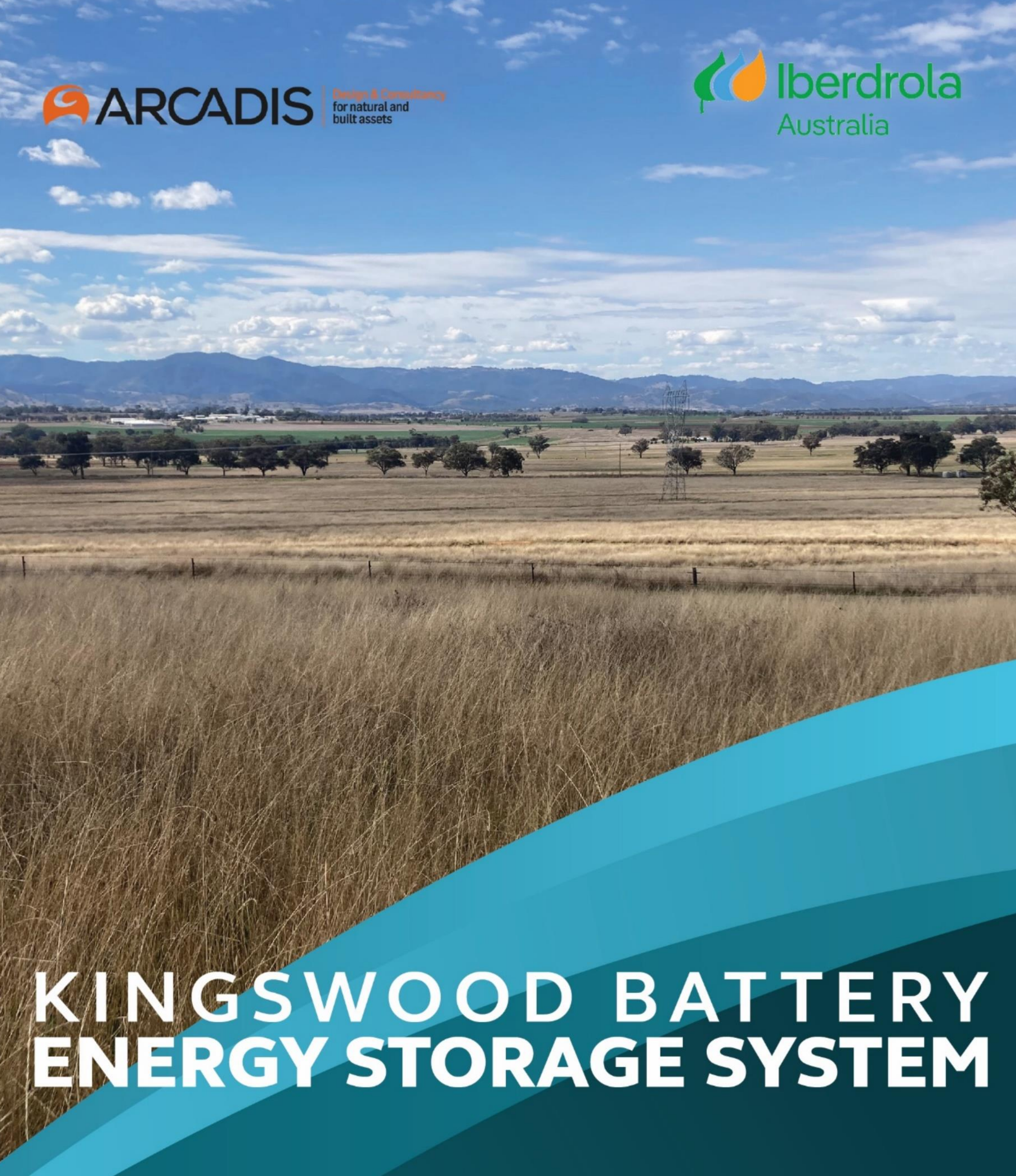

ARCADIS Design & Consultancy for natural and built assets

Iberdrola Australia

KINGSWOOD BATTERY ENERGY STORAGE SYSTEM

Appendix G
Preliminary Hazard Analysis

June 2024

SSD-63207219

PRELIMINARY HAZARD ANALYSIS

KINGSWOOD BATTERY ENERGY STORAGE SYSTEM

SSD-63207219

ARCADIS AUSTRALIA PACIFIC PTY LTD

PREPARED FOR:	**Arcadis Australia Pacific Pty Limited** **Stephan Mitchell**
DOCUMENT NO:	**21817-RP-001**
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Title: **Preliminary Hazard Analysis** **Kingswood Battery Energy Storage System** **SSD-63207219**	**QA verified:** S. Chan
	Date: 14-May-2024

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TABLES

FIGURES

ABBREVIATIONS

AC	Alternating Current
AEGL	Acute Exposure Guideline Level
ARPANSA	Australian Radiation Protection & Nuclear Safety Agency
AS/NZS	Australian Standard/New Zealand Standard
APZ	Asset Protection Zone
BESS	Battery Energy Storage System
BMS	Battery Management System
CCTV	Closed Circuit Television
DA	Development Application
DC	Direct Current
DG	Dangerous Good(s)
DoP	Department of Planning
DP	Deposited Plan
DPHI	Department of Planning, Housing and Industry
DVC	Decisive Voltage Classification
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EP&A	Environmental Planning and Assessment
ERPG	Emergency Response Planning Guideline
FHA	Final Hazard Analysis
FRNSW	Fire and Rescue NSW
G	Gauss
HAZID	Hazard Identification
HF	Hydrogen Fluoride
HIPAP	Hazardous Industry Planning Advisory Paper
HV	High Voltage
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
km	Kilometres
kV	Kilovolt
kV/m	Kilovolt per metre
kW	Kilowatt
kWh	Kilowatt hours
LEL	Lower Explosive Limit
LFL	Lower Flammability Level
LFP	Lithium Iron Phosphate
LGA	Local Government Area
MW	Megawatt
MWh	Megawatt hour(s)
NEM	National Electricity Market

NFPA	National Fire Protection Association
NMC	Nickel Manganese Cobalt
NSW	New South Wales
OEM	Original Equipment Manufacturer
OH&S	Occupational Health & Safety
O&M	Operations and Maintenance
PCS	Power Conversion System
PCU	Power Conversion Unit
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
RFS	Rural Fire Service
SDS	Safety Data Sheet
SEARs	(Planning) Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SPD	Surge Protective Devices
SSD	State Significant Development
UL	Underwriters' Laboratories
V/m	Volt per metre
VBB	Victorian Big Battery

TERMINOLOGY

Term	Definition
BESS compound	The maximum area considered for the BESS facility, also known as the 'BESS footprint'.
BESS facility (or BESS)	The battery enclosures, inverters and associated infrastructure including BESS substation, control room, switchgear, and other supporting infrastructure.
Consequence	Outcome or impact of a hazardous incident, including the potential for escalation.
Non-associated residential dwellings (sensitive receptors)	Residence whose owners do not have any part of their property included in a land agreement with the proponent for the project.
Off-site	Areas extending beyond the project site boundary.
Project	The Project for which approval is being sought, namely the construction, operation and maintenance of a BESS known as the "Kingswood Battery Energy Storage System". This includes the BESS facility, high voltage transmission line connection and ancillary elements.
Project Site	Where the BESS would be located, which is at 744 Burgmanns Lane, Kingswood 2340 (Lot 43 DP1064582).
Proponent	Iberdrola Australia Development Pty Limited.
Risk	Risk is the effect of uncertainty on objectives (ISO31000). It is expressed as a combination of the consequences of an event and the associated likelihood of occurrence. The likelihood of a specified undesired event occurring within a specified period or in specified circumstances may be either a frequency (the number of specified events occurring in unit time) or a probability (the probability of a specified event following a prior event), depending on the circumstances.

1. INTRODUCTION

1.1. Background

Iberdrola Australia Development Pty Limited (Iberdrola) (the Proponent) is seeking development consent for the construction, operation and maintenance of a large-scale Battery Energy Storage System (BESS) in Kingswood, NSW at 744 Burgmanns Lane, Kingswood 2340 (Lot 43 DP1064582) (the Project Site). The BESS will have a capacity of up to 270 Megawatts (MW) and provide up to 1080 Megawatt-hours (MWh) of battery storage capacity (the Project).

The Project is considered to meet the definition of State Significant Development (SSD) under Clause 2.6 of the *State Environmental Planning Policy (Planning Systems) 2021*. The Project will be for electricity generating works on land that is permitted with development consent under Clause 2.35 of the *State Environmental Planning Policy (Transport and Infrastructure) 2021* and will have a capital investment value greater than $30 million.

The Proponent is seeking SSD approval for the Project under Part 4, Division 4.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The project SSD reference is 63207219.

The Proponent has commissioned Arcadis Australia Pacific Pty Limited (Arcadis) to prepare an Environmental Impact Statement (EIS) for the Project. Arcadis has engaged Sherpa Consulting Pty Ltd (Sherpa) to undertake a Preliminary Hazard Analysis (PHA) for input to the 'Hazards' section of the EIS.

1.2. Objectives

The overall study objective was to address for the proposed development the 'Hazards' component of the Planning Secretary's Environmental Assessment Requirements (SEARs), Ref [1]. The Hazards assessment requirements and reference to where they are addressed in this report are shown in Table 1.1.

Table 1.1: SEARs hazards assessment requirements

Assessment requirements – '*Hazards*'	Section reference
A preliminary risk screening completed in accordance with the *State Environmental Planning Policy (Resilience and Hazards)* and *Applying SEPP 33* (DoP, 2011).	Section 3
A Preliminary Hazard Analysis (PHA) prepared in accordance with Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 – *Guideline for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011). 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 HIPAP No. 4 *Risk Criteria for Land Use Safety Planning* (DoP, 2011).	Section 5 to 9

Assessment requirements – '*Hazards*'	Section reference
An assessment of potential hazards and risks including but not limited to assessment of bushfire risk[1] against the RFS *Planning for Bushfire Protection 2019*, electromagnetic fields for 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*.	APPENDIX B

1.3. Scope

The Project involves construction and operation of a standalone BESS with the capacity of up to 270 MW/ 1080 MWh. Of relevance of the PHA, the key project components include:

- BESS including battery enclosures, inverters, switch gear and control building.
- Onsite 33/330 kV substation to convert electricity between the high voltage transmission network and medium voltage BESS.
- High voltage transmission connection (above ground and/or below ground) between the BESS substation and the nearby Tamworth substation.
- Ancillary infrastructure and mitigative features including:
  - Site access to the BESS from Ascot-Calala Road
  - Internal site access road and parking
  - Permanent office and staff amenities
  - Operations and maintenance building
  - Stormwater management infrastructure
  - Services and utilities
  - Lighting, fencing and security devices
  - Noise acoustic barriers
  - Asset protection zone
  - Landscaping and screening vegetation.

The primary focus of the PHA was the BESS components.

[1] A separate bushfire hazard assessment was carried out for the project in accordance with the RFS *Planning for Bushfire Protection 2019*. Risk event associated with bushfire and the relevant controls are referenced in this PHA to demonstrate that this event has been considered.

1.4. Exclusions and limitations

The study exclusions and limitations are summarised in Table 1.2.

Table 1.2: Exclusions and limitations

No.	Item	Exclusions and limitations
1	Design elements for the BESS	Design elements for the BESS may be subject to change prior to construction. Sherpa notes that the selection of the BESS Original Equipment Manufacturer (OEM) and layout of the BESS units will be finalised during detailed design. Detailed design will be conducted following project approval. The assessment made in this study was based on the use of the Energy Vault battery system (B-Vault DC model), which was used for the project concept design.
2	Hazards associated with proposed operations	The PHA identified and assessed credible hazards associated with proposed operations of the BESS, and excluded specific hazards relating to construction, commissioning, and decommissioning. This approach is assumed to be appropriate for assessment at the DA stage aimed to obtain approval for the project.
3	Bushfire hazard assessment	The PHA does not constitute a bushfire hazard assessment. A separate bushfire hazard assessment was carried out for the project in accordance with the RFS *Planning for Bushfire Protection 2019*. Risk event associated with bushfire and the relevant controls are referenced in this PHA to demonstrate that this event has been considered.
4	Land contamination	The PHA excludes assessment of potential hazards and risks associated with land contamination for the project. A separate assessment is completed for the EIS.
5	Cumulative risk	To assess any off-site impact and interaction with other BESS sites in the vicinity, the PHA considers other SSD projects for proposed BESS facilities in the vicinity of the Project Site. The closest identified projects are: • Calala Battery Energy Storage System (SSD-52786213) – 700 metres to the north from the site boundary • Tamworth Battery Energy Storage System (SSD-23830229) – immediately adjacent to the west site boundary. The potential for interaction between the Project and other BESS developments has been considered in the PHA. See assumption 7. It is assumed that other SSD projects will also be subject to development controls to manage off-site risks.

No.	Item	Exclusions and limitations
6	Setback distances	The PHA has been used to determine the minimum setback distance from the Project Site boundary to minimise off-site interaction potentials. The calculations have been based upon the selected model by the Proponent for concept design (B-Vault DC model). The PHA results, as well as OEM recommendations for separation and relevant standards will be used by the Proponent to finalise the BESS layout.
7	Construction Safety Study	The PHA does not constitute a Construction Safety Study. Requirement for a Construction Safety Study will be subject to the conditions of consent of the project approval. For more information, refer to HIPAP No. 7 *Construction Safety*.
8	Fire Safety Study	The PHA does not constitute a Fire Safety Study. Requirement for a Fire Safety Study will be subject to the conditions of consent of the project approval. For more information, refer to HIPAP No. 2 *Fire Safety Study*.
9	OEM and layout changes	The PHA should be reviewed if there are any changes to preferred OEM or to the site layout. The Proponent would be responsible for ensuring the layout continues to meet the OEM installation requirements.

2. FACILITY DESCRIPTION

2.1. Location and project area

The Project is located at 744 Burgmanns Lane, Kingswood 2340 (Lot 43 DP1064582). The Project Site is within the Tamworth Regional Local Government Area (LGA) in the suburb of Kingswood, around six kilometres southeast of Tamworth and two kilometres west-south-west of Calala town centre and borders the suburb of Calala. The Project Site is located about 300 metres southeast of the Tamworth Transgrid substation (Tamworth substation). The Project Site is roughly rectangular in shape, covering around 40 hectares. The regional context of the Project Site and the indicative project layout are shown in Figure 2.1 and Figure 2.2, respectively. The proposed transmission line would transect land between the Project Site and the Tamworth substation.

