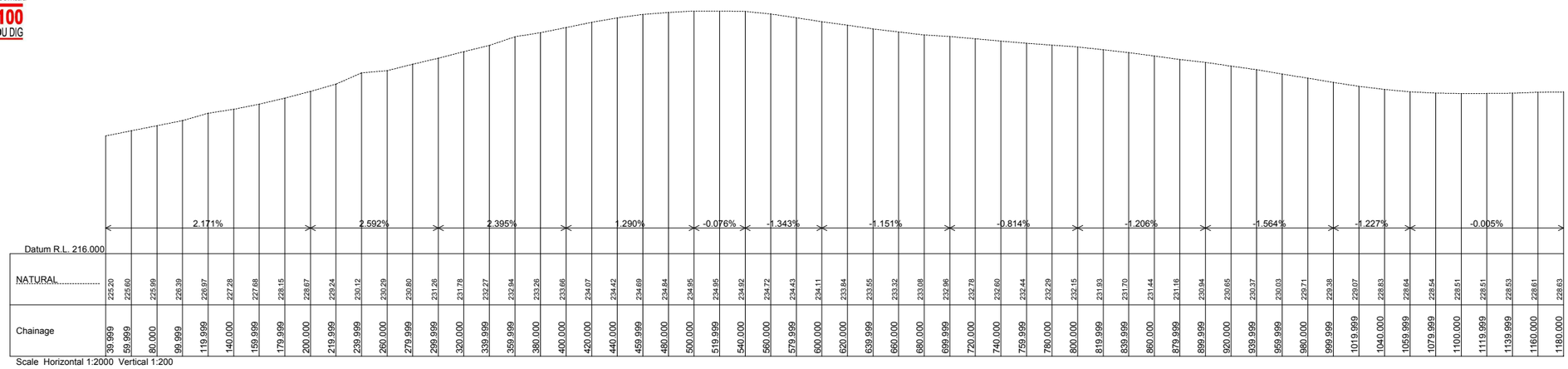
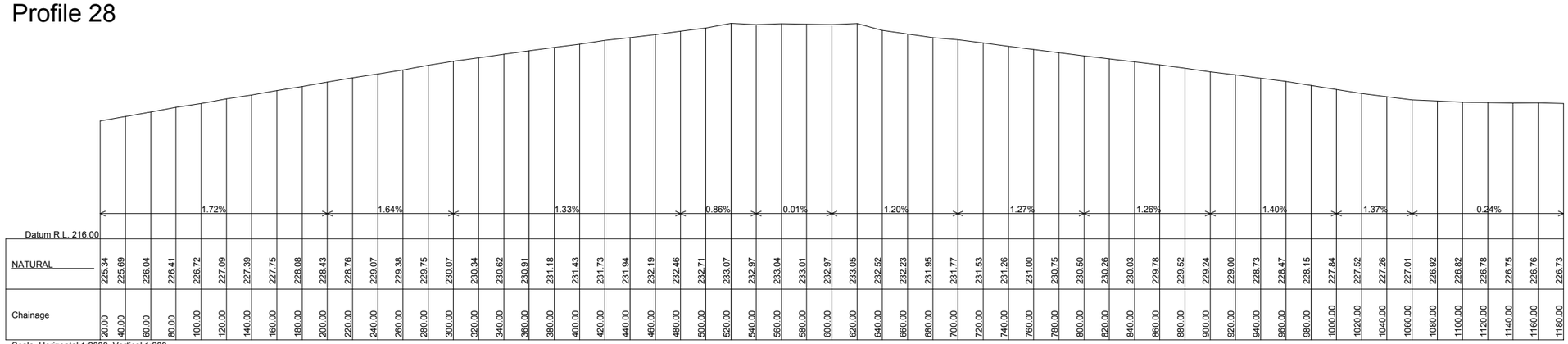


Datum R.L. 216.000

Chainage	39.999	59.999	80.000	99.999	119.999	140.000	159.999	179.999	200.000	219.999	239.999	260.000	279.999	299.999	320.000	339.999	359.999	380.000	400.000	420.000	440.000	459.999	480.000	500.000	519.999	540.000	560.000	579.999	600.000	620.000	639.999	660.000	680.000	699.999	720.000	740.000	759.999	780.000	800.000	819.999	839.999	860.000	879.999	899.999	920.000	939.999	959.999	980.000	999.999	1019.999	1040.000	1059.999	1079.999	1100.000	1119.999	1139.999	1160.000	1180.000
NATURAL	225.20	225.60	225.99	226.39	226.97	227.28	227.68	228.15	228.87	229.24	230.12	230.29	230.80	231.26	231.78	232.27	232.84	233.26	233.66	234.07	234.42	234.69	234.84	234.95	234.95	234.92	234.72	234.43	234.11	233.84	233.55	233.32	233.08	232.96	232.78	232.60	232.44	232.29	232.15	231.93	231.70	231.44	231.18	230.94	230.65	230.37	230.03	229.71	229.38	229.07	228.83	228.64	228.54	228.51	228.51	228.53	228.61	228.63

Scale Horizontal 1:2000 Vertical 1:200

Profile 28

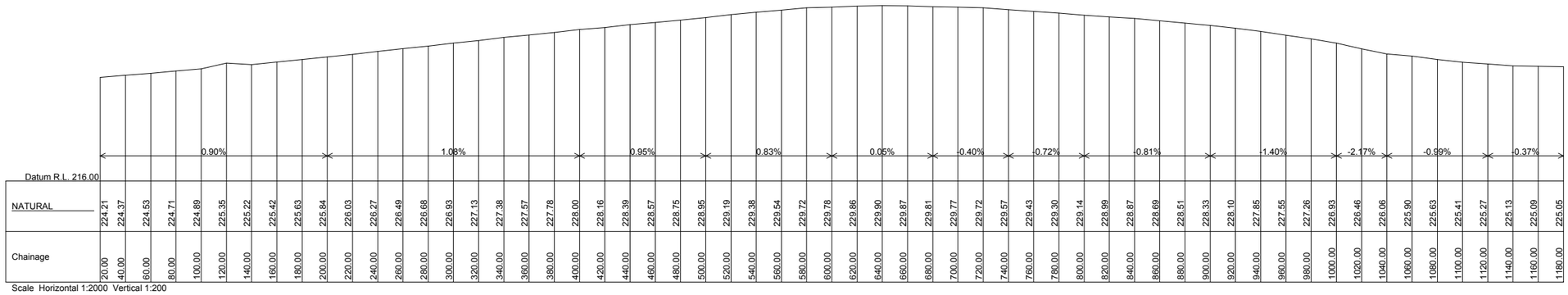


Datum R.L. 216.00

Chainage	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	900.00	920.00	940.00	960.00	980.00	1000.00	1020.00	1040.00	1060.00	1080.00	1100.00	1120.00	1140.00	1160.00	1180.00
NATURAL	225.34	225.69	226.04	226.41	226.72	227.09	227.39	227.75	228.08	228.43	228.76	229.07	229.38	229.75	230.07	230.34	230.62	230.91	231.18	231.43	231.73	231.94	232.19	232.46	232.71	233.07	232.97	233.04	233.01	232.97	233.05	232.52	232.23	231.95	231.77	231.53	231.26	231.00	230.75	230.50	230.26	230.03	229.78	229.52	229.24	229.00	228.73	228.47	228.15	227.84	227.52	227.26	227.01	226.92	226.82	226.78	226.75	226.76	226.73

Scale Horizontal 1:2000 Vertical 1:200

Profile 27

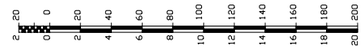


Datum R.L. 216.00

Chainage	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00	340.00	360.00	380.00	400.00	420.00	440.00	460.00	480.00	500.00	520.00	540.00	560.00	580.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00	740.00	760.00	780.00	800.00	820.00	840.00	860.00	880.00	900.00	920.00	940.00	960.00	980.00	1000.00	1020.00	1040.00	1060.00	1080.00	1100.00	1120.00	1140.00	1160.00	1180.00
NATURAL	224.21	224.37	224.53	224.71	224.89	225.35	225.22	225.42	225.63	225.84	226.03	226.27	226.49	226.68	226.93	227.13	227.38	227.57	227.78	228.00	228.16	228.39	228.57	228.75	228.95	229.19	229.38	229.54	229.72	229.78	229.86	229.90	229.87	229.81	229.77	229.72	229.57	229.43	229.30	229.14	228.99	228.87	228.69	228.51	228.33	228.10	227.85	227.55	227.26	226.93	226.46	226.06	225.90	225.63	225.41	225.27	225.13	225.09	225.05

Scale Horizontal 1:2000 Vertical 1:200

Profile 26



REDUCTION RATIO
A1: H: 1: 2000 V: 1: 200
A3: H: 1: 4000 V: 1: 400
A4: H: 1: 6000 V: 1: 600

Plot Date: 10 April 2018
J:\2018\18002 Golder Associates Pty Ltd – Narrabri Solar Farm\ACAD\Rev B\18002 Golder – Narrabri Solar Farm– Rev B.dwg

DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR

Rv	DATE	REVISIONS	REC.	APPR.
B	10-04-18	Profiles		
A	04-04-18	Initial Issue		

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | Contour Interval: 0.2m | Scale: 1:1,000

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ISO9001:2015
FS555072

CLIENT:	GOLDER ASSOCIATES PTY LTD
PROJECT:	NARRABRI SOLAR FARM
	DETAIL SURVEY Profile No.26, 27 and 28

SURVEY:	T Bolte
DESIGN:	N/A
DRAWN:	K Smith
CHECKED:	M Hanlon
APPROVED:	PROJ.MAN
DRAWING No.:	SHEET 38
REVISION	B
ORIGINAL SIZE	A1

APPENDIX D

Department Of Industry – Water Logs

NSW Office of Water
Work Summary

GW000093

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/03/1917
Final Depth: 62.40 m
Drilled Depth: 62.50 m

Contractor Name:
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Good
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	220
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-1S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6651575.0
Easting: 770481.0
Latitude: 30°14'14.4"S
Longitude: 149°48'38.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	64.10	152			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
36.50	36.50	0.00	Consolidated	29.80		0.10			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	11.27	11.27	Shale	Shale	
11.27	50.59	39.32	Sandstone Water Supply	Sandstone	
50.59	62.48	11.89	Driller	(Unknown)	

Remarks

*** End of GW000093 ***

NSW Office of Water
Work Summary

GW005122

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): NOT KNOWN

Work Type: Bore
Work Status:
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date:
Final Depth: 8.50 m
Drilled Depth:

Contractor Name:
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Good
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	154
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:

Northing: 6644599.0
Easting: 765923.0

Latitude: 30°18'04.4"S
Longitude: 149°45'54.1"E

GS Map: -

MGA Zone: 0

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	8.50	50			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

*** End of GW005122 ***

NSW Office of Water
Work Summary

GW010573

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Abandoned
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/05/1953
Final Depth: 15.50 m
Drilled Depth: 15.50 m

Contractor Name:
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Good
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	475
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6645444.0
Easting: 769152.0
Latitude: 30°17'34.4"S
Longitude: 149°47'54.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.60	15.50	152			Seated on Bottom

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
12.40	13.00	0.60	Unconsolidated			0.38			

15.50	15.50	0.00	Unconsolidated	9.10		1.26			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.21	1.21	Soil Black	Soil	
1.21	6.09	4.88	Clay	Clay	
6.09	12.49	6.40	Limestone Shaley	Limestone	
12.49	14.63	2.14	Pug Yellow Water Supply	Invalid Code	
14.63	15.54	0.91	Gravel Medium Water Supply	Gravel	

Remarks

04/02/2008: NOTE ON FILE 90BL140206 BORE ABANDONED

*** End of GW010573 ***

NSW Office of Water
Work Summary

GW010612

Licence: 90BL003660
Licence Status: CONVERTED

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): GENERAL USE

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/04/1953
Final Depth: 50.50 m
Drilled Depth: 50.60 m

Contractor Name:
Driller:
Assistant Driller:

Property: VEONE
GWMA: 601 - GREAT ARTESIAN BASIN
GW Zone: 013 - SOUTHERN RECHARGE GROUNDWATER SOURCE
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	265
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6647432.0
Easting: 769763.0
Latitude: 30°16'29.4"S
Longitude: 149°48'15.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.60	46.70	152			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

48.70	50.50	1.80	(Unknown)	18.20		0.45			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.91	0.91	Soil Black	Soil	
0.91	4.27	3.36	Clay	Clay	
4.27	50.60	46.33	Clay Yellow Limestone Water Supply	Clay	

Remarks

*** End of GW010612 ***

NSW Office of Water
Work Summary

GW011532

Licence: 90BL004746
Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Well
Work Status:
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date:
Final Depth: 7.00 m
Drilled Depth: 7.00 m

Contractor Name:
Driller:
Assistant Driller:

Property: N/A
Standing Water Level (m):
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
Salinity Description:
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	107
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6643376.0
Easting: 766775.0
Latitude: 30°18'43.4"S
Longitude: 149°46'27.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Concrete Cylinder/Timber	0.00	0.00	1282			

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)
5.10	5.10	0.00	Unconsolidated			15.16			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.21	1.21	Soil Dark	Soil	
1.21	4.87	3.66	Soil Light Some Sandy	Soil	
4.87	7.01	2.14	Gravel Coarse Water Supply	Gravel	

Remarks

*** End of GW011532 ***

NSW Office of Water
Work Summary

GW012113

Licence: 90BL115406
Licence Status: CONVERTED

Authorised Purpose(s): STOCK,IRRIGATION,DOMESTIC
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/07/1957
Final Depth: 94.40 m
Drilled Depth: 94.40 m

Contractor Name:
Driller:
Assistant Driller:

Property: N/A NSW
Standing Water Level (m):
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
Salinity Description: 0-500 ppm
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	173
Licensed:	NANDEWAR	NARRABRI	Whole Lot 1//566857

Region: 90 - Barwon
CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6645891.0
Easting: 768521.0
Latitude: 30°17'20.4"S
Longitude: 149°47'30.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.40	61.90	254			Suspended in Clamps
1	1	Casing	Threaded Steel	60.50	94.30	203			
1	1	Opening	Slots	60.60	94.40	203		1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
9.40	9.40	0.00	Unconsolidated						
44.50	49.30	4.80	Unconsolidated						
56.90	93.70	36.80	Consolidated	5.50		12.00			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	9.14	9.14	Clay	Clay	
9.14	12.49	3.35	Clay Sandy	Clay	
12.49	12.80	0.31	Clay Compacted	Clay	
12.80	15.24	2.44	Gravel	Gravel	
15.24	15.54	0.30	Clay Compacted	Clay	
15.54	21.33	5.79	Clay Sandy	Clay	
21.33	23.77	2.44	Clay Sandy	Clay	
23.77	24.38	0.61	Gravel Clay Compacted	Gravel	
24.38	24.99	0.61	Gravel Clay	Gravel	
24.99	30.48	5.49	Clay Sandy	Clay	
30.48	36.57	6.09	Clay Sandy	Clay	
36.57	40.84	4.27	Clay Cream Sandy	Clay	
40.84	44.50	3.66	Clay	Clay	
44.50	49.37	4.87	Gravel Clay Compacted	Gravel	
49.37	49.98	0.61	Clay Sandy	Clay	
49.98	52.73	2.75	Clay Sandy	Clay	
52.73	53.94	1.21	Clay Sandy	Clay	
53.94	56.08	2.14	Gravel Clay	Gravel	
56.08	56.69	0.61	Clay White	Clay	
56.69	60.35	3.66	Sandstone Yellow Water Supply	Sandstone	
60.35	72.23	11.88	Sandstone White Water Supply	Sandstone	
72.23	72.84	0.61	Sandstone Yellow Water Supply	Sandstone	
72.84	77.72	4.88	Sandstone Water Supply	Sandstone	
77.72	93.87	16.15	Sandstone White Water Supply	Sandstone	
12.49	12.80	0.31	Gravel	Gravel	
15.24	15.54	0.30	Gravel	Gravel	
30.48	36.57	6.09	Gravel Some	Gravel	
49.98	52.73	2.75	Sandstone	Sandstone	

Remarks

*** End of GW012113 ***

NSW Office of Water
Work Summary

GW012129

Licence: Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date: Final Depth:
Completion Date: 01/08/1957 Drilled Depth: 87.80 m

Contractor Name:
Driller:
Assistant Driller:

Property: Standing Water Level (m):
GWMA: Salinity Description: 0-500 ppm
GW Zone: Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	258
Licensed:			

Region: 90 - Barwon CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER Grid Zone: Scale:
Area/District:

Elevation: 0.00 m (A.H.D.) Northing: 6646012.0 Latitude: 30°17'16.4"S
Elevation (Unknown) Easting: 768605.0 Longitude: 149°47'33.1"E
Source:

GS Map: - MGA Zone: 0 Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	0.00	87.70	203			
1	1	Casing	Withdrawn	0.00	75.10	203			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

8.20	8.20	0.00	Unconsolidated	7.30					
73.10	73.70	0.60	Consolidated						
81.00	81.60	0.60	Consolidated						

Geologists Log

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	11.28	11.28	Clay	Clay	
11.28	11.89	0.61	Clay Sandy	Clay	
11.89	15.54	3.65	Gravel Clay Compacted	Gravel	
15.54	19.81	4.27	Gravel Clay Stones Compacted	Gravel	
19.81	21.34	1.53	Clay Gravel Compacted	Clay	
21.34	24.38	3.04	Clay	Clay	
24.38	26.82	2.44	Clay Gravel	Clay	
26.82	30.48	3.66	Clay Reddish Crumbly	Clay	
30.48	32.92	2.44	Clay Sandy	Clay	
32.92	40.23	7.31	Clay Gravel	Clay	
40.23	41.45	1.22	Clay	Clay	
41.45	44.81	3.36	Clay Khaki Sandy	Clay	
44.81	50.60	5.79	Clay Some Gravel	Clay	
50.60	51.82	1.22	Clay Grey	Clay	
51.82	57.30	5.48	Clay Grey Gravel	Clay	
57.30	62.79	5.49	Clay White Sandy	Clay	
62.79	70.10	7.31	Gravel Some	Gravel	
70.10	73.76	3.66	Sandstone White Soft Clay	Sandstone	
73.76	78.02	4.26	Clay Soft	Clay	
78.02	81.08	3.06	Sandstone Soft Clay	Sandstone	
81.08	81.69	0.61	Sandstone	Sandstone	
81.69	87.78	6.09	Sandstone Soft Clay	Sandstone	

Remarks

*** End of GW012129 ***

NSW Office of Water
Work Summary

GW012138

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/09/1957
Final Depth: 27.40 m
Drilled Depth: 78.00 m

Contractor Name:
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: 0-500 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	174
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6645582.0
Easting: 768541.0
Latitude: 30°17'30.4"S
Longitude: 149°47'31.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	27.40	77.90	203			
1	1	Casing	Threaded Steel	-0.60	26.40	203			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

10.30	10.30	0.00	Unconsolidated	7.30		5.05			
32.90	37.70	4.80	Unconsolidated						
64.00	70.00	6.00	Unconsolidated						

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	10.36	10.36	Clay Slightly Sandy	Clay	
10.36	11.58	1.22	Clay Sandy Water Supply	Clay	
11.58	12.80	1.22	Gravel Clay Compacted	Gravel	
12.80	15.24	2.44	Clay	Clay	
15.24	20.73	5.49	Clay	Clay	
20.73	24.99	4.26	Clay	Clay	
24.99	30.48	5.49	Clay Soft	Clay	
30.48	37.80	7.32	Clay Water Supply	Clay	
37.80	41.45	3.65	Clay Soft	Clay	
41.45	45.72	4.27	Clay Soft Sandy	Clay	
45.72	48.16	2.44	Clay	Clay	
48.16	53.64	5.48	Clay Gravel Compacted	Clay	
53.64	58.52	4.88	Clay Khaki	Clay	
58.52	59.74	1.22	Clay Khaki Gravel	Clay	
59.74	63.09	3.35	Clay Sandy Soft	Clay	
63.09	64.01	0.92	Clay Reddish Gravel	Clay	
64.01	70.10	6.09	Clay Soft	Clay	
70.10	78.03	7.93	Clay Soft	Clay	
12.80	15.24	2.44	Gravel Fine	Gravel	
37.80	41.45	3.65	Gravel	Gravel	
53.64	58.52	4.88	Gravel Stones	Gravel	
64.01	70.10	6.09	Gravel Some	Gravel	

Remarks

*** End of GW012138 ***

NSW Office of Water
Work Summary

GW012144

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Abandoned,Backfilled
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/09/1957
Final Depth: 20.70 m
Drilled Depth: 20.70 m

Contractor Name:
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: 501-1000 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	475
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6645503.0
Easting: 769261.0
Latitude: 30°17'32.4"S
Longitude: 149°47'58.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.60	17.50	203			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
10.90	10.90	0.00	Unconsolidated	8.20					

15.80	18.20	2.40	Unconsolidated						

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	9.14	9.14	Clay	Clay	
9.14	11.58	2.44	Clay Sandy Water Supply	Clay	
11.58	12.49	0.91	Clay Gravel	Clay	
12.49	15.24	2.75	Gravel Clay Compacted Stones Large	Gravel	
15.24	15.84	0.60	Gravel Clay Compacted	Gravel	
15.84	18.28	2.44	Clay Water Supply	Clay	
18.28	20.72	2.44	Clay Slightly Gravel	Clay	

Remarks

26/02/2008: BORE SITE INSPECTED BY BEN HUTT, LICENSING OFFICER. BORE NO LONGER EXISTS.

*** End of GW012144 ***

NSW Office of Water
Work Summary

GW012148

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Abandoned,Backfilled
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/09/1957
Final Depth: 64.90 m
Drilled Depth: 69.50 m

Contractor Name:
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: 0-500 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	475
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6645656.0
Easting: 769291.0
Latitude: 30°17'27.4"S
Longitude: 149°47'59.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	64.90	65.80	203			
1	1	Casing	Threaded Steel	-0.50	41.30	203			Suspended in Clamps
1	1	Casing	Drilled	41.30	64.80	203			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth	Duration (hr)	Salinity (mg/L)

							(m)		
9.10	9.10	0.00	Unconsolidated						
15.80	24.30	8.50	Unconsolidated	8.70		3.16			
41.10	41.10	0.00	Unconsolidated			5.05			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.82	1.82	Clay Black	Clay	
1.82	3.65	1.83	Clay	Clay	
3.65	4.87	1.22	Clay Sandy	Clay	
4.87	9.14	4.27	Clay	Clay	
9.14	10.97	1.83	Clay Sandy Water Supply	Clay	
10.97	12.49	1.52	Clay Some Gravel	Clay	
12.49	13.71	1.22	Clay Some Large Stones	Clay	
13.71	14.63	0.92	Clay Gravel	Clay	
14.63	15.84	1.21	Clay	Clay	
15.84	25.60	9.76	Clay Compacted Some Gravel Water Supply	Clay	
25.60	33.52	7.92	Clay Red Some Gravel	Clay	
33.52	36.57	3.05	Clay Some Gravel	Clay	
36.57	43.89	7.32	Clay Red Gravel Water Supply	Clay	
43.89	56.08	12.19	Clay Red Some Gravel	Clay	
56.08	65.83	9.75	Clay Gravel	Clay	
65.83	69.49	3.66	Clay Very Puggy	Clay	
65.83	69.49	3.66	Gravel	Unknown	

Remarks

26/02/2008: BORE SITE INSPECTED BY BEN HUTT, LICENSING OFFICER. BORE NO LONGER EXISTS

*** End of GW012148 ***

NSW Office of Water
Work Summary

GW012154

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/10/1957
Final Depth: 73.10 m
Drilled Depth: 76.20 m

Contractor Name:
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Good
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	279
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6648943.0
Easting: 767205.0
Latitude: 30°15'42.4"S
Longitude: 149°46'38.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	33.10	152			Suspended in Clamps
1	1	Casing	Withdrawn	33.40	57.20	152			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

10.60	10.60	0.00	Unconsolidated	6.90					

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.52	1.52	Clay Black	Clay	
1.52	17.07	15.55	Clay Sandy Water Supply	Clay	
17.07	24.38	7.31	Clay Yellow Cream Sandy	Clay	
24.38	30.48	6.10	Clay Yellow Cream Soft	Clay	
30.48	34.14	3.66	Clay Yellow Soft Sandy	Clay	
34.14	45.72	11.58	Sandstone Yellow Soft	Sandstone	
45.72	48.77	3.05	Clay Yellow	Clay	
48.77	54.86	6.09	Sandstone Yellow	Sandstone	
54.86	57.30	2.44	Clay Yellow Gravel	Clay	
57.30	67.06	9.76	Sandstone White Soft	Sandstone	
67.06	76.20	9.14	Clay Yellow Soft Sandstone	Clay	

Remarks

30/01/1974: ORIG. DEPTH 76M AFTER TEST 73M

*** End of GW012154 ***

NSW Office of Water
Work Summary

GW017525

Licence: 90BL009299
Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION,STOCK
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/04/1959
Final Depth: 10.60 m
Drilled Depth: 10.70 m

Contractor Name:
Driller:
Assistant Driller:

Property: PROSPECT
Standing Water Level (m):
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
Salinity Description: Fresh
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	LOT 155 DP 754944
Licensed:	NANDEWAR	NARRABRI	Whole Lot 155//754944

Region: 90 - Barwon
CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6644353.0
Easting: 765890.0
Latitude: 30°18'12.4"S
Longitude: 149°45'53.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.10	10.70	152			Seated on Bottom
1	1	Opening	Perforations	4.80	10.50	152		1	

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)
8.20	10.60	2.40	Fractured	4.20		7.58			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.09	6.09	Clay	Clay	
6.09	9.75	3.66	Gravel River Water Supply	Gravel	
9.75	10.66	0.91	Shale Water Supply	Shale	

Remarks

*** End of GW017525 ***

NSW Office of Water
Work Summary

GW019353

Licence: 90BL010712
Licence Status: CANCELLED

Authorised Purpose(s): IRRIGATION,DOMESTIC
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Bore with sandy supply
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/06/1960
Final Depth: 36.20 m
Drilled Depth: 46.90 m

Contractor Name:
Driller:
Assistant Driller:

Property: N/A
Standing Water Level (m):
GWMA: 601 - GREAT ARTESIAN BASIN
Salinity Description: Good
GW Zone: 001 - OXLEY BASIN
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	274
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6647832.0
Easting: 769773.0
Latitude: 30°16'16.4"S
Longitude: 149°48'15.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	36.20	45.30				
1	1	Casing	Threaded Steel	-0.40	44.90	152			Suspended in Clamps
1	1	Opening	Slots	19.50	22.50	152		1	A: 3.17mm
1	1	Opening	Slots	24.90	26.40	152		2	A: 3.17mm
1	1	Opening		36.20	46.80	152		4	
1	1	Opening	Slots	39.30	42.00	152		3	A: 3.17mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
18.50	22.10	3.60	Unconsolidated	13.10					
26.20	26.50	0.30	Unconsolidated	13.10					
39.00	39.60	0.60	Unconsolidated	13.10					

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.82	1.82	Soil Black	Soil	
1.82	2.13	0.31	Clay	Clay	
2.13	5.48	3.35	Clay Yellow	Clay	
5.48	7.62	2.14	Clay Yellow Calcareous Bands	Clay	
7.62	10.66	3.04	Clay Light Brown Ferruginous Bands	Clay	
10.66	11.58	0.92	Clay Yellow Calcareous Bands	Clay	
11.58	15.84	4.26	Clay Brownish	Clay	
15.84	19.50	3.66	Clay Grey Water Supply	Clay	
19.50	22.55	3.05	Clay Grey Water Supply	Clay	
22.55	26.21	3.66	Clay Yellow Sandy	Clay	
26.21	26.51	0.30	Clay Gravel Water Supply	Clay	
26.51	39.62	13.11	Clay Grey Purple Yellow Some Gravel Water Supply	Clay	
39.62	46.93	7.31	Sandstone Yellow Clayey Fine	Sandstone	
15.84	19.50	3.66	Gravel Sand Medium	Gravel	
19.50	22.55	3.05	Gravel Medium	Gravel	
22.55	26.21	3.66	Gravel Small	Gravel	
26.21	26.51	0.30	Sand	Sand	

Remarks

04/02/1976: Changed from 0m to 0m on / / GRADED SAND & GRVL INSIDE CASINGPUMPING ABOVE.2.5 L/S DRAWS SILT

*** End of GW019353 ***

NSW Office of Water
Work Summary

GW027334

Licence: 90BL019022
Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/12/1966
Final Depth: 79.20 m
Drilled Depth: 83.50 m

Contractor Name:
Driller:
Assistant Driller:

Property: N/A NSW
GWMA: 004 - UPPER NAMOI(U/S NARRABRI)
GW Zone: 005 - 005-NAMOI VALLEY (GINS LEAP TO NARRABRI) GROUNDWATER SOURCE
Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	341
Licensed:	NANDEWAR	NARRABRI	Whole Lot 1//773018

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6644826.0
Easting: 770474.0
Latitude: 30°17'53.3"S
Longitude: 149°48'44.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	79.20	83.40	203			
1	1	Casing	Threaded Steel	-0.30	78.90	203			
1	1	Opening	Slots	0.00	22.50	203		1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
14.60	22.80	8.20	Unconsolidated						
68.80	69.70	0.90	Consolidated						

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	13.10	13.10	Clay	Clay	
13.10	16.45	3.35	Stones Clay Water Supply	Gravel	
16.45	22.86	6.41	Stones Gravel Water Supply	Gravel	
22.86	30.48	7.62	Clay Red	Clay	
30.48	36.57	6.09	Clay White	Clay	
36.57	62.48	25.91	Sandstone	Sandstone	
62.48	68.88	6.40	Sandstone Hard	Sandstone	
68.88	69.79	0.91	Water Supply	(Unknown)	
69.79	70.71	0.92	Sandstone Hard Bands	Sandstone	
70.71	74.67	3.96	Sandstone Gritty Coarse	Sandstone	
74.67	75.89	1.22	Gravel Sand	Gravel	
75.89	78.02	2.13	Sandstone Yellow	Sandstone	
78.02	83.51	5.49	Sandstone White	Sandstone	

Remarks

*** End of GW027334 ***

NSW Office of Water
Work Summary

GW030121

Licence: | Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore - Nested (3)
Work Status: Instrumented
Construct.Method: Cable Tool
Owner Type: NSW Office of Water

Commenced Date: | Final Depth: 112.80 m
Completion Date: 01/04/1971 | Drilled Depth: 114.30 m

Contractor Name:
Driller:
Assistant Driller:

Property: | Standing Water Level (m):
GWMA: | Salinity Description:
GW Zone: | Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDEWAR	NARRABRI	160
Licensed:			

Region: 90 - Barwon | CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER | Grid Zone: | Scale:
Area/District:

Elevation: 211.64 m (A.H.D.) | Northing: 6643873.000 | Latitude: 30°18'27.0"S
Elevation Source: Unknown | Easting: 766600.000 | Longitude: 149°46'20.1"E

GS Map: - | MGA Zone: 55 | Coordinate Source: 1:100000 Map

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	112.80	114.30				
1		Casing	Casing Protector	-0.54	0.00				
1	1	Casing	P.V.C.	-0.40	45.30				
1	1	Opening	Slots	39.60	45.70			2	Slotted On Site
1		Casing	Casing Protector	-0.54	0.00				
1	2	Casing	P.V.C.	-0.40	103.20				
1	2	Opening	Slots	97.50	103.60			3	Slotted On Site

1		Casing	Casing Protector	-0.54	0.00				
1	3	Casing	P.V.C.	-0.40	112.40				
1	3	Casing	Withdrawn	0.00	104.60	203			
1	3	Opening	Slots	106.70	112.80			1	Slotted On Site

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
45.70	45.70	0.00	Unconsolidated	8.70		0.25			
78.90	78.90	0.00	Unconsolidated	10.40		0.51			
96.00	96.00	0.00	Unconsolidated	6.70		0.51			
105.20	105.20	0.00	Consolidated	7.00		0.51			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	7.62	7.62	Sand Grey Gravel	Sand	
7.62	14.02	6.40	Gravel Large Boulder Coarse	Gravel	
14.02	21.34	7.32	Gravel Sand Coarse Boulders Large Stones	Gravel	
21.34	27.43	6.09	Gravel Grey Green Claybound Sand Stones Large	Gravel	
27.43	36.58	9.15	Gravel Sand Stones Large Boulder	Gravel	
36.58	40.23	3.65	Gravel Coarse Sand Grey Fine	Gravel	
40.23	46.02	5.79	Gravel Blowing Sand Coarse Water Supply	Gravel	
46.02	49.38	3.36	Gravel Claybound Coarse Stones Large	Gravel	
49.38	53.34	3.96	Clay Grey Nominal	Clay	
53.34	58.52	5.18	Gravel Claybound Coarse Stones Large Boulder	Gravel	
58.52	59.13	0.61	Stones Clay Bands	Gravel	
59.13	60.05	0.92	Sand Gravel Coarse	Sand	
60.05	61.57	1.52	Clay Green	Clay	
61.57	64.01	2.44	Clay Grey	Clay	
64.01	65.53	1.52	Clay Green	Clay	
65.53	67.06	1.53	Clay Grey Sandy	Clay	
67.06	68.58	1.52	Clay Green	Clay	
68.58	70.10	1.52	Clay Yellow Stones	Clay	
70.10	71.63	1.53	Clay Grey Stones	Clay	
71.63	74.68	3.05	Clay Grey	Clay	
74.68	76.20	1.52	Clay Yellow Stones	Clay	
76.20	78.94	2.74	Clay Grey	Clay	
78.94	79.55	0.61	Gravel Coarse Water Supply	Gravel	
79.55	80.16	0.61	Sand Gravel Coarse	Sand	
80.16	80.47	0.31	Clay Grey	Clay	
80.47	81.08	0.61	Gravel	Gravel	
81.08	81.69	0.61	Gravel Coarse	Gravel	
81.69	82.30	0.61	Gravel	Gravel	
82.30	82.91	0.61	Stones	Gravel	
82.91	83.52	0.61	Gravel Sand	Gravel	
83.52	84.12	0.60	Gravel Stones	Gravel	
84.12	84.73	0.61	Stones	Gravel	
84.73	85.34	0.61	Stones Large	Gravel	
85.34	85.95	0.61	Clay Grey	Clay	
85.95	86.26	0.31	Sand	Sand	
86.26	86.87	0.61	Gravel Stones Coarse	Gravel	
86.87	91.44	4.57	Stones Large Boulder	Gravel	
91.44	92.05	0.61	Stones Large	Gravel	
92.05	93.88	1.83	Clay Grey	Clay	
93.88	96.01	2.13	Clay Gravel	Clay	
96.01	105.16	9.15	Stones Large Water Supply	Gravel	

105.16	112.17	7.01	Sandstone Hard Water Supply	Sandstone	
112.17	114.30	2.13	Sandstone	Sandstone	

Remarks

09/12/1978: NARRABRI (WEST). 3 PVCS INSERTED IN ONE HOLE.
15/04/2009: Nat Carling, 15-Apr-2009: Updated RL's & casing protector details (based on RL's), as provided in State Water Survey database.
27/09/2010: Nat Carling, 27-Sept-2010: Entered geology log.

*** End of GW030121 ***

NSW Office of Water
Work Summary

GW030242

Licence: Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore - Nested (4)
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date: Final Depth: 83.80 m
Completion Date: 01/02/1972 Drilled Depth: 83.80 m

Contractor Name:
Driller:
Assistant Driller:

Property: Standing Water Level (m):
GWMA: Salinity Description:
GW Zone: Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDEWAR	NARRABRI	RD ADJ 7//6580
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 215.40 m (A.H.D.)
Elevation Source: (unknown)

Northing: 6643724.000
Easting: 768896.000

Latitude: 30°18'30.4"S
Longitude: 149°47'46.1"E

GS Map: -

MGA Zone: 55

Coordinate Source: Surveyed

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	19.80	21.30	143			
1		Casing	Casing Protector	-0.50	0.00				
1	1	Casing	P.V.C.	0.00	19.80				
1	1	Opening	Slots	10.70	15.30			1	Slotted On Site
2		Backfill	Backfill	30.50	33.50	143			
2		Casing	Casing Protector	-0.58	0.00				
2	2	Casing	P.V.C.	0.00	30.50				

2	2	Opening	Slots	21.30	24.30			2	Slotted On Site
3		Backfill	Backfill	73.20	73.80	143			
3		Casing	Casing Protector	-0.44	0.00				
3	3	Casing	P.V.C.	0.00	73.20				
3	3	Opening	Slots	62.50	68.60			3	Slotted On Site
4		Casing	Casing Protector	-0.49	0.00				
4	4	Casing	P.V.C.	0.00	83.80				
4	4	Opening	Slots	76.20	82.30			4	Slotted On Site

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
10.70	15.30	4.60	(Unknown)			1.26			
21.30	24.30	3.00	(Unknown)			1.39			
62.50	68.60	6.10	(Unknown)						
76.20	82.00	5.80	(Unknown)			0.25			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.52	1.52	Soil Black	Soil	
1.52	6.10	4.58	Clay Black	Clay	
6.10	10.97	4.87	Clay Yellow	Clay	
10.97	14.63	3.66	Gravel Sand	Gravel	
14.63	16.76	2.13	Gravel Claybound	Gravel	
16.76	21.34	4.58	Clay Some Gravel	Clay	
21.34	24.38	3.04	Gravel	Gravel	
24.38	32.61	8.23	Gravel Grey Claybound	Gravel	
32.61	38.10	5.49	Clay Some Gravel	Clay	
38.10	42.67	4.57	Clay Grey Some Gravel	Clay	
42.67	50.29	7.62	Clay Gravel	Clay	
50.29	53.04	2.75	Gravel	Gravel	
53.04	54.25	1.21	Gravel Clay	Gravel	
54.25	56.39	2.14	Clay Grey	Clay	
56.39	57.91	1.52	Sand	Sand	
57.91	69.80	11.89	Gravel	Gravel	
69.80	70.10	0.30	Clay Dark Brown	Clay	
70.10	74.98	4.88	Clay	Clay	
74.98	75.29	0.31	Clay Gravel	Clay	
75.29	79.25	3.96	Sandstone	Sandstone	
79.25	82.14	2.89	Driller	(Unknown)	
82.14	83.79	1.65	Driller	(Unknown)	

Remarks

09/12/1978: NARRABRI (WEST). HOLE 1 19.8M CASNO 1-2 SCNNO 1. HOLE 2 30.5M CASNO 4-5 SCNNO 3. HOLE 3 73.2M CASNO 7-8 SCNNO 5. HOLE 4 83.8M CASNO 10 SCNNO 7. AIRLIFT PUMP TESTS ON COMPREPORT.
19/01/2009: Nat Carling, 19-Jan-2009: Updated RL's, casing protector details (based on RL's) & cadastre (was entered as 'TSR 43564'), as provided in State Water Survey database.
13/10/2010: Nat Carling, 13-Oct-2010: Entered geology log.

