

REPORT

PRELIMINARY HAZARD ANALYSIS

CALALA BATTERY ENERGY STORAGE SYSTEM

SSD-52786213

EQUIS ENERGY (AUSTRALIA) PROJECTS (NGUMI 4) PTY LTD

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ABBREVIATIONS

AC	Alternating Current
ADGC	Australian Dangerous Goods Code
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS/NZS	Australian Standard/New Zealand Standard
BESS	Battery Energy Storage System
BMS	Battery Management System
DA	Development Application
DC	Direct Current
DG	Dangerous Goods
DoP	Department of Planning
DP	Deposited Plan
DPE	Department of Planning and Environment
DVC	Decisive Voltage Classification
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EP&A	Environmental Planning and Assessment
FRNSW	Fire and Rescue NSW
G	Gauss
ha	Hectare
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
HV	High Voltage
ha	Hectare
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IP	Ingress Protection
km	Kilometres
kV	Kilovolt
kV/m	Kilovolt per metre

kW	Kilowatt
kWh	Kilowatt hours
LEL	Lower Explosive Limit
LEP	Local Environmental Plan
LFP	Lithium Iron Phosphate
LGA	Local Government Area
MW	Megawatt
MWh	Megawatt hours
NEM	National Electricity Market
NFPA	National Fire Protection Association
NSW	New South Wales
OEM	Original Equipment Manufacturer
OH&S	Occupational Health & Safety
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
SSD	State Significant Development
T	Tesla
UL	Underwriters' Laboratories
V/m	Volt per metre

TERMINOLOGY

Term	Definition
Consequence	Outcome or impact of a hazardous incident, including the potential for escalation.
Calala BESS extent	The extent of actual surface disturbance required for construction and operation of the BESS, excluding any easements and underground transmission line connection between the BESS and the nearby TransGrid Tamworth 330 kV substation.
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 Calala BESS extent boundary.
Project	Calala Battery Energy Storage System.
Proponent	Equis Energy (Australia) Projects (Ngumi 4) Pty Ltd, as trustee for the Equis Energy (Australia) Ngumi 4 Asset Trust.
Risk	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 unit time) or a probability (the probability of a specified event following a prior event), depending on the circumstances.

1. INTRODUCTION

1.1. Background

Equis Energy (Australia) Projects (Ngumi 4) Pty Ltd (Equis), as trustee for the Equis Energy (Australia) Ngumi 4 Asset Trust, proposes to develop the Calala Battery Energy Storage System (the project); a large -scale Battery Energy Storage System (BESS) and associated infrastructure. The project will have a discharge capacity of up to 300 megawatts (MW) and energy storage capacity of up to 1,200 megawatt hours (MWh) (four hours storage).

The project site is located approximately 2 km south-east of the township of Calala and 6 km south-east of Tamworth, in north-east New South Wales (NSW). The project site is within the Tamworth Local Government Area (LGA).

The project is a State Significant Development (SSD) under the *State Environmental Planning Policy (Planning Systems) 2021 (Planning Systems SEPP)* and requires an Environmental Impact Statement (EIS) to accompany the Development Application (DA) submission, in accordance with Environmental Planning and Assessment (EP&A) Regulation.

Equis has retained Mecone Group Pty Ltd (Mecone) to prepare an EIS for the project. Equis has engaged Sherpa Consulting Pty Ltd (Sherpa) to undertake an assessment that addresses the ‘Hazards’ component of the Planning Secretary’s Environmental Assessment Requirements (SEARs), Ref [1].

1.2. Objectives

The study objective was to address the ‘Hazards’ component of the SEARs, Ref [1]. The Hazards assessment requirements and references where they are addressed in this report are shown in Table 1.1.

Table 1.1: Hazards assessment requirements

Assessment requirements - <i>Hazards</i>	Section reference
A preliminary risk screening completed in accordance with the <i>State Environmental Planning Policy No. 33 – Hazardous and Offensive Development</i> ¹ and <i>Applying SEPP 33</i> (DoP, 2011).	Section 3
A Preliminary Hazard Analysis (PHA) must be prepared in accordance with Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 <i>Hazard Analysis and Multi-Level Risk Assessment</i> (DoP, 2011). The PHA must consider all recent standards and codes and verify separation distances to onsite and off-site receptors to prevent fire propagation and compliance with HIPAP No. 4 <i>Risk Criteria for Land Use Safety Planning</i> (DoP, 2011)	Sections 4-10

¹ 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.

Assessment requirements - Hazards	Section reference
An assessment of potential hazards and risks ² including but not limited to bushfires, land contamination ³ , spontaneous ignition, electromagnetic fields for the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) <i>Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields</i>	Sections 4-10

1.3. Scope

The project involves construction and operation of a large-scale BESS with discharge capacity of up to 300 MW and 1200 MWh storage capacity and associated infrastructure, and connection to the Tamworth substation via underground transmission lines.

The project will comprise:

- Large-scale BESS including battery enclosures, inverters, DC and AC combiner boxes, transformers and auxiliary components.
- 33/330 kV switchyard.
- Underground transmission line connection between the BESS and the nearby TransGrid Tamworth 330 kV substation.
- Ancillary elements including:
 - Site access from Calala Lane, internal access roads and parking.
 - Warehouse, control room and staff amenities.
 - Stormwater and fire management infrastructure.
 - Noise attenuation walls (up to 5 m high).
 - Utilities, signage, fencing, security systems and landscaping.

For the PHA, the scope included all infrastructure within the project extent boundary ('Calala BESS extent', as shown in Figure 2.2) with primary focus on the BESS.

1.4. Exclusions and limitations

The study exclusions and limitations are summarised in Table 1.2.

² The "assessment of hazards and risks" followed the PHA methodology, in accordance with DPIE HIPAP No. 6 and the Multi-Level Risk Assessment guidelines (i.e. focused on off-site impacts).

³ Sherpa's scope of work excludes assessment of existing and the potential for future land contamination.

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 upon project approval. The assessment made in this study was based on the use of the Wärtsilä's GridSolv Quantum battery system, 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	Verification that the BESS would be accommodated within the area designated for the BESS compound	Verification of the areas designated for the BESS compound was undertaken to ensure sufficient area for the proposed capacity would be available, taking into account separation distances between BESS sub-units. This was conducted based on the known dimensions from the concept BESS design (make and model) and configuration adopted at the time of the study. An indicative configuration of the battery units, AC-DC combiner box, and inverter is shown in Figure 7.2.
4	Bushfire hazard assessment	A bushfire hazard assessment was completed for the project and accompanies the EIS, Ref [2]. Risk events associated with bushfire and the relevant controls (e.g. Asset Protection Zone) have been included in the PHA to demonstrate that this event has been considered.
5	Land contamination	The PHA excludes assessment of potential hazards and risks of land contamination for the project. A preliminary site investigation was completed for the EIS, Ref [3].
6	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 <i>Construction Safety</i> .
7	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 <i>Fire Safety Study</i> .

2. FACILITY DESCRIPTION

2.1. Location and project site

The project will be developed at 57 Burgess Lane, Calala NSW 2340 (also known as 474 Calala Lane, Calala), approximately 2 km south-east of the Calala and 6 km south-east of Tamworth, within the Tamworth LGA.

The total site area is approximately 36 hectares (ha) and has a frontage of approximately 500 m to Calala Lane. The proposed BESS will be located in the south-eastern portion of the site, occupying an area of approximately 8.9 ha⁴ (referred to as the 'Calala BESS extent').

The location of the project site and site plan are shown in Figure 2.1 and Figure 2.2, respectively. The project site is situated on Lot 17 of Deposited Plan (DP) 629969. The project will establish an underground transmission cable corridor which will connect the BESS to the TransGrid Tamworth substation on Lot 6 DP 219993.

2.2. Surrounding land use

The project site is located on rural land zoned 'RU4 Primary Production Small Lots' under the Tamworth Local Environmental Plan (LEP). Land along the proposed transmission line easement and substation are also within the same zone.

The surrounding area is primarily cleared land used for agricultural and grazing purposes, with scattered rural residences and agricultural buildings and infrastructure.

Another major project planned in the vicinity of the project site is the Tamworth BESS (SSD-23830229); a 200 MW BESS facility approximately 700 m south of the project site.

The nearest town centre to the project is Calala, approximately 2 km north-west of the project.

There are approximately 78 residences within 1 km of the project. These are primarily located in clusters west of the project site, with most lying between 500 and 1,000 m from the project extent boundary. The locations of the residential dwellings in the surrounding area of the project site are presented in Figure 2.3.

Non-associated residential dwellings⁵ or occupied areas are considered as sensitive receptors for the purposes of this risk assessment. There are 2 non-associated residential dwellings within 500 m of the project extent boundary (R2 and R9). The nearest one is located approximately 443 m from the project extent boundary (R9).

⁴ The extent of actual surface disturbance required for construction and operation of the BESS, excluding any access, easements and underground transmission line connection between the BESS and the nearby TransGrid Tamworth 330 kV substation.

⁵ Residence whose owners do not have any part of their property included in a land agreement with the proponent for the project.

