ERM

APPENDIX Q PRELIMINARY HAZARD ANALYSIS

ERM

Garoo Solar Farm and BESS

Preliminary Hazard Analysis

BNTL00206_0019-REP-001-3

31 OCTOBER 2025

DISCLAIMER

This Report has been prepared on behalf of and for the exclusive use of ERM and is subject to and issued in accordance with ERM instruction to Engeny Australia Pty Ltd (Engeny). The content of this Report was based on previous information and studies supplied by ERM.

Engeny accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this Report by any third party. Copying this Report without the permission of ERM or Engeny is not permitted.

Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
0	18/06/2025	Draft Issue	Chris Bonomini	Susan Shield	Laura Vincent	Susan Shield
1	24/07/2025	Client Issue	Chris Bonomini	Susan Shield	Laura Vincent	Susan Shield
2	25/07/2025	Client Issue	Chris Bonomini	Susan Shield	Laura Vincent	Susan Shield
3	31/10/2025	Client Issue	Chris Bonomini	Susan Shield	Laura Vincent	Susan Shield
Signatures:						

CONTENTS

1. Introduction 1
   1.1 Overview 1
   1.2 Purpose and Scope 7
2. Preliminary Hazard Analysis 9
   2.1 Preliminary Risk Screening 11
      2.1.1 Storage Quantity Screening 11
      2.1.2 Transport Quantity Screening 11
3. Level of Assessment 12
4. Level 1 Qualitative Risk Assessment 13
   4.1 Methodology 13
   4.2 Level 1 Risk Analysis Scoring Criteria 13
   4.3 Hazards 13
      4.3.1 Hazardous Materials 13
      4.3.2 Electromagnetic Fields 20
   4.4 Hazard Study 22
5. EMF Impact Assessment 25
6. Risk Assessment 26
7. Risk Management 27
   7.1 Technical Control Measures 27
   7.2 Non-technical Control Measures 29
   7.3 Emergency Plan Outline 29
8. Conclusions 31
9. References 32
10. Qualifications 33

Appendices

Appendix A: Hazard Identification Workshop Minutes 34

Tables

Table 1.1: Project Summary 1
Table 1.2:Temporary Workforce Accomodation Camp 3
Table 1.3: Secretary's Environmental Assessment Requirements 7
Table 1.4: Agency PHA Related Requirements 7
Table 3.1: Tallawang Solar Farm BESS Consequence Analysis Results 12
Table 4.1: Health Effects of Low Frequency EMFs 21
Table 4.2: Typical Electric and Magnetic Field Strengths 22
Table 4.3: BESS Proximity to Nearest Dwellings and Accomodation Camp 23
Table 6.1: Qualitative Risk Evaluation 26
Table 7.1: Emergency Plan Structure and Content 30

Figures

Figure 1.1: Project Layout 4
Figure 1.2:Workforce Accommodation Camp Location 5
Figure 1.3:Workforce Accommodation Camp Area 6
Figure 2.1: Overview of PHA Methodology 10
Figure 4.1: Lithium Ion Battery Hazard Event Tree 15
Figure 4.2: Dwellings and BESS Locations 24

1. INTRODUCTION

Engeny Australia Pty Ltd (Engeny) was engaged by ERM Australia Pty Ltd to undertake a Preliminary Hazard Analysis (PHA), inclusive of an assessment of the potentially harmful impacts of electromagnetic fields, of the Garoo Solar Farm and Battery Energy Storage System (BESS) (the Project) for the Trustee for GreenPulse Solar Farm and BESS Unit Trust ('GreenPulse' or 'the Applicant').

This report supports a State Significant Development (SSD- 79747209) (SDD) Development Consent approval under Part 4, Division 4.7 of the *Environmental Planning and Assessment Act 1979*, as part of the Environmental Impact Statement (EIS) for the Project.

1.1 Overview

The Project is situated in the rural locality of Garoo, approximately 40 kilometres (km) (by road) south of Tamworth and 370 km northwest of Sydney. Located entirely within the Tamworth Regional LGA, the Project Area extends across approximately 368 hectares (ha), comprising 17 freehold land parcel and one Crown Land lot. The land is currently used for agricultural activities, predominantly livestock grazing and irrigated cropping.

The Project will involve the construction, operation, maintenance and, where relevant, decommissioning of an AC solar farm, BESS and associated supporting ancillary infrastructure.

An overview of the Project Layout and Workforce Accommodation Camp (WAC) are provided in Figure 1.1, Figure 1.2 and Figure 1.3, with key Project components summarised in Table 1.1 and Table 1.2.

TABLE 1.1: PROJECT SUMMARY

Project Terminology	Summary
Project Details	
Project	Garoo Solar Farm and BESS
Applicant	The Trustee for GreenPulse Solar Farm and BESS Unit Trust
Project Address	291 Garoo Road, Garoo NSW 2340
Project Area	The Project Area extends over approximately 369 hectares (ha).
Development Footprint	Maximum directly impacted area by Project construction and operation, which is approximately 305.43 ha. The Development Footprint is located entirely in the Project Area. It includes all temporary and permanent disturbance areas, and all areas where vegetation may be removed during project construction and operations.
Study Area	Subject area for individual assessments will differ commensurate with the relevant legislation and guidelines for individual aspects.
EDC	Estimated total Project cost of $500 million
Project Elements	
Solar Panels	• Approximately 234,000 Solar photovoltaic (PV) modules (solar panels); and • Maximum generation capacity of 133.76 MW AC.
BESS	• Storage capacity of approximately 360 MW / 1,440 MWh; and • Located on Lot 16 DP755341;
Electrical Reticulation Infrastructure	• Two onsite substations (330 kV), including switching station, transformers and associated structures; and • Approximately 16.6 km of underground electrical reticulation connecting solar panels to the substations and associated infrastructure. – Conduits housing electrical reticulation will be attached to the Tamarang Creek bridge crossing.

Project Terminology	Summary
Access	• The Project will be accessed via Garoo Road, at the northwest corner of the Project Area (refer Figure 3 1).
Emergency Access	• There are two emergency access points, one will be via Garoo Road, at the northwest corner of the Project Area and the second emergency access will be via Bulls Road from the southwest corner of the Project Area.
On-site Supporting Infrastructure	• Permanent Operations & Maintenance (O&M) compound, including – A control room; – Storage facilities; – Supervisory Control and Data Acquisition (SCADA) facilities; – Basic office amenities; and – Car parking area. • Laydown area; • New or upgraded access roads; – Single bridge across Tamarang Creek (Lot 1 and Lot 2, DP 755341); • New or upgraded drainage system; and • Security fencing (approximately 2.4 m high) and lighting.
Off-site Supporting Infrastructure	• Existing transport network; • Existing telecommunications network; • Waste and wastewater disposal facilities • Temporary quarry for construction material (if required); and • Temporary accommodation/housing for construction workers (if required).
Construction	
Construction Duration	• Approximately 18 months.
Construction Hours	• As per standard daytime construction working hours (or as defined in Section 3.5 of the EIS).
Construction Workforce	• Approximately 250 Full Time Equivalent (FTE) during peak construction.
On-site Temporary Infrastructure	• Temporary construction compounds with offices, car parking and amenities; • Temporary workers accommodation camp (capacity 250 FTE) for 15 months (refer Figure 3 2); • On-site borrow pits, laydown and storage areas, fencing, and access; and • Utilities, including water sourcing, power supply, and communications
Ancillary Activities	• Delivery of Project components, including solar panels, battery modules, substations, transformers and associated components; • Installation of underground and overhead cabling, maintenance and environmental managements processes and equipment; • Access road upgrades; and • Earthworks, as required.
Services and Utilities	• Adjustment, protection or relocation of existing utilities, including: – Liddell-Tamworth transmission line; and – Public roads.
Transport Route	• Main equipment and Over Size, Over Mass (OSOM) deliveries via Port of Newcastle; and • Associated external road upgrades (also used for operational maintenance or decommissioning activities)
Operations	
Duration	• Development Consent in perpetuity; and • Infrastructure life minimum of 30 years.
Hours of Operation	• 24 hours a day, seven days a week.
Operational Workforce	• Approximately ten FTE staff to operate the Project, once constructed.

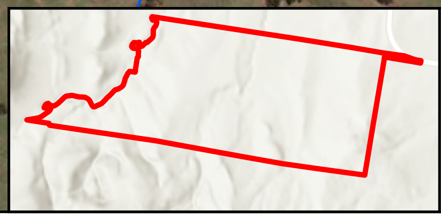
TABLE 1.2:TEMPORARY WORKFORCE ACCOMODATION CAMP

Facilities / Items	Description of facilities and items
Accommodation	• Portable cabins (4x 4x15 m).
Ancillary buildings	• Laundry, amenities blocks (Showers / washrooms), gymnasiums, recreation facilities, site office, storage, training room, retail shop and maintenance container; and • First aid facilities with an on-site nurse.
Amenities infrastructure	• The following infrastructure would be provided to the amenities: • Electricity – generator with solar panels, A/C unit; • Water – Water storage for potable water, fire water, fire pump and fire hydrant; • Sewerage – Grey wastewater treatment plant, including compost toilets; and • Internet and telecommunication services – mobile facilities.
Waste Facilities	• Grease trap; and • Waste collection area.
Fuel / Gas / Chemical Storage	• Storage facility for generator fuel; • 210kg Gas container; and • Chemical container for WWTP.
Transport and Parking	• The camp will be accessed via two site access points connected to internal access roads; • Car parking for up to 130 car spaces; • Four shuttle bus parking; and • Truck loading / unloading area

Source:
Boundary: Client Provided (20250415)
Base Data: NSW DCDB/DTDB.
Imagery: ESRI World Imagery

Legend

- Project Area
- Development Footprint
- Preferred access point
- Emergency Access point
- Transmission Lines (existing)
- Maintained Existing Water Dams
- Avoidance Area
- Associated Dwelling
- Non-Associated Dwelling
- PV (Mounting Structure - Half Table)
- PV (Mounting Structure - Full Table)
- Internal Road
- Parking and Laydown Area
- Customer Substation Area
- Transgrid Substation Area
- Inverters
- Bridge
- PCS Station
- OHL Interconnection
- BESS Container
- Strategic Road Upgrade
- Fence
- O&M Building
- Bridge Piers
- Noise Walls - PCS Stations
- Noise Wall - High Voltage Transformer
- Mitigation Planting Areas
- Local Road
- Local Track-Vehicular



Coordinate System: GDA2020 MGA Zone 56
Date: 28/10/2025
Created By: NB
Drawing Size: A3

0 400m
1:12,000

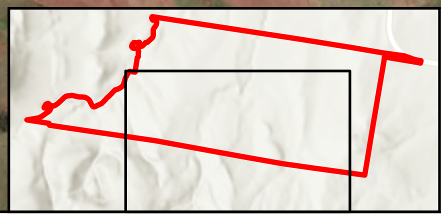
Project Layout
Map 1 of 7

Figure 1.1

Garoo Solar Farm and BESS
Environmental Impact Assessment
The Trustee for GreenPulse Solar Farm and BESS Unit Trust

ERM

0751705_SolarAndBESS_EIA_G001_R0.aprx



Coordinate System:
GDA2020 MGA Zone 56

Date: 28/10/2025

Created By: NB

Drawing Size: A3

0 200m

1:6,000

Project Layout
Map 2 of 7

Figure 1.1

Garoo Solar Farm and BESS
Environmental Impact Assessment

The Trustee for GreenPulse Solar Farm and BESS Unit Trust

ERM

0751705_SolarAndBESS_EIA_G001_R0.aprx

Coordinate System:
GDA2020 MGA Zone 56
Date: 28/10/2025
Created By: NB
Drawing Size: A3
0 30m
1:1,000

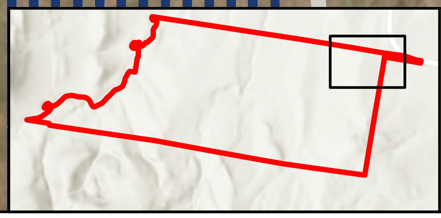
Project Layout
Map 3 of 7

Figure 1.1

Garoo Solar Farm and BESS
Environmental Impact Assessment
The Trustee for GreenPulse Solar Farm and BESS Unit Trust

ERM

0751705_SolarAndBESS_EIA_G001_R0.aprx



Coordinate System:
GDA2020 MGA Zone 56
Date: 28/10/2025
Created By: NB
Drawing Size: A3

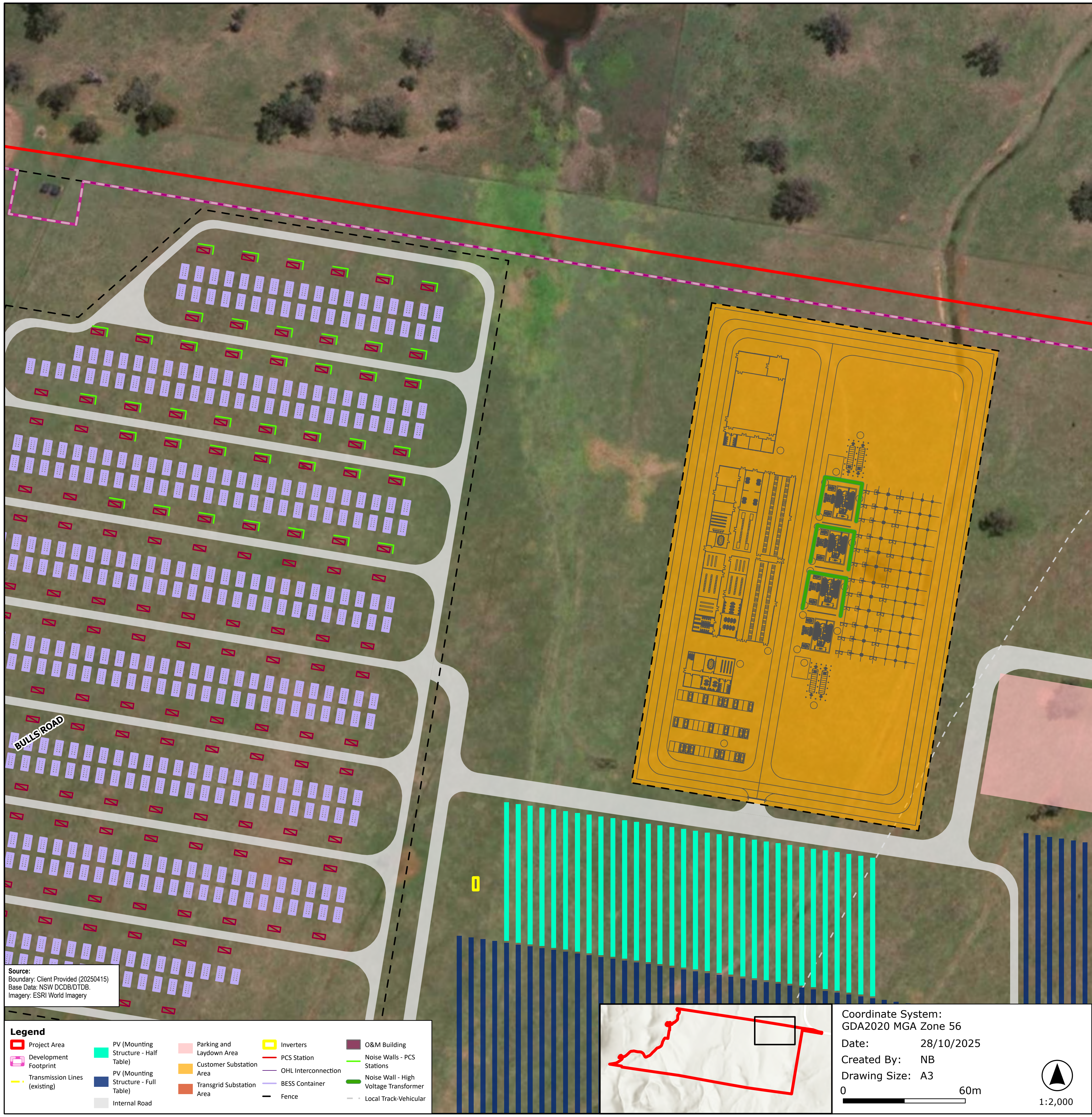
Project Layout
Map 4 of 7

Figure 1.1

Garoo Solar Farm and BESS
Environmental Impact Assessment
The Trustee for GreenPulse Solar Farm and BESS Unit Trust