2.2. Surrounding land use

Tamworth is a rural region dominated by agricultural land uses, particularly cattle and sheep grazing for slaughter, and hay and cereal cropping. Consistent with regional setting and its immediate surrounds, the Project Site is zoned RU4 Primary Production Small Lots and is used as a private farm.

The nearest residential zoned land to the Project Site boundary is located in Calala around 470 metres north of the Project Site boundary. Isolated receptors are present in adjacent properties on Burgmanns Lane and Ascot-Calala Road. Residential receptors located within one kilometre of the Project Site are shown in Figure 2.3.

The Tamworth Agricultural Institute land is situated northeast of the Project Site. The institute site boundary and buildings on the Institute land are approximately 290 and 1800 metres from the BESS compound, respectively.

There are two other BESS projects seeking development approval within one kilometre of the Project Site, including:

- Calala Battery Energy Storage System (SSD-52786213) with a capacity of 300 MW/ 1200 MWh, located 700 metres from the Project Site northern boundary.
- Tamworth Battery Energy Storage System (SSD-23830229) with a capacity of 200 MW/ 400 MWh, immediately adjacent to the west Project Site boundary.

A review of distances to the offsite receptors is provided in Section 6.4.1.

Figure 2.1: Project location

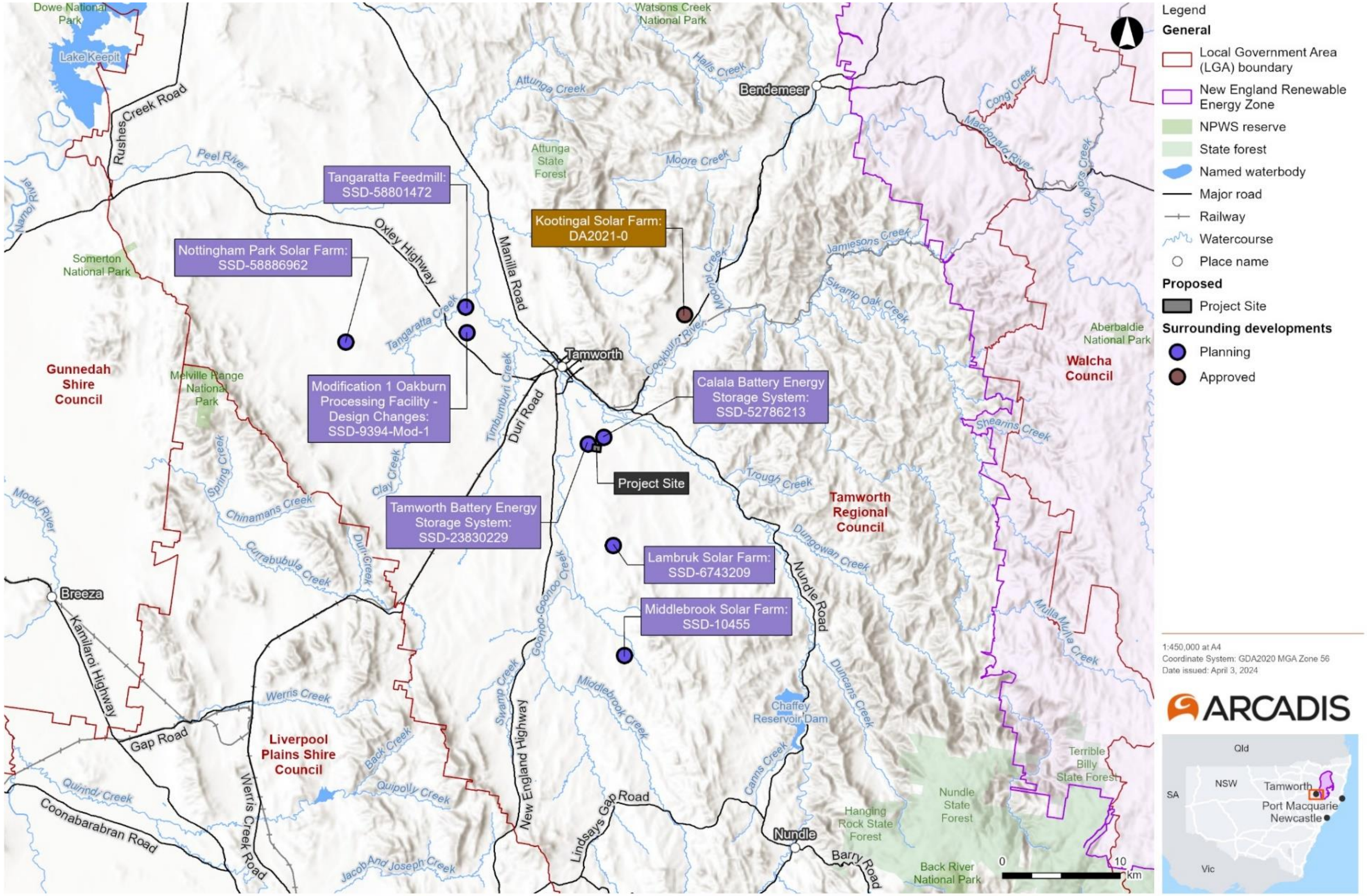


Figure 2.2: Project overview

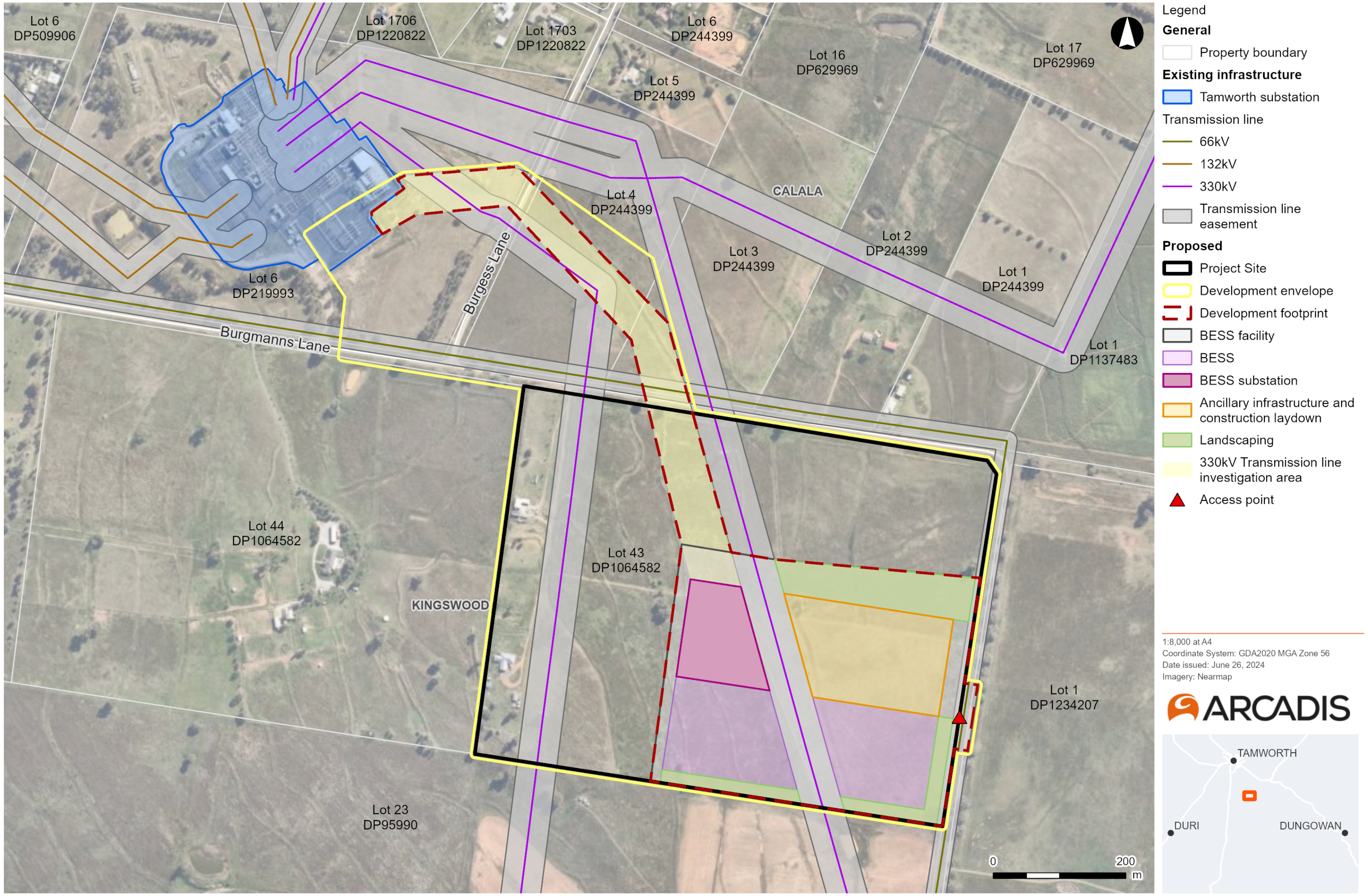
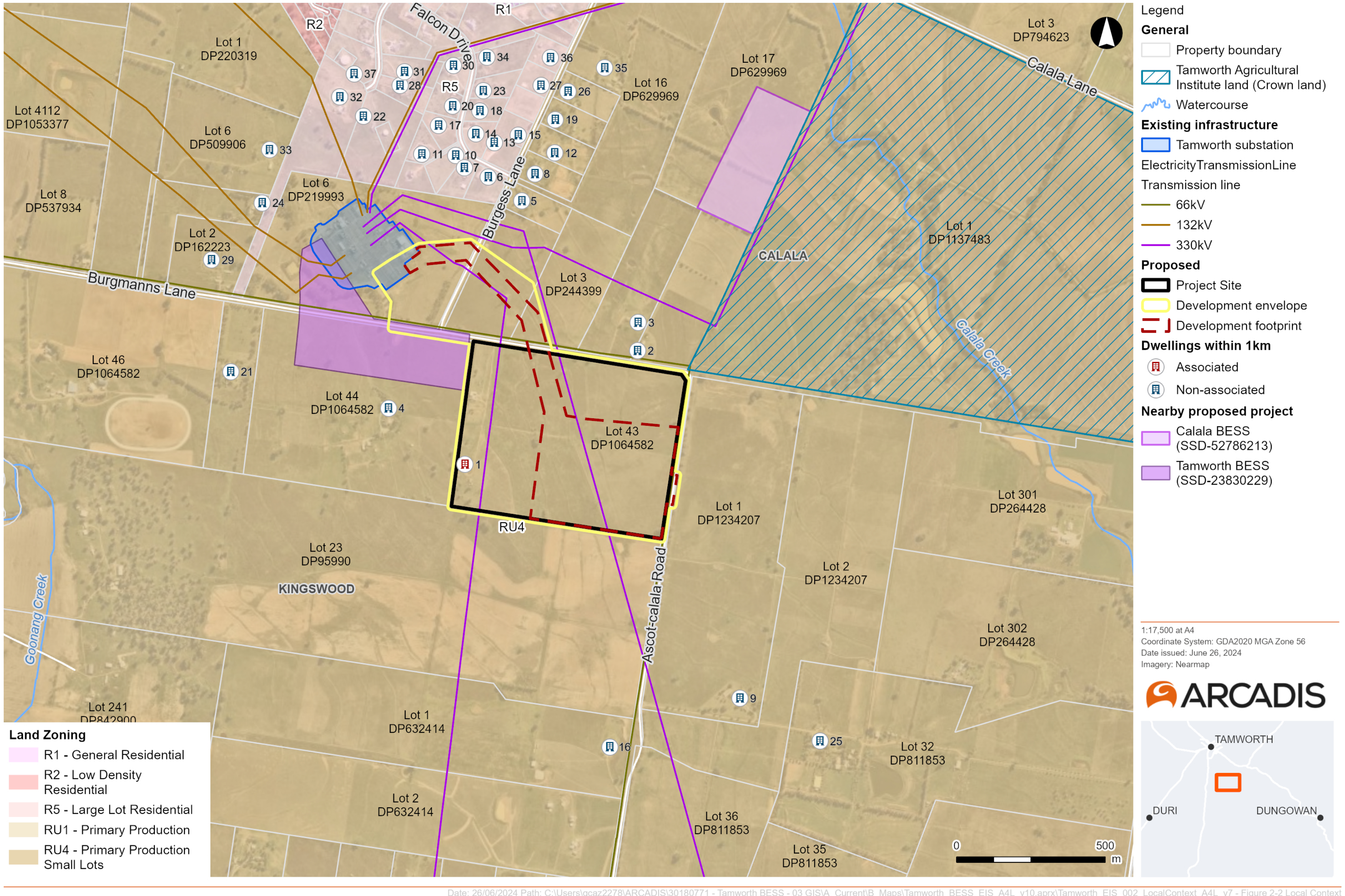


Figure 2.3: Sensitive receptors in the surrounding area



2.3. Project key infrastructure

2.3.1. Battery Energy Storage System

A BESS is a type of energy storage system that utilises batteries to store and discharge energy in the form of electricity. The energy is stored in Direct Current (DC) and converted to Alternating Current (AC) via a bi-directional inverter to convert the current between the BESS and the grid.

The BESS would store excess energy during peak production periods to later transmit into the grid when required (e.g. peak demand periods), and support stabilising the supply of electricity to the National Electricity Market (NEM).

The proposed BESS will have a capacity of up to 270 MW/ 1080 MWh. The assessment made in this study was based on the use of the Energy Vault battery system (B-Vault DC model, Lithium Iron Phosphate (LFP) chemistry), which was used for the project concept design. Major components and specific features of the battery system are described in Table 2.1 and shown in Figure 2.4.

The selection of the BESS supplier and layout of the BESS units within the BESS footprint (shown in Figure 2.4) will be finalised during detailed design. Detailed design will be conducted following project approval.

