

REPORT

PRELIMINARY HAZARD ANALYSIS

CALALA BATTERY ENERGY STORAGE SYSTEM

SSD-52786213

**EQUIS ENERGY (AUSTRALIA) PROJECTS (NGUMI 4) PTY LTD
ATF EQUIS ENERGY (AUSTRALIA) NGUMI 4 HOLDING TRUST**

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ABBREVIATIONS

| | |
|---------|---|
| AC | Alternating Current |
| ADGC | Australian Dangerous Goods Code |
| AHJ | Authority Having Jurisdiction |
| 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 |
| DPHI | Department of Planning, Housing and Infrastructure |
| DPI | Department of Primary Industries |
| 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 |
| HF | Hydrogen fluoride |
| HIPAP | Hazardous Industry Planning Advisory Paper |
| HV | High Voltage |
| 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 |
| PCS | Power Conversion System |
| PHA | Preliminary Hazard Analysis |
| PPE | Personal Protective Equipment |
| RFS | Rural Fire Service |
| RMU | Ring Main Unit |
| SCADA | Supervisory Control and Data Acquisition |
| SDS | Safety Data Sheet |
| SEARs | (Planning) Secretary's Environmental Assessment Requirements |
| SEPP | State Environmental Planning Policy |
| SiD | Safety in Design |
| SSD | State Significant Development |
| T | Tesla |
| TAI | Tamworth Agricultural Institute |
| UL | Underwriters' Laboratories |
| V/m | Volt per metre |

TERMINOLOGY

| Term | Definition |
|--------------------------------------|--|
| Consequence | Outcome or impact of a hazardous incident, including the potential for escalation. |
| Development 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 | 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 development 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 Holding 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 Holding 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 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-52786213) 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.

An EIS was prepared for the project and submitted to the NSW Department of Planning, Housing and Infrastructure¹ (DPHI) in September 2023. A Preliminary Hazard Analysis (PHA) was prepared by Sherpa (21717-RP-001-Rev0) to address the 'Hazards' component of the Planning Secretary's Environmental Assessment Requirements (SEARs), Ref [1], and support the EIS.

Following exhibition of the EIS and response to submissions, Equis has amended the proposal to reduce the environmental impacts associated with the project. An overview of the new proposal is as follows:

- The amended BESS will be positioned on the same land parcel and generally within the same footprint, however the BESS will be smaller in size and will operate at a reduced output capacity.
- Underground grid connection to the Tamworth 330kV substation follows the same alignment and is generally unchanged.
- Connection infrastructure at the Tamworth substation now includes minor extension works to the existing switchyard.

Key changes proposed compared to the original proposal relevant for the PHA is shown in Table 1.1.

Equis has retained Mecone Group Pty Ltd (Mecone) to prepare an Amendment Report for the project and Sherpa Consulting Pty Ltd (Sherpa) to update the PHA (Rev 1) to support responses to submissions and the Amendment Report.

¹ Previously known as Department of Planning and Environment (DPE).

Table 1.1: Proposed amendments

| Component | Original proposal | Changes proposed | Notes on improved design |
|--|--|---|---|
| Battery type | Wärtsilla GridSolv Quantum and SMA battery technology | Tesla Megapack 2 XL | The OEM offers a fully integrated product with a smaller footprint with no requirement for auxiliary distribution infrastructure. |
| Battery enclosure and associated equipment | 960 battery storage enclosures 120 inverters and transformers 6 Ring Main Units (RMU) and auxiliary transformers | 164 battery enclosures 82 Medium Voltage (MV) transformers 16 RMUs (switchgears) | Fewer battery enclosures – battery area footprint reduced 60%. |
| | The enclosure dimension is (W) 2076 mm x (D) 3169 mm x (H) 2462 mm. | The enclosure dimension is (W) 8800 mm x (D) 1650 mm x (H) 2785 mm. | Bigger battery enclosure, but each enclosure contains larger energy capacity. |
| Battery output capacity | 300 MW | 300 MW | No change. |
| Battery storage duration | 1200 MWh | 600 MWh | Reduced storage capacity and battery area footprint. |
| Noise attenuation walls | 4 m tall northern noise barrier | Deletion of northern noise barrier | Reduced visual impact. |
| | 4 m tall nearfield HV transformer noise barriers | Deletion of nearfield HV transformer noise barriers | Improved internal accessibility and reduced visual impact. |
| Setbacks - Asset Protection Zone (APZ) | North – 37 m East – 26 m South – 10 m West – 22 m | North – 10 m East – 25 m South – 20 m West – 10 m | Northern and western APZ economised to align with minimum requirement specified in RFS <i>Planning for Bushfire Protection</i> guideline (Section 8.3.5 'Wind and solar farms') |
| Tamworth substation connection | Underground cable connecting to the existing Tamworth substation | Connection to Tamworth substation includes associated substation augmentation and ancillary works as required | Connection alignment to the substation remains unchanged. |

1.2. Objectives

The PHA 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 1.2. No additional assessment requirements were identified for the Amendment Report.

Table 1.2: Hazards assessment requirements

| Assessment requirements – Hazards | Section reference |
|---|-------------------|
| A preliminary risk screening completed in accordance with the <i>State Environmental Planning Policy No. 33 – Hazardous and Offensive Development</i> ² 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 |
| An assessment of potential hazards and risks ³ including but not limited to bushfires, land contamination ⁴ , 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 rated capacity of up to 300 MW/600 MWh and associated infrastructure, and connection to the Tamworth substation via underground transmission lines.

The project will comprise:

- Large-scale BESS including battery enclosures, MV transformers and RMUs.
- 33/330 kV switchyard.
- Underground transmission line connection between the BESS and the nearby TransGrid Tamworth 330 kV substation.
- Ancillary elements including:

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

³ 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).

⁴ Sherpa’s scope of work excludes assessment of existing and the potential for future land contamination.

- Site access from Calala Lane, internal access roads and parking.
- Warehouse, control room and staff amenities.
- Stormwater basin and fire water tank.
- Noise attenuation wall (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 ('Development 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 1.3.

Table 1.3: 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 battery Original Equipment Manufacturer (OEM) and layout of the battery enclosures and associated equipment within the battery area 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 Tesla Megapack 2 XL 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 | 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 (battery make and model) and configuration adopted at the time of the study. An indicative configuration of the battery units, transformers and switchgears is shown in Figure 6.2. |
| 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]. |

| No. | Item | Exclusions and limitations |
|-----|--------------------------------------|--|
| 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> . |
| 8 | Knock-on effects and cumulative risk | The PHA excluded assessment of knock-on effects to other SSD projects. The cumulative risk impact to off-site receptors from existing and proposed developments has not been assessed in this PHA. The PHA found that off-site impact is not expected based on separation distance to the existing off-site receptors. It is assumed that adjacent developments will also be subject to development controls to manage off-site risks and hence cumulative risk at offsite receptors. |

2. FACILITY DESCRIPTION

2.1. Location and project site

The project will be developed at 474 Calala Lane, Calala, approximately 2 km south-east of the Calala township 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 project will be located in the south-eastern portion of the site, comprising a total impact footprint of approximately 14.8 ha⁵ (the 'Development extent'), however the proposed battery area will be significantly less than this.

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. The Tamworth Agricultural Institute (TAI) is located immediately east of the development extent boundary.

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.

Residential dwellings are primarily located in clusters west of the project site. Figure 2.3 shows the residences within 1 km of the 'BESS facility'. There is only 1 non-associated residence within 500 m of the 'BESS facility', located approximately 475 m south (R9). The nearest town centre is Calala, approximately 2 km north-west of the project.

For the PHA, the TAI and existing non-associated residential dwellings⁶ are considered as off-site receptors.

⁵ 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.