ERM

0751705_SolarAndBESS_EIA_G001_R0.aprx



Project Layout
Map 5 of 7

Figure 1.1

Garoo Solar Farm and BESS
Environmental Impact Assessment
The Trustee for GreenPulse Solar Farm and BESS Unit Trust

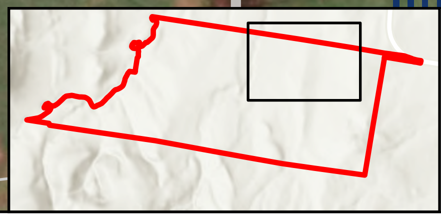
ERM

0751705_SolarAndBESS_EIA_G001_R0.aprx

Source:
Boundary: Client Provided (20250415)
Base Data: NSW DCDB/DTDB.
Imagery: ESRI World Imagery

Legend

- Project Area
- Development Footprint
- PV (Mounting Structure - Half Table)
- PV (Mounting Structure - Full Table)
- Internal Road
- Parking and Laydown Area
- Customer Substation Area
- Transgrid Substation Area
- Inverters
- Bridge
- PCS Station
- OHL Interconnection
- BESS Container
- Fence
- O&M Building
- Bridge Piers
- Noise Walls - PCS Stations
- Noise Wall - High Voltage Transformer
- Local Track-Vehicular



Coordinate System:
GDA2020 MGA Zone 56

Date: 28/10/2025

Created By: NB

Drawing Size: A3

0 100m

1:3,000

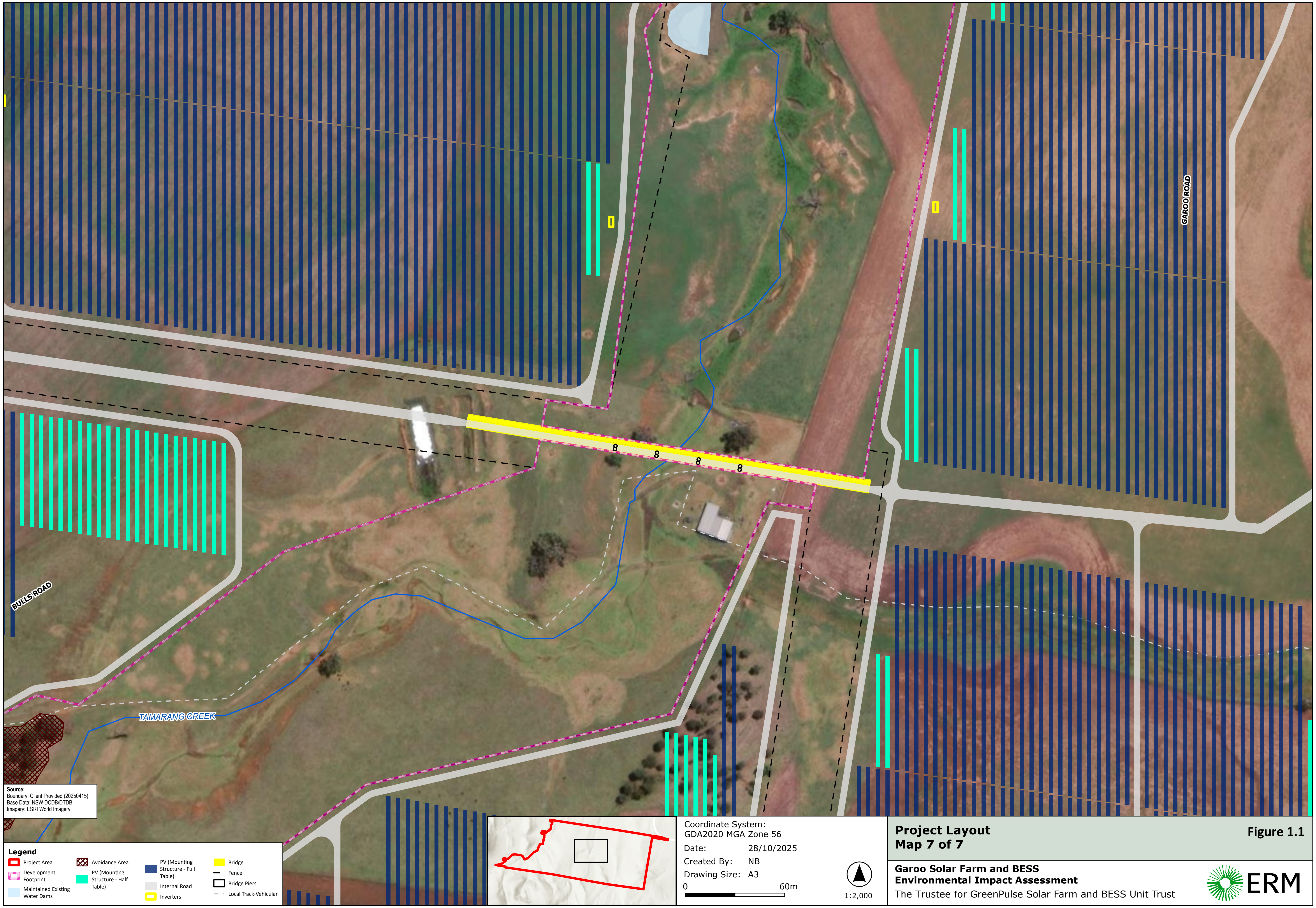
Project Layout
Map 6 of 7

Figure 1.1

Garoo Solar Farm and BESS
Environmental Impact Assessment
The Trustee for GreenPulse Solar Farm and BESS Unit Trust

ERM

0751705_SolarAndBESS_EIA_G001_R0.aprx



Coordinate System:
GDA2020 MGA Zone 56

Date: 28/10/2025

Created By: NB

Drawing Size: A3

0 60m

1:2,000

Project Layout
Map 7 of 7

Figure 1.1

Garoo Solar Farm and BESS
Environmental Impact Assessment
The Trustee for GreenPulse Solar Farm and BESS Unit Trust

ERM

0751705_SolarAndBESS_EIA_G001_R0.aprx

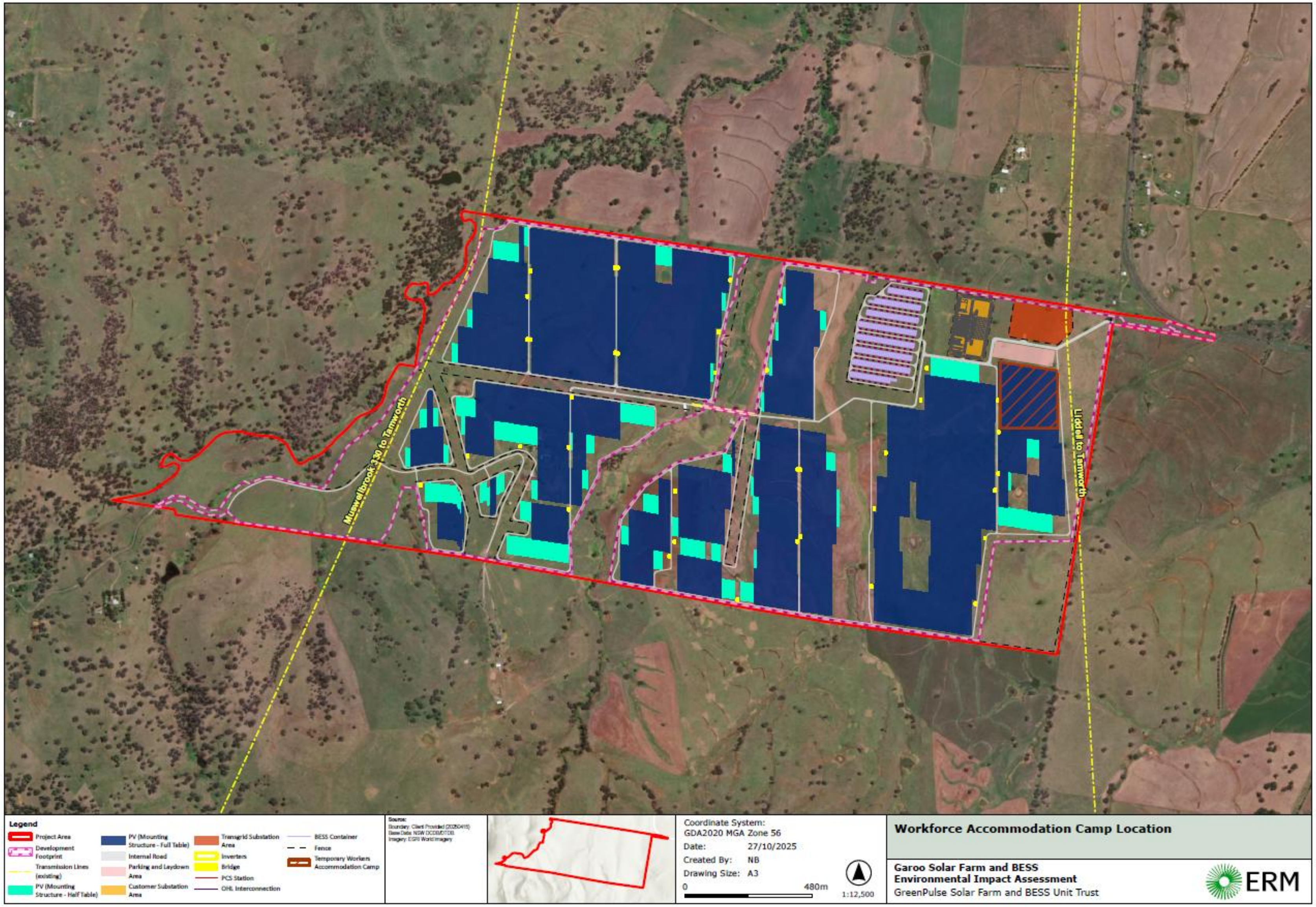


Figure 1.2:Workforce Accommodation Camp Location

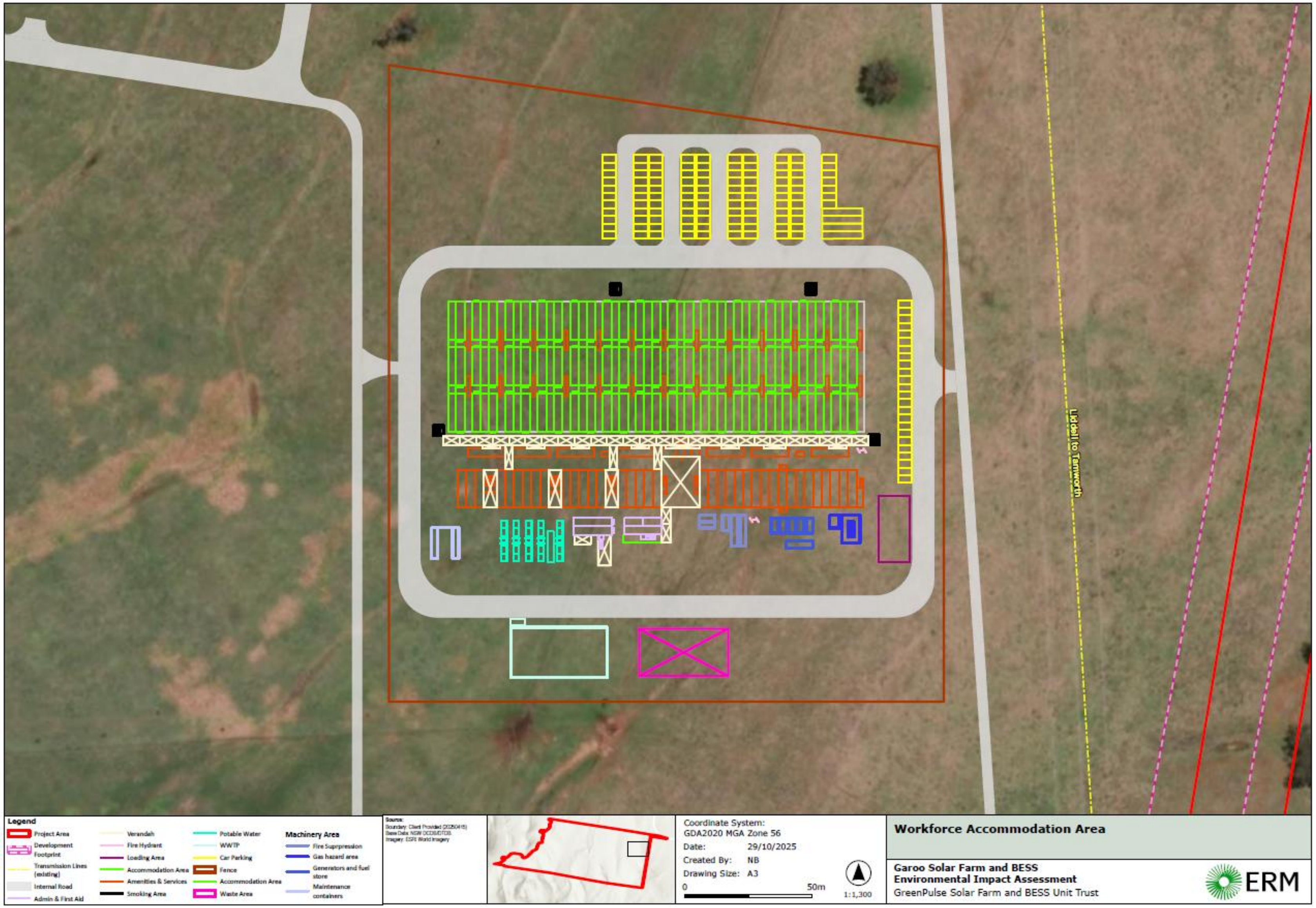


Figure 1.3:Workforce Accommodation Camp Area

1.2 Purpose and Scope

This Preliminary Hazard Analysis (PHA) has been prepared by Engeny Australia Pty Ltd (Engeny), to satisfy relevant Secretary's Environmental Assessment Requirements (SEARs) issued by the former Department of Planning and Environment (DPE) (now Department of Planning, Housing and Infrastructure (DPHI))on 4 March 2025 and the requirements of *State Environmental Planning Policy (Resilience and Hazards) 2021* (the Resilience and Hazards SEPP). The PHA is inclusive of an assessment of the potential hazards and risks associated with electromagnetic fields, however, potential hazards and risks associated with bushfires are not addressed other than as a possible initiating mechanism for a hazardous event. The SEARs relating to this PHA are presented in Table 1.3.

TABLE 1.3: SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

Requirement	Where addressed in this report
Hazards – including:	
• Health - an assessment of potential hazards and risks including but not limited to fires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields;	Sections 4.3.2 and 5.
• Dangerous Goods - a preliminary risk screening completed in accordance with the State Environmental Planning Policy (Resilience and Hazards) 2021; and	Section 2.1.
• Battery Energy Storage System - a Preliminary Hazard Analysis (PHA) prepared in accordance with Hazardous Industry Planning Advisory Paper No. 6 – Guideline for Hazard Analysis (DoP, 2011) and Multi-Level Risk Assessment. The PHA must consider all recent standards and codes and verify separation distances to on-site and off-site receptors to prevent fire propagation and compliance with Hazardous Industry Advisory Paper No. 4, Risk Criteria for Land Use Safety Planning. The PHA must consider the effect of bushfires on batteries or other components of the BESS.	This report.

In addition to the SEARs presented in Table 1.3, DPHI Industry Assessments has indicated that the PHA must also address the requirement presented in the Table 1.4.

