Appendix M:
Preliminary Hazard Assessment

MENDHAM CONSULTANTS

Safety, Risk and Reliability Engineers

Peninsula Solar Power Station

Preliminary Hazard Analysis

Accent Environmental on behalf of Edify Energy

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Prepared by

Mendham Consultants Pty Ltd

PO Box 4113

Eight Mile Plains, QLD 4113

www.mendhamconsult.com

ABN 25 627 265 589

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Abbreviation	Description
AFARP	As Far as is Resonably Practicable
AS	Australian Standard
BESS	Battery Energy Storage System
DA	Development Application
DGs	Dangerous Goods
DPIE	Department of Planning, Infrastructure and Environment
FRNSW	Fire and Rescue New South Wales
HIPAP	Hazardous Industry Planning Advisory Paper
LoC	Loss of Containment
PHA	Preliminary Hazard Analysis
SEP	Surface Emissive Power
SEPP	State Environmental Planning Policy
SPS	Solar Power System
VCE	Vapour Cloud Explosions

Executive Summary

The following Preliminary Hazard Analysis (PHA) addresses the proposed Peninsula Solar Power Station (SPS) development at Paytens Bridge, 27km south-east of Forbes, New South Wales.

The SPS will consist of a solar farm and an associated Battery Energy Storage System (BESS) with power conversion systems having a capacity in the order of 80MW/160MWh, dependent on final inverter selection.

The proponent is yet to finalise procurement for key supply partners, as options exist for either a i) DC coupled solar plus storage system design (decentralised), or a more traditional ii) AC coupled solar plus storage system design (centralised). Both design options are under consideration.

The purpose of the subject PHA is to assist in the assessment of the proposed site to accommodate the proposed development in relation to off-site effects, such as fires and explosions and toxic or other harmful chemical effects and how the potential impact of such events, should they occur, can be managed with appropriate safeguards.

Based on the assessment, separation distances between BESS units and the project boundary and between separate BESS unit groupings have been determined. For each risk factor considered, the separation distances presented are worst case, as they assume no mitigation measures have been adopted to reduce risk.

As design progresses from conceptual to detailed, and technology selection is made, these separation distances will be able to be reduced substantially, if and as required, by adoption of appropriate mitigation measures. Future project hazard assessments will utilise the application of recognised standards and performance-based solutions to reduce separation distances to boundaries while achieving compliance with prescribed boundary conditions.

Separation due to fire risk

BESS units without specific fire protection or explosion suppression controls (whether Containerised or Modular) should be separated from the site boundary by approximately **25m** such that a radiant heat flux of 4.7kw/m^2 is not exceeded at the boundary. Where decreased separation distances to the boundary are required, fire and explosion risk reduction measures such as prescriptive or engineered solutions may be implemented.

In the absence of risk mitigation measures, a radiant heat flux of 12.6 kw/m^2 from an adjacent fire-involved BESS unit (based on external flames above the unit) leads to the estimation of a required separation distance of approximately **2.5m** between adjacent units (either Containerised or Modular). The number of BESS units allowed to be grouped such that they are at fire risk from adjacent units is at the discretion of the proponent in consultation with regulatory authorities.

To prevent heat transfer horizontally between adjacent BESS units (i.e., through the walls of the BESS units i.e., non-door side of Modular units or either side of containerised BESS units), if the risk of external flames above the unit has been appropriately mitigated, a separation distance of 15cm is required, as per UL9540A.

Separation due to overpressure

The recommended safe overpressure distance to the site boundary from a Containerised BESS unit or to any exposed person on site is approximately 25m unless suitable risk mitigation measures are adopted. Such measures include those that enable safe venting or prevention of explosion, or the use of fire protection systems that do not depend on a sealed room for extinguishment (e.g., water mist suppression).

The overpressure separation distance is comparable to or marginally less than the radiant heat flux separation distance. Therefore, a minimum of approximately **25m** separation distance to the boundary should be observed in the absence of mitigation measures.

If externally accessed BESS units are installed, a separation distance for blast overpressure is not considered to be required.

General recommendations

Some general recommendations for the project include the following: -

- Access to BESS units and static inverters should be restricted to competent trained employees. Contractors should be supervised.
- BESS and Static Inverter ventilation must be maintained in accordance with manufacturer specifications.
- Water has been shown to be the most effective extinguishing agent for BESS fires, as it provides both extinguishing and cooling, whereas gaseous suppression provides only extinguishing. Deep seated fires associated with Lithium-ion batteries have been known to cause a fire to reignite long after the gaseous system has discharged, and the gaseous agent has dispersed to atmosphere.
- Sufficient firefighting water should be made available for fire brigade responders via compliant hydrant and water supply systems.

1.0 Peninsula Solar Power Station

1.1 Introduction

Projects such as the proposed Peninsula Solar Power Station (SPS) require the development of a hazard analysis, which in its initial form is termed a Preliminary Hazard Analysis (PHA). A PHA is developed when the available information is in its preliminary stage being not fully developed.

1.2 Background

Edify Energy propose to construct the Peninsula Solar Power Station (SPS) at Lot 441 DP1124885, Lot 442 DP1124885, Lot 9 DP752938, Paytens Bridge, 27km south-east of Forbes, 2871, New South Wales.

The Peninsula SPS will consist of a solar farm and an associated Battery Energy Storage System (BESS) with power conversion systems having a capacity in the order of 80MW/160MWh, dependent on final inverter selection.

The proponent is yet to finalise procurement for key supply partners, as options exist for either a) a DC coupled solar plus storage system design or b) a more traditional AC coupled solar plus storage system design. Both design options are under consideration.

Figure 1 provides a site overview of the Peninsula SPS.

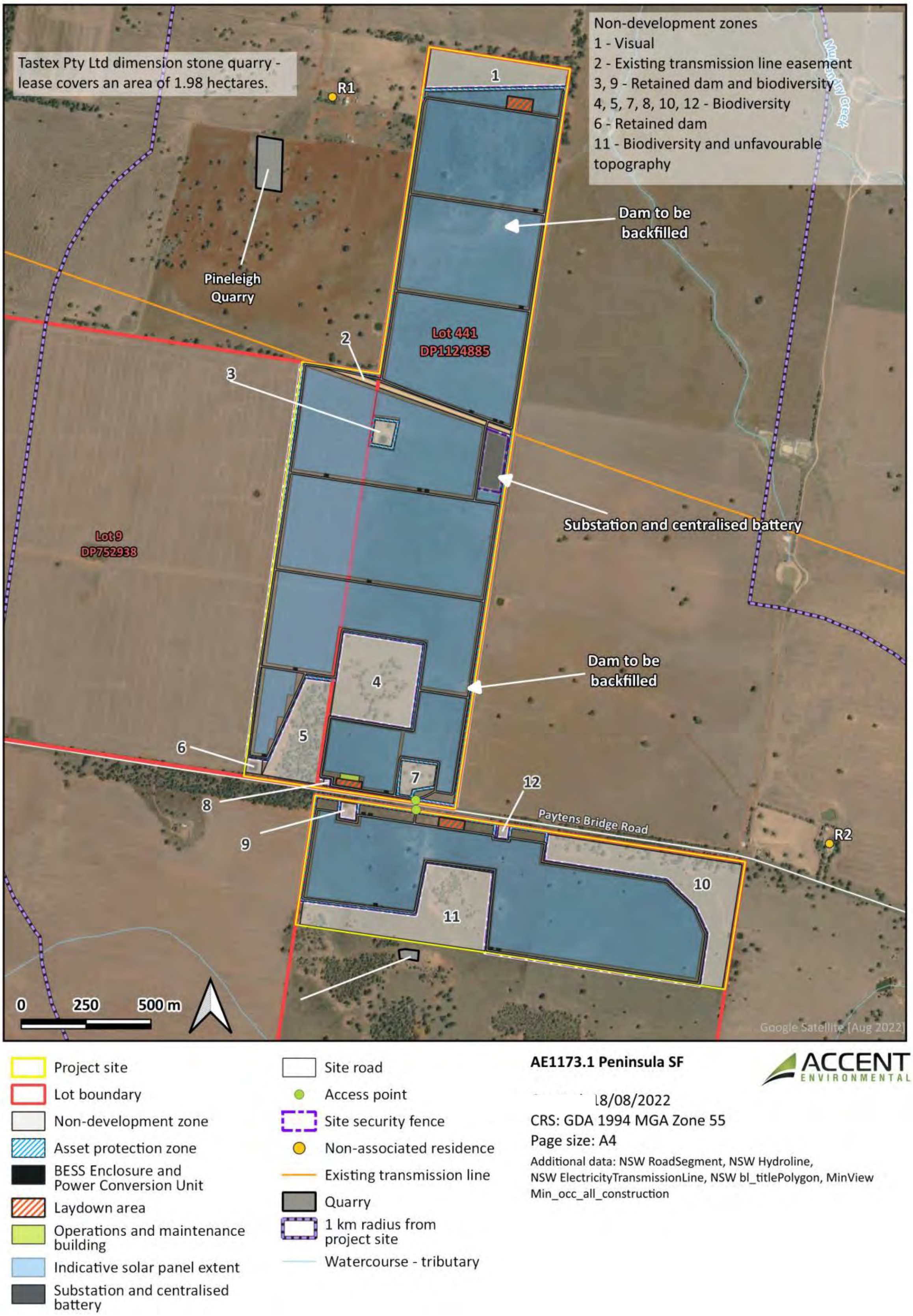

Figure 1: Peninsula Solar Power Station Site Overview (Figure from Accent Environmental)

1.3 Regulatory Framework

NSW government regulates the planning framework for the assessment and determination of State significant large-scale solar energy projects under the Environmental Planning and Assessment Act 1979 (EP&A Act) [1].