⁶ 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

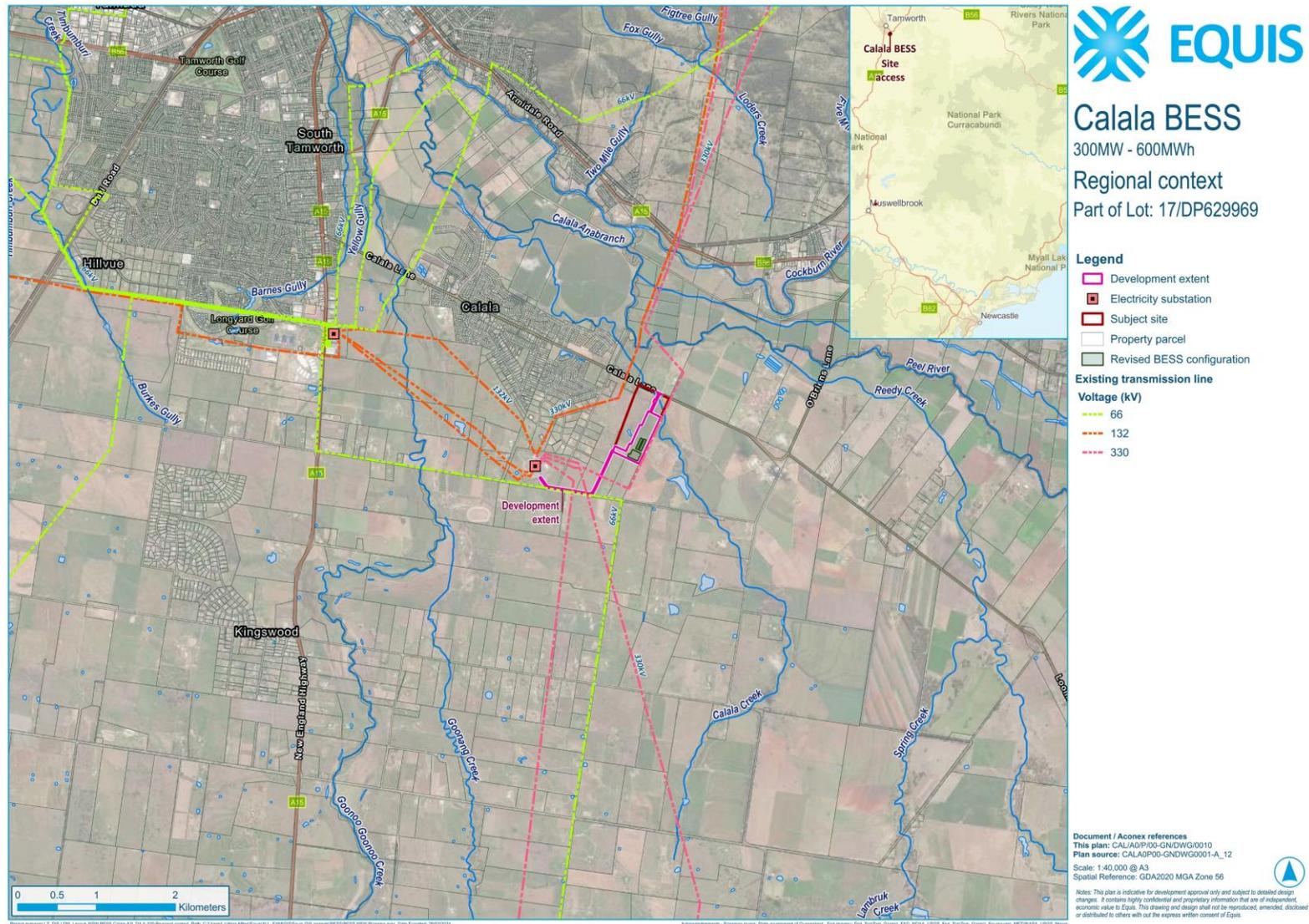


Figure 2.2: Site plan

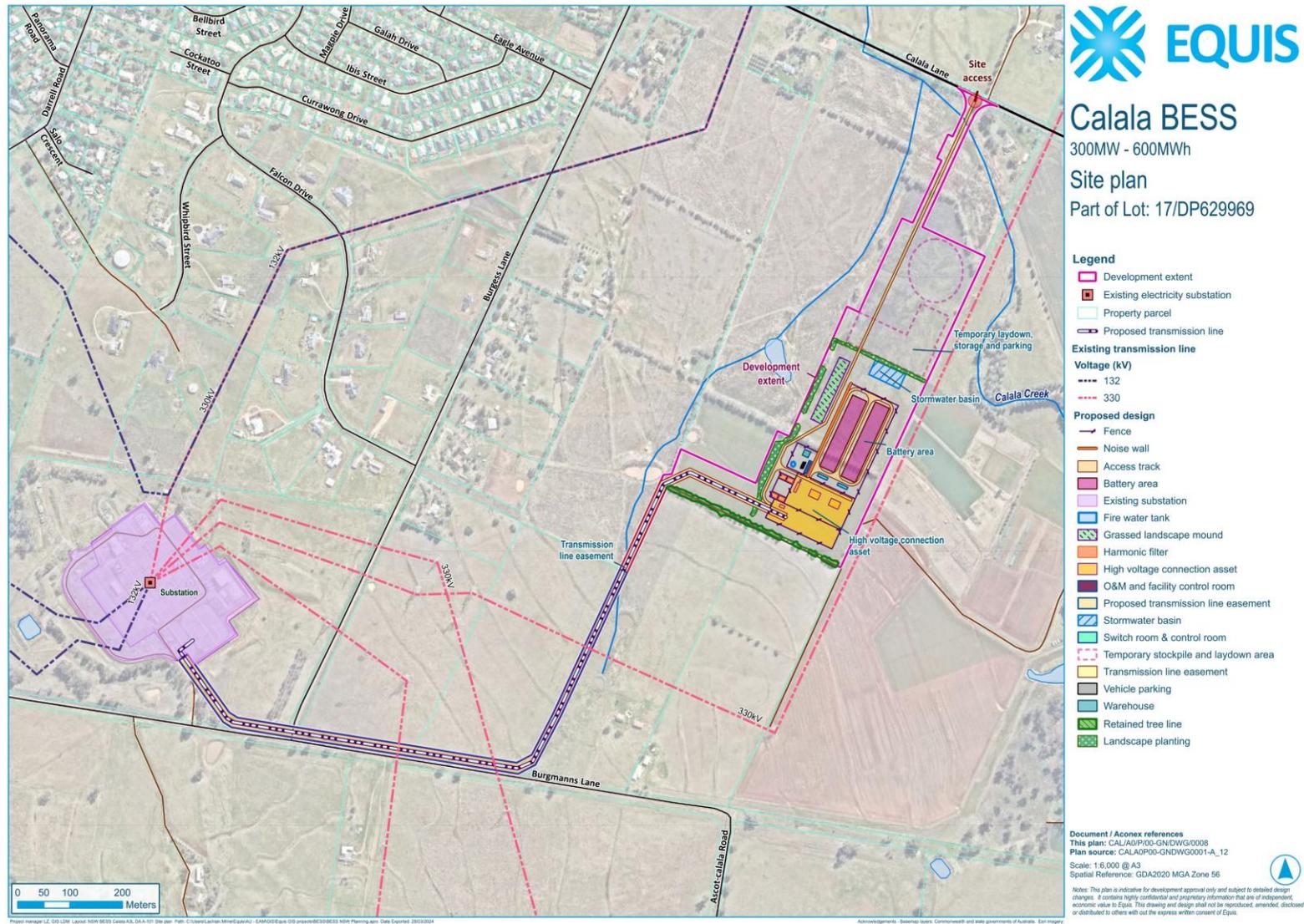
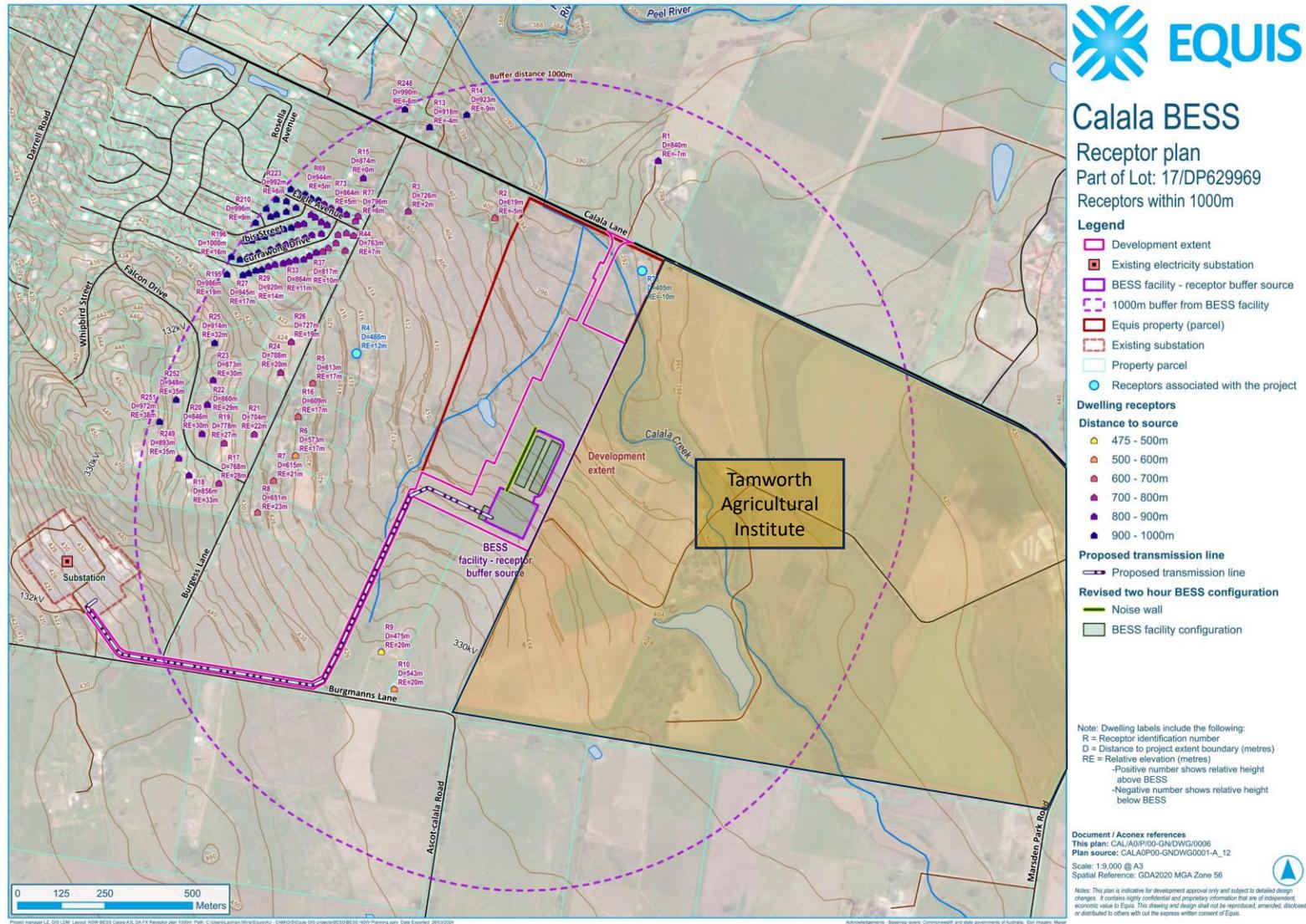


Figure 2.3: Receptor plan



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/600 MWh (2 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 battery OEM. The assessment made in this study was based on the use of the Tesla Megapack 2 XL 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], [5], [6]. An indicative configuration of the battery units, transformers and switchgears is shown in Figure 6.2.