TABLE 1.4: AGENCY PHA RELATED REQUIREMENTS

Agency	Requirement	Where addressed in this report
DPHI Industry Assessments	We have reviewed the draft Secretary's Environmental Assessment Requirements (SEARs). We agree with the SEARs requirements for a:	
	Risk screening of dangerous goods, and	Section 2.1
	PHA for batteries.	This Report
	Lithium-Ion Batteries The following information is provided to assist the Applicant in undertaking a PHA for a BESS using lithium batteries. The PHA should:	
	• Demonstrate that the separation distances between the BESS to on-site or off-site receptors and the separation distances between battery enclosures will reduce the risk of fire propagation. For information, Fire and Rescue NSW has released a technical information on the requirements of a Fire Safety Study and this guideline should be considered. See Fire Safety Guideline, Technical Information, D22/107002, Large-scale external lithium-ion battery energy storage system- Fire Safety Study Guidelines, Version 01, 26 July 2023.	Sections 4.3.1.4 and 4.4
	Verify that the areas designated for BESS are sufficient considering separation distances between battery enclosures; and	Section 4.3.1.4
	Demonstrate that the fire risks from BESS can comply with the Department's Hazardous Industry Advisory Paper No. 4, 'Risk Criteria for Land Use Safety Planning.'	Section 6

Agency	Requirement	Where addressed in this report
	In undertaking the hazard analysis, the following should be included:	
	Consideration of the most recent standards and codes such as and not limited to FM Global DS 5-33, NFPA 855, AS 5139, IEC 62897, UL 9540, and UL 9540A test reports when establishing separation distances; and	Section 4.3.1.4
	Consideration of the scenarios and findings from the reports on the 2021 Victorian Big Battery fire, including fire propagation to the topside of the adjacent batteries.	Section 4.3.1.2
Tamworth Regional Council	The Scoping report identifies that there are two (2) non-project related residences within 500m of the site and approximately fourteen (14) non-project related residences within a 4km radius of the site. In this regard, it is important that the EIS adequately considers all potential impacts on residential receptors, including but not limited to:	
	• Concerns regarding impacts of electro-magnetic energy and the cumulative impacts of this noting the proximity of the electricity sub-station;	Sections 4.3.2 and 5.
	• Concerns regarding the risk of explosion of batteries. A risk assessment should be prepared which also refers to the applicable safety standards for the proposed use;	Sections 2.1, 3, 4 and 6.
	• The EIS should also clearly describe any proposed mitigation measures and the likely effectiveness of such measures.	Section 7.
Fire and Rescue NSW (FRNSW)	FRNSW will likely recommend a Fire Safety Study (FSS) be developed in accordance with the Hazardous Industry Planning Advisory Paper No 22 as a condition of consent. The FSS should be used to inform the design and as such it is FRNSW Position that the FSS be developed to the satisfaction of FRNSW prior to any further submission being made to FRNSW; this includes: an Initial Fire Safety Report (IFSR) and / or Performance-Based Design Brief / Fire Engineering Brief Questionnaire (FEBQ). The FSS should be prepared consistent with the relevant FRNSW Fire Safety Guidelines and FRNSW Technical Information Sheets[4].	Section 7.2.
Transgrid	We can advise the proponent has a Connection Progress Agreement in progress and discussions with the Transgrid Group will continue regarding the proposed grid connection. It is Transgrid Group's expectation that all grid connection works are included in the Customer's approval documentation. The proponent will be responsible to procure all property related tenure arrangements as part of the project and consult with Transgrid to understand these requirements. For preliminary advice on *Transgrid's Easement Guidelines*, please refer to the following hyperlink: https://www.transgrid.com.au/safety/community-safety/	Section 7.2

This PHA considers the hazards and risks posed to off-site receivers and dwellings associated with the transport, storage and use of hazardous materials for the Project and has been prepared in general accordance with and/or with reference to:

- State Environmental Planning Policy (Resilience and Hazards) 2021.
- Applying SEPP 33 (NSW Department of Planning (Department of Planning (DoP), 2011a).
- Multi-Level Risk Assessment (DoP, 2011b).
- Hazardous Industry Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning (DoP, 2011c).
- Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis (DoP, 2011d).
- D22/107002 Large-scale external lithium-ion battery energy storage systems - Fire safety study considerations (Fire and Rescue NSW, 2023).
- Guidelines For Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz) (International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2010).

2. PRELIMINARY HAZARD ANALYSIS

Under the Resilience and Hazards SEPP there is a requirement to undertake a preliminary risk screening to determine the need for a PHA. A preliminary screening undertaken in accordance with Applying SEPP 33 (DoP, 2011a) (noting that while State Environmental Planning Policy 33 (SEPP 33) has been repealed and replaced with the Resilience and Hazards SEPP, Applying SEPP 33 is still applicable for the preliminary screening process) involves the identification and assessment of the storage and transport of specific dangerous goods classes that have the potential for significant off-site effects. Should the risk level exceed the acceptable criteria for impacts on the surrounding land use at the proposed location, and in the presence of controls, the development is classified as 'hazardous' or 'offensive' industry and may not be permissible within most land use zones in NSW.

A proposal that continues to pose a significant risk when all locational, technical, operational and organisational safeguards are employed, is considered to be a 'hazardous industry'. A proposal that results in a significant level of offence (e.g. odour or noise) even when controls are implemented is considered an 'offensive industry'. Separate air quality and noise and vibration assessments have been completed for this Project to address potentially offensive impacts. A proposal must firstly be identified as 'potentially hazardous' or 'potentially offensive' and subjected to the assessment requirements of the Resilience and Hazards SEPP before it can be considered hazardous. Should proposal be assessed as 'potentially hazardous' with respect to the storage of hazardous materials, a PHA is required for the development. Applying SEPP 33 (DoP, 2011a) contains a range of assessment criteria for the storage of hazardous materials that have the potential to create off-site impacts.

If the number of traffic movements for the transport of hazardous materials exceeds the annual or weekly criteria outlined in Table 2 of Applying SEPP 33 (DoP, 2011a) for the proposed development it will also be considered 'potentially hazardous' and a route evaluation study is likely to be required.

Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis (HIPAP 6) (DoP, 2011d) and Multi-level Risk Assessment (MLRA) (DoP, 2011b) indicate that a PHA should identify and assess all hazards that have the potential for off-site impact. The expectation is that the hazards would be analysed to determine the consequence to people, property and the environment and the likelihood that the hazards will occur.

The methodology (based on the methodology detailed in HIPAP 6 (DoP, 2011d) and MLRA (DoP, 2011b)) used to identify and assess the potential Project hazards and associated failure scenarios that have the potential for off-site impacts is outlined in Figure 2.1. Further detail on how the methodology is applied to identify and assess potential off-site impacts is provided in the respective sections of this PHA.

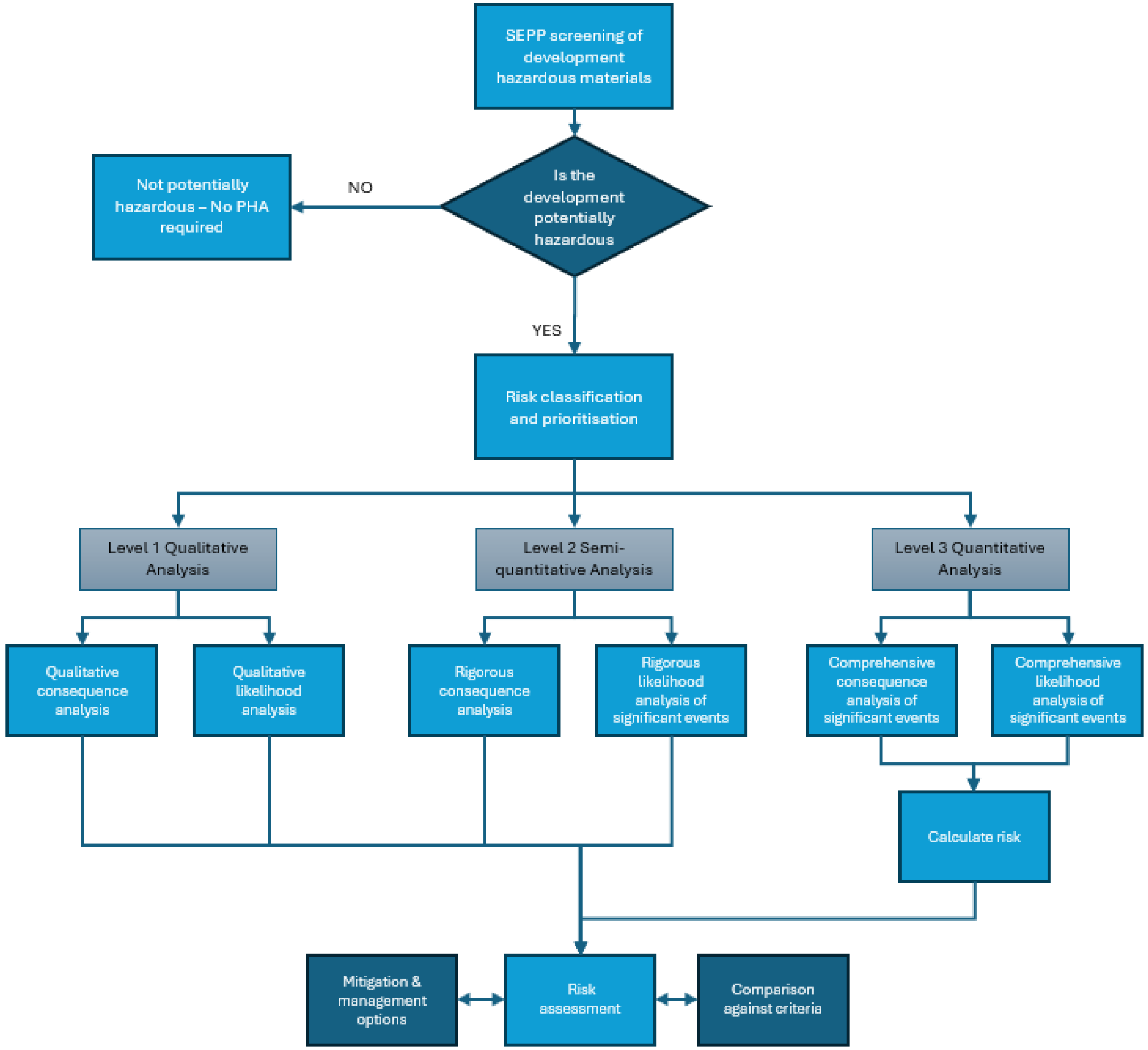


Figure 2.1: Overview of PHA Methodology

Preliminary Screening

Preliminary risk screening generally involves comparison of the quantities of hazardous materials to be stored and used as well as the size and frequency of road movements of hazardous materials to be transported to/from the proposed development.

If the storage or transport of hazardous materials exceeds the respective screening thresholds contain in *Applying SEPP 33* (DOP, 2011), the development is considered potentially hazardous and a preliminary hazard analysis (PHA) is required. However, if thresholds are not exceeded, it is typically considered that no further analysis is necessary and development safety management can rely on relevant industry codes and standards. Notwithstanding this, *Applying SEPP 33* (DOP, 2011) indicates that the screening thresholds should not be used in isolation and 'other factors' should be taken into account. As such, a development where the hazardous materials storage and transport do not exceed thresholds can still be considered 'potentially hazardous'.

Risk Classification and Prioritisation

Techniques to broadly estimate the consequences and likelihood of hazardous events are used to rank the facility with respect to societal risk. The outputs from the risk classification and prioritisation process are compared against respective criteria for determining the appropriate level of analysis required for the PHA.

Level 1 Qualitative Analysis – Significant but not serious potential for harm

- Detailed hazard identification.
- Objective is to demonstrate that the development does not pose a significant off-site risk.
- Further analysis may be required where the qualitative analysis does not demonstrate no significant off-site risk.

Level 2 Semi-quantitative Analysis – Medium potential for harm

- Supplements the qualitative analysis by quantifying the main risk contributors to determine whether their consequences are acceptable with respect to relevant criteria.

Level 3 Quantitative Analysis – High potential for harm

- Required when the screening and hazard identification process has identified risk contributors with consequences beyond the site boundaries.
- Involves a comprehensive quantification of hazardous event consequences and their associated likelihood of occurrence.

Risk Assessment

Results of the risk analysis (qualitative and/or quantitative) are compared with the respective risk criteria. In the event where the risks are not assessed as acceptable, risk minimisation, mitigation and management options are applied as required (often as part of an iterative process where the residual risk is estimated following implementation of the options) to enable to the development to meet the respective risk criteria.

2.1 Preliminary Risk Screening

As outlined in Section 2, preliminary risk screening is undertaken to determine the requirement for a PHA and/or route evaluation study.

2.1.1 Storage Quantity Screening

The hazardous materials that will be stored and used for the Project include:

- Up to approximately 9,600 tonnes of lithium-ion batteries (LIBs) (assumes a LIB energy density of 150 Wh/kg), a Class 9 miscellaneous dangerous good.
- Approximately 238.7 kL (approximately 212.5 tonnes based on an assumed specific gravity of 0.89) of electrical transformer insulating oil (approximately 236.5 kL in substation transformers and 2.2 kL in BESS and PV inverters) which is not classified as a dangerous good (DG) under the *Australian Code for the Transport of Dangerous Goods* (ADGC) (National Transport Commission (NTC), 2022).

Applying SEPP 33 (DoP, 2011a) does not have a relevant screening threshold for either LIB or electrical transformer insulting oil. However, the potential hazards associated with LIBs has become evident with the rapid proliferation of LIBs in portable devices, electric vehicles, energy storage systems and a range of other applications in recent years. It has been well established that LIBs may present fire, explosion and toxic gas release hazards as a result of manufacturing faults or a range of battery abuse scenarios (refer to Section 4.3.1).

Applying SEPP 33 (DoP, 2011a) indicates that the risk screening process for determining if a proposal is 'potentially hazardous' under the Resilience and Hazards SEPP should not be used in isolation and 'other factors' should be taken into account. While 'other factors' is not defined in Applying SEPP 33 (DoP, 2011a), the potential for hazardous events such as fire, explosion and toxic release involving LIBs and the significant scale of the Project BESS (i.e., up to 1,440 MWh total storage capacity) are considered to be relevant. Further, given the limited global experience with large capacity, grid connected LIB BESSs, and to maintain a conservative approach with respect to the assessment of hazards and risk, further assessment is considered appropriate.

The workforce accommodation camp (WAC) will store up to 210 kg of liquefied petroleum gas in cylinders which is significantly less than the Applying SEPP 33 (DoP, 2011) threshold of 10,000 kg for above ground storage. Other hazardous materials (e.g. flammable liquids as fuels or paints, compressed gases for maintenance activities, herbicides) will be stored at the Project in quantities below relevant Applying SEPP 33 (DoP, 2011a).

2.1.2 Transport Quantity Screening

Similarly to the storage of LIBs and electrical transformer insulating oil, there are no transport screening thresholds in Applying SEPP 33 (DoP, 2011a) for either of these hazardous materials. It is expected that the transportation of LIBs to/from the Project site in significant quantities and at a relatively high frequency will only occur during Project construction and decommissioning. Transport of LIBs to the Project site for replacement of failed units will occur in relatively small quantities and infrequently during Project operation. All dangerous goods and hazardous materials, including LIBs, will be transported to site by a suitably accredited freight company using dangerous goods licensed vehicles and drivers.

As with LIBs, the transportation of electrical transformer insulating oil to the Project will only occur in significant quantities during Project construction and maintenance when the oil is replaced to ensure safe and efficient transformer operation. Delivery of electrical transformer insulating oil to the Project site during operations will be very infrequent.

Given the very low frequency of hazardous materials transport to the Project site and the use of suitably accredited freight companies, no further assessment of transport risks (e.g., a transport route evaluation study) is considered necessary.