Under the EP&A Act [1] and the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP) [2], a solar energy project is State significant development if it is not permissible without consent and: -

1. Has a capital investment value of more than $30 million; or
2. Has a capital investment value of more than $10 million and is in an environmentally sensitive area of State significance.

Alternatively, under the EP&A Act [1], the Minister for Planning may, by way of an order, declare a specified development on specified land as State significant development. However, the Minister must first obtain and make publicly available advice from the Independent Planning Commission on the State or regional planning significance of the development.

As the project involves a grid connected BESS, in accordance with the State Environmental Planning Policy No.33 – Hazardous and Offensive Development (SEPP33) [3], a Preliminary Hazard Analysis (PHA) must be prepared in accordance with Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis [4] and Multi-Level Risk Assessment [5].

The proposed Peninsula SPS is subject to the above regulatory requirements.

1.4 Objectives and Relevant Issues

Hazards and risks associated with the Peninsula SPS project, are those addressed by the subject PHA.

Safety related hazards and risks considered in this PHA are those related to the construction, operation and decommissioning of the solar energy project, including hazardous materials (i.e., from battery storage and stored hazardous chemicals) and the associated threats of potentially hazardous materials (i.e. radiant heat, overpressure, electromagnetic field, stored chemicals, and toxic release).

1.5 SEARs Requirements

The Planning Secretary's Environmental Assessment Requirements (SEARs) for the project require an assessment of hazards including:

> *- a Preliminary Hazard Analysis (PHA) prepared in accordance with Hazardous Industry Planning Advisory Paper No. 6 – Guideline for Hazard Analysis (DoP, 2011) and Multi-Level Risk Assessment (DoP, 2011);*
>
> *- an assessment of potential hazards and risks including but not limited to bushfires, electromagnetic fields for the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields.*

2.0 Hazard Analysis Process

It should be noted that a distinction is made in this report between preliminary hazard analysis (PHA) and final hazard analysis (FHA). This PHA addresses the early stage of the Peninsula SPS project and is provided to assist with any required development application and with proponent decision making.

The current PHA is based on limited preliminary information, as complete data on the design and its associated safeguards are not currently available, however it is considered to be as comprehensive as the available information allows. It is envisaged that an outcome of this PHA will facilitate the ultimate selection of technology for the proposed site and will form a refining of the input to the later stages of the project development.

Note that SEPP33 [3] Threshold Screening Assessments are not required for the subject assessment.

2.1 Purpose

The purpose of the subject PHA is to assist in the assessment of the proposed site to accommodate the proposed development in relation to off-site effects, such as fires and explosions and toxic or other harmful chemical effects and how the potential impact of such events, should they occur, can be managed with appropriate safeguards.

Additionally, the development of SPSs using emerging technology must be well understood and allowed for by emergency services responders to facilitate their safe incident intervention. PHAs relating to SPS are useful in facilitating necessary pre-incident planning for the safety of our responders.

The purpose of this PHA is to consider the following: -

a) The nature and quantities of hazardous materials (and hazardous articles i.e., batteries) stored and used in process (i.e., BESS units) on the site;

b) The type of plant and equipment in use;

c) The adequacy of proposed technical, operational, and organisational safeguards;

d) The surrounding land uses or likely future land uses; and

e) The interactions of these factors.

This information is incorporated into the hazard analysis.

Figure 2 outlines the recommended hazards related assessment process (Refer HIPAP 6 [4]).

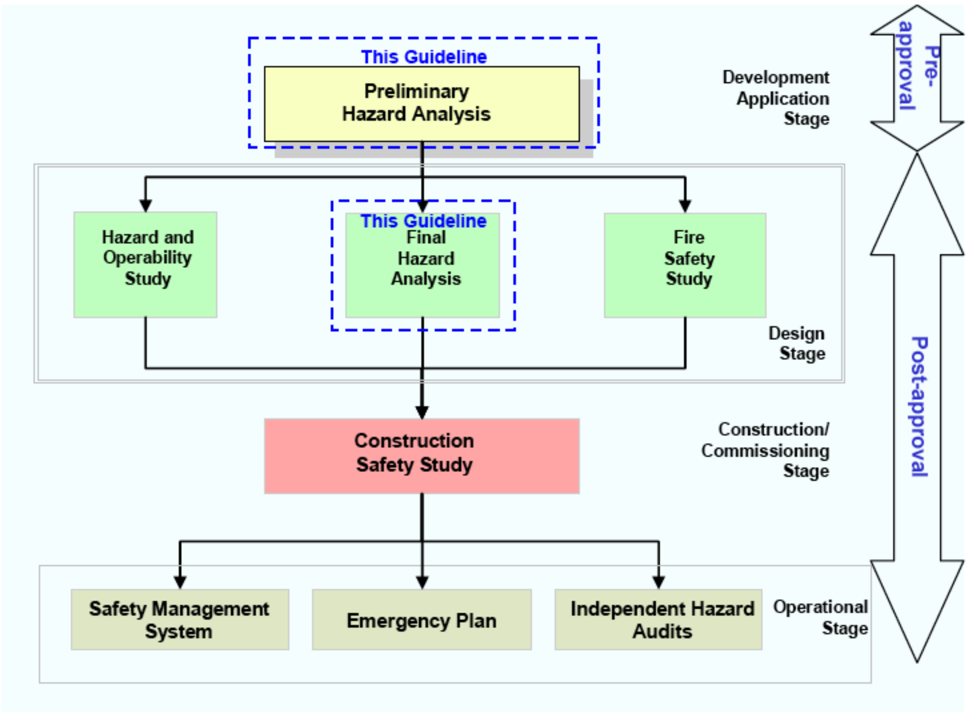

Figure 2: The hazards related assessment process (Refer HIPAP 6)

2.2 Identification of Hazards

A Hazard Identification (HAZID) process has been carried out as part of this PHA in order to ascertain all significant hazardous materials, hazardous equipment and related environmental hazards associated with the proposed Peninsula SPS.

'Appendix 1: HAZID' details and characterises the identified hazards associated with the project with a summary of the key hazards outlined below. These listed hazards are further addressed throughout this PHA to the extent necessary to meet the objectives of this document.

2.3 Energy Conversion Systems Hazards

Options exist for the proposed energy conversion systems that may be used at the Peninsula SPS.

2.3.1 Preliminary Option 1: DC Coupling

In Direct Current (DC) coupling, the co-located solar and energy storage assets share the same interconnection, are connected on the same DC bus, and use the same inverters. They are dispatched together as a single facility.

DC coupling reduces efficiency losses, which occur when electrical current is converted, such as from DC to AC. *(Refer: https://www.energy-storage.news/blogs/go-big-go-dc-an-in-depth-look-at-dc-coupled-solar-plus-storage)*.

2.3.2 Preliminary Option 2: AC Coupling

In Alternating Current (AC) coupled solar-plus-storage installations, the battery asset will be centralised and located adjacent to the substation. The BESS will comprise separate inverters from those of the photovoltaic array and for the Battery Energy Storage System (BESS).

With this system configuration, both the battery and solar array can be discharged at maximum power, and they can be dispatched independently or together, providing the operator with more flexibility in terms of how they operate and dispatch the asset. Located at the same site the solar array and energy storage facility can either share a single point of interconnection to the grid or have two separate interconnections.