*** End of GW030242 ***

NSW Office of Water
Work Summary

GW045073

Licence: 90BL103153
Licence Status: CONVERTED

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Needs Reconditioning
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date:
Final Depth: 30.50 m
Drilled Depth: 30.50 m

Contractor Name:
Driller:
Assistant Driller:

Property: NOONAMEENA
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	192
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6645387.0
Easting: 771451.0
Latitude: 30°17'34.3"S
Longitude: 149°49'20.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.50	30.40	127			Seated on Bottom
1	1	Casing	Threaded Steel	0.00	0.00	152			
1	1	Opening	Slots	24.40	30.50	127		1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth	Duration (hr)	Salinity (mg/L)

							(m)		
24.40	25.30	0.90	(Unknown)	13.70		3.79			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	13.72	13.72	Driller	(Unknown)	
13.72	30.48	16.76	Rock Water Supply	Rock	

Remarks

17/05/1978: Changed from 13.716m to 30.48m on 12/07/76 R/C DETAILS OF ORIG BORE UNKNOWN

*** End of GW045073 ***

NSW Office of Water
Work Summary

GW047774

Licence: 90BL109538
Licence Status: CANCELLED

Authorised Purpose(s): STOCK,IRRIGATION,DOMESTIC
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/03/1981
Final Depth: 85.30 m
Drilled Depth: 85.30 m

Contractor Name:
Driller: James Thomas Davern (Dec.)
Assistant Driller:

Property: N/A NSW
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	L22 DP6850 (150)
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6644283.0
Easting: 767493.0
Latitude: 30°18'13.4"S
Longitude: 149°46'53.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Annulus	(Unknown)	0.00	85.30	356			Graded
1	1	Casing	Threaded Steel	-1.00	85.30	356			Seated on Bottom
1	1	Casing	Drilled	0.00	0.00	559			
1	1	Opening	Slots - Vertical	42.60	83.30	356		1	Oxy-Acetylene Slotted, A: 3.18mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
42.00	51.80	9.80	Unconsolidated						
55.70	70.10	14.40	Unconsolidated						
76.80	82.20	5.40	Unconsolidated						

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.82	1.82	Topsoil	Topsoil	
1.82	10.66	8.84	Clay	Clay	
10.66	42.00	31.34	Clay Sandy	Clay	
42.00	51.80	9.80	Sand Small Gravel	Sand	
51.80	55.70	3.90	Sand Clay Bands	Sand	
55.70	70.10	14.40	Sand Gravel	Sand	
70.10	76.80	6.70	Clay	Clay	
76.80	82.20	5.40	Sand Coarse Gravel	Sand	
82.20	83.82	1.62	Sand Clay	Sand	
83.82	85.30	1.48	Clay	Clay	
70.10	76.80	6.70	Sand Bands	Sand	

Remarks

*** End of GW047774 ***

NSW Office of Water
Work Summary

GW053461

Licence: 90BL119154
Licence Status: CONVERTED

Authorised Purpose(s): STOCK,IRRIGATION,DOMESTIC
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/08/1981
Final Depth: 54.90 m
Drilled Depth: 54.90 m

Contractor Name:
Driller: James Thomas Davern (Dec.)
Assistant Driller:

Property: N/A NSW
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	271
Licensed:	NANDEWAR	NARRABRI	Whole Lot 2//586990

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6646468.0
Easting: 768883.0
Latitude: 30°17'01.4"S
Longitude: 149°47'43.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Annulus	(Unknown)	0.00	54.90	203			Graded
1	1	Casing	Threaded Steel	-1.00	54.90	203			Seated on Bottom
1	1	Opening	Slots - Vertical	38.40	50.20	203		1	Oxy-Acetylene Slotted, A: 3.18mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
13.10	19.50	6.40	(Unknown)						
38.40	42.00	3.60	(Unknown)						
45.70	50.30	4.60	(Unknown)						

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.52	1.52	Topsoil	Topsoil	
1.52	5.48	3.96	Clay	Clay	
5.48	8.53	3.05	Clay Gravel	Clay	
8.53	10.06	1.53	Gravel	Gravel	
10.06	13.71	3.65	Clay Water Bearing	Clay	
13.71	19.50	5.79	Gravel Water Bearing	Gravel	
19.50	38.40	18.90	Clay	Clay	
38.40	42.00	3.60	Sand Gravel Water Bearing	Sand	
42.00	45.72	3.72	Clay	Clay	
45.72	50.29	4.57	Sand Gravel Water Bearing	Sand	
50.29	53.34	3.05	Clay	Clay	
53.34	54.86	1.52	Sandstone	Sandstone	

Remarks

*** End of GW053461 ***

NSW Office of Water
Work Summary

GW054434

Licence: 90BL116053
Licence Status: CONVERTED

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/01/1981
Final Depth: 46.30 m
Drilled Depth: 46.30 m

Contractor Name:
Driller:
Assistant Driller:

Property: BUDDAH
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	220
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-1S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6651226.0
Easting: 770873.0
Latitude: 30°14'25.3"S
Longitude: 149°48'53.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	46.30	140			Seated on Bottom
1	1	Opening	Slots - Vertical	33.50	45.70	140		1	Oxy-Acetylene Slotted, A: 3.18mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

26.20	28.00	1.80	Consolidated	23.20					
38.40	40.80	2.40	Consolidated	23.20					

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	7.92	7.92	Clay	Clay	
7.92	21.64	13.72	Sandstone	Sandstone	
21.64	23.47	1.83	Clay	Clay	
23.47	26.21	2.74	Sandstone Water Bearing	Sandstone	
26.21	28.04	1.83	Sandstone Soft	Sandstone	
28.04	38.40	10.36	Sandstone Yellow	Sandstone	
38.40	46.33	7.93	Sandstone Water Bearing	Sandstone	

Remarks

*** End of GW054434 ***

NSW Office of Water
Work Summary

GW056947

Licence: 90BL124287
Licence Status: CANCELLED

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/03/1983
Final Depth: 15.00 m
Drilled Depth: 15.00 m

Contractor Name:
Driller:
Assistant Driller:

Property: N/A
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	LT 154 DP 754944
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6644571.0
Easting: 765788.0
Latitude: 30°18'05.4"S
Longitude: 149°45'49.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Annulus	Waterworn/Rounded	0.00	15.00	250			Graded
1	1	Casing	P.V.C.	-0.60	15.00	160			Seated on Bottom
1	1	Opening	Slots - Vertical	5.50	6.50	160		1	Mechanically Slotted, A: 2.00mm
1	1	Opening	Slots - Vertical	13.10	15.00	160		2	Mechanically Slotted, A: 2.00mm

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)
5.50	6.50	1.00	Unconsolidated	6.00					
13.10	15.00	1.90	Unconsolidated	6.00					

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.70	3.70	Topsoil	Topsoil	
3.70	5.50	1.80	Clay	Clay	
5.50	6.50	1.00	Sand Gravel	Sand	
6.50	13.10	6.60	Sand Clay	Sand	
13.10	15.00	1.90	Sand Gravel	Sand	

Remarks

*** End of GW056947 ***

NSW Office of Water
Work Summary

GW059136

Licence: 90BL120098
Licence Status: CONVERTED

Authorised Purpose(s): STOCK,IRRIGATION,DOMESTIC
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/12/1984
Final Depth: 87.00 m
Drilled Depth: 87.00 m

Contractor Name:
Driller: Reginald John Parkes
Assistant Driller:

Property: N/A NSW
Standing Water Level (m):
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
Salinity Description: 501-1000 ppm
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	319
Licensed:	NANDEWAR	NARRABRI	Whole Lot 1//566857

Region: 90 - Barwon
CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6644422.0
Easting: 768084.0
Latitude: 30°18'08.4"S
Longitude: 149°47'15.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Annulus	(Unknown)	0.00	87.00				Graded
1	1	Casing	Welded Steel	-0.30	87.00	324			Seated on Bottom
1	1	Opening	Slots - Vertical	12.00	27.00	324		1	A: 2.00mm
1	1	Opening	Slots - Vertical	48.00	85.00	324		2	A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
12.00	22.00	10.00	Unconsolidated	9.00					
24.00	27.00	3.00	Unconsolidated	9.00					
48.00	55.50	7.50	Unconsolidated	9.00					
57.00	73.50	16.50	Unconsolidated	9.00					
75.00	82.00	7.00	Unconsolidated	9.00					
83.40	85.50	2.10	Unconsolidated						

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Soil Black	Soil	
2.00	6.00	4.00	Clay Red	Clay	
6.00	11.90	5.90	Clay Gravel	Clay	
11.90	21.90	10.00	Gravel Water Bearing Sand	Gravel	
21.90	24.00	2.10	Clay Gravel	Clay	
24.00	24.90	0.90	Sand Gravel Water Bearing	Sand	
24.90	27.00	2.10	Gravel Large Water Bearing	Gravel	
27.00	28.50	1.50	Clay Gravel	Clay	
28.50	33.00	4.50	Clay	Clay	
33.00	34.50	1.50	Clay Gravel	Clay	
34.50	36.00	1.50	Clay Black	Clay	
36.00	48.00	12.00	Clay	Clay	
48.00	55.50	7.50	Gravel Water Bearing	Gravel	
55.50	57.00	1.50	Clay	Clay	
57.00	59.10	2.10	Sand Water Bearing	Sand	
59.10	73.50	14.40	Sand Gravel Water Bearing	Sand	
73.50	75.00	1.50	Clay	Clay	
75.00	81.90	6.90	Gravel Water Bearing Sand	Gravel	
81.90	83.40	1.50	Clay	Clay	
83.40	85.50	2.10	Sand Gravel Water Bearing	Sand	
85.50	87.00	1.50	Sandstone	Sandstone	

Remarks

*** End of GW059136 ***

NSW Office of Water
Work Summary

GW062164

Licence: 90BL114871
Licence Status: LAPSED

Authorised Purpose(s): STOCK,IRRIGATION,DOMESTIC
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/09/1986
Final Depth: 70.10 m
Drilled Depth: 76.20 m

Contractor Name:
Driller: Reginald John Parkes
Assistant Driller:

Property: N/A NSW
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	LOT 7 DP 6580
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6643599.0
Easting: 768973.0
Latitude: 30°18'34.4"S
Longitude: 149°47'49.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Annulus	(Unknown)	0.00	70.10	508			Graded
1		Backfill	Backfill	70.10	76.20				
1	1	Casing	Welded Steel	-0.90	70.10	355			Seated on Bottom
1	1	Opening	Slots - Vertical	11.00	24.40	355		1	Oxy-Acetylene Slotted, A: 3.17mm
1	1	Opening	Slots - Vertical	38.10	68.00	355		2	Oxy-Acetylene Slotted, A: 3.17mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
11.00	18.90	7.90	Unconsolidated						
21.30	23.40	2.10	Unconsolidated						
38.10	39.00	0.90	Unconsolidated						
47.20	53.30	6.10	Unconsolidated						
54.90	60.30	5.40	Unconsolidated						
65.50	67.90	2.40	Unconsolidated	8.80					

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.43	2.43	Topsoil	Topsoil	
2.43	7.62	5.19	Clay	Clay	
7.62	10.97	3.35	Clay Sandy	Clay	
10.97	18.89	7.92	Gravel Water Bearing	Gravel	
18.89	19.81	0.92	Clay	Clay	
19.81	21.33	1.52	Clay	Clay	
21.33	23.46	2.13	Gravel Water Bearing	Gravel	
23.46	27.43	3.97	Clay	Clay	
27.43	38.10	10.67	Clay Soft Sandy	Clay	
38.10	39.01	0.91	Gravel	Gravel	
39.01	47.24	8.23	Clay Sandy	Clay	
47.24	51.81	4.57	Sand Water Bearing Clay	Sand	
51.81	53.34	1.53	Sand Coarse Water Bearing	Sand	
53.34	54.86	1.52	Clay Sandy	Clay	
54.86	60.35	5.49	Sand Coarse Gravel Water Bearing	Sand	
60.35	62.48	2.13	Clay Gravel	Clay	
62.48	64.00	1.52	Clay	Clay	
64.00	65.53	1.53	Clay Gravel	Clay	
65.53	67.97	2.44	Gravel Water Bearing	Gravel	
67.97	70.10	2.13	Clay Sticky	Clay	
70.10	71.62	1.52	Clay Sandy	Clay	
71.62	73.15	1.53	Clay	Clay	
73.15	74.67	1.52	Clay White	Clay	
74.67	76.20	1.53	Sandstone White	Sandstone	

Remarks

*** End of GW062164 ***

NSW Office of Water
Work Summary

GW064436

Licence: 90BL137100
Licence Status: CONVERTED

Authorised Purpose(s): DOMESTIC
Intended Purpose(s): DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary Mud
Owner Type: Private

Commenced Date:
Completion Date: 01/01/1988
Final Depth: 43.90 m
Drilled Depth: 45.70 m

Contractor Name:
Driller: Reginald John Parkes
Assistant Driller:

Property: N/A NSW
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description: Good
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	L166 DP6580 (137)
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6643847.0
Easting: 770156.0
Latitude: 30°18'25.3"S
Longitude: 149°48'33.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Annulus	Waterworn/Rounded	0.00	43.90	203			
1	1	Casing	Steel	-0.50	43.90	152			Seated on Bottom
1	1	Opening	Slots - Vertical	24.40	27.40	152		1	Oxy-Acetylene Slotted, A: 3.18mm
1	1	Opening	Slots - Vertical	35.00	43.50	152		2	Oxy-Acetylene Slotted, A: 3.18mm

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)
25.90	28.90	3.00	Unconsolidated	13.70		1.50			
36.50	43.50	7.00	Unconsolidated	13.70		1.50			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.82	1.82	Topsoil	Topsoil	
1.82	6.70	4.88	Clay	Clay	
6.70	11.58	4.88	Gravel Dry	Gravel	
11.58	19.81	8.23	Clay Sandy	Clay	
19.81	20.11	0.30	Gravel Large	Gravel	
20.11	25.90	5.79	Clay Sandy	Clay	
25.90	28.95	3.05	Gravel Water Bearing Water Supply	Gravel	
28.95	36.57	7.62	Clay Sandy	Clay	
36.57	43.58	7.01	Gravel Water Bearing Water Supply	Gravel	
43.58	45.72	2.14	Clay Sandy	Clay	

Remarks

*** End of GW064436 ***

NSW Office of Water
Work Summary

GW065028

Licence: 90BL140206
Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Rotary Mud
Owner Type: Private

Commenced Date:
Completion Date: 01/01/1989
Final Depth: 141.00 m
Drilled Depth:

Contractor Name:
Driller: Alan Francis Ryan
Assistant Driller:

Property: N/A NSW
GWMA: 004 - UPPER NAMOI(U/S NARRABRI)
GW Zone: 005 - 005-NAMOI VALLEY (GINS LEAP TO NARRABRI) GROUNDWATER SOURCE
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	475
Licensed:	NANDEWAR	NARRABRI	Whole Lot 1002//826698

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6645443.0
Easting: 769179.0
Latitude: 30°17'34.4"S
Longitude: 149°47'55.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Steel	-1.00	96.00	276			

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

*** End of GW065028 ***

NSW Office of Water
Work Summary

GW067438

Licence: 90BL137783
Licence Status: CONVERTED

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 31/12/1988
Final Depth: 23.00 m
Drilled Depth:

Contractor Name:
Driller:
Assistant Driller:

Property: N/A NSW
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	PT271
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6646506.0
Easting: 768867.0
Latitude: 30°17'00.1"S
Longitude: 149°47'42.5"E

GS Map: -
MGA Zone: 0
Coordinate Source: GD.,ACC.GIS

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	P.V.C.	0.00	0.00	152			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

*** End of GW067438 ***

NSW Office of Water
Work Summary

GW067672

Licence: 90BL139349
Licence Status: CONVERTED

Authorised Purpose(s): DOMESTIC
Intended Purpose(s):

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date: 16/06/1989
Completion Date: 23/06/1989
Final Depth: 28.50 m
Drilled Depth: 28.50 m

Contractor Name: ALJ & JA CAMERON
Driller: James Alexander Cameron
Assistant Driller:

Property: N/A NSW
Standing Water Level (m): 5.100
GWMA: -
Salinity Description: Fresh
GW Zone: -
Yield (L/s): 0.660

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	LT1 DP719222
Licensed:	NANDEWAR	NARRABRI	Whole Lot 1//719222

Region: 90 - Barwon
CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6644207.0
Easting: 765552.0
Latitude: 30°18'17.4"S
Longitude: 149°45'40.6"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	28.50	310			Percussion
1		Annulus	Waterworn/Rounded	10.00	28.50	310	130		Graded, Q:3.000m3
1	1	Casing	P.V.C.	-1.50	28.50	130			Seated on Bottom
1	1	Opening	Slots - Vertical	12.00	15.00	130		1	Sawn, PVC, A: 2.00mm
1	1	Opening	Slots - Vertical	17.00	28.50	130		2	Sawn, PVC, A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
7.00	7.50	0.50	Unconsolidated						
12.10	14.50	2.40	Unconsolidated	5.10		0.66			
17.50	28.50	11.00	Unconsolidated	5.10	5.50	0.66	28.50		

Geologists Log

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.10	2.10		Topsoil	
2.10	4.30	2.20		Clay	
4.30	7.00	2.70	Sandy Clay	Clay	
7.00	7.50	0.50	Sand And Gravel	Sand	
7.50	12.10	4.60	Gravelly Clay	Clay	
12.10	14.50	2.40		Gravel	
14.50	17.50	3.00		Clay	
17.50	28.50	11.00	Bands Of Gravel And Clay	Gravel	

Remarks

23/06/1989: ACC=7

*** End of GW067672 ***

NSW Office of Water
Work Summary

GW070974

Licence: 90BL150874 Licence Status: CONVERTED

Authorised Purpose(s): DOMESTIC
Intended Purpose(s): DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date: Final Depth: 59.70 m
Completion Date: 13/03/1993 Drilled Depth:

Contractor Name:
Driller: James Alexander Cameron
Assistant Driller:

Property: N/A LOT 4 9 KILLARNEY ST NARRABRI 2390 NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	L4 DP812575 (274)
Licensed:	NANDEWAR	NARRABRI	Whole Lot 4//812575

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 240.00 m (A.H.D.)
Elevation Source: Est. Contour >15M.

Northing: 6649164.0
Easting: 770742.0

Latitude: 30°15'32.3"S
Longitude: 149°48'50.1"E

GS Map: -

MGA Zone: 0

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	P.V.C.	-0.30	59.70	140			Seated on Bottom
1	1	Opening	Slots - Vertical	46.00	59.50	140		1	Mechanically Slotted, A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

45.80	59.70	13.90	Consolidated	30.60		4.00			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.75	0.75	topsoil	Unknown	
0.75	2.50	1.75	sandy clay	Unknown	
2.50	8.30	5.80	sandy clay	Unknown	
8.30	11.20	2.90	sandstone	Unknown	
11.20	59.70	48.50	sandstone	Unknown	

Remarks

*** End of GW070974 ***

NSW Office of Water
Work Summary

GW071333

Licence: 90BL151790
Licence Status: CONVERTED

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore - GAB
Work Status:
Construct.Method: Rotary
Owner Type: Private

Commenced Date:
Completion Date: 09/03/1993
Final Depth: 36.50 m
Drilled Depth: 36.50 m

Contractor Name: Drillwell Construction
Driller: Alec Linton
Assistant Driller:

Property: VEONE MOREE ROAD NARRABRI 2390 NSW
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description: Fair
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	2//812575
Licensed:	NANDEWAR	NARRABRI	Whole Lot 2//812575

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6649806.0
Easting: 771108.0
Latitude: 30°15'11.2"S
Longitude: 149°49'03.2"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	36.50	200			Rotary Mud
1	1	Casing	Pvc Class 9	-0.40	36.50	150			Seated on Bottom
1	1	Opening	Slots - Horizontal	24.50	36.50	150		1	Oxy-Acetylene Slotted, PVC Class 9, A: 4.00mm

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)
32.00	36.00	4.00	Unknown	15.24		3.70	36.50		

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.90	0.90	BLACK SOIL	Unknown	
0.90	14.32	13.42	BROWN CLAYS	Unknown	
14.32	27.73	13.41	CLAY MATRIX RIDGE GRAVEL	Unknown	
27.73	31.39	3.66	FINE SAND	Unknown	
31.39	36.50	5.11	COARSE GRAINED SAND	Unknown	

Remarks

19/12/2003: cadaster info. obtained form GDS; Charting done at the center of the property using Arc View GIS due to lack of actual site data.

*** End of GW071333 ***

NSW Office of Water
Work Summary

GW901095

Licence: 90BL246603
Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Rot. Rev. Circ. Air
Owner Type:

Commenced Date:
Completion Date: 11/07/1997
Final Depth: 162.00 m
Drilled Depth: 162.00 m

Contractor Name: ARFRAC DRILLING PTY LTD
Driller: Warren James Crowley
Assistant Driller:

Property: MURRAGANG NEWELL HIGHWAY NARRABRI 2390
GWMA: 601 - GREAT ARTESIAN BASIN
GW Zone: 013 - SOUTHERN RECHARGE GROUNDWATER SOURCE
Standing Water Level:
Salinity:
Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	LOT 3 DP 812575
Licensed:	NANDEWAR	NARRABRI	Whole Lot 3//812575

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6649427.0
Easting: 770080.0
Latitude: 30°15'24.4"S
Longitude: 149°48'25.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	2.50	350			Rotary
1		Hole	Hole	2.50	125.00	250			Rotary Air
1		Hole	Hole	125.00	162.00	150			Rotary Air
1	1	Casing	Steel	-0.50	125.00	168	155		Cemented, Welded
1	1	Casing	Steel	0.00	2.50	324	309		

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
35.00	160.00	125.00	Unknown	10.20		19.00	160.00		

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	dark brown top soil	Unknown	
1.00	2.00	1.00	brown sandy clay	Unknown	
2.00	6.00	4.00	white greyy sandstone weathered	Unknown	
6.00	8.00	2.00	brown grey clay	Unknown	
8.00	12.00	4.00	brown red grey sandy clay	Unknown	
12.00	29.00	17.00	red clay sticky	Unknown	
29.00	31.00	2.00	grey brown clay	Unknown	
31.00	35.00	4.00	red clay	Unknown	
35.00	36.00	1.00	red grey clay silty	Unknown	
36.00	42.00	6.00	brown yellow fine sandy clay	Unknown	
42.00	43.00	1.00	grey yellow silty clay	Unknown	
43.00	49.00	6.00	brown yellow sandy silty clay	Unknown	
49.00	51.00	2.00	brown grey silty clay minor carb	Unknown	
51.00	52.50	1.50	yellow clay	Unknown	
52.50	56.00	3.50	grey yellow small gravel	Unknown	
56.00	58.00	2.00	grey yellow silty clay	Unknown	
58.00	62.00	4.00	yellow brown clay	Unknown	
62.00	67.00	5.00	grey brown sandy clay	Unknown	
67.00	72.00	5.00	yellow brown sandy clay	Unknown	
72.00	74.00	2.00	yellow white clay	Unknown	
74.00	76.00	2.00	off white/yellow fine sand/small gravel	Unknown	
76.00	77.00	1.00	yellow small gravel	Unknown	
77.00	81.00	4.00	clay ironstone lenses	Unknown	
81.00	85.00	4.00	grey siltstone	Unknown	
85.00	87.00	2.00	brown yellow sandy clay	Unknown	

Remarks

*** End of GW901095 ***

NSW Office of Water
Work Summary

GW901193

Licence: 90BL247213
Licence Status: CONVERTED

Authorised Purpose(s): INDUSTRIAL (LOW SECURITY)
Intended Purpose(s): INDUSTRIAL

Work Type: Bore
Work Status:
Construct.Method:
Owner Type:

Commenced Date:
Completion Date: 15/06/1995
Final Depth: 20.00 m
Drilled Depth:

Contractor Name: JAMES THOMAS DAVERN
Driller: James T. Davern
Assistant Driller:

Property: N/A 38 WEE WAA ROAD NARRABRI 2390
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Standing Water Level: 10.500
Salinity:
Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	LT 10 DP 1018627
Licensed:	NANDEWAR	NARRABRI	Whole Lot 10//1018627

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6643837.0
Easting: 766813.0
Latitude: 30°18'28.4"S
Longitude: 149°46'28.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	20.00	165			(Unknown)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth	Duration (hr)	Salinity (mg/L)

							(m)		

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

15/06/1995: Form A Remarks:
original copy of log lost, Engaged Mr J Cameron to inspect bore with a bore hole video camera going information.

*** End of GW901193 ***

NSW Office of Water
Work Summary

GW901529

Licence: 90BL246628
Licence Status: CANCELLED

Authorised Purpose(s): IRRIGATION,STOCK
Intended Purpose(s): TEST BORE

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 16/10/1998
Final Depth: 36.59 m
Drilled Depth: 36.59 m

Contractor Name: Drillwell Construction
Driller: Alec Linton
Assistant Driller:

Property: VEONE MOREE ROAD NARRABRI 2390
GWMA: 601 - GREAT ARTESIAN BASIN
GW Zone: -
Standing Water Level: 16.000
Salinity:
Yield: 0.200

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:		.	
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6649820.0
Easting: 771041.0
Latitude: 30°15'10.8"S
Longitude: 149°49'00.7"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	6.50	169			Rotary Air
1		Hole	Hole	6.50	36.59	169			Rotary Air
1	1	Casing	Steel	-0.30	6.50	168	159		Driven into Hole

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)
18.50	18.80	0.30	Unknown	16.00		0.20	20.00		

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.60	0.60	soil - black	Invalid Code	
0.60	14.90	14.30	clay - light brown	Clay	
14.90	18.10	3.20	clay with gravel	Clay	
18.10	19.40	1.30	sandstone	Sandstone	
19.40	36.59	17.19	sandy gravel (consolidated)	Invalid Code	

Remarks

23/01/2004: Nominated bore location based on cadastral details provided either by Form A or licence. Charted bore location will differ from actual location. Krish

*** End of GW901529 ***

NSW Office of Water
Work Summary

GW902203

Licence: 90BL248921 Licence Status: CANCELLED

Authorised Purpose(s): TEST BORE
Intended Purpose(s): TEST BORE

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date: Final Depth: 102.00 m
Completion Date: 31/03/1998 Drilled Depth: 102.00 m

Contractor Name: Reginald John PARKES
Driller: Reginald John Parkes
Assistant Driller:

Property: NOONAMEENA NOONAMEENA NARRABRI 2390 Standing Water Level:
GWMA: - Salinity:
GW Zone: - Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:		.	
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon CMA Map:
River Basin: - Unknown Grid Zone: Scale:
Area/District:

Elevation: 0.00 m (A.H.D.) Northing: 6644093.0 Latitude: 30°18'18.4"S
Elevation Source: Unknown Easting: 768932.0 Longitude: 149°47'47.1"E

GS Map: - MGA Zone: 0 Coordinate Source: Map Interpretation

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	102.00	0			Rotary

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
15.00	21.00	6.00	Unknown						

48.00	58.00	10.00	Unknown							
60.00	66.00	6.00	Unknown							
67.00	69.50	2.50	Unknown							

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	topsoil	Topsoil	
2.00	9.50	7.50	brown clay	Clay	
9.50	12.00	2.50	gravel	Gravel	
12.00	15.00	3.00	gravel and clay	Gravel	
15.00	17.00	2.00	sand	Sand	
17.00	18.00	1.00	gravel	Gravel	
18.00	21.00	3.00	gravel and clay	Gravel	
21.00	23.00	2.00	gravely clay	Gravel	
23.00	27.00	4.00	brown clay	Clay	
27.00	33.00	6.00	gravelly clay	Gravel	
33.00	38.00	5.00	brown clay	Clay	
38.00	39.00	1.00	grey clay	Clay	
39.00	40.00	1.00	gravel and clay	Gravel	
40.00	45.00	5.00	brown clay	Clay	
45.00	48.00	3.00	grey clay	Clay	
48.00	50.00	2.00	sand	Sand	
50.00	58.00	8.00	sand	Sand	
58.00	60.00	2.00	clay	Clay	
60.00	63.00	3.00	gravel	Clay	
63.00	66.00	3.00	gravel and clay	Gravel	
66.00	67.00	1.00	grey clay	Clay	
67.00	69.50	2.50	sand and gravel	Sand	
69.50	102.00	32.50	clay	Clay	

Remarks

*** End of GW902203 ***

NSW Office of Water
Work Summary

GW902386

Licence: 90BL249721
Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION,STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC, IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 02/06/2000
Final Depth: 24.00 m
Drilled Depth: 24.00 m

Contractor Name: Reginald John PARKES
Driller: Reginald John Parkes
Assistant Driller:

Property: NARRABRI RURAL SKILLS CENTRE LOT 5821 DP 844304 NARRABRI 2390
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Standing Water Level:
Salinity:
Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	5821
Licensed:	NANDEWAR	NARRABRI	Whole Lot 5821//844304

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6643846.0
Easting: 767722.0
Latitude: 30°18'27.4"S
Longitude: 149°47'02.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	24.00	190			Rotary Mud
1		Annulus	(Unknown)	0.00	24.00				Graded, Q:1.000m3
1	1	Casing	P.V.C.	0.00	24.00	140	122		Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	8.00	23.00	140		1	Sawn, PVC Class 9, SL: 250.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
8.00	20.00	12.00	Unknown	8.00	17.00	3.00	24.00	01:00:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	TOPSOIL	Unknown	
1.00	6.00	5.00	BROWN CLAY	Unknown	
6.00	8.00	2.00	FINE SAND	Unknown	
8.00	15.00	7.00	BROWN GRAVEL	Unknown	
15.00	18.00	3.00	BLUE CLAY	Unknown	
18.00	20.00	2.00	BLUE GRAVEL	Unknown	
20.00	24.00	4.00	BLUE CLAY	Unknown	

Remarks

*** End of GW902386 ***

NSW Office of Water
Work Summary

GW902817

Licence: 90BL247876
Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 01/05/1996
Final Depth: 96.00 m
Drilled Depth: 96.00 m

Contractor Name: Reginald John PARKES
Driller: Reginald John Parkes
Assistant Driller:

Property: OAKVILLE OAKVILLE NARRABRI 2390
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Standing Water Level: 8.000
Salinity:
Yield: 94.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	316
Licensed:	NANDEWAR	NARRABRI	Whole Lot 223//811798

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6644501.0
Easting: 767391.0
Latitude: 30°18'06.4"S
Longitude: 149°46'49.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	96.00	0			Unknown
1		Annulus	(Unknown)	0.00	96.00				Graded, Q:20.000m3
1	1	Casing	Steel	0.00	96.00	406	387		Seated on Bottom, Welded
1	1	Opening	Screen - Wire Wound	39.00	41.50	406		1	Stainless Steel, Welded, A: 2.00mm

1	1	Opening	Screen - Wire Wound	47.00	49.50	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	51.00	53.50	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	63.00	67.00	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	72.50	75.00	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	76.00	78.50	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	79.50	81.50	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	82.00	84.00	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	84.50	86.00	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	87.00	89.50	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	90.00	92.00	406		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	93.00	94.00	406		1	Stainless Steel, Welded, A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
10.00	20.00	10.00	Unknown						
38.00	54.00	16.00	Unknown						
63.00	67.00	4.00	Unknown						
72.00	95.00	23.00	Unknown						

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	TOPSOIL	Unknown	
1.00	9.00	8.00	CLAY	Unknown	
9.00	10.00	1.00	GRAVEL	Unknown	
10.00	20.00	10.00	SAND & GRAVEL	Unknown	
20.00	38.00	18.00	SILTY CLAYS	Unknown	
38.00	54.00	16.00	SANDS & GRAVEL	Unknown	
54.00	63.00	9.00	BLUE CLAY	Unknown	
63.00	67.00	4.00	BLUE SAND & GRAVEL	Unknown	
67.00	72.00	5.00	BLUE CLAY	Unknown	
72.00	95.00	23.00	BLUE SAND & GRAVEL WITH CLAY SEAMS	Unknown	
95.00	96.00	1.00	BLUE SOFT SAND STONE	Unknown	

Remarks

*** End of GW902817 ***

NSW Office of Water
Work Summary

GW965081

Licence: 90BL150134
Licence Status: CONVERTED

Authorised Purpose(s): RECREATION - LOW SECURITY
Intended Purpose(s): RECREATION (GROUNDWATER)

Work Type: Bore
Work Status:
Construct.Method:
Owner Type:

Commenced Date:
Completion Date:
Final Depth: 25.00 m
Drilled Depth:

Contractor Name:
Driller: Unknown Unknown
Assistant Driller:

Property: N/A NSW
GWMA: -
GW Zone: -
Standing Water Level:
Salinity:
Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	LT372 DP754944
Licensed:	NANDEWAR	NARRABRI	Whole Lot 372//754944

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6644190.0
Easting: 766234.0
Latitude: 30°18'17.4"S
Longitude: 149°46'06.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	25.00	0			(Unknown)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

*** End of GW965081 ***

NSW Office of Water
Work Summary

GW965287

Licence: 90BL250234
Licence Status: CONVERTED

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 30/09/2001
Final Depth: 16.76 m
Drilled Depth: 18.00 m

Contractor Name: Reginald John PARKES
Driller: Reginald John Parkes
Assistant Driller:

Property: OAKHAM NARRABRI 2390
GWMA: -
GW Zone: -
Standing Water Level: 7.000
Salinity:
Yield: 2.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	LT 2 DP 719222
Licensed:	NANDEWAR	NARRABRI	Whole Lot 2//719222

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6644391.0
Easting: 765570.0
Latitude: 30°18'11.4"S
Longitude: 149°45'41.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GPS - Global Positioning System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	16.76	200			Rotary Mud
1		Annulus	(Unknown)	0.00	16.76				Graded
1	1	Casing	P.V.C.	0.00	16.76	140			Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	7.00	16.00	140		1	Sawn, PVC Class 9, SL: 200.0mm, A: 3.00mm

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)
8.00	13.00	5.00	Unknown	7.00	14.00	1.00	16.76		
14.00	16.00	2.00	Unknown	7.00	14.00	1.00	16.76		

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	5.00	5.00	topsoil	Topsoil	
5.00	13.00	8.00	gravel	Gravel	
13.00	14.00	1.00	blue clay	Clay	
14.00	16.00	2.00	gravel	Gravel	
16.00	18.00	2.00	blue clay	Clay	

Remarks

*** End of GW965287 ***

NSW Office of Water
Work Summary

GW965355

Licence: 90BL248922
Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type:

Commenced Date:
Completion Date: 29/05/2000
Final Depth: 72.50 m
Drilled Depth: 102.00 m

Contractor Name: Reginald John PARKES
Driller: Reginald John Parkes
Assistant Driller:

Property: NOONAMEENA NOONAMEENA NARRABRI 2390
GWMA: 004 - UPPER NAMOI(U/S NARRABRI)
GW Zone: 005 - 005-NAMOI VALLEY (GINS LEAP TO NARRABRI) GROUNDWATER SOURCE
Standing Water Level: 11.000
Salinity:
Yield: 75.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	LT 26 DP 6580
Licensed:	NANDEWAR	NARRABRI	Whole Lot 26//6580

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6644057.0
Easting: 768880.0
Latitude: 30°18'19.6"S
Longitude: 149°47'45.2"E

GS Map: -
MGA Zone: 0
Coordinate Source: GPS - Global Positioning System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	72.50	508			Cable Tool
1		Annulus	(Unknown)	0.00	72.50				Graded
1	1	Casing	Steel	0.00	72.50	355	336		Seated on Bottom, Cemented
1	1	Opening	Slots - Vertical	12.00	23.00	355		1	Oxy-Acetylene Slotted, Steel, SL: 250.0mm, A:

									3.00mm
1	1	Opening	Screen - Wire Wound	49.50	52.00	336		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	53.00	55.00	336		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	57.50	64.00	336		1	Stainless Steel, Welded, A: 2.00mm
1	1	Opening	Screen - Wire Wound	66.50	69.50	336		1	Stainless Steel, Welded, A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
12.00	20.00	8.00	Unknown	11.00	75.00	62.00	72.50		
48.00	58.00	10.00	Unknown	11.00	75.00	62.00	72.50		
58.00	64.00	6.00	Unknown	11.00	75.00	62.00	72.50		
66.50	69.50	3.00	Unknown	11.00	75.00	62.00	72.50		

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	topsoil	Topsoil	
2.00	9.50	7.50	brown clay	Clay	
9.50	12.00	2.50	gravel	Gravel	
12.00	15.00	3.00	clay	Clay	
15.00	18.00	3.00	gravel	Gravel	
18.00	21.00	3.00	gravel	Gravel	
21.00	23.00	2.00	clay	Clay	
23.00	27.00	4.00	brown clay	Clay	
27.00	33.00	6.00	clay	Clay	
33.00	38.00	5.00	brown clay	Clay	
38.00	39.00	1.00	grey clay	Clay	
39.00	40.00	1.00	clay	Clay	
40.00	45.00	5.00	brown clay	Clay	
45.00	48.00	3.00	grey clay	Clay	
48.00	50.00	2.00	sand	Sand	
50.00	58.00	8.00	sand	Sand	
58.00	60.00	2.00	clay	Clay	
60.00	63.00	3.00	gravel	Gravel	
63.00	66.00	3.00	clay	Clay	
66.00	67.00	1.00	grey clay	Clay	
67.00	69.50	2.50	sand and gravel	Sand	
69.50	102.00	32.50	solid clay	Invalid Code	

Remarks

*** End of GW965355 ***

NSW Office of Water
Work Summary

GW965590

Licence: 90BL248699
Licence Status: CONVERTED

Authorised Purpose(s): IRRIGATION,STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC, IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 16/11/2000
Final Depth: 30.50 m
Drilled Depth: 30.50 m

Contractor Name: Drillwell Construction
Driller: Alec Linton
Assistant Driller:

Property: FERNLEIGH FERNLEIGH NARRABRI 2390
GWMA: 001 - LOWER NAMOI GROUNDWATER SOURCE
GW Zone: 005 - MAIN FAN AREA PRIMARY RECHARGE
Standing Water Level:
Salinity:
Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.021	LT 1011 DP 883764
Licensed:	NANDEWAR	NARRABRI	Whole Lot 1011//883764

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6649833.0
Easting: 765613.0
Latitude: 30°15'14.7"S
Longitude: 149°45'37.8"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	30.50	160			Rotary Air
1	1	Casing	P.V.C.	0.00	30.50	140			Seated on Bottom, Glued
1	1	Casing	Steel	0.60	5.00				Driven into Hole
1	1	Opening	Slots - Vertical	18.00	30.00	140		1	Sawn, PVC Class 9, SL: 12.0mm, A: 4.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
20.40	20.70	0.30	Unknown			0.56	22.00		
27.30	30.00	2.70	Unknown	8.00		1.50	30.50		

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	topsoil	Topsoil	
0.30	4.70	4.40	grey clay	Clay	
4.70	9.20	4.50	clay	Clay	
9.20	20.40	11.20	clay	Clay	
20.40	30.50	10.10	sandstone	Sandstone	

Remarks

*** End of GW965590 ***

NSW Office of Water
Work Summary

GW966867

Licence: 90BL145678
Licence Status: CONVERTED

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date:
Final Depth:
Drilled Depth:

Contractor Name:
Driller: Unknown Unknown
Assistant Driller:

Property: N/A NSW
GWMA: -
GW Zone: -
Standing Water Level:
Salinity:
Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	LT390 DP754944
Licensed:	NANDEWAR	NARRABRI	Whole Lot //

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation (Unknown)
Source:
Northing: 6647941.0
Easting: 766511.0
Latitude: 30°16'15.4"S
Longitude: 149°46'13.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

16/12/2009: Reviewed data - nothing to update.

*** End of GW966867 ***

NSW Office of Water
Work Summary

GW966924

Licence: 90BL252196
Licence Status: CONVERTED

Authorised Purpose(s): DOMESTIC,STOCK
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary - Percussion (Down Hole Hammer)
Owner Type:

Commenced Date:
Completion Date: 24/11/2004
Final Depth: 48.00 m
Drilled Depth: 48.00 m

Contractor Name: Mannion Drilling Pty Ltd
Driller: Jason Roger Mannion
Assistant Driller:

Property: GRUIE NARRABRI 2390
GWMA: -
GW Zone: -
Standing Water Level: 20.000
Salinity:
Yield: 0.500

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	252 709089
Licensed:	NANDEWAR	NARRABRI	Whole Lot 252//709089

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6651167.0
Easting: 769735.0
Latitude: 30°14'28.2"S
Longitude: 149°48'10.6"E

GS Map: -
MGA Zone: 0
Coordinate Source: Map Interpretation

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	48.00	165			Rotary - Percussion (Down Hole Hammer)
1		Annulus	Waterworn/Rounded	0.00	48.00				Graded
1	1	Casing	Pvc Class 9	-0.30	48.00	140	125		Seated on Bottom, Glued
1	1	Opening	Slots - Diagonal	34.00	48.00	152		1	Casing - Machine Slotted, PVC Class 9, SL: 100.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
36.00	44.00	8.00	Unknown	20.00		0.50			

Geologists Log

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	topsoil	Topsoil	
0.30	6.00	5.70	clay	Clay	
6.00	12.00	6.00	sandstone	Sandstone	
12.00	18.00	6.00	clay	Clay	
18.00	32.00	14.00	clay	Clay	
32.00	45.00	13.00	sand	Clay	
45.00	48.00	3.00	clay	Clay	

Remarks

23/09/2011: Adjusted Inside, Outside Diameter and Thickness due to data entry errors with advice from Madhwan Keshwan. GDS Data Cleanup project 2011.

*** End of GW966924 ***

NSW Office of Water
Work Summary

GW966926

Licence: 90BL252163
Licence Status: CONVERTED

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary Mud
Owner Type:

Commenced Date:
Completion Date: 24/11/2004
Final Depth: 46.50 m
Drilled Depth: 46.50 m

Contractor Name: Mannion Drilling Pty Ltd
Driller: Jason Roger Mannion
Assistant Driller:

Property: KILLARNEY NARRABRI 2390
GWMA: -
GW Zone: -
Standing Water Level: 30.000
Salinity:
Yield: 1.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	24 248483
Licensed:	NANDEWAR	NARRABRI	Whole Lot 24//248483

Region: 90 - Barwon
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6649929.0
Easting: 769113.0
Latitude: 30°15'08.8"S
Longitude: 149°47'48.5"E

GS Map: -
MGA Zone: 0
Coordinate Source: Map Interpretation

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	46.50	165			Rotary Mud
1		Annulus	Waterworn/Rounded	0.00	46.50				Graded
1	1	Casing	Pvc Class 6	-0.30	46.50	152	142		Seated on Bottom, Glued
1	1	Opening	Slots	34.50	46.50	152		1	Casing - Machine Slotted, PVC Class 9, A: 1.00mm

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)
35.00	44.00	9.00	Unknown	30.00		1.00		02:00:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	topsoil	Topsoil	
0.30	5.10	4.80	clay	Clay	
5.10	5.16	0.06	ironstone	Ironstone	
5.16	31.50	26.34	sandy/clay	Invalid Code	
31.50	46.50	15.00	sand	Sand	

Remarks

*** End of GW966926 ***

NSW Office of Water
Work Summary

GW967980

Licence: 90BL253562
Licence Status: CONVERTED

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Cable Tool (Mud Stabilised)
Owner Type: Private

Commenced Date:
Completion Date: 03/08/2006
Final Depth: 48.00 m
Drilled Depth: 48.00 m

Contractor Name: JNR Drilling
Driller: Reginald John Parkes
Assistant Driller:

Property: KILLARNEY NARRABRI 2390
GWMA:
GW Zone:
Standing Water Level: 30.000
Salinity: Good
Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	24//248483
Licensed:			

Region: 90 - Barwon
River Basin: 425 - DARLING RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6649614.0
Easting: 768723.0
Latitude: 30°15'19.4"S
Longitude: 149°47'34.2"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	48.00	205			Cable Tool (Mud Stabilised)
1		Annulus	Waterworn/Rounded	0.00	48.00	205	150		Graded, Q:1.500m3, PL:Poured/Shovelled
1	1	Casing	Pvc Class 9	-0.30	48.00	150	138		Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	30.00	48.00	150		1	Sawn, PVC Class 9, Glued, SL: 200.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
30.00	48.00	18.00	Unknown	30.00	30.00			06:00:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	Topsoil	Topsoil	
1.00	3.00	2.00	Clay	Clay	
3.00	12.00	9.00	Sandy Clay	Invalid Code	
12.00	21.00	9.00	Sandstone, light, fine	Sandstone	
21.00	27.00	6.00	Sandstone, light, medium	Sandstone	
27.00	30.00	3.00	Sandstone, light, coarse	Sandstone	
30.00	35.00	5.00	Fractured Sandstone, water bearing, coarse	Invalid Code	
35.00	40.00	5.00	Sandy Clay, pink	Invalid Code	
40.00	48.00	8.00	Fractured Sandstone, water bearing, coarse	Invalid Code	

Remarks

16/10/2006: Form A Remarks:
Nat Carling, 6-June-2007: Coordinates based on sketch provided with the form, completion date taken from drillers signature, letter sent to check the location.
19/09/2007: Nat Carling, 19-Sept-2007: Added missing completion date, as provided by driller.