Other hazardous materials with Applying SEPP 33 screening thresholds (e.g. flammable liquids as fuels or paints, compressed gases for maintenance activities, herbicides) will be transported to the Project in quantities and at frequencies below screening thresholds.

3. LEVEL OF ASSESSMENT

Multi-level Risk Assessment (MLRA) (DoP, 2011b) provides methodology for a preliminary analysis of the risks related to a proposed development to enable the selection of the most appropriate level of risk analysis in the PHA. The MLRA preliminary analysis includes risk classification and prioritisation using a technique adapted from the *Manual for classification of risks due to major accidents in process and related Industries* (International Atomic Energy Agency (IAEA), 1996). A comprehensive description of the technique is presented in MLRA (DoP, 2011b) and is based on a general assessment of the consequences and likelihoods of accidents and their risks to individuals and society with comparison of these risks to relevant criteria to determine the level of assessment required, be it qualitative or quantitative.

While not directly applicable to LIBs, the MLRA technique has been applied as part of PHAs for other renewable energy projects involving a LIB BESS, conservatively treating the LIBs as a source of toxic gas (refer to Section 4.3.1). However, it is understood that DPHI Industrial Assessments has indicated that the application of the MLRA technique in this manner was likely to result in an overly conservative outcome and that judgement should be exercised to determine the appropriate level of analysis for the development based on the unique site specific characteristics of the proposed BESS. As such, the MLRA risk classification and prioritisation methodology is not considered applicable to a LIB BESS.

Application of the MLRA technique to the Tallawang Solar Farm project (Umwelt, 2022) indicated that a Level 2 assessment (semi-quantitative PHA) was appropriate. The Level 2 assessment prepared by Umwelt included a hazard study involving a hazard identification workshop which identified credible hazard scenarios for quantitative analysis as listed below:

- LIB container rack fire.
- LIB container module vapour cloud explosion (VCE):
  - Generation of gas from a sufficient number of cells to form significant mass of flammable gas due to overheating/thermal runaway.
  - Ignition of gas.
- Release of toxic gas (hydrogen fluoride (HF) associated with a LIB container module fire/thermal runaway event.

The consequence analysis undertaken for the Tallawang Solar Farm project (Umwelt, 2022), which is considered to be conservative, indicated maximum distances to injury, fatality and property damage impacts for the hazardous events listed above as presented in Table 3.1.

TABLE 3.1: TALLAWANG SOLAR FARM BESS CONSEQUENCE ANALYSIS RESULTS

Hazard Scenario	Maximum Distance to Property Damage (m)	Maximum Distance to Fatality Impact (m)	Maximum Distance to Injury Impact (m)
Thermal radiation from BESS container fire	8	11	19
Overpressure from explosion of accumulated flammable gases within BESS container during LIB thermal runaway	52	52	86
Toxic gas emission (HF) from BESS container during LIB thermal runaway	-	39	61

The approach for the Tallawang Solar Farm Project, which was accepted by the Department of Planning and Environment (now DPHI) – Industrial Assessments team, was that the level of assessment for the PHA is based on consideration of the proximity to dwellings rather than the distance to the site boundary with the key focus of the PHA being to demonstrate that the Project design can achieve adequate separation distances between BESS units to ensure non-propagation.

The conceptual Project layout indicates the off site dwelling nearest to Project BESS is approximately 640 m to the north north-east (NNE). The associated dwelling nearest to the BESS is approximately 470 m to the west south-west (WSW). The WAC will be located approximately 365 m to the east (E) of the BESS but will be removed prior to BESS commissioning. As such a Level 1 assessment (qualitative) is considered appropriate for the Project.

4. LEVEL 1 QUALITATIVE RISK ASSESSMENT

As indicated in Section 3 it was concluded that a Level 1 qualitative risk assessment would be sufficient to demonstrate that the Project can comply with relevant criteria in HIPAP 4 (DoP, 2011c).

4.1 Methodology

With reference to MLRA, it is considered that a Level 1 assessment requires:

- Hazard identification using word diagrams, simplified fault/event trees and checklists.
- Identification of key scenarios and qualitative assessment of risks.
- Evaluation of the risks against the following qualitative criteria from HIPAP 4 (DoP, 2011c):

(a) All 'avoidable' risks should be avoided. This necessitates the investigation of alternative locations and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.

(b) The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.

(c) The consequences (effects) of the more likely hazardous events (i.e., those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.

(d) Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.

- Demonstration of adequacy of the proposed technical and management controls to ensure ongoing safety of the proposed development.
- Inclusion of all facilities which reported exceedances of initial screening thresholds.

4.2 Level 1 Risk Analysis Scoring Criteria

The risk scoring criteria from *Australian Standard AS 4360:2004 – Risk Management* were used for this Level 1 assessment. The criteria for consequence severity, frequency estimation and the associated risk matrix used in the Level 1 assessment are presented in Appendix A.

4.3 Hazards

4.3.1 Hazardous Materials

4.3.1.1 Lithium Ion Batteries

LIBs are the most abundant and primary hazardous material of concern that will be located at the Project site. LIBs are comprised of:

- An anode (typically graphite) with a copper current collector.
- A cathode (e.g., lithium iron phosphate - $LiFePO_4$ or LFP) with an aluminium current collector.
- A porous separating layer between the anode and cathode (typically a polymer).
- An electrolyte comprised of a lithium salt (e.g., $LiPF_6$) dissolved in a flammable organic solvent (e.g., ethylene carbonate, diethyl carbonate, ethyl methyl carbonate).

LIBs are sealed and do not vent to the atmosphere during normal operation. However, when subject to a range of abuse scenarios such as abnormal heating (external or internal) or overcharging, flammable electrolyte and electrolyte decomposition products can vaporise, rupture the battery cell and be vented (Fire Protection Research Foundation, 2016). Vented electrolyte and electrolyte decomposition products may ignite if part of a flammable mixture with air and exposed to an ignition source.

When the internal temperature of a LIB cell increases beyond its operating range it can lead to exothermic decomposition reactions generating additional heat and a phenomena known as thermal runaway. Without dissipation of the additional heat, cell temperature will continue to rise and accelerate the process of decomposition and heat generation. Thermal runaway can be initiated by a range of mechanisms including electro-chemical abuse (e.g., from overcharging, over-discharging and over voltage charging), mechanical abuse (e.g., physical damage to cell causing a short circuit), thermal abuse (overheating from an external source), manufacturing defects (e.g., internal short circuits) and design faults (e.g., inadequate clearance between cells or modules to allow heat dissipation). Fire and Rescue NSW (FRNSW) responded to 272 LIB fires in 2023 (a rate of 5.2 fires per week) and as of 15 March 2024 had recorded 67 fires (a rate of 5.7 fires per week) (https://www.fire.nsw.gov.au/incident.php?record=rec19mr6yzVvSQqQ0).

While approximately 80% of electric vehicle fires have been attributed 80% to spontaneous ignition events (Bravo-Diaz et al., 2020) indicating manufacturing defects, internal defects that develop over time and design faults are the primary cause of LIB fires, FM Global's *Property Loss Prevention Data Sheet 5-33 Lithium-Ion Battery Energy Storage Systems* (2024) indicates that electrical abuse is acknowledged to be the most common failure mode.

Of the various mechanisms that can lead to LIB thermal runaway, only electrical abuse can be interrupted by the battery management system (BMS) with early intervention initiated by detection of elevated cell temperatures or trace gases associated with early-stage electrolyte decomposition (FM Global, 2024). The BMS can isolate the relevant battery unit preventing further temperature rise in the impacted cells in response to the detection of the symptoms of electrolyte decomposition. Thermal abuse (e.g. loss of cooling system functionality or external fire) is likely to affect multiple cells simultaneously and progression to thermal runaway is considered likely to be unavoidable (FM Global, 2024). Isolation of cells that have internal short circuits (e.g. due to physical damage or manufacturing defects) will not prevent thermal runaway as the cells store their own energy (FM Global, 2024).

The temperature of vented gases from LIBs during thermal runaway can exceed 600°C and are likely to comprise of flammable (alkyl-carbonates, methane, ethylene, ethane, hydrogen gas) and toxic species (carbon monoxide (CO), hydrogen cyanide (HCN), HF, phosphorus pentafluoride and phosphoryl fluoride), soot and particulates containing oxides of nickel, aluminium, lithium, copper and cobalt. In 2017, Larsson et al. reported on experimental work undertaken for a range of different LIB cell types (including cells with a lithium cobalt oxide cathode (LiCoO2 or LCO) and LFP cathode) to measure toxic gas release rates, heat release rates and toxic gases concentrations. Measurement of both phosphoryl fluoride and HF was possible with the apparatus, however, phosphoryl fluoride was only detected during thermal runaway of the LCO type cell and indicates that phosphorus pentafluoride is short lived following release.

The Larsson et al. study (2017) found that HF was generated in amounts of approximately 20 – 200 mg/Wh of nominal battery capacity for a range of battery types and chemistries with the one of the LFP batteries tested emitting up to 200 mg/Wh. It is expected that the most likely cell type to be used in the Project BESS will be LFP. LFP cells are reported to have a greater thermal stability than LCO and lithium manganese oxide ($LiMn_2O4$ or LMO) cells with the onset of thermal runaway in LFP cells has been reported as occurring at 246°C (Kong et al., 2018).

During installation level testing of a lithium ion energy storage system "mockup", Underwriters Laboratory (2021) recorded concentrations of CO exceeding 100,000 ppm within a container housing LIB units while CO and HCN concentrations within approximately 900 mm of the outside of the container were recorded in excess of the gas meter detection limits of 2,000 ppm and 50 ppm respectively. CO concentrations were recorded in excess of 400 ppm approximately 9 m from the outside of the container. A visible vapour cloud containing gases that had not combusted was observed to form on the exterior of the container during the tests with the cloud primarily staying close to the ground with some buoyant gas behaviour observed.

Flammable gases produced during LIB thermal runaway pose both a fire risk, if gases are immediately ignited, and an explosion risk if the gases accumulate to form a flammable mixture with air within a confined space prior to ignition. As part of the installation level testing, completed by Underwriters Laboratory (2021), three scenarios were tested:

- No fire suppression.
- A gaseous fire suppression agent.
- Water spray fire suppression.

Deflagrations were recorded for all scenarios demonstrating that flammable gases accumulated to form and the explosive mixture with air and the presence of a viable ignition source. After completion of the gaseous fire suppression scenario testing when the BESS container door was opened, a flashover occurred and the accumulated flammable gases, that were at concentrations within the container above the upper flammability limit (UFL, mixed with air and ignited (Underwriters Laboratory, 2021). Temperatures in excess of 500^{o}C were recorded for a sustained period within modules during the testing which adjacent combustible construction materials were exposed to (Underwriters Laboratory, 2021).

An event tree that shows the abnormal events that can result in the venting of vaporised electrolyte and decomposition products from LIBs that have the potential for fire, explosion and toxic gas hazards are presented in Figure 4.1.

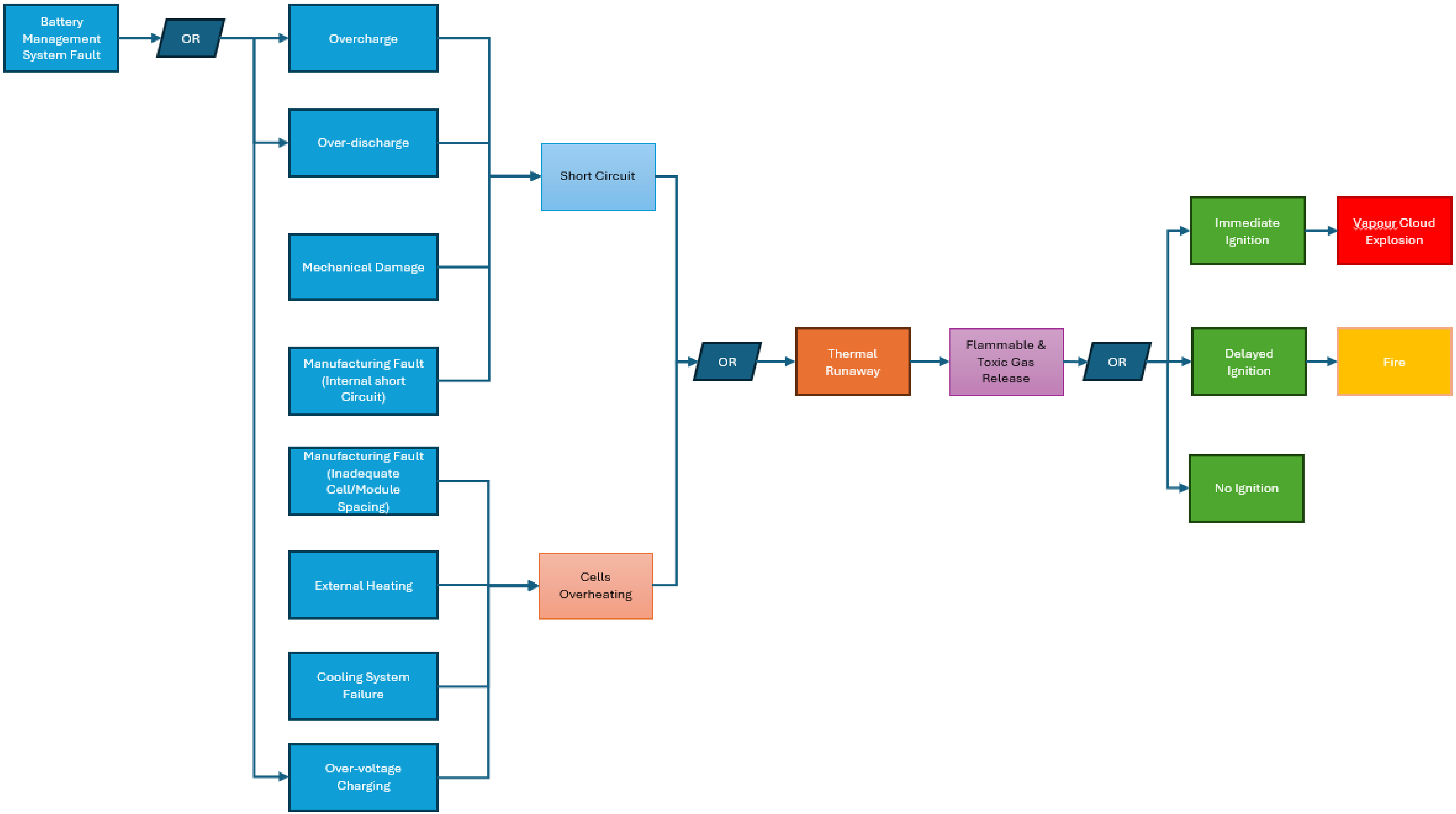


Figure 4.1: Lithium Ion Battery Hazard Event Tree

4.3.1.2 BESS Design Standards and Recent BESS Hazardous Events

With the increasing use of LIBs in various applications industry and government agencies, including emergency response agencies, have recognised the need to consider their safety and the control measures required to effectively respond to LIB hazard events, particularly thermal runaway. Thermal runaway occurs when the battery temperature reaches a critical point where self-propagating reactions generate heat and gas, leading to potentially hazardous consequences. In response to these concerns as well as learnings from actual LIB hazardous events, there have been improvements in design standards to manage the thermal runaway behaviour of LIB modules.

Outcomes of the analysis of the causes and effects of thermal runaway incidents, such as those involving the Victorian Big Battery (VBB) Fire and the McMicken Battery Storage Facility System Explosion are discussed below. Such incidents have highlighted the importance of proper battery management systems and thermal management strategies to prevent and/or mitigate thermal runaway. Recent design standards have continued to develop with research and practical experience and include requirements for features such as thermal barriers, passive and active cooling systems, and early warning sensors to detect and prevent thermal runaway.

Regulatory requirements and industry standards have also influenced design standards with agencies such as the National Highway Traffic Safety Administration (NHTSA) and the Federal Aviation Administration (FAA) establishing safety guidelines for the use of LIBs in transportation.

