Liddell Battery and Bayswater Ancillary Works Project

Appendix G – Preliminary Hazard Analysis

PRELIMINARY HAZARD ANALYSIS FOR LIDDELL BATTERY AND BAYSWATER ANCILLARY WORKS, NSW

Prepared for: **AGL Macquarie**

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Revision 1

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Preliminary Hazard Analysis for Liddell Battery and Bayswater Ancillary Works, NSW

Disclaimer

Rev	Date	Description	Prepared By	Checked By	Authorised By
0	22/02/2021	Final report	K Nilsson	A Lewis	K Nilsson
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GLOSSARY AND ABBREVIATIONS

ADGC	Australian Dangerous Goods Code
ALARP	As Low As Reasonably Practicable
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
BATSO	Battery Safety Organization
BAW	Bayswater Ancillary Works
Battery	Battery Energy Storage System
battery	Li-ion battery with associated infrastructure, located within am enclosure
DG	Dangerous Goods
DPIE	Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
ELF	Extremely low frequency
EMF	Electric and magnetic fields
EPA	Environmental Protection Agency
ESD	Emergency Shut Down
FHA	Final Hazard Analysis
FRNSW	Fire Rescue NSW
Ha	Hectare
HAZMAT	Hazardous Materials
HIPAP	Hazardous Industry Planning Advisor Paper
HSE	Health, Safety and Environment
HV	High Voltage
kL	kilolitre
km	kilometre
kV	kilovolts
LFP	lithium iron phosphate
Li-ion	Lithium-ion (battery)
MLRA	Multilevel Risk Assessment guidelines
MV	Medium Voltage
NEH	New England Highway

NZS	New Zealand Standard
ICNIRP	International Commission on Non-Ionising Radiation Protection
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSW	New South Wales
PG	Packaging Group
PM	Preventative Maintenance
PPE	Personal Protective Equipment
RFS	Rural Fire Service
SCADA	Supervisory Control And Data Acquisition
SDS	Safety Data Sheets
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SWMS	Safe Work Method Statement
PHA	Preliminary Hazard Analysis
PTW	Permit To Work
UL	Underwriters Laboratories
UN	United Nations
V	Volt
WHS	Work Health & Safety

EXECUTIVE SUMMARY

E1. Introduction

AGL Macquarie (**AGLM**) are seeking approval for a Project involving the construction and operation of the Liddell Battery (the Battery), to decouple Liddell and Bayswater power stations, works to facilitate the improved safety, reliability, efficiency and environmental performance of Bayswater, and a modern consolidated consent for the continued operation of Bayswater (**the Project**).

The Secretary's Environmental Assessment Requirements (**SEARs**) issued for the Project includes the requirements to address *Hazards and Risks* associated with any hazardous materials or reactions, bushfires, electromagnetic fields or the proposed grid connection infrastructure, as follows:

> *The Environmental Impact Statement (**EIS**) must address the following specific issues with the level of assessment of likely impacts proportionate to the significance of, or degree, of impact on, the issue, within the context of the project location and the surrounding environment:*
>
> *Hazards and Risk - including:*
>
> - a preliminary hazard analysis (**PHA**) prepared in accordance with the Department's Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis' and Multi-level Risk Assessment; and
> - an assessment of potential hazards and risks including but not limited to bushfires, electromagnetic fields or the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (**ICNIRP**) Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields.

AGLM has appointed Planager Pty Ltd (**Planager**) to prepare this hazard and risk assessment report, which has been prepared according to the requirements for the analysis of hazards and risks of potentially hazardous development, as per the NSW Department of Planning, Industry and Environment's (**DPIE**) Hazardous Industry Planning Advisory Paper No. 6 (**HIPAP**), *Hazard Analysis* and their *Multi-level Risk Assessment* guideline document. The hazard and risk assessment has been prepared in the format of a PHA.

E2. Methodology and scope

The hazard analysis process encompasses qualitative methods to assess the adequacy of the controls and to determine if the Project can be developed with the associated hazards kept As Low As Reasonably Practicable (**ALARP**) and ensuring appropriate land use safety planning.

The assessment focusses on potential high consequence – low likelihood incidents that may affect the health and safety to people and the environment outside of the site boundaries.

The following risks are included in this assessment:

- Risk from reactions and fires associated with electrical infrastructure and flammable material;
- Environmental risk from spills;
- Risks from exposure to electromagnetic fields;
- Health and safety risks to staff and to contractors from major, high consequence incidents; and
- Health and safety risk to the community.

E3. Findings – risk assessment and ALARP evaluation

The hazard and risk assessment found that the risk profile for the Project, as per the definition by AGLM, is consistently between *Moderate* and *Low* risk. No *High* or *Very High* risks were identified.

Further, the assessment found that the Project can be managed in accordance with the established risk criteria and in accordance with ALARP principles. Most hazards can be prevented by employing a combination of common measures, including following all applicable Australian (**AS**)/New Zealand (**NZS**) and with reference to international Standards, separation distances and setbacks, physical protection and control systems measures. Mitigation measures are also available within the industry to reduce the severity of the hazards should they occur, including secondary containment.

Table E1 provide an overview of the risks assessment results and ALARP conditions. A short summary discussion is provided below:

- The potential exists for the Battery to initiate a bushfire in the surrounding bush and grasslands. This presents the only potential impact to society from the Project and, provided an Asset Protection Zone (**APZ**) is established and maintained, this risk is low. The Battery site can be laid out such that sufficient separation between the Battery and external boundaries can be achieved in order to minimise off-site risk, with details on internal separation requirements to be defined in detailed design. The need for active firefighting requirements at the Battery would be determined in detailed design, in consultation with RFS and the DPIE. With application of the risk management measures detailed in this report, including an effective fire management plan, there is a low risk to society of a Battery system initiated fire event, and low risks to the environment.

- Given the remote location of the Project and provided the APZ is established and maintained, it is unlikely that the Project would have an impact on any off-site human population. The Project may alter the Electric and Magnetic Fields (**EMF**) on the site and the potential exposure to EMF would need to be considered for AGLM staff and contractors as part of health and safety management to ensure that the risk of EMF exposure is Low and managed to ALARP principles. The Project risks would be considered in any future development of surrounding lands by AGLM or third parties as part of the approval process for those projects - however, the Project is not considered likely to restrict the types of development compatible with current zoning or likely future uses of AGLM lands from a hazard and risk point of view.

- Environmental pollution is possible in the case of a rupture or major spill from the brine return pipeline(s), from overfilling an emergency diesel generator, and potentially (subject to detailed design) from a failure to contain pollutants at the Battery. If a spill is not contained, there is a potential to affect off-site sensitive receptors including in the form of threatened vegetation and fauna. Measures to prevent a leak from occurring and for secondary containment will need to be addressed in the detailed design phase for the Project, and the likelihood of a significant loss of containment event associated with this Project (Level 4) must be designed to Rare in accordance with AGL's Risk Management and Assessment Standard.

Table E1 – Overview of risks assessment results and ALARP conditions

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
Fire and pollution at the Battery as initiated by internal or external event (scenarios 1, 2, 3, 4 and 14)	Codes and Standards provide clear guidance as to how to prevent and protect against a fault in the battery escalating into a fire at the enclosure. Provided these requirements are met the risk at each individual battery is managed ALARP. Further, provided the minimum separation distances within the Battery and between the Battery and external boundaries is sufficient, as determined during detailed design in agreement with the Battery manufacturer, the Fire Rescue NSW (**FRNSW**) and RFS, and in accordance with the requirements in Codes and Standards, the risk associated with the Battery can be managed ALARP. Onsite hazardous effects are possible in case of a battery fire, and the possibility of generation of toxic gas and toxic combustion products should be considered in design to allow for safe evacuation and in any emergency response. Environmental pollution is possible from a failure to contain cooling water and oils at the Battery, and the identification and secondary containment of a spill should be considered in detailed design. Environmental pollution from run-off of fire-fighting medium is also possible and should be taken into account in emergency response. If large amounts of fire-fighting medium are to be applied during a fire-fighting operation, then the containment of such fire-fighting medium must be included in the design of the Battery. The DPIE generally requires the containment of 90 minutes of fire-fighting medium – this timeframe should be verified during the detailed design process.	Moderate risk and conforms to ALARP provided requirements in Codes and Standards are adhered to (e.g. AS 5139, AS 1940 and international Codes e.g. US NFPA 855) and the minimum separation distances between Battery infrastructure and APZ are established and maintained

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
Fire and pollution at the Medium Voltage (**MV**) and High Voltage (**HV**) infrastructure (scenarios 2 5, 7, 8)	Provided the requirements under the Australian Standards and AGLM management practices for HV and MV infrastructure are adhered to, and a formal APZ established, the risk associated with environmental pollution and fire at the MV and HV infrastructure associated with the decoupling works can be managed ALARP.	Moderate risk and conforms to ALARP provided the requirements in Australian Standards (including AS 2067 and AS 1940), AGLM management practices are adhered to and APZ is established and maintained
Fire and/or generation of dust at the MA1B conveyor (scenario 9)	Provided the requirements under the Australian Standards and management practices in place by AGLM, including rigorous management of change and hazard identification, are adhered to, it is unlikely that this hazardous event would affect areas off the site.	Low risk and conforms to ALARP provided AS 1755 and AGLM controls and risk management practices in place
Fire or pollution at the waste storage area or at the emergency diesel generators (scenarios 12 and 13)	With the upgraded bunding, runoff management and installation of new roofing of the waste storage area, the risk associated with this storage area and with the emergency diesel generators is managed ALARP provided the relevant requirements in AS1940 *Storage and handling of flammable and combustible liquids* are met. If the emergency diesel generators are to be fed directly from the fuel farm, it is likely that automatic and independent cut-off of diesel generator filling will need to be installed. The distance from the site boundary is well in excess of 10 metres and it is unlikely that a fire in the waste storage area or at the diesel generators would have effects off-site (Ref 6). Notwithstanding, the need for active firefighting at the waste storage area should be determined in detailed design.	Low to Moderate risk and conforms to ALARP provided the requirements in Australian Standard AS 1940 and AGLM management practices for change management are adhered to and that automatic and independent cut-off of diesel generator filling is installed

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
Environmental pollution and/or hazardous exposure from loss of containment of ferric chloride at the Lime Softening Plant (scenario 11)	With the upgraded ferric chloride tanks as well as any additional equipment and provided the requirements under AS 3780 for the storage and handling of corrosive liquids are adhered to, the risk associated with the ferric chloride storage is managed ALARP.	Low risk and conforms to ALARP with AS 3780 and AGLM controls in place
Environmental pollution and/or hazardous exposure from loss of containment of brine from the new pipeline(s) (scenario 10)	Detailed design would need to be verified to ensure that the risk of environmental pollution from a release from the brine pipelines is managed to ALARP and that the likelihood of a substantial release (Level 4) is reduced to Rare as per AGLM risk assessment methodology. This is likely to include the need for secondary containment and automatic shut-off of brine feed once the desired level is met.	Moderate risk provided the maximum credible spill of brine can be safely contained
Exposure to hazardous effects of EMF (scenario 15)	The design of the Project elements would consider EMF risks as well as any necessary buffer areas and proposed changes to future land use scenarios (other than electricity generation) would be explored. Given the remote location of the Project, it is unlikely that the Project would have an impact on off-site sensitive receptors. The Project may alter the EMF on the site and the potential exposure to EMF should be considered for AGLM staff and contractors as part of health and safety management practices.	Low risk and conforms to ALARP provided the applicable criteria, including Prudent Avoidance, are followed and that all permanently occupied buildings are located well away from HV/MV plant and equipment

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
	Provided the applicable criteria, including Prudent Avoidance, are adhered to, the risk of EMF can be managed ALARP.	
Natural hazards (bushfire, water/flooding, lightning, earthquake) causes a hazardous incident (scenarios 14, 17, 18, 19)	Codes and Standards are available to ensure that the risk of natural hazards such as those from bushfires, lightning, flooding, and earthquakes can be managed to ALARP.	Low risk and conforms to ALARP provided the applicable Codes and Standards are followed, including an APZ established
Security breach (scenario 16)	The site operates under a strict security protocol and only approved staff/contractors are permitted to enter the site. The main project components are generally located in secure fenced areas, with the Battery located within a double secure fenced area, except lakeside. Impact protection from vehicles will need to be provided in the form of bollards or other equivalent measures. There are security cameras monitoring the site 24 hours a day. During construction, the areas would be manned and temporary fences would be installed.	Low risk and conforms to ALARP
Onsite and off-site traffic impact causes hazardous incident (scenario 20)	Provided on-site requirement, including reduced speed limits are adhered to, and any required impact protection installed during the design phase of this project, the on-site risk of a vehicle impact on plant and equipment is low and can be managed ALARP. With reference to the findings in the Traffic and Transport Assessment in the EIS, and provided the requirements under the Australian Code for the Transport of Dangerous Goods by Road & Rail are adhered to, the risk of off-site transport of Dangerous Goods (**DGs**), including of the Li-ion batteries, is Low and can be managed ALARP.	Moderate risk and conforms to ALARP provided onsite and off-site requirements for Heavy Vehicle and for DG transport are adhered to, and any required impact protection is installed

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
Wildlife interaction with live plant causes hazardous incident (scenario 21)	The risk of wildlife damage to plant and equipment is well known and understood by AGLM and contractors therefore can be managed to ALARP.	Moderate risk and conforms to ALARP

E4. Conclusion and recommendations

In conclusion, the risk profile for the Project is consistently within the Low or Moderate risk ranking, sufficient land is available to accommodate the Battery development and ALARP can be established provided a number of AGLM commitments to safety and the following recommendations are included in the detailed design:

1. A detailed bushfire threat assessment is conducted for the Project, including establishment of an APZ, in consultation with the Rural Fire Service (**RFS**);

2. The separation distance between infrastructure within the Battery is determined in accordance with Codes and Standards and manufacturer's recommendations so that the preferred strategy of allowing a fire in one battery enclosure or inverter to burn without the risk of propagating to other infrastructure can be maintained without the need for external firefighting;

3. The separation distance within the Battery is determined in accordance with Codes and Standards and manufacturer's recommendations to allow safe escape in case of a fire;

4. All relevant requirements in the new AS5139 (2019) are adhered to at the Battery. Adherence to requirements in international standards are also considered, for example to the US NFPA 855 (2020) Code. Further, consider procurement of a battery system that is certified to UL 1642, UL 1973, IEC 61427-2 and IEC62619;

5. The need for active firefighting requirements at the Battery and at the waste storage area is determined in consultation with RFS and the DPIE, e.g. in the form of fire water tanks and connections to the RFS. Detailed fire fighting response and any need for fire water containment should be assessed and reported (e.g. in the format of a Fire Safety Study) post development approval, for review by the DPIE, NSWFR and the RFS;

6. The health and safety associated with EMF on the site and the potential exposure to EMF are considered for AGLM staff and contractors as part of AGLM's obligations for their health and wellbeing under the WHS Regulations;

7. Measures to prevent a leak from occurring at the brine pipeline, the emergency diesel generators and at the Battery, and for secondary containment should a leak occur, is addressed in the detailed design phase for the Project. The likelihood of a significant loss of containment event associated with this Project (Level 4) would be designed to Rare in accordance with AGL Risk Management and Assessment Standard;

8. The register of commitment (Appendix 1 of the PHA) is integrated into the management for the Project. This includes integration of 84 individual commitments, including for the design, installation and maintenance of the Battery automatic shutdown system on exceedance of safe limits; installation of deflagration venting and fire protection inside the battery enclosures; design of the brine pipeline, waste oil facility, emergency diesel generators and the Battery such that the risk of pollution from a release is reduced to ALARP; installation of protective barriers, including at the transformers; and application of a rigorous and formal management of change process for the Project, including detailed hazard identification and risk assessment processes.