2.3.3 Overview of Energy Conversion System Hazards

As noted above, in DC coupling, the co-located solar and energy storage assets share the same interconnection, are connected on the same DC bus, and typically use the same inverter. They are dispatched together as a single facility. DC coupling reduces efficiency losses, which occur when electrical current is converted, such as from DC to AC.

Static inverters are high energy conversion devices, which under normal operating conditions are reliable and represent a negligible hazard to exposed individuals or groups of individuals. Under failure conditions, safety controls, automatic shutdowns and fire/explosion containment/venting design features (where fitted) continue to limit the impact of failure to exposed individuals. Under conditions of rare catastrophic failure, fires may occur which may be contained by the design features of the inverter, controlled automatically using local fire suppression systems (if fitted), or controlled using fire brigade intervention. If there are no fire containment design features, inverter units are not adequately separated and fires are not controlled, fires may grow and spread.

Inverters are required in both DC coupling and AC coupling based systems. Typically, fewer inverters are used for DC coupled designs compared with AC coupled system designs as the batteries and photovoltaics can share inverters to some extent. As a result of this, it follows that the potential incidence of static inverter failure (catastrophic or otherwise) is reduced significantly for DC coupled configurations. Less inverters leads to less inverter failures, where the dependent inverter design is appropriately designed and fit for purpose.

2.4 Battery Energy Storage Systems (BESS) Hazards

2.4.1 BESS Design

BESSs are utilised to store the energy generated by the photovoltaic solar array/s located on the solar farm. Direct current is drawn from the charged battery source and subsequently inverted to alternating current and then supplied to the electricity grid.

Two (2) fundamental BESS designs are currently available and in use - each with specific associated hazards: -

2.4.2 Preliminary Option 3: BESS with External Access Only

Whilst the exact brand and type of external access BESS unit is undecided at this point for the Peninsula SPS, BESS units that is commonly utilised are shown in Figure 3 (two images provided in this figure are for illustrative purposes).

In the external access only configuration each BESS unit is typically one (1) large container size in volume and length and strategically located for maximum performance and lowest safety risk. Each container typically holds six (6) modules of lithium-ion (Li-Ion) batteries, one (1) customer interface bay and an inverter bay (where fitted). Refer to Figure 3.

1. Individually fused battery modules (active and passive) – externally serviceable
2. Touch-safe Customer Interface Bay
3. Externally serviceable inverter bay
4. Non-walk-in IP66 enclosure, with internal and external thermal insulation and deflagration mitigation
5. Thermal roof with overpressure vents

Figure 3: Externally Accessed BESS Units (From Accent Environmental provided data and from Tesla advertisement sources)

2.4.3 Preliminary Option 4: BESS with Internal Access Only

In this alternative configuration, batteries are installed in racks within a shipping container sized enclosure where access to the battery by workers is only from within the shipping container. In the internal access BESS units, the BESS and associated power conversion equipment are installed within the container enclosure. Refer Figure 4.

Figure 4: Internally Accessed BESS Units (From OSM marketing)

2.4.4 Overview of Battery Energy Storage System Hazards

BESS units are stored high energy systems that also typically incorporate high energy conversion systems (Refer Section 2.3), typically constructed within a single containerised package, as shown in Figures 3 and 4. Except for the unlikely event of a catastrophic failure and considering the physical placement of the BESS unit, BESS units may typically operate throughout their normal service life with very little risk to exposed persons and property located off site.

Minimum separation distances to BESS units from the SPS boundary are recommended to achieve attenuated effects of heat, toxic release and overpressure resulting from rare catastrophic failure events.

In terms of attendance to BESS units by emergency services during such an event, mitigations relating to radiant heat, toxic release and potential deflagrations involving overpressure exist and so must be understood and considered by responders as part of their response planning. Fire sources should be adequately separated from each other onsite so as to reduce the potential for fire spread. Fire Spread could result in higher risk intervention for firefighters and extended periods of release of products of combustion (i.e., radiant heat, overpressure, toxic release)

2.5 Other Hazards

Other hazards have been identified in the HAZID process (Refer Appendix 1), as follows: -

a) Flooding
b) Bushfire

c) Electric shock

d) Extreme weather events

e) Subsidence

f) Chemical loss of containment

g) Arson or theft

h) Lightning

i) Impact during construction, maintenance, or decommissioning

j) Manual handling incidents

2.6 Summary of Information to be Considered in the PHA

This PHA will provide the proponent with technical insight, which will be useful in implementing design actions that allow a safe and efficient configuration of the SPS and its components. Whilst the focus of a PHA is to assist in the assessment of the proposed site to accommodate the planned development in relation to off-site effects, it is also important in providing advice to emergency responders to achieve for safe intervention planning associated with on-site effects and to designers so as to facilitate such safety outcomes.

The implications of on-site emergency services intervention are essential to life safety; however, efficient and prompt emergency services fire intervention is also required for achieving successful asset loss control and business continuity, that may be considered important to the proponent and to the community.

For the purpose of hazard analysis, no fixed or first response fire protection or fire brigade intervention or emergency services response will be assumed to be present as part of the estimation of the initial potential impact assessment of the failure (i.e., fire size, explosion extent, toxic release, electrical incident, flooding etc).

Estimation of the effects of optional ‘risk controls’ will be provided as part of this PHA in terms of their implementation effect on the estimated the final risk level (i.e., residual risk), subsequent to their implementation.

3.0 Preliminary Hazard Analysis (PHA)

3.1 Aim

A Preliminary Hazardous Analysis (PHA) is provided in this report to address: -

1. Identifying all potential hazards associated with the proposal;
2. Analysing both their consequences (effects) on people and the environment, and their probability (likelihood or frequency) of occurrence;
3. Estimating the resultant risk to the surrounding land uses and environment; and
4. Ensuring that the proposed safeguards are adequate, and thus demonstrate that the operation will not impose a level of risk which is intolerable with respect to its surroundings.

3.2 Site Description

The proposed SPS is to be situated at Lot 441 DP1124885, Lot 442 DP1124885, Lot 9 DP752938 in Paytens Bridge which is approximately 27km south-east of Forbes, 2871, New South Wales. Limited native vegetation exists as the area has been extensively cropped and grazed over a long period of time. There are no native forests, rainforests, woodlands, wetlands, heathlands or shrublands. Refer Figure 5.