Figure 2.1: Project site location

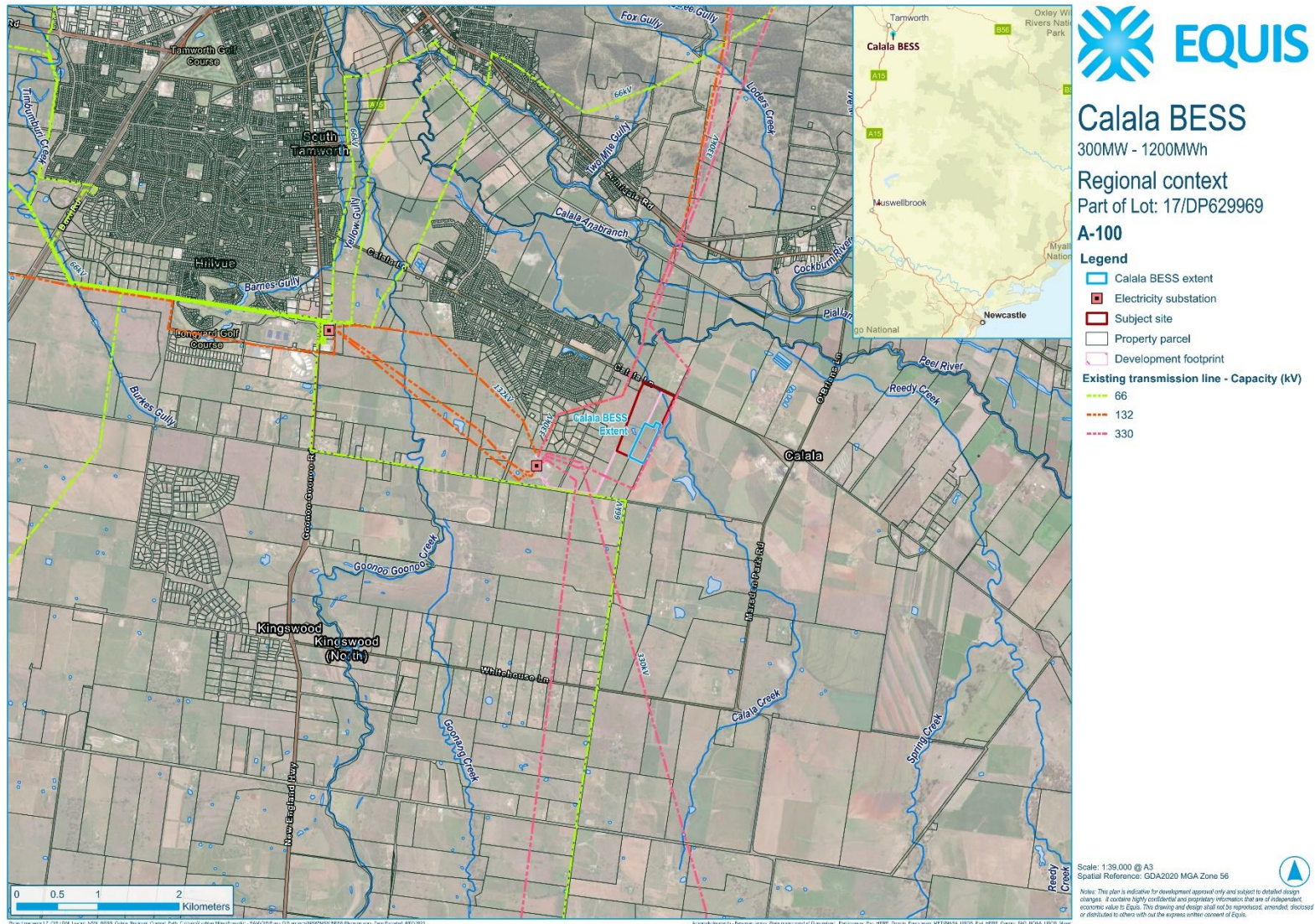


Figure 2.2: Site plan

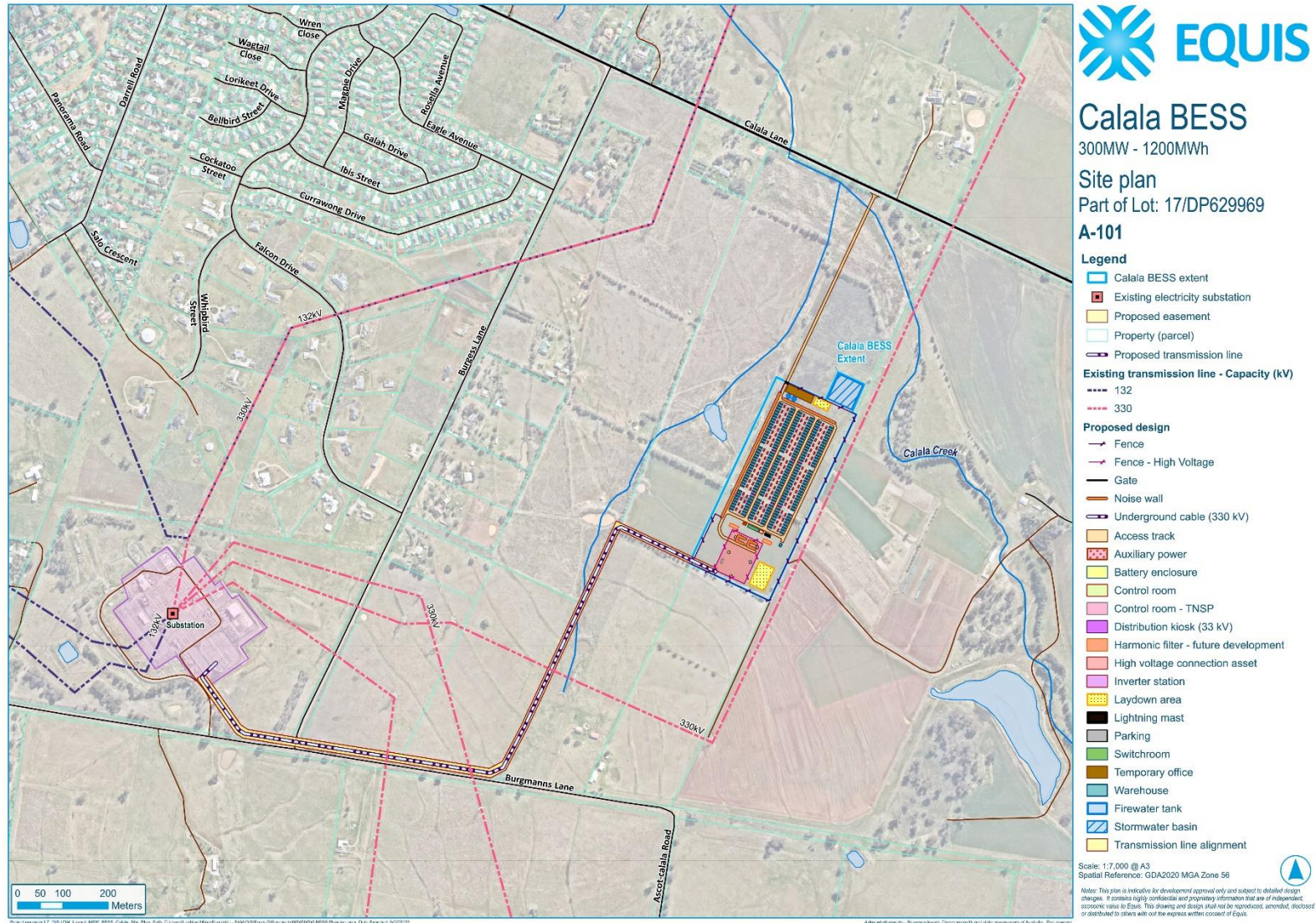
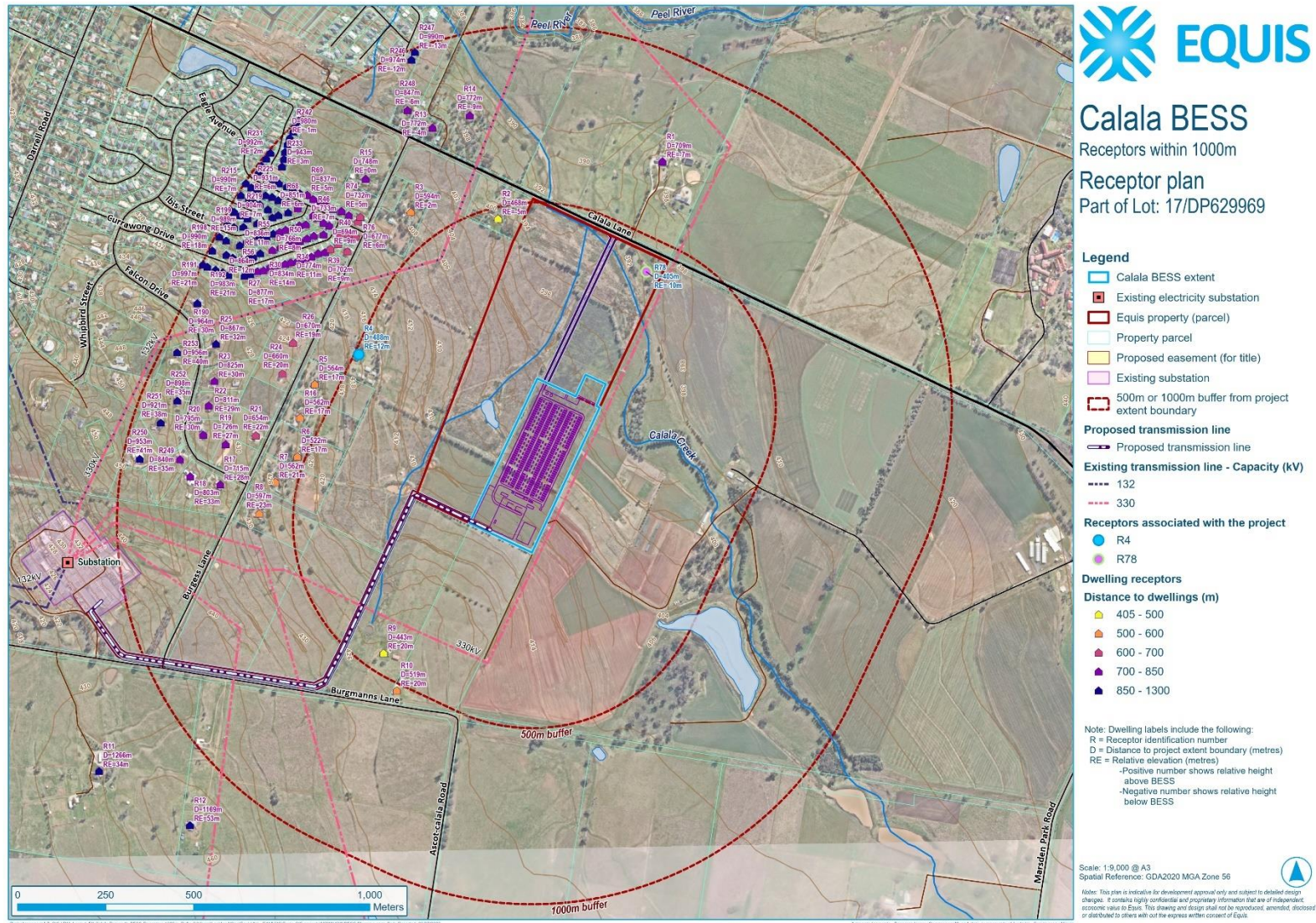