*** End of GW967980 ***

NSW Office of Water
Work Summary

GW967981

Licence: 90BL253561
Licence Status: CONVERTED

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Cable Tool (Mud Stabilised)
Owner Type: Private

Commenced Date:
Completion Date: 18/08/2006
Final Depth: 48.00 m
Drilled Depth: 48.00 m

Contractor Name: JNR Drilling
Driller: Reginald John Parkes
Assistant Driller:

Property: KILLARNY NARRABRI 2390
GWMA:
GW Zone:
Standing Water Level: 31.000
Salinity: Good
Yield: 2.500

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	24//248483
Licensed:			

Region: 90 - Barwon
River Basin: 425 - DARLING RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6648422.0
Easting: 768456.0
Latitude: 30°15'58.3"S
Longitude: 149°47'25.3"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	48.00	205			Cable Tool (Mud Stabilised)
1		Annulus	Waterworn/Rounded	0.00	48.00	205	150		Graded, Q:1.500m3, PL:Poured/Shovelled
1	1	Casing	Pvc Class 9	-0.30	48.00	150	138		Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	30.00	48.00	150		1	Sawn, PVC Class 9, Glued, SL: 250.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
30.00	48.00	18.00	Unknown	31.00	32.00	2.50		08:00:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	Topsoil	Topsoil	
1.00	10.00	9.00	Clay	Clay	
10.00	14.00	4.00	Sandy Clay	Invalid Code	
14.00	17.00	3.00	Clay	Clay	
17.00	30.00	13.00	Sandstone, fine	Sandstone	
30.00	38.00	8.00	Fractured Sandstone, coarse, water bearing	Invalid Code	
38.00	40.00	2.00	Sandstone, water bearing, fine, honeycomb	Sandstone	
40.00	48.00	8.00	Sandstone, honeycomb, coarse, water bearing	Sandstone	

Remarks

16/10/2006: Form A Remarks:
Nat Carling, 7-June-2007: Completion date was taken from drillers signature, coordinates were based on sketch provided with the form, letter sent to check locations. Driller commented on log "Strong water supply in honeycomb sandstone".
19/09/2007: Nat Carling, 19-Sept-2007: Added missing completion date, as provided by the driller.

*** End of GW967981 ***

NSW Office of Water
Work Summary

GW968561

Licence: 90WA811467
Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC
Intended Purpose(s): DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Auger - Solid Flight
Owner Type: Private

Commenced Date:
Completion Date: 04/09/2008
Final Depth: 17.00 m
Drilled Depth: 17.00 m

Contractor Name: TIMOTHY IAN ELLIS
Driller: Timothy Ian Ellis
Assistant Driller: Annette Moerike

Property: - NSW
GWMA:
GW Zone:
Standing Water Level: 10.000
Salinity:
Yield: 1.500

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	134//884175
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6643435.0
Easting: 767609.0
Latitude: 30°18'40.8"S
Longitude: 149°46'58.2"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	17.00	250			Auger - Solid Flight
1		Annulus	Grout	0.00	5.00	250	135		
1	1	Casing	Pvc Class 9	0.00	17.00	135	125		Seated, Glued
1	1	Opening	Slots - Horizontal	12.00	17.00	135		1	Casing - Hand Sawn Slot, PVC Class 9, Glued, SL: 60.0mm, A: 1.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
13.00	17.00	4.00	Unknown	10.00	10.30	1.50		01:00:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Clay, black	Clay	
2.00	5.00	3.00	Sand, coarse, tan, dry	Sand	
5.00	8.00	3.00	Gravel, coarse & Sand	Gravel	
8.00	13.00	5.00	Gravel & Clayey Sand, black	Gravel	
13.00	17.00	4.00	Sand, coarse, with Gravel from small up to ~100mm, rounded, water bearing	Sand	

Remarks

04/09/2008: Form A Remarks:
Nat Carling, 22-Jan-2009: Coordinates based on location map provided with the Form A.

*** End of GW968561 ***

NSW Office of Water
Work Summary

GW968593

Licence: 90BL254160
Licence Status: CONVERTED

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore - GAB
Work Status: Supply Obtained
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 09/02/2007
Final Depth:
Drilled Depth:

Contractor Name:
Driller: Unkown Unknown
Assistant Driller:

Property: BUDDHA NARRABRI 2390
GWMA:
GW Zone:
Standing Water Level:
Salinity:
Yield:

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	3//1111448
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-1N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6650891.0
Easting: 771687.0
Latitude: 30°14'35.6"S
Longitude: 149°49'23.8"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Steel	0.00	0.00	150			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

09/02/2007: Form A Remarks:
Nat Carling, 23-Jan-2009: Coordinates based on location map provided with the Form AG. All details were provided by owner, equipped with a Windmill.
16/12/2009: Reviewed data - nothing to update.

*** End of GW968593 ***

NSW Office of Water
Work Summary

GW968665

Licence: 90BL155132
Licence Status: CONVERTED

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore - GAB
Work Status: Supply Obtained
Construct.Method: Rotary Mud
Owner Type: Private

Commenced Date:
Completion Date: 18/07/1994
Final Depth: 45.00 m
Drilled Depth: 45.00 m

Contractor Name: Drillwell Construction
Driller: Alec Linton
Assistant Driller:

Property: SIMARES NARRABRI 2390 NSW
GWMA:
GW Zone:
Standing Water Level: 19.500
Salinity:
Yield: 0.630

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	1//812575
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-1N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6650359.0
Easting: 770420.0
Latitude: 30°14'53.8"S
Longitude: 149°48'37.0"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	45.00	250			Rotary Mud
1		Annulus	Waterworn/Rounded	0.00	45.00	250	160		Graded, Q:2.000m3
1	1	Casing	Pvc Class 9	-0.60	45.00	160			Seated on Bottom, Glued
1	1	Opening	Slots - Horizontal	33.00	45.00	160		1	Casing - Hand Sawn Slot, PVC Class 9, Glued, SL: 12.0mm, A: 4.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
36.00	43.50	7.50	Unknown	19.50		0.63		00:33:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	Topsoil	Topsoil	
0.30	3.00	2.70	Topsoil, brown	Topsoil	
3.00	12.00	9.00	Sandstone, red	Sandstone	
12.00	31.50	19.50	Clay, grey	Clay	
31.50	36.00	4.50	Sand, white	Sand	
36.00	43.50	7.50	Gravel, coarse, sandy	Gravel	
43.50	45.00	1.50	Shale, brown	Shale	

Remarks

18/07/1994: Form A Remarks:
Nat Carling, 10-Feb-2009: Coordinates based on location map provided with the Form A.

*** End of GW968665 ***

NSW Office of Water
Work Summary

GW968788

Licence: 90WA809848
Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Cable Tool (Mud Stabilised)
Owner Type: Private

Commenced Date:
Completion Date: 02/05/2008
Final Depth: 14.00 m
Drilled Depth: 14.00 m

Contractor Name: JNR Drilling
Driller: Timothy John Parkes
Assistant Driller:

Property: - NSW
GWMA:
GW Zone:
Standing Water Level: 7.000
Salinity: Good
Yield: 0.800

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	7010//1029613
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6645687.0
Easting: 765177.0
Latitude: 30°17'29.6"S
Longitude: 149°45'25.2"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	14.00	205			Cable Tool (Mud Stabilised)
1		Annulus	Waterworn/Rounded	0.00	14.00	205	140		Graded, Q:1.000m3, PL:Poured/Shovelled
1	1	Casing	Pvc Class 12	-0.50	14.00	140	120		Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	7.00	14.00	140		1	Casing - Hand Sawn Slot, PVC Class 12, Glued, SL: 250.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
7.00	14.00	7.00	Unknown	7.00	7.00	0.80		05:00:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	Topsoil, black Clay	Topsoil	
1.00	6.00	5.00	Clay, brown	Clay	
6.00	7.00	1.00	Sandy Clay	Sandy Clay	
7.00	10.00	3.00	Sand, coarse	Sand	
10.00	14.00	4.00	Gravel, free big mud loss	Gravel	

Remarks

02/05/2008: Form A Remarks:
Nat Carling, 18-May-2009: Coordinates based on location map provided with the Form A.

*** End of GW968788 ***

NSW Office of Water
Work Summary

GW968791

Licence: 90WA811546
Licence Status: CURRENT

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Cable Tool (Mud Stabilised)
Owner Type: Private

Commenced Date:
Completion Date: 16/02/2009
Final Depth: 18.00 m
Drilled Depth: 18.00 m

Contractor Name: JNR Drilling
Driller: Timothy John Parkes
Assistant Driller:

Property: MYALL PARK LOGANS LANE NARRABRI 2390 NSW
GWMA:
GW Zone:
Standing Water Level: 12.000
Salinity: Good
Yield: 0.800

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	JAMIS	JAMIS.5	2//1014459
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-1N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6651886.0
Easting: 767209.0
Latitude: 30°14'06.9"S
Longitude: 149°46'35.5"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	18.00	205			Cable Tool (Mud Stabilised)
1		Annulus	Waterworn/Rounded	0.00	18.00	205	140		Graded, Q:1.000m3, PL:Poured/Shovelled
1	1	Casing	Pvc Class 12	-0.30	18.00	140	120		Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	12.00	18.00	140		1	Mechanically Slotted, PVC Class 12, Glued, SL: 250.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
12.00	17.00	5.00	Unknown	12.00	12.00	0.80		00:05:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Clay, black	Clay	
2.00	8.00	6.00	Clay	Clay	
8.00	12.00	4.00	Sandy Clay	Sandy Clay	
12.00	14.00	2.00	Sand	Sand	
14.00	17.50	3.50	Sand & Gravel	Sand	
17.50	18.00	0.50	Clay, red	Clay	

Remarks

16/02/2009: Form A Remarks:
Nat Carling, 19-May-2009: Coordinates based on location map provided with the Form A.

*** End of GW968791 ***

NSW Office of Water
Work Summary

GW969285

Licence: 90BL253717
Licence Status: CONVERTED

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Cable Tool (Mud Stabilised)
Owner Type: Private

Commenced Date:
Completion Date: 25/08/2009
Final Depth: 23.00 m
Drilled Depth: 23.00 m

Contractor Name: JNR Drilling
Driller: Timothy John Parkes
Assistant Driller:

Property: PROSPECT NARRABRI 2390
GWMA:
GW Zone:
Standing Water Level: 9.000
Salinity: Good
Yield: 1.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	155//754944
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6644350.0
Easting: 765780.0
Latitude: 30°18'12.5"S
Longitude: 149°45'49.0"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	23.00	205			Cable Tool (Mud Stabilised)
1		Annulus	Waterworn/Rounded	0.00	23.00	205	140		Graded, Q:0.750m3, PL:Poured/Shovelled
1	1	Casing	Pvc Class 9	-0.40	23.00	140	128		Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	9.00	22.00	140		1	Mechanically Slotted, PVC Class 9, Glued, SL: 250.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
9.00	22.00	13.00	Unknown	9.00	9.00	1.00		05:00:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Topsoil	Topsoil	
2.00	7.00	5.00	Clay	Clay	
7.00	9.00	2.00	Sandy Clay	Sandy Clay	
9.00	12.00	3.00	Sand	Sand	
12.00	18.00	6.00	Sand & Gravel	Sand	
18.00	22.00	4.00	Gravel, blue	Gravel	
22.00	23.00	1.00	Clay, blue	Clay	

Remarks

15/12/2006: Form A Remarks:
Nat Carling, 14-July-2010: All details were provided by current owner on Form AG.
06/09/2010: Nat Carling: 6-Sept-2010: All details were updated, as provided on Driller's Form A.

*** End of GW969285 ***

NSW Office of Water
Work Summary

GW969809

Licence: 90WA812872
Licence Status: CURRENT

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore - GAB
Work Status: Supply Obtained
Construct.Method: Rotary - Air/Foam
Owner Type: Private

Commenced Date:
Completion Date: 17/11/2009
Final Depth: 55.00 m
Drilled Depth: 55.00 m

Contractor Name: JNR Drilling
Driller: Timothy John Parkes
Assistant Driller:

Property: KILLARNEY NARRABRI 2390 NSW
GWMA:
GW Zone:
Standing Water Level: 26.000
Salinity: Good
Yield: 1.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	13//1086653
Licensed:			

Region: 90 - Barwon
River Basin: 425 - DARLING RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6649990.0
Easting: 767995.0
Latitude: 30°15'07.8"S
Longitude: 149°47'06.7"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	55.00	205			Rotary - Air/Foam
1		Annulus	Waterworn/Rounded	0.00	55.00	205			Graded, Q:2.000m3, PL:Poured/Shovelled
1	1	Casing	Pvc Class 9	-0.30	55.00				Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	43.00	55.00			1	Mechanically Slotted, PVC Class 9, Glued, SL: 250.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
46.00	54.00	8.00	Unknown	26.00	34.00	1.00		00:30:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	Topsoil	Topsoil	
1.00	6.00	5.00	Clay	Clay	
6.00	24.00	18.00	Sandy Clay	Sandy Clay	
24.00	36.00	12.00	Sandstone, fine grained	Sandstone	
36.00	39.00	3.00	Sandstone, fractured, soak	Sandstone	
39.00	46.00	7.00	Sandstone, fine grained	Sandstone	
46.00	55.00	9.00	Sandstone, fractured, water bearing	Sandstone	

Remarks

17/11/2009: Form A Remarks:
Nat Carling, 16-Nov-2011: Coordinates based on location map provided with the Form-A.

*** End of GW969809 ***

NSW Office of Water
Work Summary

GW969810

Licence: 90WA812873
Licence Status: CURRENT

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore - GAB
Work Status: Supply Obtained
Construct.Method: Rotary - Air/Foam
Owner Type: Private

Commenced Date:
Completion Date: 22/02/2010
Final Depth: 53.50 m
Drilled Depth: 53.50 m

Contractor Name: JNR Drilling
Driller: Timothy John Parkes
Assistant Driller:

Property: KILLARNEY NARRABRI 2390 NSW
GWMA:
GW Zone:
Standing Water Level: 18.000
Salinity: Good
Yield: 1.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	12//1086653
Licensed:			

Region: 90 - Barwon
River Basin: 425 - DARLING RIVER
Area/District:
CMA Map: 8837-S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6648925.0
Easting: 768990.0
Latitude: 30°15'41.5"S
Longitude: 149°47'44.8"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	53.50	205			Rotary - Air/Foam
1		Annulus	Waterworn/Rounded	0.00	53.50	205	140		Graded, Q:2.000m3, PL:Poured/Shovelled
1	1	Casing	Pvc Class 9	-0.40	53.50	140	128		Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	41.50	53.50	140		1	Mechanically Slotted, PVC Class 9, Glued, SL: 250.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
42.00	52.00	10.00	Unknown	18.00		1.00		00:30:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	Topsoil	Topsoil	
1.00	4.00	3.00	Clay	Clay	
4.00	10.00	6.00	Sandy Clay	Sandy Clay	
10.00	36.00	26.00	Sandy Clay, red	Sandy Clay	
36.00	38.00	2.00	Sandstone, fractured, soak	Sandstone	
38.00	42.00	4.00	Sandstone, yellow, coarse grained	Sandstone	
42.00	52.00	10.00	Sandstone, fractured, fine grained, water bearing	Sandstone	
52.00	53.50	1.50	Clay, pink	Clay	

Remarks

22/02/2010: Form A Remarks:
Nat Carling, 16-Nov-2011: Coordinates based on location map provided with the Form-A.

*** End of GW969810 ***

NSW Office of Water
Work Summary

GW970476

Licence: 90WA832004
Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore - GAB
Work Status: Replacement
Construct.Method: Rotary Mud
Owner Type: Private

Commenced Date:
Completion Date: 12/03/2013
Final Depth: 54.00 m
Drilled Depth: 55.00 m

Contractor Name: JOHN CARRIGAN PTY LTD
Driller: John Carrigan
Assistant Driller: Donna Martin

Property: Veone 12872 Moree Road Narrabri 2390
Standing Water Level: 15.000
GWMA:
Salinity:
GW Zone:
Yield: 4.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	2//812575
Licensed:			

Region: 90 - Barwon
CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6649927.0
Easting: 770236.0
Latitude: 30°15'08.0"S
Longitude: 149°48'30.5"E

GS Map: -
MGA Zone: 0
Coordinate Source: GPS - Global Positioning System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	55.00	200			Rotary Mud
1		Annulus	Cement	0.00	2.00	200	140		PL:Poured/Shovelled
1		Annulus	Waterworn/Rounded	2.00	43.00	200	140		Graded, PL:Poured/Shovelled
1		Annulus	Bentonite/Grout	43.00	46.00	200	140		PL:Poured/Shovelled
1		Annulus	Waterworn/Rounded	46.00	54.00	200	140		Graded, PL:Poured/Shovelled
1		Backfill	Drilled Cuttings	54.00	55.00	200			

1	1	Casing	Pvc Class 9	-0.30	48.00	140	128		Seated, Glued
1	1	Opening	Slots - Horizontal	48.00	54.00	140		1	Mechanically Slotted, PVC Class 9, Glued, A: 1.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
48.00	54.00	6.00	Unknown	15.00		4.00		02:00:00	314.00

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	Topsoil, black	Topsoil	
1.00	2.00	1.00	Clay, brown	Clay	
2.00	8.00	6.00	Clay, white	Clay	
8.00	10.00	2.00	Sandy Clay, red/white	Sandy Clay	
10.00	12.00	2.00	Gravel, red ridge	Gravel	
12.00	16.00	4.00	Sandy Clay, brown	Sandy Clay	
16.00	21.00	5.00	Sandy Clay, pink	Sandy Clay	
21.00	23.00	2.00	Sandy Clay, brown - sand bands	Sandy Clay	
23.00	32.00	9.00	Sandy Clay, very fine - sand bands v/narrow	Sandy Clay	
32.00	44.00	12.00	Sand, brown, claybound, coloured	Sand	
44.00	46.00	2.00	Sand, brown	Sand	
46.00	48.00	2.00	Clay, brown	Clay	
48.00	50.00	2.00	Sand, very fine, brown	Sand	
50.00	52.00	2.00	Sand, white	Sand	
52.00	53.00	1.00	Sand, large stone Gravel, large water loss	Sand	
53.00	55.00	2.00	Sand, brown	Sand	

Remarks

12/03/2013: Form A Remarks:
Nat Carling, 10-Sept-2013; GPS provided by the drillers. This is a replacement bore - unsure which bore it is to replace.

*** End of GW970476 ***

NSW Office of Water
Work Summary

GW970625

Licence: 90WA827844
Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary Mud
Owner Type: Private

Commenced Date:
Completion Date: 20/12/1997
Final Depth: 18.00 m
Drilled Depth: 19.00 m

Contractor Name: RJ PARKES
Driller: Reginald John Parkes
Assistant Driller:

Property: - 72 - 74 WEE WAA ROAD NARRABRI 2390
Standing Water Level: 10.000
GWMA:
GW Zone:
Salinity: Good
Yield: 2.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	NANDE	NANDE.21	203//846935
Licensed:			

Region: 90 - Barwon
CMA Map: 8837-S
River Basin: 419 - NAMOI RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6643935.0
Easting: 766120.0
Latitude: 30°18'25.7"S
Longitude: 149°46'02.1"E

GS Map: -
MGA Zone: 0
Coordinate Source: GIS - Geographic Information System

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	19.00	200			Rotary Mud
1		Annulus	Waterworn/Rounded	0.00	18.00	200	140		Graded, PL:Poured/Shovelled
1		Backfill	Gravel	18.00	19.00	200			
1	1	Casing	Pvc Class 9	-0.60	18.00	140	126		Seated on Bottom, Glued
1	1	Opening	Slots - Vertical	10.00	17.00	140		1	Sawn, PVC Class 9, Glued, SL: 200.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
10.00	16.00	6.00	Unknown	10.00	12.00	2.00		02:00:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.00	3.00	Topsoil	Topsoil	
3.00	6.00	3.00	Clay; brown, gravelly	Clay	
6.00	10.00	4.00	Clay; blue	Clay	
10.00	16.00	6.00	Gravel; blue, water bearing	Gravel	
16.00	19.00	3.00	Clay; blue	Clay	

Remarks

20/12/1997: Form A Remarks:
Nat Carling, 6-Dec-2013; Coordinates based on location map provided with the Form-A.

*** End of GW970625 ***

APPENDIX E

Laboratory Summary Table

APPENDIX E: Laboratory Test Result Summary Table

Borehole ID	Depth (m)		USCS Symbole	Material Type	Moisture Content (%)	PSD			Plasticity				Specific Gravity (t/m^3)	Shrink Swell Index (Iss %)	Aggressivity				Thermal Testing		Compressive Strength
	From	To				Clay/Silt <75µm	Sand 75µm - 2mm (%)	Gravel 2mm - 63mm (%)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	Linear Shrinkage (%)			pH	Saturated Resistivity (ohm.cm)	Sulfate as So42- (mg/kg)	Chloride (mg/kg)	Thermal Conductivity at OMC (W/(m.K)	Thermal Resistivity at OMC (W/(m.K)	Maximum Principal Stress (kPa)
GA-BH01	0.15	0.3	CL	Sandy CLAY	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	2.127	0.47	-
	0.5	0.65	CL	Sandy CLAY	-	-	-	-	-	-	-	-	1.96	1.9	-	-	-	-	-	-	-
	2	2.45	CL	Silty CLAY	7.7	-	-	-	32	8	24	12	-	-	-	-	-	-	-	-	-
	3.5	3.95	SC	Clayey SAND	-	34	66	0	-	-	-	-	-	-	-	-	-	-	-	-	-
GA-BH02	0.6	1.05	CI	Sandy CLAY	-	-	-	-	-	-	-	-	-	-	8.9	770	160	190	-	-	-
	5	5.45	SC	Clayey SAND	-	28	72	0	-	-	-	-	-	-	-	-	-	-	-	-	-
GA-BH03	2	2.1	CI	Silty CLAY	13.6	-	-	-	39	13	26	14	2.036	1.4	-	-	-	-	-	-	-
	3.5	3.77	CL-CI	Silty CLAY	13.8	-	-	-	36	15	21	11.5	-	-	-	-	-	-	-	-	-
GA-BH04	0.5	0.7	CI	Silty CLAY	9.4	-	-	-	44	14	30	16	2.199	2.2	-	-	-	-	-	-	-
	2	2.45	CH	Sandy CLAY	-	-	-	-	-	-	-	-	-	-	5.4	390	410	690	-	-	-
	3.5	3.95	CI-CH	Sandy CLAY	-	47	47	6	-	-	-	-	-	-	-	-	-	-	-	-	-
GA-BH05	2	2.27	CH	CLAY	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	317
	3.5	3.95	CH	Silty CLAY	26.6	-	-	-	76	39	37	17	-	-	-	-	-	-	-	-	-
GA-BH07	0.1	0.3	CI	Sandy CLAY	8.1	-	-	-	-	-	-	-	-	-	-	-	-	-	2.398	0.417	-
	2	2.45	CI	Sandy CLAY	-	-	-	-	-	-	-	-	-	-	8.6	1480	110	20	-	-	-
	3.5	3.95	CI	Sandy CLAY	-	43	56	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	5.45	CI	Sandy CLAY	15.9	-	-	-	43	20	23	11.5	-	-	-	-	-	-	-	-	-
GA-BH08	0.5	0.95	CI	Silty CLAY	-	-	-	-	-	-	-	-	-	-	8.2	450	1040	150	-	-	-
	2	2.45	SC	Clayey SAND	-	20	78	2	-	-	-	-	-	-	-	-	-	-	-	-	-
GA-BH09	0.1	0.3	CH	Silty CLAY	9.6	-	-	-	-	-	-	-	-	-	-	-	-	-	2.063	0.485	-
	0.5	0.95	CH	Silty CLAY	-	-	-	-	-	-	-	-	-	-	9	1150	150	140	-	-	-
	3.5	3.95	SC	Clayey SAND	-	35	61	4	-	-	-	-	-	-	-	-	-	-	-	-	-
GA-BH10	2	2.36	CI	Sandy CLAY	-	-	-	-	-	-	-	-	-	-	9.7	700	100	60	-	-	-
	3.5	3.95	SC	Clayey SAND	-	35	65	0	-	-	-	-	-	-	-	-	-	-	-	-	-
GA-BH11	0.5	0.69	CI	CI Silty CLAY	10.1	-	-	-	45	13	32	16	2.148	2	-	-	-	-	-	-	-
	2	2.45	SC	Clayey SAND	-	22	78	0	-	-	-	-	-	-	-	-	-	-	-	-	-
GA-BH12	2	2.45	CI	Sandy CLAY	20.1	-	-	-	46	26	20	10.5	-	-	-	-	-	-	-	-	-
GA-BH13	5	5.45	CI-CH	Sandy CLAY	26.6	-	-	-	58	30	28	14	-	-	-	-	-	-	-	-	-
GA-BH14	0.15	0.3	CH	Silty CLAY	9	-	-	-	-	-	-	-	-	-	-	-	-	-	2.227	0.449	-
	1.5	1.7	CH	Silty CLAY	19.5	-	-	-	63	20	43	21	1.955	4.6	-	-	-	-	-	-	-
	3.5	3.95	CI-CH	Sandy CLAY	-	-	-	-	-	-	-	-	-	-	9.7	310	520	910	-	-	-
GA-BH15	1.5	1.7	CH	CLAY	22.7	-	-	-	137	26	111	24.5	-	8	-	-	-	-	-	-	186
GA-BH16	0.2	0.4	CH	CLAY	20.1	-	-	-	-	-	-	-	-	-	-	-	-	-	1.565	0.639	-
	0.5	0.72	CH	CLAY	27.3	-	-	-	88	25	63	20	-	7.3	-	-	-	-	-	-	-
GA-BH17	5	5.45	CI	CLAY	-	-	-	-	-	-	-	-	-	-	10	360	70	330	-	-	-
GA-BH18	2	2.45	CI	Sandy CLAY	9.1	-	-	-	42	13	29	14.5	-	-	-	-	-	-	-	-	-
GA-BH19	3.5	3.8	SC	Clayey SAND	-	15	82	3	-	-	-	-	-	-	-	-	-	-	-	-	-
GA-BH20	0.2	0.5	MH	Clayey SILT	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	2.279	0.439	-
	0.5	0.67	MH	Clayey SILT	18.9	-	-	-	75	47	28	14	2.114	4.3	-	-	-	-	-	-	-

APPENDIX F

Laboratory Test Certificates

SOILTECH
Testing Services Pty Ltd
1300 736 724
www.soiltech.com.au

Atterberg Limits Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 1/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.9.2, 3.2.1, 3.3.2, 3.4.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 1 of 3**

Sample Number :	18612	18613	18614	18615
Test Number :	Sample 2	Sample 3	Sample 4	Sample 5
Date Sampled :	27/02/2018	27/02/2018	27/02/2018	28/02/2018
Date Tested :	22/03/2018	22/03/2018	22/03/2018	22/03/2018
Sampled By :	Paul Sheppard	Paul Sheppard	Paul Sheppard	Paul Sheppard
Sampling Method :	AS1289.1.2.1 (6.5.3)	AS1289.1.2.1 (6.5.3)	AS1289.1.2.1 (6.5.3)	AS1289.1.2.1 (6.5.3)
Material Source :	In situ	In situ	In situ	In situ
Material Type :	Natural	Natural	Natural	Natural
Sample Location :	GA-BH01 2.00 - 2.45m	GA-BH03 2.00 - 2.10m	GA-BH03 3.50 - 3.77m	GA-BH04 0.50 - 0.70m
Lot Number :				
Moisture Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Field Moisture Content (%) :	7.7	13.6	13.8	9.4
Sample History :	Oven Dried	Oven Dried	Oven Dried	Oven Dried
Sample Preparation :	Dry	Dry	Dry	Dry
Notes :	Curl	Curl	Curl	Curl
Mould Length (mm) :	150.0	150.0	150.0	150.1
Liquid Limit (%) :	32	39	36	44
Plastic Limit (%) :	8	13	15	14
Plasticity Index (%) :	24	26	21	30
Linear Shrinkage (%) :	12.0	14.0	11.5	16.0
SPECIFICATION DETAILS				
Specification Number :				
Liquid Limit - Max :				
Plasticity Index - Max :				
Linear Shrinkage - Max :				
Remarks :	-			

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO / IEC 17025 - Testing
Laboratory Location:
194 Stephen Street,
Toowoomba, QLD, 4350

APPROVED SIGNATORY

Stephen Ott - Senior Technician
NATA Accreditation Number :
2117

SOILTECH
Testing Services Pty Ltd
1300 736 724
www.soiltech.com.au

Atterberg Limits Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 1/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.9.2, 3.2.1, 3.3.2, 3.4.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 2 of 3**

Sample Number :	18616	18617	18618	18619
Test Number :	Sample 7	Sample 8	Sample 10	Sample 11
Date Sampled :	28/02/2018	27/02/2018	28/02/2018	28/02/2018
Date Tested :	22/03/2018	22/03/2018	22/03/2018	22/03/2018
Sampled By :	Paul Sheppard	Paul Sheppard	Paul Sheppard	Paul Sheppard
Sampling Method :	AS1289.1.2.1 (6.5.3)	AS1289.1.2.1 (6.5.3)	AS1289.1.2.1 (6.5.3)	AS1289.1.2.1 (6.5.3)
Material Source :	In situ	In situ	In situ	In situ
Material Type :	Natural	Natural	Natural	Natural
Sample Location :	GA-BH05 3.50 - 3.95m	GA-BH07 5.00 - 5.45m	GA-BH11 0.50 - 0.69m	GA-BH12 2.00 - 2.45m
Lot Number :				
Moisture Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Field Moisture Content (%) :	26.6	15.9	10.1	20.1
Sample History :	Oven Dried	Oven Dried	Oven Dried	Oven Dried
Sample Preparation :	Dry	Dry	Dry	Dry
Notes :	Cracked & Curl		Curl	Curl
Mould Length (mm) :	150.3	150.0	150.2	149.9
Liquid Limit (%) :	76	43	45	46
Plastic Limit (%) :	39	20	13	26
Plasticity Index (%) :	37	23	32	20
Linear Shrinkage (%) :	17.0	11.5	16.0	10.5
SPECIFICATION DETAILS				
Specification Number :				
Liquid Limit - Max :				
Plasticity Index - Max :				
Linear Shrinkage - Max :				
Remarks :	-			

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Stephen Ott - Senior Technician
NATA Accreditation Number :
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Atterberg Limits Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 1/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.9.2, 3.2.1, 3.3.2, 3.4.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 3 of 3**

Sample Number :	18620	18621	18622	18632
Test Number :	Sample 12	Sample 15	Sample 16	Sample 38
Date Sampled :	28/02/2018	01/03/2018	28/02/2018	28/02/2018
Date Tested :	22/03/2018	22/03/2018	22/03/2018	22/03/2018
Sampled By :	Paul Sheppard	Paul Sheppard	Paul Sheppard	Paul Sheppard
Sampling Method :	AS1289.1.2.1 (6.5.3)	AS1289.1.2.1 (6.5.3)	AS1289.1.2.1 (6.5.3)	AS1289.1.2.1 (6.5.3)
Material Source :	In situ	In situ	In situ	In situ
Material Type :	Natural	Natural	Natural	Natural
Sample Location :	GA-BH13 5.00 - 5.45m	GA-BH18 2.00 - 2.45m	GA-BH20 0.50 - 0.67m	GA-BH14 1.50 - 1.70m
Lot Number :				
Moisture Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Field Moisture Content (%) :	26.6	9.1	18.9	19.5
Sample History :	Oven Dried	Oven Dried	Oven Dried	Oven Dried
Sample Preparation :	Dry	Dry	Dry	Dry
Notes :	Cracked & Curl	Cracked & Curl	Cracked & Curl	Cracked & Curl
Mould Length (mm) :	150.1	150.0	150.1	150.1
Liquid Limit (%) :	58	42	75	63
Plastic Limit (%) :	30	13	47	20
Plasticity Index (%) :	28	29	28	43
Linear Shrinkage (%) :	14.0	14.5	14.0	21.0
SPECIFICATION DETAILS				
Specification Number :				
Liquid Limit - Max :				
Plasticity Index - Max :				
Linear Shrinkage - Max :				
Remarks :	-			

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Ph: +61 8 9258 8323

ATTERBERG LIMITS TEST REPORT

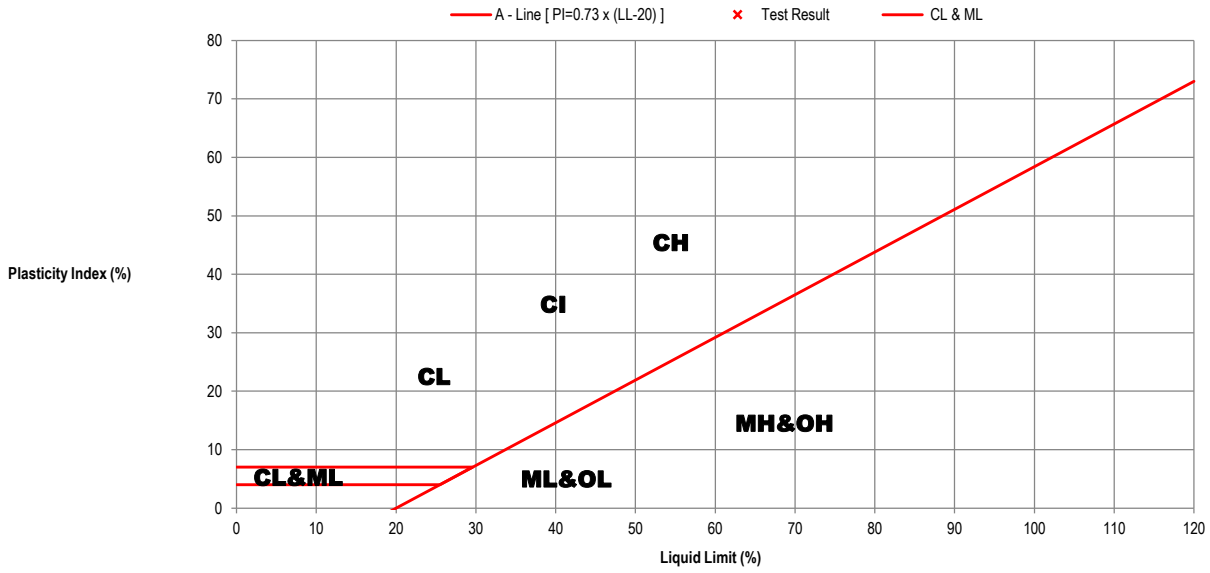
Test Method: AS 1289 2.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1

Client	Golder Associates Pty Limited	**Report No.**	GA100343-AL
Address	PO Box 1734 MILTON BC QLD 4064	**Request No.**	1792350_TR01
		Test Date	28/03/2018
Project	Narrabri Solar Farm	**Report Date**	9/04/2018
Project No.	1792350	**Client Sample No.**	13
Bore Hole	GA-BH15	**Depth From (m)**	1.5
		Depth To (m)	1.7
Description	U		

RESULTS OF TESTING

Liquid Limit (%)	**137**	
Plastic Limit (%)	**26**	
Plasticity Index (%)	**111**	
Linear Shrinkage (%)	**24.5**	**Cracking & Curling Ocurred**
Moisture Content (%)	**22.7**	
Preparation Method	**Dry Sieved and Oven Dried**	

Plasticity Chart



Remarks:

Sample/s supplied by client

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

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Laboratory No. 9926

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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ATTERBERG LIMITS TEST REPORT

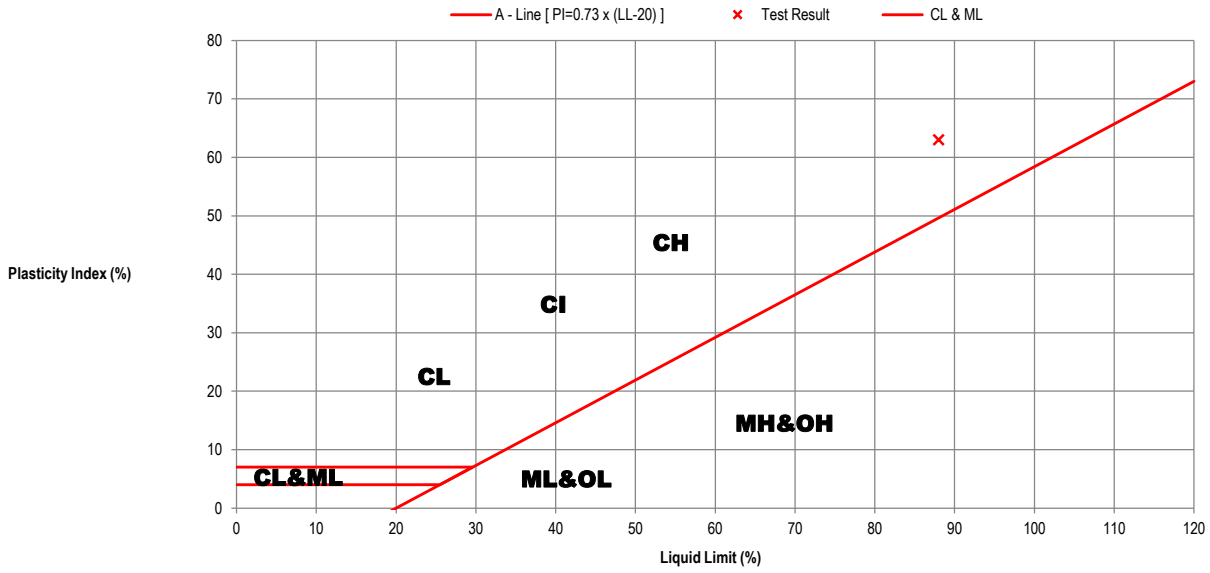
Test Method: AS 1289 2.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1

Client	Golder Associates Pty Limited	**Report No.**	GA100344-AL
Address	PO Box 1734 MILTON BC QLD 4064	**Request No.**	1792350_TR01
		Test Date	28/03/2018
Project	Narrabri Solar Farm	**Report Date**	9/04/2018
Project No.	1792350	**Client Sample No.**	14
Bore Hole	GA-BH16	**Depth From (m)**	0.5
		Depth To (m)	0.72
Description	U		

RESULTS OF TESTING

Liquid Limit (%)	**88**	
Plastic Limit (%)	**25**	
Plasticity Index (%)	**63**	
Linear Shrinkage (%)	**20.0**	**Cracking & Curling Ocurred**
Moisture Content (%)	**27.3**	
Preparation Method	**Dry Sieved and Oven Dried**	

Plasticity Chart



Remarks:

Sample/s supplied by client

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Authorised Signatory

C. Channon

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Laboratory No. 9926

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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Particle Size Distribution Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 2/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.6.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 1 of 9**

Sample Number :	18623
Sampling Method :	AS1289.1.2.1 (6.5.3)
Sampled By :	Paul Sheppard
Date Sampled :	27/03/2018
Date Tested :	22/03/2018
Material Type :	Natural
Material Source :	In situ
Remarks :	