The following key points were assessed for Energy Vault batteries in this study:

1. The BESS units will be installed in accordance with the OEM's instructions provided for mitigation of fire propagation, including clearance requirements.
2. The BESS units will be installed and meet requirements of the relevant Australian Standards and other codes and standards.
3. The specific BESS (make and model) is tested to Underwriters' Laboratories (UL) 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* to evaluate the thermal runaway and fire propagation characteristics, informing the required protection for installation and operation of the respective BESS. A UL 9540A test is considered successful if a fire does not propagate from one unit/cabinet to another during the test.
4. The designated area for BESS components and associated infrastructure will be sufficient for the proposed battery type and total capacity, considering on-site and off-site receptors.

Table 2.1: BESS components, Ref [2], [3], [4]

Component	Description
Overview	The assessment made in this study was based on the use of the B-Vault DC model which integrates batteries, battery management system, thermal management system, and safety features. Modular inverters are not included within the battery enclosure and external inverters will be installed in the BESS area.
Enclosure	Each battery unit is enclosed in a (L) 9.99 m x (W) 2.44 m x (H) 2.93 m container rated to IP 55 and NEMA 3X, suited for outdoor use.
Battery modules	The battery system utilises Lithium Iron Phosphate (LFP) batteries. The rated energy for each unit will be approximately 1.491 MW/ 5.963 MWh (4 hours storage). To provide the proposed capacity, it is anticipated that up to 184 units will be installed.
Power Conversion System (PCS)	PCS or inverters are electrical devices that convert DC to AC or vice versa (i.e. bi-directional). The PCS will function to convert the current between the battery and the grid. It is anticipated that up to 92 inverters will be installed for the project (i.e. each inverter will be connected to 2 battery units).
Battery Management System (BMS)	A BMS is the electronic system that monitors and manages the battery system electric and thermal states, enabling it to operate within the safe operating region of the battery (e.g. protection against overcurrent, over-charge, over-discharge, overheating, over voltage). The B-Vault DC BMS includes: • Battery Module Unit, which collects the voltage of each battery cell and temperatures. • String Battery Control Unit, which is located in the battery switchgear and collects the data from battery modules in the string. It also has direct access to the relays that can isolate the string during abnormal events. • Master Battery Control Unit, which can send a signal to the inverters to safely shut down the container during abnormal conditions.
Thermal management system	The B-Vault DC thermal management system includes: • Liquid-cooling system: door-mounted liquid chillers for battery packs using 50% ethylene glycol aqueous solution as coolant. • Air-cooling system: door mounted air-conditioners for the battery compartments to control temperature and humidity, using R134A as refrigerant.
Fire and explosion protection system	The safety system designed for the B-Vault DC batteries includes: • Fire detection (smoke and heat detectors) • Hydrogen gas sensors • Temperature and humidity sensors • Fire alarm control panel, performing actions during a thermal event • Visual and audible alarms • Fire suppression system.

<table>
<tr><th>Component</th><th>Description</th></tr>
<tr><td></td><td>2-hour rated fire wall
NFPA 69 compliant exhaust system (active ventilation)
Emergency stop button outside of the battery units.</td></tr>
<tr><td>Standards, Codes and Testing</td><td>Key standards, tests and/or certification claimed include:
<table>
<tr><th>Standards/ tests</th><th>Title</th><th>Component</th></tr>
<tr><td>IEC 62619</td><td>Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications</td><td>Cell/ Rack</td></tr>
<tr><td>IEC 63056</td><td>Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems</td><td>Rack</td></tr>
<tr><td>UL 1973</td><td>Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail Applications</td><td>Cell/ Module/ Pack/ Rack</td></tr>
<tr><td>UL 9540A</td><td>Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems</td><td>Cell/ module/ unit</td></tr>
<tr><td>UN38.3</td><td>Certification for Lithium Batteries</td><td>Transportation</td></tr>
</table></td></tr>
</table>

2.3.2. Substation

A substation would be established to convert the medium voltage power produced by the BESS to high voltage power to enable connection to the Tamworth substation (and subsequently the grid). The substation will be within an indicative footprint of approximately 50 m x 130 m and established on a concrete pad. The substation would include transformer switch bays and switchgear housed in portable substation containers. The substation would connect to the BESS by underground 33 kV cables.

2.3.3. Grid connection

The BESS substation will be connected to a new 330 kV bay at the existing Tamworth substation (located approximately 300 metres northwest of the Project Site), via a new above ground and/or underground 330 kV cable.

2.3.4. Supporting infrastructure

The BESS compound will be supported by ancillary infrastructure including:

- Site access to the BESS from Ascot-Calala Road
- Internal site access road and parking
- An O&M building, including amenities
- Stormwater management infrastructure

- Security fencing, lighting and closed-circuit television (CCTV)
- Noise acoustic barriers
- Water tank
- Utilities
- Landscaping and screening vegetation.

2.4. Operations

The BESS will be online 24 hours a day, seven days a week. The number of operations (charging and discharging cycles) per day will depend on market conditions.

During operations, the BESS will be able to be operated remotely, and there will be no need for permanent staff on-site. From time to time, maintenance activities (preventative and corrective) will be undertaken by staff or contractors. Land management activities including weed, pest and landscaping management will be undertaken on a regular basis.

The expected project operational life is 20 years, subject to component replacement and life extension.

2.5. Decommissioning

Once the project reaches the end of its operational life, the project infrastructure will either be upgraded and re-powered, or decommissioned.

Figure 2.4: B-Vault DC component breakdown

1. Battery Compartment
2. BOP Compartment (Balance of Plant)
3. SWGR Compartment (DC Disconnect Switchgear)
4. Liquid Cooled Chillers
5. HVAC Units
6. Air Intake Dampers
7. Exhaust Damper & Fan Assembly
8. Firewall (2-hour rated)
9. Water Hose Hookup
10. Fire Strobe and Alarm
11. E-Stop Button
12. Grounding Connections
13. Anchoring Points

3. PRELIMINARY RISK SCREENING

3.1. Overview

The objective of the preliminary risk screening was to determine whether the project is considered as 'potentially hazardous' in the context of *SEPP (Resilience and Hazards) 2021*, Ref [5].

SEPP (Resilience and Hazards) 2021 defines potentially hazardous industry as follows:

> *"'Potentially hazardous industry' means a development for the purposes of any industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:*
>
> *(a) to human health, life or property, or*
>
> *(b) to the biophysical environment,*
>
> *and includes a hazardous industry and a hazardous storage establishment."*

Development proposals that are classified as 'potentially hazardous industry' must undergo a PHA as per the requirements set in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [6], to determine the risk to people, property, and the environment. If the residual risk exceeds the acceptability criteria, the development is considered as a 'hazardous industry' and may not be permissible within NSW.

To determine whether a proposed development is potentially hazardous, the NSW Department of Planning, Housing and Industry (DPHI) *Applying SEPP 33* guideline[2], Ref [7], is used to undertake the risk screening process. The risk screening process considers the type and quantity of hazardous materials to be stored on site, distance of the storage area to the nearest site boundary, specific types of industry and operations as well as the expected number of transport movements.

'Hazardous materials' are defined within Applying SEPP 33 as substances that fall within the classification of the Australian Dangerous Goods Code (ADGC), i.e. have a Dangerous Goods (DG) classification. Detail of the DG classification is typically obtained from the materials' Safety Data Sheet (SDS).

The *Applying SEPP 33* guideline is based on the 7th edition of ADGC, Ref [8], and refers to hazardous chemicals by their DG classification. Risk screening is undertaken by comparing the storage quantity and the number of road movements of the hazardous materials with the screening threshold specified in the guideline. The screening

[2] SEPP No. 33 *Hazardous and Offensive Development* (SEPP 33) has been revoked and incorporated as Chapter 3 of *SEPP (Resilience and Hazards) 2021*. For the preliminary risk screening, the guidance document *Applying SEPP 33* still applies.

threshold presents the quantities below which it can be assumed that significant off-site risk is unlikely.

3.2. Risk screening

The Project was assessed based on LFP batteries. These batteries are classified under DG class 9. Transformer oil and battery coolant (ethylene glycol aqueous solution) are not classified as DGs, and if not stored with other flammable or reactive materials are not considered to be potentially hazardous under the SEPP.

A summary of the expected hazardous materials to be stored and handled on site during the operational phase of the project, transport movements, and the relevant SEPP screening threshold is presented in Table 3.1.

3.3. Other risk factors

Appendix 2 of *Applying SEPP 33* outlines other risk factors for consideration to identify hazards outside the scope of the risk screening method.

A review of these risk factors was completed, and it was noted that the project would <u>not</u> involve:

- Storage or transport of incompatible materials (i.e. hazardous and non-hazardous). Hazardous materials will be stored in dedicated areas and storage protocols in accordance with standard and guidelines will be followed.
- Generation of hazardous waste.
- Possible generation of dusts within confined areas.
- Activities involving hazardous materials with potential to cause significant off-site impacts.
- Incompatible, reactive or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition.
- Storage or processing operations involving high (or extremely low) temperature and/or pressures.
- Hazardous materials and processes with known past incidents (or near misses) that resulted in significant off-site impacts at similar BESS developments.

3.4. Industries that may fall within the Resilience and Hazards SEPP

Appendix 3 of *Applying SEPP 33* provides a list of industries that may be potentially hazardous. It is noted that this list is illustrative rather than exhaustive. The current edition of the guideline does not include BESS facilities in the example industry listings that may fall within the Resilience and Hazards SEPP or considered as potentially hazardous.

3.5. Conclusions

The preliminary risk screening found that the project is not considered as 'potentially hazardous' within the meaning of Resilience and Hazards SEPP and does not require a PHA.

The main findings of the preliminary risk screening are summarised as follows:

- The storage and transport of hazardous materials for the project will not exceed the relevant risk screening threshold.
- No other risk factors (i.e. Greenfield site) have been identified that could result in significant off-site impacts.
- The project is not considered as 'potentially hazardous' with respect to DG storage and transportation and does not require a PHA.

Table 3.1: Preliminary risk screening summary

Material	DG Class	Category	Storage threshold	Transport threshold		Project storage quantities and applicable SEPP screening	Exceed threshold?
				Movements	Quantities		
BESS battery (Lithium ion-LFP)	9	Miscellaneous DGs	N/A	> 1000 (annual) > 60 (weekly)	No limit	No applicable SEPP screening threshold and excluded from risk screening. Transport movement threshold will not be exceeded. Movements are expected to occur during construction only and minimal during operation and maintenance (e.g. battery replacement).	No
BESS coolant (50% ethylene glycol aqueous solution)	-	-	N/A	N/A	N/A	Not classified as DG. No applicable SEPP screening threshold and excluded from risk screening.	No
BESS refrigerant (R134A)	2.2	Non-flammable Non-toxic	N/A	N/A	N/A	No applicable SEPP screening threshold and excluded from risk screening. Class 2.2 is not considered to be potentially hazardous with respect to off-site risk.	No
Transformer oil	-	-	N/A	N/A	N/A	Not classified as DG. No applicable SEPP screening threshold and not stored with flammable liquids - excluded from risk screening.	No

4. HAZARDS AND RISK ASSESSMENT METHDOLOGY

4.1. Overview

Regardless of the conclusion of the SEPP 33 screening, the *Hazards* assessment section of the SEARs require (1) a PHA, and (2) an assessment of hazards and risks for the proposed BESS facility be undertaken. The objective of these assessments is to identify the hazards and assess the risks associated with the proposed BESS facility when in operation as understood at the DA planning stage and determine risk acceptability from a land use safety planning perspective.

To address the above requirements, a PHA was completed following the methodology specified in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [6], which is focused on off-site impacts.

The HIPAP No. 6 methodology includes the following steps:

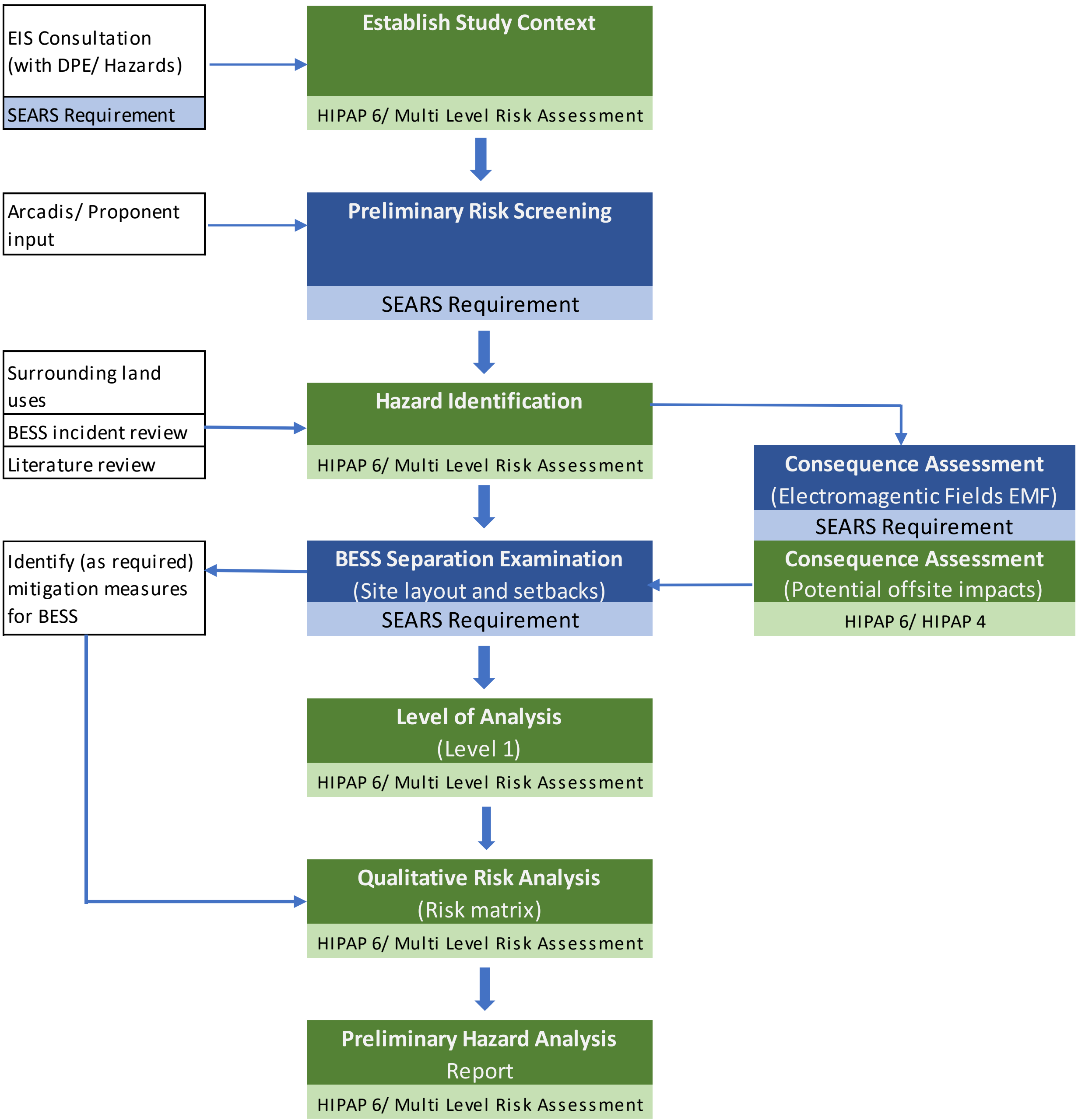
1. Establishment of the study context.
2. Identification of hazards resulting from the proposed BESS operations and events with the potential for off-site impact *(Hazard Identification)*.
3. Analysis of the severity of the consequences for the identified events with potential off-site impact, e.g. fires and explosions *(Consequence Analysis)*. This has been used by the Proponent for the preliminary design layout to establish the setback distance to the site boundary and minimise the potential for the off-site impact.
4. Determination of the level of analysis and risk assessment criteria.
5. Analysis of the risk of the identified events with off-site impact (*Risk Analysis*).
6. Assessment of the estimated risks from identified events against risk criteria to determine acceptability (*Risk Assessment)*.