Figure 2.3: Residential dwellings in the surrounding area



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). Indicatively for this project, the proposed BESS will have a capacity of 300 MW/1,200 MWh (4 hours energy storage) and make use of lithium-ion technology.

At the time of this study, Equis has not made a final decision on the BESS OEM. The assessment made in this study was based on the use of the Wärtsilä's GridSolv Quantum battery system, which was used for the project concept design. Major components and specific features of the battery system are described in Table 2.1, Ref [4] and [5]. An indicative configuration of the battery units, AC-DC combiner box, and inverter is shown in Figure 7.2.

The selection of the BESS OEM and layout of the BESS units within the BESS compound will be finalised during detailed design. Detailed design will be conducted upon project approval. The following were assumed for the PHA:

1. The BESS units will be installed in accordance with the OEM's instructions provided for best practice 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) has been 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.

Additionally, Equis has also indicated that:

- The BESS OEM and Contractors will be responsible for demonstrating compliance with fire and safety during detailed design. A monitoring system will be available to monitor critical system faults and de-energize the system if required.
- The final layout will be designed in collaboration with the BESS OEM and Balance of Plant provider to ensure the BESS is designed in a safe manner.

- The Contractors will be responsible for demonstrating compliance with all safety and other legislative requirements by providing Safety Data Sheet (SDS), Emergency Response Guide, and Safety Manual during detailed design.

Table 2.1: Typical BESS components

Component	Description
Overview	<p>The GridSolv Quantum is a fully integrated and modular energy storage system, which consists of the following components:</p> <ul style="list-style-type: none"> • Enclosures with pre-installed liquid-cooled battery racks. • AC and DC outdoor rated cabinet, which connects battery strings with the inverter and provides an interface for auxiliary power and communications.
Enclosure	<p>The battery enclosure is rated to min. IP 55, providing protection from dirt, dust, oil and other non-corrosive material. The enclosure dimension is (W) 2076 mm x (D) 3169 mm x (H) 2462 mm.</p>
Battery unit	<p>The GridSolv Quantum utilises CATL Lithium Iron Phosphate (LFP) batteries. It can be installed as a single enclosure (unit), or as a system of several parallel units. Each GridSolv Quantum can host up to four liquid-cooled racks. It is anticipated that up to 960 battery units will be installed to provide the required capacity for the project (300 MW/1200 MWh).</p>
Power Conversion Units (PCUs) or inverters	<p>Inverters are electrical devices that convert DC to AC or vice versa (i.e. bi-directional). The inverters will function to convert the current between the battery and the grid. It is anticipated that up to 120 inverters will be installed for the project (i.e. each inverter will connect to 8 battery units).</p>
Battery Management System (BMS)	<p>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 BMS constantly monitors the battery cell, module, and rack level.</p> <p>The GridSolv Quantum is also equipped with:</p> <ul style="list-style-type: none"> • Isolation device to allow an operator to manually isolate the battery system at either rack-level or row-level. • A hard wired process stop button (via emergency stop relays), allowing shutdown command to the inverter.
Thermal management system	<p>The GridSolv Quantum is designed with individual rack-based cooling circuits (water-glycol mixture) and equipped with ventilation system for the enclosure.</p>
Fire protection system	<p>The GridSolv Quantum is designed with:</p> <ul style="list-style-type: none"> • A 60-minute enclosure wall fire rating • Gas detection - hydrogen and (optional) carbon monoxide detector • Fire detection (photoelectric smoke detector) • A roof-mounted deflagration panel providing pressure relief by redirecting gases, smoke and flame in the event of fire, compliant with NFPA 68 Standard on Explosion Protection by Deflagration Venting.

Component	Description		
Standards, Codes and Testing	The GridSolv Quantum is compliant with Australian and international standards, including standards that are generally accepted to demonstrate minimum safety considerations. Key standards and tests claimed include:		
	Standards and tests	Title	Component/ Aspect
	UL 1642	Standard for Lithium Batteries	Cell
	UL 9540	Standard for Energy Storage Systems and Equipment	Full system
	UL 9540A	Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems	Unit level test completed
	UN 38.3	Certification for Lithium Batteries	Transportation
	NFPA 68	Standard on Explosion Protection by Deflagration Venting	Venting of combustion gases and pressures resulting from a deflagration within an enclosure
	NFPA 69	Standard on Explosion Prevention Systems	Prevention and control of explosions in enclosures that contain flammable concentrations
	NFPA 855	Standard for the Installation of Stationary Energy Storage Systems	Requirements for the installation of stationary energy storage systems including safety considerations

2.3.2. Grid connection

For connection between the BESS and the grid, two High Voltage (HV) transformers will be provided to transform the 33 kV reticulated electricity from the BESS to 330 kV. A 33/330 kV switchyard and an underground transmission line will be established to connect the BESS and the TransGrid Tamworth 330 kV substation, located approximately 950 m south-west of the site.

2.3.3. Supporting infrastructure

The supporting infrastructure for the project will include:

- Control building, including a control room and amenities
- Warehouse facility

- Noise attenuation walls (up to 5 m high)
- Site access from Calala Lane, internal access roads and parking area
- Drainage and stormwater management
- Fire management infrastructure (e.g. fire water tanks)
- Utilities, signage, fencing, security systems and landscaping.

2.4. Construction

Subject to approval, construction of the project will take approximately 12 months. Including commissioning, this is expected to be completed within 15-18 months. Construction works will include site establishment, delivery, and installation of BESS infrastructure.

Temporary construction facilities and laydown area will be established when the construction work commences. All temporary infrastructure will be strategically placed to minimise potential environmental impacts during the construction phase of the project. The infrastructure will be dismantled, and its footprint rehabilitated once the project is built and moves into the operational stage.

2.5. Operations

The expected project operational life is approximately 25 years, subject to component replacement and life extension.

The BESS will operate 24 hours per day, seven days per week, 365 days per year and be operated remotely. The BESS is expected to be on standby for the majority of the time and undergo one to two full cycles of charging and discharging per day.

The BESS will create approximately 4 full time jobs during operations. However these operational roles do not require a consistent presence at the BESS location. Ongoing site access will be on an as-needs basis only.

2.6. Decommissioning

Once the project reaches the end of its operational life, the project infrastructure will either be replaced, upgraded or decommissioned.

Decommissioning would involve removal of the built infrastructure from site and the project area would be returned to its pre-development land use, as far as reasonably practicable.

3. PRELIMINARY RISK SCREENING

3.1. Overview

The objective of the preliminary risk screening was to determine whether the proposed development is considered as 'potentially hazardous' in the context of *SEPP (Resilience and Hazards) 2021*, Ref [6].

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 [7], 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 and Environment (DPE) *Applying SEPP 33* guideline⁶, Ref [8], 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, as well as the expected number of transport movements.

'Hazardous materials' are defined within the guideline 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 [9], 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 threshold presents the quantities below which it can be assumed that significant off-site risk is unlikely.

⁶ 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.

3.2. Risk screening

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

Other materials considered as part of the SEPP risk screening include transformer oil and battery coolant (aqueous ethylene glycol mixture). Generally, these are not classified as DGs and are excluded from the risk screening. Additionally, these materials will not be stored with other flammable materials and hence not considered to be potentially hazardous under the SEPP.

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 not 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.
- Type of activities involving the 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.

Table 3.1: Preliminary risk screening summary

Material	DG Class	Category	Storage threshold	Transport threshold		Project storage quantities and applicable SEPP screening	Threshold exceeded
				Movements	Quantities		
BESS battery (Lithium ion)	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

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.
- There are no other risk factors 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.

4. HAZARDS AND RISK ASSESSMENT

4.1. Overview

Notwithstanding the outcome of the preliminary risk screening, the *Hazards* assessment requirements of the SEARs require (1) a PHA, and (2) an assessment of hazards and risks for the project to be undertaken. The objective of these assessments was to identify the hazards and assess the risks associated with the project when in operation as they are understood at the planning stage of the DA 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 [7], which is focused on off-site impacts.

The HIPAP No. 6 methodology included the following steps:

1. Establishment of the study context.
2. Identification of hazards resulting from the project 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 off-site impact, e.g. fires and explosions (*Consequence Analysis*).
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 assesses if the development is appropriate for the location.