Generally, a growing awareness of the safety risks associated with these LIBs has led to the improvement in design standards to manage thermal runaway behaviour of LIB modules.

4.3.1.2.1 Victorian Big Battery Fire

Located in Geelong, Victoria, the VBB facility is a 450 MWh grid scale BESS consisting of 212 Tesla Megapack units. Tesla Megapacks are self-contained LIB BESS units consisting of battery modules, power electronics, a thermal management system and control systems. Below is a summary of a fire incident that occurred at the VBB in July 2021, based on *Victorian Big Battery Fire: July 30, 2021, Report Of Technical Findings* (Fisher Engineering and Energy Safety Response Group, 2022).

At around 10:00 am on Friday 30 July 2021 while testing and commissioning was being undertaken at the VBB facility, smoke was observed to be coming from one Megapack that was shut down as it was not part of the testing and commissioning program for the day. All Megapacks at the facility were promptly electrically isolated and the Country Fire Authority (CFA) called to site. The CFA arrived at the VBBN facility at approximately 10:30 am and observed flames escaping from the Megapack. Cooling water was applied to nearby infrastructure by the CFA but not directly to the burning Megapack in accordance with Tesla emergency response guidance. At approximately 12:00 pm flames were observed to be coming from an adjacent Megapack. By approximately 12:30 pm and 4:00pm, visible flames from the first and second Megapacks respectively had subsided. The CFA maintained a fire watch until approximately 3:00 pm on Monday 2 August 2021 at which time the CFA deemed the site under control. An investigation into the VBB fire identified the following key findings relating to causes and contributing factors:

- The most likely cause of the fire was a leak within the liquid cooling system causing arcing in the power electronics of the Megapack's battery modules.
- At the time of the fire the Megapack supervisory control and data acquisition (SCADA) system required 24 hours to setup a connection for new equipment and provide full telemetry data functionality and remote monitoring by Tesla operators. The Megapack that ignited had only been in service for 13 hours prior to being shut down via the keylock switch on the morning of the fire and as such, had not been on-line for the required 24 hours preventing the unit from transmitting telemetry data (internal temperatures, fault alarms, etc.) to Tesla's off-site control facility.
- The liquid coolant leak onto the battery modules is likely to have disabled the power supply to the circuit that actuates the "pyro disconnect" which is designed to interrupt current passing through the battery module prior to it escalating into a fire event.
- Flames emitting from the roof of first Megapack to ignite were subject to 37 to 56 km/h winds, directing the flames towards the roof of the second Megapack that ignited. The direct flame impingement on the thermal roof of the second Megapack ignited plastic overpressure vents that seal the battery bay from the thermal roof. The burning overpressure vents provided a direct path for flames and hot gases to enter the battery bays, raising the battery modules to temperatures above their thermal runaway threshold. While Tesla Megapacks have been tested in accordance Underwriters Laboratory (UL) 9540A *Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* (Underwriters Laboratory, 2019) (UL 9540A), wind conditions during testing UL9540A are limited to 19.3 km/h, approximately two to three times lower than the wind conditions experienced during the VBB fire incident.

An investigation into the VBB fire identified the following key findings relating to fire response:

- Effective pre-incident planning was in place at the VBB facility with an Emergency Action Plan (EAP) and an Emergency Response Plan (ERP) available to emergency responders. The investigation concluded that the EAP and ERP were effectively used during the VBB fire with all site employees and contractors following proper evacuation protocols.
- Subject matter experts, how to contact them, their role and other key tasks were clearly identified in pre-incident plans and VBB facility subject matter experts provided valuable information and expertise to the CFA incident controller throughout the event.
- While available data and visual observations indicated that cooling water application to adjacent Megapacks had limited effectiveness in terms of limiting fire propagation the cooling water was effective in protecting other equipment which was not designed with the same level of thermal protection as a Megapack. Megapack thermal insulation appears to be the primary factor in reducing heat transfer to adjacent Megapacks.

The VBB fire investigation identified a number of gaps in commissioning procedures, electrical fault protection devices and thermal roof design which subsequently resulted in the implementation of procedural, firmware, and hardware mitigations to address the gaps. The VBB fire also demonstrates the importance of understanding the limitations and parameters of testing undertaken to achieve certification to a particular standard (e.g., the wind speed parameters in UL9540A) and the need to undertake site specific assessments (risk assessments, design reviews etc) to minimise the likelihood of unforeseen hazard events.

4.3.1.2.2 McMicken Battery Energy Storage System Explosion

Located in Arizona, USA, the 2 MWh McMicken containerised BESS consisted of over 10,000 LIB cells arranged in racks and modules (*Institute of Electrical and Electronics Engineers Spectrum* (IEEE Spectrum), 2020). In response to a call reporting smoke and odour in the area on 19 April 2019, the Peoria Arizona Hazmat team attended the McMicken BESS. Upon opening the door of the BESS, the flammable gases that had accumulated in the container mixed with air to form an explosive mixture which ignited. The deflagration threw the Hazmat team captain approximately 22 m and another fire fighter 10 m from the BESS container door resulting in serious injuries to both.

Investigations into the explosion event were undertaken separately by a third party (DNV-GL) and the battery manufacturer (LG Chem). While DNV-GL concluded that a single battery cell failure had initiated a cascading thermal runaway event that generated the flammable gases, LG Chem disputed this finding and concluded that external heating (e.g., electrical arcing) had initiated the thermal runaway event. Although the event that initiated thermal runaway cannot be confirmed, a number of other factors that contributed to the resulting explosion wer identified including:

- The absence of adequate thermal barrier protections between battery cells allowing rapid propagation through the battery rack.
- The container not being ventilated to the outside, therefore allowing for accumulation of flammable gases.

4.3.1.2.3 Genex Bouldercombe BESS

Located approximately 20 km south of Rockhampton, Queensland, the Genex Power Bouldercombe Battery is a 100 MWh BESS consisting of Tesla Megapacks (https://www.pv-magazine.com/2023/11/07/study-shows-grid-behind-recent-large-scale-battery-fire-in-australia/). On 26 September 2023, during commissioning, a fire occurred in one of the 40 Megapacks at the Bouldercombe Battery with reports on the PV Magazine website indicating that the fire was initiated on the grid side of the unit. In accordance with established protocols, the low intensity fire was allowed to burn out with no application of fire water required. An adjacent Megapack suffered minor thermal damage to its electrical insulation. While Genex indicated in November 2023 that they expected the full investigation by Tesla would be made public, a search has not been able to find a formal incident investigation report.

Similarly to the VBB fire, the Bouldercombe fire occurred during commissioning highlighting the increased risks during the commissioning phase and the need to have appropriate emergency planning in place at this stage of a project.

4.3.1.3 LIB Fire Response

LIB fires can be extinguished by a range of different suppressants (including dry chemical powder, inert gas, foam and water), however, events involving thermal runaway typically re-ignite unless cooling is sufficient to inhibit the exothermic decomposition reactions. In a fire suppression test conducted by the Fire Protection Research Foundation on a full-scale model vehicle in 2013, the battery reignited 22 hours after the open flame was extinguished (Kong et al., 2018).

Based on a range of studies, water is considered to be the most effective method for extinguishing thermal runaway LIB fires and preventing re-ignition (Ghiji et al., 2020) and installation level testing completed by Underwriters Laboratory has demonstrated that ceiling water sprays positioned above battery units have the potential to prevent propagation of thermal runaway to adjacent units (Underwriters Laboratory, 2021). It is noted, however, that the during the testing, the sprays did not prevent propagation between modules within each unit and after cessation of water supply to the sprays, thermal runaway continued in the unit and propagated to an immediately adjacent unit

(Underwriters Laboratory, 2021). It was concluded, however, that continuous operation of a water suppression system is likely to prevent propagation of thermal runaway to adjacent units.

As with the VBB fire, and where the installation permits, response to a LIB fire can involve allowing the battery pack to slowly burn itself out while applying cooling to nearby infrastructure as required. Emergency response guidance from Tesla advises this passive approach to a Megapack fire (Fisher Engineering and Energy Safety Response Group, 2022) where the installation is designed and installed such that fire propagation between battery packs does not occur when subject to the conditions UL 9540A.

To suppress and minimise the risk of propagation of a LIB BESS thermal incident in a BESS enclosure, FM Global's *Property Loss Prevention Data Sheet 5-33 Lithium-Ion Battery Energy Storage Systems* (2024) provides recommendations for fire water supply as follows:

- Sprinkler rate of 12 mm/min over the room area.
- Additional allowance for 946 L/min for hose streams.
- The expected duration of a fire should be determined based on the number of racks in a fire area.
- A fire area is comprised of a row or rows of racks where minimum separation is not provided in accordance the following:
  - 1.8 m separation between the accessible face of LIB rack to non-combustible construction elements, non-combustible materials and adjacent racks;
  - 2.7 m separation between accessible face of LIB rack to combustible construction elements and materials;
  - Separation between non-accessible sides of adjacent racks to be determined by installation fire level testing (e.g., UL9540A testing).
- Fire water supply should be available for the full fire duration which can be estimated based on the number of adjacent LIB racks in a single fire area multiplied by 45 minutes.

Fire safety guideline *D22/107002 Large-scale external lithium-ion battery energy storage systems - Fire safety study considerations* (FRNSW, 2023) outlines FRNSW considerations relating to the assessment and determination of fire safety studies (FSS) for facilities containing large scale LIB BESS. FRNSW recognise a LIB BESS as an electrical, hazardous chemical and fire risk that requires special consideration at the design phase and throughout the project lifecycle (FRNSW, 2023), and also note that there are a range of LIB cell chemistries and the FSS should be based on the specific battery cell chemistry to be used on the site.

The requirement for a FSS in NSW is often imposed as a condition within the project approval, requiring the FSS to be prepared in accordance with *Hazardous Industry Planning and Advisory Paper No2 Fire Safety Study Guidelines* (HIPAP 2) (DoP, 2011e). FRNSW advise consideration of the following with respect to a fire safety for a LIB BESS during planning phase of the Project.

Assessment of Potential Consequences of Credible Incidents

A credible incident is considered by FRNSW to be one which propagates within a LIB BESS and involves the full unit/container. Propagation and secondary incidents, including the potential for contaminated fire water runoff to impact receiving waters, should be considered as part of the consequence analysis for a BESS. If the fire safety strategy is to involve application of water, fire water containment is likely to be required and will need to be considered in the Project design.

Defining the Fire Safety Strategy

Effective fire strategies are to include measures to minimise the likelihood, severity and extent of an incident. The potential consequences of credible incidents must be considered when developing an effective fire strategy to inform Project design with respect to minimisation of the likelihood, severity and extent of an incident through the inclusion of appropriate measures that may include separation distances, abnormal LIB BESS condition detection systems, fire barriers, on-site fire water supply and fire water containment systems.

FRNSW do not support the adoption of fire safety strategies that are partially or wholly reliant on fire brigade intervention.

Electrical Hazards Posed to Firefighters

Significant electrical hazards may be present during a LIB BESS incident including:

- The state of charge of an affected LIB BESS unit may be unable to be determined.
- High voltages can still be present at low states of charge.
- Stranded energy may still be present in the LIB BESS unit.
- It may not be possible to isolate the affected LIB BESS unit inputs and/or outputs.
- Exposure to heat may degrade the ingress protection rating of the involved LIB BESS unit and surrounding units.

The responding fire brigade may determine that no intervention activities can be undertaken in the event of an incident if the risk of potential for electrical hazards to firefighters is considered to be unacceptable. Therefore, Project design should consider ways to reduce uncertainty relating to the energy state of LIB BESS units as well as limiting radiant heat impacts on adjacent LIB BESS units to as far as reasonably practicable to enable the responding fire brigade to undertake appropriate intervention activities.

Fire Brigade Intervention

Intervention activities will be undertaken in a manner similar to that for large scale electrical infrastructure where fire brigade personnel may not enter the affected compound until an electrical facility representative has confirmed isolation of power. As indicated for electrical hazards, the responding fire brigade may determine that no intervention activities can be undertaken in the event of an incident due to electrical hazards posed and/or other potential hazards such as toxic gas release and explosion.

Implemented Fire Safety Systems

Required fire detection and protection measures will be informed by the assessment of credible incidents that may occur at the site and should be automatic in nature (i.e. not require manual operation by a first responder attending the incident) with the selected fire detection and protection measures should be aligned with the objectives of the fire safety strategy.

FRNSW advise the fire safety systems should include a fire hydrant system, even where the fire safety strategy does not rely on direct fire attack with water, to address other credible fire scenarios and protect LIB BESS units from becoming involved due to heating from adjacent/nearby fire incidents. It is important to note that street fire hydrants are not considered adequate to provide coverage for a LIB BESS facility.

BESS Unit Separation

FRNSW consider the separation of LIB BESS units and containers by distance or using appropriately rated fire barriers to be a suitable fire safety strategy. An assessment demonstrating non-propagation will be required where separation distance is proposed to prevent propagation between surrounding racks, containers and/or associated infrastructure.

BESS Unit Ventilation and Flammable and Toxic Gases

As indicated in Section 4.3.1.1, a LIB BESS can produce large volumes of flammable, corrosive and toxic vapours and gases during a thermal event resulting in a hazardous atmosphere being generated within a BESS enclosure. Designs must consider the detection and management of flammable, corrosive and toxic vapours during a thermal event. Management measures are to include means to mitigate the impacts of a deflagration or explosion should a flammable atmosphere within a BESS container/unit be ignited.

Environmental Impacts

A LIB BESS will generate toxic air emissions during a thermal runaway incident (refer to Section 4.3.1.1) and has the potential to impact off-site receivers and first responders with the quantity of LIB cells involved in the incident and meteorological conditions influencing the extent and location of the impacted area. As such, the risk of potential toxic impacts to off-site receivers and first responders should be limited limiting the quantity of LIB cells involved in a thermal incident (i.e. ensuring non-propagation between adjacent modules, racks and units/containers) and selecting an appropriate location for the LIB BESS with first responder access and egress to the LIB BESS from alternate directions (i.e. to allow access and egress via upwind direction).

As previously indicated, if the fire safety strategy relies in application of water for suppression of the thermal incident, fire water containment with sufficient capacity to capture all contaminated fire water runoff for the expected duration of the incident must be incorporated into the site design.

4.3.1.4 Project Batteries and Energy Density of BESS

As indicated in Section 4.3.1.1 the LIB cell type that will most likely be utilised at the Project will be a LFP which is considered to have greater thermal stability compared to other typical LIB cell types (e.g., LCO or LMO).

The Project BESS will consist of approximately 426 containerised units in a centralised BESS (refer to Figure 1.1) with an approximate aggregate energy storage capacity of 1,440 MWh. The BESS units will be/have been subject to UL 9540A testing to determine the minimum separation distance between units to prevent propagation of thermal runaway events from unit to unit.

The centralised BESS footprint will be approximately 73,100 m^2 and based on the 1,440 MWh capacities, the approximate stored energy density will be 19.7 kWh/m^2. LIBs have the highest average energy density of current commercial battery technologies and for a containerised BESS, the average effective energy density of such systems has been estimated to be 145 kWh/m^2 (Ara Ake, 2023). Given the low energy density of the proposed Project BESS, it is considered that there will be sufficient area to enable adequate separation between BESS containers/units and adjacent BESS containers/units as well as other sensitive equipment to achieve non-propagation of thermal incidents.

The fire safety strategy for the BESS will be determined during the detailed design phase and preparation of a FSS for the Project.

4.3.1.5 Electrical Transformers

The Project will incorporate two substations, one supplier side and one customer side, with two transformers at each substation containing approximately 236.5 kL of transformer oil as well as BESS and PV array inverters containing approximately 2.2 kL of transformer oil (refer to Figure 1.1). Transformer oils are typically combustible mineral oils that are used for their electrical insulating properties (thermally conductive) and stability at high temperature. The primary function of the mineral oil is to insulate and cool the transformer.