The selection of the battery OEM and layout of the battery enclosures and associated equipment within the battery area will be finalised during detailed design. Detailed design will be conducted following project approval. The following were assumed for the PHA:

1. The BESS will be installed in accordance with the OEM's instructions, industry standards and codes, Safety in Design (SiD) principles, and best practice for mitigation of fire propagation, including clearance requirements.
2. The BESS will be installed and meet requirements of the relevant Australian Standards and other codes and standards.
3. The specific battery system (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 battery system. A UL 9540A test is considered successful if a fire does not propagate from one unit/enclosure 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 centralised Battery Management System (BMS) and Supervisory Control and Data Acquisition (SCADA) system will be available to monitor critical system faults, alert the remote control room, 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 accordance with the SiD principles and industry best practices.
- 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: BESS components

| Component | Description |
|--|--|
| Overview | The Megapack 2 XL (Megapack) is a modular and fully integrated AC-coupled energy storage system. Each Megapack system includes battery modules, inverter, thermal system, circuit breakers and system controller. |
| Enclosure | The Megapack enclosure is a non-walk-in enclosure with ingress protection rating of IP 66 and is classified to NEMA 3R certification, suitable for outdoor use. The enclosure dimension is (W) 8800 mm x (D) 1650 mm x (H) 2785 mm. |
| Battery unit | The Megapack uses Lithium Iron Phosphate (LFP) batteries. Each Megapack contains up to 24 battery modules. For a 2-hour energy storage configuration, the rated capacity for each unit is 1927 kW/3854 kWh. It is anticipated that up to 164 Megapack units will be installed to provide the required capacity for the project (300 MW/600 MWh). |
| Power Conversion System (PCS) or inverters | 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 power grid. Each Megapack is equipped with 24 inverters, i.e. one per battery module. No auxiliary inverter will be installed. |
| Battery Management System (BMS) | A BMS is the electronic system that monitors and manages the battery system electric and thermal states enabling it to operate within the safe operating region of the battery (e.g. protection against overcurrent, overcharge, over-discharge, overheating, over voltage). The BMS constantly monitors the battery cell, module, and unit level. |
| Thermal management system | Thermal management is provided to the internal Megapack components via (1) an active liquid cooling and heating system which utilises 50-50 ethylene glycol and water mixture and (2) R-134a refrigerant. The thermal system is comprised of the: <ul style="list-style-type: none"> • Thermal cabinet which includes pumps that circulate coolant through the unit and a compressor that maintains thermal control, in addition to an in-line heater that can warm the coolant. • Thermal roof (or top cabinet of the enclosure) which provides ventilation airspace and contains fans and radiators that cool the ethylene glycol-water coolant solution. |
| Fire protection system | The Megapack does not contain built-in smoke, gas, or fire detection or suppression devices. However, the BMS is capable of sensing more than 1000 health parameters which will immediately alert the central SCADA should they fall outside the normal range. When required by the Authority Having Jurisdiction (AHJ), third-party multi-spectrum infrared heat or flame detectors can be installed externally at the site level. The Megapack has |

| Component | Description | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------------------------------|---|---------------------------|--|---------------------|-------|-------------------|---------|--------------------------------|------------|------------|--|--------------|---------|--|--------------|---------|---|--------------|----------|---|---------------------------|-----------|--|--------------|-----------|---|--------------|
| | been reviewed and validated both at the product level and for the results of large- scale fire testing, Ref [5]. | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Explosion mitigation system | The Megapack is equipped with built-in deflagration vents in the roof of the unit that will vent any smoke and flame out of the top of the unit and front thermal system intake louvers. | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Standards, Codes and Testing | <p>Key standards, tests and/or certifications claimed include:</p> <table border="1" data-bbox="512 521 1370 1274"> <thead> <tr> <th data-bbox="512 521 703 584">Standards and tests</th> <th data-bbox="703 521 1179 584">Title</th> <th data-bbox="1179 521 1370 584">Component/ Aspect</th> </tr> </thead> <tbody> <tr> <td data-bbox="512 584 703 627">UL 1642</td> <td data-bbox="703 584 1179 627">Standard for Lithium Batteries</td> <td data-bbox="1179 584 1370 627">Cell level</td> </tr> <tr> <td data-bbox="512 627 703 772">UL 1741 SB</td> <td data-bbox="703 627 1179 772">Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources – incorporating testing requirements in IEEE 1547.1</td> <td data-bbox="1179 627 1370 772">System level</td> </tr> <tr> <td data-bbox="512 772 703 862">UL 1973</td> <td data-bbox="703 772 1179 862">Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail Applications</td> <td data-bbox="1179 772 1370 862">System level</td> </tr> <tr> <td data-bbox="512 862 703 925">UL 9540</td> <td data-bbox="703 862 1179 925">Standard for Energy Storage Systems and Equipment</td> <td data-bbox="1179 862 1370 925">System level</td> </tr> <tr> <td data-bbox="512 925 703 1014">UL 9540A</td> <td data-bbox="703 925 1179 1014">Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems</td> <td data-bbox="1179 925 1370 1014">Unit level test completed</td> </tr> <tr> <td data-bbox="512 1014 703 1160">IEC 62619</td> <td data-bbox="703 1014 1179 1160">Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications</td> <td data-bbox="1179 1014 1370 1160">System level</td> </tr> <tr> <td data-bbox="512 1160 703 1274">IEEE 1547</td> <td data-bbox="703 1160 1179 1274">Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces</td> <td data-bbox="1179 1160 1370 1274">System level</td> </tr> </tbody> </table> | | | Standards and tests | Title | Component/ Aspect | UL 1642 | Standard for Lithium Batteries | Cell level | UL 1741 SB | Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources – incorporating testing requirements in IEEE 1547.1 | System level | UL 1973 | Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail Applications | System level | UL 9540 | Standard for Energy Storage Systems and Equipment | System level | UL 9540A | Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems | Unit level test completed | IEC 62619 | Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications | System level | IEEE 1547 | Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces | System level |
| Standards and tests | Title | Component/ Aspect | | | | | | | | | | | | | | | | | | | | | | | | | |
| UL 1642 | Standard for Lithium Batteries | Cell level | | | | | | | | | | | | | | | | | | | | | | | | | |
| UL 1741 SB | Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources – incorporating testing requirements in IEEE 1547.1 | System level | | | | | | | | | | | | | | | | | | | | | | | | | |
| UL 1973 | Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail Applications | System level | | | | | | | | | | | | | | | | | | | | | | | | | |
| UL 9540 | Standard for Energy Storage Systems and Equipment | System level | | | | | | | | | | | | | | | | | | | | | | | | | |
| UL 9540A | Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems | Unit level test completed | | | | | | | | | | | | | | | | | | | | | | | | | |
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| IEEE 1547 | Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces | System level | | | | | | | | | | | | | | | | | | | | | | | | | |

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, switchrooms and amenities
- Warehouse facility
- Noise attenuation wall (west side of the battery area)
- 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

Construction of the project is expected to be completed over approximately 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. The infrastructure will be dismantled as the project is commissioned 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 facility will be unmanned. The BESS will be active 24 hours per day, seven days per week, 365 days per year and be operated remotely. The BESS is anticipated to be on standby for the majority of the time and typically undergo one cycle of charging and discharging per day.

The project will create approximately 7 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 [7].

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 [8], 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 guideline*⁷, Ref [9], 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 [10], 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.

⁷ 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.

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 negligible during operations. | No |
| BESS coolant (ethylene glycol aqueous solution) | - | - | N/A | N/A | N/A | Not classified as DG. No applicable SEPP screening threshold and excluded from risk screening. | No |
| BESS refrigerant (R134a) | 2.2 | Non-flammable Non-toxic | N/A | N/A | N/A | No applicable SEPP screening threshold and excluded from risk screening. Class 2.2 is not considered to be potentially hazardous with respect to off-site risk. | No |
| Transformer oil | - | - | N/A | N/A | N/A | Not classified as DG. No applicable SEPP screening threshold and not stored with flammable liquids—excluded from risk screening. | No |

3.5. Conclusions

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

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

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

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 [8], 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 'Development 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 off-site receptors (i.e. the TAI and existing non-associated residential dwellings).

4.2. Level of analysis

The *Multi-Level Risk Assessment* guidelines, Ref [11], 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 [12], 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], design and installation manual, Ref [5], and the emergency response guide, Ref [6],
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 battery systems.
4. Previous risk assessments for similar battery 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 battery OEM. The assessment made in this study was based on the use of the Tesla Megapack 2 XL battery system, which was used for the concept design.

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.

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 10 m to the north, 25 m to the east, 20 m to the south and 10 m to the west, Ref [14].

Table 5.1: Identified hazards and events

| Hazard | Event | Project infrastructure | | |
|------------------|--|------------------------|-----------------------------|---------------------|
| | | Battery system | MV transformer & switchgear | HV connection asset |
| 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) | ✓ | ✓ | ✓ |

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 APPENDIX B.

Based on the review, this study concludes that:

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

5.4. Potential off-site impact and separation distances to off-site receptors

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

1. A battery enclosure on fire (e.g. propagated thermal runaway resulting in a fully developed fire). The resulting heat radiation impact from the fire was modelled.
2. Toxic gas generation from decomposition of battery electrolyte due to fire. For LFP batteries, there is a potential for hydrogen fluoride (HF) to be formed following electrolyte decomposition from a battery enclosure fire event. In this study, as HF is considered to be the most toxic decomposition product, dispersion of HF was modelled to better understand the impact to receptors. The following Pasquill weather stability and wind conditions were used for the dispersion modelling:
 - Typical day condition (D5): Neutral (Class D) and wind speed of 5 m/s.
 - Typical night condition (F2): Very stable (Class F) and wind speed of 2 m/s.