The boundary of the project extent (referred to as 'Calala BESS extent' in Figure 2.2) was used to define and determine off-site impact (i.e. impact extending outside of the project extent boundary). Off-site impact was determined based on potential to impact sensitive receptors (i.e. non-associated residential dwellings).

4.2. Level of analysis

The *Multi-Level Risk Assessment* guidelines, Ref [10], sets out three levels of risk analysis that may be appropriate for a land use safety planning assessment, as shown in Table 4.1. This guidance document was consulted to determine the level of analysis required for this study.

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

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.

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 [11], appropriate for the level of analysis determined (based on guidance outlined in Table 4.1).

5. HAZARD IDENTIFICATION

5.1. Overview

Hazard Identification (HAZID) aims to identify all reasonably foreseeable hazards and associated events that may arise due to the operation of the facilities and defining the relevant controls through a systematic and structured approach.

The HAZID process was completed using the following input:

1. Review of the battery system specification sheet, Ref [4], safety sheet, Ref [5], and UL 9540A unit level test result, Ref [12].
2. Review of AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment*, Ref [13].
3. Literature research of past incidents involving similar BESS systems.
4. Previous risk assessments for similar BESS systems completed by Sherpa.
5. Consultation and feedback from Equis for review and acceptance.

At the time of this study, Equis has not made a final decision on the BESS OEM. The assessment made in this study was based on the use of the Wärtsilä's GridSolv Quantum battery system, which was used for the project concept design. Sherpa assumed that the HAZID undertaken for the BESS is representative of other lithium-ion based battery systems from other manufacturers, as the modes of failure and control mechanisms are not dissimilar.

5.2. Identified hazards and events

The following factors were considered to identify the hazards:

- BESS component and type of equipment.
- Hazardous substances/DG present.
- Proposed operation and maintenance activities.
- BESS incident history
- External factors (e.g. 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 with 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 5.1.

Table 5.1: Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Arc flash	Release of energy
Fire	Infrastructure fire
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	Unauthorised access/trespasser, bushfire, lightning storm, water ingress (rain and flood)

In this study, bushfire was considered as a cause of fire resulting from encroachment of an off-site bushfire impacting the BESS. A bushfire hazard assessment was completed for the project as part of the EIS. Identified controls such as Asset Protection Zones (APZs) and fire management plan have been referenced in this study, where applicable. For the project, the proposed APZs to the infrastructure are 37 m to the north, 26 m to the east, 10 m to the south and 22 m to the west, Ref [2].

A summary of the hazard present at/applicable to the BESS is provided in Table 5.2.

Table 5.2: Hazards by BESS component

Hazard	BESS component			
	Battery system	PCUs (inverters)	MV kiosk/ RMU	HV connection asset
Electrical	✓	✓	✓	✓
Energy (arc flash)	✓	✓	✓	✓
Fire	✓	✓	✓	✓
Chemical	✓	-	-	-
Explosive gas	✓	-	-	-
Reaction	✓	-	-	-
EMF	✓	✓	✓	✓
External factors	✓	✓	✓	✓

5.3. 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 Section 6.

5.4. Separation distances to off-site receptors

To inform whether the consequence of a hazardous event has the potential to impact off-site receptors, separation distances from the project extent boundary to the nearest non-associated residential dwellings were reviewed. This review is provided in Section 7.

5.5. HAZID register

The identified hazards, events, applicable BESS component/project infrastructure, and the relationships with causes, consequences and controls are summarised in the HAZID register.

The HAZID register is provided in Table 5.3. The findings are as follows:

- A total of 13 hazardous events were identified.
- As some of the project infrastructure will be located close to the project extent boundary, some hazardous events (i.e. fires) may extend beyond this boundary (i.e. off-site impact in the context of HIPAP No. 6). However, the consequences from these events are not expected to result in significant off-site impacts (serious injury and/or fatality to the public or off-site population) as:
 - The project will be situated in a rural area.
 - APZs will be established and maintained around the perimeter of the BESS. This will provide a suitable separation from the BESS infrastructure to the project extent boundary.
 - The nearest sensitive receptor/non-associated residential dwelling (R9) is located approximately 443 m from the project extent boundary.

Table 5.3: HAZID register

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact
1.	Electrical	Battery system PCUs (inverters, transformers) MV Kiosk or RMU HV connection asset	Exposure to voltage	<u>Short circuit/electrical connection failure</u> <ul style="list-style-type: none"> - 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> <ul style="list-style-type: none"> - Electrical faults 	<ul style="list-style-type: none"> - 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 there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	<ul style="list-style-type: none"> - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - 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 and training (i.e. high voltage areas) - Electrical switch-in & switch-out protocol - BESS equipment fault detection and safety shut-off - Earthing study (mitigate touch and step potentials) - Earthing as per manufacturer and standards requirements - Perimeter fence with signage (warning of electrical hazard) - Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Use of appropriate PPE - Rescue kits (i.e. insulated hooks) 	-	No
2.	Energy	Battery system PCUs (inverters, transformers) MV Kiosk or RMU HV connection asset	Arc flash	<ul style="list-style-type: none"> - Incorrect procedure (i.e. installation / maintenance) - Disobeying instruction and/or operation manual - Faulty equipment (e.g. corrosion on conductors) - Faulty design - Human error during maintenance - Insufficient isolation/insulation to applied voltage - Mechanical damage 	<ul style="list-style-type: none"> - 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 - Battery Fire Localised effects, the effects are not expected to have an off-site impact.	<ul style="list-style-type: none"> ✓ Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards AS 2067 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 - 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 Section 7 for assessment) - BESS equipment fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1)Emergency Response Plan - External firefighting protocol (FRNSW & 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). 	Arc flash is an electrical explosion or discharge, which occurs between electrified conductors during a fault or short circuit condition, Ref [13]. Arc flash occurs when electrical current passes through the air between electrified conductors when there is insufficient isolation or insulation to withstand the applied voltage. Arc flash may result in rapid rise in temperature and pressure in the air between electrical conductors, causing an explosion known as an arc blast.	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact
3.	Fire	Battery system PCUs (inverters, transformers) MV Kiosk or RMU	BESS fire	<ul style="list-style-type: none"> - Faulty equipment - Arc flash - Electrical fault - 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. fire from adjacent infrastructure) - Bushfire (e.g. encroachment of off-site bushfire, escalated event due to fire from other project infrastructure) 	<ul style="list-style-type: none"> - Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees <p>As the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - 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's requirements for the HV connection asset (33/330 kV switchyard) will be met - Circuit breakers provided for the HV connection asset - 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 Section 7 for assessment) - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - BESS equipment fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defensible fire-fighting boundary) - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS) 	Release of toxic gas is expected to be minimal.	No
4.	Fire	Transformers HV connection asset (33/330 kV switchyard)	Transformer / HV connection asset fire	<ul style="list-style-type: none"> - Faulty equipment - Transformer oil leak - Arc flash - Vandalism - External fire (e.g. fire escalation from adjacent BESS) - Bushfire 	<ul style="list-style-type: none"> - Release of toxic combustion products - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees <p>As the transformers and HV connection asset will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 2067) 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 (refer to Section 7 for 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, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS) 	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact
5.	Fire	BESS (overall)	Bushfire	<ul style="list-style-type: none"> - Encroachment of off-site bushfire - Escalated event due to fire from other project infrastructure 	<ul style="list-style-type: none"> - Escalation to the entire BESS - Injury and/or fatality to onsite employees <p>As the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - Fire Management Plan - Defendable boundary for firefighting will be established - Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Inclusion of APZ buffer to minimise bushfire encroachment - Use of appropriate PPE 	-	No
6.	Chemical	Battery system	Release of electrolyte (liquid/vented gas) from the battery cell	<p><u>Mechanical failure/damage</u></p> <ul style="list-style-type: none"> - Dropped impact (e.g. during installation/maintenance) - Damage (e.g. crush/penetration/puncture) <p><u>Abnormal heating/elevated temperature</u></p> <ul style="list-style-type: none"> - Thermal runaway - Bushfire - External fire (e.g. fire from adjacent infrastructure) 	<ul style="list-style-type: none"> - Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte - Release of vented gas from cells - Fire and/or explosion in battery enclosure - Release of toxic combustion products <p>Injury and/or fatality to onsite employees</p> <p>As the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards and guidelines - Equipment will be procured from reputable supplier - Shock sensors - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Battery cells and modules are enclosed with external casing - 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 Section 7 for assessment) - Venting and containment requirements of the BESS manufacturer and FRNSW to be followed - Battery modules are enclosed with external casing - Spill clean-up using dry absorbent material - BESS equipment fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS) 	Vented gases are early indicator of a thermal runaway reaction	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact
7.	Chemical	Battery system (Thermal management system)	BESS coolant or refrigerant leak	<ul style="list-style-type: none"> - Mechanical failure/damage - Incorrect maintenance 	<ul style="list-style-type: none"> - 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. <p>As the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards 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 - Battery cells and modules are enclosed with external casing - Spill cleanup using dry absorbent material - 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 Section 7 for assessment) - BESS equipment fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS) 	<p>The coolant is ethylene glycol aqueous solution.</p> <p>Ethylene glycol is not flammable but does pose a health risk when exposed to personnel in sufficient quantity.</p>	No ⁷
8.	Explosive Gas	Battery system	<p>Generation of explosive gas (e.g. hydrogen)</p> <p><u>Note:</u> also refer to Item 6 (release of vented gas)</p>	<ul style="list-style-type: none"> - Thermal runaway - Bushfire - External fire (e.g. fire from adjacent infrastructure) 	<ul style="list-style-type: none"> - Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees <p>As the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. NFPA 68) 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 (refer to Section 7 for assessment) - Ventilation requirements as per manufacturer's instruction - BESS equipment fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS) 	-	No

⁷ 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.