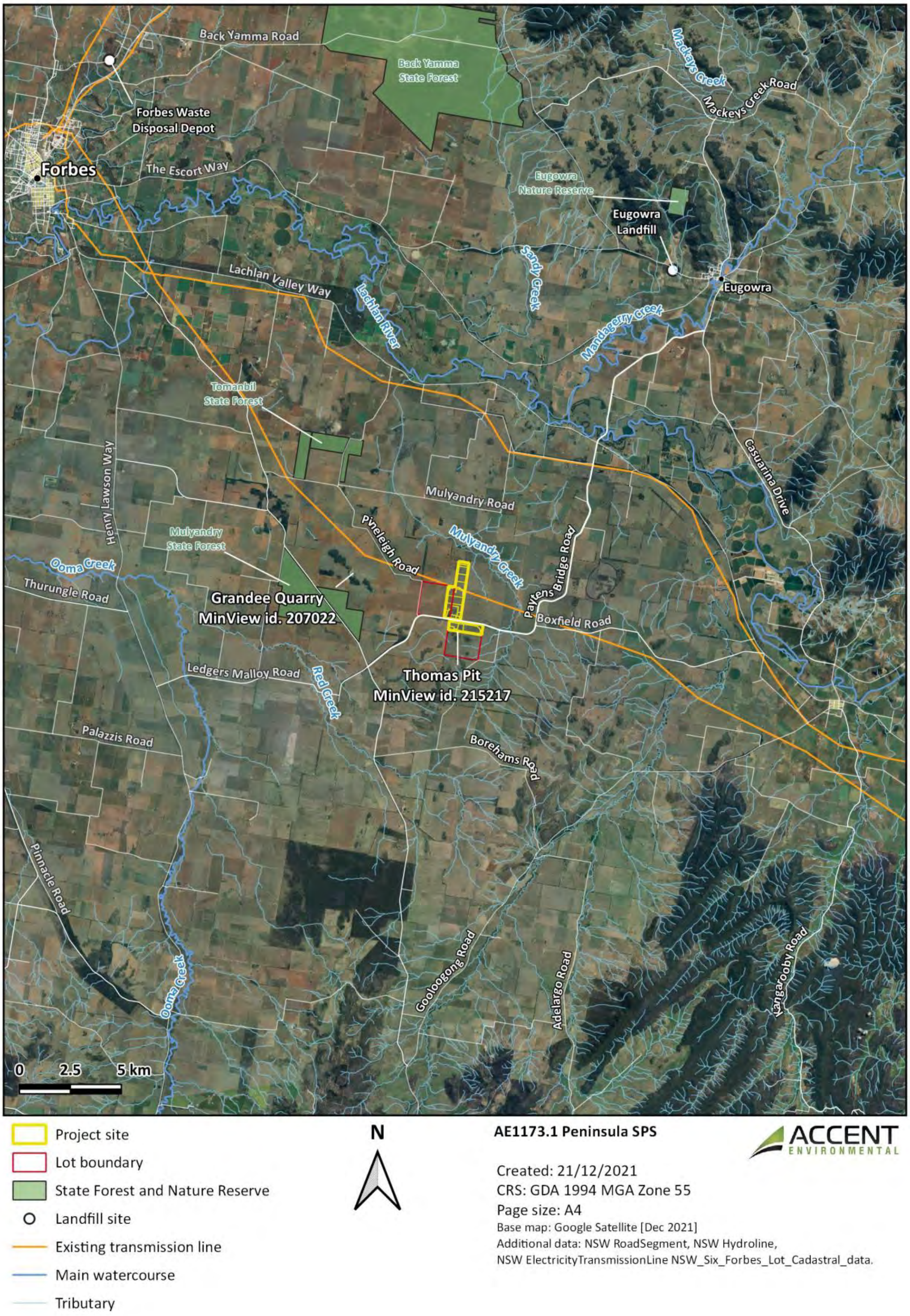

Figure 5: Peninsula SPS Site Overview (Figure from Accent Environmental)

3.3 Occupancy

During construction, up to 250 workers will be present carrying out a range of activities from surveying to earthworks, fabrication and commissioning. Subsequent to commissioning, site attendance will significantly reduce to scheduled maintenance activities with occasional reactive maintenance activities. It is likely that up to five (5) full time jobs would be created when operational with approximately two (2) full time staff based on site (16 hrs x 52 weeks = 832 exposed person hours per year).

These exposure rates will vary depending on the final type of technology selected, however should be used as a guide to occupancy fort the PHA assessment.

3.4 Adjacent Land Uses

Adjacent farming land is utilised for grazing and cropping.

3.5 Surrounding Environment

Most of the project site is flat with low hills present towards the southern section of the site (south of Paytens Bridge Road) and a single low hill in the southern part of the northern section of the site (north of Paytens Bridge Road). There are no defined natural waterways across the site. Mulyandry Creek is located to the east and north of the project site (within approximately 600 m at its closest point), within the catchment of the Lachlan River which is located approximately 9 km to the north.

The three large paddocks on which the project site is located are largely cleared and cultivated for agricultural purposes. Native vegetation is found in a number of locations within and next to the site, particularly within the southern section of the site. However, little vegetation clearance will be required.

3.6 Project Environmental Impacts

The construction of the proposed SPS may have potential impacts regarding native vegetation habitat clearance (albeit minor), fauna disturbance and weed invasion.

Potential impacts upon watercourses and hydrology, particularly during construction of the project, include the erosion of soil and sedimentation through stormwater runoff, the accidental release of hydrocarbons or other chemicals by inappropriate storage, use and disposal of chemicals and contamination from effluent and putrescibles.

With respect to noise impacts, there are one associated and four non-associated receivers, and one industry (rock quarry) identified within 2km of the site. Noise impacts will be associated with vehicles and machinery during construction and the operation of the substation and BESS units during operation.

3.7 Description of Dangerous Goods Stored and Handled

Minor storage volumes (i.e., in accordance with applicable Australian dangerous goods standards including AS1940 [6] etc) of hazardous chemicals will be stored on site for the purposes of maintenance, pest and weed control activities and for portable fire pumps used for bushfire management. All chemicals are proposed to be stored in Chemical Storage Cabinets. Chemicals to be stored providing compliant separation from 'Protected Places' and required segregation for incompatible hazardous chemicals.

Clause 1.4.5.6 of Standard AS1940 defines a protected place as:

> *Any of the following:*
>
> *(a) A dwelling, residential building, place of worship, public building, school or college, hospital, theatre, and any building or open area in which persons are accustomed to assemble whether it is within or outside the property boundary of the installation.*
>
> *(b) A factory, workshop, office, store, warehouse, shop, or building where persons are employed, that is outside the property boundary of the installation.*
>
> *(c) A ship lying at permanent berthing facilities.*
>
> *(d) Any storage facility for dangerous goods outside the property boundary of the installation, except for those defined as minor storages in this or other Standards or regulations."*[6]

3.8 Dangerous Goods Inventory

The proposed hazardous chemicals (including hazardous articles) and volumes to be stored on site include: -

a) Diesel – up to 2500 L stored in double walled 'Cube' tank or similar.

b) Machine oils – approximately 100 L stored in a Flammable Liquids Storage Cabinet.

c) Lubricants – approximately 100 L stored in a Flammable Liquids Storage Cabinet.

d) Hydraulic fluid – approximately 100 L stored in a Flammable Liquids Storage Cabinet.

e) Herbicides – approximately 100 L stored in a Miscellaneous Dangerous Goods (Class 9) Storage Cabinet.

f) Lithium-ion batteries – approximately 102 inverters and 17 power stations at approximately 13 tonnes each.

3.9 Risk Analysis and Assessment Process

The risk analysis and assessment process undertaken utilises a qualitative (Level 1) approach whereby a HAZID table is developed, and from this, credible risk scenarios are identified and analysed (See Appendix 1: HAZID and Risk Assessment).

Where the initial level of risk does not exceed an estimated 'Low' level (Refer to Table 1), that is where the risk is considered to be managed to an extent that is low As Far As is Reasonably Practicable (AFARP), no further action is required.

Where the risk exceeds a level that is low AFARP, further analysis (i.e., radiant heat analysis, overpressure estimation) is undertaken so as to quantify additional risk controls (mitigations) that can be suggested to the proponent for implementation to subsequently achieve a residual risk level that is low AFARP.

3.10 Hazard Identification Table and Risk Register

A summary of hazards and risk identified (Refer Table 1), as detailed in Appendix 1, is as follows: -

Table 1: Hazards and Risks

Hazard	Risk	Additional Controls Recommended	Initial Risk Level	Residual Risk Level
Flooding	Plant Outage – No Offsite Risks	Nil	Low (AFARP)	NA
Bushfire	Radiant heat or ember attack causing damage to assets - No Offsite Risks	Nil	Low (AFARP)	NA
Electric Shock	Injury to worker - No Offsite Risks	Nil	Low (AFARP)	NA
Extreme Weather Events	Damage to infrastructure from very strong wind - No Offsite Risks	Nil	Low (AFARP)	NA
Subsidence	SPS outage - No Offsite Risks	Nil	Low (AFARP)	NA
Subsidence	Plant Outage and potential damage to assets – No Offsite Risks	Nil	Low (AFARP)	NA
Hazardous Chemical Loss of Containment	Potential for environmental and safety impacts – No offsite effects	Yes	Moderate	Low (AFARP)
Arson/theft	Arsonists start fire	Yes	Moderate	Low (AFARP)
Lightning	Lightning starts fire	Yes	Moderate	Low (AFARP)
Vehicular or access equipment impact during construction, commissioning,	Impact starts fire	Yes	Moderate	Low (AFARP)

Hazard	Risk	Additional Controls Recommended	Initial Risk Level	Residual Risk Level
maintenance, or decommissioning				
Manual handling incidents	Loss of Containment (LoC) of Battery Contents	Nil	Low (AFARP)	NA
BESS or Static Inverter Fire (Localised)	Equipment failure starts fire	Yes	Moderate	Low (AFARP)
BESS or Static Inverter Fire (Beyond unit of origin)	Equipment failure starts fire	Yes	Moderate	Low (AFARP)
BESS Explosion	Equipment failure causes overpressure	Yes	Moderate	Low (AFARP)
BESS Toxic Release	Equipment failure causes toxic gas/vapour release	Yes	Moderate	Low (AFARP)

3.11 Hazard Properties and Impacts

3.11.1 Hazards Relating to High Energy Systems and Dangerous Goods

Fires: Both BESS units and high-power inverters are subject to fires, as noted from a recent BESS fire event in Victoria [13].

Whilst high power inverter fires alone are not seen as a cause of offsite effects, an inverter fire could initiate a fire in an adjacent BESS unit if located close enough to cause fire spread.