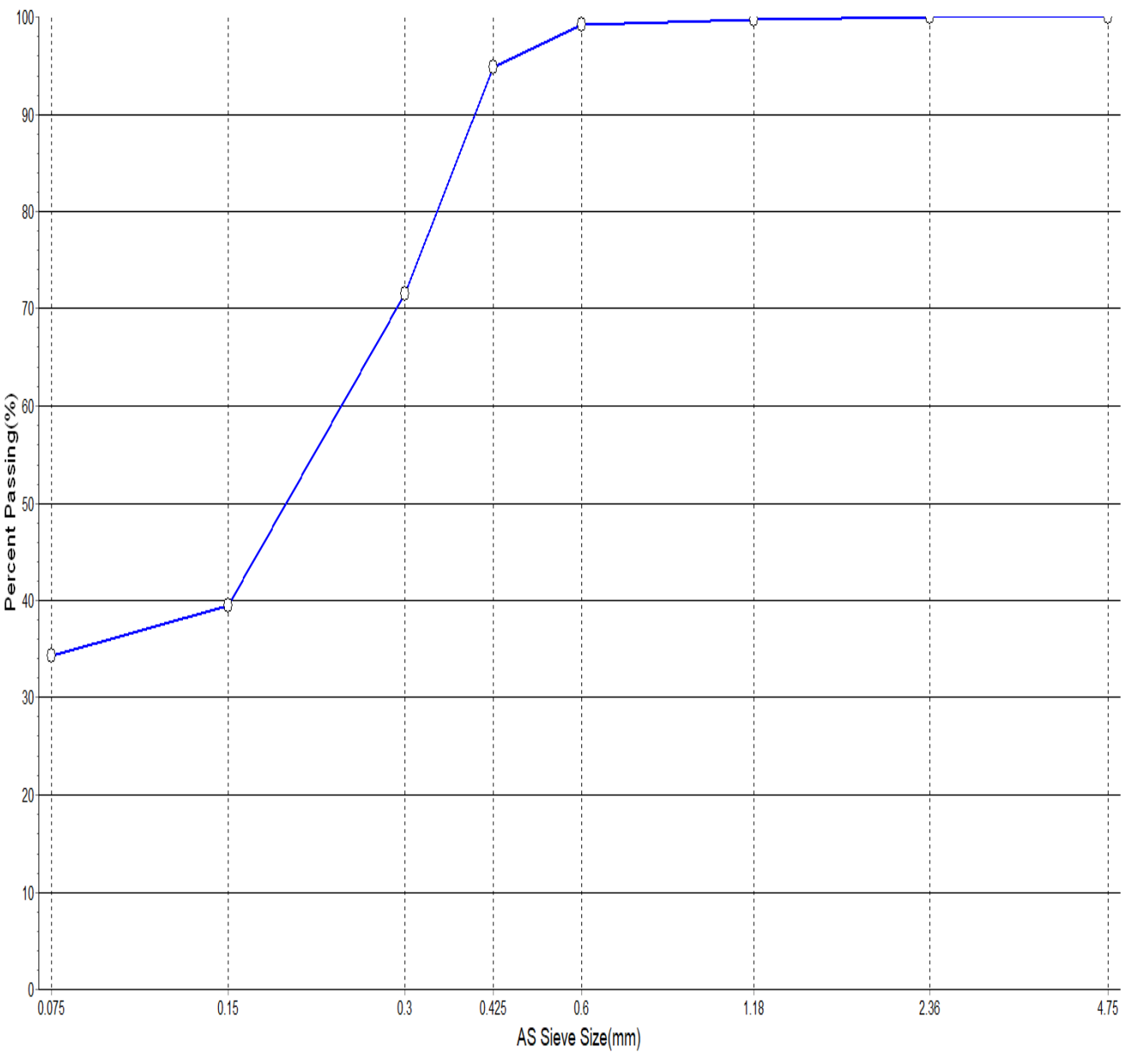
SAMPLE LOCATION

GA- BH01

3.50 - 3.95m

Test Number :	**Sample 17**
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5		
6.7		
4.75	**100**	
2.36	**100**	
1.18	**100**	
0.600	**99**	
0.425	**95**	
0.300	**72**	
0.150	**39**	
0.075	**34**	



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Particle Size Distribution Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 2/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.6.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 2 of 9**

Sample Number :	18624
Sampling Method :	AS1289.1.2.1 (6.5.3)
Sampled By :	Paul Sheppard
Date Sampled :	27/02/2018
Date Tested :	22/03/2018
Material Type :	Natural
Material Source :	In situ
Remarks :	

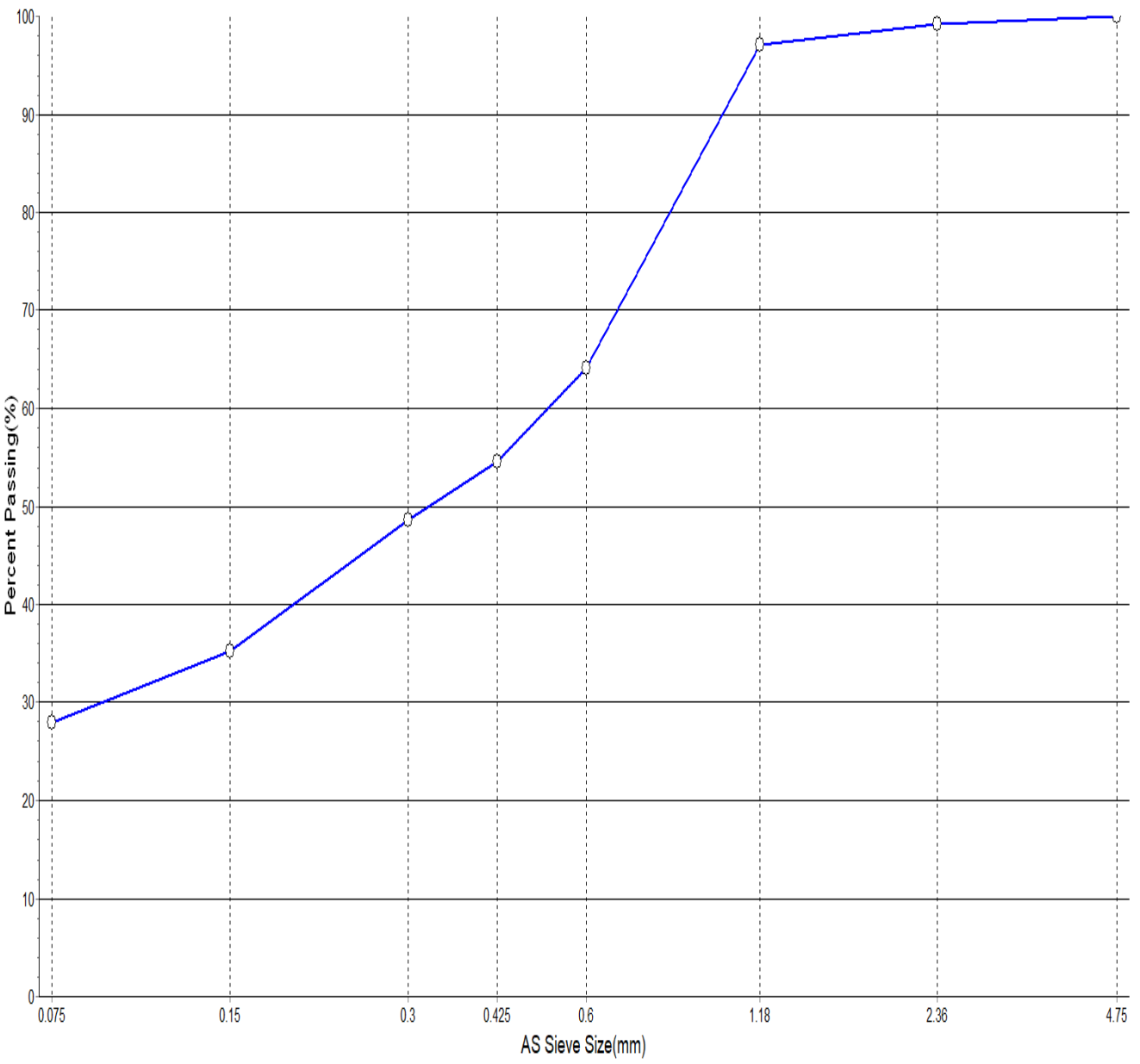
SAMPLE LOCATION

GA-BH02

5.00 - 5.45m

Test Number :	**Sample 18**
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5		
6.7		
4.75	**100**	
2.36	**99**	
1.18	**97**	
0.600	**64**	
0.425	**55**	
0.300	**49**	
0.150	**35**	
0.075	**28**	



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Particle Size Distribution Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 2/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.6.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 3 of 9**

Sample Number :	18625
Sampling Method :	AS1289.1.2.1 (6.5.3)
Sampled By :	Paul Sheppard
Date Sampled :	28/02/2018
Date Tested :	22/03/2018
Material Type :	Natural
Material Source :	In situ
Remarks :	

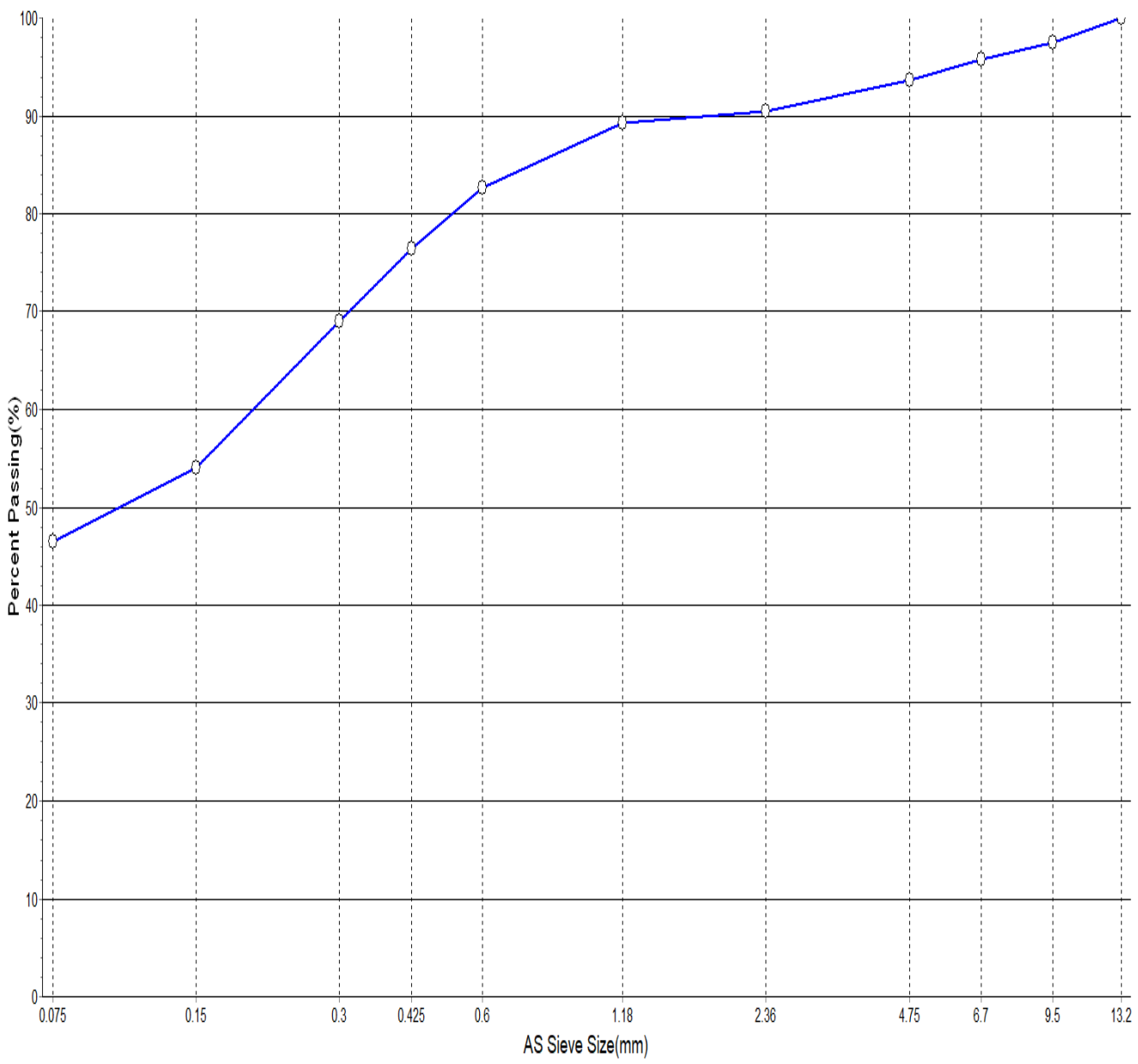
SAMPLE LOCATION

GA-BH04

3.50 - 3.95m

Test Number :	**Sample 19**
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2	**100**	
9.5	**97**	
6.7	**96**	
4.75	**94**	
2.36	**90**	
1.18	**89**	
0.600	**83**	
0.425	**76**	
0.300	**69**	
0.150	**54**	
0.075	**47**	



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Particle Size Distribution Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 2/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.6.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 4 of 9**

Sample Number :	18626
Sampling Method :	AS1289.1.2.1 (6.5.3)
Sampled By :	Paul Sheppard
Date Sampled :	27/02/2018
Date Tested :	22/03/2018
Material Type :	Natural
Material Source :	In situ
Remarks :	

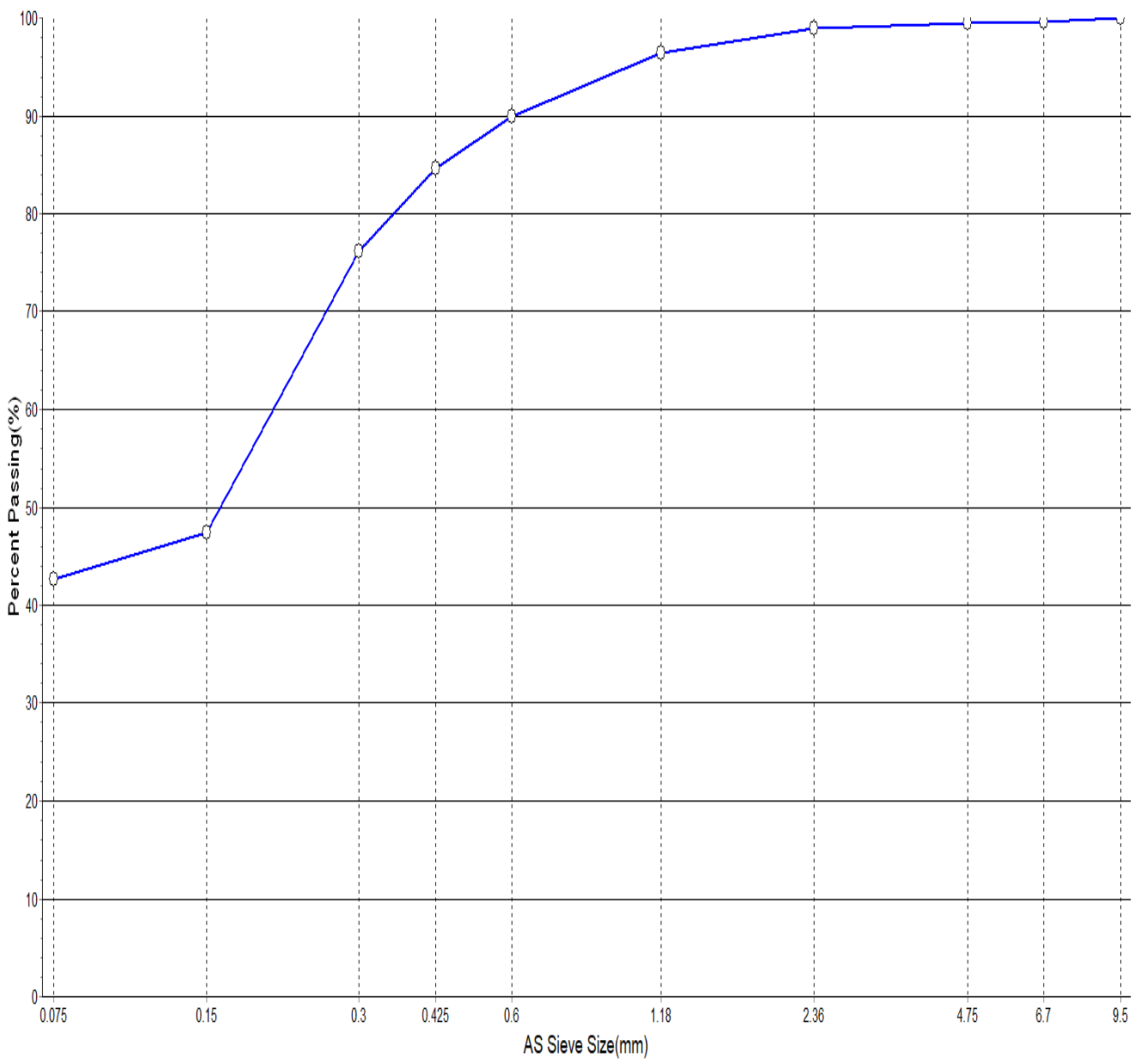
SAMPLE LOCATION

GA-BH07

3.50 - 3.95m

Test Number :	**Sample 20**
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5	**100**	
6.7	**100**	
4.75	**99**	
2.36	**99**	
1.18	**96**	
0.600	**90**	
0.425	**85**	
0.300	**76**	
0.150	**47**	
0.075	**43**	



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Particle Size Distribution Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 2/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.6.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 5 of 9**

Sample Number :	18627
Sampling Method :	AS1289.1.2.1 (6.5.3)
Sampled By :	Paul Sheppard
Date Sampled :	27/02/2018
Date Tested :	22/03/2018
Material Type :	Natural
Material Source :	In situ
Remarks :	

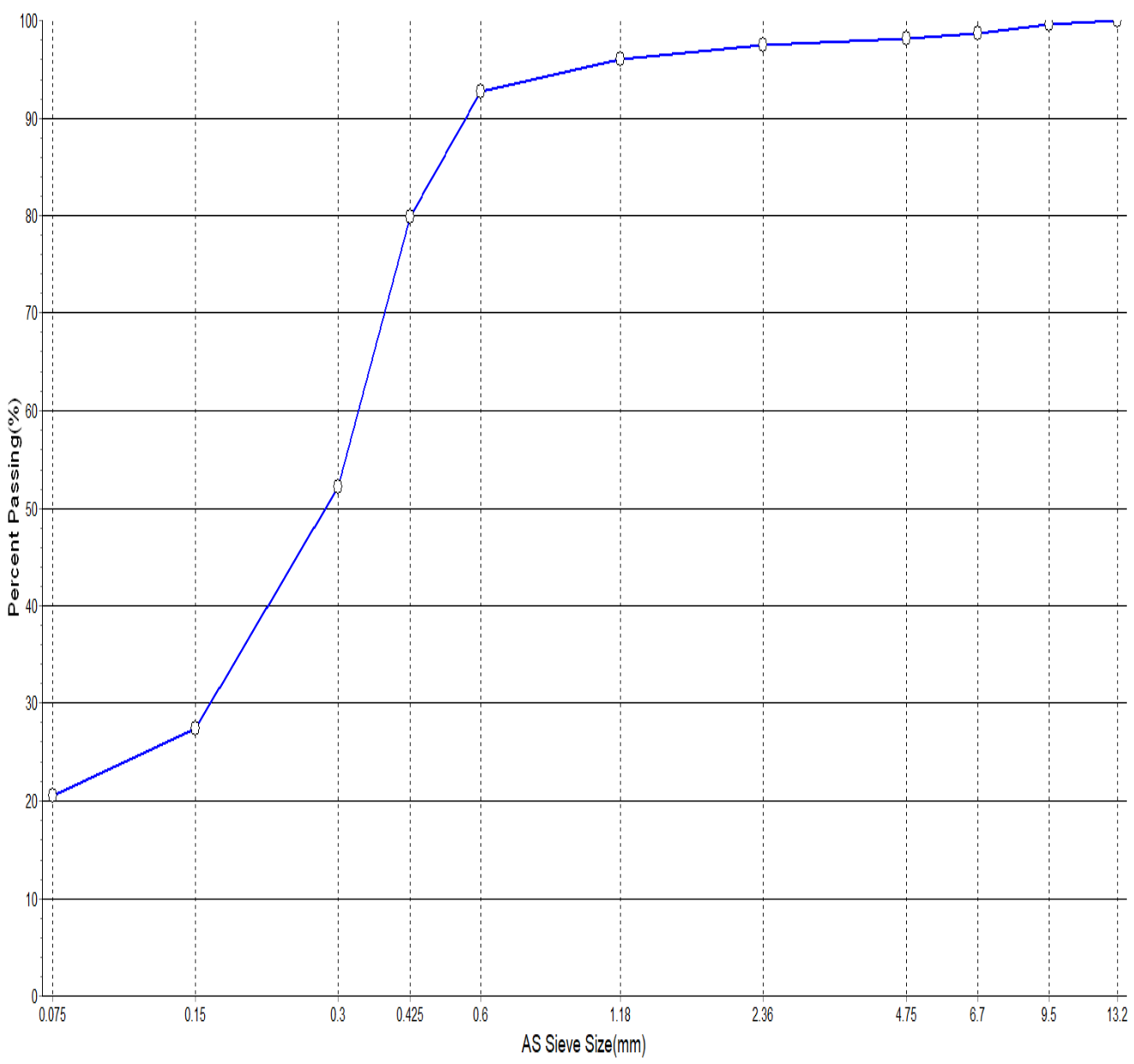
SAMPLE LOCATION

GA-BH08

2.00 - 2.45m

Test Number :	**Sample 21**
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2	**100**	
9.5	**100**	
6.7	**99**	
4.75	**98**	
2.36	**97**	
1.18	**96**	
0.600	**93**	
0.425	**80**	
0.300	**52**	
0.150	**27**	
0.075	**20**	



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Particle Size Distribution Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 2/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.6.1**
Location:	**Narrabri Solar Farm , Narrabri**		

Sample Number :	18628
Sampling Method :	AS1289.1.2.1 (6.5.3)
Sampled By :	Paul Sheppard
Date Sampled :	28/02/2018
Date Tested :	22/03/2018
Material Type :	Natural
Material Source :	In situ
Remarks :	

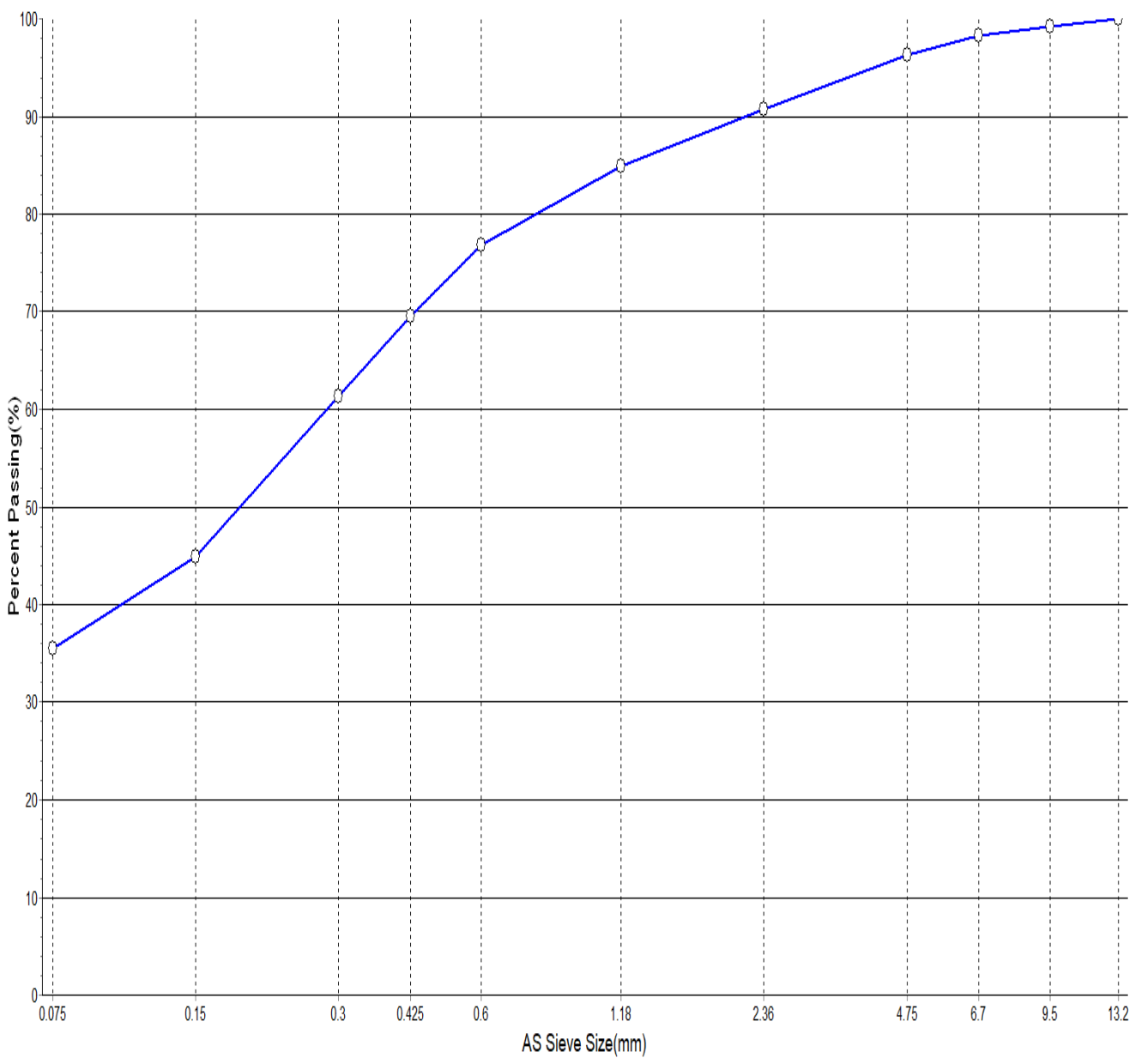
SAMPLE LOCATION

GA-BH09

3.50 - 3.95m

Test Number :	**Sample 22**
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2	**100**	
9.5	**99**	
6.7	**98**	
4.75	**96**	
2.36	**91**	
1.18	**85**	
0.600	**77**	
0.425	**70**	
0.300	**61**	
0.150	**45**	
0.075	**35**	



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Particle Size Distribution Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 2/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.6.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 7 of 9**

Sample Number :	18629
Sampling Method :	AS1289.1.2.1 (6.5.3)
Sampled By :	Paul Sheppard
Date Sampled :	01/03/2018
Date Tested :	22/03/2018
Material Type :	Natural
Material Source :	In situ
Remarks :	

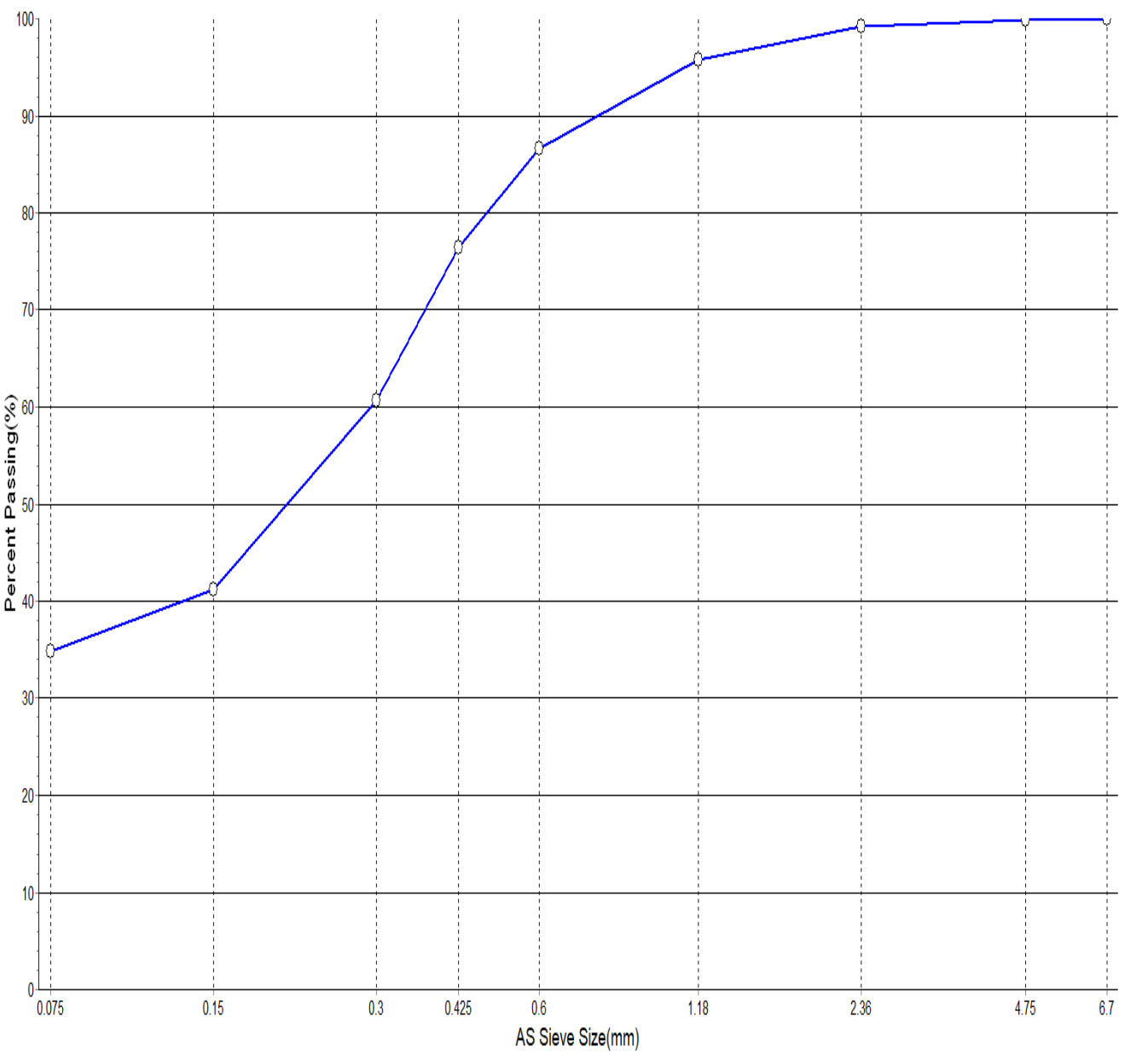
SAMPLE LOCATION

GA-BH10

3.50 - 3.95m

Test Number :	**Sample 23**
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5		
6.7	**100**	
4.75	**100**	
2.36	**99**	
1.18	**96**	
0.600	**87**	
0.425	**76**	
0.300	**61**	
0.150	**41**	
0.075	**35**	



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Particle Size Distribution Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 2/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.6.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 8 of 9**

Sample Number :	18630
Sampling Method :	AS1289.1.2.1 (6.5.3)
Sampled By :	Paul Sheppard
Date Sampled :	28/02/2018
Date Tested :	22/03/2018
Material Type :	Natural
Material Source :	In situ
Remarks :	

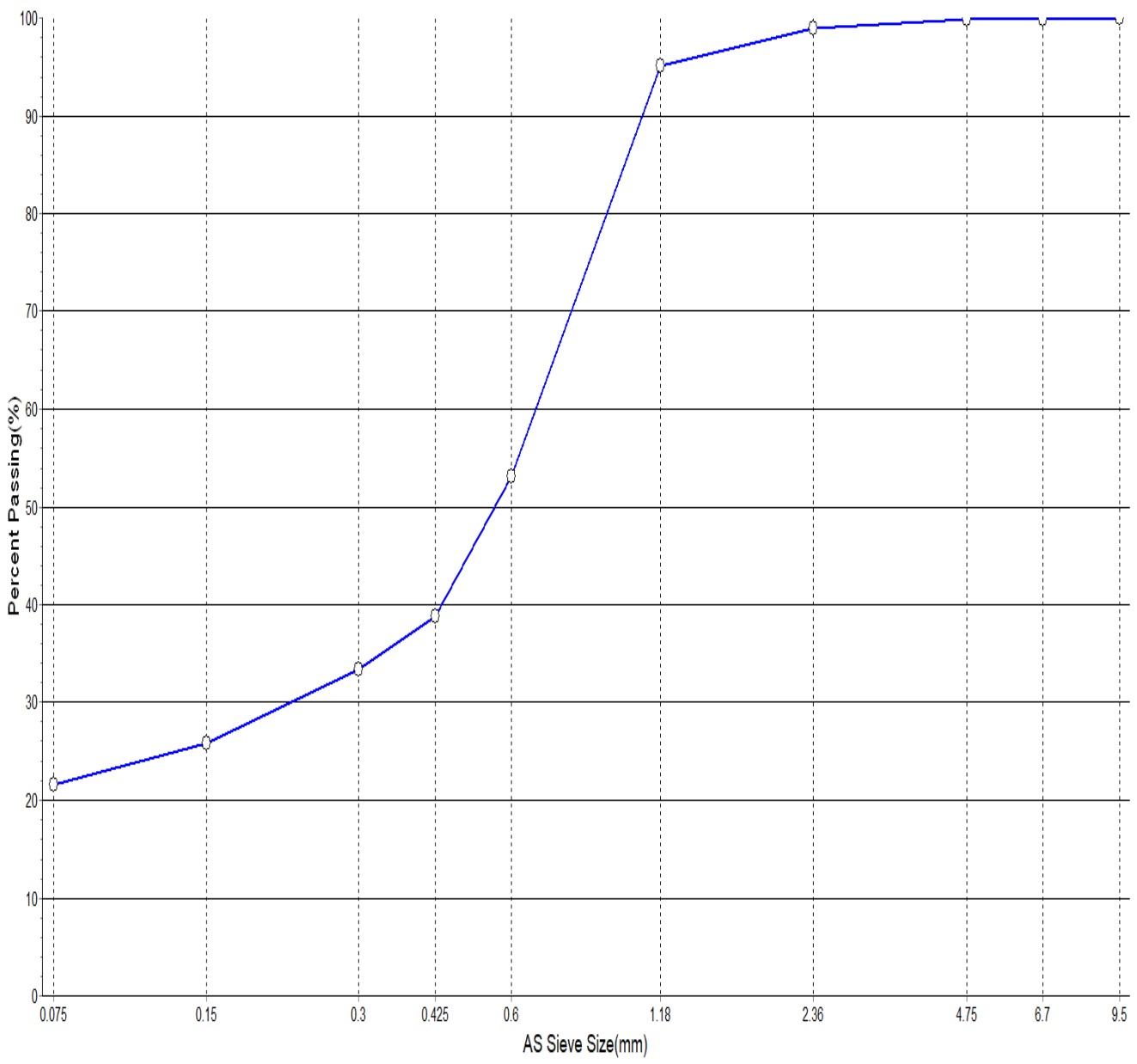
SAMPLE LOCATION

GA-BH11

2.00 - 2.45m

Test Number :	**Sample 24**
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2		
9.5	**100**	
6.7	**100**	
4.75	**100**	
2.36	**99**	
1.18	**95**	
0.600	**53**	
0.425	**39**	
0.300	**33**	
0.150	**26**	
0.075	**22**	



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Particle Size Distribution Report

Client :	**Golder Associates Pty Ltd**	Report Number:	**W04418 - 2/1**
Address :	**147 Coronation Drive, Milton, QLD, 4064**	Report Date :	**23/03/2018**
Project Name :	**Geotechnical Investigation**	Order Number :	
Project Number :	**W04418**	Test Method :	**AS1289.3.6.1**
Location:	**Narrabri Solar Farm , Narrabri**		**Page 9 of 9**

Sample Number :	18631
Sampling Method :	AS1289.1.2.1 (6.5.3)
Sampled By :	Paul Sheppard
Date Sampled :	27/02/2018
Date Tested :	22/03/2018
Material Type :	Natural
Material Source :	In situ
Remarks :	

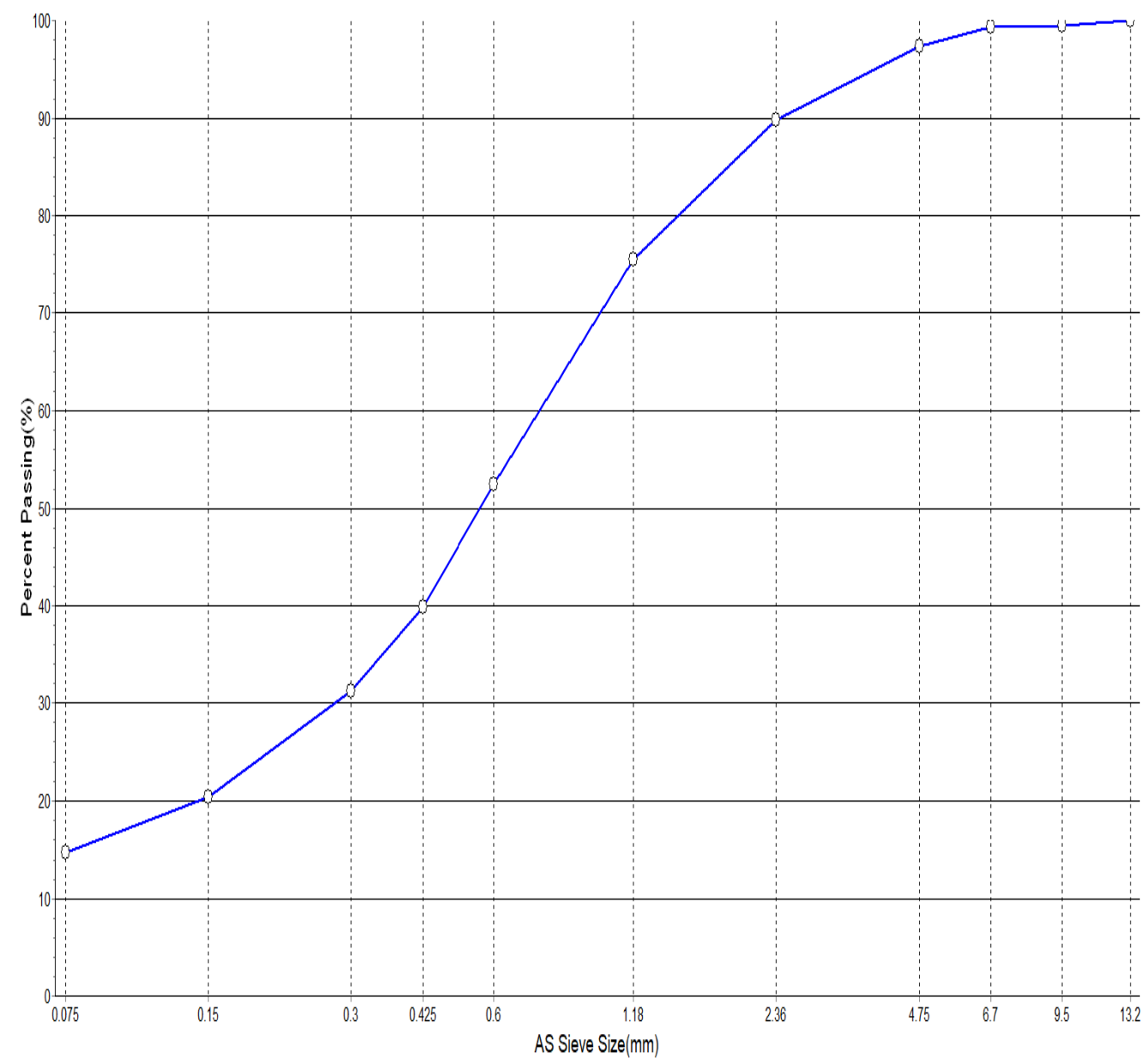
SAMPLE LOCATION

GA-BH19

3.50 - 3.80m

Test Number :	**Sample 25**
Lot Number :	
Specification Number :	

AS Sieve Size(mm)	Percent Passing	Specification Limits
100		
75		
63		
53		
37.5		
26.5		
19.0		
16.0		
13.2	**100**	
9.5	**100**	
6.7	**99**	
4.75	**97**	
2.36	**90**	
1.18	**76**	
0.600	**52**	
0.425	**40**	
0.300	**31**	
0.150	**20**	
0.075	**15**	



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WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO / IEC 17025 - Testing
Laboratory Location:
194 Stephen Street,
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Stephen Ott - Senior Technician
NATA Accreditation Number
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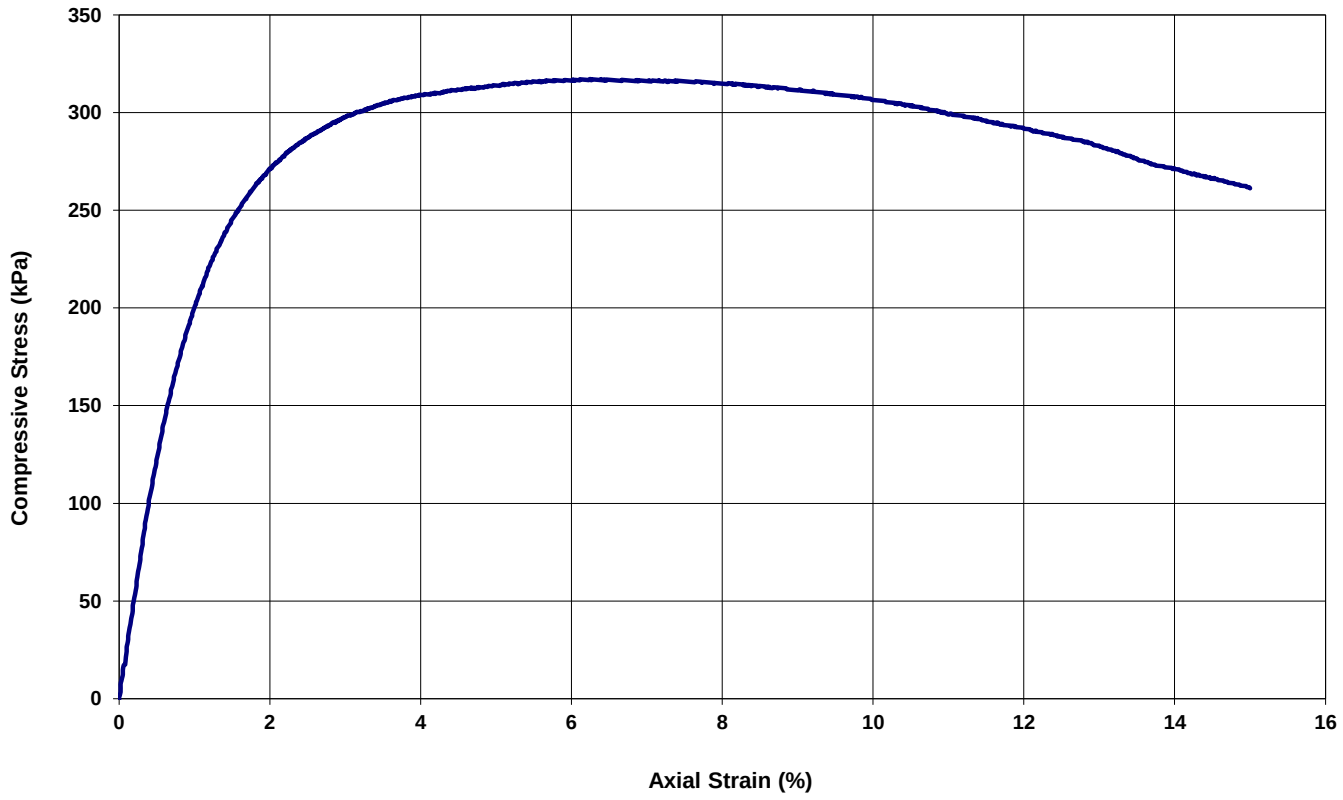
COMPRESSIVE STRENGTH OF A SOIL TEST REPORT