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

- A battery enclosure on fire: the distance to the injury level (4.7 kW/m² heat radiation) was used to determine potential for off-site impact, which is approximately 15 m.
- Toxic gas dispersion: the distances to the injury (AEGL-2) and irritation (AEGL-1) levels at D5 condition are 10 m and 23 m, respectively. For the plume rise from fire model, further downwind distance was observed at the D5 condition compared to F2 condition. As a conservative approach, the distance to the irritation level (AEGL-1) at D5 condition was used to determine potential for off-site impact, i.e. 23 m.

For a battery enclosure fire, accounting for both thermal radiation and toxic dispersion impacts, the impact distance is approximately 23 m. This was used to determine potential for off-site impact based on separation distances to the off-site receptors.

A review of the separation distances from the 'BESS facility' area to the nearest off-site receptors is provided in Section 6. Based on the separation distances to off-site receptors, the effects from a battery enclosure fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products to the off-site receptors).

5.5. HAZID findings

The identified hazards, events, applicable BESS component/project infrastructure, and the relationships with causes, consequences and controls are summarised in the HAZID register presented in APPENDIX A. The HAZID findings are as follows:

- A total of 13 hazardous events were identified.
- Incidents involving the batteries:

- A battery thermal runaway event may result in a battery enclosure on fire. Based on the separation distances to the off-site receptors, the effects from a battery enclosure fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products to the off-site receptors). Refer to Section 5.4.
- A battery enclosure fire has the potential for escalation, affecting the entire BESS infrastructure. To minimise fire escalation between the battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the OEM and/or applicable standards. A review of the OEM specified clearances is provided in Section 6.
- Incidents not involving the batteries are expected to be localised and not expected to result in significant off-site impacts.

6. BESS SEPARATION DISTANCES

6.1. Overview

As per the project SEARs, the PHA also includes a requirement to ‘*consider all recent standards and codes and verify separation distances to onsite and off-site receptors to prevent fire propagation*’. Based on clarification with DPHI, this additional requirement (to that of a conventional PHA) is intended to ensure that fire risks from the BESS⁸ 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 does 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.

6.2. Separation distances between BESS sub-units

6.2.1. NFPA 855

The National Fire Protection Association (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems*, recently updated in 2023, is widely recognised globally as a comprehensive set of best practice guide in the industry. A review of NFPA 855 was undertaken to determine the required separation distances between battery enclosures, Ref [15].

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

⁸ Applicable for projects that include a BESS exceeding a peak delivery capacity of 30 MW.

clearances as specified by the BESS manufacturer) form a key parameter to determine clearances.

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

A UL 9540A (4th edition) unit level test was completed for the Tesla Megapack 2 XL. The test result found that all performance requirements for outdoor ground mounted equipment were met, Ref [16]. The test results are as follows:

- No flaming outside the initiating battery enclosure was observed.
- No flying debris or explosive discharge of gases was observed.
- No sparks, electrical arcs, or other electrical events were observed.
- Burn marks were observed on the initiating module, but no external damage was observed to the initiating battery enclosure. No damage to target battery enclosure or adjacent walls was observed.

6.2.2. OEM specified clearances

Sherpa has reviewed the Megapack 2 XL design and installation manual, Ref [5], which specifies the minimum clearances for the battery enclosures. The OEM minimum clearances are as follows:

- Front: 2440 mm
- Side: 150 mm
- Back-to-back: 230 mm.

The conceptual BESS layout and clearances between the battery enclosures are shown in Figure 6.1 and Figure 6.2, respectively. Upon review of the clearances between the battery enclosures, Sherpa found that the configuration meets the OEM minimum clearances.

Figure 6.1: Concept BESS layout

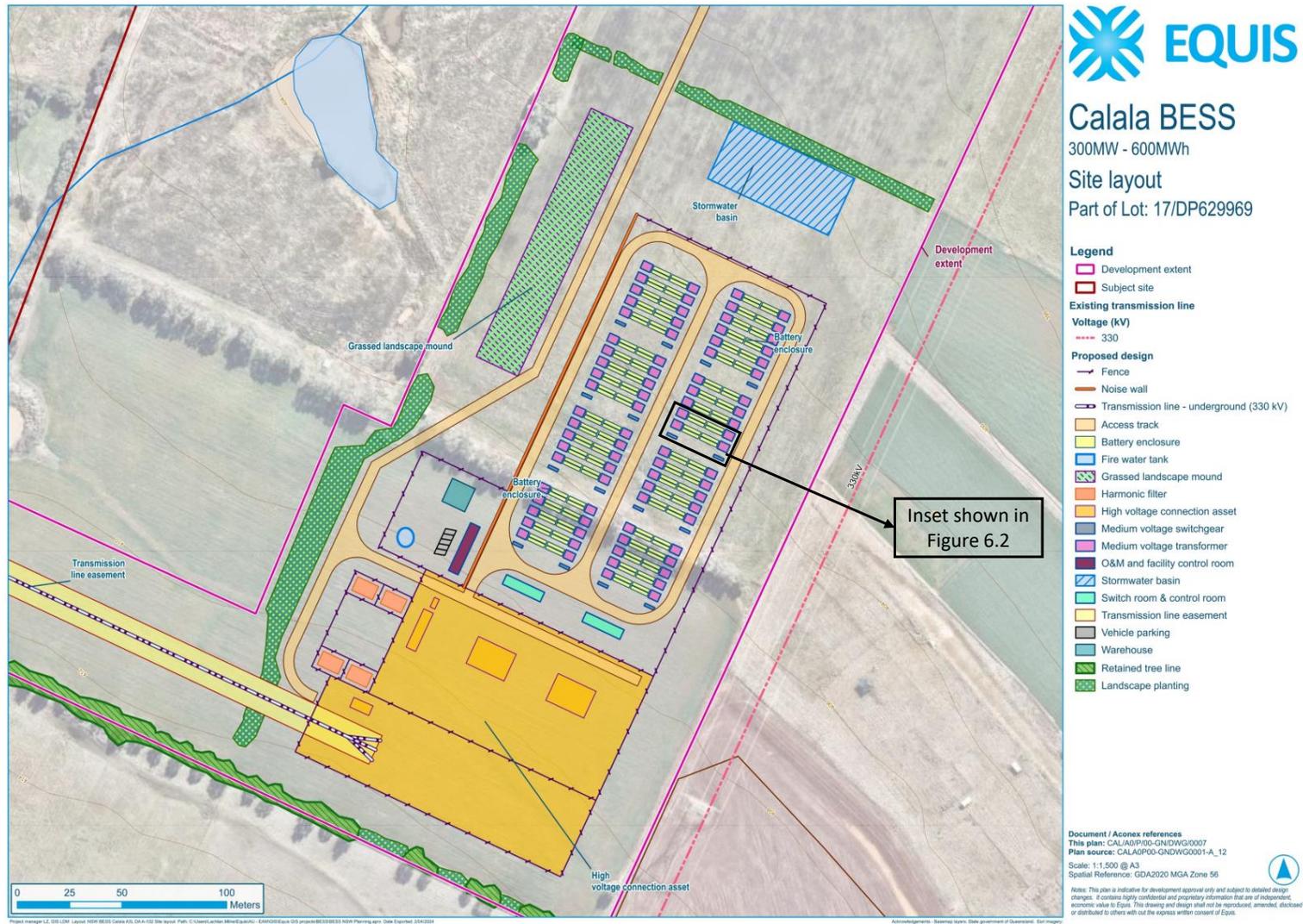
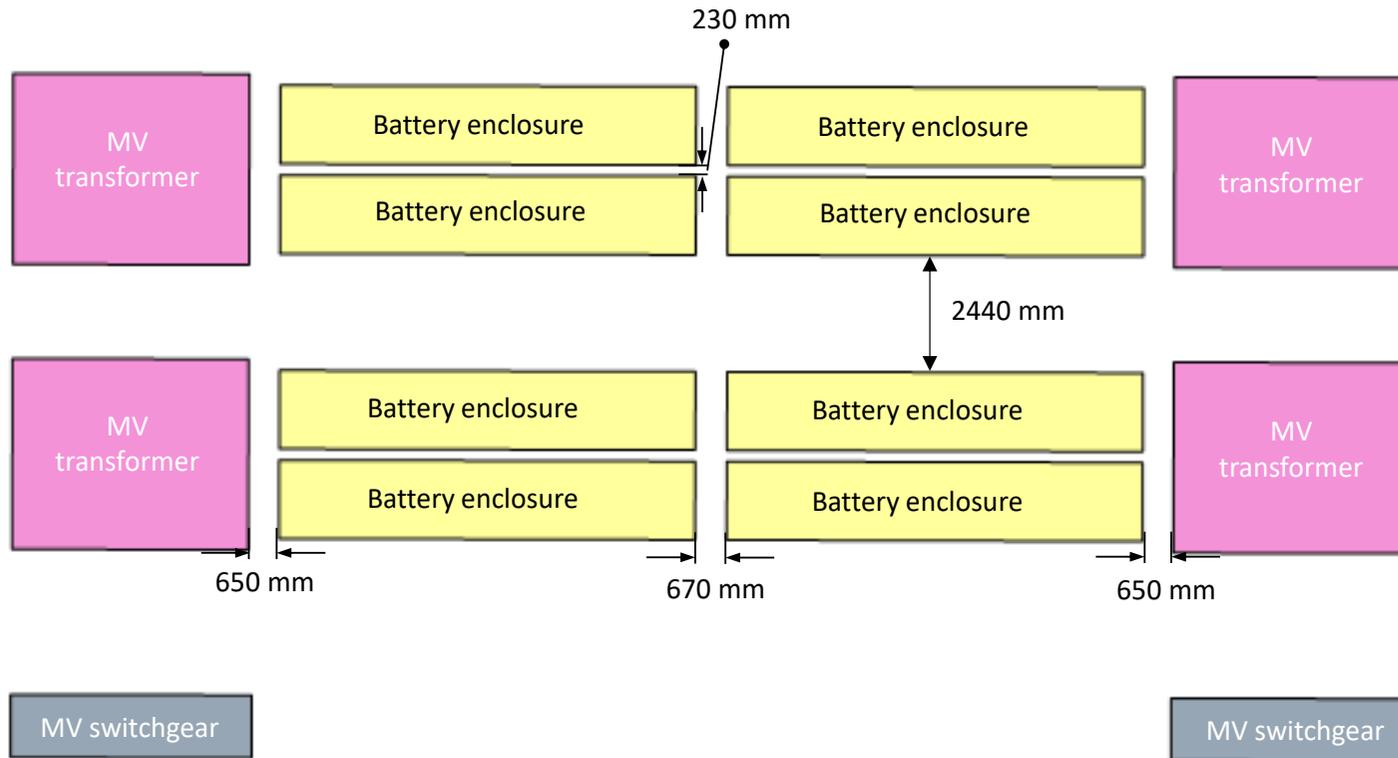