Leakage of transformer oil can result in environmental impacts due to toxicity and fire and/or explosion accidents should leaking oil directly contact high-voltage elements or other ignition sources. Mineral oils within a transformer can produce hydrogen and methane gases due to chemical decomposition under abnormal operating conditions when the internal temperature of a transformer reaches 150 to 300°C (El-Harbawi & Fahad Al-Mubaddel, 2020). If temperatures exceed 300°C ethylene is formed with large amounts of both hydrogen and ethylene being produced when temperatures exceed 700°C (El-Harbawi & Fahad Al-Mubaddel, 2020). While contained in the transformer, these gases tend to dissolve in the mineral oil but if release to atmosphere, will form flammable mixtures if released from the transformer oil compartment, potentially resulting in fire or explosion events if a source of ignition source is present (El-Harbawi & Fahad Al-Mubaddel, 2020).

4.3.2 Electromagnetic Fields

An electromagnetic field (EMF) is a combination of electrical and magnetic force fields that are generated by both natural phenomena and human activities. EMFs are generated through the use of electricity with equipment including small handheld devices (e.g. mobile phones) through to high voltage distribution and transmission equipment (e.g. power lines) producing EMFs. Electric fields are generated where an electric charge is present while magnetic fields are generated where electrical charge is moving, i.e. electric current (International Commission on Non-Ionizing Radiation Protection (ICNIRP), 2010).

EMFs generated by human activities reverse their direction at regular time intervals of time producing EMFs with frequencies ranging from high radio frequencies (mobile phones), through to intermediate frequencies (computer screens) and extremely low frequencies (power lines). Electric fields are typically measured in the units volts per metre (V/m) while magnetic fields are typically measured in the units Tesla (T). The strength of electric and magnetic fields rapidly decline as the distance increases from the source of the field with electric field strength typically being inversely proportional to the square of the distance and the magnetic field also being inversely proportional but the power of the relationship varying depending (first order through to third order) on the type of equipment (Energy Networks Australia (ENA), 2016). Shielding from common building materials also attenuates the strength of electric fields but not magnetic fields.

The propagation of electromagnetic energy as a wave is termed electromagnetic radiation (EMR) (ENA, 2016). Given the daily use of electrical devices and the presence of electrical distribution equipment throughout our inhabited environment, humans are typically exposed to EMR on a daily basis. The potential effects of EMR on human health vary depending on the frequency, intensity of the fields and duration of exposure.

EMR is classified as either ionising or non-ionising based on its capacity to break chemical. High frequency radiation such as ultraviolet, x-rays and gamma rays are ionising while the lower frequency EMR associated with typical electrical transmission and appliances is non-ionising. Acute health effects are evident and reasonably well understood for high and radio frequency EMR, for example the heating effects associated with being in close proximity to antenna with a high power transmitter (the same mechanism as that used in a microwave oven). However, the chronic effects of human exposure to extremely low frequency (ELF) EMR are not as well understood and have been the subject of various epidemiological studies across the globe. Reviews of the biological effects of human exposure to EMFs by the International Agency for Research on Cancer (IARC) (2002), the ICNIRP (2003) and the World Health Organisation (2007) form the scientific basis for ICNIRP guidelines for limiting human exposure to EMFs. Conclusions drawn by ICNIRP presented in the *Guidelines For Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz)* (ICNIRP, 2010) in relation to the health effects of low frequency EMFs are summarised in Table 4.1.

ENGENY

TABLE 4.1: HEALTH EFFECTS OF LOW FREQUENCY EMFS

System/Behaviour Impacted	Summary of ICNIRP Conclusions on Effects
Neurobehaviour	• Exposures to ELF electric fields causes well-defined biological responses ranging from perception to annoyance. • In a study, the threshold for perception of annoyance in the most sensitive 10% of volunteers at 50-60 Hz ranged from 2 to 5 kV/m, with 5% reporting annoyance at 12 to 20 kV/m. • The most well established effect of ELF electric fields below the threshold of direct nerve or muscle excitation is the perception of flickering light in the periphery of the visual field caused by the induction of magnetic phosphenes with the minimum magnetic field strength threshold of 5 mT at 20Hz. • A study investigating the effects of weak electric fields applied directly to the head of volunteers via an electrode was investigated and found effects on visual cortical activity (perception of cortical phosphenes at around 10 Hz) as well as a small but statistically significant number of volunteers effected while performing of a visuo-motor task (slowing of hand movement). • Evidence of other neurobehavioural effects on brain electrical activity, cognition, sleep and mood is much less clear than physical effects outlined in the above point. • There is only inconsistent and inconclusive evidence that EMF exposure causes depressive symptoms. • Evidence from double blind provocation studies does not support claims by some people who claim to be hypersensitive to EMFs.
Neuroendocrine System	In addition to volunteer studies, residential and occupational epidemiological studies do not suggest that the neuroendocrine system is adversely affected by exposure to 50–60 Hz electric or magnetic fields.
Neurodegenerative Disorders	Studies investigating the association between low frequency EMF exposure are inconsistent and generally evidence for an association between exposure and Alzheimer's disease and amyotrophic lateral sclerosis (ALS) is inconclusive.
Cardiovascular Disorders	Studies of indicate that while electric shock is an obvious health hazard, overall, the evidence does not suggest an association between EMF exposure and cardiovascular disease.
Reproduction and Development	• Epidemiological studies have not shown an association between human adverse reproductive outcomes and maternal or paternal exposure to low frequency fields. • Exposure of mammals to EMFs was not found to result in gross external, visceral or skeletal malformations using fields up to 20 mT. • Generally, the evidence for an association between exposure to low frequency EMFs and developmental and reproductive effects is very weak.
Cancer	Research suggests that there may be a weak association between the higher levels of exposure to residential 50–60 Hz magnetic fields and childhood leukemia risk. The IARC classifies low frequency electromagnetic fields as "possible carcinogenic to humans. ICNIRP considers the evidence that prolonged exposure to low frequency magnetic fields is causally related with an increased risk of childhood leukemia is too weak to form the basis for exposure guidelines.

In light of the review of various the epidemiological studies and consideration of a range of other factors that contribute to the potential impacts of exposure, ICNIRP developed EMF reference levels for both occupational and public exposure. Electricity is supplied to homes as an alternating current (AC) at a frequency 50 Hz and the electric and magnetic fields produced by equipment carrying the 50 Hz AC power falls into the range defined as extremely low frequency (ELF) (New Zealand Ministry of Health, 2013). As such, electric and magnetic fields generated by the Project that may be experienced by off-site receivers near the Project will be in the ELF range. Table 4.2 presents a comparison of typical electric and magnetic field strengths with the *Guidelines For Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz)* (2010) public exposure reference levels for exposure to EMF at 50 Hz. The data presented in Table 4.2 indicates that the strength of electric and magnetic fields that the public would typically be exposed to from electrical transmission equipment is likely to be below ICNIRP public exposure guidelines.

TABLE 4.2: TYPICAL ELECTRIC AND MAGNETIC FIELD STRENGTHS

Source	Electric Field Strength (V/m)[1]	Electric Field ICNIRP Reference Level (V/m)	Magnetic Field Strength (µT)[1]	Magnetic Field ICNIRP Reference Level (µT)
High Voltage Power Lines	**Directly underneath** 300 – 3000 **40 m from line** 10 - 100	5,000	**Directly underneath** 0.5 – 5 **40 m from line** 0.1 – 0.7	200
Distribution Power Lines	10 – 100		0.05 – 2	
Substations	Generally <10 except near where overhead lines enter/leave the station.		Generally decrease to ~5 within 5 m of equipment except near where overhead lines enter/leave the station.	
Inside a House or Office	3 – 30		0.05 – 0.5	
Near Home Appliances	60 – 600		0.02 – 0.5	

Notes:

[1] Data source: *Electric and Magnetic Fields and Your Health, Information on electric and magnetic fields associated with transmission lines, distribution lines and electrical equipment, 2013 edition* (New Zealand Ministry of Health, 2013).

4.4 Hazard Study

As indicated in Section 3, Level 1 assessment (qualitative) is considered appropriate for the Project. The Level 1 assessment undertaken included of a hazard identification workshop with key Project stakeholders using guidewords as prompts to assist with identification of potential hazardous events and scenarios that could have off-site impacts. Risk scoring was applied for each of the credible hazardous events and scenarios recorded in the workshop. It is noted that the workshop was undertaken prior to inclusion of the accommodation camp in the Project. Appendix A contains the worksheets from the workshop.

The workshop identified the following hazard scenarios associated with the BESS and substation with the potential for off-site consequences:

- A LIB fire.
- A LIB vapour cloud explosion that involves:
  - The generation of gas from sufficient number of cells to form a significant mass of flammable gas due to thermal runaway within the BESS container.
  - Ignition of the vapour cloud.
- A release of toxic gases (e.g. HF) associated with a thermal runaway event in a LIB.
- A transformer fire or explosion.

Section 3 provides an overview of the potential impacts of the hazardous events listed above and indicates that the consequences (thermal radiation, explosion overpressure and toxic gas concentrations) associated with a BESS hazardous event are expected to be near field (i.e., less than 90 m).

Modelling of thermal radiation indicates the distance to injurious impacts would be approximately 19 m with this predicted impact distance based on the conservative assumption of the BESS container wall reaching 1,000ºC during a fire. As the temperatures within BESS modules were of the order of 500ºC during installation level thermal runaway testing (Underwriters Laboratory, 2021) and the modules are for the Project will be accommodated within units that are themselves within containers, a fire scenario where the BESS container wall exceeds 500ºC is not considered credible. As such, the distances to injurious impacts and fire propagation impacts due to thermal radiation are likely to be much less than 19 m. and it is considered that further analysis of off-site thermal radiation impacts associated with a BESS is not required given the centralised BESS will be located at least 35 m from the Project boundary and any associated dwellings.

Given some BESS units are located just over 30 m from the Project boundary, potential injurious or fatal impacts associated with a BESS explosion or toxic gas release could extend beyond the site boundary, however, the impacts are not considered likely to extend to the nearest off-site dwelling or associated dwelling. The dwelling nearest to the BESS (R1) is associated with the Project and located approximately 470 m to the WSW of the nearest BESS container. The non-associated dwelling nearest to the BESS (R5) is located approximately 640 m to the NNE of the nearest BESS container. Table 4.3 provides distances to the dwellings from the BESS and Figure 4.2 shows the relative locations of the dwellings listed in Table 4.3 relative to the centralised BESS.

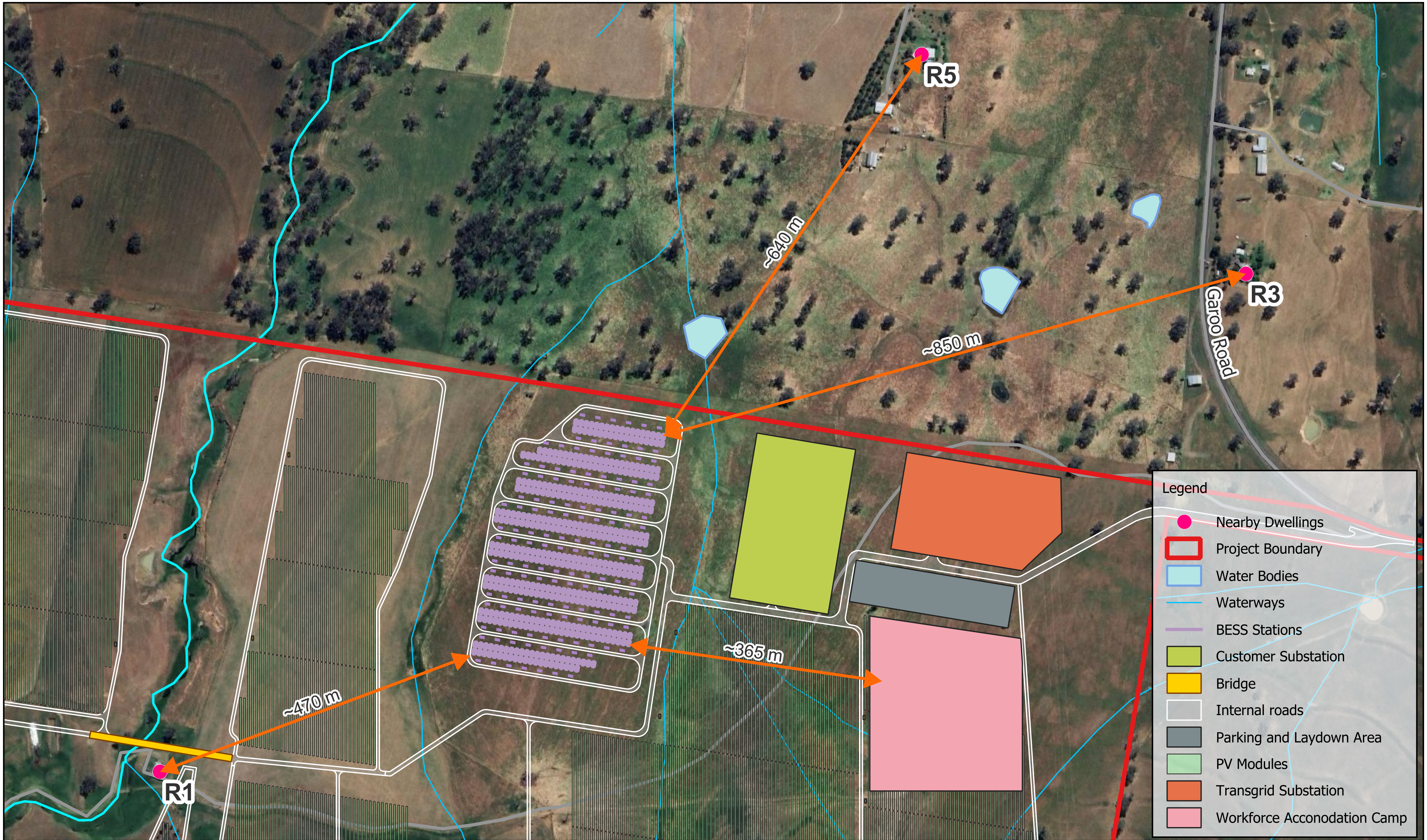
While the WAC is located closer to the BESS than the associated and non-associated dwellings, the camp is 360 m which is over 250 m beyond the likely injurious impact distance associated with a BESS hazardous event. Further, the WAC is temporary only and will be removed prior to BESS commissioning.

Based on the low likelihood of impacts to nearby dwellings and DPE advice (refer to Section 3) it is considered that quantitative analysis of the explosion or toxic release scenarios is not warranted.

TABLE 4.3: BESS PROXIMITY TO NEAREST DWELLINGS AND ACCOMODATION CAMP

Dwelling ID	Associated Dwelling?	Direction from BESS	Approximate Distance from BESS (m)
R1	Yes	WSW	470
R5	No	NNE	640
R3	No	ENE	850
Accommodation Camp	NA	E	365

Transformer fire and explosion scenarios were also identified as credible events with the potential for off-site impacts during the workshop. However, it is considered that substation design, installation, commissioning, operation and maintenance of the transformers in accordance with relevant Australian Standards will be adequate to ensure off-site risks are acceptable. Further, the substation layout and plant installed will also comply with any specific development, regulatory, environmental or TransGrid design requirements applicable to the substation installation. It is also noted that the substation will be located greater than 500 m from the nearest dwellings (R3 and R5).