Test Method: AS 1289.6.4.1 - 1998

Client	Golder Associates Pty Limited	**Sample No.**	GA100342-QU
Address	PO Box 1734 MILTON BC QLD 4064	**Request No.**	1792350_TR01
		Test Date	23/03/2018
Project	Narrabri Solar Farm	**Report Date**	29/03/2018
Project No.	1792350	**Client Sample No.**	6
BoreHole	GA-BH05	**Depth From (m)**	2
		Depth To (m)	2.27
Description	SILTY CLAY- grey		



Average Sample Diameter (mm)	47.6	Maximum Principal Stress (kPa)	317
Average Sample Height (mm)	99.0	Strain at Failure (%)	6.4
Height to Diameter Ratio	2.1	Average rate of Strain (%/min)	1.0
Wet Density (t/m^3)	2.06	Moisture Content (%)	23.0
Dry Density (t/m^3)	1.68		
Mode of Failure of Specimen	Shear		

Notes/Remarks:

Sample/s supplied by the client

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The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

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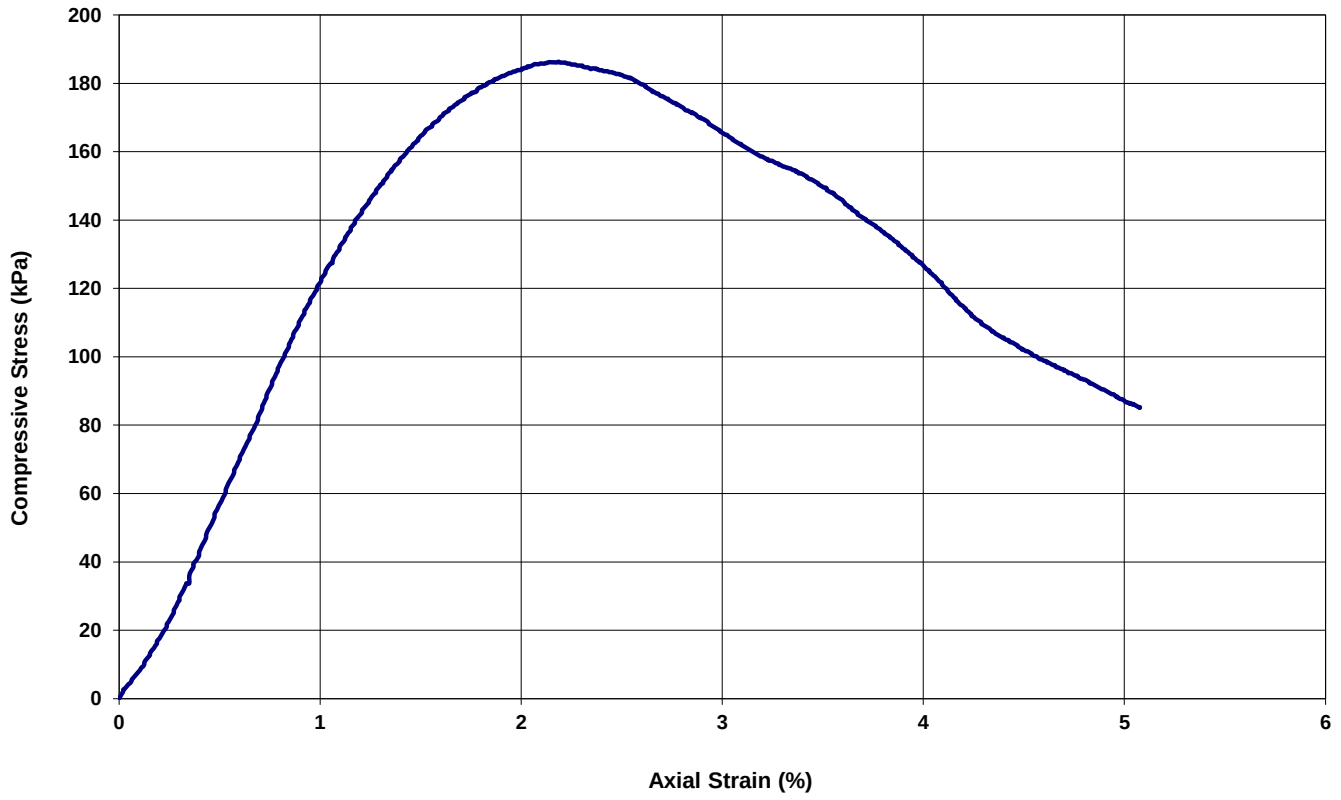
COMPRESSIVE STRENGTH OF A SOIL TEST REPORT

Test Method: AS 1289.6.4.1 - 1998

Client	Golder Associates Pty Limited	**Sample No.**	GA100343-QU
Address	PO Box 1734 MILTON BC QLD 4064	**Request No.**	1792350_TR01
		Test Date	23/03/2018
Project	Narrabri Solar Farm	**Report Date**	29/03/2018
Project No.	1792350	**Client Sample No.**	13
BoreHole	GA-BH15	**Depth From (m)** 1.5	**Depth To (m)** 1.7
Description	SANDY SILTY CLAY- grey		



Average Sample Diameter (mm)	72.8	Maximum Principal Stress (kPa)	186
Average Sample Height (mm)	143.2	Strain at Failure (%)	2.2
Height to Diameter Ratio	2.0	Average rate of Strain (%/min)	0.7
Wet Density (t/m^3)	1.92	Moisture Content (%)	22.7
Dry Density (t/m^3)	1.57		
Mode of Failure of Specimen	Shear		

Notes/Remarks:

Sample/s supplied by the client

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Authorised Signatory

C. Channon

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

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Shrink Swell Index Report

Client:	**Golder Associates Pty Ltd**	Report Number:	**W04418-3-1**
Client Address:	**147 Coronation Drive, Milton, QLD, 4064**	Page Number:	
Job Number:	**W04418**	Report Date:	**26/03/2018**
Project:	**Geotechnical Investigation**	Order Number:	
Location	**Narrabri Solar Farm , Narrabri**	Test Method :	**AS1289.7.1.1**
Lab No:	**18611**	Sample Location	
Date Sampled:	**27/02/2018**	GA BH01	
Date Tested:	**20/03/2048**	0.5 - 0.65m	
Sampled By:	**PGS**		
Sample Method:	**U70**		
Material Source:	**In situ**		
For Use As:	**-**	Lot Number:	**-**
Remarks:		Item Number :	**-**

Shrinkage Moisture Content (%) :	**14.2**	Swell MC Before(%):	**14.1**
Shrinkage (%) :	**2.16**	Swell MC After(%) :	**25.2**
Unit Weight (t/m³) :	**1.960**	PP Before (kPa):	**600+**
Swell (%) :	**2.42**	PP After (kPa):	**120**
Shrink Swell Index (Iss %):	**1.9**		

Visual Classification :	**Refer to log**
Inert Material Estimate(%):	**2**
Cracking :	**No**
Crumbling :	**No**

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Shrink Swell Index Report

Client:	**Golder Associates Pty Ltd**	Report Number:	**W04418-3-1**
Client Address:	**147 Coronation Drive, Milton, QLD, 4064**	Page Number:	
Job Number:	**W04418**	Report Date:	**28/03/2018**
Project:	**Geotechnical Investigation**	Order Number:	
Location	**Narrabri Solar Farm , Narrabri**	Test Method :	**AS1289.7.1.1**
Lab No:	**18615**	Sample Location	
Date Sampled:	**28/02/2018**	GA BH04	
Date Tested:	**20/03/2048**	0.5 - 0.7m	
Sampled By:	**PGS**		
Sample Method:	**U50**		
Material Source:	**In situ**		
For Use As:	**-**	Lot Number:	**-**
Remarks:		Item Number :	**-**

Shrinkage Moisture Content (%) :	**9.4**	Swell MC Before(%):	**8.4**
Shrinkage (%) :	**0.42**	Swell MC After(%) :	**16.3**
Unit Weight (t/m³) :	**2.199**	PP Before (kPa):	**600+**
Swell (%) :	**6.97**	PP After (kPa):	**240**
Shrink Swell Index (Iss %):	**2.2**		

Visual Classification :	**Refer to log**
Inert Material Estimate(%):	**2**
Cracking :	**Yes**
Crumbling :	**Yes**

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APPROVED SIGNATORY

Paul Sheppard - Managing Director

NATA Accreditation Number : 2117

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Shrink Swell Index Report

Client:	**Golder Associates Pty Ltd**	Report Number:	**W04418-3-1**
Client Address:	**147 Coronation Drive, Milton, QLD, 4064**	Page Number:	
Job Number:	**W04418**	Report Date:	**26/03/2018**
Project:	**Geotechnical Investigation**	Order Number:	
Location	**Narrabri Solar Farm , Narrabri**	Test Method :	**AS1289.7.1.1**
Lab No:	**18618**	Sample Location	
Date Sampled:	**28/02/2018**	GA BH11	
Date Tested:	**20/03/2048**	0.5 - 0.69m	
Sampled By:	**PGS**		
Sample Method:	**U50**		
Material Source:	**In situ**		
For Use As:	**-**	Lot Number:	**-**
Remarks:		Item Number :	**-**

Shrinkage Moisture Content (%) :	**10.1**	Swell MC Before(%):	**10.0**
Shrinkage (%) :	**0.82**	Swell MC After(%) :	**20.9**
Unit Weight (t/m³) :	**2.148**	PP Before (kPa):	**600+**
Swell (%) :	**5.45**	PP After (kPa):	**200**
Shrink Swell Index (Iss %):	**2.0**		

Visual Classification :	**Refer to log**
Inert Material Estimate(%):	**2**
Cracking :	**No**
Crumbling :	**No**

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Client:	**Golder Associates Pty Ltd**	Report Number:	**W04418-3-1**
Client Address:	**147 Coronation Drive, Milton, QLD, 4064**	Page Number:	
Job Number:	**W04418**	Report Date:	**28/03/2018**
Project:	**Geotechnical Investigation**	Order Number:	
Location	**Narrabri Solar Farm , Narrabri**	Test Method :	**AS1289.7.1.1**
Lab No:	**18632**	Sample Location	
Date Sampled:	**28/02/2018**	GA BH14	
Date Tested:	**20/03/2048**	1.5 - 1.7m	
Sampled By:	**PGS**		
Sample Method:	**U50**		
Material Source:	**In situ**		
For Use As:	**-**	Lot Number:	**-**
Remarks:		Item Number :	**-**

Shrinkage Moisture Content (%) :	**19.5**	Swell MC Before(%):	**17.9**
Shrinkage (%) :	**3.27**	Swell MC After(%) :	**25.0**
Unit Weight (t/m³) :	**1.955**	PP Before (kPa):	**600+**
Swell (%) :	**9.95**	PP After (kPa):	**160**
Shrink Swell Index (Iss %):	**4.6**		

Visual Classification :	**Refer to log**
Inert Material Estimate(%):	**2**
Cracking :	**Yes**
Crumbling :	**No**

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SHRINK SWELL INDEX TEST REPORT

Test Method AS 1289 7.1.1

Client	Golder Associates Pty Limited			**Report No.**	GA100343-ISS
				Request No.	1792350_TR01
Address	PO Box 1734 MILTON BC	QLD	4064	**Test Date**	16/03/2018
				Report Date	29/03/2018
Project	Narrabri Solar Farm				
Description	SANDY SILTY CLAY- grey				

Sample No.	13
Client ID	GA-BH15
Depth (m)	1.5-1.7

RESULTS OF TESTING

SWELL SPECIMEN

Swell Pressure (kPa) *	-
Wet Density (t/m^3)	1.89
Initial Moisture Content (%)	22.7
Final Moisture Content (%)	40.5
Swell (%)	**16.6**

SHRINKAGE SPECIMEN

Estimated Inert Inclusions (%)	5-10
Extent of Crumbling	Nil
Extent of Cracking	High
Moisture (%)	21.0
Shrinkage (%)	**6.1**

SHRINK SWELL INDEX (Iss) (%)	**8.0**

Notes/Remarks:

Sample/s supplied by client Tested as received

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Tested at Trilab Brisbane Laboratory

Authorised Signatory

C. Channon

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SHRINK SWELL INDEX TEST REPORT

Test Method AS 1289 7.1.1

Client	Golder Associates Pty Limited			**Report No.**	GA100344-ISS
				Request No.	1792350_TR01
Address	PO Box 1734 MILTON BC	QLD	4064	**Test Date**	16/03/2018
				Report Date	29/03/2018
Project	Narrabri Solar Farm				
Description	CLAY- grey brown				

Sample No.	14
Client ID	GA-BH16
Depth (m)	0.5-0.72

RESULTS OF TESTING

SWELL SPECIMEN

Swell Pressure (kPa) *	-
Wet Density (t/m^3)	1.92
Initial Moisture Content (%)	27.3
Final Moisture Content (%)	42.9
Swell (%)	**12.5**

SHRINKAGE SPECIMEN

Estimated Inert Inclusions (%)	<5
Extent of Crumbling	Nil
Extent of Cracking	High
Moisture (%)	27.5
Shrinkage (%)	**7.3**

SHRINK SWELL INDEX (Iss) (%)	**7.6**

Notes/Remarks:

Sample/s supplied by client Tested as received

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Authorised Signatory

C. Channon

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Laboratory No. 9926

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Shrink Swell Index Report

Client:	**Golder Associates Pty Ltd**	Report Number:	**W04418-3-1**
Client Address:	**147 Coronation Drive, Milton, QLD, 4064**	Page Number:	
Job Number:	**W04418**	Report Date:	**28/03/2018**
Project:	**Geotechnical Investigation**	Order Number:	
Location	**Narrabri Solar Farm , Narrabri**	Test Method :	**AS1289.7.1.1**
Lab No:	**18622**	Sample Location	
Date Sampled:	**28/02/2018**	GA BH20	
Date Tested:	**20/03/2048**	0.5 - 0.67m	
Sampled By:	**PGS**		
Sample Method:	**U70**		
Material Source:	**In situ**		
For Use As:	**-**	Lot Number:	**-**
Remarks:		Item Number :	**-**

Shrinkage Moisture Content (%) :	**18.9**	Swell MC Before(%):	**18.6**
Shrinkage (%) :	**2.51**	Swell MC After(%) :	**29.5**
Unit Weight (t/m³) :	**2.114**	PP Before (kPa):	**600+**
Swell (%) :	**10.56**	PP After (kPa):	**110**
Shrink Swell Index (Iss %):	**4.3**		

Visual Classification :	**Refer to log**
Inert Material Estimate(%):	**2**
Cracking :	**Yes**
Crumbling :	**No**

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Paul Sheppard - Managing Director

NATA Accreditation Number : 2117

Soils and soft rock testing - Determination of the Thermal Conductivity

By thermal needle probe procedure

ASTM D5334-14

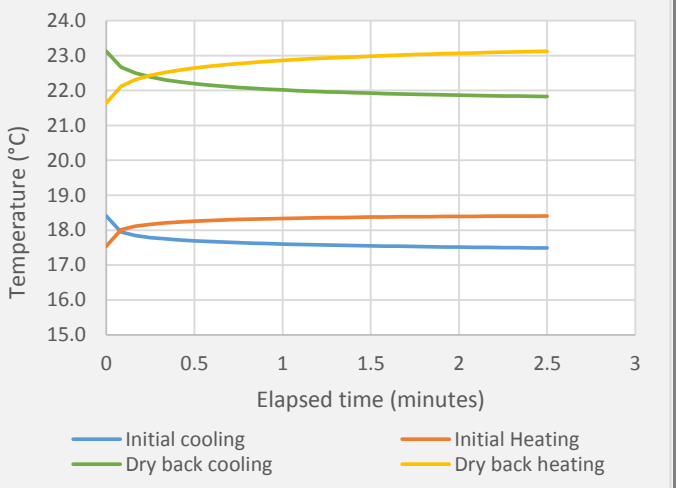
GOLDER

Test request #:	**TRM18-0144**	**Lab sample ID:**	LMEL201803150	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			**MELBOURNE GEOTECHNICAL LABORATORY**	
Client address:				Building 7, Botanicca Corporate Park 570 - 588 Swan Street Richmond, Victoria 3121	
Project ID:	**1792350**	**Exporatory Hole**			
Lab project name:	**Narrabri Solar Farm**	**GA-BH01**		**Sample depth (m):**	0.15 - 0.30
				Client sample ref.:	26
Location:	-	**Project reference:**	-		
Specimen description: (Based on visual and tactile assessment)	CI , CLAY ,medium plasticity , grey brown			**Sampled by:**	**Golder engineer**
				Sampled type:	**Remoulded**

SPECIMEN PREPARATION - SUMMARY OF INITIAL DENSITY AND MOISTURE CONTENT TEST RESULTS

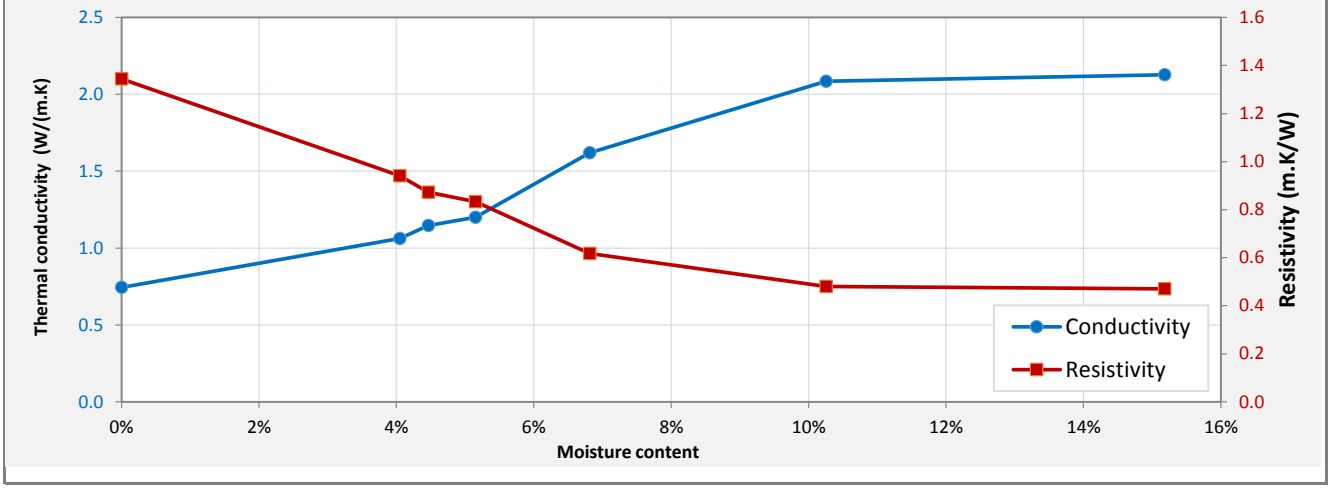
Initial moisture content:	**7.1%**	**As rcvd.**
Compaction method:	AS1289.5.1.1-2017 Standard	
Maximum dry density (t/m^3):	**1.80**	
Optimum moisture content:	**15.0%**	
Oversize material (>19mm):	**0.0%**	
Compaction density (t/m^3):	**1.98**	
Compaction moisture content:	**15.2%**	
Density ratio at compaction:	**95%**	
Moisture ratio at compaction:	**101%**	

Note: Remoulded condition: Sample remoulded to target of 95% SMDD at 100% OMC.



SUMMARY OF THERMAL CONDUCTIVITY TESTING

Moisture content when tested:	15.2%	10.3%	6.8%	5.2%	4.5%	4.1%				0.0%	**OMC**	**Dry Back**
Density when tested (t/m^3):	1.98	ND	ND	ND	ND	ND				ND	**1.98**	**ND**
Thermal conductivity (W/(m.K)	2.127	2.084	1.619	1.201	1.147	1.063				0.744	**2.127**	**0.744**
Thermal resistivity (m.K/W)	0.470	0.480	0.618	0.833	0.872	0.941				1.344	**0.470**	**1.344**



Definitions:
ND = Not determined

Specimen prepared by: YL
Results reviewed by: GSamaradiwakara
Test performed by: YL
Date reported: 6-Apr-18

Cert. ref.: 1792350_GA-BH01_1803150_TRM18-0144_TR_R18015087

Approved signatory:

NATA

NATA accreditation number: 1961 - Site:1250 - Melbourne

Accredited for compliance with ISO/IEC 17025 - Testing

Gayani Samaradiwakara - Senior Laboratory Engineer

Phone: +61 (03) 8862 3500 **Fax:** +61 (03) 8862 3501 **E-mail:** melbgeolab@golder.com.au **Web:** www.golder.com.au

This test was carried out in accordance with ASTM D5334-14.

Soils testing - Determination of the dry density moisture relationship
Standard compaction method
AS 1289.5.1.1-2017

GOLDER

Test request ID:	**TRM18-0144**	**Lab sample ID:**	LMEL201803150	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			MELBOURNE GEOTECHNICAL LABORATORY	
Client address:				Building 7, Botanicca Corporate Park	
				570 - 588 Swan Street	
Project ID:	**1792350**	**Lab report ref.:**	LMEL_18015053_5	Richmond, Victoria 3121	
Project name:	Narrabri Solar Farm	**Exporatory Hole**	**GA-BH01**	**Sample depth (m):**	0.15 - 0.30
				Client sample ref:	26
Location:		**Project alias:**	-		

Specimen description: (Based on visual and tactile assessment)	Silty CLAY, medium plasticity, brown, trace organics	**Sampling co-ordinates** **Easting (m)**	**Northing (m)**	**Reduced Level**

Curing compliance:	**Liquid Limit**			**Moisture content:**	7.1% Field
Material type	**Measured:**	**Assumed:**	**Adopted:** 50%		*AS 1289 2.1.1-2005*
Cohesive	**Curing times are compliant**		**Cure:** 168 hrs	**Portion test performed on:**	-19 mm

TEST REPORT - COMPACTION RESULTS

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Dry density (t/m³):	1.73	1.75	1.78	1.80		
Moisture content:	17.8%	11.5%	13.4%	15.8%		

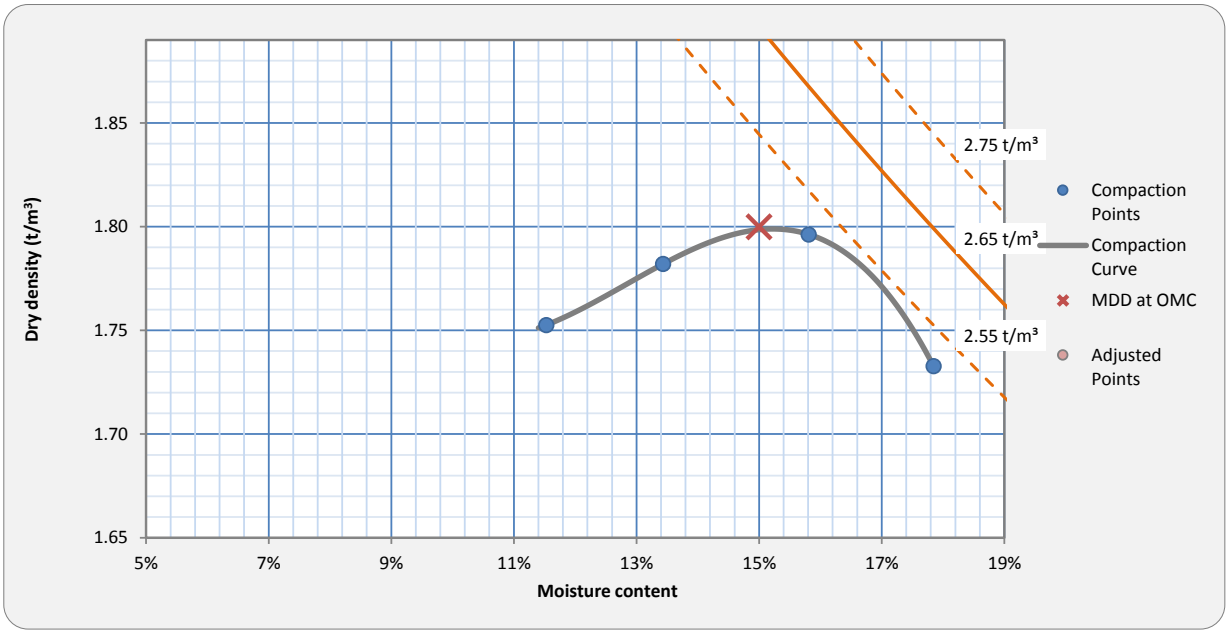
Oversize material - (by wet mass)

No oversize correction required

+19 mm:

+37.5 mm:

No oversize material present



Notes:

	Result	**Adjusted for oversize**
Standard maximum dry density (t/m³):	1.80	
Standard optimum moisture content:	15.0%	

Specimens prepared by:		**Tests performed by:**	PA	**Date tested:**	23/03/2018
Definition:	ND = Not Determined	**Results reviewed by:**	A.Stevenson	**Date reported:**	06/04/2018

Cert. ref.:	**1792350_GA-BH01_TRM18-0144_StndComp_s1803150_Rep18015053_5**	**Approved signatory:**
NATA	**NATA accreditation number: 1961 - Site:1250 - Melbourne** Accredited for compliance with ISO/IEC 17025 - Testing	
	THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL	**Aaron Stevenson - Senior Technician**

Phone: +61 (03) 8862 3500 **Fax:** +61 (03) 8862 3501 **E-mail:** melbgeolab@golder.com.au **Web:** www.golder.com.au

Soils and soft rock testing - Determination of the Thermal Conductivity

By thermal needle probe procedure

ASTM D5334-14

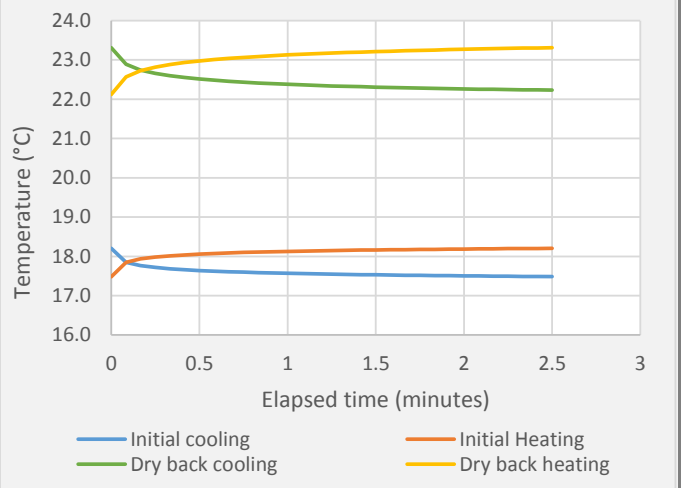
GOLDER

Test request #:	**TRM18-0144**	**Lab sample ID:**	LMEL201803154	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			**MELBOURNE GEOTECHNICAL LABORATORY**	
Client address:				Building 7, Botanicca Corporate Park 570 - 588 Swan Street Richmond, Victoria 3121	
Project ID:	**1792350**	**Exporatory Hole**			
Lab project name:	**Narrabri Solar Farm**	**GA-BH07**		**Sample depth (m):**	0.10 - 0.30
				Client sample ref.:	
Location:	-	**Project reference:**	-		
Specimen description: (Based on visual and tactile assessment)	CI , CLAY, medium plasticity , grey brown			**Sampled by:**	**Golder engineer**
				Sampled type:	**Remoulded**

SPECIMEN PREPARATION - SUMMARY OF INITIAL DENSITY AND MOISTURE CONTENT TEST RESULTS

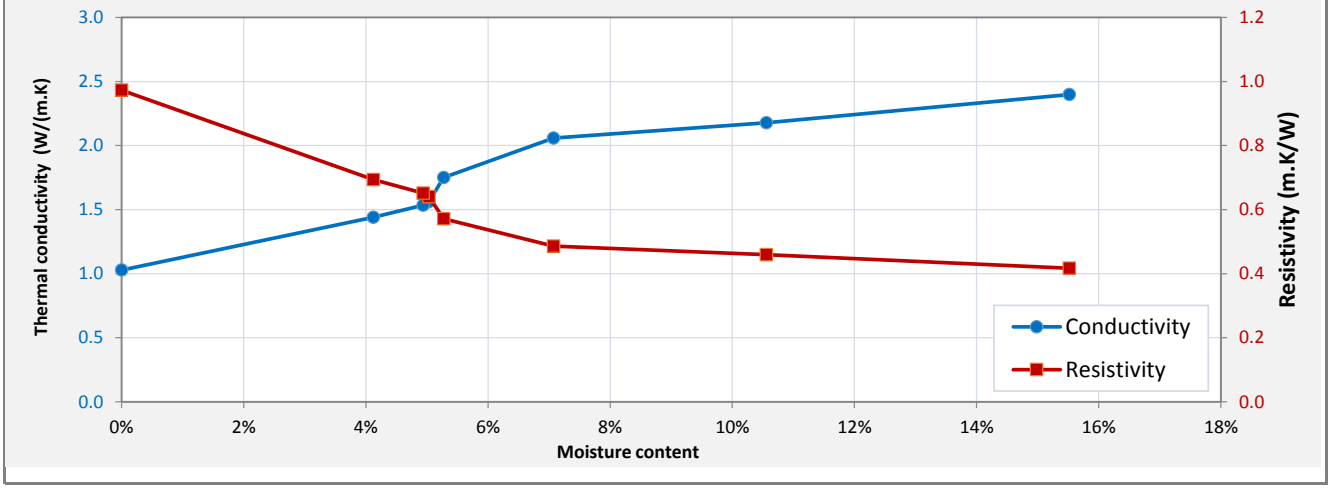
Initial moisture content:	**8.1%**	**As rcvd.**
Compaction method:	AS1289.5.1.1-2017 Standard	
Maximum dry density (t/m^3):	**1.79**	
Optimum moisture content:	**15.0%**	
Oversize material (>19mm):	**0.0%**	
Compaction density (t/m^3):	**1.96**	
Compaction moisture content:	**15.5%**	
Density ratio at compaction:	**95%**	
Moisture ratio at compaction:	**103%**	

Note: Remoulded condition: Sample remoulded to target of 95% SMDD at 100% OMC.



SUMMARY OF THERMAL CONDUCTIVITY TESTING

Moisture content when tested:	15.5%	10.6%	7.1%	5.3%	5.0%	4.9%	4.1%			0.0%	**OMC**	**Dry Back**
Density when tested (t/m^3):	1.96	ND	ND	ND	ND	ND	ND			ND	**1.96**	**ND**
Thermal conductivity (W/(m.K)	2.398	2.177	2.058	1.750	1.562	1.535	1.441			1.028	**2.398**	**1.028**
Thermal resistivity (m.K/W)	0.417	0.459	0.486	0.571	0.640	0.651	0.694			0.973	**0.417**	**0.973**



Definitions:
ND = Not determined

Specimen prepared by: YL
Results reviewed by: GSamaradiwakara

Test performed by: YL
Date reported: 6-Apr-18

Cert. ref.: 1792350_GA-BH07_1803154_TRM18-0144_TR_R18015088

Approved signatory:

NATA

NATA accreditation number: 1961 - Site:1250 - Melbourne

Accredited for compliance with ISO/IEC 17025 - Testing

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This test was carried out in accordance with ASTM D5334-14.

Soils testing - Determination of the dry density moisture relationship
Standard compaction method
AS 1289.5.1.1-2017

GOLDER

Test request ID:	**TRM18-0144**	**Lab sample ID:**	LMEL201803154	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			MELBOURNE GEOTECHNICAL LABORATORY	
Client address:				Building 7, Botanicca Corporate Park	
				570 - 588 Swan Street	
Project ID:	**1792350**	**Lab report ref.:**	LMEL_18015054_3	Richmond, Victoria 3121	
Project name:	Narrabri Solar Farm	**Exporatory Hole**	**GA-BH07**	**Sample depth (m):**	0.10 - 0.30
				Client sample ref:	
Location:				**Project alias:**	-

Specimen description: (Based on visual and tactile assessment)	Sandy Silty CLAY, medium plasticity, grey	**Sampling co-ordinates** Easting (m) / Northing (m)	**Reduced Level**

Curing compliance:	**Liquid Limit**			**Moisture content:**	8.1% Field — *AS 1289 2.1.1-2005*
Material type	**Measured:**	**Assumed:**	**Adopted:** 50%		
Cohesive	**Curing times are compliant**		**Cure:** 169.17 hrs	**Portion test performed on:**	-19 mm

TEST REPORT - COMPACTION RESULTS

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Dry density (t/m³):	1.69	1.74	1.78	1.74		
Moisture content:	19.5%	12.0%	14.2%	17.9%		

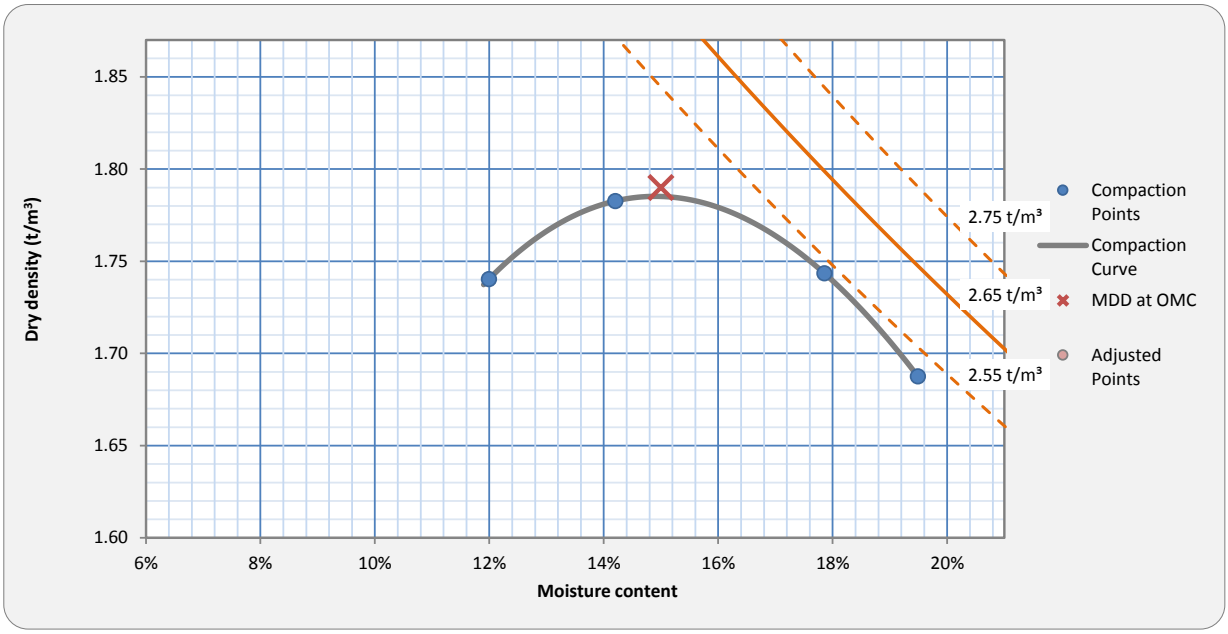
Oversize material - (by wet mass)

No oversize correction required

+19 mm:

+37.5 mm:

No oversize material present



Notes:

	Result	Adjusted for oversize
Standard maximum dry density (t/m³):	1.79	
Standard optimum moisture content:	15.0%	

Specimens prepared by:		**Tests performed by:**	PA	**Date tested:**	23/03/2018
Definition:	ND = Not Determined	**Results reviewed by:**	A.Stevenson	**Date reported:**	06/04/2018

Cert. ref.:	**1792350_GA-BH07_TRM18-0144_StndComp_s1803154_Rep18015054_3**	**Approved signatory:**
NATA	**NATA accreditation number: 1961 - Site:1250 - Melbourne** Accredited for compliance with ISO/IEC 17025 - Testing	
	THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL	**Aaron Stevenson - Senior Technician**

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Soils and soft rock testing - Determination of the Thermal Conductivity

By thermal needle probe procedure

ASTM D5334-14

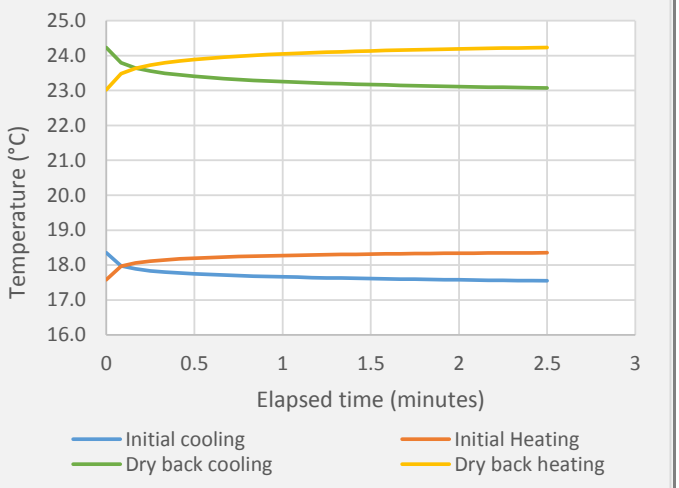
GOLDER

Test request #:	**TRM18-0144**	**Lab sample ID:**	LMEL201803153	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			**MELBOURNE GEOTECHNICAL LABORATORY**	
Client address:				Building 7, Botanicca Corporate Park 570 - 588 Swan Street Richmond, Victoria 3121	
Project ID:	**1792350**	**Exporatory Hole**			
Lab project name:	**Narrabri Solar Farm**	**GA-BH09**		**Sample depth (m):**	0.10 - 0.30
				Client sample ref.:	
Location:	-	**Project reference:**	-		
Specimen description: (Based on visual and tactile assessment)	CI , CLAY , medium plasticity , grey brown			**Sampled by:**	**Golder engineer**
				Sampled type:	**Remoulded**

SPECIMEN PREPARATION - SUMMARY OF INITIAL DENSITY AND MOISTURE CONTENT TEST RESULTS

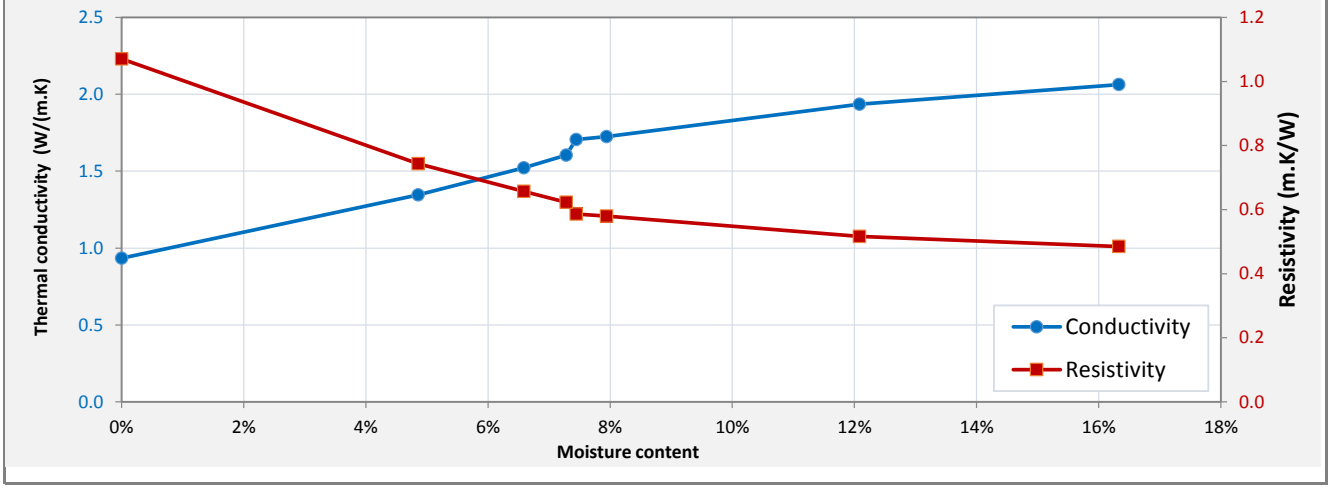
Initial moisture content:	**9.6%**	**As rcvd.**
Compaction method:	AS1289.5.1.1-2017 Standard	
Maximum dry density (t/m^3):	**1.75**	
Optimum moisture content:	**16.5%**	
Oversize material (>19mm):	**0.0%**	
Compaction density (t/m^3):	**1.93**	
Compaction moisture content:	**16.3%**	
Density ratio at compaction:	**95%**	
Moisture ratio at compaction:	**99%**	

Note: Remoulded condition: Sample remoulded to target of 95% SMDD at 100% OMC.



SUMMARY OF THERMAL CONDUCTIVITY TESTING

Moisture content when tested:	16.3%	12.1%	7.9%	7.4%	7.3%	6.6%	4.9%			0.0%	**OMC**	**Dry Back**
Density when tested (t/m^3):	1.93	ND	ND	ND	ND	ND	ND			ND	**1.93**	**ND**
Thermal conductivity (W/(m.K)	2.063	1.936	1.724	1.705	1.605	1.522	1.345			0.934	**2.063**	**0.934**
Thermal resistivity (m.K/W)	0.485	0.517	0.580	0.587	0.623	0.657	0.743			1.071	**0.485**	**1.071**



Definitions:
ND = Not determined

Specimen prepared by: YL
Results reviewed by: GSamaradiwakara

Test performed by: YL
Date reported: 6-Apr-18

Cert. ref.: 1792350_GA-BH09_1803153_TRM18-0144_TR_R18015089

Approved signatory:

NATA

NATA accreditation number: 1961 - Site:1250 - Melbourne

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This test was carried out in accordance with ASTM D5334-14.