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact
9.	Reaction	Battery system	Thermal runaway in battery	<p><u>Elevated temperature</u></p> <ul style="list-style-type: none"> - Bushfire - External fire (e.g. fire from adjacent infrastructure) <p><u>Electrical failure</u></p> <ul style="list-style-type: none"> - Short circuit - Excessive current/voltage - Imbalance charge across cells <p><u>Mechanical failure</u></p> <ul style="list-style-type: none"> - Internal cell defect - Damage (crush/ penetration/puncture) <p><u>Systems failure</u></p> <ul style="list-style-type: none"> - BMS failure - Thermal management system failure 	<ul style="list-style-type: none"> - Fire and/or explosion in battery enclosure - Escalation to the entire BESS - Injury and/or fatality to onsite employees <p>As the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - Equipment and systems will be designed and tested to comply with the relevant international and Australian standards 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 (refer to Section 7 for assessment) - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS) 	<p>Thermal runaway is a temperature-dependent process wherein the battery cell experiences an exothermic reaction, resulting in the release of energy that further increases the temperature. Such processes initiated from inside/outside the battery cell, keeps generating more heat. Chemical reactions inside the cell in turn generate additional heat until there are no reactive agents left in the cell and eventually lead to destruction of the battery.</p> <p>Vented gases are early indicator of a thermal runaway reaction.</p>	No
10.	EMF	BESS (overall)	Exposure to electric and magnetic fields	<p>Operations of energy storage system and associated equipment</p>	<ul style="list-style-type: none"> - 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 <p>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 considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - Location siting and selection (i.e. separation distance to sensitive receptors) - Optimising equipment layout and orientation - 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 - Studies found that the EMF for commercial power generation facilities comply with ICNIRP occupational exposure limits. Refer to section 6 for assessment. 	<p>Adverse health effects from EMF have not been established based on findings of science reviews conducted by credible authorities, Ref [14].</p> <p>No established evidence that Extremely Low Frequency (ELF) EMF is associated with long term health effects (ARPANSA) , Ref [15].</p>	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact
11.	External factors	BESS (overall)	Water ingress	<ul style="list-style-type: none"> - Rain - Flood 	<ul style="list-style-type: none"> - Electrical fault/short circuit - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees <p>As the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - Location siting (i.e. outside of flood prone area) - The GridSolv Quantum enclosure is IP 55 rated suitable for outdoor use - HV connection asset (33/330 kV switchyard) will be 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 (refer to Section 7 for assessment) - BESS equipment fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS) 	-	No
12.	External factors	BESS (overall)	Vandalism	<ul style="list-style-type: none"> - Unauthorised personnel access - Trespassing - Deliberate damage to BESS infrastructure Asset damage 	<ul style="list-style-type: none"> - Asset damage - BESS failure/fire - Potential hazard to unauthorised person (e.g. electrocution) - Injury and/or fatality to trespasser <p>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.</p> <p>For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.</p>	<ul style="list-style-type: none"> - The BESS will be located in a rural location - The BESS will be located within a secure area and will be fenced - Warning signs (i.e. trespassers and on-site hazards) - Security cameras will be provided for the BESS area 	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact
13.	External factors	BESS (overall)	Lightning strike	Lightning storm	<ul style="list-style-type: none"> - Fire - Injury and/or fatality to onsite employees <p>As the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.</p>	<ul style="list-style-type: none"> - Lightning protection mast and surge protection devices - Earthing as per manufacturer and standards requirements - Activation of emergency shutdown - 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 Section 7 for assessment) - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS) 	-	No

6. ELECTRIC AND MAGNETIC FIELDS

6.1. Overview

EMF 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 [14].

Electric fields are created where there is flow of electricity. Electric fields are related to and directly proportional to voltage (i.e. higher the voltage 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 effect 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 is 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 6.1, Ref [16].

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 Australia⁸ as Extremely Low Frequency⁹ (ELF) EMF, Ref [14].

Table 6.1: 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

⁸ Energy Networks Association is the peak national body representing gas distribution and electricity transmission and distribution businesses throughout Australia.

⁹ ELF EMF occupy the lower part of the electromagnetic spectrum in the frequency range 0-3000 Hz.

6.2. Effects of exposure to EMF

6.2.1. Acute effect

Studies have been conducted to determine the effects of EMF exposure. There have been a number of well-established acute effects on the nervous system due to exposure to high levels of EMF. These include direct stimulation of the nerve and muscle tissue, and induction of retinal phosphene (i.e. sensation of ring or spot of light on eye ball). However, it should be noted that exposure to high levels of EMF is not normally found in everyday environment from electrical sources. There is also indirect scientific evidence that EMF can transiently affect visual processing and motor coordination. For certain occupational instances, the ICNIRP considered that with appropriate training, it is reasonable for workers to voluntarily experience transient effects such as retinal phosphene and minor changes in brain function since these are not believed to result in long term or pathological health effects, Ref [17].

6.2.2. Chronic effect

Numerous studies have been conducted to understand the effects of long-term exposure to EMF. Some studies have linked prolonged exposure to EMF to increased rates of childhood leukemia. Based largely on limited evidence, the International Agency for Research on Cancer has classified ELF magnetic fields as 'possibly carcinogenic to humans'. The ICNIRP views that the current existing scientific evidence is too weak to ascertain a causal relationship that prolonged exposure to ELF magnetic fields is related with increased risk of childhood leukemia, Ref [17].

6.2.3. Advice from public authority

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 [15].*
- *“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 [18].*

6.3. Study approach

Although the adverse health impacts have not been established, the possibility of impact due to exposure to EMF cannot be ruled out. As part of a precautionary approach, the study will assess the typical exposure levels to EMF for the proposed 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 [19]. Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

6.4. 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 6.2, Ref [17]. 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 6.2: 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

6.5. BESS and grid connection infrastructure EMF

6.5.1. 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 BESS, the study has assumed the typical magnetic field is not too dissimilar with that of a substation. The 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.

6.5.2. PCU

Due to the limited EMF information available, this study assumed that EMF generated from PCUs on a grid-scale BESS facility is not dissimilar to PCUs 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 [20]. 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 μ T) and transformer (258 μ T). These fields were lower than the ICNIRP's occupational exposure limit.
- The highest AC magnetic fields were measured adjacent to the inverter (110 μ T) and transformer (177 μ T). 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.

6.5.3. HV connection asset

In this study, the magnetic field associated with the HV connection asset (33/330 kV switchyard) was assumed to be similar to that of an electrical 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 measurement of typical magnetic field reported which ranges between 1-8 μ T at the fence, Ref [21].

6.5.4. Underground transmission lines

The magnetic field from transmission lines will vary with configuration, phasing and load. The typical magnetic fields near overhead transmission lines measured at one metre above ground level range between 1-20 μ T (directly underneath) and 0.2-5 μ T (at the edge of easement), Ref [21].

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 400 kV¹⁰ underground transmission cable buried 1 m below ground are approximately 21-24 μ T (directly above) and 2-3 μ T (5 m from centreline), Ref [22].

6.6. 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 boundary 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.

6.7. Conclusion

Based on the review completed in the preceding sections, the 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, the 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 ('Insignificant') in reference to the consequence impact rating shown in Table 9.2.

¹⁰ This is the available information on typical magnetic field for underground transmission cable at the time of this study. The project's underground transmission line(s) will be 330 kV. The typical magnetic field for a 400 kV transmission cable was assumed not dissimilar to a 330 kV transmission cable.

7. BESS SEPARATION DISTANCES

7.1. Overview

As per the project SEARs, the PHA also includes a requirement to ‘*consider all recent standards and codes and verify separation distances to onsite and off-site receptors to prevent fire propagation*’. Based on clarification with the DPE, this additional requirement (to that of a conventional PHA) is intended to ensure that fire risks from the BESS¹¹ have been considered in designing the project.

Specifically, the proponent must demonstrate 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 do not propagate to neighbouring sub-units; and
- The overall BESS and other onsite or off-site receptors.

This section covers the following:

1. Review of separation distances/clearances provided between the BESS sub-units against applicable codes and standards and manufacturer specification.
2. Verification that the required land area for the proposed BESS capacity would fit within the land area designated for the BESS.
3. Review of separation distances between the BESS and onsite and off-site receptors.

7.2. Separation distances between BESS sub-units

7.2.1. NFPA 855

The National Fire Protection Agency (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 [23].

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.

¹¹ Applicable for projects that include a BESS exceeding a peak delivery capacity of 30 MW.

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.

Wärtsilä has completed a UL 9540A unit level test for the GridSolv Quantum. The test result found that all performance requirements for outdoor ground mounted equipment per UL 9540A were met, Ref [12]. The test results are as follows:

- If the battery cells within a battery module go into thermal runaway, it would not propagate to adjacent modules or units.
- The Lower Explosive Limit (LEL) remained below 25%, with no risk of deflagration.
- No flaming occurred beyond the outer dimensions of the battery system enclosure (i.e. no external flaming).
- No explosion hazards were exhibited.

7.2.2. Manufacturer specified clearances

The conceptual BESS layout and clearances between the units are shown in Figure 7.1 and Figure 7.2, respectively.

As advised by Equis, the concept layout has been designed with considerations of the (1) dimensions of the BESS units and (2) required clearances for safety, operability and maintainability specified by the OEM. Sherpa has assumed that the OEM specified clearances between units have taken into account the requirements of NFPA855. The clearances included in the concept design are as follows:

- Front clearance / distance between each battery row: 3 m
- Between a battery row and a distribution kiosk: ~3.5 m
- Between AC-DC combiner box and inverter: 3 m.