Fires represent a range of hazards both on-site and off-site, particularly in relation to exposure to individuals or groups to radiant heat, overpressure from explosions caused by flammable vapour deflagrations and the release of toxic products of combustion, which have the propensity to migrate off site.

A number of BESS suppliers advertise a range of systems which are demonstrated (e.g., through certification against UL9540A) to mitigate the impacts of fire events. While fires can occur in a BESS, a notable example of a fire during commissioning [9] demonstrates that even with just moderate intervention from firefighters (who only implemented measures to stop the spread of the fire), the fire only spread to a single adjacent battery module, even after burning for four days. Information on recent BESS fires are important to this PHA, as it is tangible evidence that may be used to estimate the effects of such fires in terms of radiant heat and the likelihood of fire spreading between battery units.

Overpressure: There are no current reports of overpressure (explosions) from BESS units utilised in utility grid capacity to estimate the effects of installations in Australia, or from static inverter systems similarly deployed in such installations.

There is no evidence to show that explosive conditions may form externally to a BESS unit, which indicates that Vapour Cloud Explosions (VCE) are not likely to occur outside the BESS unit. This is likely due to the rapid dispersion in outside air of the flammable vapour and gases from a battery fault discharge with the subsequent flammable mixture dispersing outside the BESS below its Lower Explosive Limit (LEL). This is not likely to be the case with an internally accessed BESS unit.

Overpressure explosion venting of hot gases in internally accessed BESS units is preferred such that their exhaust is directed away from attending personnel (i.e., through the roof using explosion protection/venting systems).

Controls that should be considered by the proponent and assessor in relation to the management of potential overpressure (i.e., explosions) include utilising BESS units that discharge fault related flammable gases directly to atmosphere and a preference for externally accessed BESS units so that workers are not exposed to sudden catastrophic explosions as part of gaining access to the interior of the BESS unit.

It is also noted that internally accessed BESS system gaseous fire suppression systems may be compromised due to the gaseous agent being expelled from the space. This is due to the formation of pressurised battery fault gases developed within the container. Considerations are needed as part of the fire protection design through appropriate venting or the use of fire protection systems that do not depend on a sealed room for extinguishment (e.g. water mist suppression).

Toxic Release: Significantly harmful products of combustion (PoC) may eventuate from BESS failure. Typical PoC include gases from the deflagration of lithium hexafluorophosphate (LiPF), a common electrolyte in batteries, as shown in Table 2).

Table 2: Typical BESS LiPF electrolyte gas composition in relation to deflagration [10]

Compound	Mass %
Ethylene	64%
Carbon Monoxide	34.5%
Ethane	0.8%
Carbon Dioxide	0.4%
Methane	0.3%

During the 2021 Victorian BESS fire event [7], authorities recommended that nearby local community members stay within their homes and lock windows and doors due to the release of potentially toxic smoke. A smoke haze was seen up to several kilometres from the incident, however, according to Energy Safe Victoria [9], traces of toxic gas emissions were not evident.

3.11.2 Hazards Relating to External Events

Some external events have the propensity to impact on SPS components, including BESS and high energy conversion plant.

Weather events including flooding, high wind, subsidence, bushfire etc typically lead to outages of the SPS due to their disruptive effect on system performance, such as effects on electrical connections etc leading to automatic shutdown of systems.

The risk assessment of all external hazards identified indicate that safety related offsite impacts are unlikely to occur.

3.11.3 Injury and Property Impacts (Offsite/Onsite)

Injury and property impacts are based on HIPAP 6 guidance [4], as follows: -

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 result)
12.6	Significant chance of fatality for extended exposure. High chance of injury After long exposure, causes the temperature of wood to rise to a point where it can be readily ignited by a naked flame Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.
23	Likely fatality for extended exposure and chance of fatality for instantaneous exposure Spontaneous ignition of wood after long exposure Unprotected steel will reach thermal stress temperatures which can cause failures Pressure vessel needs to be relieved or failure will occur
35	Cellulosic material will pilot ignite within one minute's exposure Significant chance of fatality for people exposed instantaneously

Figure 6: Effects of Heat Radiation

Explosion Overpressure	Effect
3.5 kPa (0.5 psi)	90% glass breakage No fatality and very low probability of injury from overpressure.
7 kPa (1 psi)	Damage to internal partitions and joinery, but can be repaired Probability of injury is 10%. No fatality
14 kPa (2 psi)	House uninhabitable and badly cracked
21 kPa (3 psi)	Reinforced structures distort Storage tanks fail 20% chance of fatality to a person in a building
35 kPa (5 psi)	House damaged beyond repair Wagons and plant items overturned Threshold of eardrum damage 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open
70 kPa (10 psi)	Threshold of lung damage 100% chance of fatality for a person in a building or in the open Complete demolition of houses

Figure 7: Effects of Overpressure

3.11.4 Environmental Impacts (Offsite/Onsite)

Environmental impacts are based on HIPAP 6 guidance [4], as follows: -

The effect of a release of SPS hazardous chemicals or PoC on the environment are dependent on a range of factors. Some of these factors include: -

a) The quantity and nature of materials released;

b) The environmental pathways by which the contaminant may be transported;

c) The fate of the contaminant in the environment;

d) The concentration of the contaminant in the environment; and

e) The species and populations at risk.

Isolation of fugitive emissions from the environment reduces environmental stress. The assessment of the impact of fugacity (i.e., effective partial pressure, for a measure of chemical potential) is quite complex and is site specific.

3.12 Identified Hazards Location Diagram

The specific details of the location of the BESS units and associated power conversion equipment are as yet, undefined.

Traditionally, a centralised location for SPS plant items (BESS units etc) is employed where the BESS and Inverters are located centrally on the SPS site, and adjacent to the project's substation. A centralised BESS inherently provides significant separation distance between boundaries to neighbouring property, but may have increased risk of fire spread. Decentralised BESSs have BESS units distributed around the site in BESS unit groupings (a number of BESS units grouped together in a single location).

Under catastrophic failure conditions, units in a centralised BESS, or decentralised BESS unit groupings, need to be readily accessible by emergency responders. BESSs proposed in NSW would need to meet the access requirements of Fire and Rescue NSW as a condition of approval.

Figure 8 shows a schematic of a DC Coupled BESS unit grouping surrounded by solar panels, as part of a decentralised BESS.

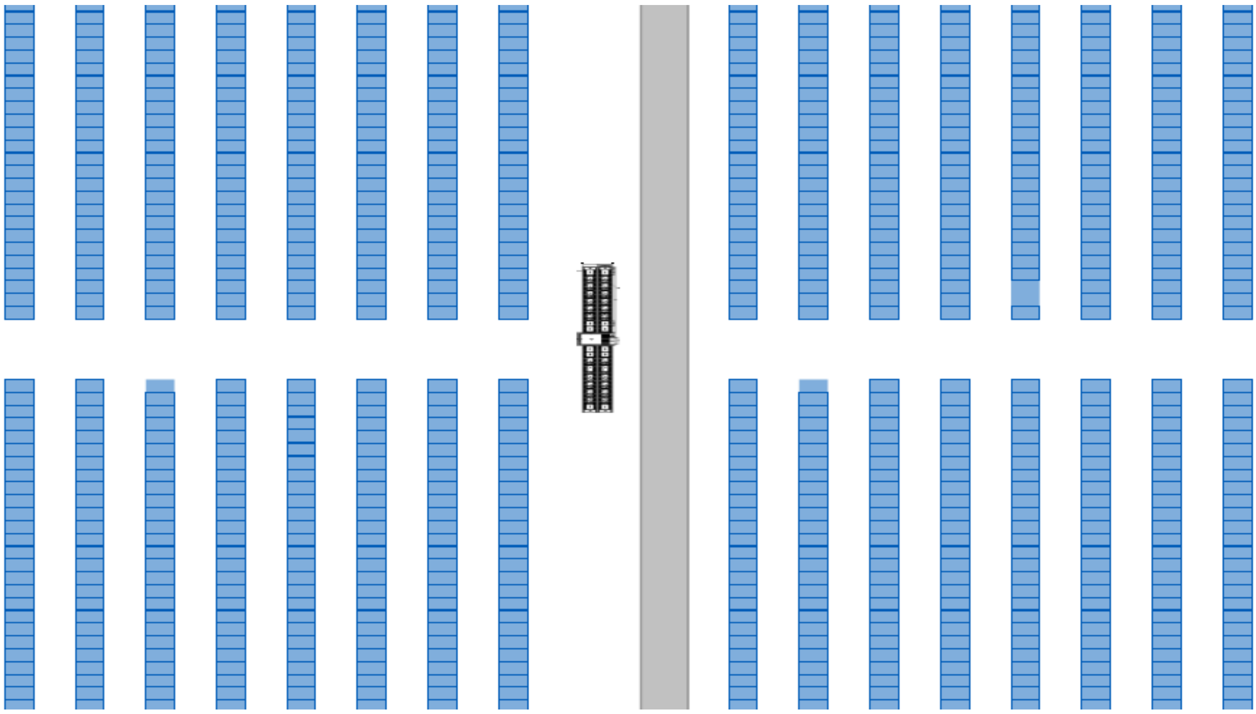

Figure 8: DC Coupled configuration showing BESS unit grouping in decentralised BESS

3.13 Estimation of Consequences of Incidents Carried Over for Further Analysis

3.13.1 Credible Event Scenarios

The following credible scenarios have been considered based on HIPAP 6 [4] requirements. In accordance with HIPAP 6, this initial assessment assumes that no specific risk controls have been incorporated into the design of the BESS unit.