REPORT

1 INTRODUCTION

1.1 BACKGROUND

AGL Macquarie (**AGLM**) are seeking approval for a Project involving the construction and operation of a Liddell Battery (the Battery) works to decouple Liddell and Bayswater power stations, works to facilitate the improved safety, reliability, efficiency and environmental performance of Bayswater, and a modern consolidated consent for the continued operation of Bayswater (**the Project**).

The Secretary's Environmental Assessment Requirements (**SEARs**) issued for the Project includes the requirements to address *Hazards and Risks* associated with any hazardous materials or reactions, bushfires, electromagnetic fields or the proposed grid connection infrastructure against the ICNIRP Guidelines, as follows:

> *The EIS must address the following specific issues with the level of assessment of likely impacts proportionate to the significance of, or degree, of impact on, the issue, within the context of the project location and the surrounding environment:*
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> *Hazards and Risk - including:*
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> - a preliminary hazard analysis (**PHA**) prepared in accordance with the Department's Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis' and Multi-level Risk Assessment; and
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1) and their *Multi-level Risk Assessment* guideline document (Ref 2). The hazard and risk assessment has been prepared in the format of a PHA.

1.2 Project scope

The following Project scope has potential hazard and risk implications:

- *Battery*: A grid connected Battery with capacity of up to 500 megawatts (**MW**) and 2 gigawatt hour (**GWh**). The development of the battery system is required for the transition from thermal power generation to renewable generation. The operation of the Battery will be complementary to the ongoing operation of Bayswater;

- *Decoupling works*: Alternative network connection arrangements for the Liddell 33 kilovolts (**kV**) Switching Station that provides electricity to infrastructure required for the ongoing operation of Bayswater and associated ancillary infrastructure and potential third-party industrial energy users;

- *Bayswater Ancillary Works* (**BAW**): Works associated with Bayswater which include upgrades to ancillary infrastructure such as pipelines, conveyor systems, roads and assets to enable maintenance, repairs, replacement, expansion or demolition.

1.3 Scope and aim of the PHA

The overall study objective is to address the *Hazards and Risks* component of the SEARs as detailed in section 1.1 above, notably to assess potential hazards and risks associated with the Project, including any hazardous materials or reactions, bushfires, electromagnetic fields (EMFs) or the proposed grid connection infrastructure against the ICNIRP Guidelines.

The hazard analysis process encompasses qualitative methods to assess the adequacy of the controls and to determine if the Project can be developed with the associated hazards kept As Low As Reasonably Practicable (**ALARP**) and ensuring appropriate land use safety planning.

The PHA is prepared in accordance with DPIE methodology in their HIPAP6 *Hazard analysis* (Ref 1) and *Multi-level risk assessment* (Ref 2).

As per the methodology (Ref 1), the assessment focusses on potential high consequence – low likelihood incidents during construction and operation of the Project that may affect the health and safety to people and the environment outside of the site boundaries.

The following risks are assessed as part of this assessment:

- Risk from reactions and fires associated with electrical infrastructure and flammable material;
- Environmental risk from spills;
- Risks from exposure to electromagnetic fields;
- Health and safety risks to staff and to contractors from major, high consequence incidents; and
- Health and safety risk to the community.

1.4 Exclusions and limitations

The study exclusions are summarised as follows:

- Bushfire threat assessment;
- This study does not constitute a Construction Safety Study and does not include detailed identification and assessment of construction and commissioning risks;
- The PHA was based on an early / concept design and the results depend on the implementation of the commitments made during the study (refer Appendix 1) and the recommendations made as part of the development of this PHA.

1.5 Method and report structure

The process utilised for this assessment follows standard processes established internationally and in Australia for hazard and risk assessments, and outlined in DPIE's guidelines for hazard analysis (Ref 1) and the *Multilevel risk assessment* (Ref 2). It includes the following steps:

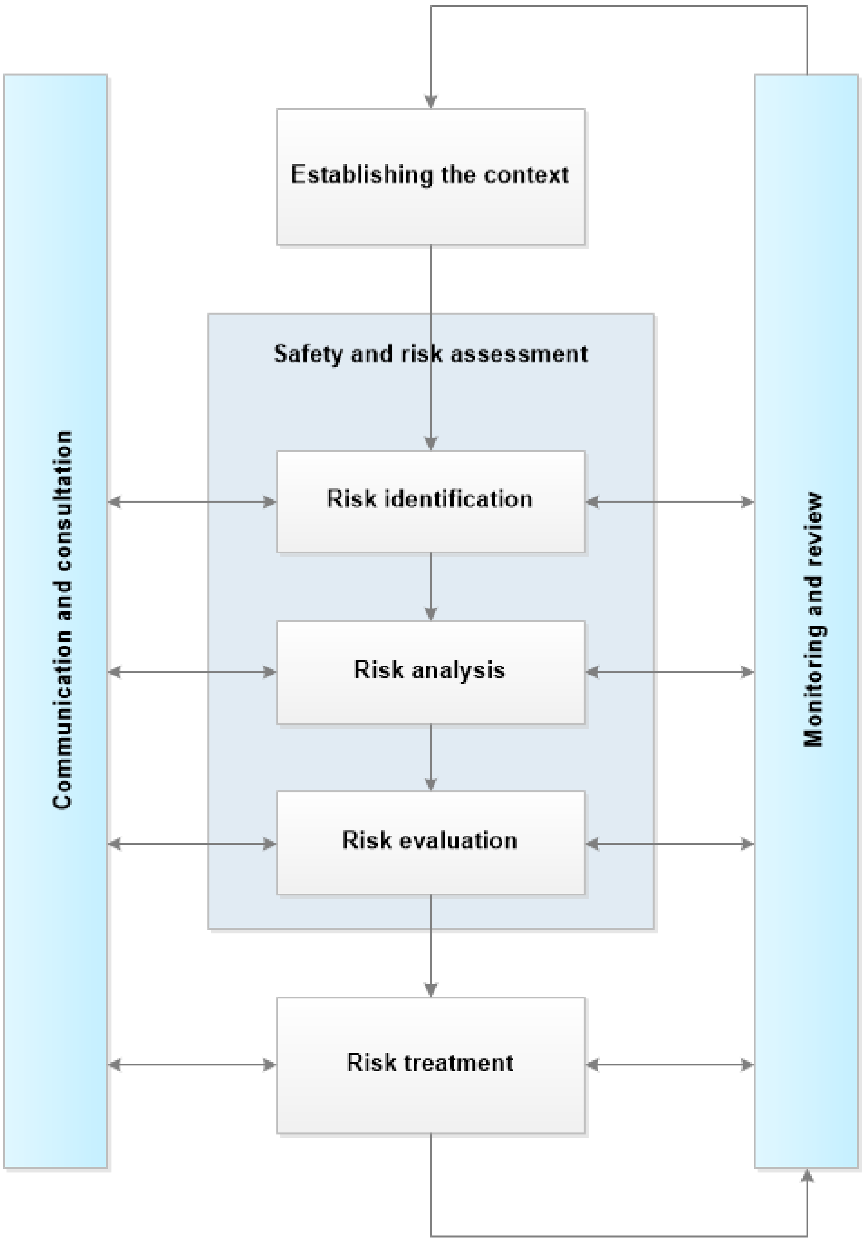
- Establish context, as detailed in Sections 1 and 2;
- Hazard identification and incident screening, as discussed in Section 3;
- Risk analysis, evaluation, classification, prioritisation and evaluation of risk treatment, as per Sections 4 and 5;
- Conclusions and summary of major findings, as per Section 6.

A detailed Commitments Register in Appendix 1 provides the basis for the assessment.

Consultation with stakeholders, including with DPIE's Hazard Branch, was conducted as part of the establishment of the context and the hazard identification for the full scope of the Project. Consultation with NSW Rural Fire Service (**RFS**) will need to be conducted in conjunction with the establishment of detailed design.

An overview of the methodology employed in the hazard and risk assessments is depicted in Figure 1.

Figure 1 – General risk management framework



1.6 RISK CRITERIA

Risk evaluation is the decision of whether the risks adhere to generally acceptable risk criteria and have been reduced ALARP. The risk evaluation has three possible outcomes:

- Well below criteria - further risk reduction may be impracticable;
- Sufficiently close to or above criteria for further risk reduction controls to be investigated seriously using ALARP principles;
- Well above criteria - further controls need to be found or continued operation questioned.

The risk criteria used for this PHA are provided in Appendix 2.

Qualitative guidelines are given to ensure that off-site risk is eliminated or prevented and where that is not possible, controlled. In addition to meeting the qualitative criteria, risk minimisation and use of best practice must be demonstrated. These terms imply:

- Risk Minimisation - Risks should be reduced to ALARP, regardless of calculated risk levels and criteria.
- Best Practice - Industry best practicable should be used in the engineering design, and industry best practice management systems should be used for the operation of new plant.

1.7 SAFETY MANAGEMENT SYSTEMS

Risk assessments can only be a valid tool for assisting in the overall assessment of a site if the facility being examined is or will be subject to appropriate management control of hazards. Without such control, the assumptions inherent to the assessment techniques become invalid in two general areas. First, the identification of hazards is based on experience in similar installations and on engineering judgement. Without proper management control of safety issues, the range and impact of potential hazards becomes unpredictable. Second, the frequency at which incidents of any type may occur cannot be adequately estimated using historical data.

Safety management systems allow the risk from potentially hazardous installations to be minimised by a combination of hardware and software factors. It is essential to ensure that the reliability of the hardware systems and software procedures used to ensure the safe operation of the facility are of the highest standards.

AGLM have a commitment to workplace health and safety and have numerous policies and procedures to achieve a safe workplace. These include, but are not limited to:

- The operation of the existing and proposed new facility is continually monitored and controlled from a central control room via a Supervisory Control and Data Acquisition (**SCADA**) system.
- An incident reporting and response system is established, providing 24-hour coverage.
- The elements included in the Project will comply with all codes and statutory requirements with respect to design and work conditions.
- All personnel required to work with Dangerous Goods (**DG**) substances and with electricity are trained in their safe use and handling, and are provided with all the relevant safety equipment and documentation e.g. Safety Data Sheets (**SDS**) and Personal Protective Equipment (**PPE**).
- Emergency procedures, including for pollution incident response, have been developed and personnel are trained in emergency response.
- The site has Operations Managers with overall responsibility who are supported by suitably qualified personnel trained in the operation, maintenance and support of the facility.
- A Permit to Work (**PTW**) system, including Hot Work Permit for any work that could provide an ignition source, and control of modification systems are in use on site to control work and to protect plant and structures from substandard and potentially hazardous modifications.
- Protective systems are routinely inspected and tested to ensure they are, and remain, in a good state of repair and function reliably when required to do so. This will include scheduled testing of shutdown valves, trips and alarms, and relief devices associated with the Project.
- All personnel on site have been provided with appropriate PPE suitable for use with the specific type of activity i.e. handling of hazardous substances.
- Multiple first aid stations are present and are provided comprising an appropriate first aid kit and first aid instructions, i.e. SDS's, for all substances kept or handled on the premises.