DRAWN	SGG	APPROVED	CB
CHECKED	CB	DATE	30-10-2025

NOTES:

N

0 100 200 m

SCALE @ A4 - 1:7,000
GDA94 / MGA zone 56

DISCLAIMER
Engeny has endeavoured to ensure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
NSW Government Open Data Source

ENGENY

Garoo SF & BESS PHA

Figure 4.2: Distance From BESS to Dwellings and Workforce Accomodation Camp

Drg Ref. BNTL:00206_00919-FIG-001-0-BESS to Dwellings

\\online.com\files\NCManagement\NTL_Projects\NTL00206 ERM Australia Pty Ltd\BNTL00206_0019 GreenPulse Solar & BESS WRIA & PHA\05 Design\QGIS\Workspaces\BNTL00206_0019-WOR-003-A_Greenpulse Solar & BESS PHA.qgz

5. EMF IMPACT ASSESSMENT

As indicated in Section 4.3.2, EMFs are generated by electrical equipment that has the potential for human health impacts and the following Project infrastructure will generate EMFs:

- Power Conversion Equipment (e.g. Inverters).
- Transformers.
- Substation Components, e.g.:
  - Capacitors.
  - Bus bars.
  - Reactors.
  - Cable runs.
  - Transformers.
  - Circuit breakers.
- Power Lines and Cable Runs.
- BESS Components (it is noted that the chemical process within batteries does not produce EMR), e.g.:
  - Inverters.
  - Circuit breakers.
  - Cable runs.

A field study at two large scale solar facilities operated by the Southern California Edison Company in Porterville and San Bernardino was undertaken in 2011 and 2012 respectively to measure EMF strengths (Tell et al., 2015). The following EMF strength measurements and observations were recorded:

- The highest AC magnetic fields were measured were:
  - 110 µT adjacent to an inverter with the field strength falling to <10 µT within 1 m from the inverter.
  - 177 µT adjacent to a transformer with the field strength falling to <10 µT within 1 m from the transformer.
- The highest direct current (DC) magnetic fields measured were:
  - 277 µT around the perimeter of an inverter.
  - 258 µT adjacent to a transformers.
- Electric field strengths were measured at negligible levels or were non-detectable.

The data collected indicated in the field study demonstrates that all EMFs at the two facilities complied with occupational ICNIRP reference levels. While DC magnetic field levels were > 200 µT (the ICNIRP reference level for public exposure to time vary magnetic fields), it is noted that there are no reference levels or limits specified for exposure to DC generated magnetic fields, nor would it be likely that a member of the public be in such close proximity to an inverter or transformer to be exposed to a magnetic field strength exceeding 200 µT.

As shown in Figure 4.2 the separation distances between major EMF generating infrastructure (e.g. substation) and dwellings (associated and non-associated) is significant and the EMF strengths associated with the Project that are experienced at the dwellings will be negligible. Further to the distances the distance between the overhead power lines (approximately 8 m high) entering/leaving the Project and a person standing at the site boundary will be approximately 6 m. Based on the EMF field measurements undertaken at the Southern California Edison Company in Porterville and San Bernardino facilities, the data presented in Table 4.2 indicating EMF strengths underneath power lines and the proximity to dwellings, it is considered that the strengths of the EMFs generated by the Project experienced by off-site receivers will be significantly below ICNIRP reference levels (refer to Table 4.2).

6. RISK ASSESSMENT

Table 6.1 presents an evaluation of the Project risks with respect to HIPAP 4 qualitative risk criteria.

TABLE 6.1: QUALITATIVE RISK EVALUATION

HIPAP 4 Criteria	Project Risk Evaluation
All 'avoidable' risks should be avoided. This necessitates the investigation of alternative locations and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.	All hazardous materials and equipment to be stored and/or operated at the Project is necessary to deliver the required Project outcomes (e.g. electricity generation, supply and energy storage). While the hazards associated with the battery technology (LIBs) proposed (i.e. fire, explosion and toxic gas) are acknowledged, proposed technology has been selected as it has proven to be an effective and reliable option which accompanied by appropriate design, installation and maintenance can be safely managed. The hazardous components of the Project (i.e. BESS and substation) are located at distances greater than the expected impacts of a credible hazard event hazard event from the nearest associated and non-associated dwellings (refer to Section 4.4). It is considered that all 'avoidable' risks have been avoided and the Project location is appropriate.
The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.	A range of technical and non-technical measures to minimise the likelihood of a hazardous event involving the BESS and substation will be implemented at the Project (refer to Section 7). These measures are considered to, as far as practicable, ensure that likelihood of a hazardous event involving the BESS and substation are very low.
The consequences (effects) of the more likely hazardous events (i.e., those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	Given the location of the BESS and substation as well as the conservative consequence modelling results for the Tallawang Project (refer to Section 3), it is considered possible that the impacts of a toxic release or explosion event associated with BESS thermal runaway could extend off-site to the adjacent farmland. However, the injurious impact area of such events would not extend to nearest associated and non-associated dwellings.
Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	No other high risk hazardous installations are located within the vicinity of the Project that would contribute to an increase in cumulative off-site risk. Presently, the Middlebrook Solar Farm and BESS, the Lambruk Solar Farm and the Kingswood BESS projects are in the approvals phase and are located 25 km, 37 km and 41 km from the Project respectively. At such significant distances, there is no potential for these three projects to contribute to the cumulative off-site risks in the vicinity of the Project. Given the Project location, it is also considered that no future potentially hazardous industry developments would be located close enough to the Project to contribute to an increase in cumulative off-site risk.

7. RISK MANAGEMENT

Risk control is a process where measures are implemented to eliminate risks wherever possible, mitigate the residual risks identified using appropriate control measures and, lastly, accepting the residual risk (for risks that cannot be eliminated) and managing the impacts should the hazardous event occur. The risk control strategies and their level of effectiveness are broadly described as:

- Engineering control to either completely eliminate the risk (100% effectiveness) or to implement physical controls and safeguards (typically minimum 90% effectiveness).
- Administrative control based around procedures (typically maximum 50% effectiveness).
- Personnel control using training and the control of work methods (typically maximum 30% effectiveness).

The Level 1 assessment undertaken for the Project identified a range of technical and non-technical measures that will be put in place to eliminate or mitigate the level of off-site risk associated with the construction and operation of the Project.

Technical measures are those controls that are incorporated into the process or control system hardware, software or firmware. Non-technical measures are management and operational controls including operating procedures, maintenance procedures, emergency response plans and security plans and training. Technical and non-technical measures can also be categorised as preventive controls that are designed to inhibit or prevent a hazardous event from occurring and detective controls such as control system alarms that warn of unacceptable process deviations (technical) and maintenance/condition monitoring regimes that identify equipment that is deteriorating prior to failure (non-technical).

The following four components are key to mitigating LIB thermal runaway events (Bravo-Diaz et al., 2020):

- Prevention – aims to prevent thermal runaway being initiated and may be achieved with control of heat generation by:
  - Avoiding short circuits with cushioning or isolation materials for cell spacing to avoid mechanical abuse.
  - Applying cell internal safety design such as shut down separators to reduce or cut off current when short circuit occurs.
  - Using more thermally stable cathode materials such as LFP instead of LCO.
- Compartmentation – aims to contain or delay fire propagation within a battery pack once ignition occurs. This may be achieved by designing systems to have increased cell spacing, have battery packs divided into several compartments with barriers that reduce heat transfer and mechanical impact between compartments.
- Detection – aims to detect battery conditions (e.g., abnormal terminal voltages, cell temperatures, gas emissions) with a Battery Management System which are indicative of the onset of thermal runaway and ignition and automatically respond with appropriate system shutdowns and alarms to initiate preparation for emergency response.
- Suppression - which may involve chemical suppression, cooling (i.e., water mist) or fire isolation.

Sections 0 and 0 outline the technical and non-technical control measures that will be implemented as part of the Project to address the four key components for mitigation of LIB thermal runaway events as well as the control measures relating to electrical transformer hazards and EMF.

7.1 Technical Control Measures

The following technical control measures that will be implemented as part of the Project to address LIB hazards:

- The Project BESS will be separated from off-site dwellings and associated dwellings by at least 90 m which exceeds the maximum predicted fatality, injury and property damage/accident propagation consequence distances (refer to Section 3).
- The Project BESS units purchased will:
  - Be designed and constructed to meet the requirements of UL 9540 Standard for Safety of Energy Storage Systems and Equipment (UL 9540) (Underwriters Laboratory, 2022).
  - Have demonstrated to fire propagation avoidance by being tested in accordance with UL 9540A.
  - Be designed to account for the anticipated local climatic conditions (e.g. wind speeds) with respect to fire propagation.
  - Have appropriate interlocks and telemetry to detect and mitigate unsafe conditions during commissioning.

- Incorporate adequate instrumentation, interlocks and alarms to minimise the risk of the LIB incubation period (the time at a particular temperature at which thermal runaway is likely to initiate) being approached by shutting down modules/racks and alarming unsafe temperatures or other unsafe conditions such as:
  - Loss of cooling.
  - Charge/discharge voltage or current outside design parameters.
  - Internal electrical resistance outside design parameters during charging or discharge.
  - Rack fail-to-trip detected.
  - Inverter/charge fail-to-trip detected.
- Have been subject to rigorous factory acceptance testing prior to dispatch from the supplier.
- Have an effective fire suppression system that will function for the full duration of fire event should the fire safety strategy involve suppression (e.g. as per Property Loss Prevention Data Sheet 5-33 Lithium-Ion Battery Energy Storage Systems (FM Global, 2024) requirements).

- The design will ensure the separation distances between BESS containers are set to reduce the risk of accident propagation in accordance with manufacturer's instructions, appropriate standards/guidelines that may include NFPA 855 Standard for the Installation of Stationary Energy Storage Systems (NFPA 855) (National Fire Protection Association, 2022) and Property Loss Prevention Data Sheet 5-33 Lithium-Ion Battery Energy Storage Systems (FM Global, 2024) and in line with testing conditions set during type testing for UL9540A.
- Designing and constructing the BESS with an appropriate freeboard (to be determined during detailed design) above the 1% Annual Exceedance Probability (AEP) flood level.
- Installing lightning protection at the Project site to reduce the risk of lightning directly or indirectly initiating a LIB hazard event.
- Visual and audible alarms external to BESS units and at the remote monitoring centre that will be initiated should the BMS detect an unsafe BESS condition and/or thermal runaway event.
- Provisioning the Project site with adequate fire safety systems (e.g., provision of fire water tanks, hydrant booster sets and fire water containment) that will be informed by a FSS prepared in accordance with *Hazardous Industry Planning and Advisory Paper No. 2 – Fire Safety Study Guidelines* (HIPAP 2) (DoP, 2011e) and *Large-scale external lithium-ion battery energy storage systems - Fire safety study considerations* (FRNSW, 2023) and consultation with FRNSW.
- Designing the Project site layout to ensure emergency services have clear access and egress to all areas of the site (including alternate access and egress routes) that may require an emergency response.

The Project substation and transformers will be designed, installed, operated and maintained in accordance with the technical control measures contained in the following standards to address the hazards associated with electrical transformers:

- AS/NZS 60076.1:2014 Power transformers General.
- AS/NZS 60076.2:2013 Power transformers Temperature rise for liquid immersed transformers.
- AS/NZS 60076.5:2012 Insulated bushings for alternating voltages above 1000 V.
- AS/NZS 60076.6:2013 Power transformers Loading guide for oil-immersed power transformers.
- AS 60296:2017 Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear.
- AS 2067-2016 Substation and High Voltage Installations exceeding 1 kV AC.
- AS 2374.8-2000 Power Transformers – Application Guide.

Technical controls to limit off-site exposure to EMF will include:

- Design and procurement of electrical equipment that complies with relevant international and Australian standards.
- Maintaining separation between EMF generating equipment and off-site receivers to distances that will keep EMF strength below ICNIRP reference levels for public exposure.

7.2 Non-technical Control Measures

The following non-technical measures will be implemented for the Project:

- A final hazard analysis (FHA) will be completed for the Project when the Project design has achieved an adequate level of detail.
- A suitably accredited freight company using dangerous goods licensed vehicles and drivers will transport the LIBs to site.
- An Emergency Plan (EP) consistent with *Hazardous Industry Planning and Advisory Paper No. 1 – Emergency Planning* (HIPAP 1) (DoP, 2011f) and *Planning for Bushfire Protection* (NSW Rural Fire Service (RFS), 2019) will be prepared for the Project in consultation with relevant emergency services organisations (i.e., FRNSW, RFS, NSW Ambulance) and the Local Emergency Management Committee (LEMC)). An overview of the likely EP content is provided in Section 7.3.
- Post construction inductions will be made available to first responders to make them aware of Project hazards (including those specific to LIBs and electrical hazards that pose a threat during emergency response) and appropriate responses to Project hazard events.
- Adjacent landholders and associated dwellings will be consulted with to ensure they are aware of the hazards associated with the BESS and understand the emergency systems and protocols (visual and audible alarms, communications from site, evacuation plans etc.) that will be implemented in the event of a hazard event at the Project.
- Security measures will include perimeter fencing and CCTV monitoring of the BESS and electrical substations.
- All activities undertaken within Transgrid easements during construction and operation of the Project will be undertaken in accordance with the requirements of *Easement Guidelines – Living and working with electricity transmission lines* (Transgrid, 2024).
- An asset protection zone (APZ) with a width determined in accordance with *Planning for Bush Fire Protection (RFS, 2019)* will be maintained to minimise the risk of bush/grass fires impacting Project equipment and a combustible materials (including vegetation) exclusion zone of 20 m will be maintained around the substation and BESS components to reduce the risk of fire propagation between items of equipment.
- Project site vehicle speed and traffic flow directions will be managed based on the assessment of on-site hazards and the location of the battery storage facilities and electrical substations.
- Appropriate training will be provided for all personnel responsible for operations, maintenance and emergency response.
- Hot work/safe work procedures will be prepared for any maintenance works Project equipment.
- Maintenance regimes will include:
  - Routine preventative maintenance.
  - Interlock testing.
  - Condition monitoring (e.g. thermography, insulating oil analysis) of BESS components and electrical transformers.
- Waste batteries will be segregated from other waste and disposed of at an appropriate facility by suitably licensed waste contractors.

7.3 Emergency Plan Outline

As indicated in Section 0, an EP consistent with HIPAP 1 (DoP, 2011f) and the *Planning for Bushfire Protection* (RFS, 2019) will be developed and implemented for the Project in consultation with RFS, FRNSW and the LEMC. As part of the preparation of the EP, a hazard identification workshop involving key Project personnel and key stakeholders will be undertaken to identify emergency scenarios that could arise during Project construction and operation as well as hazard and risk mitigation measures (including the requirement to develop particular emergency response procedures). Table 7.1 presents the general structure and overview of content that will likely be adopted for the EP:

TABLE 7.1: EMERGENCY PLAN STRUCTURE AND CONTENT

Section	Content
Introduction	General outline of the Project and location and the definition of an emergency.
Aim and Objectives	A statement of the aims and objectives of the plan.
Roles of Agencies, Industry, Community and Other Groups	Define the roles and requirements of key stakeholder groups (e.g., RFS and FRNSW) and when consultation is required (e.g., EP review and update).
Hazards	Detail the identified hazards that could have a significant impact on emergency events and the ability to respond to such events including dangerous goods/hazardous materials, electrical hazards and natural hazards (a figure (or figures) detailing the location of hazards will be included).
Emergency Events	The types and level of emergency events that may occur on site or impact the site.
Emergency Organisation Structure and Responsibilities	List of Garoo Solar Farm and BESS personnel and external agencies with emergency management functions, including contact details, their respective responsibilities in emergency planning and emergency events and how they can be identified in an emergency event.
Site Security and Access	Details and provisions for 24/7 access for emergency services.
Emergency Resources	Details of the resources (e.g., communication equipment, alarms, firefighting equipment, material safety data sheets, PPE, water supplies) that are available for use in an emergency event (a figure (or figures) showing the location of emergency response equipment and other resources will be included).
Reporting of Emergency Events	Requirements for internal and external reporting of emergency events and post-emergency investigations.
EP Testing and Training Requirements	Requirements for training of personnel in emergency response, periodic drills to test the preparedness and effectiveness of the EP and relevant record keeping.
EP Review, Update and Document Control	Requirements/triggers (periodic or event based) for EP review and update and associated document control.
Glossary	Glossary of terms and abbreviations.
Appendices	• Emergency Procedures – clear, concise and practical procedures for the prevention and management of emergency events, likely to include: – Evacuation Plan Drawings (construction and operational phases). – Evacuation Procedure. – On-site Fire Response Procedure. – Bushfire Mitigation and Response Procedure. – Major Chemical Spill Procedure. – Flammable and Combustible Liquids Storage Procedure. – Hot Work Procedure. – Flood Response Procedure. – Severe Storm Response Procedure. – Significant Personal Injury or Medical Emergency Response Procedure. – Bomb or Substance Threat Response Procedure. – Cyberattack Response Procedure. • Emergency Services Information Package • Material Safety Data Sheets • FRNSW, RFS and LEMC consultation records.