Figure 6.2: Concept BESS layout – Clearances between battery enclosures



6.3. Land area designated for the BESS

The proposed BESS will be located in the ‘BESS facility’ area within the development footprint. The designated land area is sufficient to accommodate the proposed battery enclosures, MV transformers and switchgears as shown in Figure 6.1, which accounts for the OEM specified clearances.

6.4. Onsite receptors

The closest onsite receptors from the battery enclosures will be other project infrastructure including:

- Control room and switch rooms
- O&M and facility control room
- Warehouse
- HV connection asset (33/330 kV switchyard).

The separation distances between the closest battery enclosure and the identified onsite receptors are shown in Table 6.1. The separation distances are illustrated in Figure 6.3. The TransGrid Tamworth substation is located approximately 950 m south-west from the project extent boundary and is not shown in Figure 6.3.

Based on the propagation characteristics determined from the UL 9540A test completed for the battery system, in the event of thermal runaway resulting in a battery enclosure on fire, escalation due to heat radiation is not expected to affect other onsite receptors.

Table 6.1: Separation distances to onsite receptors

| Onsite receptors | Separation distance from the closest battery enclosure |
|--|--|
| Control room and switch room | 19 m |
| O&M and facility control room | 23 m |
| Warehouse | 32 m |
| HV connection asset (33/330 kV switchyard) | 51 m |

6.5. Off-site receptors

For the PHA, the TAI and existing non-associated residential dwellings are considered as off-site receptors for determination of off-site impact. A review of the separation distances to off-site receptors within 500 m of the ‘BESS facility’ area is provided in Table 6.2, and shown in Figure 6.4. The nearest receptor is the TAI, located directly east of the development extent boundary. Details of the assessment of hazards impacts on the TAI is provided in APPENDIX D.

The separation distance from the closest battery enclosure to the off-site receptors was used to determine off-site impact. Based on the completed consequence analysis for a battery enclosure on fire and the separation distances, the effects from a battery

enclosure fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products to the off-site receptors).

Table 6.2: Separation distances to off-site receptors within 500 m of the BESS facility area

| Offsite receptors | Separation distance (m) from | |
|-------------------------------|------------------------------|---------------------------|
| | BESS facility area | Closest battery enclosure |
| TAI western site boundary | 35 | 43 |
| Non-associated residence (R9) | 475 | 616 |

6.6. Review findings

The review of BESS separation distances found that:

- The concept layout has been designed including clearances specified by the OEM. Additionally, the Megapack 2 XL has been tested to UL 9540A and the results indicate that:
 - No flaming outside the initiating battery enclosure was observed.
 - No flying debris or explosive discharge of gases was observed.
 - No external damage was observed to the initiating battery enclosure nor the target battery enclosures.
- The designated land area can accommodate the proposed BESS to meet the proposed capacity.
- In the event of thermal runaway resulting in a battery enclosure on fire, fire escalation to adjacent battery enclosures is not expected based on the propagation characteristics determined from the UL 9540A test. In combination with the APZ, fire propagation is also not expected to affect onsite receptors.
- The nearest off-site receptor is the TAI, located approximately 43 m from the closest battery enclosure. Consequence analysis for a battery enclosure fire indicates that the impact distances to serious injury from heat radiation and irritation from toxic combustion products are approximately 15 m and 23 m, respectively. Based on the separation distances to off-site receptors, serious injury due to heat radiation or irritation from toxic combustion products are not expected.

Figure 6.3: Separation distance to onsite receptors

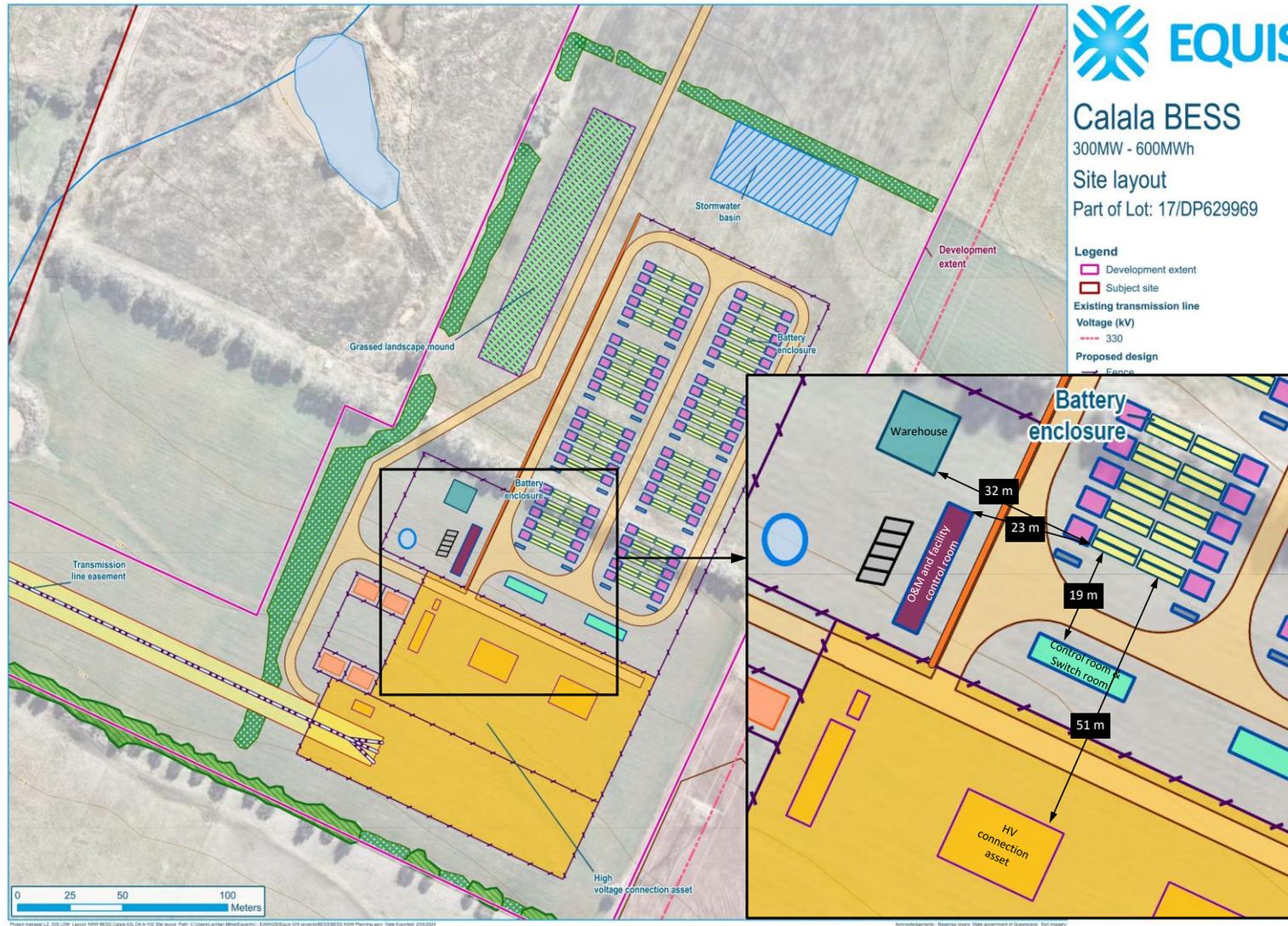
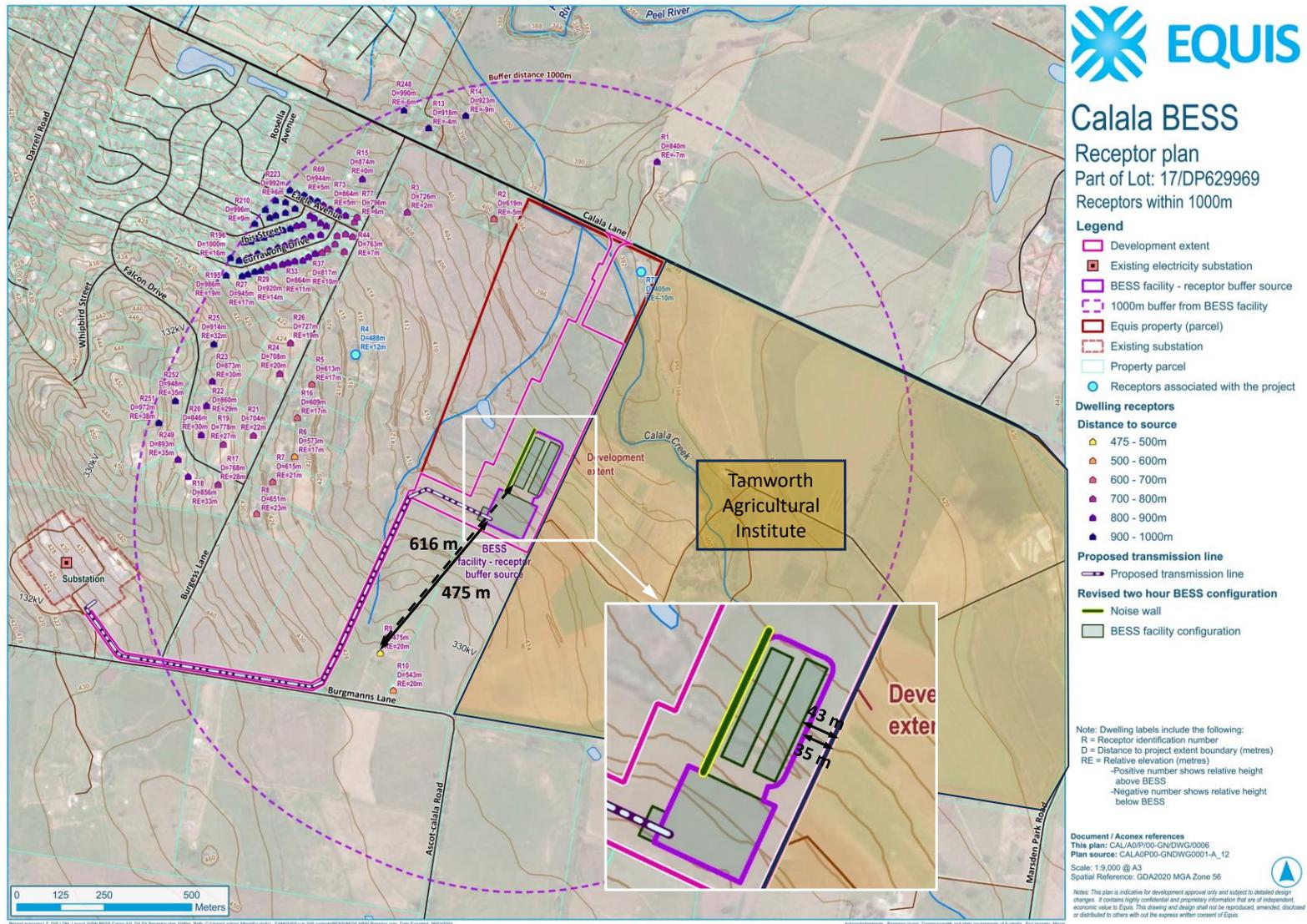