Figure 7.1: Concept BESS layout

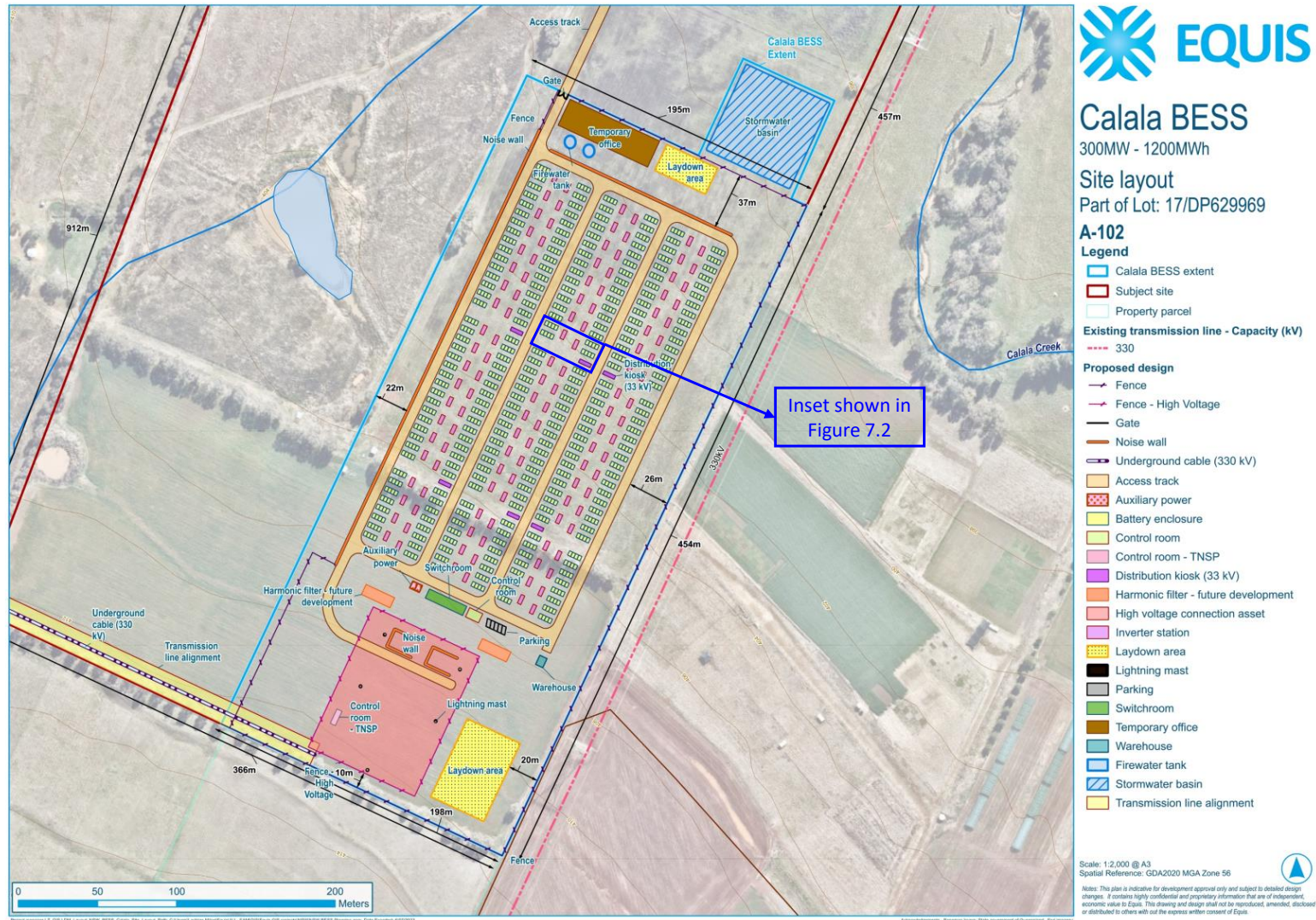
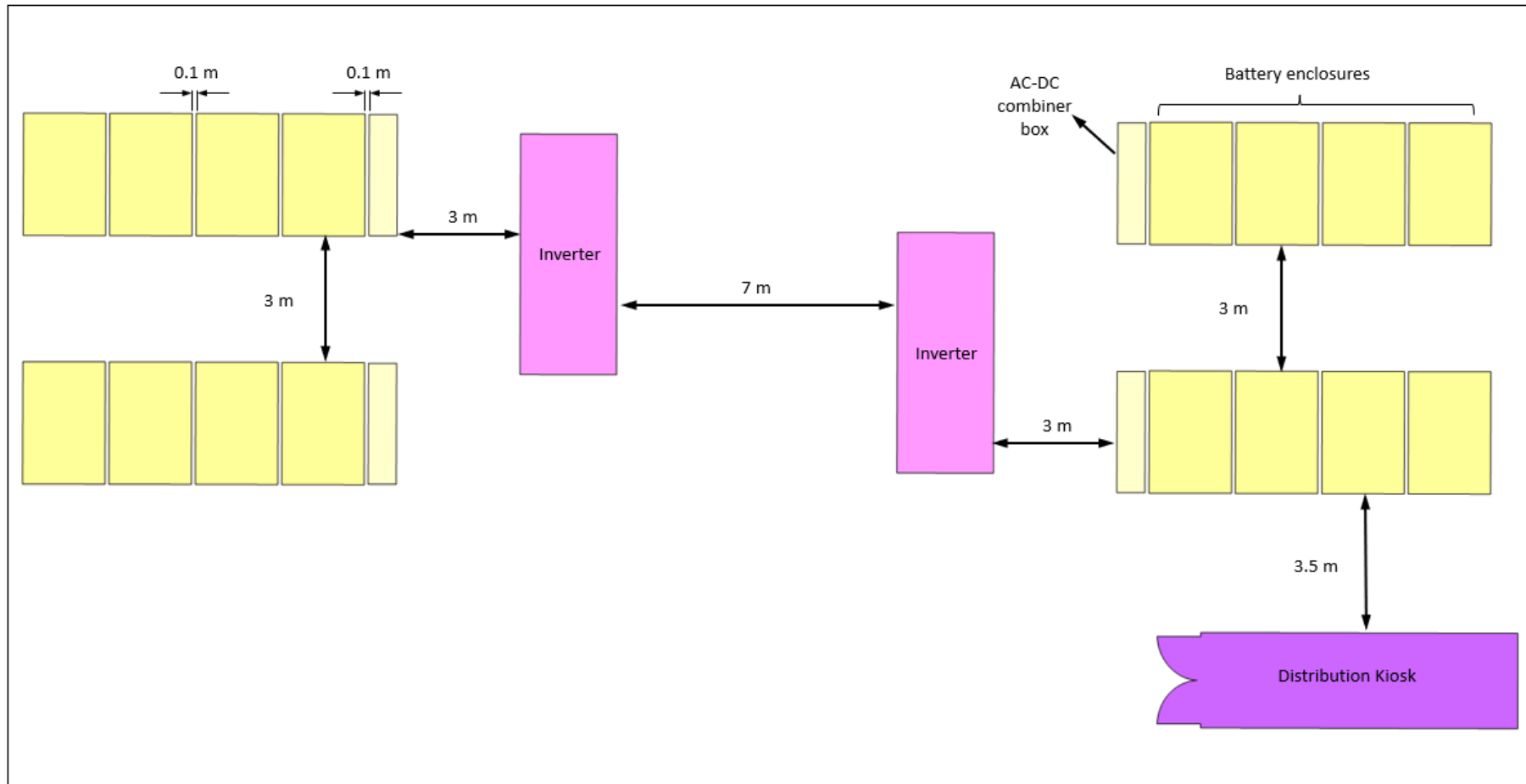


Figure 7.2: Concept BESS layout – Clearances between units



7.3. Land area designated for the BESS

The proposed BESS will be located in a dedicated area within the project extent footprint. The designated land area is sufficient to accommodate the proposed BESS units as shown in Figure 7.1, which accounts for the manufacturer specified clearances in accordance with NFPA 855 (refer to Section 7.2.2).

7.4. Onsite receptors

The closest onsite receptors to the BESS will be other project infrastructure including:

- Control room
- Switchroom
- Warehouse
- HV connection asset (33/330 kV switchyard).

The separation distances between the BESS and the identified onsite receptors are shown in Table 7.1. The separation distances are illustrated in Figure 7.3. The TransGrid Tamworth substation is located approximately 950 m south-west from the project extent boundary and is not shown in Figure 7.3.

Both the control room and switchroom are located approximately 13 m from the closest BESS. Based on the UL 9540A results, Ref [12], the battery enclosure will be installed no less than 10 feet (3 m) from buildings as per NFPA 855.

Table 7.1: Separation distances to onsite receptors

Onsite receptors	Separation distance from the closest BESS
Control room	13 m
Switchroom	13 m
Warehouse	21 m
HV connection asset (33/330 kV switchyard)	38 m

7.5. Off-site receptors

For the PHA, the non-associated residential dwellings or occupied areas are considered as sensitive receptors for determination of off-site impact. The nearest township to the proposed BESS is Calala, located approximately 2 km north-west of the site.

For fire events involving the BESS, the separation distances from the BESS to the non-associated residential dwellings were used to determine off-site impact. Additionally, APZs will be established and maintained around the perimeter of the BESS. This will provide further separation from the BESS infrastructure to the project extent boundary.

There are 2 sensitive receptors within 500 m of the project extent boundary (R2 and R9). A review of the separation distances to off-site receptors is provided in Table 7.2, and shown in Figure 7.4.