2 DESCRIPTION OF SITE AND FACILITY

2.1 LOCATION

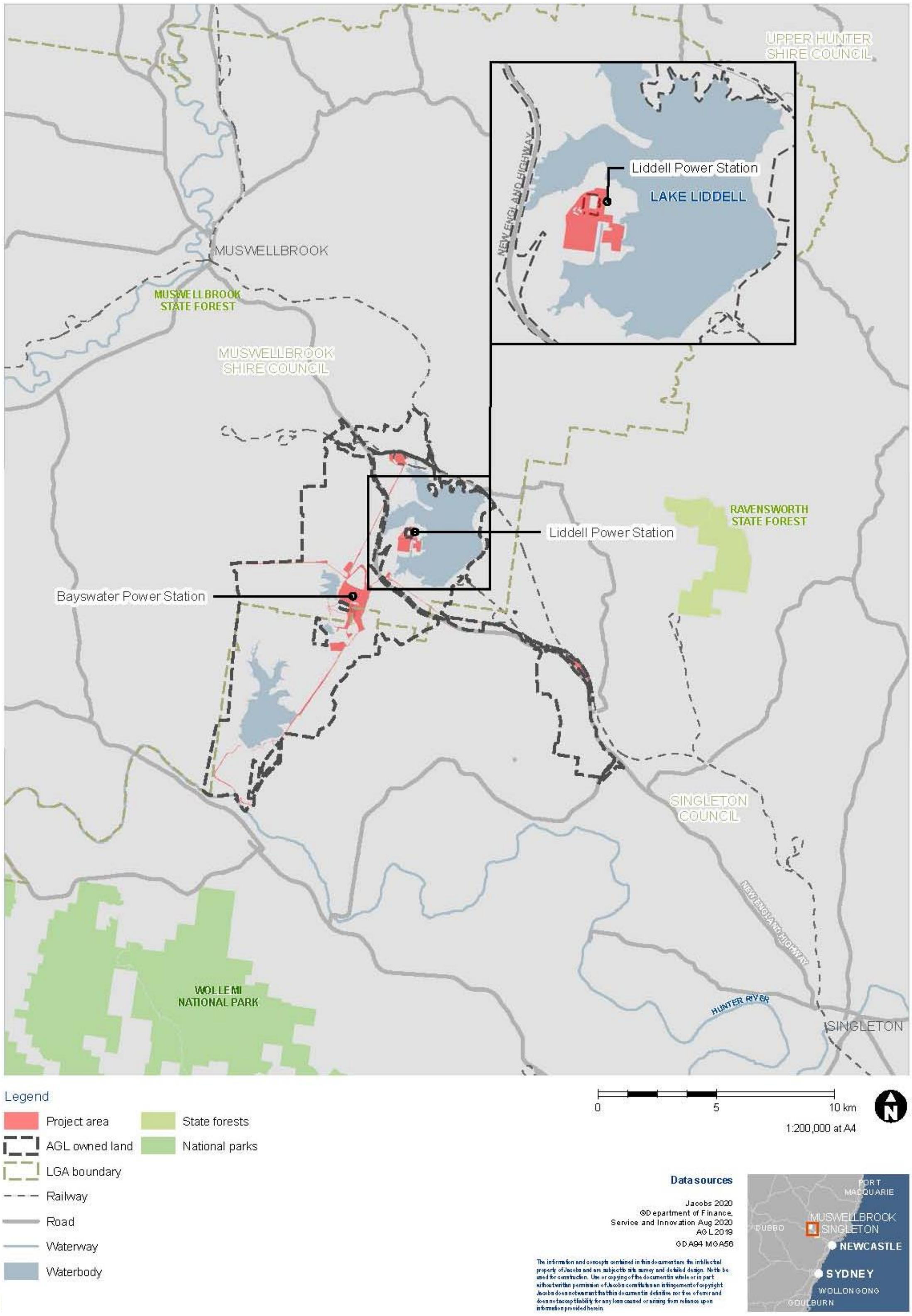
Liddell and Bayswater are located approximately 15 kilometres (**km**) south-east of Muswellbrook, 25 km north-west of Singleton, and approximately 165 km west-north- west of Sydney, New South Wales (**NSW**). The total area of the AGLM landholding is approximately 10,000 hectares (**ha**), including Bayswater, Liddell, Ravensworth, Lake Liddell, Lake Plashett and surrounding buffer lands.

The indicative Project location is shown in Figure 2. The works associated with the Project would be almost entirely within the AGLM landholding except for minor works to the switchyard and where AGLM infrastructure crosses road reserves, Crown land or Council property.

The Project is located within an area dominated by mining and power generation. The landscape local to Liddell and Bayswater is heavily influenced by industrial activity. Local land use is dominated by large-scale infrastructure associated with Bayswater and Liddell and open cut mining activities at Ravensworth Mine Complex, Mount Arthur Coal, Hunter Valley Operations, Liddell Coal Mine and the former Drayton Mine. Agricultural clearing for the purposes of grazing is also present within and surrounding the AGLM landholding. There are limited social infrastructure and sensitive receivers in the locality of the Project. The closest social infrastructure is the Lake Liddell Recreation Area with a dwelling located approximately 2 km from the Project. The closest residential area is the Antiene subdivision, which is located approximately 4 km north of the Project.

The New England Highway (**NEH**) runs between Liddell and Bayswater, with access from the highway provided by means of a dedicated road network designed to service the power stations. The Northern Railway Line runs to the east of the AGLM landholding.

Figure 2 – Project location



2.2 Existing environment

The majority of the Project area has been previously disturbed during the construction and operation of Liddell and Bayswater.

The Project could occur in parallel with the closure and repurposing of Liddell and ongoing operation of Bayswater however the Battery construction and commissioning component of the project may occur sooner. Construction of the Battery and Decoupling components would generally be undertaken in close proximity to Liddell and, where possible, would use previously disturbed operational lands no longer required for Liddell operations. BAW would be predominantly located in close proximity to existing infrastructure where prior disturbance has likely occurred.

The land associated with the Project is partly designated as a bushfire prone area according to the RFS bushfire prone area search engine (November 2020, Ref 3).

Other constraints including air quality, noise and vibration, traffic and transport, biodiversity, land and contamination, Aboriginal and Non-Aboriginal heritage, visual amenity, waste and social and economic impacts are discussed in greater detail within the EIS.

2.3 Project description

Key features of the Project with potential implications on hazards and risks management are:

- The Battery – see Section 2.3.1
- Decoupling works – see Section 2.3.2
- BAW – see Section 2.3.3

A project overview is provided in Figure 3.

The location of the Battery is yet to be finalised, with the existing solar array area (Option 1), the non-process development land (Option 2), or the existing coal storage yards (Option 3), as shown in Figure 4, still under consideration. The location for the decoupling works is also shown in Figure 4.

The Bayswater ancillary works items are shown in Figure 5.

The Development site for the Project is approximately 353 ha within the Project area consisting of:

- Battery footprint of approximately 56 ha of which approximately 20 ha would be selected
- Decoupling works areas of approximately 23 ha with a limited proportion of which would ultimately be disturbed
- BAW works areas of approximately 274 ha with a limited proportion impacted within this application.

Land included in the Development site but not immediately proposed for disturbance is included to accommodate potential future works.