Figure 6.4: Separation distance to off-site receptors



7. LEVEL OF ANALYSIS DETERMINATION

7.1. Level of analysis

The HAZID, supplemented with a consequence analysis, found that for all identified events the resulting consequences are not expected to have significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products), based on the separation distances to the nearest off-site receptors.

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 non-associated residential dwelling is located approximately 475 m from the 'BESS facility' area (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 [11], and guidance to determine the required level of analysis for the PHA (Table 4.1), a qualitative approach (i.e. Level 1 analysis) was determined appropriate for this study. The risk analysis is presented in Section 8.

7.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [12], 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 8.

8. RISK ANALYSIS AND ASSESSMENT

8.1. Overview

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

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 8.1. Although AS/NZS 5139 may not be relevant to this project, 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 8.1: Risk matrix

| Consequence | Likelihood | | | | |
|---------------|------------|----------|----------|---------|----------------|
| | Rare | Unlikely | Possible | Likely | Almost Certain |
| Catastrophic | Medium | High | High | Extreme | Extreme |
| Major | Medium | Medium | High | High | Extreme |
| Moderate | Low | Medium | Medium | High | High |
| Minor | Very Low | Low | Medium | Medium | Medium |
| Insignificant | Very Low | Very Low | Low | Medium | Medium |

8.2. Risk analysis

8.2.1. 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 8.2 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 populations.

Table 8.2: 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 |

8.2.2. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 8.3 which was reproduced from AS/NZS 5139.

Table 8.3: 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 accessed or operated |
| | The event may occur at some time |
| Unlikely | Probability of occurrence: 20% - 39% |
| | Expected to occur in unusual instances 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.

8.2.3. Risk results and findings

The qualitative risk results for the identified events are shown in Table 8.4.

The risk analysis findings are as follows:

- **Consequence:** The worst-case consequence for the identified events is a battery enclosure 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 the resulting consequences are not expected to have significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products), based on the separation distances to the nearest off-site receptors.
- **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 development footprint resulting in vandalism/asset damage to the infrastructure, with no significant off-site impact expected. A 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. 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. Based on the identified controls, the highest likelihood for these events were rated as 'Unlikely'.

Table 8.4: Risk results

| ID | Hazard | BESS component/ infrastructure | Event | Consequence | Off-site consequence | Significant off-site impact? | Risk analysis (off-site and public impact) | | |
|----|------------|---|--|---|--|------------------------------------|---|------------|----------|
| | | | | | | | Severity | Likelihood | Risk |
| 1 | Electrical | Battery system MV transformers and switchgears HV connection asset | Exposure to voltage | <ul style="list-style-type: none"> - Electrocutation - 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 there is a sufficient separation distance to the nearest existing off-site receptor to prevent touching live equipment. | No | Insignificant | Rare | Very Low |
| 2 | Energy | Battery system MV transformers and switchgears HV connection asset | 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 |
| 3 | Fire | Battery system | 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 based on separation distance to existing off-site receptors. | No | Insignificant | Rare | Very Low |
| 4 | Fire | Transformers HV connection asset (33/330 kV switchyard) | 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 there is a sufficient separation distance to the nearest existing off-site receptor. | No | Insignificant | Rare | Very Low |
| 5 | Fire | BESS (overall) | Bushfire | <ul style="list-style-type: none"> - Escalation to the entire BESS - Injury and/or fatality to onsite employees | No off-site impact expected based on separation distance to existing off-site receptors. | No | Insignificant | Rare | Very Low |
| 6 | Chemical | Battery system | 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 based on separation distance to existing off-site receptors. | No | Insignificant | Unlikely | Very Low |
| 7 | Chemical | Battery system (Thermal management system) | 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 based on separation distance to existing off-site receptors. | No | Insignificant | Unlikely | Very Low |

| ID | Hazard | BESS component/ infrastructure | Event | Consequence | Off-site consequence | Significant off-site impact? | Risk analysis (off-site and public impact) | | |
|----|------------------|-----------------------------------|--|--|--|------------------------------------|---|------------|----------|
| | | | | | | | Severity | Likelihood | Risk |
| 8 | Explosive gas | Battery system | 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 based on separation distance to existing off-site receptors. | No | Insignificant | Rare | Very Low |
| 9 | Reaction | Battery system | 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 based on separation distance to existing off-site receptors. | No | Insignificant | Rare | Very Low |
| 10 | EMF | BESS (overall) | 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 based on separation distance to existing off-site receptors. | No | Insignificant | Rare | Very Low |
| 11 | External factors | BESS (overall) | 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 based on separation distance to existing off-site receptors. | No | Insignificant | Rare | Very Low |
| 12 | External factors | BESS (overall) | 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 based on separation distance to existing off-site receptors.</p> | No | Major | Unlikely | Medium |
| 13 | External factors | BESS (overall) | Lightning strike | <ul style="list-style-type: none"> - Fire - Injury and/or fatality to onsite employees | No off-site impact expected based on separation distance to existing off-site receptors. | No | Insignificant | Rare | Very Low |

8.3. Risk assessment

8.3.1. 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 an unauthorised person accessing the development footprint, resulting in vandalism/asset damage to the project 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. The proposed BESS will be within a secure area with 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'.

None of the identified events are expected to have significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products to the off-site receptors). Based on the study risk acceptance criteria, the risk profile for the proposed BESS is considered to be tolerable.

8.3.2. Assessment against HIPAP No. 4 criteria

Assessment against the HIPAP No. 4 qualitative land use planning risk criteria is provided in Table 8.5.

Table 8.5: 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.</p> <p>The separation distance from the closest battery enclosure to the off-site receptors was used to determine off-site impact. Based on the completed consequence analysis for a battery enclosure on fire and the separation distances to off-site receptors, the effects from a battery enclosure fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products).</p> <p>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 completed consequence analysis for a battery enclosure on fire and the separation distances to off-site receptors, the effects from a battery enclosure fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products).</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 project.</p> <p>Based on the completed consequence analysis for a battery enclosure on fire and the separation distances to off-site receptors, the effects from a battery enclosure fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products).</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 |

9. CONCLUSIONS

9.1. Preliminary risk screening

A preliminary risk screening was completed in accordance with the *Applying SEPP 33* guideline to determine whether the project is considered as 'potentially hazardous' in the context of SEPP (Resilience and Hazards) 2021.