The PHA assessed the events associated with proposed operation of the BESS (i.e. excluded construction related events). At the DA stage, the PHA is focused on the risk to surrounding land uses (i.e. off-site impacts) and assess if the development is appropriate for the location.

The Project Site boundary was used to define off-site impact (i.e. impact extending outside of this boundary). Off-site impact was determined based on potential to impact sensitive receptors and adjacent land use.

The study flowchart adopted for the proposed BESS facility is shown in Figure 4.1.

Figure 4.1: PHA Study Flowchart – Kingswood BESS Facility



4.2. Level of analysis

The *Multi-Level Risk Assessment* guidelines, Ref [9], sets out three levels of risk analysis that may be appropriate for a land use safety planning assessment. The levels and a high-level summary of the justification required for each level are shown in Table 4.1. This guidance document was consulted to determine the level of analysis required for this study.

Table 4.1: Level of analysis

Level	Analysis type	Appropriate/ can be justified if
1	Qualitative	There are no potential events with significant off-site consequences and societal risk is negligible.
2	Partially quantitative	The frequency of occurrence of risk contributors having off-site consequences is low.
3	Quantitative	There are significant off-site risk contributors, and a Level 2 analysis is unable to demonstrate that the risk criteria will be met.

The outcomes of the *Hazard Identification* and *Consequence Analysis* were used to determine the level of analysis appropriate for the PHA.

4.3. Risk assessment criteria

The risk criteria used for assessment followed the guidance provided in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [10], appropriate for the level of analysis determined (based on guidance outlined in Table 4.1).

5. HAZARD IDENTIFICATION

5.1. Overview

The primary objective of the Hazard Identification (HAZID) is to identify all reasonably foreseeable hazards and associated events that may arise due to the operation of the facilities through a systematic and structured approach. The HAZID was extended to include relevant controls and was used as an input to the risk assessment process.

The HAZID is representative of an indicative LFP battery system as the modes of failure and control mechanisms are similar between LFP battery types.

The HAZID process was completed using the following inputs:

1. Review of lithium-ion battery system product specification sheets, Ref [11], [12], [13], and product brochure, Ref [14], [15].
2. Review of AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment*, Ref [16].
3. Literature research of past incidents involving similar BESS systems.
4. Previous risk assessments for similar BESS systems completed by Sherpa.
5. Review of satellite and input from EIS provider to understand the potential interactions between the proposed BESS and surrounding land uses.
6. Consultation and feedback from the Proponent for review and acceptance.

5.2. Lithium-ion battery hazards

Currently, LFP batteries are the dominant battery chemistry used in large scale BESS facilities. A typical lithium-ion battery comprises:

- An anode (typically graphite) with a copper current collector.
- A cathode (e.g. lithium iron phosphate – LiFePO4 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 solvent (e.g. ethylene carbonate and diethyl carbonate).

It is important to recognise that there is considerable research and development in evolving lithium-ion chemistry and that this hazard identification is based upon available knowledge of the BESS types in January 2024. Table 5.1 summarises the lithium-ion battery chemistry reviewed. Assessment is based on Energy Vault battery which is LFP.

Table 5.1: Lithium-ion Battery chemistry overview

Battery chemistry	Advantages	Disadvantages and hazards
Lithium-ion Li-ion chemistries are diverse. Nickel Manganese Cobalt (NMC) and LFP formulations are commonly used within BESS facilities. The assessment is based on LFP chemistry for BESS.	- Energy efficiency >90% - High energy density, ranging between 100-265 Watt hours per kilogram (Wh/kg) - Wide availability and cost effective - Due to high energy density, footprint of land required for facility is comparatively lower than other low energy density formulations	- Potential for thermal runaway (greater for NMC formulation) - Most electrolytes are flammable - Limited temperature performance window (i.e. not compatible with extreme cold or hot conditions) - Compatibility issues - Reactive and hazardous in off-nominal conditions - Previous incidents of failures of safety systems during electrical surges - Potential for explosion from accumulation of gases produced in a fire

As indicated in Table 5.1, the potential hazardous events associated with lithium-ion batteries for the Project could be:

- Thermal runaway leading to a BESS fire
- Toxic vapour generation (e.g. decomposition of lithium hexafluoride phosphate within the battery electrolyte due to the fire)
- Flammable gas accumulation due to electrolyte decomposition within a confined space (e.g. in an enclosed module) and a vented explosion.

5.2.1. Thermal runaway

Thermal runaway occurs when the internal temperature of a lithium-ion cell increases beyond its design range leading to exothermic decomposition reactions generating additional heat. If the additional heat is not dissipated, the cell temperature is further elevated, accelerating the process of decomposition and heat generation. This becomes a self-sustaining exothermic reaction and in the worst case, the consequences could be battery (which is a collection of cells) destruction and fire.

The causes of thermal runaway involving lithium-ion batteries may occur from a variety of failure modes including:

- Electrical abuse (e.g. overcharging / discharging).
- Thermal abuse (e.g. overtemperature).
- Mechanical abuse (e.g. external impact).
- Existing, latent defect (e.g. electrolyte leaks, faulty components).

Whilst the OEMs provide design measures to eliminate or reduce the potential of these failure mechanisms, the PHA has considered thermal runaway as a credible hazardous event due to reported BESS facility incidents (refer to Section 5.3). Details of calculations are provided in APPENDIX C.

5.2.2. Toxic vapour generation

Lithium hexafluorophosphate ($LiPF_6$) is widely used as a salt in the electrolytes for LFP chemistry. In the event of a LFP battery fire involving the electrolyte, there is the potential to generate toxic gases (e.g. hydrogen fluoride - HF). Experiments at a bench scale (Ref [17]) has indicated that HF can be evolved from lithium-ion LFP battery fire.

As Energy Vault utilises LFP chemistry for the Project, this study has considered the potential for toxic gas generation in a fire event. Details of calculations are provided in APPENDIX C.

5.2.3. Explosion

In a fire event, decomposition of the electrolyte could result in the generation of flammable gas (e.g. carbon monoxide). A literature review of various BESS UL 9540A test results reported the concentration of generated flammable gas is below the Lower Flammability Limit (LFL). B-Vault batteries state they have undergone the UL 9540A test. However, the result report is not publicly available. In this PHA, Sherpa assumed that B-Vault meets the NFPA 855 requirements (i.e. flammable gas concentration generated not exceeding 25% LEL) and the UL 9540A large-scale fire test requirements. Based on this assumption, an explosion would not be a credible event and was not further assessed in this PHA.

5.3. BESS Incident history

There have been incidents involving large scale lithium-ion BESS facilities as reported in the public domain. Table 5.2 presents an incident summary (2019 to date) and selected events from the Australian Energy Council (Ref [18]) and reported events. This table shows that BESS with NMC battery chemistry were more susceptible to fire incidents than LFP chemistry. The Project is proposing LFP chemistry.

Table 5.2: Selected BESS fire events, REF [18]

Date	Location	Facility Size	Description
April 2019	Arizona McMicken Facility, USA	2 MW/ 2 MWh	**Battery Fire** The investigation found that the following were contributing factors: - Internal defect within the LG Chemical batteries (Li-NMC) which initiated an "extensive cascading thermal runaway event" - Lack of thermal barriers between battery cells - Storage container design did not allow the vapour and gases produced during the

Date	Location	Facility Size	Description
			incident to vent, leading to a build-up of flammable / explosive gases within the container - Inadequate emergency response plan which did not instruct personnel how to extinguish the fire or specify the entry procedure.
July 2021	Moorabool, Victoria Big BESS facility, Australia	300 MW/ 450 MWh	**Battery Fire** The Tesla Megapack batteries were of a Li-NMC chemistry. Energy Safe Victoria investigation found that the probable root cause of the thermal escalation event was a leak in the internal coolant system of the Tesla Megapack 1.0 design in combination with unmapped SCADA systems during the commissioning. The event started in one Megapack and escalated to another, and thermal radiation from this fire damaged two adjacent megapacks.
September 2021, February 2022, September 2022	Monterey County, California Moss Landing BESS facility, USA	400 MW / 1,600 MWh	**Overheating (Sept 2021, Feb 2022)** Li-ion battery modules (Phase 1) were operating above their operational temperature limit. The investigation found overheating of the battery was not the cause of the incident. Rather, it was possibly due to a fan bearing causing smoke which triggered the water system. Due to faulty couplings, the water system improperly sprayed the battery racks which led to overheating of the batteries. A similar incident again occurred in February 2022. **Battery Fire (Sept 2022)** This incident resulted in highway closure due to possible hazardous gas releases during a fire incident. The root causes are not provided. Although there was an earlier incident in that period possibly caused by the overheating incident described above.
September 2023	Bouldercombe Battery Project, Queensland, Australia	50MW/ 100MWh	**Battery Fire** One of 40 Tesla Megapack 2.0 battery units caught fire without propagating to other units. The fire occurred at the final stages of commissioning phase. Hazardous smoke was spread across the local area. However, no injuries were reported. The root causes have not been published as yet.

5.4. Hazard identification

Sherpa developed the HAZID in consultation with the Proponent and Arcadis. The following factors were considered to identify the BESS hazards:

- Lithium-ion battery chemistry, specifically LFP chemistry.
- BESS component and type of equipment.
- Proposed operation and maintenance activities.
- BESS incident history.
- External factors (e.g. bushfire, unauthorised personal access, lightning storm).

Events with the potential to result in significant impacts to people (i.e. injury and/ or fatality) were identified. The study excluded hazards related to Occupational Health & Safety (OH&S), e.g. slips, trips and falls.

The types of hazards and associated events considered were informed from AS/NZS 5139. The identified hazards and events are presented in Table 5.3.

In this study, bushfire was considered as a cause of a BESS fire resulting from encroachment of an off-site bushfire impacting the BESS. A bushfire assessment was completed for the project as part of the EIS and identified controls (e.g. Asset Protection Zone (APZ)) have been referenced in this study. A minimum APZ of 12 m is proposed to maintain around the BESS compound, Ref [19].

Table 5.3: Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Release of energy	Arc flash
Fire	Infrastructure fire, bushfire
Chemical	Release of hazardous materials
Explosive gas	Generation of explosive gas
Reaction	Battery thermal runaway
EMF	Exposure to Electric and Magnetic Fields (EMF)
External factors	Water ingress (rain and flood), unauthorised access/trespasser, lightning storm, high ambient temperature

A summary of the hazard present at/ applicable to the proposed Kingswood BESS facility is provided in Table 5.4.

Table 5.4: Hazards by Project

	BESS components/ substation					
Hazard	**Battery modules**	**PCS**	**BMS**	**Thermal management system**	**BESS substation**	**Tamworth substation**
Electrical	✓	✓	✓	-	-	-
Energy (arc flash)	✓	✓	✓	-	-	-
Fire	✓	✓	✓	✓	✓	✓

Hazard	BESS components/ substation					
	Battery modules	PCS	BMS	Thermal management system	BESS substation	Tamworth substation
Chemical	✓	-	✓	✓	-	-
Explosive gas	✓	-	-	-	-	-
Reaction	✓	-	-	-	-	-
EMF	✓	✓	-	-	✓	✓
External factors	✓	✓	✓	✓	✓	✓

5.5. Exposure to EMF

The SEARs for '*Hazards*' include a requirement to assess potential hazards and risks associated with exposure to EMF against the ICNIRP guidelines. Details on exposure to EMF and assessment against ICNIRP guideline and reference levels are presented in APPENDIX B.

Based on the detail in APPENDIX B, this study concludes that:

- EMF created from the project will not exceed the ICNIRP occupational exposure reference level.
- As the strengths of EMF attenuate rapidly with distance, this study determined that the ICNIRP reference level for exposure to the general public will not be exceeded and impact to the general public in surrounding land uses will be negligible.
- For the risk assessment, consequence from exposure to EMF was assumed to result in no or minor injury ('Non-material') in reference to the consequence impact rating shown in Table 8.2.

The identified contributors to the cumulative EMF in the vicinity of the project are listed in Table 5.5. The cumulative exposure to EMF from the Kingswood BESS and other proposed developments in the vicinity of the project (shown in Figure 2.1) is considered unlikely as the strength of EMF attenuates rapidly with distance. Thus, no off-site impact is expected from EMF, and it is not carried forward for risk assessment or further assessment.