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Figure 3 – Project overview

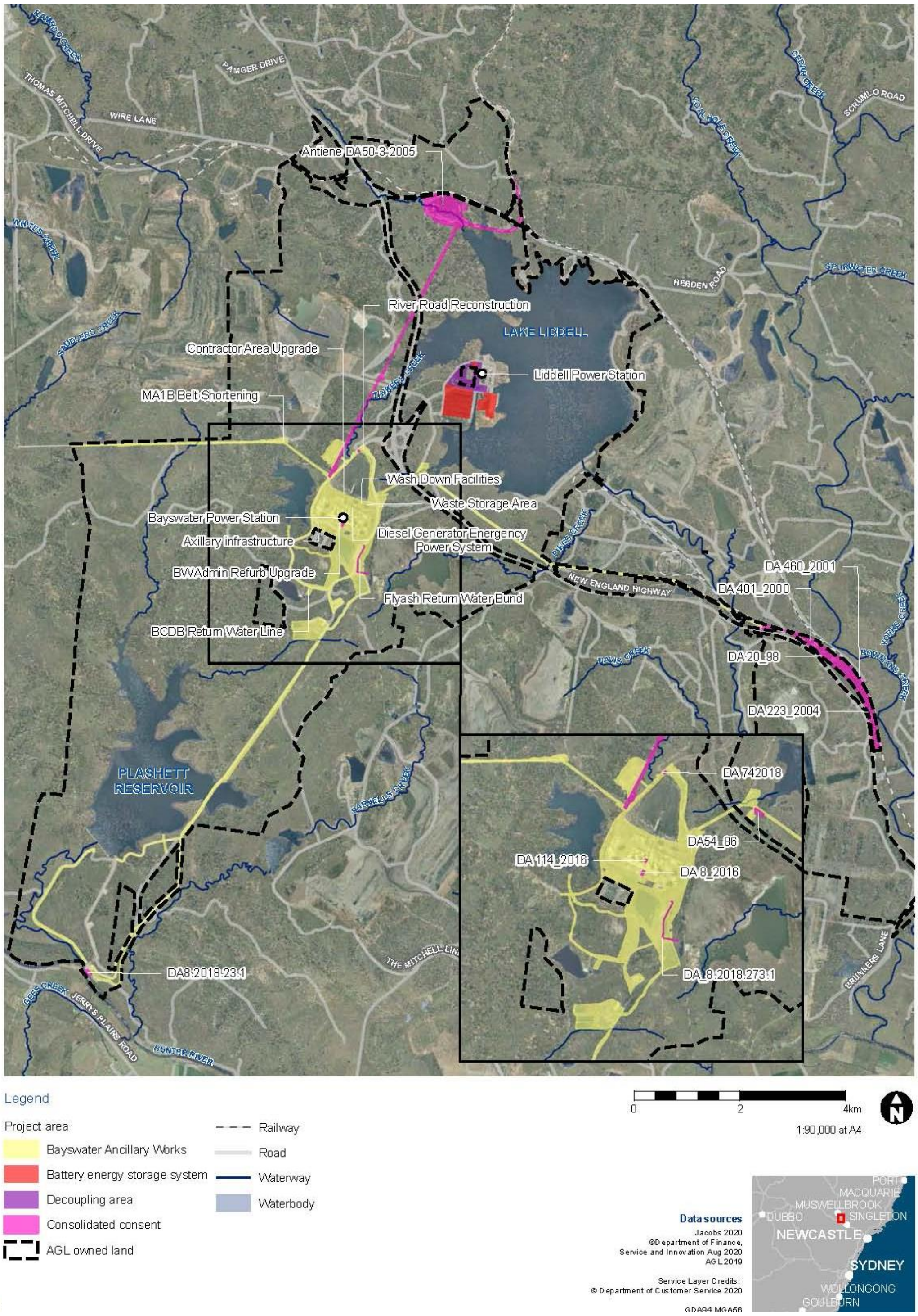

Figure 4 – The Battery and decoupling

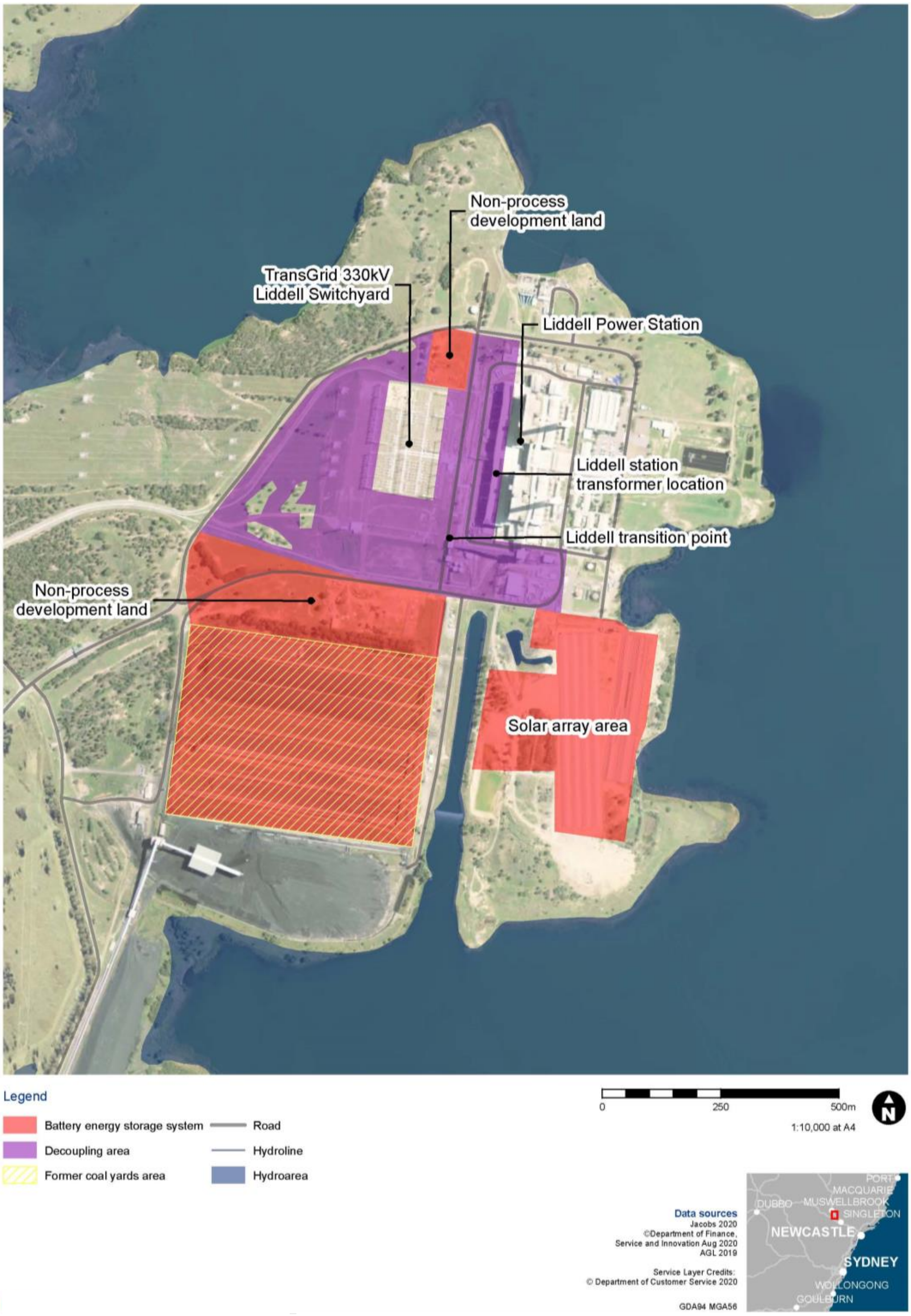

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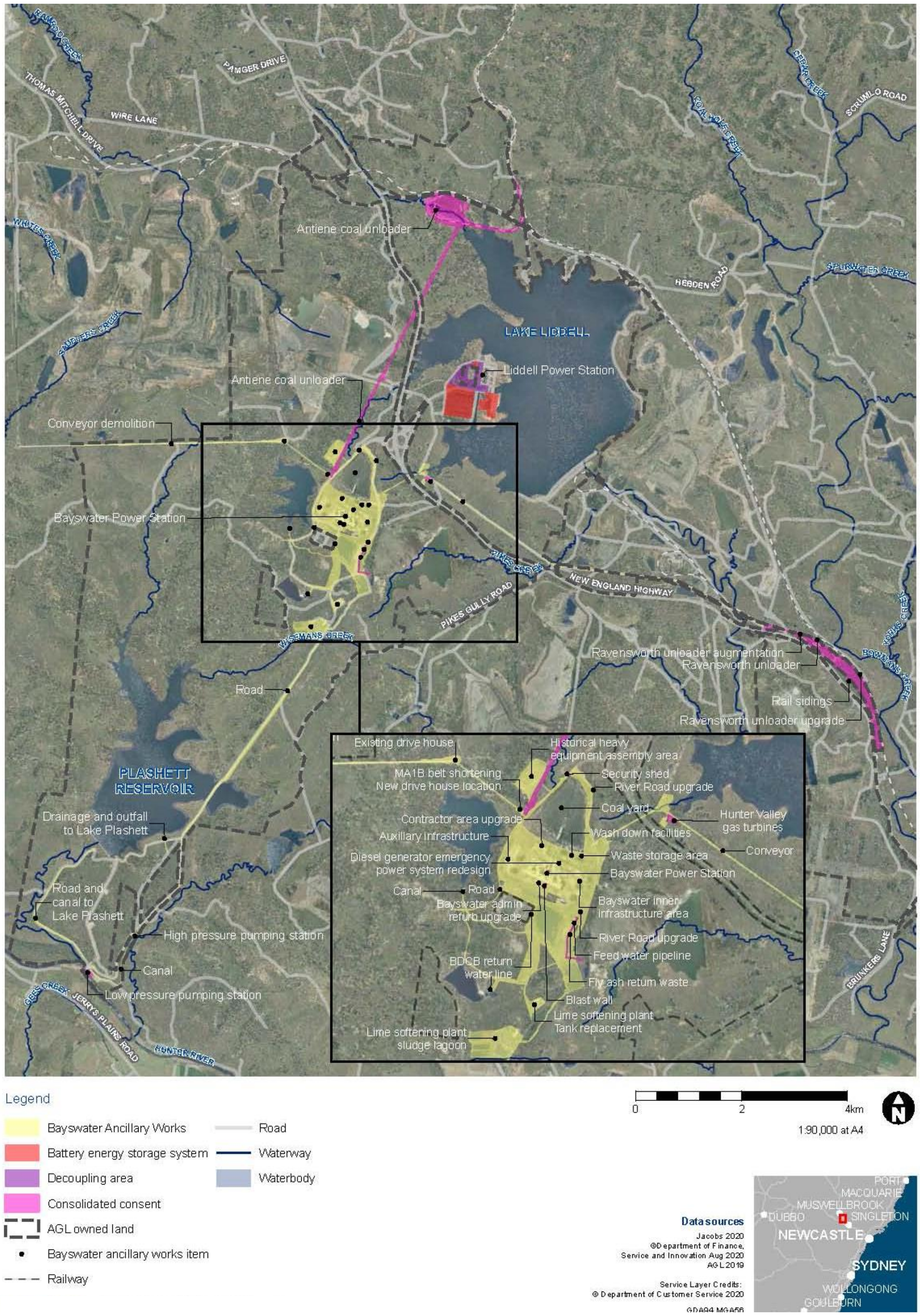
Figure 5 – Bayswater Ancillary Works



2.3.1 Battery

The Battery component comprises the following works:

- Construction and operation of the Battery with a nominal capacity of 500 MW for a four-hour period or up to 2 GWh; and
- Connection of the Battery facility to the Liddell 330 kV switchyards.

These works will involve the following:

- Lithium-ion (**Li-ion**) batteries inside battery enclosures (non walk-in, installed outdoors);
- Inverters including medium voltage transformers and switchgear / low voltage switchgear and interconnection;
- Cabling and collector units;
- Electrical connection between the Battery and transformer compound or TransGrid switchyard;
- Security fencing and lighting, access, internal roads;
- Drainage and stormwater management;
- Other ancillary infrastructure.

The batteries are connected to the Battery Management System (**BMS**), which provides a range of safety measures including preventing overcharging and current surges, maintaining voltage levels and ensuring the automatic cut-out in the event of electrical shorts, overheating or other unplanned events.

A Heating, Ventilating, and Air Conditioning (**HVAC**) system maintains the batteries in the enclosure within safe operational temperature limits.

An indicative Battery layout is provided in Figure 6.

Figure 6 – Indicative Battery layout

2.3.2 Decoupling works

The existing Liddell 33 kV switching station currently receives 33 kV supply via overhead feeders from Liddell's existing 330/33 kV station transformers.

At the closure of Liddell, a new connection between the TransGrid 330 kV switchyard and the Liddell 33 kV switching station is required to facilitate ongoing power supply to assets that are common to both Bayswater and Liddell, as well as some third party entities. The purpose of Decoupling is to ensure continuity of supply of power to the Liddell 33 kV switching station.

The Decoupling works include the following:

- Establishment of a new 330/33 kV transformer compound adjacent to the TransGrid 330 kV switchyard (*switchyard*)
- Installation of new switch/control room building/s, and equipment located within 200 metres of the existing Liddell Transition Point (33 kV feeders *730* and *731* underground to overhead (***UGOH***)) inclusive of auxiliary supplies
- Installation of two 330/33 kV station transformers adjacent to the switchyard
- Installation of new 33 kV cables to connect the 330/33 kV station transformers to the existing 730 and 731 33 kV feeders to the new 33 kV switch room
- Connection to the TransGrid switchyard.

AGLM are exploring the opportunity to re-use Liddell 330/33 kV Transformers and other infrastructure as part of these works.

2.3.3 Bayswater Ancillary Works

The following elements are proposed for BAW:

- MA1B conveyor shortening
- Various environmental improvements (Environmental Uplift Program)
- Chemical storage tank upgrades (ferric chloride tanks)
- Brine Concentrator Return Water Pipeline(s)

- Waste storage area formalisation
- Emergency diesel generators upgrades

These elements have been assessed in this PHA for potential hazard and risk implications[1].

Further explanations are provided below.

Other components that fall outside of the scope of the PHA are the installation of axillary infrastructure; establishment of a cultural heritage storage area; upgrades to the contractor area and river road refurbishment/reconstruction.

MA1B conveyor shortening

The MA1B conveyor is used to carry coal overland at Bayswater. The proposed shortening involves the removal of approximately 1.1 km of the tail end section of the conveyor, leaving approximately 500 metres of conveyor. The tail pulley of the conveyor would be moved closer to the Antiene Check Weigh Bin within a new concrete foundation. The basins located near the Check Weigh Bin would be used for the containment of coal fines.

Environmental uplift program

Various environmental improvement projects are proposed which are associated with existing infrastructure at identified high risk areas such as the lime softening plant, water treatment plant and demineralisation plant including the installation, replacement or relocation of environmental controls such as bunding, diversions, drainage, pipes, pits and waste management structures. These upgrades are required to ensure the on-going maintenance, as well as safe and continued operation of existing infrastructure across the site.

Apart from the replacement of the existing ferric chloride tanks with two new polyethylene tanks, discussed further below, the environmental uplift program would not involve any new or changed storage or handling of DG or interconnection with such storage or handling. Therefore, no new hazards associated with these works have been identified.

[1] The ammonia upgrade, initially communicated to the NSW DPIE and included in the Project scoping report, has been removed from the Project scope and therefore also excluded from the PHA.

Chemical storage tanks upgrades

The upgrade involves the replacement of the existing two 27 kilolitres (**kL**) rubber lined ferric chloride steel tanks with two new 30 kL polyethylene tanks. The new tanks will be contained within the existing lime softening plant on hardstand.

Operation of the new ferric chloride tanks is assessed in this PHA. Disposal of the redundant ferric chloride tanks will follow well AGLM established environmental protocols, including the AGL Waste Standard. With appropriate decontamination of redundant equipment, off-site risk of ferric chloride release during transportation is considered non credible and not included in the PHA.

Brine Concentrator Return Water Pipe

This work includes either the installation of new pipeline(s) or the upgrade of the existing pipeline to allow for brine to be returned from the Brine Concentrator Decant Basin to the Brine Concentrator. A new pipeline would consist of approximately 2.5 to 3 kilometres of pipeline(s). Photographs of the existing brine pipeline are provided below, for information.

Figure 7 - Existing brine concentrate pipeline (looking South)

Figure 8 - Existing brine concentrate pipeline (looking North)

Waste storage area

A formalised waste storage area is proposed for storage of hydrocarbons, oils and greases and other wastes. The waste storage area will comprise environmental controls such as bunding, runoff management and roofing.

Emergency diesel generators

Three new 415 Volt (**V**) diesel generators are proposed to replace ageing generators. The purpose of the upgrade is to provide a more robust and reliable supply of emergency backup power to critical equipment on the site, while providing a safe operating environment.

Two of the generators would be located just outside the existing diesel generator building and connected to the existing 6.6 kV network via the existing 415 V/6.6 kV step up transformers. The third diesel generator would remain connected to the 1/2 end 415 V diesel generator switchboard via a change-over switch so that power can be supplied from the third DG or via the 6.6kV network.

The diesel generator fuel oil is stored in day-tank(s) which are located close to the generators. The day-tank(s) would be made up from the large fuel storage tank in the tank farm (e.g. the 'A' Fuel Oil Tank), with a capacity in excess of 1 million litres.

2.4 SITE OCCUPANCY AND OPERATIONAL WORKFORCE

Bayswater and Liddell operate continuously with on-site personnel 24 hours per day. There will be no change to current operating hours at Bayswater as a result of the Project.

The Battery would be available to operate at least once per day. A typical daily cycle would include an approximate six hours of charging and four hours of discharge availability. The typical operating scenario is expected to involve one cycle per weekday with weekend operation subject to National Electricity Market (**NEM**) requirements.

Battery operations and maintenance status would be supervised remotely by existing AGL and / or the Original Equipment Manufacturer (**OEM**) personnel. Routine inspections and maintenance of the Battery would be undertaken on a regular basis (as per manufacturer's recommendations) with repairs, undertaken on an as needs basis, by contractors.

The Battery compounds and asset protection areas would be maintained in accordance with existing site management arrangements.

The Decoupling works are necessary to enable the closure of Liddell. It is anticipated the current operational workforce at Bayswater would be used for overall operation of the Project. Major maintenance and repair work may require contractors.

2.5 Licences and Permits

The Hazardous Chemicals Manifest for Bayswater (Ref 4) requires updating as a consequence of the increase in ferric chloride storage resulting from the replacement of the 27 kL tanks with the 30 kL tanks. This change will need to be communicated to SafeWork NSW.

All Environment Protection Authority (**EPA**) related licences/permits for safe transportation and handling of DGs and other products associated with this Project will be held by AGLM as well the contractors/sub-contractors who will be undertaking the works. This will be managed using AGLM's internal processes for the management of contractors, as per the AGLM corporate standard and the AGLM Contractor HSE Management Methodology.

2.6 Significant design standards, guideline documents and regulatory compliance

The significant statutory framework, Acts, codes, standards and guidelines that apply to ensuring the safety of the Project and that form the basis of this PHA are listed below. Only those that are directly related to the PHA are included.

The full list of relevant Acts, Codes and Standards will be identified by the AGLM Engineering Contractor selected for each element of this Project, with the Engineering Contractor ultimately responsible for nominating the applicable Standards and Codes.

2.6.1 Acts and Regulations

- NSW Work Health and Safety Act 2011 and Regulation 2017
- NSW Electricity Supply Act 1995, Electrical Supply (General) Regulation 2014 and Electricity Supply (Safety and Network Management) Regulation 2014
- NSW Environmental Planning and Assessment Act 1979 and Regulations 2000

For a detailed discussion on the regulatory environment for the Project, please refer to the EIS.

2.6.2 Governmental Policy and guideline documents

- Guidelines for *Hazard analysis,* 2011 (Ref 1)
- Guidelines for *Multilevel risk assessment,* 2011 (Ref 2)
- State Environmental Planning Policy No 33, 1992 (SEPP33, Ref 5)
- Guidelines for *Applying SEPP 33,* 2011 (Ref 6)
- Planning for Bushfire Protection, 2019 (Ref 7)

2.6.3 Codes and standards

Numerous codes, standards and protocols are relevant (including documents created by Standards Australia, (US) National Fire Protection Association (**NFPA**), (US) Underwriters Laboratories (**UL**), Institute of Electrical and Electronics Engineers (**IEEE**), National Electrical Manufacturers Association (**NEMA**), International Electrotechnical Commission (**IEC**), United Nations (UN), and Battery Safety Organization (**BATSO**). It is beyond the scope of this report to discuss all National and international codes, standards and protocols; however, a summary of the many codes, standards is provided below. Please also refer to the notes below the table.