Table 3: Credible Event Scenarios

Consequence	Scenario	Assumed Existing Control	Impact
BESS / Static Inverter Fire	Cell failure causing spread within BESS enclosure - potential for off-site effects (Injury) NOTE: this scenario represents 1 BESS unit on fire.	Nil	Potential radiant heat exposure exceeding 4.7kw/m^2 to persons located at boundary, based on HIPAP 6 [4]: "The suggested injury risk criterion for heat radiation is: • Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7kw/m^2 at a frequency of more than 50 chances in a million per year." [11]
BESS / Static Inverter Fire	Spread of fire beyond BESS of origin - Potential for off-site effects NOTE: this scenario represents more than 1 BESS unit on fire.	Nil	Potential radiant heat exposure exceeding 4.7kw/m^2 to persons located at boundary, based on HIPAP 6 [4]: "The suggested injury risk criterion for heat radiation is: • Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7kw/m^2 at a frequency of more than 50 chances in a million per year." [11]

Consequence	Scenario	Assumed Existing Control	Impact
BESS Explosion	Cell/s failure causing high gas discharge overpressure from BESS - Potential for off-site effects NOTE: this scenario represents an explosion involving 1 BESS.	Intrinsic overpressure attenuation associated with the BESS enclosure.	Potential explosion overpressure exposure exceeding 7kPa to persons located at boundary, based on HIPAP 6 [4]: "The suggested injury/damage risk criterion for explosion overpressure is: • Incident explosion overpressure at residential and sensitive use areas should not exceed 7kPa at frequencies of more than 50 chances in a million per year" [11]
BESS Fire	Toxic release - potential for off-site effects (Injury) NOTE: this scenario represents 1 or more BESS unit on fire causing potentially toxic release.	Nil	"The suggested injury risk criteria for toxic gas/ smoke / dust exposure are: • Toxic concentrations in residential and sensitive use areas should not exceed a level which would seriously injurious to sensitive members of the community following a relatively short period of exposure at a maximum frequency of 10 in a million per year. • Toxic concentrations in residential and sensitive use areas should not cause irritations to eye or throat, coughing or other acute physiological responses in sensitive members of the community over a maximum frequency of 50 in a million per year." [11]

3.13.2 Incidents Carried Over for Further Analysis

The following incidents exhibit potential offsite impacts and are carried over for further analysis: -

Table 4: Incidents Carried Over for Further Analysis

Incident	Impact
BESS Fire	A fire involving one (1) BESS unit potentially leading to an off-site injury
BESS Explosion	An explosion involving one (1) BESS unit potentially leading to an off-site injury.

3.13.3 Consequence Factors

Exceeding the following consequence factors is considered unacceptable: -

Table 5: Consequence Factors

Consequence	Within Boundary (On site)	At Boundary (Off site)
Radiant Heat at target	12.6 kw/m^2	4.7 kw/m^2
Overpressure	7 kPa	3.5 kPa

3.14 Probability Analysis

3.14.1 Event Probability Analysis – Event A: Radiant Heat Exposure

Fire spread between BESS units can occur as a result of received radiant heat from a fire involved BESS unit to an adjacent non-fire involved BESS unit.

The quantity of fire involved BESS units impacts on the release of potentially toxic substances into the atmosphere and the ability of fire responders to control and extinguish the fully developed fire involving the acceptable quantity of BESS units. Factors, such as firefighting water supply, safe separation distances for fire fighters and appliance access are affected by the fire size, which is a consequence of the total number BESS units involved in a fire.

The purpose of assessing the extent of radiant heat transfer between a fire affected BESS unit and one (1) or more adjacent BESS units, is to estimate the number of BESS units likely to be involved in a fire.

The tolerable number of BESS units that may be involved in a fire event is subject to both agreement with fire and emergency authorities and the proponent's appetite for loss of assets and business continuity.

A review of images of a contemporary BESS fire [7] indicates that the height of the flames combined with the flame and smoke plume are approximately the width of the BESS and approximately 50% of the container height above the BESS unit.

The flames/smoke plume observed from the review of images of the contemporary BESS fire [7] were noted as being orange flames and having a grey smoke plume. This was likely due to the deflagration's involvement of a significant concentration of flammable gas, perhaps developed under battery venting conditions due to thermal runaway.

Later stages of fire typically result in black smoke and red coloured flames resulting from the combustion of carbonaceous products leading to cooler flame conditions.

This PHA assesses worst case radiant heat conditions, which in this case, involves the early stage combustion of released flammable gas.

As adjacent BESS units are typically located nearby each other, and they are located at the same height (i.e., positioned on the same ground surface) a fire in one BESS unit may cause the adjacent BESS unit to be affected by radiant heat.

12.6 kw/m^2 heat flux level is considered the maximum threshold value of the exposed adjacent BESS unit, as nominated in HIPAP 6 [4] and 3.15 of this PHA. An estimate of the required separation distance between any two (2) units is therefore required such that the radiant heat flux level on the adjacent unaffected BESS is less than 12.6 kw/m^2.

Further to the above assessment, targets at the boundary of the proposed facility are not permitted to be exposed to a radiant heat flux exceeding 4.7 kw/m^2.

An estimate of the required separation distance between a fire affected BESS Unit and the SPS boundary is necessary to ensure a maximum threshold of 4.7 kw/m^2 is not exceeded.

Figure 9 displays approximate BESS dimensions and associated estimate of fire plume dimensions based on a review of images of a contemporary BESS fire [7].

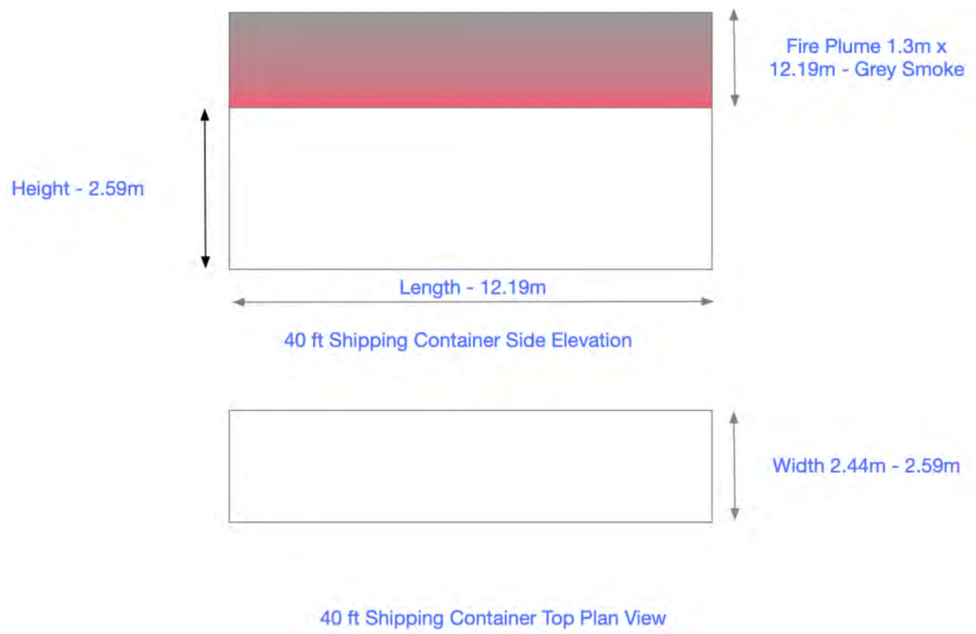

Figure 9: Estimated Fire Plume Dimensions

Radiant Heat Exposure – BESS @ 12.6 kw/m^2

An estimate of the distance from fire source to where an adjacent BESS unit receives 12.6 kw/m^2 radiant heat flux is assessed.