Table 5.5: EMF sources in project area

No	Description
1	Kingswood BESS (proposed)
2	Calala BESS (proposed)
3	Tamworth BESS (proposed)
4	Tamworth substation (existing)
5	Transmission lines (new and existing)

5.6. HAZID findings

The HAZID register is provided in APPENDIX A, and the findings indicated that:

- A total of 14 hazardous events were identified. 6 events were determined to have potential for off-site impact resulting from a BESS unit.
- Incidents involving the BESS fire (6 in total) were further assessed to inform separation distances, and the consequence results were used by the Proponent to minimise potential for off-site impact (APPENDIX C). A review of separation distances for the BESS units to on-site and off-site receptors was undertaken in Section 6.
- Incidents not involving the BESS fire (8 in total) are expected to be localised and not result in significant off-site impacts as the Project will be situated in a secure area, and there is a large separation distance between BESS compound to nearest sensitive receptors (refer to Section 6.4.1).

6. BESS SEPARATION DISTANCES

6.1. Overview

As per the project SEARs, the PHA also includes a requirement to "*consider all recent standards and codes and verify separation distances to on-site and off-site receptors to prevent fire propagation*". This requirement is intended to ensure that fire risks from the BESS have been considered.

This section covers the following:

1. Review of separation distances/ clearances between the BESS sub-units against applicable codes and standards and manufacturer specification.
2. Review of separation distances between the BESS and onsite receptors.
3. Review of separation distances between the BESS facility compound to off-site receptors.

The Proponent has determined that the proposed BESS capacity would be able to fit within the land area designated for the BESS, accounting for separation distances between the:

- BESS sub-units (racks, modules, enclosures, etc.), to ensure that a fire from a sub-unit does not propagate to neighbouring sub-units; and
- The overall BESS and other onsite or off-site receptors.

6.2. Separation distances between BESS sub-units

6.2.1. NFPA 855

The National Fire Protection Association (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems* is widely viewed as the most comprehensive set of best practice guide in the industry. A review of NFPA 855 was undertaken to determine the required separation distances between the BESS units, Ref [20].

NFPA 855 specifies the default maximum allowable energy storage unit at 50 kWh (and 600 kWh for the overall BESS installation), and minimum separation of 914 mm between units and walls (for indoor installations). However, NFPA 855 also specifies that the BESS may be installed in units with larger energy capacities or smaller separation if they meet the fire and explosion testing in accordance with UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, or equivalent test standard. As such, the results of the UL 9540A test (performed with clearances as specified by the BESS manufacturer) form a key parameter to determine clearances.

The UL 9540A testing is a destructive test method used for evaluating the thermal runaway impacts in a BESS and gathering data to assist in assessing or developing mitigation measures for the failure event, propagation of the failure, or consequences of an event, such as an explosion or fire. It is currently considered to be the most appropriate published methodology to provide comprehensive, consistent, and reliable data for battery failure testing.

Tests to UL 9540A have been carried out for the B-Vault batteries. The test result report was not provided to Sherpa for review. However, the Technology Review Report, Ref [4], summarizes the test results, which confirm that the unit level results show a resiliency of the unit to thermal runaway propagation and fire hazard in a single failure event. Module-to-module and unit-to-unit propagation were not observed at unit level, indicating the separation distances used during testing provides an adequate thermal barrier between modules and can be used as the minimum separation for installation. The Proponent has confirmed that the spacing between the BESS sub-units will comply with UL 9540A test results.

6.2.2. Manufacturer specified clearances

Energy VAULT Installation Manual details the required clearances for the B-Vault DC model (Table 6.1). The Proponent confirmed the specified clearances have been considered when developing the preliminary site layout, shown in Figure 6.1. The preliminary site layout indicates the areas designated for the battery units are sufficient to follow the OEM installation requirements.

Table 6.1: BESS OEM specified clearances, Ref [3]

Installation	Minimum clearances
Side	Right aspect 0.61 m, Left aspect 0.46 m
Back	0.152 m
Front	1.32 m
• As per B-Vault Installation Manual, The B-Vault should not be installed within 3 m (10 ft) from any accessible means of egress and exposures (such as buildings, public ways, and hazards not associated with electrical grid infrastructure as defined by the clearance requirements in the International Fire Code and NFPA 855). • Any installation requiring clearances less than 3 m (10 ft) to accessible means of egress or exposures may necessitate a freestanding fire barrier, as per the requirements in the International Fire Code and NFPA 855A.	

6.3. Onsite receptors

The onsite receptors to the BESS located within the Project Site will be:

- O&M building
- Control room
- Switchgear room
- BESS substation
- Water tank.

As shown in Figure 2.2, two separate areas are dedicated for the BESS substation and associated infrastructure. Based upon the BESS preliminary layout, the distance between the battery units and the perimeter of these areas is approximately 15 m. With reference to the BESS fire radiation analysis (APPENDIX C), the estimated distance for escalation events (23 kW/m^2) is 6 metres for a BESS unit fire. The potential for fire propagation to the substation and other onsite receptors is minimal.

From a safe design layout perspective, in the event of a transformer fire, the BESS units should be located away from the substation to minimize fire propagation.

Recommendation 1: When finalizing the BESS layout, the Proponent ensures that there is sufficient spacing between the substation and BESS units to minimise the potential for fire propagation.

6.4. Off-site impact

6.4.1. Off-site receptors

For the PHA, non-associated residential dwellings or occupied areas are considered sensitive receptors for the determination of off-site impact. There are isolated receptors in the vicinity of the Project Site. The nearest off-site receptor is located 280 metres from BESS compound (battery units and associated infrastructure footprint), which is a residential dwelling. The nearest residential zone to the BESS compound is Calala, located approximately 700 metres from the BESS compound.

The closest boundary point of the Tamworth Agriculture Institute land is about 290 metres from the BESS compound.

Separation distances from the BESS compound to the Project Site boundary and off-site receptors are shown in Figure 6.2.

6.4.2. BESS setback distances

As indicated in Section 5, the HAZID identified the following scenarios as having the potential for off-site impact:

- Fire involving a BESS unit (e.g. thermal runaway resulting in a fully developed fire).
- Toxic gas generation from decomposition of battery electrolyte due to fire.

Consequence analysis (fire radiation and toxic gas) was completed for a fire involving B-Vault DC unit to determine set-back distances to the site boundary. This was done to avoid any significant off-site impact and interaction with other BESS developments in the vicinity of the Project Site.

The analysis approach, input, assumptions and results are provided in APPENDIX C. A summary of the analysis results is as follows:

- <u>Fire involving a BESS unit</u>: the distance to the injury level (4.7 kW/m^2 heat radiation) was estimated to be 16 m.
- <u>Toxic gas dispersion:</u> the distance to the injury (AEGL-2) level at D5 condition is 12 m.

For the proposed development, the Proponent has proposed to setback the BESS units from the nearest site boundary (south) by at least 16 m to minimise off-site impact (from a fire or toxic gas generation).

The distance between the nearest Project Site boundary to BESS compound is approximately 20 metres. Based on BESS setback distances from site boundary, the effects from a BESS unit fire (serious injury and/or fatality to the public or off-site population) are not expected to extend beyond the Project Site boundary.

Recommendation 2: When finalizing the BESS layout, as a minimum, the Proponent should ensure that the setback distance from the site boundary is based upon the BESS fire and toxic gas consequence calculations.

6.4.3. Other BESS developments (cumulative impact)

The BESS developments within 1 kilometre of the Project Site are provided in Table 6.2. As no significant off-site impact from the Project is expected (Section 6.4.2), no interaction from the Project to the other BESS developments would occur. It is also assumed that a PHA was undertaken for these other developments, and that offsite risk was acceptable.

Table 6.2: Other BESS developments review

No.	Project	Distance from lot boundary to Kingswood BESS compound	Commentary
1	Calala BESS	950 m	The distances between the Kingswood BESS facility compounds and other BESS lots are shown in Figure 6.2. The injury impact distance resulting from B-Vault unit on fire is approximately 16 m. This is well below the distances from the BESS compound to the other BESS developments. The interaction between Kingswood and other BESS developments and cumulative risk impacts are expected to be minimal.
2	Tamworth BESS	300 m	

6.5. Review findings

The review of BESS separation distances found that:

- The Proponent confirmed the preliminary BESS layout (battery and inverters) will meet the recommended clearances specified by the battery OEM. Additionally, the assessed battery system was tested to UL 9540A and the unit level results indicate the resiliency to thermal runaway propagation and fire hazard in a single failure event.

- The distance between BESS units and supporting infrastructure footprint is approximately 15 metres, which is greater than the estimated heat radiation impact distance for escalation events (6 m) in case of a BESS unit fire. The Proponent confirmed the distance between BESS and on-site infrastructure in the finalized BESS layout will adhere to the OEM installation requirements and/or applicable standards to avoid propagation to other onsite infrastructure in the event of BESS thermal runaway and/or fire.
- The distance between the BESS compounds and the nearest site boundary (20 m) is greater than estimated injury distance from a BESS unit fire (16 m). The nearest sensitive off-site receptor is approximately 280 metres from the BESS compound. Therefore, no significant off-site impact to offsite receptors is expected from BESS fires.
- As no off-site injury impact from the BESS is expected, there will be no interaction between Kingswood BESS and other proposed BESS developments (Calala BESS and Tamworth BESS), and the cumulative risk is considered negligible.

Figure 6.1: Preliminary BESS layout

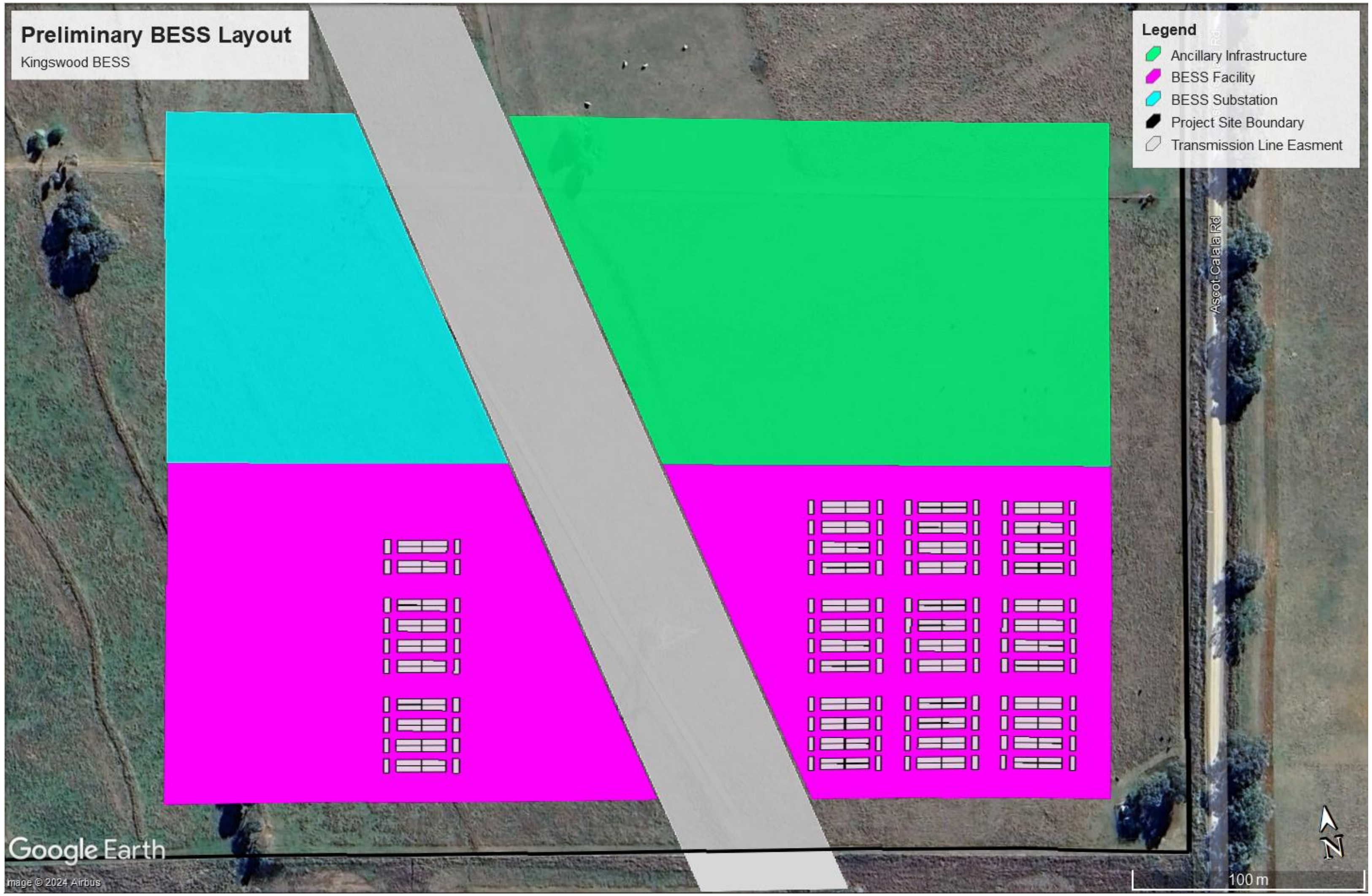
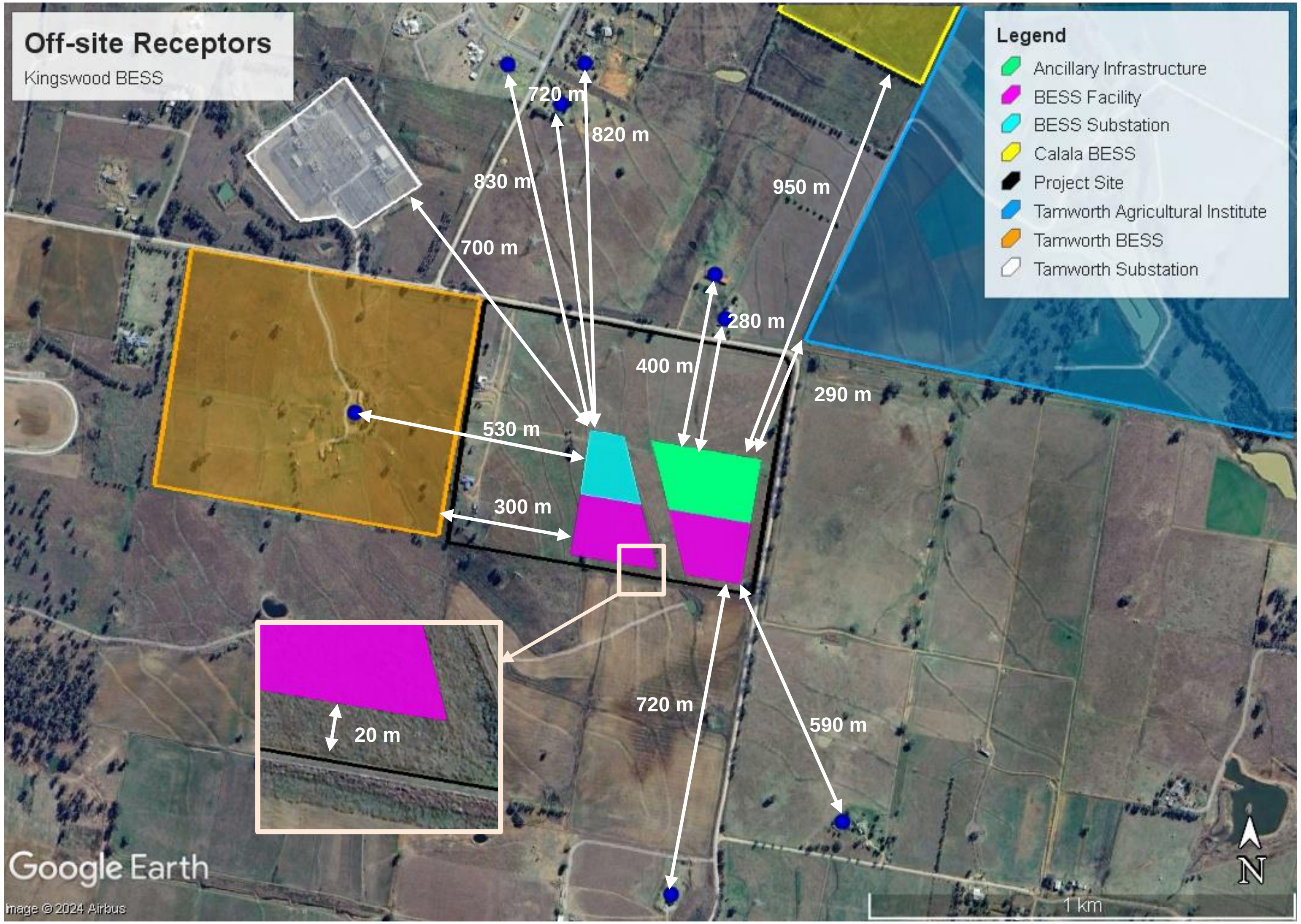