Table 1 – Significant Standards and Codes of practice

Safety aspect	Example of relevant standard
	Battery
Australian standards	AS/NZS 5139:2019, *Electrical installations — Safety of battery systems for use with power conversion equipment* (Ref 8)
	AS 1670: *Fire detection, warning, control and intercom systems*
	AS 1939 *Degrees of protection provided by enclosures (IP Code)*
	AS 3439-2002 *Low voltage switchgear and control gear assemblies*
	AS/ IEC 60364 *Low Voltage Installation - Fundamental principles, assessment of general characteristics, definitions*
	AS/ IEC 61439-1 & 2 *LV switchgear*
	AS/NZS 2430.3 *Classification of hazardous areas (all parts)*
	AS / IEC 62619 *Safety requirements for secondary lithium cells and batteries, for use in industrial applications* (Ref 9)
	AS 61508 *Functional safety of electrical/electronic/programmable electronic safety-related system*
	ASC/ESC 5000: *The Australian Battery Guide by the Energy Storage Council*
	AS 3959-2009 *Construction of buildings in bushfire prone areas*

Safety aspect	Example of relevant standard
Other Codes, for reference only	NFPA 855 *Standard for the Installation of Stationary Energy Storage Systems* (Ref 10)
	NFPA 68 *Standard on Explosion Protection by Deflagration Venting*
	IEC 62933 *Electrical energy storage (EES) systems (IEC 62933-5-1 for safety considerations)*
	IEC 62116 *Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures*
	IEC 62897, *Stationary Energy Storage Systems with Lithium Batteries – Safety Requirements*
	EN 13501-2 *Fire classification of construction products and building elements. Classification using data from fire resistance tests, excluding ventilation services*
Testing and evaluating Battery	e.g. UL standards: - UL 9540 *Standard for Energy Storage Systems and Equipment, for the basis for documenting and validating the safety of an ESS as an entire system or product* - UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, for a test method for evaluating thermal runaway propagation in battery ESS*
Decoupling works	
Australian Standards	AS 2067 *Substations and high voltage installations exceeding 1 kV a.c*
	AS 2374.1-1997 *Power transformers Part 1: General*
	AS 3000:2016 *Australian Wiring Rules*
	AS/ IEC 60076 *Transformer*
	AS/ IEC 62271-200 *MV switchgear*
	AS 1670: *Fire detection, warning, control and intercom systems*
	AS 1939 Degrees of protection provided by enclosures (IP Code)
	AS 3959-2009 *Construction of buildings in bushfire prone areas*
Industry Codes, for reference only: Ausgrid	Ausgrid NS112 *Design Standards for Industrial and Commercial Developments*
	Ausgrid NS130 *Specification for Laying Underground Cables*
	Ausgrid *Electrical safety rules*
	Ausgrid NS116 Design Standards for Distribution Equipment Earthing
	Ausgrid Bushfire Risk Management Plan (Ref 11), which incorporates the provisions of ISSC 3 Guideline for Managing Vegetation Near Power Lines, Networks NSW Vegetation Management Common Requirement (VMCR), ISSC 31 Guideline for the Management of Private Lines and ISSC 33 Guideline for Network Configuration during High Bushfire Risk Days into this Plan

Safety aspect	Example of relevant standard
MA1B conveyor shortening	
Australian Standards	AS 1755 Conveyors—Safety requirements
	AS 4024 Safety of machinery
	AS 4100 Steel structures
Chemical storage tank upgrades	
Australian Standard	AS 3780 The storage and handling of corrosive substances
Brine concentrator return water pipe	
Australian Standards	AS 3780 *The storage and handling of corrosive substances* (may be appropriate even though brine may not be corrosive)
	AS 1345: *Piping* AS 4041: *Pressure Piping*
Waste storage area (oils, greases, hydrocarbons)	
Australian Standards	AS 1940 The storage and handling of flammable and combustible liquids
	AS/NZS 2906 Fuel containers – portable – plastics and metal
Emergency diesel generators	
Australian Standards	AS 1940 The storage and handling of flammable and combustible liquids
	AS/NZS 1851 Maintenance of fire protection equipment AS/NZS 1850 Portable fire extinguishers

Notes:

- The Australian Standard AS 5139 (2019) has recently been developed and provides the basis for the safety and installation of the Battery in Australia where the individual unit is equal to or less than 200 kWh. The requirements under AS 5239 (2019) should be adhered to, where applicable, including Section 6 which refers to IEC 62619 (Ref 9).
- The US National Fire Protection Association Code NFPA855 (2020) provides the minimum requirements for mitigating the hazards associated with Li-ion Battery of at least 20 kWh[2]. The requirements under NFPA855-2019 and AS5239-2019 align in many important areas, and it is recommended that the intent of the (US) NFPA855 be adhered to, where practicable.

[2] upper limit appears to be set at 600 kWh for one battery array – to be confirmed in the detailed design

2.7 MAIN DESIGN PARAMETERS FOR THE BATTERY

Design parameters for the Battery is provided below.

Table 2 – Design parameters for the Battery

Project element	Design parameter
Discharge capacity	Up to 500 MW
Storage capacity	Up to 2000 GWh or four hours of maximum discharge capacity
Typical operating cycle	250 cycles per year (once per weekday) with weekend operation to address network requirements charging and discharging directly from and to the NEM
Battery round trip efficiency	82 percent (71% including system losses associated with network connection)
Components[3]	Approximately: ▪ 1335 pre-assembled battery enclosures containing Li-ion type batteries[4] and internal cooling ▪ 740 inverters ▪ 630 V to 33 kV step-up transformers ▪ Four control / switch rooms ▪ Underground 33 kV cable to connect to 33 kV/330 kV Transformer Compound (refer to Decoupling works for Transformer Compound description) ▪ Four 33 kV / 330 kV transformers ▪ Ancillary infrastructure including water tanks for bushfire protection purposes, lightning protection, security fencing and closed-circuit television (**CCTV**). Numbers provided are indicative only.
Dimensions	Battery compound of approximately 20 ha which may be established as smaller parcels within the overall Project footprint. Each compound would include: • Battery enclosures with approximate dimensions of 2.9 metres in height and a footprint of 3 by 2.4 metres each arranged in groups and housing Li-ion type battery cells, associated control systems and HVAC units • Inverters and transformers with approximate height not exceeding 3 metres • Control / switch room buildings with approximate height of up to 4 metres.

[3] The approximate component requirements to achieve the maximum storage capacity for the Battery has been calculated with reference to potential technology providers

[4] Batteries will be of lithium iron phosphate (LFP) design

3 SEPP 33 Screening

3.1 Overview

The objective of the risk screening in the Multilevel Risk Assessment guidelines (**MLRA**, Ref 2) as well as in the Applying State Environment Planning Policy No 33 (Applying SEPP 33, Ref 6) is to determine whether the project is considered as *potentially hazardous*' in the context of SEPP 33 as per the definition:

> *'Potentially hazardous industry' means a development for the purposes of an 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 (Ref 1) to determine the risk to people, property and the environment. If the residual risk exceeds the acceptability criteria, the development is 'hazardous industry' and may not be permissible within NSW.

The risk screening process in both the MLRA and SEPP 33 (Refs 2 and 6) 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 DG classification. Detail of the DG classification is typically obtained from the materials' SDS.

The *Applying SEPP 33* guideline is based on the 7.7th edition of ADGC (Ref 12) 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 MLRA and in the Applying SEPP 33 guideline (Ref 6) as well as the qualitative considerations of *other* aspects to be considered as part of SEPP 33 screening. The screening threshold presents the quantities below which it can be assumed that significant off-site risk is unlikely.

As such, those facilities that are unlikely to present significant off-site risk can be filtered out from the rest of the PHA, and the PHA can focus on those risks that may have significant off-site risks.

3.2 Results

The results of the MLRA and SEPP 33 screening can be found in the following table:

- Table 3, for DG storage
- Table 4, for DG transport
- Table 5, for Other aspects (as per SEPP 33)

3.3 Findings and conclusion

The main findings of the SEPP 33 risk analysis are as follows:

- The storage of hazardous materials for the project will not exceed the relevant risk screening threshold with the exception of the storage of ferric chloride.
- The transport of hazardous materials for the project will not exceed the relevant risk screening threshold during the operational phase. If the construction period is concluded within one year then the risk screening threshold would be exceeded during this period.
- *Other risk factors* (as per MLRA and SEPP 33) identified that could result in off-site impacts and that therefore require further assessment are:
- Uncontrolled reaction or decomposition within the Li-ion batteries forming part of the Battery;
- Environmental impact if there is a loss of containment from brine pipeline(s), emergency diesel generators, cooling water from the Battery or oil from transformers;
- Potential for fire and/or generation of dust and explosion as a result of the MA1B conveyor shortening.

Further to this, adopting a cautious approach, the following aspects need to be assessed:

- The possibility of a bushfire or other events initiating a hazardous incident associated with the Project;
- The effect of the Project on EMF levels in the area.

Table 3 - SEPP 33 risk screening summary - Storage

Hazardous material	DG Class & Packaging Group	Category	UN number	HAZCHEM Code	Existing quantities	New (proposed) quantities	SEPP 33 threshold (tonne)	Exceed threshold?
Diesel[5]	DG Class 3 PGIII (ADG) Or DG9 or C1 e.g. as in Caltex SDS	Flammable liquid (ADG) Or combustible liquids e.g. as in Caltex SDS	1202 3082	3Y	Assume $2m^3$ per generator, with 2 generators in one area and one separate. Max 3.3 tonnes in one area; 5 tonnes in the aggregate		For distance to boundary exceeding 10 metres: 100 tonnes	Does not exceed SEPP 33 threshold[6]
Waste oils, greases	Assumed DG3 PGII as worst case	Flammable liquid as worst case	1202 / 1203[7]	3Y / 3YE	Assume less than 100 tonnes of DG3 PGIII / PGII (less than 140kL worst case, assuming 100% petrol)			Does not exceed SEPP 33 threshold[6]
Oil in the transformers	Not a DG	Combustible liquid C1 (AS 1940)	N/A	N/A	About 50,000 Litres (45-50 tonnes) tonnes	About 50,000 Litres (45-50 tonnes)	Combustible liquid C1 is not classified as potentially hazardous material in SEPP 33	No SEPP 33 threshold available

[5] E.g. Caltex SDS specifies specific gravity of 0.83 for diesel

[6] Sufficient separation exists between diesel and waste oil storages that they can be assessed separately

[7] UN1202 (gasoil, diesel) / UN1203 (petrol, gasoline). HAZCHEM Code UN1202: 3Y / UN1203: 3YE

Hazardous material	DG Class & Packaging Group	Category	UN number	HAZCHEM Code	Existing quantities	New (proposed) quantities	SEPP 33 threshold (tonne)	Exceed threshold?
Ferric chloride (aq. solution)	DG Class 8 PGIII	Corrosive substance	2582	2X	2 x 27 kL (78 tonnes[8]) Note: Ferric chloride (aq.) is also stored in other locations within the Bayswater and Liddell site, well separated from these tanks, with no identified interaction between tanks	2 x 30 kL (87 tonnes[8])	50 tonnes	Exceeds the SEPP 33 threshold
Li-ion batteries The electrolyte is largely absorbed in electrodes, such that there is no free or "spillable" electrolyte within individual sealed cells. There is cooling water which is classified as DG9	DG Class 9	Miscellaneous dangerous goods	3480-3481	2Y	0	Each battery unit weighs approximately 15.8 tonnes but only part of this is Li-ion. Exact weight of Li-ion is not known at this stage and does not impact on the findings	Li-ion storage is not classified as potentially hazardous material in SEPP 33	No SEPP 33 threshold available

[8] IXOM SDS specifies specific gravity of 1.45 for ferric chloride solution

Hazardous material	DG Class & Packaging Group	Category	UN number	HAZCHEM Code	Existing quantities	New (proposed) quantities	SEPP 33 threshold (tonne)	Exceed threshold?
Brine pipeline	Not considered as a DG as per ADG Code (Ref 12)		N/A	N/A	650,000m^3 in brine concentrator decant basin	No change	Brine is not classified as potentially hazardous material in SEPP 33	No SEPP 33 threshold available

Table 4 - SEPP 33 risk screening summary - Transport

Hazardous material	DG Class and Packaging Group	Category	Vehicle movements		SEPP 33 threshold (tonne)	Exceed threshold?
			Cumulative annual	Peak weekly		
Li-ion batteries	DG Class 9	Miscellaneous dangerous goods	Ongoing operations: Zero During construction: Up to 1,500 deliveries of Li-ion battery enclosures	Ongoing operations: Zero During construction: Up to 320 deliveries of Li-ion battery enclosures[9]	>1,000 (annual) >60 (peak weekly)	Does not exceed SEPP 33 threshold during operational phase. It is however possible that SEPP 33 threshold is exceeded during the construction phase if it is concluded within 1 year

[9] If construction is concluded within one (1) year. The Traffic assessment (EIS) found that the Project would generate an additional 46 heavy vehicles during the morning and evening peak hours during construction. While these vehicles are unlikely to be all for batteries, as a worst case the PHA assumed a weekly peak of 7x46 = 322 vehicles carrying batteries

Hazardous material	DG Class and Packaging Group	Category	Vehicle movements		SEPP 33 threshold (tonne)	Exceed threshold?
			Cumulative annual	Peak weekly		
Diesel	DG Class 3 PG III or DG9 or C1 depending on supplier	Flammable liquid Or combustible liquids	Much less than the threshold of 1,000 vehicles (no substantial change expected from existing operation)	Much less than the threshold of 60 vehicles (no substantial change expected from existing operation)	>1,000 (annual) >60 (peak weekly)	Do not exceed SEPP 33 threshold
Waste oils	Assumed DG3 PGII (worst case)	Flammable liquid as worst case				
Oil in the transformers	Not a DG	Combustible liquid C1 (AS 1940)				
Ferric chloride (aq. solution)	DG Class 8 PGIII	Corrosive substance	Existing: 35-40 Proposed new: no substantial change	Existing: 1 Proposed new: no substantial change	>400 (annual) >30 (peak weekly)	Does not exceed SEPP 33 threshold

Table 5 - SEPP 33 risk screening summary - Other types of hazards

Other Types of Hazards	Applicable (Yes or No)	Details, where applicable	Requires further analysis
Any incompatible materials (hazardous and non-hazardous materials)	No	No incompatible materials identified for this Project	No

Other Types of Hazards	Applicable (Yes or No)	Details, where applicable	Requires further analysis
Any wastes that could be hazardous	Yes	Wastes can be hazardous. The waste area for hydrocarbons, greases, oils is assessed as part of the screening methodology for storages and transport in Table 3 above and found to not exceed SEPP 33 thresholds	No
The possible existence of dusts within confined areas	Potentially yes	Shortening of the Conveyor may potentially lead to dust ingress into areas where there was none previously (subject to detailed design). This may lead to fire and potentially to explosion	Yes
Types of activities the dangerous goods and otherwise hazardous materials are associated with (storage, processing, reaction, etc.) – if different to Table 1 above	No	No hazardous activities associated with DGs for this Project	No
Incompatible, reactive or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition	Potentially yes	Runaway reaction associated with Li-ion batteries has occurred in other similar industry in the past	Yes
Storage or processing operations involving high (or extremely low) temperatures and/or pressures	No	No extreme conditions with high (or extremely low) temperatures and/or pressures associated with this Project	No
Details of known past incidents (and near misses) involving hazardous materials and processes in similar industries	Potentially yes	Runaway reaction associated with Li-ion batteries has occurred in other similar industry in the past	Yes