Soils testing - Determination of the dry density moisture relationship
Standard compaction method
AS 1289.5.1.1-2017

GOLDER

Test request ID:	**TRM18-0144**	**Lab sample ID:**	LMEL201803153	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			MELBOURNE GEOTECHNICAL LABORATORY	
Client address:				Building 7, Botanicca Corporate Park	
				570 - 588 Swan Street	
Project ID:	**1792350**	**Lab report ref.:**	LMEL_18015055_3	Richmond, Victoria 3121	
Project name:	Narrabri Solar Farm	**Exporatory Hole**	**GA-BH09**	**Sample depth (m):**	0.10 - 0.30
				Client sample ref:	
Location:				**Project alias:**	-

Specimen description: (Based on visual and tactile assessment)	Silty CLAY, high plasticity, grey browm, trace organics, trace sand	**Sampling co-ordinates** **Easting (m)**	**Northing (m)**	**Reduced Level**

Curing compliance:	**Liquid Limit**			**Moisture content:**	9.6% Field
Material type	**Measured:**	**Assumed:**	**Adopted:** 50%		*AS 1289 2.1.1-2005*
Cohesive	**Curing times are compliant**		**Cure:** 168 hrs	**Portion test performed on:**	-19 mm

TEST REPORT - COMPACTION RESULTS

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Dry density (t/m³):	1.64	1.65	1.74	1.73		
Moisture content:	20.8%	13.9%	15.6%	17.9%		

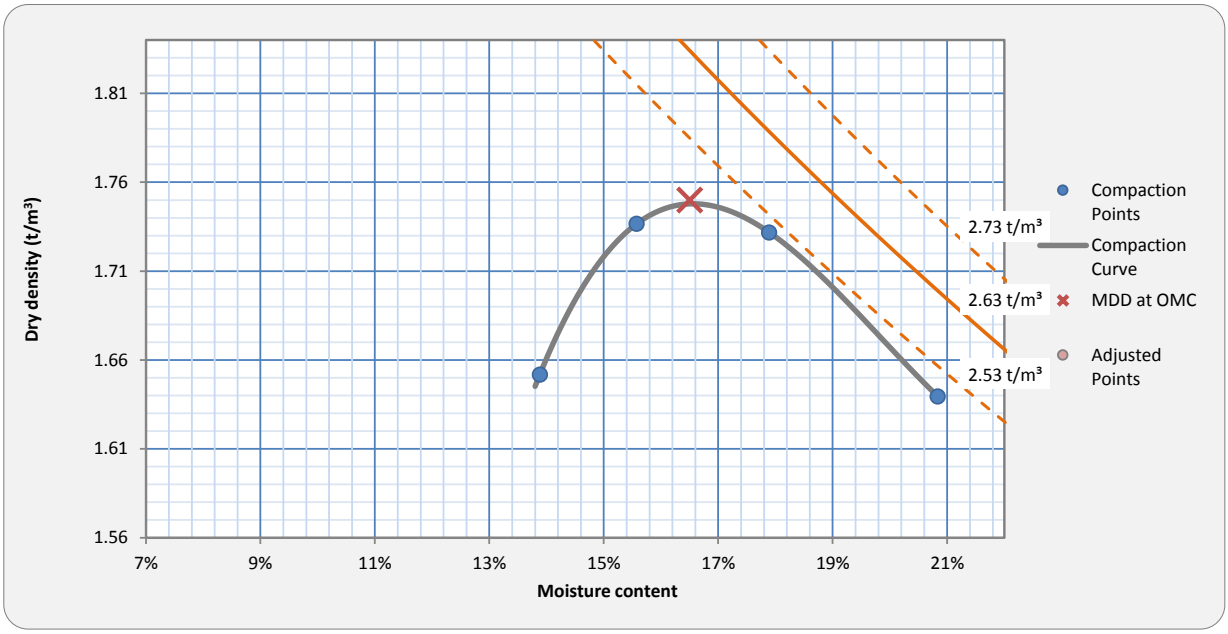
Oversize material - (by wet mass)

No oversize correction required

+19 mm:

+37.5 mm:

No oversize material present



Notes:

	Result	**Adjusted for oversize**
Standard maximum dry density (t/m³):	1.75	
Standard optimum moisture content:	16.5%	

Specimens prepared by:		**Tests performed by:**	PA	**Date tested:**	23/03/2018
Definition:	ND = Not Determined	**Results reviewed by:**	A.Stevenson	**Date reported:**	06/04/2018

Cert. ref.:	**1792350_GA-BH09_TRM18-0144_StndComp_s1803153_Rep18015055_3**	**Approved signatory:**
NATA	**NATA accreditation number: 1961 - Site:1250 - Melbourne** Accredited for compliance with ISO/IEC 17025 - Testing	
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Soils and soft rock testing - Determination of the Thermal Conductivity

By thermal needle probe procedure

ASTM D5334-14

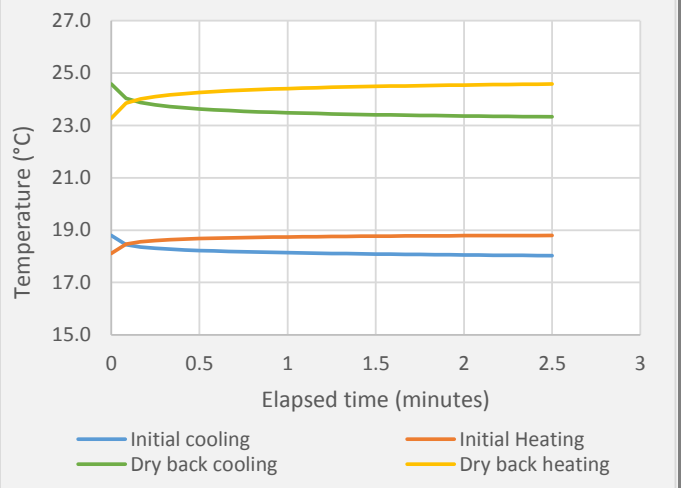
GOLDER

Test request #:	**TRM18-0144**	**Lab sample ID:**	LMEL201803155	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			**MELBOURNE GEOTECHNICAL LABORATORY**	
Client address:				Building 7, Botanicca Corporate Park 570 - 588 Swan Street Richmond, Victoria 3121	
Project ID:	**1792350**	**Exporatory Hole**			
Lab project name:	**Narrabri Solar Farm**	**GA-BH14**		**Sample depth (m):**	0.15 - 0.30
				Client sample ref.:	
Location:	-	**Project reference:**	-		
Specimen description: (Based on visual and tactile assessment)	CH , CLAY , high plasticity , grey brown			**Sampled by:**	**Golder engineer**
				Sampled type:	**Remoulded**

SPECIMEN PREPARATION - SUMMARY OF INITIAL DENSITY AND MOISTURE CONTENT TEST RESULTS

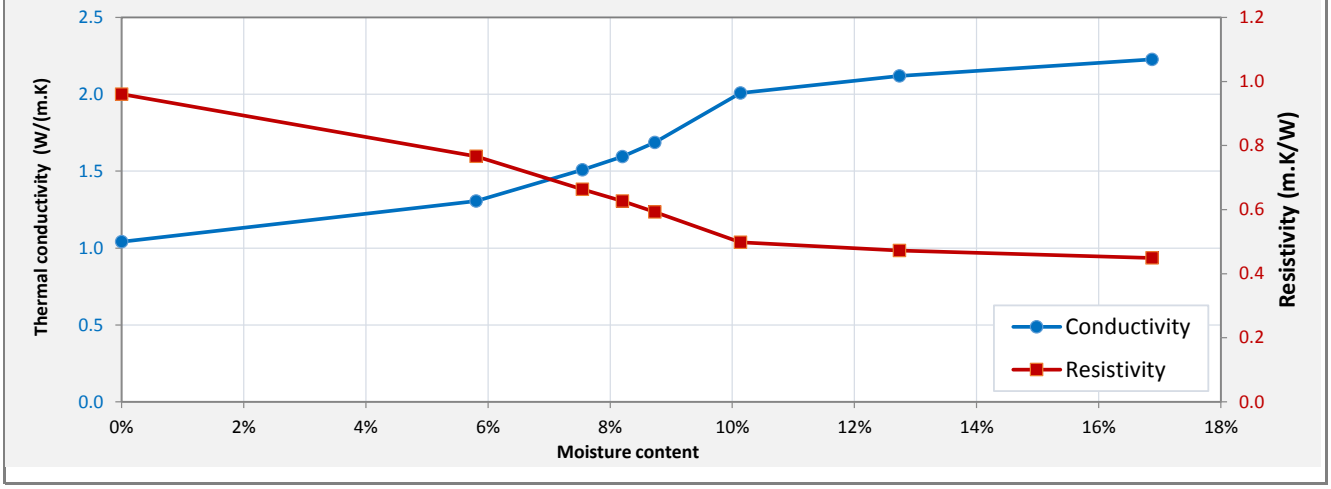
Initial moisture content:	**9.0%**	**As rcvd.**
Compaction method:	AS1289.5.1.1-2017 Standard	
Maximum dry density (t/m^3):	**1.74**	
Optimum moisture content:	**17.0%**	
Oversize material (>19mm):	**0.0%**	
Compaction density (t/m^3):	**1.92**	
Compaction moisture content:	**16.9%**	
Density ratio at compaction:	**94%**	
Moisture ratio at compaction:	**99%**	

Note: Remoulded condition: Sample remoulded to target of 95% SMDD at 100% OMC.



SUMMARY OF THERMAL CONDUCTIVITY TESTING

Moisture content when tested:	16.9%	12.7%	10.1%	8.7%	8.2%	7.5%	5.8%			0.0%	**OMC**	**Dry Back**
Density when tested (t/m^3):	1.92	ND	ND	ND	ND	ND	ND			ND	**1.92**	**ND**
Thermal conductivity (W/(m.K)	2.227	2.119	2.008	1.687	1.595	1.508	1.305			1.041	**2.227**	**1.041**
Thermal resistivity (m.K/W)	0.449	0.472	0.498	0.593	0.627	0.663	0.766			0.961	**0.449**	**0.961**



Definitions:
ND = Not determined

Specimen prepared by: YL
Results reviewed by: GSamaradiwakara

Test performed by: YL
Date reported: **6-Apr-18**

Cert. ref.: 1792350_GA-BH14_1803155_TRM18-0144_TR_R18015090

Approved signatory:

NATA

NATA accreditation number: 1961 - Site:1250 - Melbourne

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This test was carried out in accordance with ASTM D5334-14.

Soils testing - Determination of the dry density moisture relationship
Standard compaction method
AS 1289.5.1.1-2017

GOLDER

Test request ID:	**TRM18-0144**	**Lab sample ID:**	LMEL201803155	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			MELBOURNE GEOTECHNICAL LABORATORY	
Client address:				Building 7, Botanicca Corporate Park	
				570 - 588 Swan Street	
Project ID:	**1792350**	**Lab report ref.:**	LMEL_18015056_3	Richmond, Victoria 3121	
Project name:	Narrabri Solar Farm	**Exporatory Hole**	**GA-BH14**	**Sample depth (m):**	0.15 - 0.30
				Client sample ref:	
Location:				**Project alias:**	-

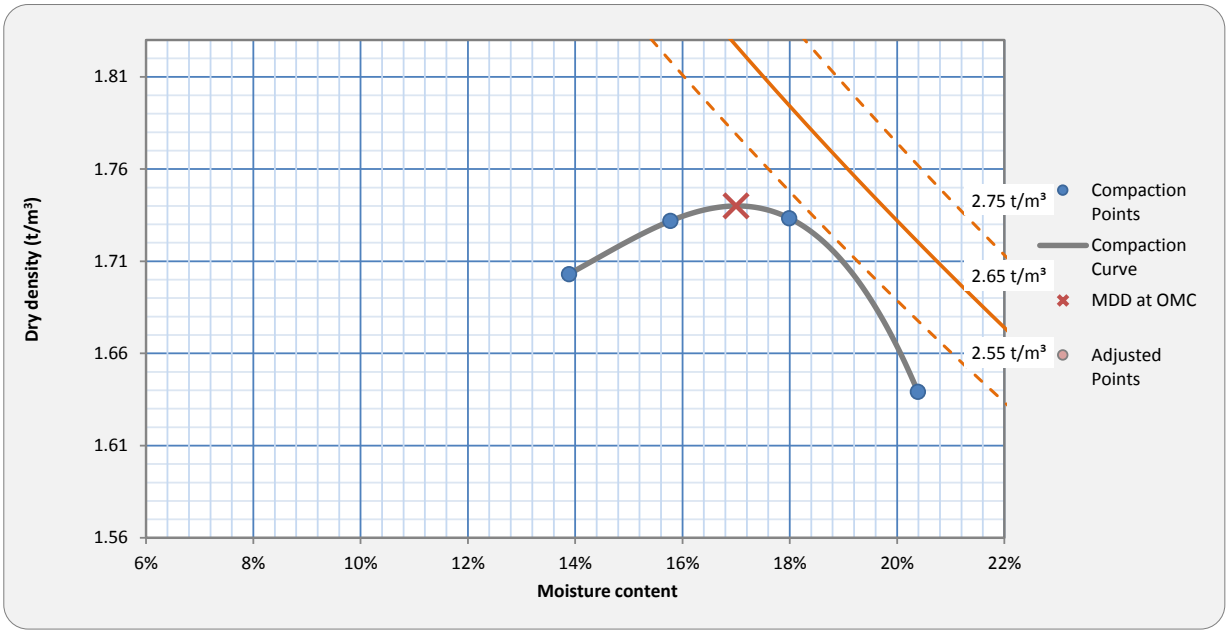
Specimen description: (Based on visual and tactile assessment)	Silty CLAY, high plasticity, grey, trace sand	**Sampling co-ordinates** Easting (m) / Northing (m)	**Reduced Level**

Curing compliance:	**Liquid Limit**			**Moisture content:**	9.0% Field — *AS 1289 2.1.1-2005*
Material type	**Measured:**	**Assumed:**	**Adopted:** 50%		
Cohesive	**Curing times are compliant**		**Cure:** 169.83 hrs	**Portion test performed on:**	-19 mm

TEST REPORT - COMPACTION RESULTS

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Dry density (t/m³):	1.70	1.73	1.73	1.64		
Moisture content:	13.9%	15.8%	18.0%	20.4%		

Oversize material - (by wet mass)
No oversize correction required
+19 mm:
+37.5 mm:
No oversize material present



Notes:

	Result	**Adjusted for oversize**
Standard maximum dry density (t/m³):	1.74	
Standard optimum moisture content:	17.0%	

Specimens prepared by:		**Tests performed by:**	PA	**Date tested:**	23/03/2018
Definition:	ND = Not Determined	**Results reviewed by:**	A.Stevenson	**Date reported:**	06/04/2018

Cert. ref.:	**1792350_GA-BH14_TRM18-0144_StndComp_s1803155_Rep18015056_3**	**Approved signatory:**
NATA	**NATA accreditation number: 1961 - Site:1250 - Melbourne** Accredited for compliance with ISO/IEC 17025 - Testing	
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Soils and soft rock testing - Determination of the Thermal Conductivity

By thermal needle probe procedure

ASTM D5334-14

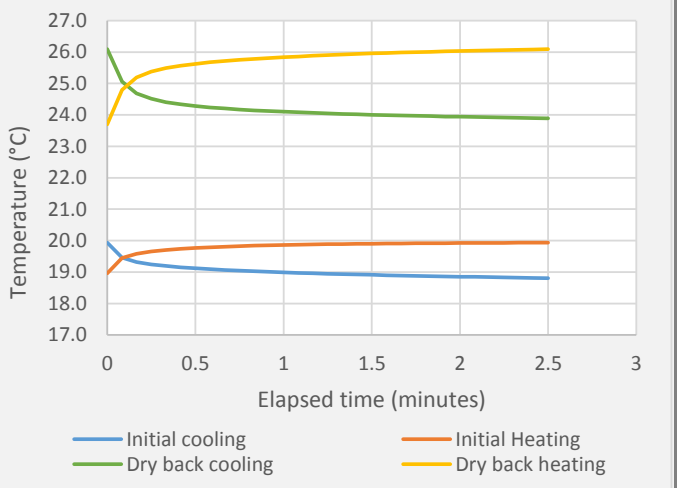
GOLDER

Test request #:	**TRM18-0144**	**Lab sample ID:**	LMEL201803151	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			**MELBOURNE GEOTECHNICAL LABORATORY**	
Client address:				Building 7, Botanicca Corporate Park 570 - 588 Swan Street Richmond, Victoria 3121	
Project ID:	**1792350**	**Exporatory Hole**			
Lab project name:	**Narrabri Solar Farm**	**GA-BH16**		**Sample depth (m):**	0.20 - 0.40
				Client sample ref.:	28
Location:	-	**Project reference:**	-		
Specimen description: (Based on visual and tactile assessment)	CH , CLAY , high plasticity , grey brown			**Sampled by:**	**Golder engineer**
				Sampled type:	**Remoulded**

SPECIMEN PREPARATION - SUMMARY OF INITIAL DENSITY AND MOISTURE CONTENT TEST RESULTS

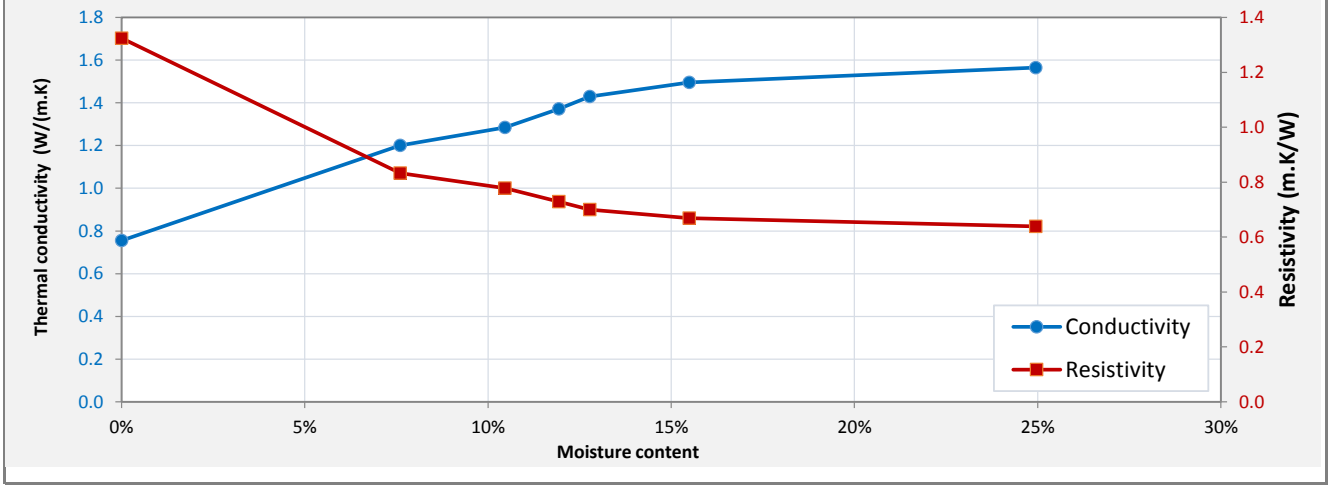
Initial moisture content:	**20.1%**	**As rcvd.**
Compaction method:	AS1289.5.1.1-2017 Standard	
Maximum dry density (t/m^3):	**1.55**	
Optimum moisture content:	**24.5%**	
Oversize material (>19mm):	**0.0%**	
Compaction density (t/m^3):	**1.83**	
Compaction moisture content:	**24.9%**	
Density ratio at compaction:	**94%**	
Moisture ratio at compaction:	**102%**	

Note: Remoulded condition: Sample remoulded to target of 95% SMDD at 100% OMC.



SUMMARY OF THERMAL CONDUCTIVITY TESTING

Moisture content when tested:	24.9%	15.5%	12.8%	11.9%	10.5%	7.6%				0.0%	**OMC**	**Dry Back**
Density when tested (t/m^3):	1.83	ND	ND	ND	ND	ND				ND	**1.83**	**ND**
Thermal conductivity (W/(m.K)	1.565	1.495	1.429	1.371	1.284	1.200				0.755	**1.565**	**0.755**
Thermal resistivity (m.K/W)	0.639	0.669	0.700	0.729	0.779	0.833				1.325	**0.639**	**1.325**



Definitions:
ND = Not determined

Specimen prepared by: YL
Results reviewed by: GSamaradiwakara
Test performed by: YL
Date reported: **6-Apr-18**

Cert. ref.: 1792350_GA-BH16_1803151_TRM18-0144_TR_R18015091

Approved signatory:

NATA

NATA accreditation number: 1961 - Site:1250 - Melbourne

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This test was carried out in accordance with ASTM D5334-14.

Soils testing - Determination of the dry density moisture relationship
Standard compaction method
AS 1289.5.1.1-2017

GOLDER

Test request ID:	**TRM18-0144**	**Lab sample ID:**	LMEL201803151	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			MELBOURNE GEOTECHNICAL LABORATORY	
Client address:				Building 7, Botanicca Corporate Park	
				570 - 588 Swan Street	
Project ID:	**1792350**	**Lab report ref.:**	LMEL_18015057_2	Richmond, Victoria 3121	
Project name:	Narrabri Solar Farm	**Exporatory Hole**	**GA-BH16**	**Sample depth (m):**	0.20 - 0.40
				Client sample ref:	28
Location:		**Project alias:**	-		

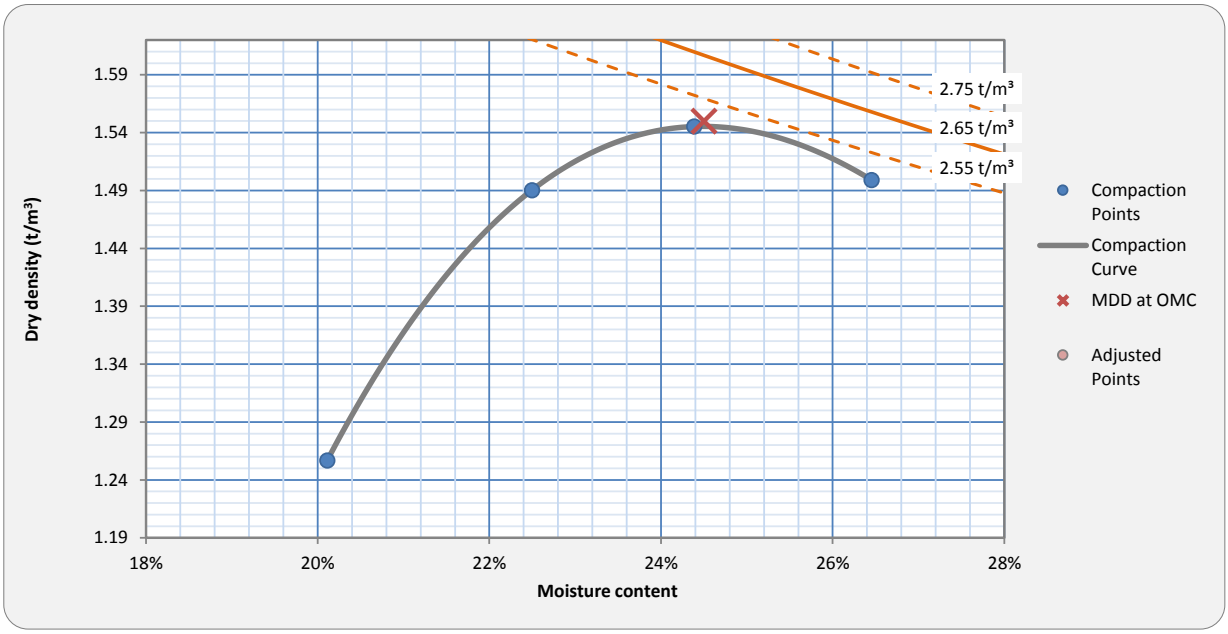
Specimen description: (Based on visual and tactile assessment)	CLAY, high plasticity, pale grey, trace organics	**Sampling co-ordinates** Easting (m)	Northing (m) / **Reduced Level**

Curing compliance:	**Liquid Limit**			**Moisture content:**	20.1% Field — *AS 1289 2.1.1-2005*
Material type	**Measured:**	**Assumed:**	**Adopted:** 50%		
Cohesive	**Curing times are compliant**		**Cure:** 168 hrs	**Portion test performed on:**	-19 mm

TEST REPORT - COMPACTION RESULTS

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Dry density (t/m³):	1.50	1.26	1.49	1.55		
Moisture content:	26.5%	20.1%	22.5%	24.4%		

Oversize material - (by wet mass)
No oversize correction required
+19 mm:
+37.5 mm:
No oversize material present



Notes:

	Result	**Adjusted for oversize**
Standard maximum dry density (t/m³):	1.55	
Standard optimum moisture content:	24.5%	

Specimens prepared by: **Tests performed by:** PA **Date tested:** 23/03/2018
Definition: ND = Not Determined **Results reviewed by:** A.Stevenson **Date reported:** 06/04/2018

Cert. ref.: 1792350_GA-BH16_TRM18-0144_StndComp_s1803151_Rep18015057_2 **Approved signatory:**

NATA

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Soils and soft rock testing - Determination of the Thermal Conductivity

By thermal needle probe procedure

ASTM D5334-14

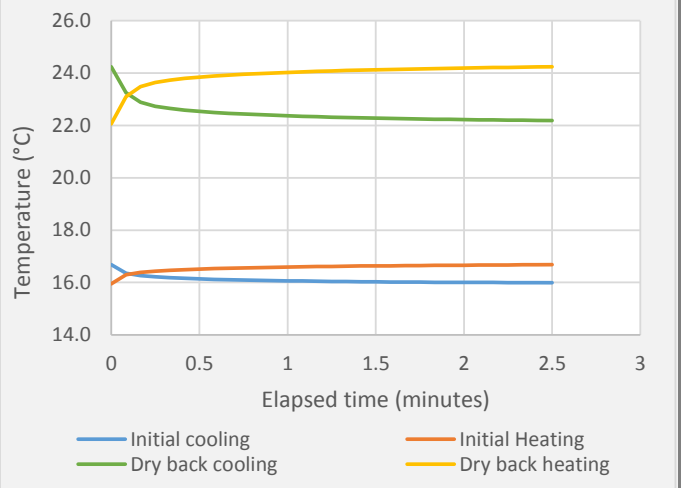
GOLDER

Test request #:	**TRM18-0144**	**Lab sample ID:**	LMEL2018040512	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			**MELBOURNE GEOTECHNICAL LABORATORY**	
Client address:				Building 7, Botanicca Corporate Park 570 - 588 Swan Street Richmond, Victoria 3121	
Project ID:	**1792350**		**Exporatory Hole**		
Lab project name:	**Narrabri Solar Farm**		**GA-BH20**	**Sample depth (m):**	0.20 - 0.50
				Client sample ref.:	
Location:	-		**Project reference:**	-	
Specimen description: (Based on visual and tactile assessment)	CI , CLAY , medium plasticity , grey brown			**Sampled by:**	**Golder engineer**
				Sampled type:	**Remoulded**

SPECIMEN PREPARATION - SUMMARY OF INITIAL DENSITY AND MOISTURE CONTENT TEST RESULTS

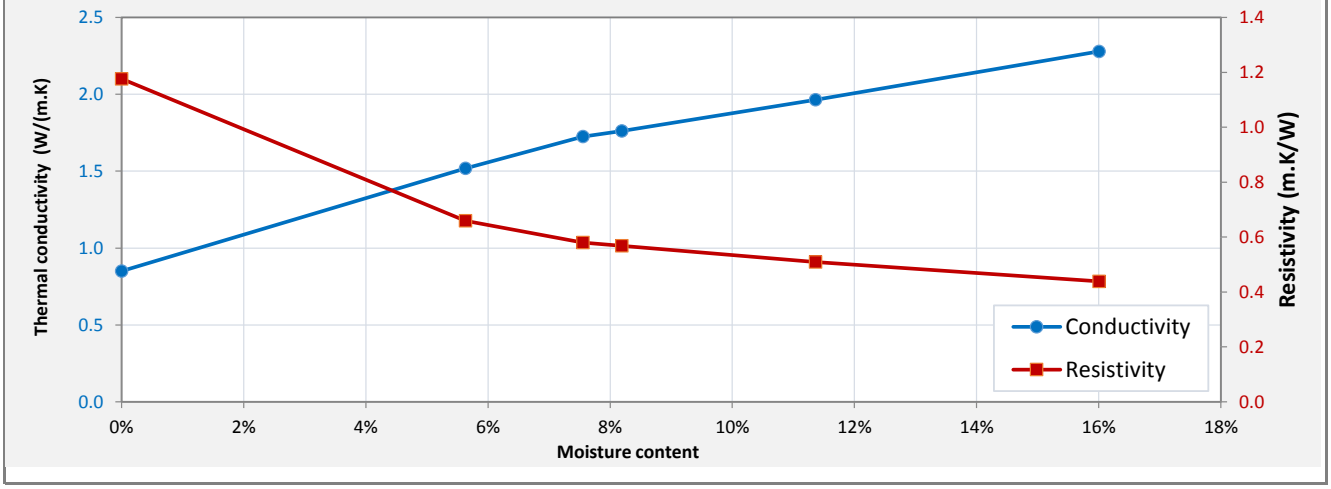
Initial moisture content:	**9.8%**	**As rcvd.**
Compaction method:	AS1289.5.1.1-2017 Standard	
Maximum dry density (t/m^3):	**1.72**	
Optimum moisture content:	**16.5%**	
Oversize material (>19mm):	**0.0%**	
Compaction density (t/m^3):	**1.90**	
Compaction moisture content:	**16.0%**	
Density ratio at compaction:	**95%**	
Moisture ratio at compaction:	**97%**	

Note: Remoulded condition: Sample remoulded to target of 95% SMDD at 100% OMC.



SUMMARY OF THERMAL CONDUCTIVITY TESTING

Moisture content when tested:	16.0%	11.4%	8.2%	7.6%	5.6%					0.0%	**OMC**	**Dry Back**
Density when tested (t/m^3):	1.90	ND	ND	ND	ND					ND	**1.90**	**ND**
Thermal conductivity (W/(m.K)	2.279	1.964	1.761	1.724	1.518					0.850	**2.279**	**0.85**
Thermal resistivity (m.K/W)	0.439	0.509	0.568	0.580	0.659					1.176	**0.439**	**1.176**



Definitions:
ND = Not determined

Specimen prepared by: YL
Results reviewed by: GSamaradiwakara

Test performed by: YL
Date reported: 6-Apr-18

Cert. ref.: 1792350_GA-BH20_18040512_TRM18-0144_TR_R18015092

Approved signatory:

NATA

NATA accreditation number: 1961 - Site:1250 - Melbourne

Accredited for compliance with ISO/IEC 17025 - Testing

Gayani Samaradiwakara - Senior Laboratory Engineer

Phone: +61 (03) 8862 3500 **Fax:** +61 (03) 8862 3501 **E-mail:** melbgeolab@golder.com.au **Web:** www.golder.com.au

This test was carried out in accordance with ASTM D5334-14.

Soils testing - Determination of the dry density moisture relationship
Standard compaction method
AS 1289.5.1.1-2017

GOLDER

Test request ID:	**TRM18-0144**	**Lab sample ID:**	LMEL201803152	**Golder Associates Pty Ltd**	
Client:	ENGIE Renewables Australia			MELBOURNE GEOTECHNICAL LABORATORY	
Client address:				Building 7, Botanicca Corporate Park	
				570 - 588 Swan Street	
Project ID:	**1792350**	**Lab report ref.:**	LMEL_18015058_2	Richmond, Victoria 3121	
Project name:	Narrabri Solar Farm	**Exporatory Hole**	**GA-BH20**	**Sample depth (m):**	0.20 - 0.50
				Client sample ref:	29
Location:		**Project alias:**	-		

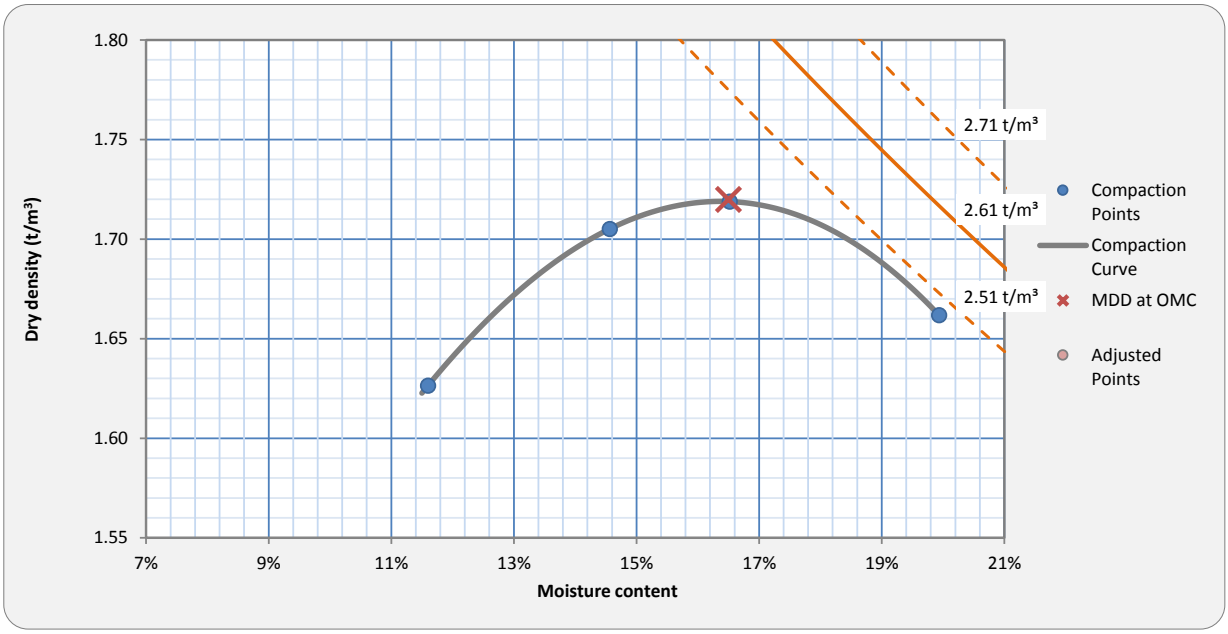
Specimen description: (Based on visual and tactile assessment)	Silty CLAY, medium plasticity	**Sampling co-ordinates** Easting (m) / Northing (m)	**Reduced Level**

Curing compliance:	**Liquid Limit**			**Moisture content:**	9.8% Field — *AS 1289 2.1.1-2005*
Material type	**Measured:**	**Assumed:**	**Adopted:** 50%		
Cohesive	**Curing times are compliant**		**Cure:** 168 hrs	**Portion test performed on:**	-19 mm

TEST REPORT - COMPACTION RESULTS

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Dry density (t/m³):	1.63	1.71	1.72	1.66		
Moisture content:	11.6%	14.6%	16.5%	19.9%		

Oversize material - (by wet mass)
No oversize correction required
+19 mm:
+37.5 mm:
No oversize material present



Notes:

	Result	**Adjusted for oversize**
Standard maximum dry density (t/m³):	1.72	
Standard optimum moisture content:	16.5%	

Specimens prepared by:		**Tests performed by:**	PA	**Date tested:**	23/03/2018
Definition:	ND = Not Determined	**Results reviewed by:**	A.Stevenson	**Date reported:**	06/04/2018

Cert. ref.:	**1792350_GA-BH20_TRM18-0144_StndComp_s1803152_Rep18015058_2**	**Approved signatory:**
NATA	**NATA accreditation number: 1961 - Site:1250 - Melbourne** Accredited for compliance with ISO/IEC 17025 - Testing	
	THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL	**Aaron Stevenson - Senior Technician**

Phone: +61 (03) 8862 3500 **Fax:** +61 (03) 8862 3501 **E-mail:** melbgeolab@golder.com.au **Web:** www.golder.com.au

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1806977**	Page	: 1 of 4
Client	: **GOLDER ASSOCIATES**	Laboratory	: Environmental Division Brisbane
Contact	: FLORIAN HITTINGER	Contact	: Carsten Emrich
Address	: P O BOX 1734 MILTON QLD, AUSTRALIA 4064	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3721 5400	Telephone	: +61-7-3243 7222
Project	: 1792350	Date Samples Received	: 16-Mar-2018 15:20
Order number	: 1793250	Date Analysis Commenced	: 21-Mar-2018
C-O-C number	: ----	Issue Date	: 29-Mar-2018 10:28
Sampler	: EJS, SJC		
Site	: Narrabri		
Quote number	: EN/002/17 National BQ		
No. of samples received	: 8		
No. of samples analysed	: 8		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- ALS is not NATA accredited for the calculation of saturated resistivity in a soil.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GA-BH02 0.6-1.05	GA-BH07 2-2.45	GA-BH04 2-2.45	GA-BH08 0.5-0.95	GA-BH09 0.5-0.67
			Client sampling date / time	27-Feb-2018 00:00	27-Feb-2018 00:00	28-Feb-2018 00:00	27-Feb-2018 00:00	28-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1806977-001	EB1806977-002	EB1806977-003	EB1806977-004	EB1806977-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**8.9**	**8.6**	**5.4**	**8.2**	**9.0**
EA084: Saturated Resistivity								
Resistivity at 25°C	----	10	ohm cm	**770**	**1480**	**390**	**450**	**1150**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**160**	**110**	**410**	**1040**	**150**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**190**	**20**	**690**	**150**	**140**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GA-BH10 2-2.36	GA-BH17 5-5.45	GA-BH14 3.5-3.95	----	----
			Client sampling date / time	01-Mar-2018 00:00	01-Mar-2018 00:00	01-Mar-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	EB1806977-006	EB1806977-007	EB1806977-008	--------	--------
				Result	Result	Result	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**9.7**	**10.0**	**9.7**	**----**	**----**
EA084: Saturated Resistivity								
Resistivity at 25°C	----	10	ohm cm	**700**	**360**	**310**	**----**	**----**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**100**	**70**	**520**	**----**	**----**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**60**	**330**	**910**	**----**	**----**

APPENDIX G

Important Information Relating to this Report

IMPORTANT INFORMATION RELATING TO THIS REPORT

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

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golder.com

Appendix G – Aeronautical impact assessment

MAY 2019

SILVERLEAF SOLAR FARM

AERONAUTICAL IMPACT ASSESSMENT

Prepared for GHD Pty Ltd

AVIATION PROJECTS

AVIATION PROJECTS

DOCUMENT CONTROL

Document Title: Silverleaf Solar Farm – Aeronautical Impact Assessment

Reference: 102301-01

Release Date: 07 March 2019

Prepared by: P Davidyuk

Reviewed by: K Tonkin

Released by: P Davidyuk

Revision History: Release

Revision History

Version	*Description*	*Transmitted*	*Reviewed by*	*Date*
0.1	First Draft	30 October 2018	D Mees	05 December 2018
0.2	Revised First Draft	06 December 2018	D Mees	11 December 2018
0.3	Final Draft	13 December 2018	D Mees	06 March 2019
0.4	Final Draft – incl YNBR OLS analysis	11 January 2019	D Mees	06 March 2019
1.0	Final Report	07 March 2019	D Mees	18 April 2019
1.1	Final Report (revised layout)	02 May 2019		

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TABLE OF CONTENTS

LIST OF FIGURES

ACRONYMS

AGL	above ground level
AHD	Australian Height Datum
AIP	Aeronautical Information Package
ALARP	as low as reasonably practicable
AMSL	above mean sea level
ARP	Aerodrome Reference Point
CAR	Civil Aviation Regulation (1988)
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulation (1998)
CFIT	controlled flight into terrain
ERSA	En Route Supplement Australia
ICAO	International Civil Aviation Organization
IFR	instrument flight rules
IMC	instrument meteorological conditions
MOS	Manual of Standards
MSA	minimum sector altitude
OLS	obstacle limitation surface
PANS-OPS	Procedures for Air Navigation Services - Aircraft Operations
RPT	regular public transport
SSF	Silverleaf Solar Farm
VFR	visual flight rules
VMC	visual meteorological conditions

UNITS OF MEASUREMENT

ft	feet	(1 ft = 0.3048 m)
km	kilometres	(1 km = 0.5399 nm)
m	metres	(1 m = 3.281 ft)
nm	nautical miles	(1 nm = 1.852 km)

EXECUTIVE SUMMARY

Introduction

GHD Pty Ltd (GHD) has been engaged by ENGIE Renewable Australia Pty Ltd to provide an Environmental Impact Statement (EIS) to support a planning application for the development of the Narrabri 120 MW Solar Farm, named Silverleaf.

The proposal site is located approximately 5 km (2.7 nm) north west of Narrabri, within the Narrabri Shire Council local government area. The proposal site consists of two rural properties located between Newell Highway in the east and Logans Lane in the west. The proposal site consists of the following lots:

- 330 Logans Lane – Lots 21 to 23 of DP 1174848; and
- 12461 Newell Highway – Lot 2 DP 586990.

The proposal site is also located adjacent to Oakville aerodrome. The aerodrome is operated by Aircair Aviation, a family owned aerial application business.

GHD engaged Aviation Projects to produce an Aeronautical Impact Assessment of potential impact of the proposed Silverleaf Solar Farm (referred to as the project in this report) on the aircraft operations at Oakville aerodrome and propose mitigation solutions if there are any impact identified during the assessment.

Conclusions

Aviation Impact Statement

The proposed Silverleaf Solar Farm:

- will not penetrate OLS surfaces of Oakville aerodrome and Narrabri Airport;
- will not affect any instrument procedures;
- will not have an impact on nearby designated air routes;
- will not have an impact on designated airspace;
- is wholly contained within Class G airspace; and
- is outside the clearance zones associated with aviation navigation aids and communication facilities.