Figure 6.2: Separation distance to off-site receptors



7. LEVEL OF ANALYSIS DETERMINATION

7.1. Level of analysis

The HAZID and preliminary consequence analysis found that for all identified events, significant off-site impacts (serious injury and/or fatality to the public or off-site population) was not expected as:

- Incidents involving a BESS fire, the separation distance between BESS compound and the site boundary and sensitive receptors, is greater than calculated impact distance for heat radiation or toxic gas injury level.
- Incidents not involving a BESS fire, as the BESS components are located in a secure area separated from sensitive receptors, no impact offsite / public is expected.

Additionally, the identified events are expected to present negligible societal risk impact as:

- The project will be in a rural area with scattered residential dwellings. The nearest sensitive receptor is approximately 280 m from the BESS compound.
- The nearest township is Calala, located approximately 700 metres north of the BESS compound.

Based on the above findings and the *Multi-Level Risk Assessment* guideline, Ref [9], and guidance to determine the required level of analysis for the PHA (Table 4.1), a qualitative approach (i.e. Level 1 analysis) was determined appropriate for this study. The risk analysis is presented in Section 8.

7.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [10], recommends a set of qualitative criteria/ principles be adopted concerning the land use safety acceptability of a development.

The risk assessment against HIPAP No. 4 criteria is provided in Section 9.

8. RISK ANALYSIS

8.1. Overview

In this study, risk is defined as the likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either a frequency (the number of specified events occurring in a unit of time) or a probability (the probability of a specified event following a prior event) depending on the circumstances.

From HAZID register (APPENDIX A), 6 events were identified with the potential offsite impact (e.g. a BESS unit on fire). For these events, the risk was qualitatively determined from the resulting severity and likelihood rating pair using the Proponent's risk matrix shown in Table 8.1. The consequence results for these events were used to identify the severity rating.

8.2. Risk Matrix and Acceptance Criteria

For this study, acceptance criteria used to assess the risk for off-site population are:

- Extreme – Unacceptable; immediate action is required.
- High– Unsatisfactory; an action plan is required which includes steps for timely risk prevention or mitigation.
- Medium – Tolerable; implement additional controls if reasonably practicable.
- Low – Acceptable; no specific action is required.

Events with risks greater than 'Low' are required for further assessment as per the Proponent's risk management requirements.

Table 8.1: Risk matrix

Consequence	Likelihood				
	Rare	**Unlikely**	**Possible**	**Likely**	**Almost Certain**
Catastrophic	Medium	High	High	Extreme	Extreme
Major	Medium	Medium	High	High	Extreme
Moderate	Low	Medium	Medium	High	High
Minor	Low	Low	Medium	Medium	Medium
Non-material	Low	Low	Low	Low	Low

8.3. Severity rating

For each event, the severity rating was assigned based on the consequence description identified in the HAZID register and the consequence analysis findings using the category scale shown in Table 8.2 which was reproduced from Risk Classification Standard developed by the Proponent.

The severity scale was then used to assess impact for off-site population. As a conservative measure, should the consequence analyses indicate the potential for offsite fatality impact, a 'catastrophic' rating was assigned. For consequences with an injury potential, then 'moderate' rating was chosen.

Table 8.2: Consequence rating – Offsite

Consequence rating	Rating definition
Catastrophic	Fatality (single or multiple) and/or serious irreversible damage or serious impairment to more than one person.
Major	Serious irreversible damage or serious impairment to one person (e.g. amputation, heart attack).
Moderate	Reversible injury or moderate irreversible damage or impairment to one or more persons. Typically a recordable Injury (i.e. requiring medical treatment, lost time or restricted duties).
Minor	Reversible injuries requiring minor treatment onsite. Typically a first aid case.
Non-material	Event reported with no first aid required (e.g. bumped or bruised knee, minor strain).

8.4. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 8.3 which was reproduced from Risk Classification Standard.

The likelihood ratings were assigned based on knowledge of historical incidents in the BESS industry (Section 5) and in consultation with the Proponent. The likelihood ratings were assigned accounting for the initiating causes, resulting consequences with controls (prevention and mitigation) in place.

Table 8.3: Likelihood rating

Likelihood rating	Rating definition
Almost certain	The event is expected to occur in most circumstances as there is a history of regular occurrences within similar industries or sites.
	Occurs more than once a year.
Likely	There is a strong possibility the event will occur as there is a history of frequent occurrences within similar industries or sites.
	Typically occurs once every 1 – 5 years.
Possible	The event might occur at some time as there is a history of casual occurrences within similar industries or sites.
	Typically occurs once every 5 – 20 years.
Unlikely	Not expected, but there is a slight possibility it may occur at some time.
	Typically occurs once every 20 – 50 years.
Rare	The event may occur in exceptional circumstances. It could happen, but probably never will.
	Greater than a 50-year event.

8.5. Risk results and analysis findings

Events with the potential for off-site impact (6 in total corresponding to BESS fire events) were extracted from the HAZID register, APPENDIX A, for qualitative risk assessment as shown in Table 8.4. Of note:

- The consequence rating of 'Non-material' was assigned. Based upon the BESS setback distances from the boundary derived from the consequence analyses, there is no significant off-site impact (serious injury or fatality).
- The likelihood was assigned as 'unlikely' and associated risk for each incident are provided in Table 8.4.

Table 8.4: Offsite risk – Kingswood BESS

HAZID ID (Appx. A)	Incident location	Potential consequences with off-site impact	Potential offsite impact (Yes/No)	Risk analysis (off-site/ public impact) – concept layout			Recommendations
				Severity	Likeli'd	Risk	
3	Battery units BMS PCS (inverters)	- A battery unit fire - Release of toxic (HF) combustion products	- No significant offsite impact expected as the BESS units and infrastructure have separation distances as per UL-9540A test results - Setback distances from the BESS units to the site boundary as per consequence analysis	Non-material	Unlikely	Low	No additional measures identified
6	Battery units BMS Thermal management system			Non-material	Unlikely	Low	No additional measures identified
8	Battery units			Non-material	Unlikely	Low	No additional measures identified
9	Battery units			Non-material	Unlikely	Low	No additional measures identified
13	BESS BESS substation Tamworth substation			Non-material	Unlikely	Low	No additional measures identified
14	Battery units			Non-material	Unlikely	Low	No additional measures identified

9. RISK ASSESSMENT AND CONCLUSION

9.1. Assessment against company risk acceptance criteria

Using the Proponent’s risk matrix, the identified hazardous events were qualitatively risk profiled and all found to be ‘Low’ risk.

None of the identified events are expected to have significant off-site impacts. This finding is a result of the Proponent using the PHA to establish setback distances from the site boundary. Based on the study risk acceptance criteria, the risk profile for the proposed BESS is considered to be acceptable, and no additional risk mitigation measures were identified.

9.2. Assessment against HIPAP No. 4 criteria

Assessment against the HIPAP No. 4 qualitative land use planning risk criteria is provided in Table 9.1.

Table 9.1: Assessment against HIPAP No. 4 qualitative risk criteria

HIPAP 4 qualitative criteria	Remarks	Complies?
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.	The PHA has identified hazardous events and assessed the risks associated with the proposed Kingswood BESS operations. The BESS location is situated in a rural and the BESS facility itself will be in a secure area. There are large separation distances to sensitive receptors (i.e. residential) to avoid off-site risks. It is not possible to eliminate batteries from a BESS development. Selection of the battery technology is a balance of cost and availability, with the most commonly used versions being lithium ion.	Yes
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 made 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.	Based on the separation distance to sensitive receptors, consequences from the identified hazardous events are not expected to have significant off-site impacts.	Yes
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.	Events with high probability of occurrence are expected to be contained within the boundaries of the installation. Specifically, for fire incidents involving a BESS unit, calculation showed that the separation distances between BESS units and site boundaries are greater than impact distances (injury and/or fatality levels), and no off-site impact beyond the site boundaries (serious injury and/or fatality to the public or off-site population) is expected.	Yes

HIPAP 4 qualitative criteria	Remarks	Complies?
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.	There are no hazardous developments (in the context of the Resilience and Hazards SEPP) in the vicinity of the project. The cumulative risk to sensitive receptors from nearby proposed BESS developments has been considered in this PHA, and no cumulative impact is expected. It is assumed that other developments will also be subject to managing off-site risks.	Yes

9.3. Conclusion

9.3.1. Preliminary risk screening

To address the *Hazards* assessment requirements of the project's SEARs, a preliminary risk screening was completed in accordance with the *Applying SEPP 33* guideline to determine whether the project is considered as 'potentially hazardous' in the context of SEPP (Resilience and Hazards) 2021.

The preliminary risk screening found that:

- The storage and transport of hazardous materials for the project will not exceed the relevant risk screening threshold.
- No other risk factors have been identified that could result in significant off-site impacts.
- The project is not considered 'potentially hazardous' in the context of the Resilience and Hazards SEPP and does not require a PHA.

9.3.2. PHA

Notwithstanding the outcome of the preliminary risk screening, the project's SEARs require (1) a PHA, and (2) an assessment of hazards and risks for the project to be undertaken. To address these requirements, a PHA was completed to identify the hazards and assess the risks associated with the proposed operations of the project to determine risk acceptability from a land use safety planning perspective.

The PHA was completed following the methodology specified in HIPAP No. 6 *Hazard Analysis* and the *Multi-Level Risk Assessment* guideline for assessment against the HIPAP No. 4 criteria. A Level 1 PHA (qualitative) was completed.

The PHA concluded that:

- EMF created from the Project will not exceed the ICNIRP occupational exposure reference level.
- For all identified events associated with the proposed operation of the project, the resulting consequences are not expected to have significant off-site impacts.
- The risk level for all identified hazardous events are rated as 'Low'.
- The project meets the HIPAP No. 4 qualitative risk criteria.

The project's SEARs also include requirement for the PHA to '*consider all recent standards and codes and verify separation distances to onsite and off-site receptors to prevent fire propagation'*. The review of BESS separation distances found that:

- The Proponent confirmed the preliminary BESS layout (battery and inverters) will meet the recommended clearances specified by the battery OEM. Additionally, the assessed battery system was tested to UL 9540A and the unit level results indicate the resiliency to thermal runaway propagation and fire hazard in a single failure event.

- The distance between BESS units and supporting infrastructure footprint is approximately 15 metres, which is greater than the estimated heat radiation impact distance for escalation events (6 m) in case of a BESS unit fire. The Proponent confirmed the distance between BESS and on-site infrastructure in the finalized BESS layout will adhere to the OEM installation requirements and/or applicable standards to avoid propagation to other onsite infrastructure in the event of BESS thermal runaway and/or fire.
- The distance between the BESS compounds and the nearest site boundary (20 m) is greater than estimated injury distance from a BESS unit fire (16 m). The nearest sensitive off-site receptor is approximately 280 metres from the BESS compound. Therefore, no significant off-site impact to offsite receptors is expected from BESS fires.
- As no off-site injury impact from the BESS is expected, there will be no interaction between Kingswood BESS and other proposed BESS developments (Calala BESS and Tamworth BESS), and the cumulative risk is considered negligible.

Upon any modifications made to the project's design, specifically the BESS, the PHA should be reviewed and updated as required to ensure that the aspects considered (e.g. control measures, clearances between BESS units, separation distance to sensitive receptors) and assessments made in this report remain valid. Similarly, once the project's design is finalised and the BESS OEM selected, the PHA should be revisited and updated as required.

9.4. Recommendations

To support the PHA conclusion, the following recommendations are provided:

Recommendation 1: When finalizing the BESS layout, the Proponent ensures that there is sufficient spacing between the substation and BESS units to minimise the potential for fire propagation.

Recommendation 2: When finalizing the BESS layout, as a minimum, the Proponent should ensure that the setback distance from the site boundary is based upon the BESS fire and toxic gas consequence calculations.

APPENDIX A. HAZARD IDENTIFICATION

This appendix provides the hazard identification (HAZID) table. It covers potential hazard scenarios arising from BESS operations.