The preliminary risk screening found that:

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

9.2. PHA

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

The PHA was completed following the methodology specified in HIPAP No. 6 Hazard Analysis and the Multi-Level Risk Assessment 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 (i.e. serious injury due to heat radiation or irritation from toxic combustion products to off-site receptors).
- The proposed BESS meets the HIPAP No. 4 qualitative risk criteria.

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

- The concept layout has been designed including clearances specified by the OEM. Additionally, the Megapack 2 XL has been tested to UL 9540A and the results indicate that:
 - No flaming outside the initiating battery enclosure was observed.
 - No flying debris or explosive discharge of gases was observed.

- No external damage was observed to the initiating battery enclosure nor the target battery enclosures.
- The designated land area can accommodate the proposed BESS to meet the proposed capacity.
- In the event of a thermal runaway resulting in a battery enclosure on fire, fire escalation to adjacent battery enclosures is not expected based on the propagation characteristics determined from the UL 9540A test. In combination with the APZ, fire propagation is also not expected to affect onsite receptors.
- The nearest existing off-site receptor is the TAI, located approximately 43 m from the closest battery enclosure. Consequence analysis for a battery enclosure on fire indicates that the impact distances to serious injury from heat radiation and irritation from toxic combustion products are approximately 15 m and 23 m, respectively. Based on the separation distances to off-site receptors, serious injury due to heat radiation or irritation from toxic combustion products are not expected.

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

APPENDIX A. HAZID REGISTER

| ID | Hazard | BESS component/ infrastructure | Event | Cause | Consequence | Controls | Other Comments | Significant off-site Impact |
|----|------------|---|---------------------|--|---|--|---|-----------------------------|
| 1. | Electrical | Battery system MV transformers and switchgears HV connection asset | Exposure to voltage | <p><u>Short circuit/electrical connection failure</u></p> <ul style="list-style-type: none"> - Faulty equipment - Incorrect installation - Incorrect maintenance - Human error during maintenance - Safety device/circuit compromised - Battery casing/enclosure damage <p><u>Earth potential rise (exposure to step and touch potentials)</u></p> <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). <p>As there is a sufficient separation distance to the nearest existing off-site receptor to prevent touching live equipment, 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 - 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 MV transformers and switchgears 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 <p>Localised effects, 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 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 battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - BESS equipment fault detection and shut-off function - 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). | <p>Arc flash is an electrical explosion or discharge, which occurs between electrified conductors during a fault or short circuit condition, Ref [13].</p> <p>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.</p> <p>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.</p> | No |

| ID | Hazard | BESS component/ infrastructure | Event | Cause | Consequence | Controls | Other Comments | Significant off-site Impact |
|----|--------|--|--|---|--|--|---|-----------------------------------|
| 3. | Fire | Battery system | 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>Consequence analysis for a battery enclosure fire indicates that the impact distance is approximately 23 m. Off-site impacts are not expected based on separation distance to the existing off-site receptors.</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 - 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 battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - BESS equipment fault detection and shut-off function - BESS 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 there is a sufficient separation distance between the HV connection asset and the nearest existing off-site receptor (52 m to the TAI), 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 - Clearance requirement for transformers as per AS 2067 - To minimise fire escalation between the battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - Electrical switch-in & switch-out protocol - BESS 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>Off-site impacts are not expected based on separation distance to the existing off-site receptors</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 - To minimise fire escalation between the battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - BESS equipment fault detection and shut-off function - BESS explosion protection system (battery system specific features, refer to Table 2.1) | - | 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 - Injury and/or fatality to onsite employees <p>Consequence analysis for a battery enclosure fire indicates that the impact distance is approximately 23 m. Off-site impacts are not expected based on separation distance to the existing off-site receptors.</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 - To minimise fire escalation between the battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - Venting and containment requirements of the BESS manufacturer and FRNSW to be followed - Battery modules are enclosed within a sealed steel compartmentalised enclosure. Each compartment has the capacity to contain liquid from a large number of individual cells - Spill clean-up as per OEM instructions - BESS equipment fault detection and shut-off function - BESS 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>Consequence analysis for a battery enclosure fire indicates that the impact distance is approximately 23 m. Off-site impacts are not expected based on separation distance to the existing off-site receptors.</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 as per OEM instructions - To minimise fire escalation between the battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - BESS equipment fault detection and shut-off function - BESS 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>The refrigerant is R134a. Under conditions of high temperature and pressure, certain R134a/air mixtures are flammable.</p> <p>The Victorian Big Battery (VBB) fire occurred on 30 July 2021 and 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.</p> | No |
| 8. | Explosive Gas | Battery system | <p>Generation of explosive gas (e.g. hydrogen)</p> <p><u>Note:</u> also refer to above item (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>Consequence analysis for a battery enclosure fire indicates that the impact distance is approximately 23 m. Off-site impacts are not expected based on separation distance to the existing off-site receptors.</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 battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - Ventilation requirements as per manufacturer's instruction - BESS equipment fault detection and shut-off function - BESS 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 |
|-----|----------|--------------------------------|--|---|--|--|--|-----------------------------|
| 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>Consequence analysis for a battery enclosure fire indicates that the impact distance is approximately 23 m. Off-site impacts are not expected based on separation distance to the existing off-site receptors.</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 battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - BESS 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 process 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. Off-site impacts are not expected based on separation distance to off-site receptors.</p> | <ul style="list-style-type: none"> - Location siting and selection (i.e. separation distance to off-site receptors) - Optimising equipment layout and orientation - Reducing conductor spacing - Balancing phases and minimising residual current - Incidental shielding (i.e. battery 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 APPENDIX B for assessment. | <p>Adverse health effects from EMF have not been established based on findings of science reviews conducted by credible authorities, Ref [17].</p> <p>No established evidence that Extremely Low Frequency (ELF) EMF is associated with long term health effects (ARPANSA) , Ref [18].</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>Off-site impacts are not expected based on separation distance to the existing off-site receptors.</p> | <ul style="list-style-type: none"> - Location siting (i.e. outside of flood prone area) - The Megapack enclosure is IP 66 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 battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - BESS equipment fault detection and shut-off function - BESS 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 based on separation distance to existing off-site receptors.</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>Off-site impacts are not expected based on separation distance to the existing off-site receptors</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 battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards (refer to Section 6 for assessment) - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS) | - | No |

APPENDIX B. ELECTRIC AND MAGNETIC FIELDS

B1. 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 [17].

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

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

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

Use of electricity means that people are exposed to EMF as part of daily life. The background electric and magnetic fields in a typical home are around 20 V/m and 0.1 μ T, respectively. These may vary depending on the number and type of appliances, configuration and positioning, and distances to the other sources (e.g. powerlines). Typical EMF strengths for common household electrical appliances (at distance of 30 cm) are shown in Table B.1, Ref [19].

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 Australia⁹ as Extremely Low Frequency¹⁰ (ELF) EMF, Ref [17].

Table B.1: Typical EMF strengths for household appliances

| Electric appliance | Electric field strength (V/m) | Magnetic field density (μ T) |
|--------------------|-------------------------------|-----------------------------------|
| 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 |

⁹ Energy Networks Association is the peak national body representing gas distribution and electricity transmission and distribution businesses throughout Australia.

¹⁰ ELF EMF occupy the lower part of the electromagnetic spectrum in the frequency range 0-3000 Hz.

B2. Effects of exposure to EMF

B2.1. 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 [20].

B2.2. 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 [20].

B2.3. 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 [18].*
- *“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 [21].*

B3. 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 [22]. Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

B4. Guidelines for limiting EMF exposure

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

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

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

The ICNIRP reference levels for exposure to EMF at 50 Hz is presented in Table B.2, Ref [20]. The guideline adopted more stringent exposure restrictions compared to occupational exposures recognising that in many cases the general public are unaware of their exposure to EMF.

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

| Exposure | ICNIRP reference levels | |
|----------------|-------------------------|---------------------|
| | Electric field (V/m) | Magnetic field (µT) |
| General public | 5,000 | 200 |
| Occupational | 10,000 | 1,000 |

B5. BESS and grid connection infrastructure EMF

B5.1. BESS

The magnetic field associated with a BESS will vary depending on a number of factors including configuration, capacity and type of housing. Due to the limited information on typical measurement of magnetic fields around 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.

B5.2. PCS

Due to the limited EMF information available, this study assumed that EMF generated from PCS on a grid-scale BESS facility is not dissimilar to PCS 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 [23]. The field study findings were adopted to estimate the EMF measurements for the project's infrastructures. The findings are as follows:

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

B5.3. 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 μT at the fence, Ref [24].

B5.4. Underground transmission line

The magnetic field from transmission lines will vary with configuration, phasing and load. The typical magnetic fields near overhead transmission lines measured at one metre above ground level range between 1-20 μT (directly underneath) and 0.2-5 μT (at the edge of easement), Ref [24].

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 kV¹¹ underground transmission cable buried 1 m below ground are approximately 21-24 µT (directly above) and 2-3 µT (5 m from centreline), Ref [25].

B6. Controls to limit exposure to EMF

The following controls were identified to limit exposure to EMF:

- The design, selection and procurement of electrical equipment for the project will comply with relevant international and Australian standards.
- Location selection for the project infrastructure (i.e. accounts for separation distance to surrounding land uses including neighbouring properties and agricultural operations) and fencing within the project 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.

B7. Conclusion

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

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

¹¹ 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.

APPENDIX C. BATTERY ENCLOSURE FIRE IMPACT ESTIMATION

C1. Overview

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

- A battery enclosure on fire (e.g. propagated thermal runaway resulting in a fully developed fire).
- Toxic gas generation from decomposition of battery electrolyte due to fire.

Impact distances associated with heat radiation due to fire and dispersion of toxic gas were estimated to determine potential for off-site impacts to off-site receptors.