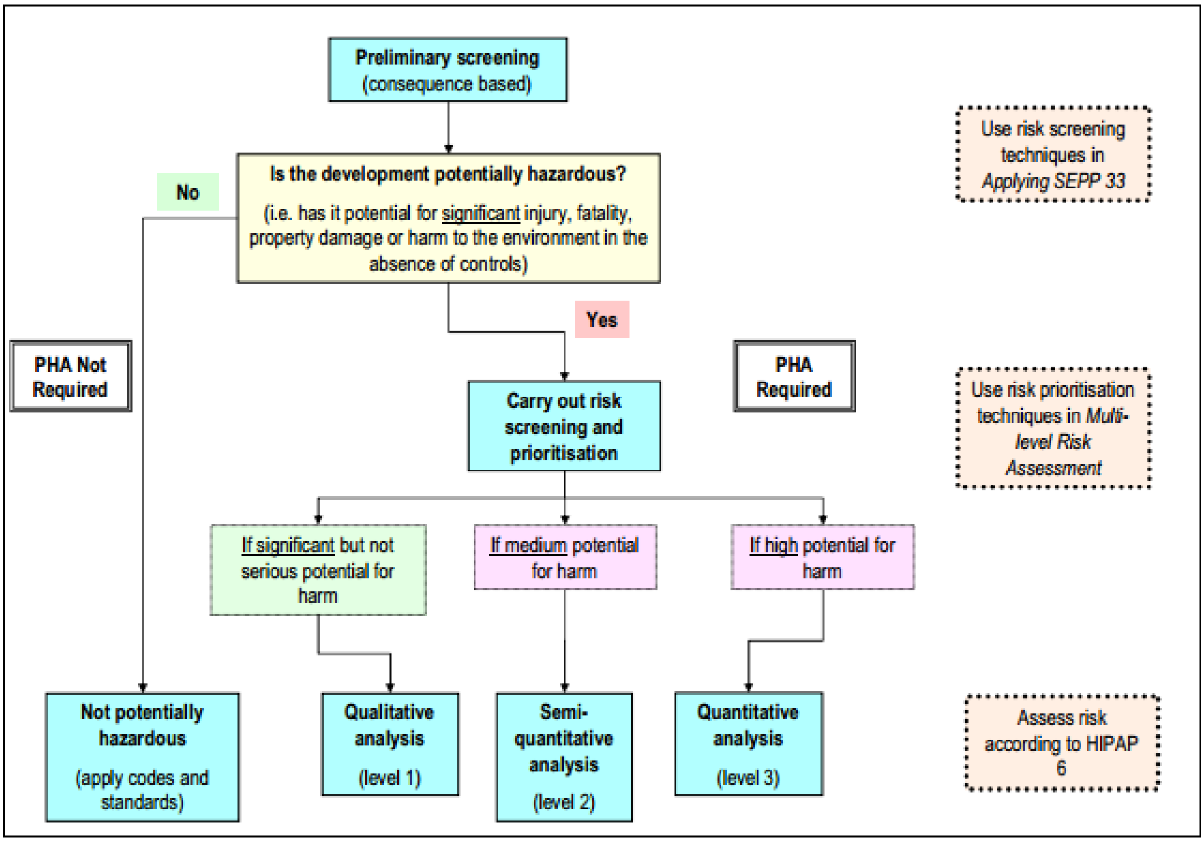
Other Types of Hazards	Applicable (Yes or No)	Details, where applicable	Requires further analysis
The Project may threaten the particular qualities of the environment (for example, the likely presence of rare or threatened species, water courses, etc.)	Yes	Some areas of the Project are located in close proximity to protected vegetation listed species and water courses if spills are not contained: - The brine pipeline(s), if damaged or leaking, may cause an environmental impact to the surrounding environment. - Overfilling the emergency diesel generators may threaten water courses if spills are not contained. - Information available for the Battery and for transformers (containing oil) is such that environmental pollution cannot be ruled out in case of spill.	Yes
The nature of the hazards that the environment will be exposed to, and the likely response of the environment to such a hazard, and the reversibility of any hazardous impact	Potentially yes	As above.	Yes

4 RISK CLASSIFICATION AND PRIORITISATION

4.1 OVERVIEW OF THE METHODOLOGY

This process, as demonstrated in Figure 4, begins by prioritising risks with any significant potential to harm people, property or environment for further analysis.

Figure 9 - Multi-level Risk Assessment process as presented (Figure 3 Ref 2)



The method is based on the Manual for the classification and prioritisation of risks due to major accidents in the process and related industries (IAEA, rev. ed. 1996). This method is risk-based and relies on broad estimations of the consequences and likelihoods of accidents. The outputs may be expressed in terms of individual and societal fatality risk which can be compared against criteria for determining the appropriate level of further assessment.

Using these criteria, the indicative level of risk, as determined in the risk classification and prioritisation stage, may lead to three possible outcomes:

- a level 1 assessment can be justified if the analysis of the facility demonstrates societal risk in the negligible zone and there are no potential accidents with significant off-site consequences
- a level 2 assessment can be justified if the societal risk estimates fall within the middle ALARP zone and the frequency of risk contributors having off-site consequences is relatively low
- a level 3 assessment is required where the societal risk from the facility is plotted in the intolerable zone or where there are significant off-site risk contributors, and a level 2 assessment is unable to demonstrate that the risk criteria will be met.

4.2 Results

The assessment found that the worst-case consequence for the identified events is a fire event associated with the Battery initiated through a thermal runaway or an electrical fault inside the battery. This would generate heat and toxic gas and combustion products.

A major fire associated with the Battery or the Decoupling works has the potential to propagate to areas outside of the site and initiate a bushfire. Provided sufficient separation distances are established between the Project infrastructure and the surrounding bushland - through the establishment and maintenance of an APZ - the risk is Low and can be managed ALARP.

The final high consequence events relates to a failure to capture a loss of containment of brine from the new pipeline(s), and diesel or oil from the emergency diesel generators or the transformers. Subject to detailed design, the potential for a major loss of containment of cooling water in the Battery has also been included. The detailed design stage needs to ensure that risks are managed to ALARP levels and that the risk of runoffs into local surface waters and groundwater systems or ground pollution is eliminated where possible or reduced to Low if elimination is not possible.

None of the consequences of potential hazardous incidents associated with the Project have a potential to any significant societal risk of harm to people outside of the site boundary, and a Level 1 assessment can be justified.

The Project risks would be considered in any future development of surrounding lands by AGLM or third parties as part of the approval process for those projects. However, the Project is not considered likely to restrict the types of development compatible with current zoning or likely future uses across the site from the point of view of hazards and risks.

5 Risk Analysis and Assessment

5.1 Hazard Identification

The hazard identification consists of the following steps:

1) List of hazardous properties of materials - Section 5.1.1

2) Identification of potentially hazardous incidents and their control - Section 5.1.2 and Appendix 3

The steps are presented below.

5.1.1 Material hazardous properties

The relevant properties of the following hazardous materials are detailed in Table 6:

- Ferric chloride
- Li-ion
- Brine
- Dust at the MA1B conveyor
- Diesel and other petroleum products

Table 6 – Summary of main materials hazards

Material	Description and potential hazards
Ferric chloride (Ref 13)	A corrosive (DG8 PGIII) aqueous solution of 30-50% of ferric chloride in water. Dark red colour. pH,2 Severely corrosive to skin and eyes. Hazardous if inhaled (e.g. mists) or ingested. Slippery when spilt. Not combustible, however may decompose into hazardous gases including hydrogen chloride (**HCl**) if involved in a fire. Hazchem or Emergency Action Code: 2X Runoff to drains and local waterways would cause pollution. Reacts exothermally with alkalis. Reacts with metals liberating flammable hydrogen gas

Material	Description and potential hazards
Li-ion batteries	Li-ion batteries can fail in thermal runaway. When in thermal runaway, Li-ion batteries can generate combustible gases and compounds. In an enclosed or localized area, these gases can explode, causing severe equipment damage. If humans are exposed to the fire or explosion conditions, it could lead to their injury or death. There can also be human exposure to hazardous voltage or arc-flash. Under normal conditions batteries do not exhaust vapours and cell electrolyte should not be encountered by persons handling a Li-ion battery on a day-by-day basis. Furthermore, in most commercial cells, the electrolyte is largely absorbed in electrodes, such that there is no free or “spillable” electrolyte within individual sealed cells. In those instances, severe mechanical damage (e.g., severe crushing) can cause a small fraction of total electrolyte quantity to leak out of a single cell; however, released electrolyte is expected to evaporate rapidly (Ref 14), subject to findings in the detail design
Brine	An uncontrolled release of brine could have an impact on the environment due to the high concentration of salts and other pollutant contents such as corrosion inhibitor dosing at the brine recovery pump station (sodium bisulfite) and hydrocarbons
Diesel and other petroleum products	If a spill reaches surface water, petroleum products can kill aquatic wildlife. Diesel fuel and gasoline are flammable and pose a serious fire hazard if not contained
Dust from MA1B conveyor	Fugitive coal dust present in the air can be hazardous to people through inhalation causing build-up in lungs. Fugitive dust is also a risk factor for fire and potentially dust explosions

5.1.2 Identification of potential hazardous incidents and their control

Overview

A rigorous hazard identification has been conducted for the Project in order to identify all reasonably foreseeable hazards and associated events that may arise during the operation of the facilities and the proposed management of the said hazards. This step includes a systematic and structured hazard identification workshop, attended by experts from the operations group (AGL Energy and AGLM) and lead by the Planager risk specialist. Further information on the workshop, including team composition and timing, is included in Appendix 3. Additionally, consultation with stakeholders has been conducted as part of the risk management process, including with DPIE’s Hazard Branch.

Prior to the workshop, desktop research was undertaken by Planager for input to the hazard identification study, included literature review of Codes, Standards and guideline documents; incidents that have occurred in similar Projects, in particular for the Battery that are emerging technologies in Australia; learnings from these incidents; and controls and management practices that are used and developing in Australia and, for reference only, internationally.

During the workshop, the following aspects were discussed:

- Identification of the potentially hazardous event;
- Listing of causes and threats which may give rise to the event;
- Determination of possible consequences, effects and impacts (immediate and ultimate) with no controls in place;
- Listing of existing and proposed new controls, which would prevent the cause from occurring, protect against the consequences, and/or limit the exposure to sensitive receptors;
- Additional controls proposed to improve management of the risk associated with the event.

The outcome of the workshop and subsequent research is formally documented in the *Hazard identification word diagram* in Appendix 3, in accordance with DPIE's methodology (HIPAP6, Ref 1). The following factors were considered to identify the hazards:

- Project infrastructure, location, workforce etc;
- Type of equipment and known events that have occurred elsewhere;
- Materials and energies, properties and associated hazards;
- Proposed operation and maintenance activities and potential threats;
- External factors.

Listing of potentially hazardous incidents

An overview of the types of hazard that are identified for each Project element is presented in Table 7 below. Only those hazards that may give rise to risks in accordance with DPIE's HIPAP6 (Ref 1) are included (i.e. risks confined to the site are excluded).

A summary of the identified hazardous events is provided in Table 8. Details of the hazardous events, causes, consequences and controls are presented in the *Hazard identification* word diagram in Appendix 3.

Table 7 – Overview of types of hazards for each Project element (HIPAP6 hazards)

Project element	Electrical hazards	Energy hazard	Fire hazard	Explosive hazard	Chemical/ pollution hazard	Toxic fume hazard	EMF	Reference (Section 2.6.3)
Battery	✓	Note 1	Note 2	Note 3	Note 4	✓	✓	AS 5139 / NFPA 855
Decoupling works	✓	✓	✓	✓	Note 4	✓	✓	AS 2067
BAW conveyor	-	Note 5	✓	✓ (dust)	Note 4	✓	✓	AS 1755
BAW ferric chloride	-	-	-	-	✓	-	-	AS 3780
BAW brine pipeline	-	-	-	-	Note 4	-	-	SDS
BAW waste storage	-	-	✓	-	-	✓	-	AS 1940
BAW diesel generators	✓	✓	✓	-	Note 4	-	✓	AS 1940

Notes:

1. Arc flash incident potential
2. Fire may be caused by thermal runaway, short circuit, over voltage / overcharge. Provided the Battery selected conforms to the *Best Practice Guide: battery storage equipment – Electrical Safety Requirements*, fire hazards may not be applicable (Ref 8).
3. The Battery that releases hydrogen under fault conditions is regarded as an explosive gas hazard (Ref 8).
4. Due to the presence of surface waters in the form of creeks etc. on the site, failure to contain a spill has a potential to cause off-site pollution.
5. The energy of the conveyor is such that it may take considerable time for it to stop on initiation of a shutdown mechanism – however, this risk is not within the scope of this PHA.
6. In addition to the potential hazards listed in Table 7, mechanical hazards are associated with each Project element, including hazards associated with weight, sharp edges and corners, moving parts, falling over / tripping / seismic, and lack of lifting or securing. These are not included as HIPAP6-type hazards and as such fall outside the scope of the PHA.

Table 8 – Summary of identified hazardous events

The Battery	MV & HV (330/33 kV and 33 kV) development
1) Thermal runaway within the battery with fire / deflagration / toxic vapours	5) Arc flash in MV cable reticulation network, substation, the Battery or transformers
2) Loss of containment of pollutant / irritant material from the Battery (cooling water with water treatment chemicals or oil from transformers) with potential exposure and pollution hazards	6) Exposure to voltage (MV and HV cable reticulation network, Substation, Transformers) leading to electrocution
	7) Fire in the transformers
3) Electrical fault inside the battery causing fire / deflagration / toxic vapours	8) Switch room fire
4) Exposure to voltage leading to electrocution	
BAW	**Site wide**
9) Maloperation of the modified conveyor MA1B	14) Bushfire impacts the new development or the development initiates a bushfire
10) Loss of containment of brine from the new pipeline/s for use to return brine from the Brine Concentrator Decant Basin to the Brine Concentrator	15) Exposure to electric and magnetic fields at the MV cable reticulation network, Substation, the Battery and Transformers
	16) Security breach
11) Loss of containment of ferric chloride (aqueous solution) from the new polyethylene tanks and associated piping	17) Lightning strike
	18) Water ingress / flooding
12) Loss of containment or fire at the new waste storage area for hydrocarbons, oils, greases	19) Earthquake or land subsidence causes structural failure of plant and equipment
13) Loss of containment or fire at / from the new emergency diesel generators	20) Onsite and off-site vehicular traffic impact e.g. due to wildlife interaction
	21) Wildlife interaction with live plant

5.2 Risk Analysis and Assessment

Classification of consequences and likelihoods of each hazardous event was conducted by Planager as an independent desk-top activity, using AGL's Risk Management and Assessment Standard. Risk classification was based on Planager's experience in similar industry and on literature reviews. The consequences levels determined were those without controls, and relate to the worst case credible event. The likelihoods assigned were those with controls, including those that already exist on site and have been defined in the preliminary design (including the commitments listed in Appendix 3) and the recommendations listed in Section 6.2.