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
1	Electrical	Battery modules BMS PCS (inverters)	Exposure to voltage	<u>Short circuit/ electrical connection failure</u> - Faulty equipment - Incorrect installation - Incorrect maintenance - Human error during maintenance - Safety device/circuit compromised - Battery casing/enclosure damage <u>Earth potential rise (exposure to step and touch potentials)</u> - Electrical faults	- Electrocution - Injury and/or fatality to onsite employees - Injury and/or fatality to member of public due to touch and step potential (e.g. transferred through fences) As the BESS will be situated in a rural area and the site itself is in a large vacant lot, there is a large separation distance to the nearest sensitive receptor. The effects are not expected to have an off-site impact.	- DC circuit breakers - Surge Protective Devices (SPD) - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines to minimise touch and step potential - Decisive Voltage Classification (DVC) followed, and equipment marked accordingly - Warning signs (electrical hazards, arc flash) - Engagement of reputable contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent owner's engineers' endorsement - Site induction/substation training (i.e. high voltage areas) - Electrical switch-in & switch-out protocol - BESS BMS fault detection and safety shut-off - Earthing study (mitigate touch and step potentials) - Earthing as per manufacturer and standards requirements - Perimeter security fence with signage (warning of electrical hazard) - Site Emergency Response Plan - External firefighting protocol (RFS) - Use of appropriate PPE - Rescue kits (i.e. insulated hooks)	No	-
2	Energy	Battery modules BMS PCS (inverters)	Arc flash	- Incorrect procedure (i.e. installation/ maintenance) - Faulty equipment (e.g. corrosion on conductors) - Faulty design - Human error during maintenance - Insufficient isolation/insulation to applied voltage - Mechanical damage - Vibration	- Arc blasts and resulting heat, may result in fires and pressure waves - Burns - Exposure to intense light and noise - Injury and/or fatality to onsite employees Localised effects, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Warning signs (arc flash boundary) - Engagement of reputable contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent owner's engineers' endorsement - Site induction and training (i.e. high voltage areas) - Maintenance procedure (e.g. de-energize equipment) - Preventative maintenance (insulation) - Electrical switch-in & switch-out protocol - Site Emergency Response Plan - External firefighting protocol (RFS) - Use of appropriate PPE for flash hazard within the arc flash boundary. Conductive items not worn while working on or near energised or live conductive parts (e.g. rings, jewellery)	No	-

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
3	Fire (internal)	Battery modules BMS PCS (inverters)	BESS fire	- Faulty equipment - Arc flash - Mechanical damage or failure of battery case (e.g. overload, insulation breakdown, connection failures) - Battery thermal runaway (e.g. short circuit, overheating, overcharge) - External fire (e.g. substation fire, fire at BESS facility[1]) - Bushfire (e.g. encroachment of off-site bushfire, escalated event due to fire from other project infrastructure) Note 1: There is a proposed BESS facility to the west and north of the Project Site.	- Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - All relevant Transgrid requirements for the substation will be met - Circuit breakers provided for the substation - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Bushfire risk assessment - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features) - Activation of emergency shutdown (by remote control room) - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Site Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (RFS)	Yes	- Whilst fire radiation or toxic gas impacts are expected to be localised, fire and toxic gas analysis will confirm the minimum distance between the BESS units and the nearest site boundaries

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
4	Fire	BESS substation Tamworth substation	Substation fire	- Faulty equipment - Transformer oil leak - Arc flash - Vandalism - External fire (e.g. fire escalation from adjacent BESS) - Bushfire	- Release of toxic combustion products - Escalation to adjacent infrastructure and thermal runaway event - Injury and/or fatality to onsite employees	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - All relevant Transgrid requirements will be met - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Bushfire risk assessment - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - Electrical switch-in & switch-out protocol - BESS fire and explosion protection system (battery system specific features) - Activation of emergency shutdown (by remote control room) - Fire Management Plan - Site Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (RFS)	No	- As the BESS will be located in a rural area away from the residential area (approx. 350 m), fire propagation is not expected - BESS fire has been considered in HAZID item 3 - Refer to the Bushfire assessment report for review of fire potential
5	Fire	BESS BESS substation Tamworth substation	Bushfire	- Encroachment of off-site bushfire - Escalated event due to fire from other project infrastructure	- Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees	- Vegetation management/ clearance around BESS - Fire Management Plan - Defendable boundary for firefighting will be established - Site Emergency Response Plan - External firefighting protocol (RFS) - Inclusion of APZ buffer to minimise bushfire encroachment - Use of appropriate PPE - Fire protection for buildings within the BESS facility	No	- Refer to the bushfire assessment report

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
6	Chemical	Battery modules BMS Thermal management system	Release of electrolyte (liquid/vented gas) from the battery cell	<u>Mechanical failure/ damage</u> - Dropped impact (e.g. during installation/ maintenance) - Damage (e.g. crush/ penetration/ puncture) <u>Abnormal heating/ elevated temperature</u> - Thermal runaway - Bushfire - External fire (e.g. main substation)	- Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte (unignited case) - Fire and/or explosion in battery enclosure - Release of toxic combustion products (ignited case) - Injury and/or fatality to onsite employees	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Each battery pack contains an integrated electrolyte sink, sized to capture all electrolyte contained within the battery pack in the event of substantial damage or pack rupture - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Selection of appropriate battery chemistry - Venting and containment requirements of the BESS manufacturer and RFS to be followed - Battery modules are enclosed with external casing - Spill clean-up using dry absorbent material - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features) - Activation of emergency shutdown (by remote control room) - Fire Management Plan - Site Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (RFS) - Use of appropriate PPE	Yes	- Whilst fire radiation or toxic gas impacts are expected to be localised, fire and toxic gas analysis will confirm the minimum distance between the BESS units and the nearest site boundaries

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
7	Chemical	Battery modules BMS Thermal management system	BESS coolant or refrigerant leak	- Mechanical failure/damage - Incorrect maintenance	- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact) - Ingress of coolant or refrigerant to battery or other electrical components (battery enclosure) leading to short circuit, thermal runaway and fire/explosion, resulting in injury and/or fatality to onsite employees	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Each pack is designed to be water resistant (IP 65 rated) and will protect a leak inside the enclosure from entering a pack or cascading between packs - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features) - Activation of emergency shutdown (by remote control room) - Fire Management Plan - Site Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (RFS) - Containment of leaks and spills - Use of appropriate PPE	No[3]	BESS fire has been discussed in HAZID item 3

[3] The Victorian Big Battery fire (30-Jul-21) was caused by a short circuit (a coolant leak from the cooling system leading to a fire in an electronic component) and subsequent overheating (thermal runaway). The fire involved 2 battery packs and was locally confined to the area. Energy Safe Victoria reported that the battery was offline and the monitoring and protection systems not being available, allowed the initial fault to go undetected. The Energy Vault safety systems will be equipped with an auxiliary backup power/ UPS system that can provide power for up to 2 hours. This will ensure that the safety systems are still operating in the event of an outage.

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
8	Explosive Gas	Battery modules	Generation of explosive gas (e.g. hydrogen)	- Thermal runaway - Bushfire - External fire (e.g. substation fire, fire from adjacent infrastructure or neighbouring sites)	- Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Ventilation requirements as per manufacturer's instruction - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features) - Activation of emergency shutdown (by remote control room) - Fire Management Plan - Site Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (RFS)	Yes	- This event has been considered in HAZID Item 3

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
9	Reaction	Battery modules	Thermal runaway in battery	Elevated temperature - Bushfire - External fire on site (e.g. Main Substation) - Fire at neighbouring sites Electrical failure - Short circuit - Excessive current/voltage - Imbalance charge across cells Mechanical failure - Internal cell defect - Damage (crush/ penetration/puncture) - Coolant leak Systems failure - BMS failure - Thermal management system failure	- Fire and/or explosion in battery enclosure - Escalation to the entire BESS - Injury and/or fatality to onsite employees	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Design includes two measures for explosion mitigation (sparkler system and deflagration panels in roof) - Warning signs - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - BESS fire and explosion protection system (battery system specific features) - Activation of emergency shutdown (by remote control room) - Fire Management Plan - Site Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (RFS) - Fire protection for buildings within the BESS facility	Yes	- Whilst fire radiation or toxic gas impacts are expected to be localised, fire and toxic gas analysis will confirm the minimum distance between the BESS units and the nearest site boundaries

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
10	EMF	BESS modules PCS (inverter) BESS substation Transmission line Tamworth substation	Exposure to electric and magnetic fields	Operations of energy storage system and associated equipment	- High level exposure (i.e. exceeding the reference limits) may affect function of the nervous system (i.e. direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) - Injury to onsite employees EMF created from the BESS will not exceed the ICNIRP reference level for exposure to the general public. Additionally, the strengths of electric and magnetic fields attenuate rapidly away from the source. As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Location siting and selection (i.e. separation distance to sensitive receptors) - Distribution and low intensity of modules - Reducing conductor spacing - Balancing phases and minimising residual current - Incidental shielding (i.e. BESS enclosure) - Equipment and systems will be designed and tested to comply with international standards and guidelines - Exposure to personnel is short duration in nature (transient) - Warning signs	No	- Adverse health effects from EMF have not been established based on findings of science reviews conducted by credible authorities No established evidence that Extremely Low Frequency (ELF) EMF is associated with long term health effects (ARPANSA) - Studies found that the EMF for commercial power generation facilities comply with ICNIRP occupational exposure limits
11	External factors	BESS BESS substation Tamworth substation	Water ingress	- Rain - Flood	- Electrical fault/short circuit - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees	- Location siting (i.e. outside of flood prone area) - Substation and switchroom will be housed in a dedicated building and constructed in accordance with relevant standards - Drainage system - Preventative maintenance (check for leaks) - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features) - Activation of emergency shutdown (by remote control room) - Fire Management Plan - Site Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (RFS)	No	- The Kingswood site is above the 1 in 100 year flood level (as noted in the EIS)

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
12	External factors	BESS BESS substation Tamworth substation	Vandalism	- Unauthorised personnel access - Trespassing - Deliberate damage to BESS infrastructure Asset damage	- Asset damage - BESS failure/fire - Potential hazard to unauthorised person (e.g. electrocution) - Injury and/or fatality to trespasser Effects to unauthorised person are expected to be localised and not expected to have an off-site impact. The impact is to a member of public but occurs onsite.	- Secure battery unit cabinets design - The BESS will be located within a secure area, which is fenced - Warning signs (i.e. trespassers and on-site hazards) - Security cameras will be provided at the substation and at the BESS compound. Control room (off-site) will initiate BESS shutdown - Site security plan for BESS site - BESS BMS has active monitoring. Interference will result in the BESS shutdown	No	-
13	External factors	BESS BESS substation Tamworth substation	Lightning strike	Lightning storm	- Fire - Injury and/or fatality to onsite employees	- Vegetation Management/ clearance around BESS - Lightning protection mast and surge protection devices - Earthing as per manufacturer and standards requirements - BESS BMS monitoring and activation of emergency shutdown for temperature deviations - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Fire Management Plan - Site Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (RFS)	Yes	- Whilst fire radiation or toxic gas impacts are expected to be localised, fire and toxic gas analysis will confirm the minimum distance between the BESS units and the nearest site boundaries

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Potential off-site Impact?	Additional commentary (Kingswood)
14	External factors	Battery modules	BESS overheating	- Extreme temperature or humidity - Dust ingress to BESS	- Potential for escalation to a thermal runaway event - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees - Asset damage	- BESS units designed for maximum expected ambient condition (e.g., temperature) - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to consequence assessment) - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - BESS fire and explosion protection system - Activation of emergency shutdown (by remote control room) - Fire Management Plan - Site Emergency Response Plan - External firefighting protocol (RFS)	Yes	- This incident is covered in HAZID Item 3 and consequence analysis to check if there is an offsite impact potential in a fire event (thermal runaway)

APPENDIX B. ELECTRIC AND MAGNETIC FIELDS

B1. Overview

EMFs are naturally present in the environment. They are present in the earth's atmosphere as electric fields, while static magnetic fields are created by the earth's core. EMF are also produced wherever electricity or electrical equipment is in use (e.g. household appliances, powerlines), Ref [21].

Electric fields are created where there is flow of electricity. Electric fields are related to and directly proportional to voltage (i.e. the higher the voltage the higher the electric field). Electric fields are often described in terms of their strength and commonly expressed in volts per metre (V/m) or kilovolts per metre (kV/m).

Magnetic fields are created whenever electric current flows. Magnetic fields are directly proportional to the current (i.e. higher the current higher the magnetic field). Magnetic fields are often described in terms of their flux density and commonly measured in either Tesla (T) or Gauss (G).

Electric and magnetic fields are strongest closest to source and their strength attenuates rapidly away from the source. The strength of electric fields is weakened due to shielding from common materials (i.e. buildings, walls), whereas magnetic fields are not.

Use of electricity means that people are exposed to EMF as part of daily life. The background electric and magnetic fields in a typical home are around 20 V/m and 0.1 µT, respectively. These may vary depending on the number and type of appliances, configuration and positioning, and distances to the other sources (e.g. powerlines). Typical EMF strengths for common household electrical appliances (at distance of 30 cm) are shown in Table B.1, Ref [22].

EMF associated with the generation, distribution and use of electricity power systems in Australia which have a frequency of 50 Hertz (Hz) are classified by Energy Networks Australia[4] as Extremely Low Frequency[5] (ELF) EMF, Ref [21].

Table B.1: Typical EMF strengths for household appliances

Electric appliance	Electric field strength (V/m)	Magnetic field density (µT)
Refrigerator	120	0.01 – 0.25
Iron	120	0.12 – 0.3
Hair dryer	80	0.01 – 7
Television	60	0.04 – 2
Vacuum cleaner	50	2 – 20
Electric oven	8	0.15 – 0.5

[4] Energy Networks Association is the peak national body representing gas distribution and electricity transmission and distribution businesses throughout Australia.

[5] ELF EMF occupy the lower part of the electromagnetic spectrum in the frequency range 0-3000 Hz.

B2. Effects of exposure to EMF

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a federal government agency assigned with the responsibility for protecting the health and safety of people and the environment from EMF.