Plume temperature and plume colour are significant inputs to the radiation assessment.

The plume colour appears to be grey, as noted from a review of images of a contemporary BESS fire [7] however significant flames exist, indicating well ventilated combustion of flammable gas, so temperature of the flame plume is estimated to be between 900 Deg C and 1500 Deg C.

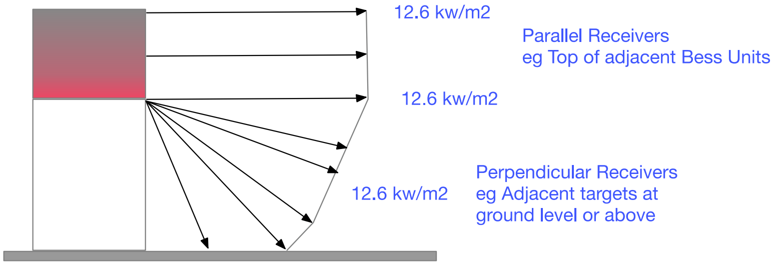

Figure 10: Radiant Heat Exposure

Distance from BESS fire to a perpendicular receiver at the same height as the roof of the fire affected BESS (i.e., the fire plume is at a greater height than the roof of the adjacent BESS unit), is estimated using a plume temperature of 1200 Deg C, as follows: -

Radiation to Perpendicular Receiver

Fire Engineering Design Guide, Third Edition

Inputs

T	Temperature of radiator	1200	°C
ε	Emissivity	0.8	
a_1	Width of Area 1 (A_1)	1.3	m
b_1	Height of Area 1 (A_1)	12.9	m
a_2	Width of gap to boundary	0	m
c	Distance to receiver	2.40	m
k_1	Radiation reduction factor	1	

where:
1 Radiation through opening (glass breaks)
0.5 Radiation through fire resistant glazing (e.g. -/60/-)

Parameters

σ	Stefan-Boltzmann constant	5.67E-11	kW/m^2K^4

Calculations

Area 1	
A =	2.36
X =	0.20
Y =	0.37
Configuration Factor for Area 1 =	0.0295
2 x Configuration Factor for Area 1 =	0.0590
Area 2	
A =	2.69
X =	0.00
Y =	0.37
Configuration Factor for Area 2 =	0.0000
2 x Configuration Factor for Area 2 =	0.0000

Output Results

Configuration factor to receiver	0.0590	
Radiation emitted	213.54	kW/m^2
Maximum radiation along boundary	98.57	kW/m^2
Distance from emitter at max.	0.10	m (to nearest 0.1 m)
Radiation received at distance 'c'	**12.60**	**kW/m^2**

The recommended minimum separation distance assuming no mitigation measures have been adopted to reduce risk between BESS units is **2.4m.**

Radiant Heat Exposure – BESS @ **4.7 kw/m^2**

An estimate of the distance from fire source to a target at ground level (i.e., a standing human) where it receives 4.7 kw/m^2 radiant heat flux is assessed.

Plume temperature and plume colour are significant inputs to the radiation assessment.

The plume colour appears to be grey, as noted from a review of images of a contemporary BESS fire [7], however significant flames exist, indicating well ventilated combustion of flammable gas, so temperature of the flame plume is estimated to be between 900 Deg C and 1500 Deg C.

Distance from BESS fire, where flames are emanating from the side walls and roof of the BESS unit to a parallel receiver using a mean plume temperature of 1200 Deg C, as follows: -

Radiation to Parallel Receiver

Fire Engineering Design Guide, Third Edition

Inputs

Te	Temperature of radiator	1200	°C
Tr	Temperature of receiver	25	°C
ε	Emissivity of radiator	0.80	
a	Width of radiator body	12.9	m
b	Height of radiator body	3.7	m
c	Distance between radiator and receiver	25.7	m

Parameters

σ	Stefan-Boltzmann constant	5.67E-11	kW/m^2K^4

Calculations

X = 0.2510

Y = 0.0720

ϕ Configuration factor 0.0220

Output Results

Radiation emitted	**213.18**	**kW/m^2**
Radiation received	**4.69**	**kW/m^2**

The recommended minimum separation distance from BESS units to the boundary or to exposed humans on site during a BESS fire, assuming no mitigation measures have been adopted to reduce risk, is **25.7m** (rounded to approximately **25 m** to reflect that this is a PHA).

3.14.2 Event Probability Analysis – Event B: Overpressure Exposure

Reviewed information indicates that predominantly Internally accessed BESS units are capable of developing an explosive mixture within the containerised envelope, potentially leading to an explosion.

Externally accessed (Modular) BESS units are typically designed such that they vent explosive gases directly to atmosphere under fault conditions. More recent contemporary designs from a number of BESS suppliers utilise a system that continually discharges sparks into an exhaust flue so as to safely ignite and eliminate any developed flammable gases. This control is not considered in this assessment; however, it is generally assumed in this PHA that externally accessed BESS units are not subject to exterior Vapour Cloud Explosions (VCEs) due to the likely rapid dilution below the Lower Explosive Limit (LEL) of exhausted flammable gases (i.e., albeit they may become involved in a deflagration/fire).

Estimates of developed overpressure are subject to considerable uncertainty using analytical means, due to the variability of internally accessed BESS designs, variability in flammable gas production, the conditions leading to the ignition of the contained flammable vapour when it is reduced below the Upper Explosive Limit (UEL) and the effects of intended or unintended venting on the development of the overpressure wave.

Developed overpressure could potentially be quite considerable under the rapid ignited release of previously confined flammable vapour.

Estimation of overpressure from opened doorway of internally accessed (Containerised) BESS unit

The methodology utilised to estimate the required separation distance resulting in a 7 kPa pressure level at a distance from the BESS unit is the TNO Multi-Energy assessment method [12].

The following input assumptions and parameters are considered in the assessment:

- It is assumed that 50% of the volume (flammable vapour within explosive limits) of the BESS unit is involved in an external VCE approximately in the location of an opened BESS doorway.
- Volume of enclosed internally accessed BESS unit = $66m^3$
- Assumed volume of potentially flammable vapour = $33m^3$
- Combustion energy per unit volume estimated to be 3.5 MJ/m^3
- Estimated total combustion energy = 115.5 MJ
- Blast radius (r_o) = 3.2m
- Scaled radius ambient pressure (P_a) = 100 kPa
- Scaled radius specific overpressure (P_s) = 7 kPa
- Scaled radius scaled peak pressure (P_s') = 0.07
- Scaled radius (from TNO Charts) (r’) = 2.25 (TNO Blast Class level 7)
- Actual separation distance required (r) = 24m

Refer to detailed calculation in TNO Multi-Energy assessment method [12].

For internally accessed (Containerised) BESS units, the recommended minimum separation distance from the units to the boundary or to exposed humans on site during a BESS overpressure event, assuming no mitigation measures have been adopted to reduce risk, is **24m** (rounded to approximately **25 m** to reflect that this is a PHA).

If externally accessed (Modular) BESS units are installed, a separation distance for blast overpressure is not considered to be required.

4.0 Recommendations

Recommended separation distances are discussed below. For each risk factor considered, the separation distances presented are worst case, as they assume no mitigation measures have been adopted to reduce risk.

As design progresses from conceptual to detailed, and technology selection is made, these separation distances will be able to be reduced substantially, if and as required, by adoption of appropriate mitigation measures. Future project hazard assessments will utilise the application of recognised standards and performance-based solutions to reduce separation distances to boundaries while achieving compliance with prescribed boundary conditions.

Mitigation measures that may be suitable for reducing separation distances are briefly listed below, together with a non-exhaustive list of examples of the evidence and standards required to establish their effectiveness.

4.1 Separation Distances

4.1.1 Radiant heat

Separation from site boundary

BESS units without specific fire protection or explosion suppression controls (i.e., unmitigated fire risk), whether internally accessed (i.e., Containerised) or externally accessed (i.e., Modular) should be separated from the site boundary by approximately 25m such that a radiant heat flux of 4.7kw/m^2 is not exceeded at that location.

Where decreased separation distances to the boundary are required, fire and explosion risk reduction measures may be considered.

Fire protection measures could include prescriptive or engineered solutions such as one or more of the following:

- Fire suppression systems that extinguish or control the fire, thereby reducing the consequence of the fire or adequate external fire management controls
- Systems and technologies to reduce the likelihood of a fire occurring, including those being considered in response to the Victorian BESS fire [13], such as those that internally isolate batteries undergoing thermal runaway from other components in the BESS unit and those that control cooling and ventilation of the BESS units.
- Internal or external fire sprinkler systems specifically designed for Lithium-Ion battery protection.
- Measures that automatically and safely seal off BESS unit vents in response to heat from a fire, minimising the potential for flame to escape outside the unit and thereby reducing the consequence of the fire.