Table 7.2: Separation distances to offsite receptors within 500 m

Offsite receptors	Separation distance (m) from	
	Project extent boundary	Closest BESS
R2	468	520
R9	443	593

7.6. Review findings

The review of BESS separation distances found that:

- The concept layout has been designed including clearances specified by the OEM for both safety as well as operability and maintainability. Additionally, the GridSolv Quantum has been tested to UL 9540A and the results indicate that:
 - Propagation to adjacent modules or units was not observed.
 - The LEL remained below 25%, with no risk of deflagration.
 - No external flaming and no explosion hazards exhibited.
- The designated land area can accommodate the proposed BESS units to meet the proposed capacity.
- In the event of thermal runaway and/or fire, propagation is not expected to affect other onsite receptors based on the propagation characteristics determined from the UL 9540A test.
- The nearest sensitive receptor (R9) is approximately 443 m and 593 m from the project extent boundary and closest BESS, respectively. No off-site impact is expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.

Figure 7.3: Separation distance to onsite receptors

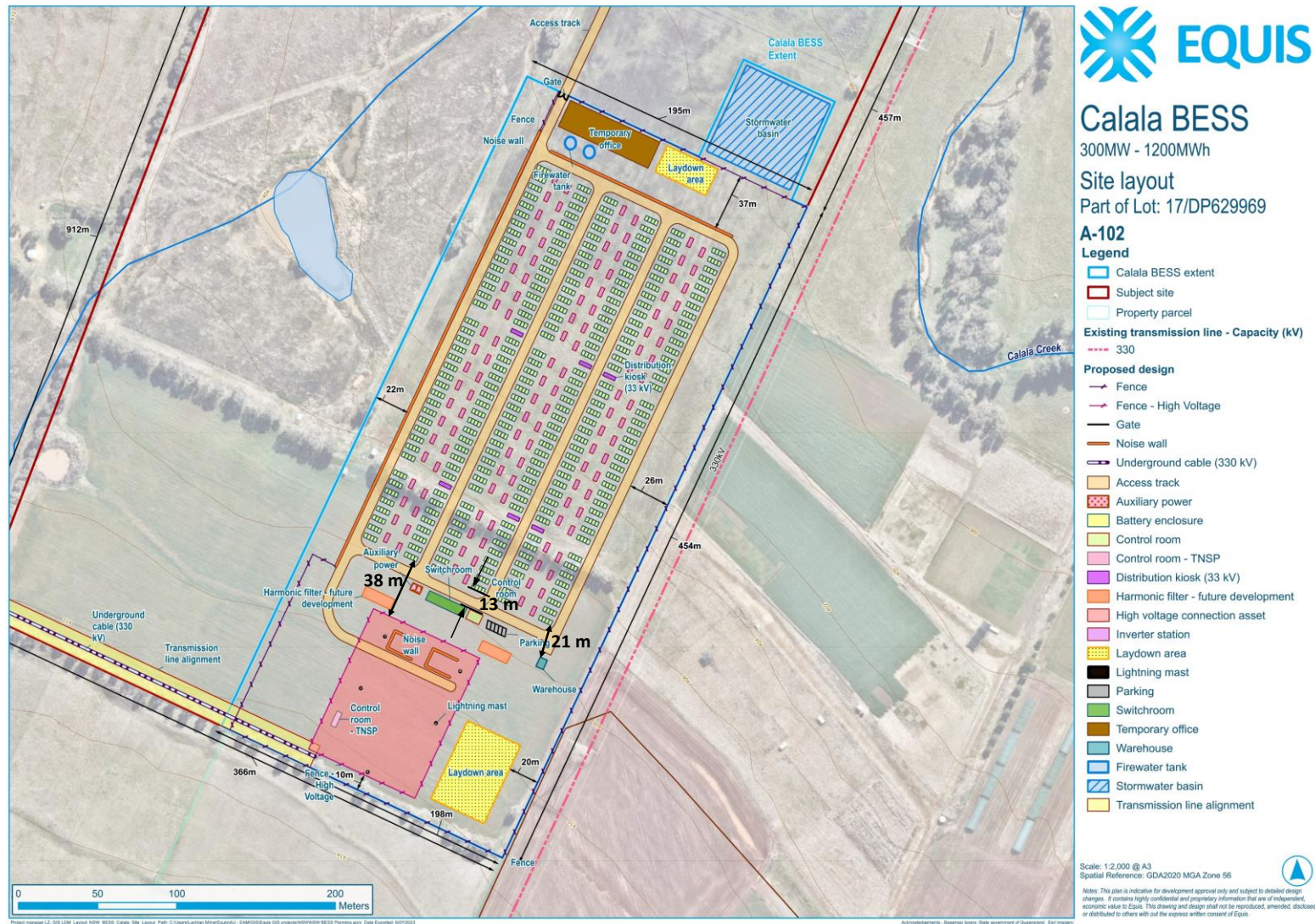
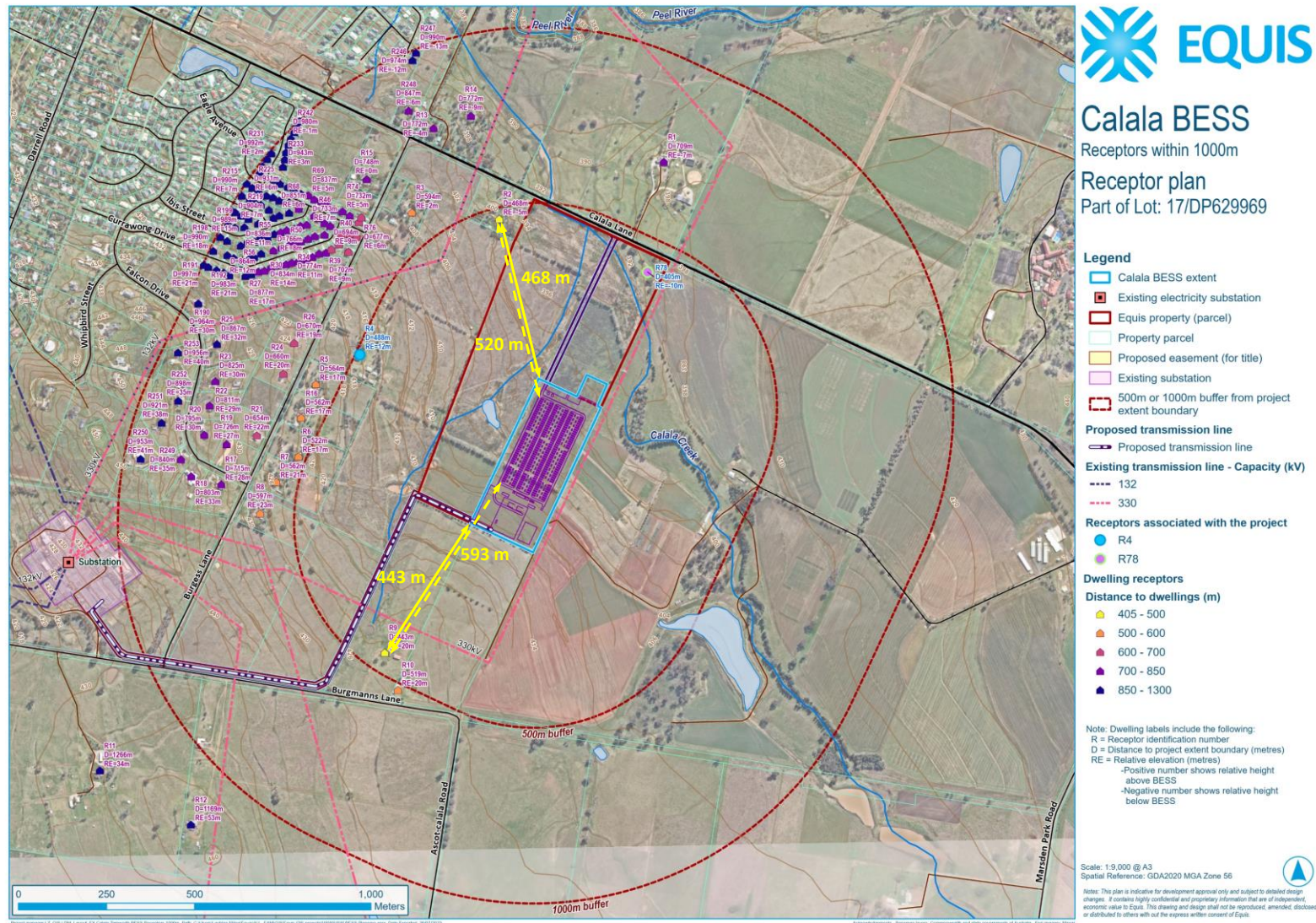


Figure 7.4: Separation distance to off-site receptors



8. LEVEL OF ANALYSIS DETERMINATION

8.1. Level of analysis

The HAZID found that for all identified events the resulting consequences are not expected to have significant off-site impacts (serious injury and/or fatality to the public or off-site population), based on the following considerations:

- The project will be situated in a rural area.
- The nearest sensitive receptor is approximately 443 m from the project extent boundary (R9; refer to Figure 7.4).

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

- The project will be situated in a rural area with the scattered residential dwellings. The nearest sensitive receptor is located approximately 443 m from the project extent boundary (R9).
- The nearest township is Calala, located approximately 2 km north-west of the project.

Based on the above findings and the *Multi-Level Risk Assessment* guideline, Ref [10], and guidance to determine the required level of analysis for the PHA (Table 4.1), a fully qualitative approach (i.e. Level 1 analysis) was determined appropriate for this study. The risk analysis is presented in Section 9.

8.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [11], 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 10.

9. RISK ANALYSIS

9.1. 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.