Aircraft operations

The operator of Oakville aerodrome (Aircair Aviation) identified concerns in relation to the issues set out in the list below. The issues were considered and it was found that the proposed solar farm would not adversely impact aircraft operations at the aerodrome:

- risk of windshear and turbulence generated by the elevated solar panels;
- close location of solar panels at the southern end of runway 19; and
- solar glare.

Solar glare analysis

- A solar glare analysis using the ForgeSolar application found that:
    - Analysis time interval and eye characteristics used are acceptable; and
    - Flight path receptor(s) do not receive yellow (unacceptable) glare.
- Incorporation of an anti-reflective coating on the solar panels may serve to further reduce any potential glare issues.

Wind shear analysis

The maximum proposed height of the panel is 4.1 m above ground level (AGL). Therefore, a solar panel with a height of 4.1 m AGL would be acceptable if it is located more than 143.5 m from the Oakville aerodrome runway 01/19 centreline, providing the site is relatively level. The current project layout provides approximately 176 m buffer of the Oakville aerodrome runway 01/19 centreline. Any changes to the height of the panels will need to comply with the NASF Guideline B to ensure suitable/safe setback from the aerodrome.

Recommendations

The proposed Silverleaf Solar Farm can be approved on the basis that it will not have an adverse impact on aviation safety.

Recommended actions resulting from the conduct of this assessment are provided below.

Aircraft safety

1. The proponent should consider NASF Guideline B *Managing the Risk of Building Generated Windshear and Turbulence at Airports* mitigation measures set in Paragraphs 51-54 to manage the risk of solar panel generated windshear and turbulence at Oakville aerodrome.
2. The proponent should consider avoiding vertical obstruction of the area of approximately 300 m to 400 m south of the southern end of the runway.
3. The proponent should consider incorporation of an anti-reflective coating on the solar panels to further reduce any potential glare issues.
4. Overhead transmission lines and/or supporting poles that are located where they could adversely affect aerial application operations should be identified in consultation with local aerial agriculture operators and marked in accordance with MOS 139 Section 8.10.2.8.

Triggers for review

5. Triggers for review of this risk assessment are provided for consideration:

    a. prior to construction to ensure the regulatory framework has not changed;

    b. following any significant changes to the context in which the assessment was prepared, including the regulatory framework; and

    c. following any near miss, incident or accident associated with operations considered in this risk assessment.

1. INTRODUCTION

1.1. Situation

ENGIE Renewable Australia Pty Ltd (ENGIE) is preparing a planning application for the development of the Silverleaf Solar Farm (the project).

The project is located approximately 5 km (2.7 nm) north west of Narrabri, within the Narrabri Shire Council local government area. It is also located just to the east of Oakville aerodrome (aircraft landing area (ALA)).

GHD engaged Aviation Projects to consult with the owner of Oakville aerodrome (Aircair Aviation) to discuss his concerns in relation to the proposed SSF Project and then produce an Aeronautical Impact Assessment.

1.2. Scope

The scope of work for this engagement was defined as:

1. assess the OLS (Obstacle Limitation Surfaces) for the airstrip based on the runway alignment;
2. assess the OLS of Narrabri Airport relative to the proposed transmission line and its power poles;
3. review MOS (Manual of Safety) 139 aviation standards as mandated by CASA (Civil Aviation Safety Authority);
4. provide minimum setbacks based on maximum heights allowable;
5. take into account the RESA (Runway End Safety Area) as applicable;
6. research for other (inter)national commercial aerodromes which have solar arrays under the flight paths;
7. provide assessment of glare analysis for pilot safety operations (required for safety assessment); and
8. provide information on possible jetblast emitted from critical aircraft type (noting no modelling has been allowed for).

1.3. Methodology

In performing this task, the following activities were undertaken:

1. Confirm scope, requirements and administration arrangements;
2. Review background material;
3. Prepare a draft report for client review, that includes consideration of aerodrome safeguarding issues and a review of solar glare analysis using the ForgeSolar glare analysis tool; and
4. Prepare a final report for client acceptance.

1.4. Report structure

This report is structured around the following areas of consideration:

- Introduction;
- Background;
- External Context;
- Aviation Impact Statement;
- Aircraft operations;
- Similar Solar Farm Projects;
- Solar Glare analysis;
- Windshear and Turbulence;
- Conclusions; and
- Recommendations.

1.5. Stakeholders

An appropriate and justified level of consultation was undertaken with the following parties and/or considered in the preparation of this report:

- Aircair Aviation (operator of Oakville aerodrome); and
- other stakeholders where noted.

1.6. Material reviewed

Material provided by the Proponent for preparation of this assessment included:

- ENGIE, Silverleaf Solar Farm Layout, file name: Silverleaf Solar Layout_29052018.pdf, received 05 September 2018;
- GHD, Silverleaf Solar Farm Layout, file name: 21_26998_Z003_EIS_SolarFarmLayout.pdf, received 06 March 2019, dated 20 February 2019;
- GHD, Silverleaf Solar Farm Proposed Site, file name: ProposalSite_SilverleafSolarFarm_GHD_20181024.kmz, received 25 October 2018;
- GHD, Silverleaf Solar Farm Transmission Corridor, file name: TransmissionCorridor_SilverleafSolarFarm_GHD_20181024.kmz, received 25 October 2018; and
- GHD, Silverleaf Narrabri Solar Farm EIS, file name: 21_26998_Z003_EIS_SolarFarmLayout.pdf, received 29 April 2019.

1.7. References

References used or consulted in the preparation of this report include:

- Airservices Australia, Aeronautical Information Package; including AIP Book, Departure and Approach Procedures, and En Route Supplement Australia effective 28 February 2019;
- Aviation Projects, Narrabri Airport Master Plan, 2014;
- Civil Aviation Safety Authority, *Civil Aviation Regulations 1998 (CAR)*, as amended;
- Civil Aviation Safety Authority, *Civil Aviation Safety Regulations 1998 (CASR)*, as amended;
- Civil Aviation Safety Authority, Civil Aviation Advisory Publication (CAAP) 92-1(1): Guidelines for aeroplane landing areas, dated July 1992;
- Civil Aviation Safety Authority, Civil Aviation Advisory Publication (CAAP) 166-1(3): Operations in the vicinity of non-controlled aerodromes, v4.1, File Ref D17/87576 dated April 2017;
- Civil Aviation Safety Authority, *Manual of Standards Part 139 – Aerodromes*, version 1.14: dated January 2017;
- Civil Aviation Safety Authority, Manual of Standards Part 173 – Standards Applicable to Instrument Flight Procedure Design, version 1.5, dated March 2016;
- Department of Infrastructure and Regional Development, Australian Government, *National Airport Safeguarding Framework, Guideline B Managing the Risk of Building Generated Windshear and Turbulence at Airports*;
- International Civil Aviation Organization (ICAO) Doc 8168 Procedures for Air Navigation Services—Aircraft Operations (PANS-OPS);
- ICAO Standards and Recommended Practices, *Annex 14—Aerodromes*;
- OzRunways, dated 08 November 2018; and
- other references as noted.

2. BACKGROUND

2.1. Site overview

The project is 5 km (2.7 nm) north west of Narrabri, within the Narrabri Shire Council local government area. It is also located to the east of Oakville aerodrome. An overview of the project boundary (in pumpkin) relative to Oakville aerodrome runway (in black) is provided in Figure 1 (source: GHD and Google Earth).

Figure 1 Project site overview

2.2. Project description

The project involves construction of a solar farm within the site boundaries, connecting to proposed overhead electricity transmission lines.

The solar photovoltaic (PV) panels will be single axis tracking systems employ an actuator system that rotates an axel so that the panels track the sun from east to west over the course of a day, with an amplitude of ±50° to ±60°. Each tracking system can support one row of PV panels (1V configuration) or two rows (2V). Based on ±60° amplitude, the maximum elevation of panels is:

- 2.4 m for 1V; and
- 4.1 m for 2V.

Note: PV plant will be either completely 1V or completely 2V.

Figure 2 shows the current layout and site project envelope (source: GHD, Silverleaf Narrabri Solar Farm EIS, Figure 3-1, Revision A, dated 21 March 2019).

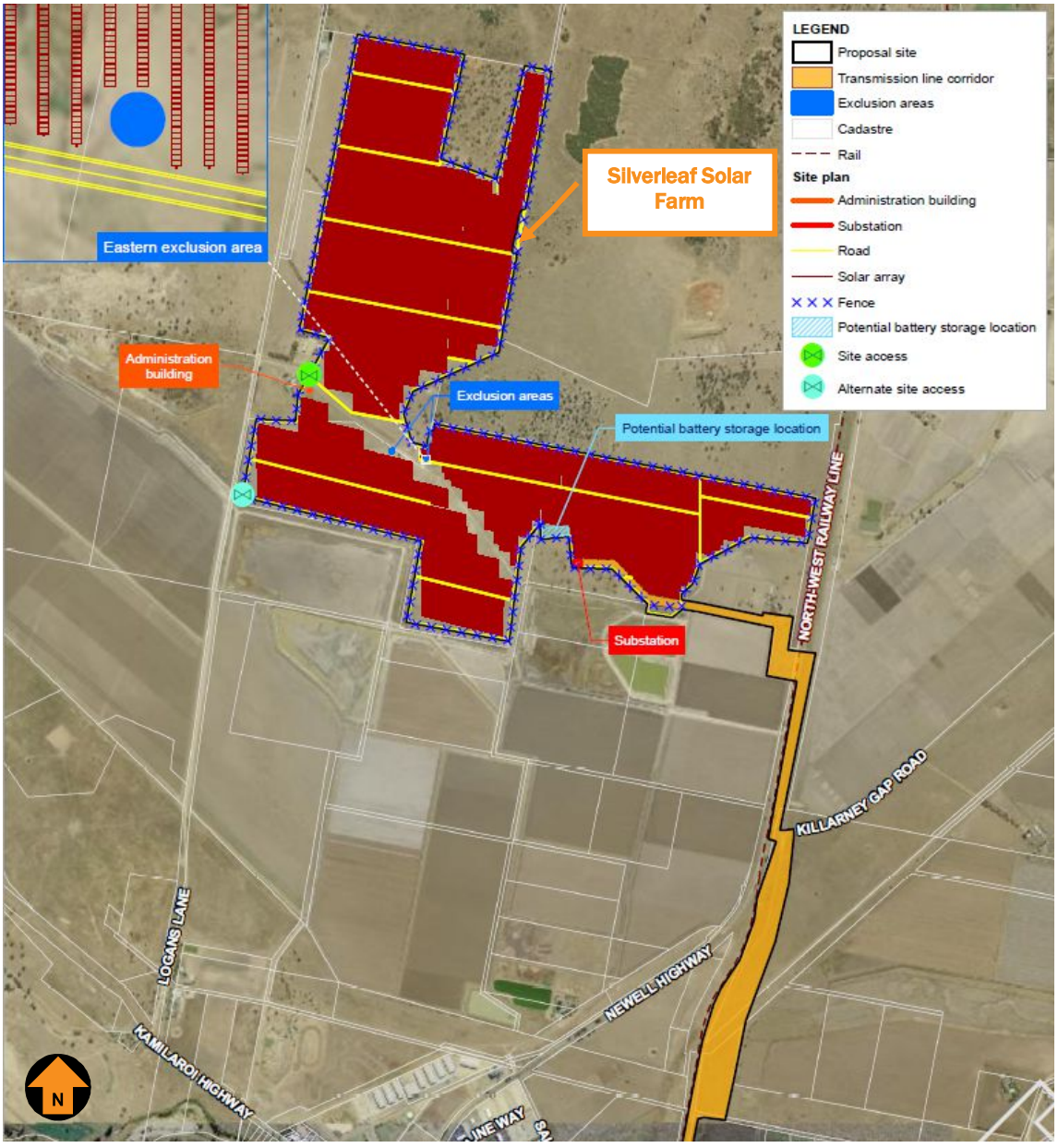


Figure 2 Project layout and project envelope

Figure 3 shows the proposed transmission line connecting the project with existing power line infrastructure (source: GHD and Google Earth).

Figure 3 Proposed transmission line

3. EXTERNAL CONTEXT

3.1. Overhead power lines

There is no regulatory requirement to mark or light power poles or overhead transmission lines.

According to the Aerial Agricultural Association of Australia (AAAA) *Powerlines Policy* dated March 2011:

> *Most agricultural land in Australia is crisscrossed with powerlines and aerial application companies and pilots put enormous effort into managing these hazards safely, generally using a risk identification, assessment and management process in line with Australian Standard AS4360/ISO 3[1]000.*
>
> *The agricultural pilot curriculum mandated by CASA includes training for the safe management of powerlines and AAAA has been active in providing ongoing professional development for application pilots that includes a focus on planning, risk management and a knowledge of human factors relevant to managing powerlines in a low-level aviation environment.*
>
> *AAAA runs a specific training course for aerial application pilots entitled 'Wire Risk Management' to address these issues.*

3.2. Civil Aviation Safety Authority

The Civil Aviation Safety Authority (CASA) regulates aviation activities in Australia. Applicable requirements include the Civil Aviation Regulations 1988 (CAR), Civil Aviation Safety Regulations 1998 (CASR) and associated Manual of Standards (MOS) and other guidance material.

Consideration could be given to marking transmission line according to the requirements set out in MOS 139 Section 8.10 Obstacle Markings; specifically:

> *8.10.2.8 Wires or cable obstacles must be marked using three-dimensional coloured objects such as spheres and pyramids, etc; of a size equivalent to a cube with 600 mm sides, spaced 30 m apart.*

It is prudent to consider potential adverse impacts on aerial application operations. Overhead transmission lines and/or supporting poles that are located where they could adversely affect aerial application operations should be identified in consultation with local aerial agriculture operators and marked in accordance with MOS 139 Section 8.10 Obstacle Markings; specifically:

> *8.10.2.8 Wires or cable obstacles must be marked using three-dimensional coloured objects such as spheres and pyramids, etc; of a size equivalent to a cube with 600 mm sides, spaced 30 m apart.*

4. AVIATION IMPACT STATEMENT

4.1. Nearby registered / certified aerodromes

Narrabri Airport (YNBR) is the only certified, registered or military aerodrome that is located within 30 nm of the project. The airport is located approximately 5.2 km (2.8 nm) south east of the southern boundary of the project and approximately 2 km (1.1 nm) south east of the proposed transmission corridor.

The location of Narrabri Airport relative to the project site and the proposed transmission corridor is shown in Figure 4 (source: GHD and Google Earth).

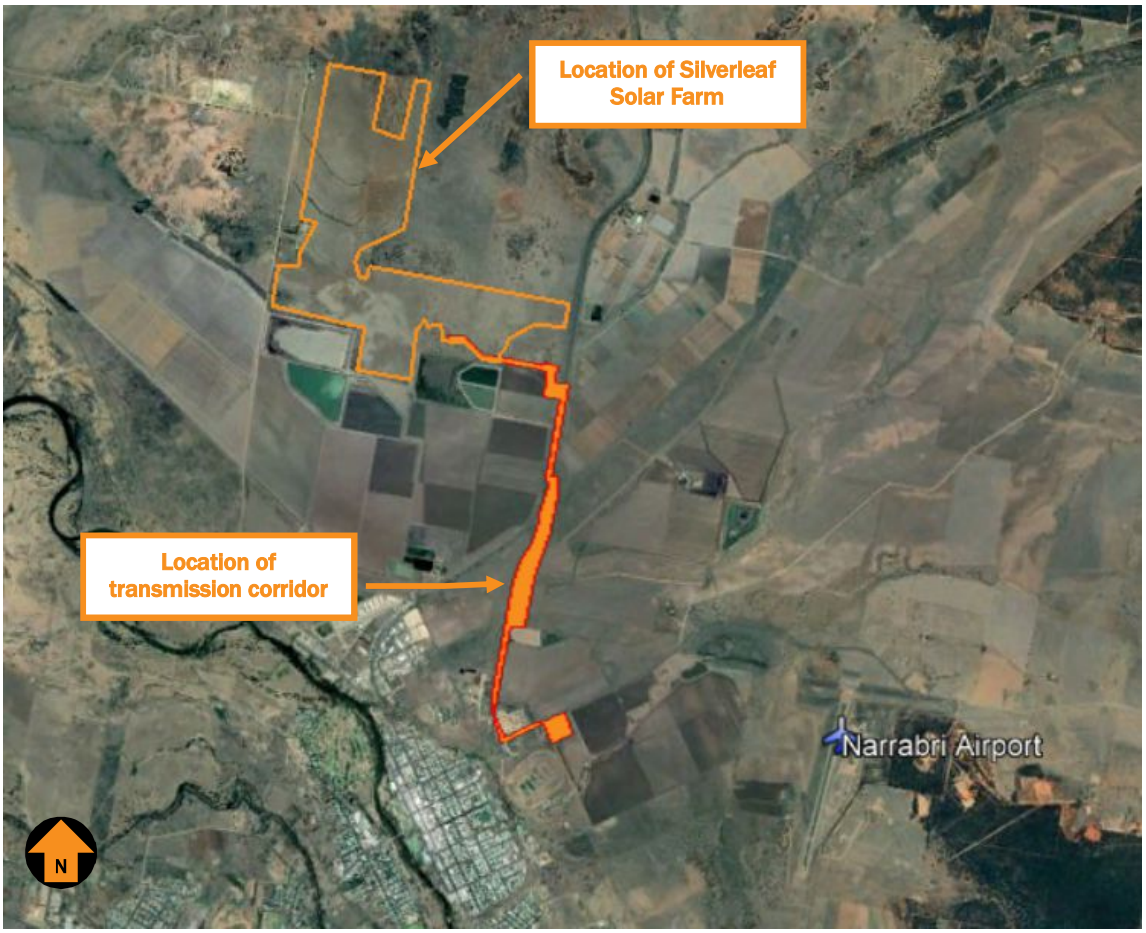


Figure 4 Project site and proposed transmission corridor relative to Narrabri Airport

Narrabri Airport is a certified, Code 3, instrument non-precision aerodrome, operated by Narrabri Shire Council, with a published aerodrome elevation of 240 m AHD (788 ft AMSL) (source: Airservices Australia, Aerodrome Chart NBRAD01-151, 25 May 2017).

Narrabri Airport has two runways:

- runway 18/36 sealed surface with a length of 1765 m, width 30 m and runway strip 150 m; and
- runway 09/27 grass surface with a length of 1213 m, width 30 m and runway strip 90 m.

Figure 5 shows the Narrabri Airport (YNBR) runway layout (source: Airservices Australia, Aerodrome Chart NBRAD01-151, 25 February 2019).

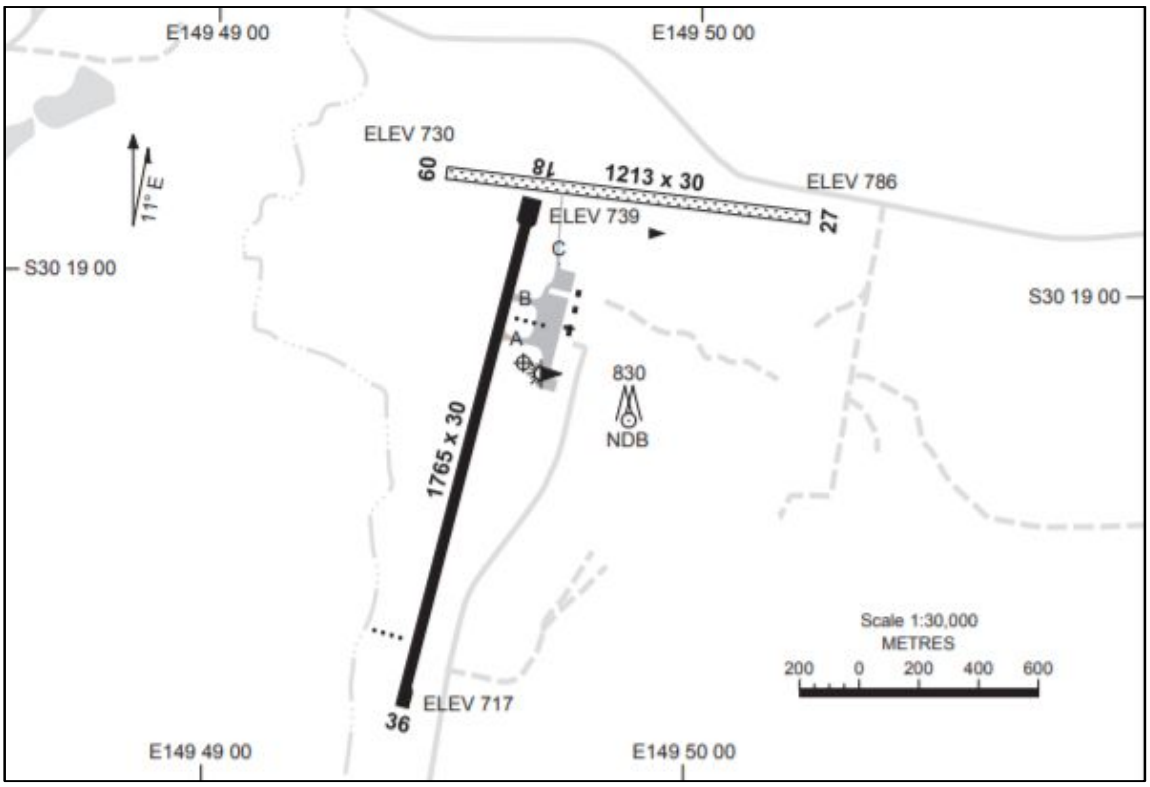


Figure 5 Narrabri Airport (YNBR) runway layout

4.2. Instrument procedures

A check of Aeronautical Information Package (AIP) via the Airservices Australia website showed that Narrabri Airport is served by non-precision terminal instrument flight procedures (source: Airservices Australia, effective 08 November 2018). Instrument procedures for Narrabri Airport in use are for runway 18/36, consisting of the NDB RWY 36 and RNAV-Z (GNSS) RWY 36.

Table 1 identifies the aerodrome and procedure charts for Narrabri Airport, designed by Airservices Australia (AsA).

Table 1 Narrabri Airport (YNBR) aerodrome and procedure charts

Chart name	*Effective date*
AERODROME CHART (AsA)	28 February 2019 (NBRAD01-158)
GNSS ARRIVAL PROCEDURES (AsA)	01 March 2018 (NBRDG01-154)
NDB RWY 36 (AsA)	24 May 2018 (NBRNB01-155)
RNAV-Z (GNSS) RWY 36 (AsA)	28 February 2019 (NBRGN01-158)

4.3. Narrabri Airport obstacle limitation surfaces

Runway 18/36 at Narrabri Airport is an instrument, non-precision Code 3 runway. According to MOS 139 Chapter 7, the critical obstacle limitation surfaces for an instrument, non-precision Code 3 runway are as follows:

- Inner horizontal surface 4000 m in radius and up to 45 m in height;
- Approach and take-off surface total length – 15 000 m; and
- Transitional surface – at 14.3% slope from the edge of a runway strip.

The maximum horizontal distance that an obstacle limitation surface (OLS) may extend for an aerodrome in Australia is 15 km (8.1 nm) from the edge of a runway strip.

4.4. Inner horizontal surface

The project site is located approximately 5 km (2.7 nm) north west of Narrabri Airport ARP, which is outside the maximum extent of the inner horizontal surface for a Code runway. Therefore, the project will not impact the inner horizontal surface of Narrabri Airport.

However, the proposed transmission corridor is located within the horizontal extent of the inner horizontal surface. This surface is a horizontal plane at 45 m above Narrabri Airport's mean elevation datum and within the radius of 4000 m from Narrabri Airport.

Figure 6 shows an indicative inner horizontal surface of Narrabri Airport relative to the project and the proposed transmission corridor (source: GHD and Google Earth).

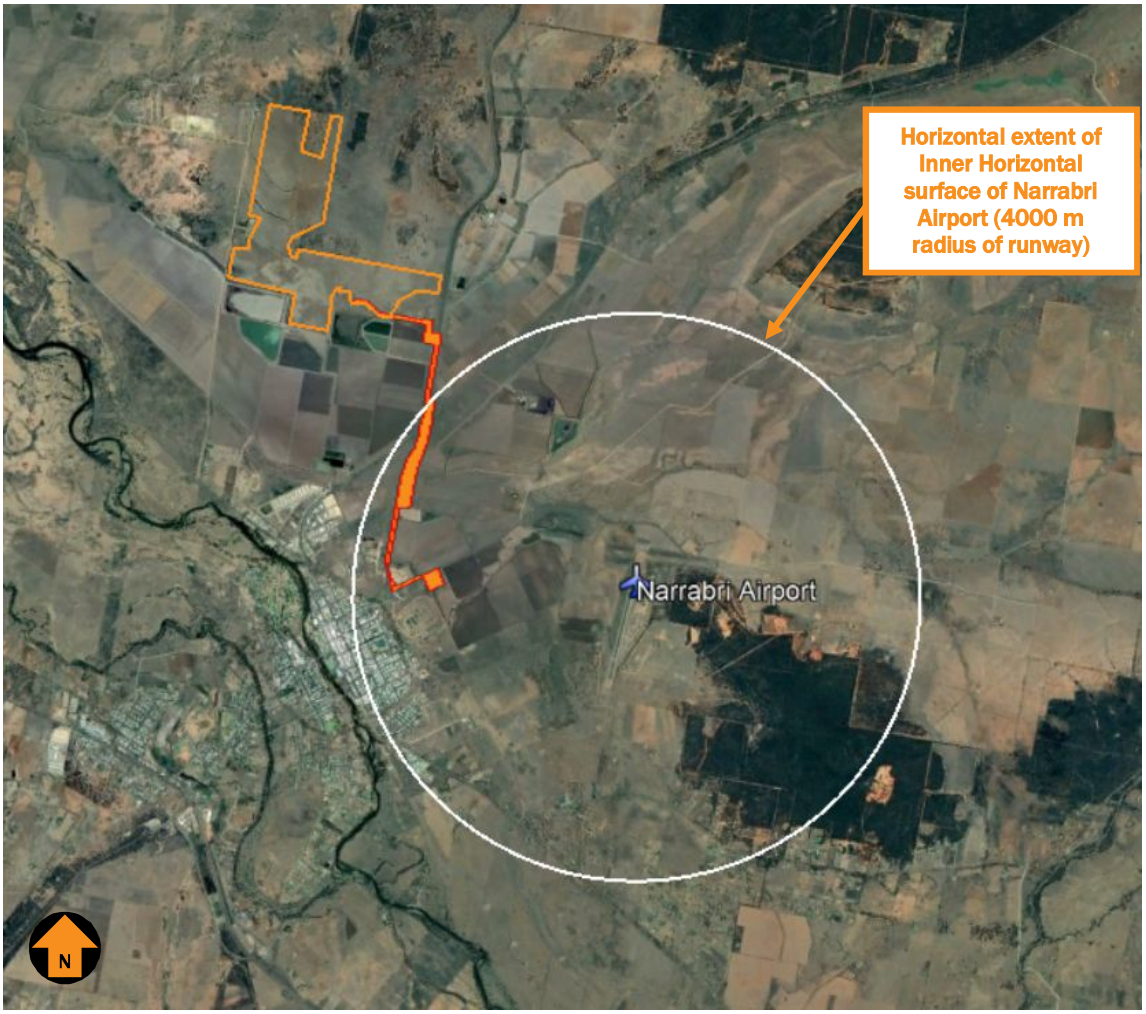


Figure 6 Narrabri Airport inner horizontal surface vs the project

The pole height is estimated between 20 m and 30 m AGL. For the purposes of this analysis, the maximum pole height of 30 m is considered.

The ground elevation at the proposed location of the transmission corridor varies. The maximum ground elevation is 219 m AHD (718 ft AMSL). Refer to Figure 7.

Note: Yellow sketched lines show an indicative location of power line poles.

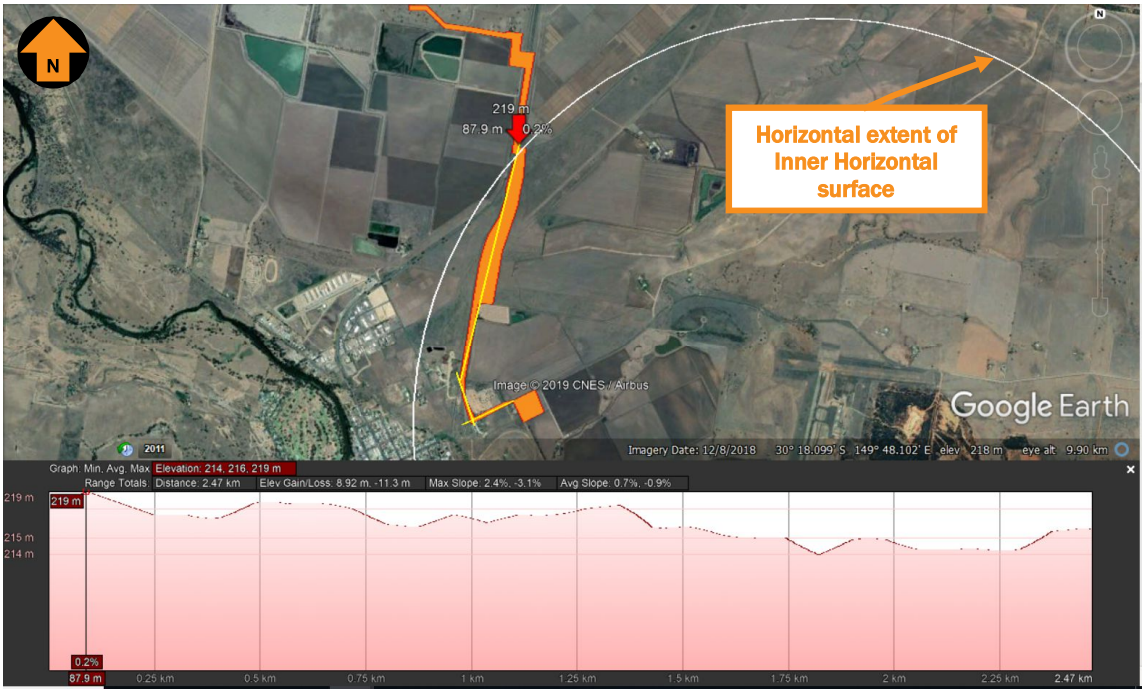


Figure 7 The ground elevation profile of the proposed transmission corridor

The proposed development site is constrained by the inner horizontal surface at a height of approximately 271 m AHD (889 ft AMSL), which is based on the average elevation of four runway thresholds at 226 m AHD (743 ft AMSL) plus 45 m height of the inner transitional surface.

The maximum power pole height is 249 m AHD (817 ft AMSL) which is approximately 22 m AHD (72.2 ft AMSL) below the upper limit of the inner horizontal surface. Therefore, the proposed transmission corridor will not impact the inner horizontal surface.

Note: The results need to be confirmed following terrain elevation survey of power line layout.

4.5. Approach and take-off surface

The project and the proposed transmission corridor will be located parallel and outside the horizontal extent of Narrabri Airport runway 18 approach surface (in white) and runway 36 take-off surface (in red) and will not have an impact on this surface. Refer to Figure 8 (source: GHD and Google Earth).

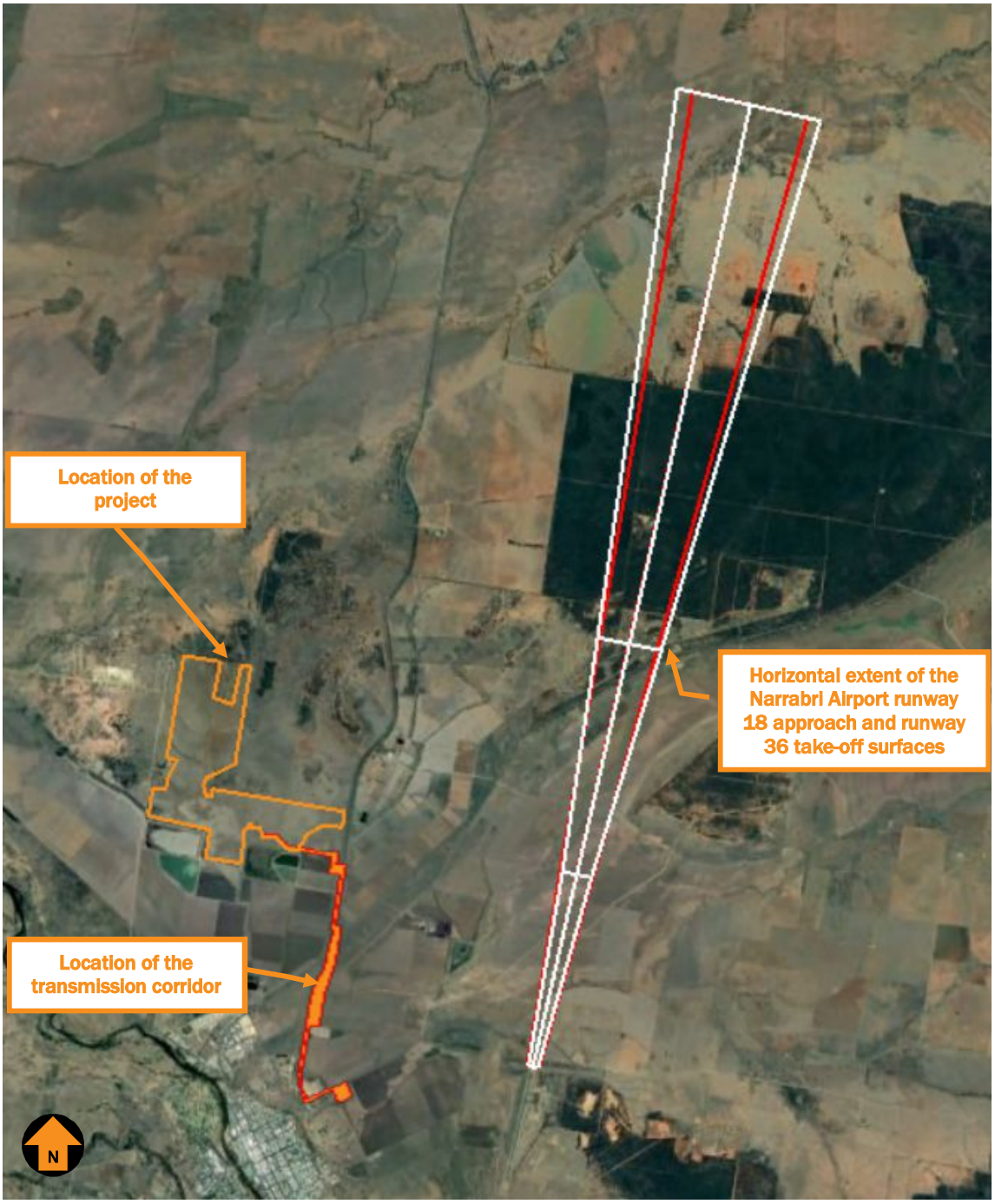


Figure 8 Narrabri Airport runway 18 approach and runway 36 take-off surfaces

The project will be located parallel and outside the horizontal extent of Narrabri Airport runway 09/27 approach and take-off surface and will not impact this surface. Refer to Figure 9.

However, the proposed transmission corridor is within the horizontal extent of Narrabri Airport runway 27 take-off surface (in red colour) but outside runway 09 approach surface (in white colour).

Currently, runway 09/27 at Narrabri Airport is a non-instrument Code 2 runway. For the purposes of this analysis, a Code 3 non-instrument runway is adopted for OLS assessment given Narrabri Airport Master Plan 2014 provides the provision for the expansion of runway 09/27.

According to MOS 139 Chapter 7, the approach surface for a Code 3 non-instrument runway extends up to 3000 m and slopes at 3.33 per cent from the ground elevation of Narrabri Airport runway 09 threshold, which is 225 m AHD.

The take-off surface for a Code 3 runway extends up to 15 000 m and slopes at 2 per cent from the ground elevation of Narrabri Airport runway 27 threshold and has the final width of 1800 m.

Runway 27 threshold elevation is 239.5 m AHD.

Figure 9 shows an indicative projection of Narrabri Airport runway 09 approach surface (in white) and runway 27 take-off surface (in red) relative to the project and the proposed transmission corridor (source: GHD and Google Earth).

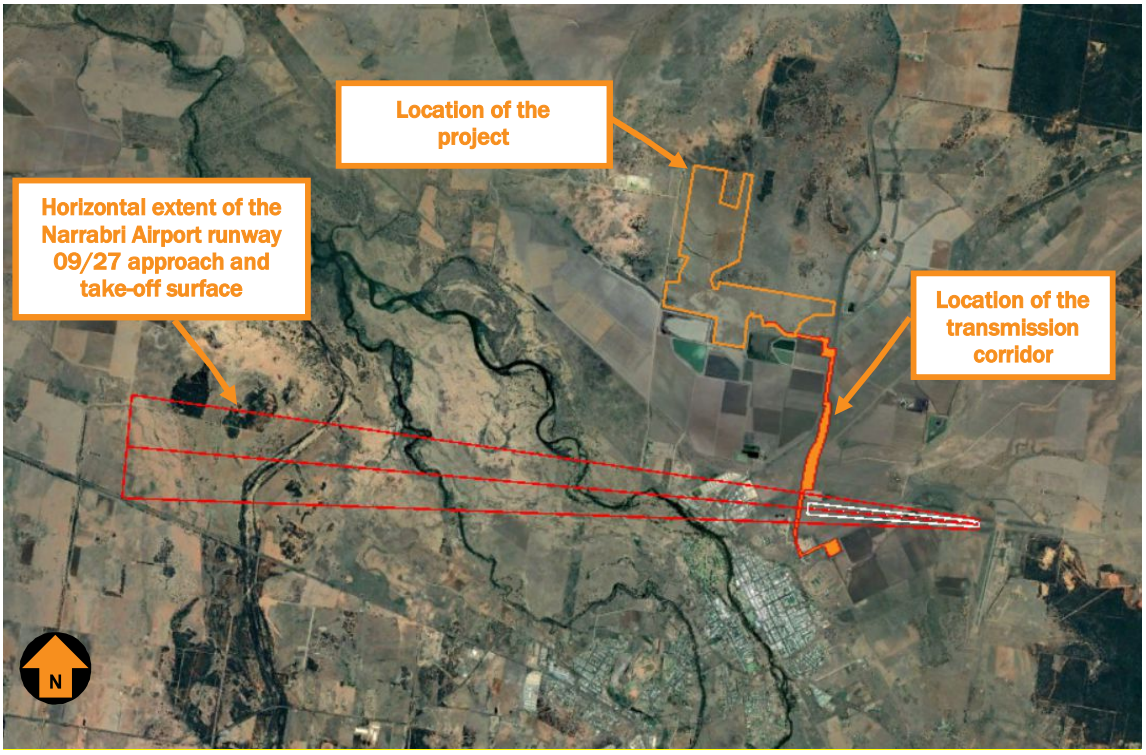


Figure 9 Narrabri Airport runway 09 approach and runway 27 take-off surfaces

The ground levels where the proposed transmission corridor intercepts the horizontal extent of runway 27 take-off surface are approximately 215 m AHD (at interception point A).

Figure 10 shows a close view of horizontal extent of runway 27 take-off surface relative to interception point A.

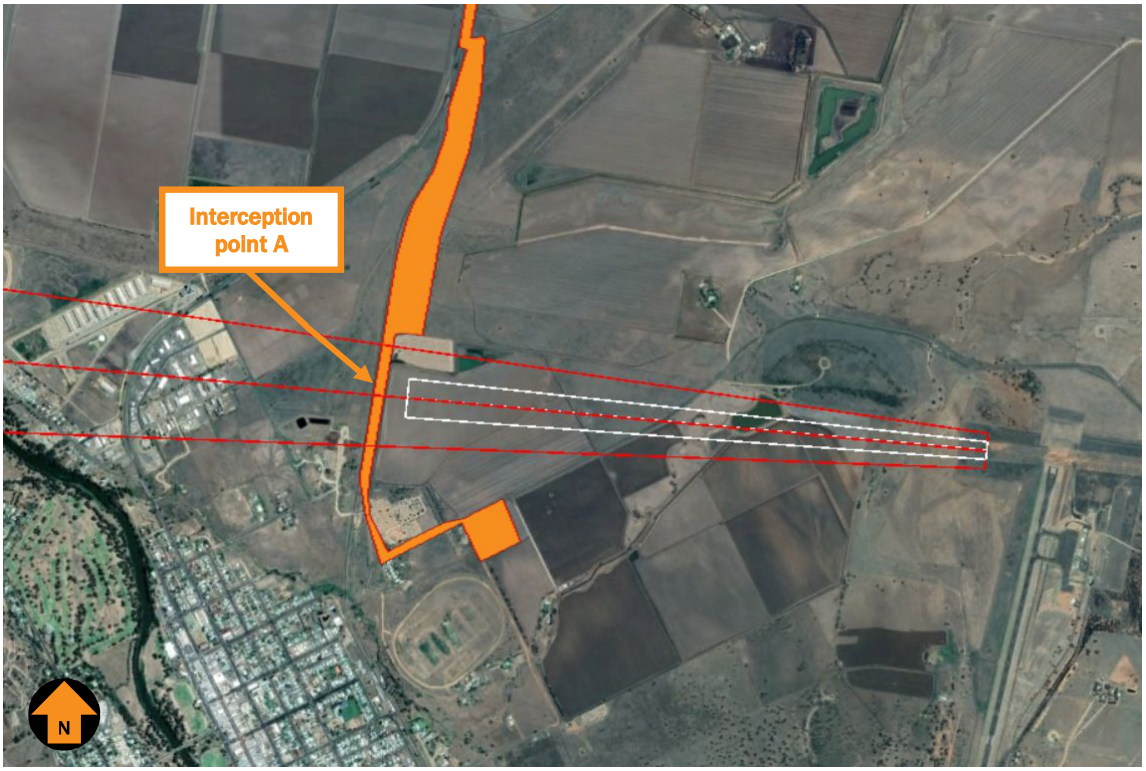


Figure 10 Narrabri Airport runway 27 take-off surface at interception point A

The maximum heights of the proposed power pole are approximately 245 m AHD (at interception point A).