The AGL Risk Management and Assessment Standard includes a set of consequence and likelihood scoring tables, presented in Appendix 2. Only considerations of risk to the environment, community, people and safety are included, as per DPIE's scope of PHA (Ref 1). The outcome of the assessment is presented in the form of a risk profile for the Project, as presented in Table 9. Details and discussion are provided in subsequent sections (Sections 5.2.1 to 5.2.12).

Table 9 – Risk profile for the Project

Hazardous incident / event	Consequence	Likelihood (with existing & recom-mended controls)	Risk	Potential off site effects (if Yes, carried over to Risk Analysis and Assessment)
The Battery				
1) Thermal runaway with fire and generation of toxic vapours	Level 4	Rare	Moderate	Yes - Section 5.2.1
2) Loss of containment of pollutant / irritant material from the Battery with potential exposure and pollution	Level 2	Rare	Low	Yes – Section 5.2.2
3) Electrical fault inside Battery causing fire	Level 4	Rare	Moderate	Yes - Section 5.2.1
4) Exposure to voltage at the battery leading to electrocution	Level 4	Rare	Moderate	No - local WHS hazard only[10]
MV & HV (330/33 kV and 33 kV) development				
5) Arc flash in MV cable reticulation network, substation, Battery or transformers	Level 4	Rare	Moderate	Yes - Section 5.2.3

[10] Only local effects and hence not carried through to further analysis

Hazardous incident / event	Consequence	Likelihood (with existing & recom-mended controls)	Risk	Potential off site effects (if Yes, carried over to Risk Analysis and Assessment)
6) Exposure to voltage leading to electrocution	Level 4	Rare	Moderate	No - local WHS hazard only[10]
7) Fire or pollution at the transformers	Level 4	Rare	Moderate	Yes - Section 5.2.3
8) Switch room fire	Level 4	Rare	Moderate	Yes - Section 5.2.3
BAW				
9) Maloperation of modified conveyor MA1B causes major consequences	Level 3	Rare	Low	Yes - Section 5.2.4
10) Loss of containment of brine from the new pipeline(s) for use to return brine from the Brine Concentrator Decant Basin to the Brine Concentrator	Level 4	Rare	Moderate	Yes - Section 5.2.7
11) Loss of containment of ferric chloride (aqueous solution) from new polyethylene tanks and associated piping	Level 3	Rare	Low	Yes - Section 5.2.6
12) Fire or pollution at new waste storage area for hydrocarbons, oils, greases	Level 3	Rare	Low	Yes - Section 5.2.5
13) Fire or pollution at from the new emergency diesel generators	Level 3 (WHS)	Rare	Low	Yes - Section 5.2.5
	Level 4 (Env)		Moderate	
Site wide				
14) Bushfire impacts new development or development initiates bushfire	Level 4	Rare	Moderate	Yes - Sections 5.2.1 & 5.2.9
15) Exposure to electric and magnetic fields at MV cable reticulation network, Substation, the Battery and Transformers	Level 3	Rare	Low	Yes - Section 5.2.8
16) Security breach causes major consequences	Level 3	Rare	Low	Yes - Section 5.2.10
17) Lightning strike causes major consequences	Level 4	Rare	Moderate	Yes - Section 5.2.9
18) Water ingress / flooding causes major consequences	Level 4	Rare	Moderate	Yes - Section 5.2.9

Hazardous incident / event	Consequence	Likelihood (with existing & recom-mended controls)	Risk	Potential off site effects (if Yes, carried over to Risk Analysis and Assessment)
19) Earthquake or land subsidence causes structural failure of plant and equipment	Level 4	Rare	Moderate	Yes - Section 5.2.9
20) Onsite or off-site vehicular traffic impact e.g. due to wildlife interaction causes major consequences	Level 4	Rare	Moderate	Yes - Section 5.2.11
21) Wildlife interaction with live plant causes major consequences	Level 4	Rare	Moderate	Yes - Section 5.2.12

The results show a consistently Low and Moderate risk profile:

- 15 are of *Moderate* risk, and
- 6 are of *Low* risk

The consequences of the *Moderate* risk events are consistently defined as Level 4, implying a serious injury or even fatality or significant, offs-site pollution. The likelihoods of all events (both Moderate and Low risk rating) can be designed and managed to Rare likelihood provided commitments to safety (Appendix 1) and recommendations in this PHA are implemented. This should be verified in detailed design.

The worst case consequences identified for the Project are associated with a fire event in the Battery initiated through a thermal runaway or an electrical fault inside one of the battery enclosures. The fire in a battery enclosure has the potential to propagate to areas outside of the site and to initiate a bushfire. Provided sufficient separation distances are established inside the Battery and between the Battery and the surrounding bushland (through an APZ) the risk of propagation is managed ALARP.

Other high consequence events relate to electrical fires and high energy events at the Battery or the 330/33 kV and 33 kV developments associated with Decoupling works. Again, provided sufficient separation distances are established between these electrical installations and the surrounding bushland (through an APZ) the risk is managed ALARP.

The final high consequence event relates to a loss of containment of brine from the new pipeline(s) or the diesel generators. The detailed design stage needs to prove that this risk is managed to ALARP levels. As a prudent approach, the potential for a loss of containment and environmental pollution from the Battery (cooling water or oil at the transformers) has also been included here – detailed design may find that this risk has been eliminated.

Details as to consequences, likelihood and risk is provided below together with ALARP justification in subsequent sections.

5.2.1 Fire at the Battery

Scenario number in Table 8 and Table 9: #'s 1, 3 and 14
Hazardous event: Fire at the Battery may be caused as an internal event, e.g. through uncontrolled reaction (e.g. thermal runaway), overcharge, short-circuit, damage or decomposition within the Li-ion batteries forming part of the Battery (events #'s 1 & 3) or as an external event such as a bushfire encroaching into the Battery (events # 14) or other causes (impact, earthquake, lightning etc.). Thermal runaway is triggered when the cell reaches a certain temperature (~160°C), the heat source could be external or internal (cell failure).
Consequences (immediate and ultimate): Two types of reactions occur: a conventional fire involving packaging material, cable insulation etc., and a thermal runaway reaction inside the cell by interaction of different chemicals. A fire event would generate heat, deflagration overpressure and toxic gas and combustion products. Depending on the design and manufacture of the Li-ion battery, projectiles or cell explosions in case of failure to vent off-gases may occur (Refs 10, 14). Toxic gas and combustion products formed during a fire event may contain decomposition products which can vaporise and be vented from cells, and the vented electrolyte may be flammable, and may ignite (Ref 14). Battery cell vent gas composition will depend upon a number of factors, including cell composition, cell state of charge, and the cause of cell venting. Depending on battery manufacture, vent gases may include volatile organic compounds (**VOCs**), hydrogen gas, carbon dioxide, carbon monoxide, soot, and particulates containing oxides of nickel, aluminium, lithium, copper, and cobalt, and phosphorus pentafluoride (**PF5**), phosphoryl fluoride (**POF3**), and hydrogen fluoride (**HF**) vapours (Ref 14). Vented gases may irritate the eyes, skin, and throat. Cell vent gases are typically hot and upon exit from a cell, can exceed 600 degrees Celsius (**°C**) (Ref 14). If the battery cells are located close to combustible material within the enclosure or if the enclosure is located close to other infrastructure there is a potential for escalation to the enclosure, to adjacent infrastructure and, potentially, escalation to the entire Battery. The result would be increasing generation of heat and toxic gases and combustion products. If the Battery is located close to the surrounding environment, including to neighbouring bushland, the fire may propagate to this, potentially initiating fire in the surrounding area. With the remote location of the Battery, the heat and toxic gases and combustion products generated by the fire involving only one battery / battery enclosure is unlikely to cause any hazardous effects off-site. If the fire continues to spread to other enclosures and more batteries then further hazardous effects may occur, potentially affecting land use outside of the site boundary. The battery enclosure design and the Battery layout must therefore be such that the potential for escalation between battery enclosures and other Battery infrastructures is minimised. Further, sufficient APZ must be established to ensure the risk of propagation to and from the surrounding bushland is minimised. Separation distances to minimise the risk

of propagation to adjacent infrastructure and to surrounding bushland will be established at detailed design, using, as one of the inputs, fire tests likely to have been conducted in accordance with Underwriters Limited UL9540A *Test Method for Evaluated Thermal Runaway Fire Propagation in Battery Energy Storage Systems* (Ref 15), refer also Recommendation #2 in this PHA.

Consequence ranking	Level 4: Serious injury or fatality.

Risk management strategy and likelihood:

The strategy for this Battery development is as follows:

1. Preventing, as far as reasonably practicable a thermal runaway or short circuit or other fault within the battery from occurring, as detailed in events #1 and #3 in the Hazard Identification Word Diagram in Appendix 3. This includes rigorous approach to design, testing, installation and maintenance of the battery and the battery management system including automatic shut down in case of any safe limits of voltage, current and temperature being exceeded.

   Strategies for the prevention of, and protection from, a bushfire are detailed in event #13 in Appendix 3, and include controls during construction, installation and maintenance as well as the establishment and maintenance of an APZ.

2. Minimising the consequences of a hazardous event through (subject to detailed design) installation of gas venting, fire barrier, deflagration panel/plate, and (if required) automatic fire quenching inside the enclosure if required in Codes and Standards/manufacturer's recommendations. Fitting of smoke and temperature sensors so that, if there is a fire/ smoke/ high temperature the module is isolated and shut down.

3. Ensuring that people inside the enclosure can escape through appropriate openings, and warnings in accordance with Codes and Standards, e.g. Building Code of Australia, and that people outside of the enclosures have sufficient space to move through and egress from the Battery. Access into the enclosure during a hazardous event is prevented, e.g., through visible annunciation fitted on the outside of the enclosure.

4. Ensuring sufficient separation between enclosures and to other Battery infrastructure such that a fire in a battery cell and potentially within an enclosure can be allowed to burn without the need for external fire-fighting to control escalation. The separation distance of the battery cell and between individual battery enclosures will be set during detailed design following the recommendations by the battery manufacturer and with reference to the relevant national and international Standards (e.g. NFPA 855, Ref 10).

   Note that the Battery is unmanned and personnel would only be in the Battery during inspection and maintenance activities.

5. The need for active firefighting measures will be determined during detailed design following recommendations by the battery manufacturer and in accordance with national and international Codes and Standards, e.g. NFPA 855, Ref 10. A Fire Safety Study will be developed in consultation with the RFS and the DPIE.

The commitments for safety for this Battery, as listed in Appendix 1 conform in general with the requirements in AS 5139 (Ref 8) and NFPA 855 (Ref 10), with further verification required in the detailed design stage.

A review of preliminary design against separation distances set in Standards and Codes shows as follows:

- The Battery site is large and should be able to be laid out such that sufficient separation between the Battery and external boundaries is achieved in order to minimise off-site risk.

  For example, NFPA855 (Ref 10) specifies a minimum of 30.5 metres (100 feet) between an indoor Battery with no / limited fire-fighting capability and *buildings, lot lines that can be built upon, public ways, stored combustible materials, hazardous materials, high-piled stock, and other exposure hazards not associated with electrical grid infrastructure.* A similar separation requirement has not been found in Codes and Standards for outdoor remote Battery. Further investigation is therefore required in the detailed design stage, and in consultation with the battery manufacturer, to determine the required buffer zones to the surrounding environment including establishment of an appropriate APZ.

- The APZ surrounding the Battery is to be defined through the application of a rigorous bushfire threat assessment to minimise the threat from a bushfire threatening.

- The separation distance between the battery enclosure and the inverters and other Battery infrastructure needs to be determined during detailed design to ensure that it (1) does not compromise the strategy of allowing a battery enclosure to burn without fire-fighting and (2) allows sufficient room for people to escape from the Battery. An estimate of the minimum footprint of the Battery, allowing for preliminary estimations of the required separation distances (as per Codes and Standards), is included in Appendix 4.

Likelihood ranking	Level 1: Rare provided the requirements in Codes and Standards are adhered to and the minimum separation distances between Battery infrastructure and APZ are established and maintained

Risk and ALARP evaluation:

A number of Codes and Standards are available for the Battery (see Section 2.6.3), providing detailed information on the required management of the battery inside the enclosure and the connection of the Battery to the electricity grid. Provided these requirements are met, the risk associated with each battery cell and battery enclosure can be managed ALARP.

Less information and guidance is available for the required separation between each battery enclosure and between the Battery and other infrastructure and the surrounding environment to minimise the risk of escalation of an event in one enclosure to other areas within and external to the Battery, including the initiation of a bushfire. Further guidance on separation distances will need to be sought with the Battery manufacturer, once selected. Also, the methods available in *Planning for Bushfire Protection* and in AS3959 *Construction of buildings in bushfire prone areas* apply, and the APZ determined for the Battery will help ensuring sufficient separation from the Battery to surrounding bushland. A preliminary estimation of the footprint of the site, allowing for separation distance in Codes and Standards to be applied, is presented in Appendix 4.

Provided minimum separation distances within the Battery and between the Battery and external boundaries is sufficient, as determined during detailed design in agreement with the Battery manufacturer, FRNSW and the Rural Fire Service NSW, and in accordance with the requirements in Codes and Standards, the risk associated with the Battery can be managed ALARP. Onsite hazardous effects are possible as a result of a battery fire, and the possibility of generation of toxic gas and toxic combustion products should be taken into account in emergency response procedures. Environmental pollution from run-off of firefighting medium is also possible and should also be taken into account in emergency response procedures. If large amounts of fire-fighting medium are to be applied during a fire-fighting operation then the containment of such fire-fighting medium must be included in the design of the Battery. The DPIE generally requires the containment of 90 minutes of fire-fighting medium (Ref 16) – this timeframe should be verified during the detailed design process.