For each identified event, the risk to off-site population was qualitatively determined from the resulting severity and likelihood rating pair using the risk matrix shown in Table 9.1. In the absence of a suitable company risk matrix, the risk matrix provided in AS/NZS 5139 was used for the study. In line with AS/NZS 5139, events with risks greater than 'Low' should be discussed with the system owner and operator, and anyone involved in the installation of the system.

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

- High and Extreme – Unlikely to be tolerable; review if activity should proceed.
- Medium – Tolerable, if So Far As Reasonably Practicable.
- Very Low and Low – Broadly acceptable.

Table 9.1: 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	Very Low	Low	Medium	Medium	Medium
Insignificant	Very Low	Very Low	Low	Medium	Medium

9.2. Severity rating

For each event, the severity rating was qualitatively assigned based on the consequence description identified in the HAZID register using the category scale shown in Table 9.2 which was reproduced from AS/NZS 5139.

For this study, the severity scale was used to assess impact for off-site population. For example, an event with consequence outcome identified as 'localised effects' or 'effects are not expected to have an off-site impact' was assigned an 'Insignificant' rating to indicate minimal impact to off-site population.

Table 9.2: Consequence rating

Consequence rating	Rating definition
Catastrophic	Any fatality of staff, contractor or public
Major	Non-recoverable occupational illness or permanent injury Injury or illness requiring admission to hospital
Moderate	Injury or illness requiring medical treatment by a doctor Dangerous/reportable electrical incident
Minor	Injury requiring first aid Circumstances that lead to a near miss
Insignificant	No or minor injury

9.3. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 9.3 which was reproduced from AS/NZS 5139.

Table 9.3: Likelihood rating

Likelihood rating	Rating definition
Almost certain	Probability of occurrence: greater than 90%
	Expected to occur whenever system is accessed or operated
	The event is expected to occur in most circumstances
Likely	Probability of occurrence: 60% - 89%
	Expected to occur when system is accessed or operated under typical circumstances
	There is a strong possibility the event may occur
Possible	Probability of occurrence: 40% - 59%
	Expected to occur in unusual instances when the system is access or operated
	The event may occur at some time
Unlikely	Probability of occurrence: 20% - 39%
	Expected to occur in unusual instanced for non-standard access or non-standard operation
	Not expected to occur, but there is a slight possibility it may occur at some time
Rare	Probability of occurrence: 1% - 19%
	Highly unlikely to occur in any instance related to coming in contact with the system or associated systems
	Highly unlikely, but it may occur in exceptional circumstances, but probably never will

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

9.4. Risk results and analysis findings

The qualitative risk results for the identified events are shown in Table 9.4.

The risk analysis findings are as follows:

- **Consequence:** The worst-case consequence for the identified events is a BESS fire and/or explosion event which may result from causes such as battery thermal runaway, encroachment from off-site bushfire, or a substation fire. The study found that for all events, the impacts are not expected to have significant off-site impacts. This was assessed based on the location of the proposed BESS (i.e. rural area) and separation distance between the BESS and sensitive receptors (i.e. non-associated residential dwellings).
- **Likelihood:** The highest likelihood rating for the identified events is 'Unlikely' (i.e. not expected to occur, but there is a slight possibility it may occur at some time).
- **Risk analysis:** A total of 13 hazardous events were identified. The breakdown of these events according to their risk ratings are as follows:
 - 'Medium' risk event: 1

This event relates to unauthorised person access to the proposed BESS footprint resulting in vandalism/asset damage to the infrastructure, with no significant off-site impact expected. Severity rating of 'Major' was assigned to account for the trespasser potentially injuring themselves in the act.

The PHA noted that the controls for this event are well understood and will be implemented accordingly. In addition to the rural location of the site, it is anticipated that security fencing, cameras and warning signs will be provided. These measures are expected to reduce the likelihood of this event. The likelihood rating for this event was rated as 'Unlikely'.
 - 'Very Low' risk events: 12

Most of these events relate to fire and/or explosion events, with no significant off-site impact expected (i.e. more likely to affect onsite employees). The study identified proposed prevention controls to reduce the likelihood of these fire events and mitigation controls to contain the fires to minimise potential for escalated events (e.g. fire management plan). Based on the identified controls, the highest likelihood for these events were rated as 'Unlikely'.

Table 9.4: Risk results

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
Electrical	Exposure to voltage	<ul style="list-style-type: none"> - Electrocution - Injury and/or fatality to onsite employees - Injury and/or fatality to member of public due to touch and step potential 	No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low
Energy	Arc flash	<ul style="list-style-type: none"> - 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.	No	Insignificant	Rare	Very Low
Fire	BESS fire	<ul style="list-style-type: none"> - Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees 	No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low
Fire	Transformer / HV connection asset fire	<ul style="list-style-type: none"> - Release of toxic combustion products - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees 	No off-site impact expected as the transformers and HV connection asset will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low
Fire	Bushfire	<ul style="list-style-type: none"> - Escalation to the entire BESS - Injury and/or fatality to onsite employees 	No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low
Chemical	Release of battery electrolyte (liquid/vented gas) from the battery cell	<ul style="list-style-type: none"> - Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte - Release of vented gas from cells - Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees 	No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
Chemical	BESS coolant or refrigerant leak	<ul style="list-style-type: none"> - 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 and fire, resulting in injury and/or fatality to onsite employees 	No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low
Explosive gas	Generation of explosive gas	<ul style="list-style-type: none"> - Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees 	No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low
Reaction	Thermal runaway in battery	<ul style="list-style-type: none"> - Fire and/or explosion in battery enclosure - Escalation to the entire BESS - Injury and/or fatality to onsite employees 	No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low
EMF	Exposure to EMF	<ul style="list-style-type: none"> - 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 project will not exceed the ICNIRP reference level for exposure to the general public. No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low
External factors	Water ingress (e.g. rain, flood)	<ul style="list-style-type: none"> - Electrical fault/short circuit - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees 	No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low
	Vandalism due to unauthorised personnel access and deliberate damage to the BESS	<ul style="list-style-type: none"> - Asset damage - BESS failure/fire - Potential hazard to unauthorised person (e.g. electrocution) - Injury and/or fatality to trespasser 	<p>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.</p> <p>For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.</p>	No	Major	Unlikely	Medium

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
External factors	Lightning strike	<ul style="list-style-type: none"> - Fire - Injury and/or fatality to onsite employees 	No off-site impact expected as the BESS will be situated in a rural area and there is a considerable separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low

10. RISK ASSESSMENT

10.1. Assessment against company risk acceptance criteria

Using the study risk matrix referenced from AS/NZS 5139, the identified hazardous events were qualitatively risk profiled. Of the 13 events identified, all were rated as 'Very Low' risks except for one 'Medium' risk event. The medium risk event is related to unauthorised person access to the proposed BESS footprint, resulting in vandalism/asset damage to the infrastructure with the potential for self-injury during the act. The PHA noted that the controls for this event are well understood and will be implemented accordingly. In addition to the rural location of the site, the proposed BESS will be located in a secure area with fencing and warning signs will be provided. These measures are expected to reduce the likelihood of this event. The likelihood rating for this event was rated as 'Unlikely'.

All identified events are not expected to have significant off-site impacts. Based on the study risk acceptance criteria, the risk profile for the proposed BESS is considered to be tolerable.

10.2. Assessment against HIPAP No. 4 criteria

Assessment against the HIPAP No. 4 qualitative land use planning risk criteria is provided in Table 10.1.

Table 10.1: Assessment against HIPAP No. 4 qualitative risk criteria

HIPAP 4 qualitative criteria	Remarks	Complies
<p><i>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.</i></p>	<p>The PHA has identified hazardous events and assessed the risks associated with the proposed operations of the BESS. The BESS location is situated in a rural area with considerable separation distance to sensitive receptors 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.</p>	Yes
<p><i>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.</i></p>	<p>Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events are not expected to have significant off-site impacts.</p>	Yes
<p><i>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.</i></p>	<p>Events with high probability of occurrence are expected to be contained within the boundaries of the installation. Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events (e.g. fire and explosion) are not expected to have significant off-site impacts.</p>	Yes
<p><i>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.</i></p>	<p>There are no hazardous developments (in the context of the Resilience and Hazards SEPP) in the vicinity of the project site.</p>	Yes

10.3. Conclusion and recommendations

A PHA was completed to identify the hazards and assess the risks associated with the proposed operations of the BESS at the planning stage to determine risk acceptability from 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 guidelines for assessment against HIPAP No. 4 criteria. A Level 1 PHA (qualitative) was completed.

The PHA concluded that:

- For all identified events associated with the proposed operation of the BESS, the resulting consequences are not expected to have significant off-site impacts.
- The proposed BESS meets the HIPAP No. 4 qualitative risk criteria.

The following recommendations were identified:

1. Equis to review the investigation reports on the Victorian Big Battery (VBB) Fire (occurred on 31 July 2021) and confirm with the BESS OEM that the BESS systems have been designed and/or improved to address the lessons learnt from the VBB fire incident. Additionally, Equis to ensure that the BESS OEM's requirements on equipment clearances, installation, commissioning, operations and maintenance, and emergency response are met. The publicly available investigation reports include:
 - Energy Safe Victoria: Statement of Technical Findings on fire at the Victorian Big Battery, Ref [24].
 - Fisher Engineering and Energy Safety Response Group: Report of Technical Findings on Victorian Big Battery Fire, Ref [25].
2. Equis to consult with Fire and Rescue NSW (FRNSW) to ensure that the relevant aspects of fire protection measures have been included in the design. These may include: (i) type of firefighting or control medium (ii) demand, storage and containment measures for the medium. The above aspects will form an input to the Fire Safety Study which may be required as part of the development consent conditions, for review and approval by FRNSW.

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