This appendix summarises the consequence modelling approach, input, assumptions, and results.

C2. Battery enclosure fire

C2.1. Modelling approach

Consequence modelling was undertaken based on the Stefan–Boltzmann correlation to analyse the heat transfer effect between two parallel planes, simulating a battery enclosure on fire and the heat radiation exposure to a receptor, as shown in Figure C.1. Distances to heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [26], were calculated.

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

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

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

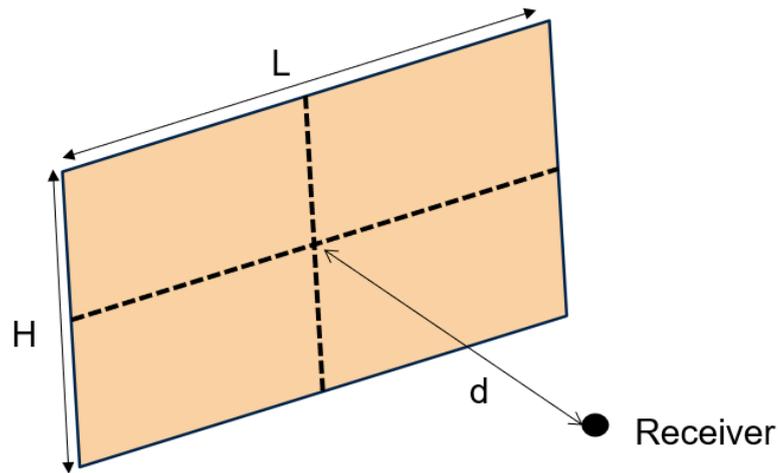
The heat flux received was estimated using the view factor method, where d is receiver distance to the battery enclosure on fire:

$$\phi = \frac{1}{2\pi} \left[\frac{a}{(1+a^2)^{1/2}} \tan^{-1} \frac{b}{(1+a^2)^{1/2}} + \frac{b}{(1+b^2)^{1/2}} \tan^{-1} \frac{a}{(1+b^2)^{1/2}} \right]$$
$$a = \frac{0.5 H}{d}, a = \frac{0.5 L}{d}$$

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

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

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



C2.2. Input and assumptions

The modelling input and assumptions used were as follows:

- The flame temperature of the emitting surface was set at 1000°C , which is value typical for lithium metallic fires, Ref [27].
- An emissivity value of 0.9 (a black body has an emissivity value of 1).
- Receptor height was set at 1.5 m.
- The heat radiation calculation was performed for the front aspect of the battery enclosure and assumed a full planar fire. This is conservative as the front aspect has the largest surface area and consequently highest heat radiation impact. This approach is deemed appropriate to determine off-site impacts.

C2.3. Heat radiation criteria

Consequences of various heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [26], are shown Table C.1. For this PHA, distances to 4.7 kW/m^2 (injury), 12.6 kW/m^2 (fatality), and 23 kW/m^2 (structural failure) were calculated.

Table C.1: Consequences of heat radiation

| Heat radiation (kW/m^2) | Effect |
|------------------------------------|---|
| 1.2 | Received from the sun at noon in summer |
| 2.1 | Minimum to cause pain after 1 minute |
| 4.7 | Will cause pain in 15-20 seconds and injury after 30 seconds' exposure (at least second degree burns will occur) |
| 12.6 | <ul style="list-style-type: none"> • Significant chance of fatality for extended exposure. High chance of injury |

| Heat radiation (kW/m ²) | Effect |
|-------------------------------------|---|
| | <ul style="list-style-type: none"> Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure |
| 23 | <ul style="list-style-type: none"> Likely fatality for extended exposure and chance of fatality for instantaneous exposure Spontaneous ignition of wood after long exposure Unprotected steel will reach thermal stress temperatures which can cause failure Pressure vessel needs to be relieved, or failure would occur |

C2.4. Results

The distances to the specified heat radiation levels are presented in Table C.2. Distance to the injury level (4.7 kW/m²) was used to determine potential for off-site impact, which is approximately 15 m.

Table C.2: Heat radiation impact – Battery enclosure on fire

| BESS | Size (W x D x H, m) | Surface T (°C) | Heat radiation at the eastern project boundary | Distance (m) at receptor height (1.5 m) to radiation levels | | |
|---------------------|---------------------|----------------|--|---|-----------------------------------|---|
| | | | | 4.7 kW/m ² (injury) | 12.6 kW/m ² (fatality) | 23 kW/m ² (structural failure) |
| Tesla Megapack 2 XL | 8.8 x 1.7 x 2.8 | 1000 | 0.4 kW/m ² | 15 | 9 | 6 |

C3. Dispersion of toxic gas

C3.1. Modelling approach

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

Consequence modelling was performed using the Gexcon EFFECTS v12.2 software (Plume Rise from Fire model) to simulate HF dispersion during a battery enclosure fire. The HF generation rate was based upon published experimental literature for LFP batteries. The downwind distances to the Acute Exposure Guideline Level (AEGL) concentrations for HF were determined.

C3.2. Input and assumptions

The modelling input and assumptions used were as follows:

- Hydrogen fluoride is considered the most toxic decomposition products from the batteries fire, Ref [28].
- A lithium-ion battery cell experiment, Ref [28], indicates that the HF quantity released from a 1 Wh battery varies between 20 mg and 200 mg, depending on the battery type and state of charge. As a conservative approach, generation rate of 200 kg per 1 MWh was adopted for the analysis. The HF generation rate was calculated based on the capacity a single battery enclosure and fire duration of 1 hour. The resulting HF generation rate used for analysis is conservative as typically the fire duration is longer than 1 hour.
- Release is continuous, with concentration averaging time of 60 minutes used for reporting.
- Surface roughness factor of 0.1 m was used (represents low crops and occasional large obstacles).
- The heat release rate from the battery (with 100% state of charge) is estimated to be 882 kW/m², Ref [29].
- The plume was assumed to be released from the top of the battery enclosure. This is viewed as a reasonable approach, based on observation from recent BESS fire incidents (e.g. Victoria Big Battery fire).
- Receptor height was set at 1.5 m
- Wind and weather stability conditions of D 5 m/s (D5) and F 2 m/s (F2) were used to represent typical day and night conditions, respectively.

C3.3. Dispersion criteria

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

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

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

Note: The AEGLs for HF are almost identical to the corresponding Emergency Response Planning Guideline (ERPG) levels that account for exposure for up to 60 minutes.

C3.4. Results

The distances to AEGL concentrations at receptor height of 1.5 m are presented in Table C.4. As a conservative approach, distance to the irritation level (AEGL-1) was used to determine potential for off-site impact, which is approximately 23 m.

Table C.4: Toxic dispersion impact (HF) – Battery enclosure on fire

| BESS | Capacity per unit (MWh) | HF generation rate (kg/s) | Heat release (kW/m ²) | Wind weather stability | Distance (m) at receptor height (1.5 m) to AEGL levels | | |
|---------------------|-------------------------|---------------------------|-----------------------------------|------------------------|--|-----------------|-------------------|
| | | | | | AEGL-1 (irritation) | AEGL-2 (injury) | AEGL-3 (fatality) |
| Tesla Megapack 2 XL | 3.854 | 0.21 | 882 | D5 | 23 | 10 | 7 |
| | | | | F2 | 3 | 2 | 2 |

APPENDIX D. HAZARD IMPACTS ON THE TAI

D1. Context

Following the EIS submission, NSW Department of Primary Industries – Agriculture (DPI Agriculture) requested that the potential for hazardous impacts (fire and exposure to EMF) on TAI staff and activities be advised. A response was prepared by Sherpa to address this request (21717-LET-001-Rev1 dated 15 February 2024).

An updated response is incorporated in this PHA to reflect the new BESS make and model (Tesla Megapack 2 XL) and inform the potential impacts on the TAI.

D2. BESS fire impact estimation

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

1. A battery enclosure on fire (e.g. propagated thermal runaway resulting in a fully developed fire).
2. Toxic gas generation from decomposition of battery electrolyte due to fire.

Impact distances associated with heat radiation due to fire and dispersion of toxic gas were estimated. The modelling approach, input, assumptions, and results are provided in APPENDIX C.

The analysis results with respect to impact on the TAI are as follows:

- A battery enclosure on fire: the heat radiation at receptor height of 1.5 m at the eastern project boundary is approximately 0.4 kW/m². This is considerably less than the injury threshold at 4.7 kW/m².
- Toxic gas dispersion: the distances to the injury (AEGL-2) and irritation (AEGL-1) levels at D5 condition are approximately 10 m and 23 m, respectively. For the plume rise from fire model, further downwind distance was observed at the D5 condition compared to F2 condition. As a conservative approach, the distance to the irritation level (AEGL-1) at D5 condition was used to determine potential impact to the TAI, i.e. 23 m.
- Based on the separation distance from the nearest battery enclosure to the closest TAI boundary (43 m), the effects from a battery enclosure fire are not expected to result in injury or irritation to the TAI staff standing on the boundary.
- A battery enclosure fire has the potential for escalation, affecting the entire BESS infrastructure. To minimise fire escalation between the battery enclosures and also onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the OEM and/or applicable standards.

D3. EMF exposure

Assessment of EMF exposure from the BESS and grid connection infrastructure is provided in APPENDIX B. The assessment included the BESS, Power Conversion System (PCS), HV connection asset, and the underground transmission lines.

The assessment found that:

- EMF created from the Calala BESS development will not exceed the International Commission on Non-Ionizing Radiation Protection (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. This includes the TAI, of which the closest site boundary is located 43 m from the nearest battery unit.

APPENDIX E. REFERENCES

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