8. CONCLUSIONS

The PHA prepared for the Project identified a number of hazard events involving LIBs and electrical transformers with the potential for harmful off-site impacts. Other than LIBs and electrical transformer oil, there will be no hazardous materials stored at, or transported to, the Project in significant quantities. However, given the adjacent land is typically unoccupied (farmland) and the large separation distances from the BESS containers and substation to dwellings, off-site individual injury, individual fatality or property damage impacts associated with LIB or electrical transformer hazardous events are not considered credible.

An evaluation of the identified Project risks was undertaken and found the Project to be compliant with respect to HIPAP 4 qualitative risk criteria. Note that compliance with HIPAP 4 criteria is conditional on the technical and non-technical risk mitigation and management measures presented in Sections 0 and 0 being implemented.

A FSS will be undertaken as the Project design progresses toward completion to ensure the final Project design adheres to the risk management measures outlined in Section 7 and that the separation distances to the dwellings are appropriate for the specific battery cell type (i.e., chemistry and capacity) to be used at the Project.

Based on the EMF field measurements undertaken at the Southern California Edison Company in Porterville and San Bernardino facilities, the data presented in Table 4.2 indicating EMF strengths near electrical infrastructure and the proximity to dwellings, it is considered that the strengths of the EMFs generated by the Project experienced by off-site receivers will be significantly below ICNIRP reference levels (refer to Table 4.2).

9. REFERENCES

Ara Ake, 2023. Stationary Battery Energy Storage Systems Analysis.

Barowy et al., 2021. UL 9540A Installation Level Tests with Outdoor Lithium-ion Energy Storage System Mockups.

Bravo Diaz L et al., 2020. Review—Meta-Review of Fire Safety of Lithium-Ion Batteries: Industry Challenges and Research Contributions, Journal of The Electrochemical Society: 167, 090559.

El-Harbawi M and Al-Mubaddel F, 2020. Risk of Fire and Explosion in Electrical Substations Due to the Formation of Flammable Mixtures, Scientific Reports: 10, 6295.

Energy Networks Australia, 2016. EMF Management Handbook.

Fire and Rescue NSW, 2023. Large-scale external lithium-ion battery energy storage systems - Fire safety study considerations.

Fire Protection Research Foundation, 2016. Hazard Assessment of Lithium Ion Battery Energy Storage Systems. Report prepared by Blum AF and Thomas Long Jr. R.

Fisher Engineering Inc. and Energy Safety Response Group, 2022. Victorian Big Battery Fire: July 30, 2021, Report Of Technical Findings.

Ghiji M, Novozhilov V, Moinuddin K, Joseph P, Burch I, Seundermann B and Gamble G, 2020. A Review of Lithium-Ion Battery Fire Suppression, Energies: 13, 5117.

Institute of Electrical and Electronics Engineers Spectrum, 2020. Dispute Erupts Over What Sparked an Explosive Li-ion Energy Storage Accident. Report by DC Wagman, https://spectrum.ieee.org/.

International Atomic Energy Agency, 1996. Manual for the Classification and Prioritization of Risks due to Major Accidents in Process and Related Industries.

International Commission on Non-Ionizing Radiation Protection, 2010). Guidelines For Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz).

Kong L, Li C, Jiang J and Pecht MG, 2018. Li-Ion Battery Fire Hazards and Safety Strategies, Energies: 11, 2191.

Larsson F, Andersson P, Blomqvist P and Mellander BE, 2017. Toxic fluoride gas emissions from lithium-ion battery fires, Scientific Reports: 7, 10018.

National Fire Protection Association, 2022. NFPA 855 Standard for the Installation of Stationary Energy Storage Systems.

NSW Department of Planning, Department of Planning, 2011a. Applying SEPP 33.

NSW Department of Planning, Department of Planning, 2011b. Multi-Level Risk Assessment

NSW Department of Planning, Department of Planning, 2011f. Hazardous Industry Advisory Paper No. 1 – Emergency Planning.

NSW Department of Planning, Department of Planning, 2011e. Hazardous Industry Advisory Paper No. 2 – Fire Safety Study Guidelines.

NSW Department of Planning, Department of Planning, 2011c. Hazardous Industry Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning.

NSW Department of Planning, Department of Planning, 2011d. Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis.

NSW Rural Fire Service, 2019. Planning for Bush Fire Protection.

New Zealand Ministry of Health, 2013. Electric and Magnetic Fields and Your Health.

Standards Australia, 2019. AS/NZS 5139:2019 Electrical Installations – Safety of battery systems for use with power conversion equipment.

Umwelt, 2022. Preliminary Hazard Analysis Tallawang Solar Farm.

Underwriters Laboratory, 2019. UL 9540A Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems.

Underwriters Laboratory, 2022. UL 9540 Standard for Safety of Energy Storage Systems and Equipment.

10. QUALIFICATIONS

(a) In preparing this document, including all relevant calculation and modelling, Engeny Australia Pty Ltd (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

(b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

(c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

  (i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

  (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

(d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

(e) This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this Report.

(f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

(g) This Report does not provide legal advice.

APPENDIX A: HAZARD IDENTIFICATION WORKSHOP MINUTES

Hazard ID Workshop

Date of Workshop: 20-May-25
Location: Online

Project Title: Garoo SF & BESS Preliminary Hazard Analysis **Job Number:** BNTL00206_0019

Project Description:	The Project is situated in the rural locality of Garoo, approximately 40 kilometres (km) (by road) south of Tamworth and 370 km northwest of Sydney. Located entirely within the Tamworth Regional LGA, the Project Area extends across approximately 368 hectares (ha), comprising 17 freehold land parcel and one Crown Land lot. The land is currently used for agricultural activities, predominantly livestock grazing and irrigated cropping. The Project will involve the construction, operation, maintenance and, where relevant, decommissioning of an AC solar farm, BESS and associated supporting ancillary infrastructure.

Purpose, Scope and Context:	The purpose of this workshop is to identify associated with the Project hazards that may have off-site impacts on people, property and the environment. NSW Department of Housing, Planning and Infrastructure (DPHI) Secretary's Environmental Assessment Requirements (SEARs) have identified off-site hazard and risk as an area to be addressed in the Project Environmental Impact Statement (EIS). Risk screening, classification and prioritisation (undertaken in accordance with State Environmental Planning Policy (Resilience and Hazards) 2021, Applying SEPP 33 (NSW Department of Planning (Department of Planning (DoP), 2011) and Multi-Level Risk Assessment (DoP, 2011)) indicated the requirement for a Level 1 Qualitative Preliminary Hazard Analysis (PHA). This hazard identification workshop is a key component of the Level 1 PHA. This workshop will focus on health and safety risks posed to the surrounding off-site land users and the risks posed to the surrounding biophysical environment. i.e. the risk rankings are relevant to off-site land users not on-site personnel. The scope of the workshop includes the BESS, substation and section of transmission line within the Project area.

Workshop Attendees

Name	Company	Position/Role	Part Day
Chris Bonomini	Engeny	Principal Engineer/Facilitator	
Lucy Baker	ERM	Partner/PD	
Tarek Alsampaile	Bright Path Renewables		
Ethan Wong	Jinko Power		
Andy Xun	Jinko Power		

AS 4360 Risk Scoring System

Scoring Matrix

Likelihood		1	2	3	4	5
Level		**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
A	Almost Certain	11	16	20	23	25
B	Likely	7	12	17	21	24
C	Possible	4	8	13	18	22
D	Unlikely	2	5	9	14	19
E	Rare	1	3	6	10	15

Legend

18 to 25:	EXTREME RISK; immediate action required;
10 to 17:	HIGH RISK; senior management attention needed;
6 to 9:	MODERATE RISK; management responsibility must be specified; and
1 to 5:	LOW RISK; managed by routine procedures.

Qualitative Measures of Likelihood

	Level	Description
A	Almost Certain	The event is expected to occur in most circumstances
B	Likely	The event will probably occur in most circumstances
C	Possible	The event might occur at some time
D	Unlikely	The event could occur at some time
E	Rare	The event may occur only in exceptional circumstances

Qualitative Measures of Consequence or Impact or Severity

	Level	People Losses	Environmental Harm	Equipment Damage	Production Loss
1	Insignificant	No injuries	No-off site effects	Low financial loss	No production loss
2	Minor	First aid treatment	On-site release immediately contained	Medium financial loss	Up to 1 day production loss
3	Moderate	Medical treatment	On-site release contained with outside assistance	High financial loss	Between 1 to 5 days production loss
4	Major	Extensive injuries	Off-site release with no detrimental effects	Major financial loss	Between 5 to 20 days production loss
5	Catastrophic	Death	Toxic release off-site with detrimental effect	Huge financial loss	More than 20 days production loss

Hazard Identification

Date 20-May-25 **Job:** Garoo SF & BESS Preliminary Hazard Analysis **Job #:** BNTL00206_0019

Section/Area: BESS

Ref	Asset	Guideword	Hazard Event Description	Threat (cause of hazard event)	Consequence	Current Barriers	C	L	R	Action
1	BESS	Flooding	Changes to flood regimes/overland flows (divert watercourse) and therefore change in flood levels/flows off-site	High rainfall and installation of BESS infatsructure	Possible minor changes to flood flows and levels	Flood modelling has been undertaken and project design modified to ensure infrastructure does not have signifcant impacts on flood regimes. Flood modelling of the modified design will completed to confirm negligible impacts to upstream and downstream properties.	1	D	2	Complete flood modelling for modified project layout.
2	BESS	Flooding	Contamination of water	High rainfall and storage of environmentally hazardous substances.	Release of chemicals into flood waters	All chemicals to be stored in appropriate bunds and in accordance with any relevant Australian Standards. BESS to be located above the 1% AEP + appropriate freeboard and modelling considered increased rainfall associated with climate change.	1	E	1	Complete flood modelling for modified project layout.
3	BESS	Fire/Explosion	Thermal runaway event	Manufacturing fault Electrical abuse (e.g. over charging) Mechanical abuse (e.g. vehicle collision with BESS unit) External fire Lightning strike Commissioning	Injuries from: Thermal radiation Overpressure from explosion Release of toxic fumes	Separation distance from dwellings (minimum distance of ~470m to an associated dwelling and ~640m to a non-associated dwelling) will be maintained to as far as practicable ensure fire, explosion and toxic gas release off-site impacts are within NSW land use planning risk criteria. BESS to be designed and constructed by supplier to UL 9540 Standard for Safety of Energy Storage Systems and Equipment (or equivalent) to minimise the likelihood of propagation between battery modules and racks. BESS to be installed will have met the large scale fire testing requirements of UL9540A Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems (or equivalent) . BESS monitoring and interlocks for early detection of unsafe conditions (e.g. high temperatures), thermal runaway and trips to disconnect/shutdown impacted racks. On-site vehicle speed limit of 10 km/h to limit severity of vehicle collisions. Design of BESS to consider likely severe weather conditions including lightning protection. Asset protection zones (APZ) to reduce risk of bush fire impacting BESS. Emergency management plan to be developed to ensure preparedness and response systems are in place to minimise likelihood and manage bushfires. Perimeter road for emergency services access. Controlled access to containers and all personnel (operations, maintenance, contractors) will be trained in regard to the hazards of lithium ion batteries (LIBs) and safe work procedures.	2	D	5	Consideration of increased risks during commissioning and include appropriate controls in commissioning procedures.

4	BESS	Environmental Impact	Fire water applied to BESS during thermal runaway event	Response to a fire event by application of water and products of combustion or other materials contaminate fire water	Fire water release to the environment - pollution of water and/or soils		4	E	10	Fire Safety Study (FSS) to be prepared in accordance with Hazardous Industry Planning and Advisory Paper No 2 Fire Safety Study Guidelines (HIPAP 2) (DoP, 2011) with consideration of Fire safety guideline D22/107002 Large-scale external lithium-ion battery energy storage systems - Fire safety study considerations (FRNSW, 2023). Develop a fire/thermal runaway response strategy appropriate for the specific BESS units/battery type to be installed at the Project.

Hazard Identification

Date 20-May-25 **Job:** Garoo SF & BESS Preliminary Hazard Analysis **Job #:** BNTL00206_0019

Section/Area: Substation

Ref	Asset	Guideword	Hazard Event Description	Threats (causes of hazard event)	Consequence	Current Barriers	C	L	R	Action
1	Substation	Flooding	Changes to flood regimes/overland flows (divert watercourse) and therefore change in flood levels/flows off-site.	High rainfall and installation of Substation infratsructure	Possible minor changes to flood flows and levels	Flood modelling has been undertaken and project design modified to ensure infrastructure does not have signifcant impacts on flood regimes. Flood modelling of the modified design will completed to confirm negligible impacts to upstream and downstream properties.	1	D	2	Complete flood modelling for project layout.
2	Substation	Flooding	Contamination of water	High rainfall	Release of chemicals into flood waters	Transformer to be bunded in accordance with relevant standards.	1	E	1	
3	Substation	Fire/Explosion	Fire/explosion involving transformer oil.	Insulation breakdown Connection short circuit External fire	Possible injury.	Transformers will be designed and installed in accordance with relevant Australian Standards as well as state and local standards. Routine preventative maintenance, inspections and condition monitoring (e.g. oil analysis to detect insulation breakdown) will be undertaken. Asset protection zones (APZ) to be maintained to limit likelihood of bushfires impacting substation or substation initiating a bushfire. Perimeter road for emergency services access.	2	D	5	
4	Substation	EMF	Electrical equipment generates harmful Electromagnetic Fields (EMFs) that impact off-site receivers	Operation of electrical equipment gerenates EMFs	Long term health effects.	Large distance (relative to likely extent of harmful EMF strengths from EMF inducing electrical equipment) to dwellings and other locations where people could be exposed for long durations. Design and procurement of electrical equipment that complies with relevant international and Australian standards.	1	E	1	

Hazard Identification

Date 20-May-25 **Job:** Garoo SF & BESS Preliminary Hazard Analysis **Job #:** BNTL00206_0019

Section/Area: Solar Array

Ref	Asset	Guideword	Hazard Event Description	Threats (causes of hazard event)	Consequence	Current Barriers	C	L	R	Action
1	Solar Panels	Flooding	Changes to flood regimes/overland flows (divert watercourse) and therefore change in flood levels/flows off-site.	High rainfall and installation of solar array	Possible minor changes to flood flows and levels	Flood modelling has been undertaken and project design modified to ensure infrastructure does not have signifcant impacts on flood regimes. Flood modelling of the modified design will completed to confirm negligible impacts to upstream and downstream properties.	1	D	2	Complete flood modelling for project layout.
2	Solar panels	Fire	Solar panels initaite a fire that spreads off-site	Electrical fault	Property damage Environmental damage	Asset protection zones (APZ) to be maintained to limit likelihood of bushfires impacting solar array or solar array initiating a bushfire. Emergency procedures and plans (including bushfire plan developed in consultation with RFS/FRNSW) including communication protocols for notifying neighbours and evacuation. Emergency preparedness including access to water from dams for fire fighting and a hydrant system. Equipment design standards and maintenance. Remote (SCADA) monitoring systems to detect abnormal events and allow for prompt response. Perimeter road for emergency access.	2	E	3	