Such measures would typically be considered acceptable if supported by a fire test of appropriate scope and performed to appropriate standards and demonstrated to meet NSW requirements at the project site under HIPAP 6. Such standards include those specified by the UL, NFPA, IEEE, IEC or other recognised developers of international technical and safety standards. Allowance should be made for the reliability of the proposed measure.

Explosion risk reduction measures are discussed below under ‘Overpressure’.

Separation of BESS units

A radiant heat flux of 12.6 kw/m^2 leads to the estimation of a required separation distance of approximately 2.5m between adjacent BESS units (either Containerised or Modular) to reduce the risk of fire spread from overhead flame radiant heat (i.e., where no fire protection mitigations are included in the BESS design).

Separation distances between BESS units can be reduced with respect to overhead flame radiant heat by adopting suitable fire and explosion risk reduction measures, as discussed above in relation to site boundary separation.

In the absence of mitigation, the number of BESS units allowed to be grouped such that they are at risk from external flames above an adjacent fire-involved BESS unit is at the discretion of the proponent in consultation with regulatory authorities.

To prevent heat transfer horizontally between adjacent BESS units (i.e., through the walls of the BESS units i.e. non-door side of Modular units or either side of containerised BESS units), if the risk of external flames above the unit has been appropriately mitigated, a separation distance of 15cm is required, as per UL9540A.

4.1.2 Overpressure

The recommended safe overpressure distance to the site boundary from a Containerised BESS unit or to any exposed person on site is approximately 25m, unless suitable risk mitigation measures are included in the Containerised BESS' design that allow the distance to be reduced. The overpressure separation distance is comparable to or marginally less than the radiant heat flux separation distance. Therefore, a minimum of approximately 25m separation distance to the boundary should be observed in the absence of appropriate mitigation measures.

Mitigation measures that are able to reduce separation distances for Containerised units include measures that enable safe venting or prevention of explosion, or the use of fire protection systems that do not depend on a sealed room for extinguishment (e.g., water mist suppression). Such measures are expected to be acceptable if:

- designed to NFPA 68, NFPA 855, NFPA 69, or an international equivalent to reduce this risk and demonstrated to meet NSW requirements at the project site under HIPAP 6; or if more specific test data is available and provides a suitable basis for hazard assessment
- if allowances have been made for the reliability of the measure.

If externally accessed BESS units are installed, a separation distance for blast overpressure is not considered to be required.

4.2 General Recommendations

Access to BESS units and static inverters should be restricted to competent trained employees. Contractors should be supervised.

BESS and Static Inverter ventilation must be maintained in accordance with manufacturer specifications.

Water has been shown to be the most effective extinguishing agent for BESS fires, as it provides both extinguishing and cooling, whereas gaseous suppression provides only extinguishing. Deep seated fires associated with Lithium-ion batteries have been known to cause a fire to reignite long after the gaseous system has discharged, and the gaseous agent has dispersed to atmosphere.

Sufficient firefighting water should be made available for fire brigade responders via compliant hydrant and water supply systems.

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6.0 Appendix 1: HAZID and Risk Assessment

MENDHAM CONSULTANTS RISK ASSESSMENT TOOL (RAT)											
RAT Process Step A (Context)	RAT Process Step B (Risk Identification)			RAT Process Step C (Risk Analysis)		RAT Process Step D (Risk Evaluation)	RAT Process Step E (Risk Treatment)	RAT Process Step F (Monitoring and Review)			
Risk Title	Description	Existing or Currently Proposed Controls	Cause(s)	Before Mitigation			Mitigation/Control (include additional recommended controls, potential for emergency response etc)	After Mitigation			
				Likelihood	Consequence	Risk/Impact Level		Likelihood	Consequence	Risk/Impact Level
Flooding	Ingress of water into operational energy conversion or energy storage systems causing plant outage - No off-site impact	Elevated positioniong	Extreme weather events	Rare	Insignificant	L	AFARP			
Bushfire	Radiant heat or ember attack from nearby vegetation fire impacting on assets - No off-site impact	Asset Protection Zoning	Catastrophic Bushfire Outbreak	Rare	Insignificant	L	AFARP			
Electric shock	Electric shock - Exposed energised surfaces greater than ELV - No off-site impact	Insulated surfaces	Electrical worker in contact with live electrical surface during maintenace activity	Rare	Moderate	L	AFARP			
Extreme weather events	Damage to infrastructure from high velocity wind - No off-site impact	Structural reinforcement of facilities and compliant fixing to foundations/slabs	Effects of cyclone or tornado	Rare	Minor	L	AFARP			
Subsidence	Movement of ground causing outage of energy storage or energy conversion equipment - No off-site effects	Compliant footings support and foundations	Development of sinkhole, seismic event	Rare	Minor	L	AFARP			
Chemical Loss of Containment	Contamination of surrounding soil - No off-site effects	Bunding	LoC of hydrocarbons into nearby environment	Unlikely	Moderate	M	Compliant chemical storage cabinets	Unlikely	Minor	L
Chemical Loss of Containment	Skin burns, eye contamination of worker - No off-site effects	Bunding	Improper handling of dangerous goods	Unlikely	Moderate	M	Compliant chemical storage cabinets	Unlikely	Minor	L
Arson or theft	Fire event initiated by youths - No Off site effects	Security fencing	Arson perpetrators instigate a fire near fuel storage or near BESS	Unlikely	Moderate	M	CCTC surveillance, security patrols	Rare	Moderate	L

Continued…..

Arson or theft	Fire event initiated by youths - No Off site effects	Security fencing	Arson perpetrators instigate a fire near fuel storage or near BESS	Unlikely	Moderate	M	CCTC surveillance, security patrols	Rare	Moderate	L
Lightning	Lightning strike on BESS or Static Inverter causing fire - No off site effects	Nil	Electrical Storm	Unlikely	Moderate	M	Lightning protection based on AS1768, Fire Protection Systems fitted to BESS containers - water mist, gaseous suppression, available safe access to BESSs by Emergency Services Responders	Unlikely	Insignificant	L
Vehicular or height access equipment impact during construction, maintenance, or decommissioning	Battery cell fire or explosion caused by impact of vehicle or scaffolding on exposed BESS units - Potential for off-site affects	Nil	Uncontrolled Construction or maintenance action	Unlikely	Moderate	M	Defined separation exclusion zones to BESS systems from vehicles, bollards, water filled barriers etc	Rare	Moderate	L
Manual Handling incidents	Dropping of inadequately restrained BESS causing LoC of hazardous Chemicals	Nil	Uncontrolled Construction or maintenance action	Unlikely	Minor	L	Defined lifting processes with inherent safety constraints, secondary lifting harnesses.	Rare	Moderate	L
BESS / Static Inverter Fire	Cell failure causing spread within BESS enclosure - potential for off site effects (Injury) - Potential for off-site affects	Nil	BESS located too close to boundary, but not close enough to allow effective fire brigade intervention	Unlikely	Moderate	M	Fire Protection Systems fitted to BESS containers - water mist, gaseous suppression, available safe access to BESSs by Emergency Services Responders	Unlikely	Insignificant	L

Continued…..

BESS / Static Inverter Fire	Spread of fire beyond BESS of origin - Potential for off-site effects	Nil	BESS located too close to boundary, but not close enough to allow effective fire brigade intervention	Rare	Major	M	Distribution (decentralisation) of BESS systems throughout the SPS with aequte separation distance between BESS on site. Fire Protection Systems fitted to BESS containers - water mist, gaseous suppression, available safe access to BESSs by Emergency Services Responders	Rare	Minor	L
BESS Explosion	Cell/s failure causing high gas discharge overpressure from BESS - Potential for off-site effects	Intrinsic overpressure attenuation associated with the BESS enclosure.	BESS located too close to boundary, but not close enough to allow effective fire brigade intervention	Unlikely	Moderate	M	Explosion protection venting, active explosion supression	Unlikely	Insignificant	L
BESS Fire	Toxic release - potential for off site effects (Injury) - Potential for off-site effects	Nil	BESS located too close to boundary, but not close enough to allow effective fire brigade intervention	Unlikely	Moderate	M	Edify to establish communbications protocol with local community in case of emergencies, such as SMS messaging.	Rare	Moderate	L