The maximum heights of horizontal extent of runway 27 take-off surface at the interception point A with the proposed powerline corridor are approximately 302.7 m AHD. Therefore, the proposed 30 m high power pole will be approximately 57.7 m below the take-off surface at interception point A and will not penetrate this surface.

Note: The results need to be confirmed following terrain elevation survey of power line layout.

4.6. Transitional surface

The transitional surface originates at the lower edge from Narrabri Airport runway strip and is below the inner horizontal surface. Therefore, the project and the proposed transmission corridor will not impact the transitional surface of Narrabri Airport.

4.7. Nearby ALAs

The nearest aircraft landing area (ALA) is Oakville aerodrome, which is an uncertified privately-owned aerodrome. The aerodrome is located just to the west of the project, as shown in Figure 11 (source: OzRunways, Hybrid VFR overlay).

Note: Narrabri Airport is located approximately 4.9 km (2.7 nm) south east of the proposal site.

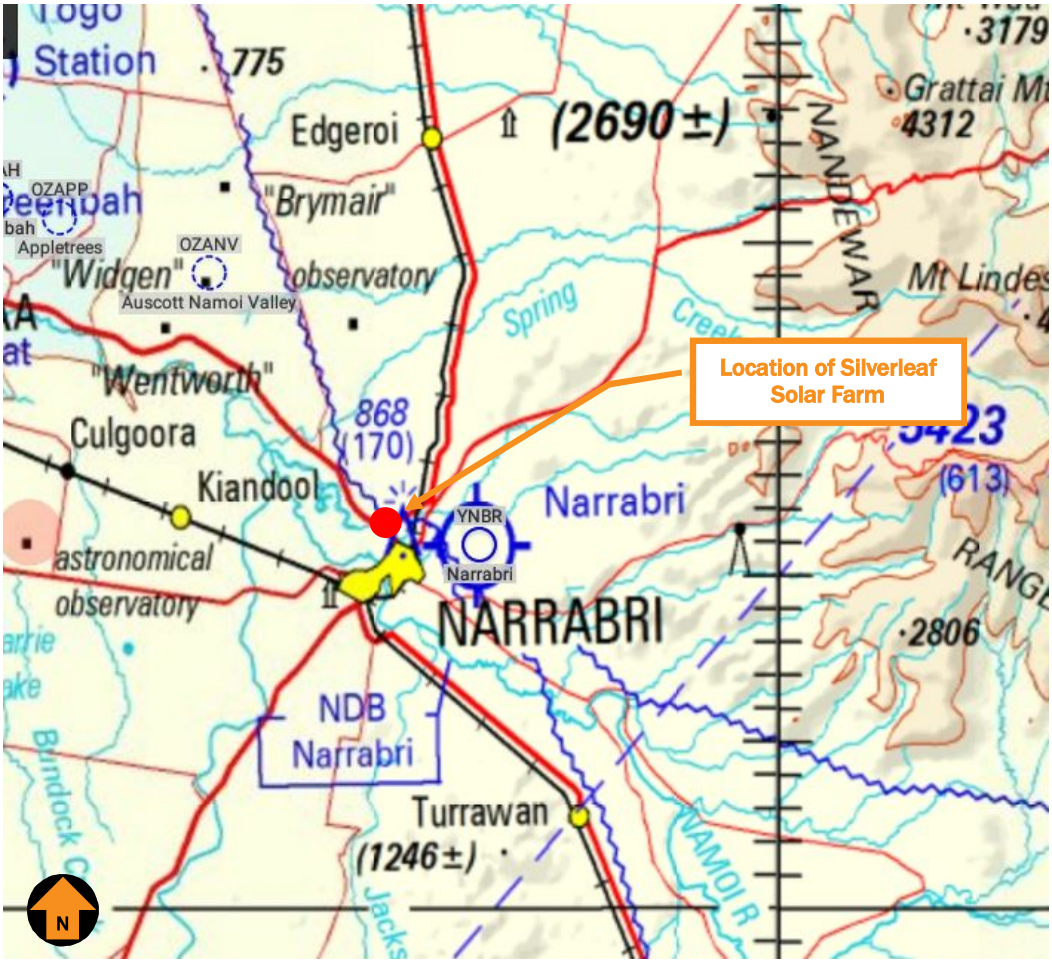


Figure 11 Location of project in relation to Oakville aerodrome

4.8. Instrument procedures

Oakville aerodrome is not equipped with instrument procedures.

4.9. Oakville aerodrome obstacle limitation surfaces

As a means of providing guidance to ALA operators, CASA has published recommended practices in its Civil Aviation Advisory Publication (CAAP) 92-1(1) Guidelines for aeroplane landing areas.

The purpose of the CAAP 92-1(1) guidance is described as follows:

> *These guidelines set out factors that may be used to determine the suitability of a place for the landing and taking-off of aeroplanes. Experience has shown that, in most cases, application of these guidelines will enable a take-off or landing to be completed safely, provided that the pilot in command:*
>
> *a. has sound piloting skills; and*
>
> *b. displays sound airmanship.*

A copy of CAAP 92-1(1) Figure 2A – *Single engined and Centre-Line Thrust Aeroplanes not exceeding 2000 kg MTOW (day operations),* which shows the physical characteristics applicable to the circumstances, is provided in Figure 12.

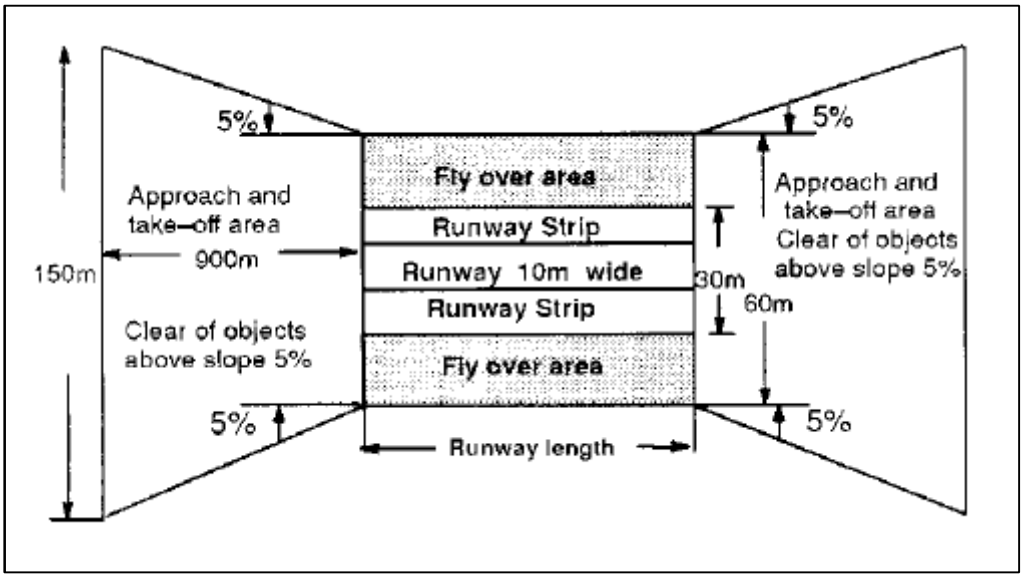


Figure 12 CAAP 92-1(1) Figure 2A

The approach and take-off surface for each runway end commence at the runway end (threshold) at a distance of 75 m either side of the runway centreline and diverge at a rate of 5% to a distance of 900 m (source: CAAP 92-1 (1)).

If there are obstacles located within a distance of 900 m from the runway centreline and/or at a distance of 75 m either side of the runway centreline the flight safety is compromised.

Figure 13 shows indicative approach and take-off surface (in red) at Oakville aerodrome relative to the proposed SSF site (in pumpkin) (source: GHD and Google Earth).

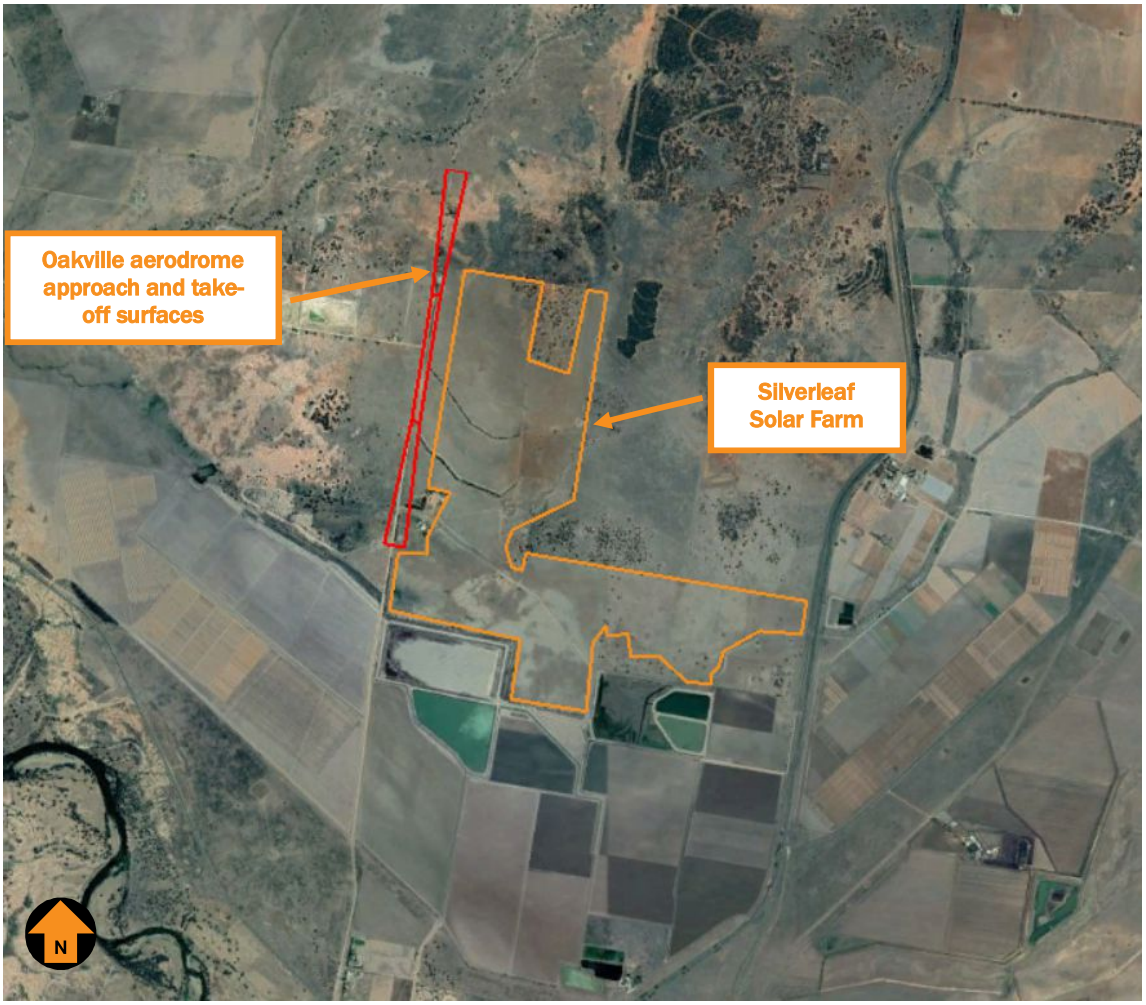


Figure 13 Indicative approach and take-off surfaces at Oakville aerodrome

The project site is located at a distance from the Oakville aerodrome runway 01/19 centreline and will not likely impact the approach and take-off surfaces of Oakville aerodrome.

4.10. Airspace

The project is located outside of controlled airspace (wholly within Class G airspace) and is not located in any Prohibited, Restricted and Danger areas.

The nearest restricted area R524 is located approximately 24 km (13 nm) west of the project. The area is vertically limited from the ground surface up to 2500 ft AMSL and operated by CSIRO Narrabri 24 hours/day.

Therefore, the site area of the project is outside R524 restricted area and will not have an impact on controlled or designated airspace.

4.11. Air routes and LSALT

The project will not affect air routes or grid lowest safe altitudes. Refer to Figure 14 (source: OzRunways, ERC Low National overlay, 24 April 2019).

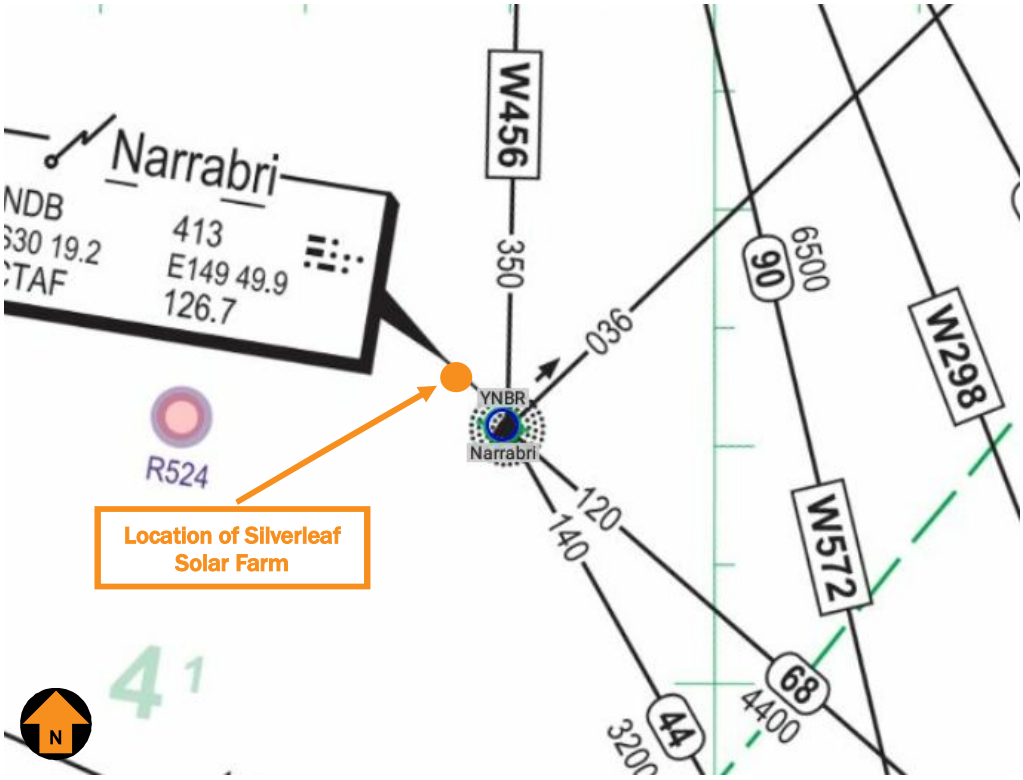


Figure 14 Enroute Chart overlay

4.12. Aviation facilities

A search on OzRunways, which sources its data from Airservices Australia (AIP) and AOPA National Airfield Directory datasets, was conducted to identify any aviation facilities that may be affected by the project. The closest aviation facility is a non-directional beacon (NDB) located at Narrabri Airport at a distance of approximately 5.5 km (3 nm). According to National Airports Safeguarding Framework Guideline G *Protecting Aviation Facilities - Communication, Navigation and Surveillance (CNS),* a NDB's building restricted area (BRA) is within a maximum radius of 300 m. As a result, the project will not interfere with Narrabri NDB and any other aviation facilities.

4.13. Radar

With respect to aviation radar facilities, the closest radar is Mt Sandon Secondary Surveillance Radar (SSR) located approximately 197 km (106 nm) south east from the proposed SSF site. Given the height of solar panels and a distance at which radar is located, the project will not interfere with Mt Sandon SSR.

4.14. Summary

The project:

- will not penetrate OLS surfaces of Oakville aerodrome and Narrabri Airport;
- will not affect any instrument procedures;
- will not have an impact on nearby designated air routes;
- will not have an impact on designated airspace;
- is wholly contained within Class G airspace; and
- is outside the clearance zones associated with aviation navigation aids and communication facilities.

5. AIRCRAFT OPERATIONS

5.1. Operations at Oakville aerodrome

Oakville aerodrome is an uncertified privately-owned aerodrome, meaning that it is not regulated by the Civil Aviation Safety Authority (CASA). The aerodrome features one runway – 01/19 which is approximately 1100 m long.

The aerodrome is operated by Aircair Aviation, a family owned aerial application business. Further information on Aircair Aviation business can be found on the company corporate website (http://www.aircair.com.au/#1#home).

Runway 01 is used for departure (in strong northerly wind conditions) and arrival while runway 19 is mainly used for departure. The aircraft operations are mainly conducted during the day hours with some infrequent take offs at night.

The following types of aircraft are operating from Oakville aerodrome:

- Air Tractor AT502;
- Air Tractor AT802; and
- light aircraft (i.e., Cessna).

The maximum take-off weight (MTOW) of aircraft operating from Oakville aerodrome is not exceeding 7500 kg.

5.2. Operator consultation

A phone conference was conducted on 26 October 2018 with Mr Angus Ashby, the owner of Oakville aerodrome. He provided a detailed description of aircraft operations that are conducted at the aerodrome, commensurate with its uncertified status:

- aerial agricultural operations; and
- private operations using VH-registered and recreational aviation (ultralight) aircraft.

The aerial agricultural operations are mainly performed during dry seasons and have a low number of aircraft movement during the months of May, June, October and November.

5.3. Other

Royal Flying Doctor Service (RFDS) does not perform flights to Oakville aerodrome.

An aerial view of Oakville aerodrome is provided at Figure 15 (source: GHD and Google Earth).

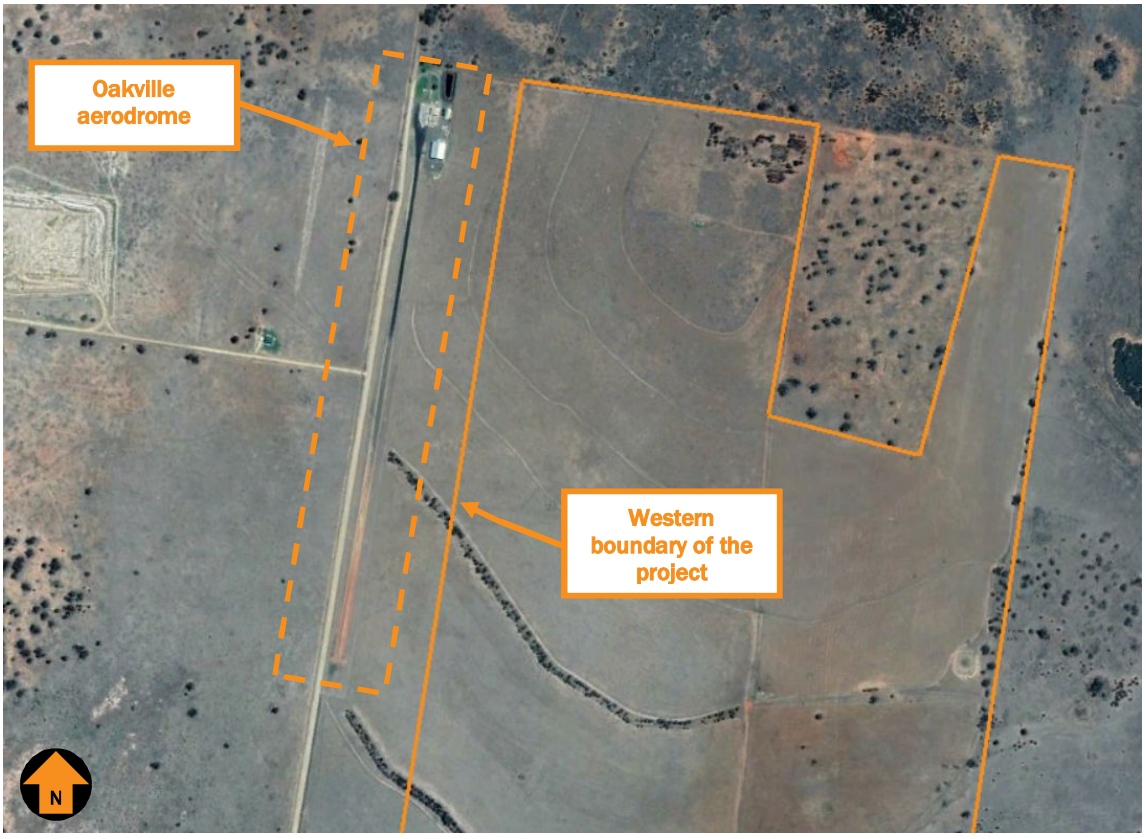


Figure 15 Aerial view of Oakville aerodrome

Figure 16 provides a close view of the northern end of runway 01 with adjacent area, three sheds and a small office building (source: Google Earth).

Figure 16 Runway 01 (northern end) and aerodrome infrastructure

5.4. Requested clear area

The project is located approximately 144 m east of the Oakville aerodrome fence. Some of the solar panels are proposed south of the southern end of the runway. This has been identified as a specific cause for concern to operator of Oakville aerodrome. However, the client will be satisfied if there are no panels located between the row of trees located approximately 600 m south of the runway (circled in Figure 17) and the southern end of the runway. Figure 17 shows the concept layout of the project (source: GHD, Silverleaf Solar Farm layout, 20 February 2019).

Figure 17 Project concept layout

Based on the project layout and solar panel locations a clear area of approximately 867 m will be provided south of the runway 19 end.

6. SIMILAR SOLAR FARM PROJECTS

Numerous airports around the world have solar farms located on their premises.

6.1. Projects in Australia

Among those airports in Australia where solar farms have been constructed are Karratha Airport (WA), Darwin Airport (Northern Territory) and Ballarat Airport VIC).

Figure 18 illustrates the location of the solar farm relative to Karratha Airport runway 08/26 which located approximately 1110 m north west of runway 26 threshold (source: Google Earth).

Figure 18 Karratha Airport and solar farm

The most similar solar farm project to the Silverleaf SF project is located at Darwin Airport in Northern Territory. Figure 19 shows the location of the solar farm located approximately 189 m north east of runway 29 centreline (source: Google Earth).

Figure 19 Darwin International Airport and solar farm

Figure 20 shows the location of the solar farm located approximately 188 m south west runway 05 threshold at Ballarat Airport (source: Google Earth).

Figure 20 Ballarat Airport and solar farm

6.2. International projects

Internationally, solar farms have been installed at or near airports in USA, India, Germany and other countries.

Figure 21 illustrates the location of the solar farm at Fresno Yosemite International Airport (California, USA) which is located approximately 742 m south east of runway 29R threshold and approximately 1100 m south east from runway 29R centreline extension.

Figure 21 Fresno Yosemite International Airport and solar farm

Figure 22 shows the location of the solar farms relative to runway 09/27 which are located approximately 400 m to 700 m north from the runway centreline at Cochin International Airport (Kochi, India).

Figure 22 Cochin International Airport and solar farms

The most similar international solar farm project to the Silverleaf SF project is Neuhardenberg Solar Park which is located in a close proximity to Neuhardenberg Airport (Germany). Figure 23 provides an aerial view of Neuhardenberg Solar Park (source: Google Earth, 2010) and Figure 24 provides an image of the solar park (source: Google, 2018).

Figure 23 Neuhardenberg Solar Park - aerial view

Figure 24 Neuhardenberg Solar Park – image

6.3. Summary

No evidence could be found from existing solar energy projects around the world of any reported problems of glare or windshear affecting pilots. This includes many projects in Australia and worldwide.

7. SOLAR GLARE ANALYSIS

Solar photovoltaic panels can produce glint (a momentary flash of bright light) and glare (a continuous source of bright light), which could result in an ocular impact to pilots.

7.1. Civil Aviation Safety Authority

The Civil Aviation Safety Authority (CASA) regulates aviation safety outcomes in Australia. CASA has not published any formal direction in relation to the consideration of solar glare.

The National Airport Safeguarding Framework provides guidance on the potential risk of distractions to pilots of aircraft from lighting and light fixtures near airports but does not specifically address solar glare.

7.2. Federal Aviation Administration

The Federal Aviation Administration (FAA) provided a free tool called *Solar Glare Hazard Analysis Tool* (SGHAT) and supporting Interim Policy 78 FR 63276 for the assessment of solar glare.

The assessment requirement specified:

> *No potential for glare or "low potential for after-image" along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath.*

SGHAT was withdrawn from public access in 2017. The ForgeSolar glare analysis tool is recommended instead for non-military/government users.

7.3. ForgeSolar analysis

A glare analysis was prepared using the ForgeSolar application.

The analysis determined that flight path (FP) 1, the approach to runway 19, is exposed 11,227 minutes of green (acceptable) glare during the year. Flight path (FP) 2, the approach to runway 01, has no exposure of green or yellow glare.

In terms of adherence to the FAA policy, it was found that:

1. Analysis time interval and eye characteristics used are acceptable; and
2. Flight path receptor(s) do not receive yellow glare.

The analysis was prepared on the basis that there is no anti-reflective coating on the solar panels. Incorporation of an anti-reflective coating may serve to further reduce any potential glare issues. The revised project layout (21_26998_Z003_EIS_SolarFarmLayout, 20 February 2019) will unlikely change the results of the ForgeSolar glare analysis given that the revised project site area is within the original area of investigation.

A full copy of the glare analysis report is provided at Annexure 1.

8. WINDSHEAR AND TURBULENCE

Solar photovoltaic panels can produce windshear by reflecting north east and south east winds, which are common in the area of the project. The windshear could affect aircraft airspeed during take-off and landing. This has been identified as a specific cause for concern to pilots operating at Oakville aerodrome.

8.1. Department of Infrastructure, Regional Development and Cities

The Department of Infrastructure, Regional Development and Cities released the National Airports Safeguarding Framework (NASF) Principles and Guidelines. *Guidelines B Managing the Risk of Building Generated Windshear and Turbulence at Airports* is purposed to:

> *To provide guidance to Commonwealth, state/territory and local government decision makers and airport operators to manage the risk of building generated windshear (i.e. changes in wind speed and/or direction between two points) and building generated turbulence (i.e. rapid irregular changes in wind speed and/or direction at a fixed point) at airports.*

Guidelines B provides details on mitigation of risk by building siting and location. Figure 25 provides a copy of Figure 1 of the Guidelines B that shows assessment trigger area around runways, within which building should be assessed.

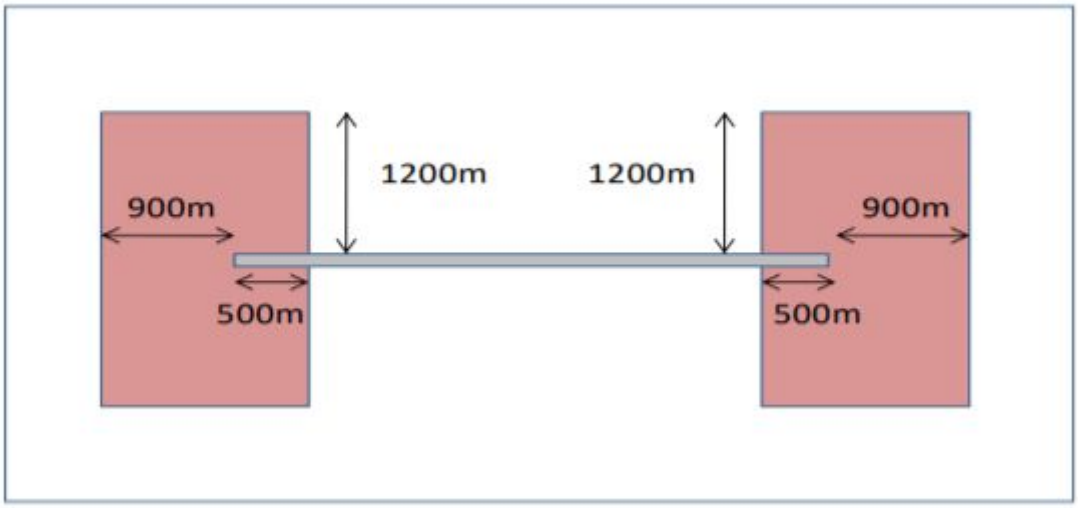


Figure 25 NASF Guideline B – Figure 1

The project is located within 1200 m perpendicular from the Oakville aerodrome runway 01/19 centreline and could pose a safety risk to aircraft operating from/to aerodrome.

The rule adopted in Australia, based on Guideline B, is that building should not penetrate a 1:35 surface extending perpendicular from the runway centreline.

The maximum proposed height of the panel is 4.1 m above ground level (AGL). Therefore, a solar panel with a height of 4.1 m AGL would be acceptable if it is located more than 143.5 m from the Oakville aerodrome runway 01/19 centreline, providing the site is relatively level.

The proposed SSF layout relative to Oakville aerodrome showing a buffer of approximately 176 m of the runway 01/19 centreline is provided in Figure 26 (source: GHD, Silverleaf Solar Farm layout, 20 February 2019).

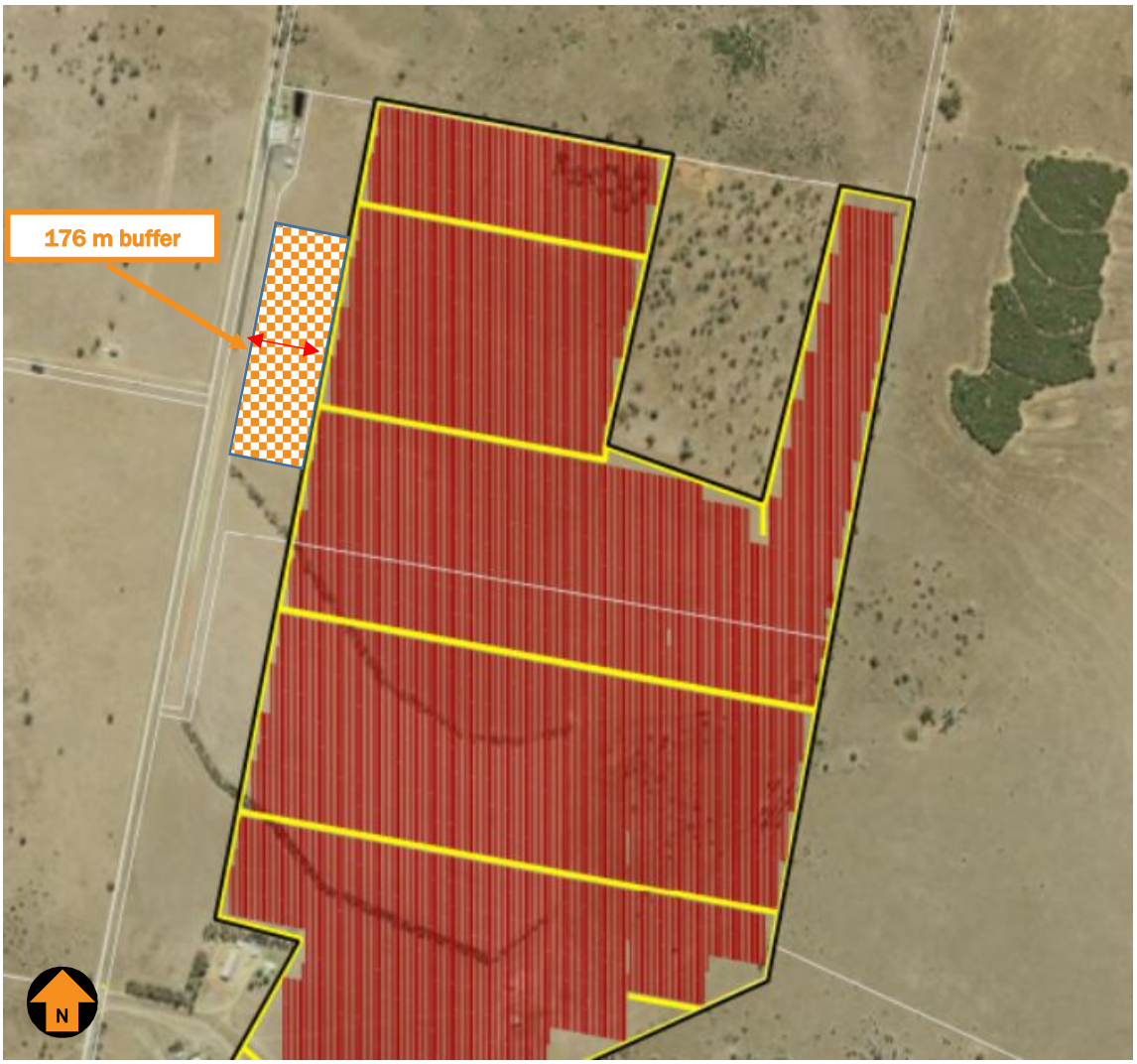


Figure 26 Silverleaf Solar Farm project site relative to Oakville aerodrome

9. CONCLUSIONS

The results of this study are summarised as follows:

9.1. Project description

The proposed Silverleaf Solar Farm involves construction of a solar farm to the east of Oakville aerodrome near the town of Narrabri. The solar photovoltaic (PV) panels will be single axis tracking installations up to 4.1 m above ground level at the maximum point of travel.

9.2. Aviation Impact Statement

The proposed Silverleaf Solar Farm:

- will not penetrate OLS surfaces of Oakville aerodrome and Narrabri Airport;
- will not affect any instrument procedures;
- will not have an impact on nearby designated air routes;
- will not have an impact on designated airspace;
- is wholly contained within Class G airspace; and
- is outside the clearance zones associated with aviation navigation aids and communication facilities.

9.3. Aircraft operations

The operator of Oakville aerodrome (Aircair Aviation) identified concerns in relation to the issues set out in the list below: The issues were considered, and it was found that the proposed solar farm would not adversely impact aircraft operations at the aerodrome:

- risk of solar panel generated windshear and turbulence;
- close location of solar panels at the southern end of the runway; and
- solar glare.

9.4. Solar glare analysis

- A solar glare analysis using the ForgeSolar application found that:
    - Analysis time interval and eye characteristics used are acceptable; and
    - Flight path receptor(s) do not receive yellow (unacceptable) glare.
- Incorporation of an anti-reflective coating on the solar panels may serve to further reduce any potential glare issues.

9.5. Wind shear analysis

The maximum proposed height of the panel is 4.1 m above ground level (AGL). Therefore, a solar panel with a height of 4.1 m AGL would be acceptable if it is located more than 143.5 m from the Oakville aerodrome runway 01/19 centreline, providing the site is relatively level. The current project layout provides approximately 176 m buffer of the Oakville aerodrome runway 01/19 centreline.

10. RECOMMENDATIONS

The proposed Silverleaf Solar Farm can be approved on the basis that it will not have an adverse impact on aviation safety.

Recommended actions resulting from the conduct of this assessment are provided below.

Aircraft safety

1. The proponent should consider NASF Guideline B *Managing the Risk of Building Generated Windshear and Turbulence at Airports* mitigation measures set in Paragraphs 51-54 to manage the risk of solar panel generated windshear and turbulence at Oakville aerodrome.
2. The proponent should consider avoiding vertical obstruction of the area of approximately 300 m to 400 m adjacent south of the southern end of the runway.
3. The proponent should consider incorporation of an anti-reflective coating on the solar panels to further reduce any potential glare issues.
4. Overhead transmission lines and/or supporting poles that are located where they could adversely affect aerial application operations should be identified in consultation with local aerial agriculture operators and marked in accordance with MOS 139 Section 8.10.2.8.

Triggers for review

5. Triggers for review of this risk assessment are provided for consideration:
    a. prior to construction to ensure the regulatory framework has not changed;
    b. following any significant changes to the context in which the assessment was prepared, including the regulatory framework; and
    c. following any near miss, incident or accident associated with operations considered in this risk assessment.

ANNEXURE

1. ForgeSolar Glare Analysis

FORGESOLAR GLARE ANALYSIS

Project: **Silverleaf Solar Farm**
The proposed site east of Oakville aerodrome

Site configuration: **Maximum site coverage**
Analysis conducted by Keith Tonkin (ktonkin@aviationprojects.com.au) at 23:26 on 29 Oct, 2018.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
Flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	N/A	No ATCT receptors designated

Default glare analysis and observer eye characteristics are as follows:

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 22169.3832

PV Array(s)

Name: PV panels
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0°
Tracking axis tilt: 50.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
Rated power: -
Panel material: Smooth glass without AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-30.279504	149.766272	211.67	0.00	211.67
2	-30.275446	149.767130	213.00	0.00	213.00
3	-30.275446	149.769147	213.18	0.00	213.18
4	-30.274463	149.769319	214.86	0.00	214.86
5	-30.271684	149.771035	216.00	0.00	216.00
6	-30.271295	149.769319	215.85	0.00	215.85
7	-30.257291	149.772239	228.50	0.00	228.50
8	-30.258848	149.782710	231.43	0.00	231.43
9	-30.271969	149.780393	220.50	0.00	220.50
10	-30.273971	149.774943	216.42	0.00	216.42
11	-30.274953	149.774835	216.34	0.00	216.34
12	-30.275972	149.775543	215.63	0.00	215.63
13	-30.276250	149.776745	217.02	0.00	217.02
14	-30.275509	149.776981	218.19	0.00	218.19
15	-30.278631	149.797784	218.55	0.00	218.55
16	-30.280975	149.797344	217.00	0.00	217.00
17	-30.280836	149.794083	217.37	0.00	217.37
18	-30.281846	149.791637	217.35	0.00	217.35
19	-30.282958	149.791390	216.96	0.00	216.96
20	-30.283403	149.790843	216.04	0.00	216.04
21	-30.284014	149.790703	214.86	0.00	214.86
22	-30.284357	149.790156	214.42	0.00	214.42
23	-30.284218	149.788740	216.61	0.00	216.61
24	-30.283782	149.788793	217.00	0.00	217.00
25	-30.282383	149.786540	215.41	0.00	215.41
26	-30.282138	149.784620	217.48	0.00	217.48
27	-30.281360	149.784749	216.79	0.00	216.79
28	-30.281137	149.783054	215.11	0.00	215.11
29	-30.280535	149.782646	215.21	0.00	215.21
30	-30.281100	149.782109	215.94	0.00	215.94
31	-30.285909	149.781155	213.42	0.00	213.42
32	-30.284927	149.775802	212.69	0.00	212.69
33	-30.280999	149.776618	212.11	0.00	212.11

Flight Path Receptor(s)

Name: FP 1
Description:
Threshold height: 15 m
Direction: 187.8°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-30.258817	149.770071	226.68	15.24	241.92
Two-mile	-30.230173	149.774630	224.10	186.51	410.61

Name: FP 2
Description:
Threshold height: 15 m
Direction: 10.1°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-30.267002	149.768512	219.32	15.24	234.56
Two-mile	-30.295470	149.762652	211.66	191.59	403.25

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV panels	SA tracking	SA tracking	11,227	0	-

Total annual glare received by each receptor

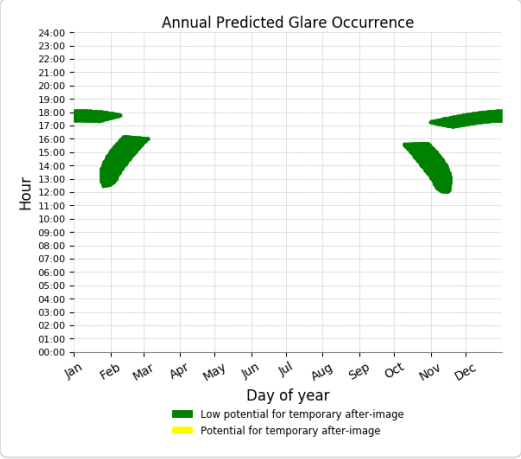
Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
FP 1	11227	0
FP 2	0	0

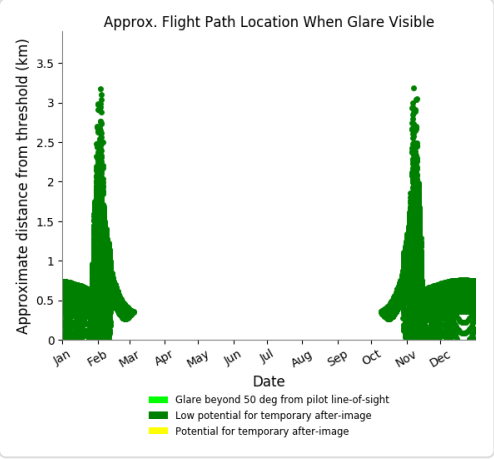
Results for: PV panels

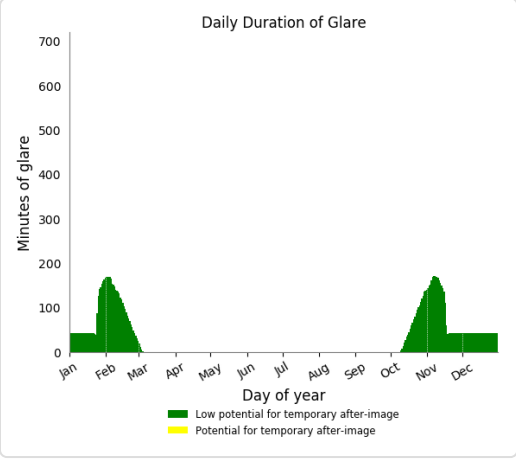
Receptor	Green Glare (min)	Yellow Glare (min)
FP 1	11227	0
FP 2	0	0

Flight Path: FP 1

0 minutes of yellow glare
11227 minutes of green glare







Flight Path: FP 2

0 minutes of yellow glare
0 minutes of green glare

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values may differ.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	B James	P Carson D Mees	*P Carson*	D Mees	*D Mees*	06/05/2019
1	B James	P Carson D Mees	*P Carson*	D Mees	*D Mees*	25/06/2019
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