ARPANSA advises that:

- *"The scientific evidence does not establish that exposure to ELF EMF found around the home, the office or near powerlines and other electrical sources is a hazard to human health.",* Ref [23].
- *"There is no established evidence that ELF EMF is associated with long term health effects. There is some epidemiological research indicating an association between prolonged exposure to higher-than-normal ELF magnetic fields (which can be associated with residential proximity to transmission lines or other electrical supply infrastructure, or by unusual domestic electrical wiring), and increased rates of childhood leukaemia. However, the epidemiological evidence is weakened by various methodological problems such as potential selection bias and confounding. Furthermore this association is not supported by laboratory or animal studies and no credible theoretical mechanism has been proposed.",* Ref [24].

B3. Study approach

Although the adverse health impacts have not been established, the possibility of impact due to exposure to EMF has not been ruled out. As part of a precautionary approach, the study assessed the typical exposure levels to EMF for the project infrastructure.

A task group assembled by the World Health Organisation to assess any potential health risks from exposure to ELF EMF in the frequency range of 0 to 100,000 Hz found that there are no substantive health issues related to ELF electric fields at levels generally encountered by the general public, Ref [25]. Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

B4. Guidelines for limiting EMF exposure

The ICNIRP has produced a publication to establish guidelines for limiting EMF exposure to assist in providing protection against adverse health effects. Separate guidance is given for general public and occupational exposure within the guideline.

The guideline has defined general public and occupational exposures as follows:

- General public – individuals of all ages and of varying health status which might increase the variability of the individual susceptibilities.
- Occupational exposure – adults exposed to time-varying EMF from 1 Hz to 10 MHz at their workplaces, generally under known conditions, and as a result of performing their regular or assigned job.

The ICNIRP reference levels for exposure to EMF at 50 Hz is presented in Table B.2, Ref [26]. The guideline adopted more stringent exposure restrictions compared to occupational exposures recognising that in many cases the general public are unaware of their exposure to EMF.

Table B.2: Reference levels for EMF levels at 50 Hz

Exposure	ICNIRP Reference Levels	
	Electric field (V/m)	Magnetic field (µT)
General public	5,000	200
Occupational	10,000	1,000

B5. BESS and grid connection infrastructure EMF

B5.1. BESS

The magnetic field associated with a BESS will vary depending on a number of factors including configuration, capacity and type of housing. Due to the limited information on typical measurement of magnetic fields around BESSs, this study has assumed the typical magnetic field will not be too dissimilar with that of a substation. This study also assumed that the BESS will be designed in accordance with electrical safety standards and codes which will result in exclusion of general public exposures from these sources.

B5.2. PCS

Due to the limited EMF information available, this study assumed that EMF generated from PCS units on a grid-scale BESS facility is not dissimilar to PCS units used on a large-scale solar farm facility. A field study was undertaken to characterise the EMF between the frequencies of 0-3 GHz at two large scale solar facilities operated by the Southern California Edison Company in Porterville and San Bernardino, Ref [27].

The field study findings were adopted to estimate the EMF measurements for the project’s infrastructures. The findings are as follows:

- The highest DC magnetic fields were measured adjacent to the inverter (277 µT) and transformer (258 µT). These fields were lower than the ICNIRP’s occupational exposure limit.
- The highest AC magnetic fields were measured adjacent to the inverter (110 µT) and transformer (177 µT). These fields were lower than the ICNIRP’s occupational exposure limit.
- The strength of the magnetic field attenuated rapidly with distance (i.e. within 2-3 m away, the fields drop to background levels).
- Electric fields were negligible to non-detectable. This is mostly likely attributed to the enclosures provided for the electricity generating equipment.

B5.3. Substation

The main sources of magnetic fields within a large substation (e.g. transmission substation) include transformer secondary terminations, cable runs to the switch room, capacitors, reactors, bus-bars, and incoming and outgoing feeders. For the majority of cases, the highest magnetic fields at the boundary come from the incoming and outgoing transmission lines.

Generally, the application of electrical safety standards and codes (e.g. fence, enclosure, distance) will result in exclusion of general public exposures from these sources. This is consistent with the reported measurements of typical magnetic fields at the substation fence, which range between 1-8 µT, Ref [28].

B5.4. Transmission line

The magnetic field from transmission lines will vary with configuration, phasing and load. The typical magnetic fields near overhead transmission lines measured at 1 m above ground level range between 1-20 µT (directly underneath) and 0.2-5 µT (at the edge of easement), Ref [28].

For underground transmission lines, the cables are typically installed 1 m below ground, whereas the conductors of an overhead line are typically more than 10 m above ground. Therefore, the magnetic field directly above an underground cable is usually higher than that directly below the equivalent overhead line. However, as the individual cables are installed much closer together than the conductors of an overhead line, the magnetic field attenuates more quickly with distance than the magnetic field from overhead lines. Overall, larger magnetic field is observed directly above and for a small distance to the sides, but at larger distances to the sides the cable produces a lower field than the overhead line. The typical magnetic fields for a 330 kV underground cable[6] buried 1 m depth are approximately 24 µT (directly above) and 3 µT (5 m from centreline), Ref [29].

B6. Controls to limit exposure to EMF

The following controls were identified to limit exposure to EMF:

- The design, selection and procurement of electrical equipment for the project will comply with relevant international and Australian standards.
- Location selection for the project infrastructure (i.e. accounts for separation distance to surrounding land uses including neighbouring properties and agricultural operations) and fencing within the project's development footprint will assist to limit the exposure to EMF for the general public.
- Exposure to EMF (specifically magnetic fields) from electrical equipment will be localised and the strength of the field attenuates rapidly with distance.
- Duration of exposure to EMF for personnel onsite will be transient.

[6] Estimated from magnetic field information for 400 kV underground cables.

B7. Conclusion

Based on the review completed in the preceding sections, this study concludes that:

- EMF created from the project will not exceed the ICNIRP occupational exposure reference level.
- As the strengths of EMF attenuate rapidly with distance, this study determined that the ICNIRP reference level for exposure to the general public will not be exceeded and impact to the general public in surrounding land uses will be negligible.
- For the risk assessment, consequence from exposure to EMF was assumed to result in no or minor injury ('Non-material') in reference to the consequence impact rating shown in Table 8.2.

The cumulative exposure to EMF from other proposed developments in the vicinity of the project has been qualitatively assessed in this study (Section 5.5). However, as the strength of EMF attenuates rapidly with distance, cumulative impacts at the closest sensitive receptors are considered unlikely.

APPENDIX C. BESS FIRE IMPACT ESTIMATION

C1. Overview

Consequence analysis of a BESS unit on fire was completed to determine the potential for off-site impacts. The following scenarios were analysed:

- Fire involving a BESS unit (e.g. propagated thermal runaway resulting in a fully developed fire).
- Toxic gas generation from decomposition of battery electrolyte due to fire.
- Impact distances associated with heat radiation due to fire and dispersion of toxic gas were estimated to determine potential for off-site impacts to sensitive receptors
- This appendix summarises the consequence modelling approach, input, assumptions, and results.

C2. BESS fire

C2.1. Modelling approach

Consequence modelling was undertaken based on the Stefan–Boltzmann correlation to analyse the heat transfer effect between two parallel planes, simulating a BESS unit on fire and the heat radiation exposure to a receptor, as shown in Figure C.1. Distances to heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [30], were calculated.

To estimate the heat radiation generated from a BESS unit on fire, the emitted heat flux was calculated using the Stefan - Boltzman Law:

$$E_{emitted} = e\sigma T^4$$

Where E is the radiant emittance, e is the emissivity, σ is the Stefan-Boltzmann constant and T is the surface temperature.

The heat flux received was estimated using the view factor method, where *d* is receiver distance to BESS unit on fire:

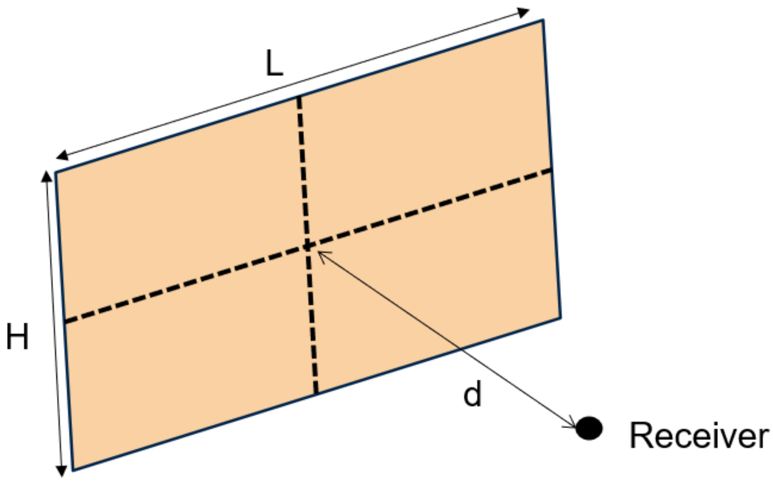
$$\emptyset = \frac{1}{2\pi}\left[\frac{a}{(1+a^2)^{1/2}} tan^{-1}\frac{b}{(1+a^2)^{1/2}} + \frac{b}{(1+b^2)^{1/2}} tan^{-1}\frac{a}{(1+b^2)^{1/2}}\right]$$

$$a = \frac{0.5\,H}{d}\ , a = \frac{0.5\,L}{d}$$

To calculate the heat radiation experienced by the receptor at height 1.5 m (approximately half of the BESS unit height), the surface area of the BESS unit (front aspect) is divided into 4 equal sections. Figure B1 illustrates the graphical depiction of the parameters used in the calculation.

$$E_{received} = 4\ \emptyset\ E_{emitted}$$

Figure C.1: The graphical depiction of the parameters (L, H, d)



C2.2. Input and assumptions

The modelling input and assumptions used were as follows:

- The flame temperature of the emitting surface was set at 1000°C, which is value typical for lithium metallic fires, Ref [31].
- An emissivity value of 0.9 (a black body has an emissivity value of 1)
- Receptor height was set at 1.5 m.
- The heat radiation calculation was performed for the front aspect of the BESS unit and assumed a full planar fire. This is conservative as the front aspect has the largest surface area and consequently highest heat radiation impact. This approach is deemed appropriate to determine off-site impacts.

C2.3. Heat radiation criteria

Consequences of various heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [30], are shown Table C.1. For this PHA, distances to 4.7 kW/m^2 (injury), 12.6 kW/m^2 (fatality), and 23 kW/m^2 (structural failure) were calculated.

Table C.1: Consequences of heat radiation

Heat Radiation (kW/m^2)	Effect
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds' exposure (at least second degree burns will occur)
12.6	• Significant chance of fatality for extended exposure. High chance of injury

Heat Radiation (kW/m^2)	Effect
	• Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
23	• Likely fatality for extended exposure and chance of fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved, or failure would occur
35	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of fatality for people exposed instantaneously

C2.4. Results

The distances to the specified heat radiation levels are presented in Table C.2. Distance to the injury level (4.7 kW/m^2) was used to determine potential for off-site impact, which is approximately 16 m.

Table C.2: Heat radiation impact – BESS unit on fire

			Distance (m) at receptor height (1.5 m) to radiation levels		
BESS model	Front aspect (L x H, m)	Surface Temperature (°C)	4.7 kW/m^2 (injury)	12.6 kW/m^2 (fatality)	23 kW/m^2 (structural failure)
B-Vault	10 x 3	1000	16	9	6

C3. Dispersion of toxic gas

C3.1. Modelling approach

In the event of a BESS fire, there is a potential for toxic gas to be generated (1) from decomposition of the battery electrolyte, and/or (2) as a result of combustion products. For LFP batteries, there is a potential for hydrogen fluoride (HF) to be formed following electrolyte decomposition from a BESS fire event. In this study, as HF is considered to be the most toxic decomposition product, dispersion of HF was modelled to better understand the impact to receptors.

Consequence modelling was performed using the Gexcon EFFECTS v12.2.0 software (Plume Rise from Fire model) to simulate HF dispersion during a BESS fire. The HF generation rate was based upon published experimental literature for LFP batteries. The downwind distances to the Acute Exposure Guideline Level (AEGL) concentrations for HF were determined.

C3.2. Input and assumptions

The modelling input and assumptions used were as follows:

- Hydrogen fluoride is considered the most toxic decomposition products from the batteries fire, Ref [17].
- A lithium-ion battery cell experiment, Ref [17], indicates that the HF quantity released from a 1 Wh battery varies between 20 mg and 200 mg, depending on the battery type and state of charge. As a conservative approach, generation rate of 200 kg per 1 MWh was adopted for the analysis. The HF generation rate was calculated based on the capacity a single BESS unit and fire duration of 1 hour. The resulting HF generation rate used for analysis is conservative as typically the fire duration is longer than 1 hour.
- Release is continuous, with concentration averaging time of 60 minutes used for reporting.
- Surface roughness factor of 0.1 m was used (represents low crops and occasional large obstacles).
- The heat release rate from the battery (with 100% state of charge) is estimated to be 882 kW/m^2, Ref [32].
- The plume was assumed to be released from the top of the BESS unit. This is viewed as a reasonable approach, based on observation from recent BESS fire incidents (e.g. VBB fire).
- Receptor height was set at 1.5 m.
- Wind and weather stability conditions of D 5 m/s (D5) and D 1.5 m/s (D1.5) were used to represent typical day and night conditions, respectively.

C3.3. Dispersion criteria

The AEGL concentration levels (60-minute exposure) for HF are presented in Table C.3 These concentrations were used to inform harm levels following exposure (irritation, injury and fatality).

Table C.3: AEGL values for HF (60-minute)

AEGL level	Health effects	HF concentration (ppm)
AEGL-1	Irritation threshold	1
AEGL-2	Injury threshold	24
AEGL-3	Life-threatening health effects threshold	44

C3.4. Results

The distances to AEGL concentrations at receptor height of 1.5 m are presented in Table C.4.

Table C.4: Toxic dispersion impact (HF) – BESS unit on fire

BESS model	Capacity per unit (MWh)	HF generation rate (kg/s)	Heat Release (kW/m^2)	Wind Weather Stability	Distance (m) at receptor height (1.5 m) to AEGL levels		
					AEGL-1 (irritation)	**AEGL-2 (injury)**	**AEGL-3 (fatality)**
B-Vault	5.7	0.3	882	D5	24	12	9
				D1.5	3	2	2

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