Risk ranking	Moderate
ALARP justified provided requirements in Codes and Standards are adhered to and the minimum separation distances between Battery infrastructure and APZ are established and maintained	Yes

5.2.2 Loss of containment of pollutant / irritant material from the Battery

Scenario number in Table 8 and Table 9: #2
Hazardous event: Loss of containment of pollutant or irritant material from the Battery (cooling water from the batteries or oil from associated infrastructure, e.g. medium voltage transformers)
Consequences (immediate and ultimate) Consequences include pollution of ground and potential run-off into local creeks leading to environmental pollution if not contained, and possible injury from exposure to irritant material. Quantities are likely to be relatively minor, and with the application of Codes and Standards (e.g. AS1940 for oil), secondary containment, training and use of PPE, the WHS and environmental consequences are likely to be limited to Level 2 (to be verified in detailed design).

Consequence ranking	Level 2 (WHS / Env): Injury or illness that requires off site medical treatment / Minor impact extending beyond AGLM's operational area which is contained, and short term clean up

Risk management strategy and likelihood: Preventative and protective strategy includes stringent requirement for equipment selection, installation and maintenance including preventative maintenance and condition monitoring including voltage control, charge/discharge current control and temperature monitoring in compliance with relevant standards and guidelines. Automatic safety shut-off function in case of safe limits exceeded. Protection includes battery

housed in dedicated enclosure(s) with only restricted personnel allowed; PPE and Safety shower / Eye wash station. Spill clean-up using dry absorbent material and activation of PIRMP applies.

Likelihood ranking	Level 1: Rare, provided the requirements in Australian Standards, including AS 5139 and international standards, e.g. US NFPA 855 (for battery), AS 2067 (for transformers), and AS 1940 (for combustible liquids) AGLM and management practices are adhered to, and that the maximum size of pollutants from the battery enclosure can be captured within the enclosure or through other suitable manner of management

Risk and ALARP evaluation:

Detailed design to explore the risk management of the Battery, including the worst case size and retention of a potential spill of cooling water and other pollutant material at adjacent infrastructure, e.g. transformers.

Risk ranking	Low
ALARP justified provided the requirements in Australian Standards (including AS 2067) and management practices are adhered to and APZ is established and maintained and that the maximum credible spill at the batteries and transformers can captured	Yes

5.2.3 Fire and pollution at MV and HV infrastructure

Scenario number in Table 8 and Table 9: #'s 5, 7 to 8

Hazardous event:

Fire at the MV and HV infrastructure can be caused by electrical faults. Failure to capture and contain a loss of containment of oils may lead to environmental pollution

Consequences (immediate and ultimate):

Consequences include arc flash and other types of fire in HV/MV cable reticulation network, substation, Battery or transformers. Generation of heat and pressure waves may lead to burns, injury and/or fatality. There is also a potential for propagation to adjacent infrastructure and domino effects and further fire, release of toxic combustion products as well as exposure to intense light and noise.

Failure to contain a spill of oil may lead to pollution of ground and potential run-off into local creeks leading to environmental pollution. Quantities are likely to be relatively minor, and with the application of Codes and Standards (e.g. AS1940 for oil), secondary containment, training and use of PPE, the WHS and environmental consequences are likely to be limited to Level 2 (to be verified in detailed design).

Consequence ranking	Level 4 (WHS): Serious injury or fatality. Level 2 (Env.): Minor impact extending beyond AGLM's operational area which is contained, and short term clean up.

Risk management strategy and likelihood:

The infrastructure included in the decoupling works is well known and understood and essentially covered under Codes and Standard, including those listed under Section 2.6.3.

Preventative and protective strategy includes stringent requirement for equipment selection, installation and maintenance including preventative maintenance and condition monitoring including thermography and automatic shut-off if the safe window of operation is exceeded, e.g. using current limiting devices and shut-offs (trips) as per AS 2067 *Substations and high voltage installations exceeding 1 kV a.c.*

Protective barriers or solid covers as per AS 2067 requirements limit the extent of damage to arc flash and transformer fires. Fire suppression system will be determined during design e.g. deluge initiated through fusible link / fusible bulb or other at the transformers.

Secondary containment of oil, e.g. during unloading or handling of oil at the transformers will be as per Codes and Standards, e.g. AS 1940 for combustible liquids.

Likelihood ranking	Level 1: Rare provided the requirements in Australian Standards (including AS 2067 and AS 1940) and management practices are adhered to and APZ is established and maintained

Risk and ALARP evaluation:

Provided the requirements under the Australian Standards (including AS 2067 and AS 1940) and management practices in place by the Operator are adhered to, the risk associated with fire at the MV and HV infrastructure is managed ALARP. Provided adequate APZ is established and maintained, as determined through a rigorous bushfire threat assessment to the requirements under *Planning for Bushfire Protection* and AS3959 *Construction of buildings in bushfire prone areas*, it is unlikely that these hazardous events cause effect off site.

Risk ranking	Moderate
ALARP justified provided the requirements in Australian Standards (including AS 2067 and AS 1940) and management practices are adhered to and APZ is established and maintained	Yes

5.2.4 Dust fire and explosion at MA1B

Scenario number in Table 8 and Table 9: # 9

Hazardous event:

Fire or potential explosion involving dust is possible in any major conveyor handling coal dust in an industrial application

Consequences (immediate and ultimate):

A major conveyor belt or coal fire would generate heat and toxic combustion products which could potentially lead to structural damage to the conveyor, with subsequent potential for spillage and environmental damage if the failure leads to major, unmanaged loss of containment of coal.

Consequence ranking	Level 3: Medical treatment, temporary impairment.

Risk management strategy and likelihood: The MA1B conveyor has been operating safely for many years and the Operator is experienced in the management of coal and particulate matter. Further, conveyor safety is detailed in a number of Codes and Standards (refer to Section 2.6.3, including AS1755 *Conveyors—Safety requirements*. In addition, the AGLM has a Policy and procedures to ensure safe operation of plant and equipment under their control. The modification will be controlled under a change management system, and changes will be reviewed using detailed hazard identification techniques (e.g. HAZOP study, if determined as useful in this application).

Likelihood ranking	Level 1: Rare provided the requirements in Australian Standards (including AS 1755) and AGLM management practices for change management are adhered to

Risk and ALARP evaluation:

Provided the requirements under the Australian Standards AS 1755 *Conveyors—Safety requirements* and management practices in place by AGLM, including rigorous management of change and hazard identification, are adhered to it is unlikely that this hazardous event would cause off-site effects.

Risk ranking	Low
ALARP justified provided the requirements in Australian Standards (including AS 1755) and AGLM management practices for change management are adhered to	Yes

5.2.5 Fire and pollution at the waste oil area or emergency diesel generators

Scenario number in Table 8 and Table 9: #'s 12 and 13

Hazardous event:

Loss of containment and/or fire involving material stored at the new waste storage area for hydrocarbons, oils and greases is covered in event #12. Loss of containment and/or fire at the emergency diesel generators is covered in event #13

Consequences (immediate and ultimate):

The maximum sizes of the containers to be stored in the waste storage area is 20 kL per container with a total volume of less than 150 kL. With the bunding exceeding the total volume of stored material, a spill would be captured within the bund and off-site environmental pollution is not considered credible.

A maximum of 3.3 tonnes of diesel will be stored in each generator / 5 tonnes in the aggregate. However, if the diesel generators are fed from the fuel farm it is possible to overflow storage and exceed bunding capacity, potentially leading to off-site event, in particular seeing that one of the diesel generators is located in proximity to stormwater drains that flow directly to Tinkers Creek.

The use of fire-fighting medium could produce large amounts of polluted material (foam / water) which could run off and cause further pollution.

A fire involving flammable and combustible liquids would generate heat radiation and toxic combustion products. Exposure of nearby containers in the waste storage area to heat from the fire may cause damage and further spill and fire. Injury could occur if personnel are exposed to toxic combustion products or heat.

With the available separation distance to site boundary propagation of a fire to off-site locations is unlikely (Ref 6).

Consequence ranking	Level 3 (WHS): Medical treatment, temporary impairment. Level 4 (Env) for emergency diesel generators only: Localised area affected and extends beyond AGLM's operational areas which is contained medium term clean up.

Risk management strategy and likelihood:

Use of formal systems for the waste storage area and the emergency diesel generators including ensuring any spills can be contained and managed through the upgraded bunding, runoff management and roofing associated with these areas. If the diesel generators are to be fed from larger storages (e.g. from the fuel farm) then the likelihood of a failure to stop filling and cause overflow must be designed to Rare level. This is likely to require an independent automated shut-off, including cut-off valves, when the desired fuel level has been reached.

Likelihood ranking	Level 1: Rare provided the requirements in Australian Standard AS1940 and AGLM management practices for change management are adhered to. If the emergency diesel generators are to be fed directly from the fuel farm, it is likely that automatic and independent cut-off of diesel generator filling will need to be installed

Risk and ALARP evaluation:

The distance from the site boundary is well in excess of 10 metres and a fire in the waste storage area or the diesel generator areas is unlikely to affect off-site land use (Ref 6). Environmental pollution is possible in the case of overflow (e.g. if the generators are to be filled from the tank farm), in particular as one of the diesel generator areas is located in proximity stormwater drains that flow directly to Tinkers Creek. With the upgraded bunding, runoff management and roofing of the waste area, with automatic shut-off to prevent overfilling of diesel generators, and provided the requirements under AS1940 for the storage and handling of flammable and combustible liquids are adhered to, the risk associated with the waste storage area and the emergency diesel generators is managed ALARP.

Risk ranking	Moderate
ALARP justified provided the requirements in Australian Standard AS1940 and AGLM management practices for change management are adhered to. If the emergency diesel generators are to be fed directly from the fuel farm, it is likely that automatic and independent cut-off of diesel generator filling will need to be installed	Yes

5.2.6 Loss of containment of ferric chloride

Scenario number in Table 8 and Table 9: 11
Hazardous event: Loss of containment of ferric chloride (aqueous solution) from the new polyethylene tanks and associated piping

Consequences (immediate and ultimate):

Unless contained in the bund or curbing, the spill of ferric chloride (aq. solution) may run off and cause environmental pollution. There is also a potential for injury if exposure occurs.

Ferric chloride also reacts exothermally with alkalis and reacts with metals liberating flammable hydrogen gas. Provided experienced engineers are involved in the design and construction of this storage, reaction with incompatible materials leading to a significant, off-site event, is not considered a credible consequence as no incompatible materials such as alkalis will be located in the vicinity.

Consequence ranking	Level 3: Medical treatment, temporary impairment.

Risk management strategy and likelihood:

Prevention and protection against spills and leaks from tanks and associated piping is detailed in event #11 and includes preventative maintenance and overfill protection as well as bunding. The new tanks and bunding, including capture of spills from tanker unloading, will be designed to the requirements in AS 3780 *The storage and handling of corrosive substances*. There will be spill kit(s) located at the tanker unloading bay, and PPE requirements will be clearly stated (as per Policy and procedures outlined within Induction training). Ferric chloride is a common industrial chemical and the site has experience in manage this material. The potential for reaction with structural steel elements will be taken into account during design and there is minimal chance of ferric chloride contacting and damaging steel structures.

Likelihood ranking	Level 1: Rare provided the requirements in Australian Standards (including AS 3780) and AGLM management practices for change management are adhered to

Risk and ALARP evaluation:

With the upgraded ferric chloride tanks and provided the requirements under AS3780 *The storage and handling of corrosive substances* are adhered to, the risk associated with the ferric chloride storage is managed ALARP.

Risk ranking	Low
ALARP justified provided the requirements in Australian Standards (including AS 3780) and AGLM management practices for change management are adhered to	Yes

5.2.7 Loss of containment of brine from the new pipeline(s)

Scenario number in Table 8 and Table 9: # 10

Hazardous event:

Loss of containment of brine from new piping used to return brine from the Brine Concentrator Decant Basin to the Brine Concentrator may lead to a pollution event

Consequences (immediate and ultimate):

An uncontrolled release of brine would impact the environment due to the high concentration of salts and other pollutant contents such as corrosion inhibitor dosing at the brine recovery pump station (sodium

bisulfite) and hydrocarbons. Off-site impact is possible due to the presence of drainage lines and stormwater drains that report to Tinkers Creek and which could be impacted if a loss of containment is not appropriately mitigated. There is also a potential for injury to personnel if exposure occurs.	
Consequence ranking	Level 3 (WHS): Medical treatment, temporary impairment. Level 4 (Env): Extends beyond AGLM's operational areas which is contained medium term clean up.
Risk management strategy and likelihood: General prevention of leaks from pipeline applies including correct design and preventative maintenance strategy. There are shut off valves to stop the decant basin from draining. Closures of shut-off valves (automatic or manually remote activated) upon detection of major leak and rupture of pipeline are yet to be defined.	
Likelihood ranking	Detailed design would need to demonstrate that the likelihood of this event is reduced to a Level 1: Rare
Risk and ALARP evaluation: The detailed design needs to include verification that the maximum credible spill can be contained. The size of the maximum credible spill will depend on the design of the shut-off valves and on the design of the secondary containment, to be determined in detailed design, ensuring that the risk of environmental pollution from a release from the brine pipelines is managed to ALARP.	
Risk ranking	Moderate
ALARP provided the maximum credible spill of brine can be safely contained. This is likely to include the need for secondary containment and automatic shut-off of brine feed.	Yes

5.2.8 Exposure to electromagnetic fields

Scenario number in Table 8 and Table 9: # 14

Hazardous event: Exposure to EMF at any electrical infrastructure including the MV cable reticulation network, Substation, the Battery and the transformers

Consequences (immediate and ultimate):

Whenever electrical equipment is in service, it produces an electric field and a magnetic field. The electric field is associated with the voltage of the equipment and the magnetic field is associated with the current (amperage). In combination, these fields cause energy to be transferred along electric wires.

- *Electric fields:* Being related to voltage, the electric fields associated with high voltage equipment remain relatively constant over time, except where the operating voltage changes. The strength of the electric field depends on the voltage and is present in any live wire whether an electrical appliance is being used or not.
- *Magnetic fields:* Being related to current, the magnetic field strength resulting from an electrical installation varies continually with time as the load on the equipment varies.

The electric and magnetic fields associated with electrical equipment, whilst interrelated, are not dependent on each other and as such can exist independently.

The Australian Radiation Protection and Nuclear Safety Agency (**ARPANSA**) states (in Ref 17) that there is no established scientific evidence that exposure to EMF causes adverse health effects but that there are some epidemiological (population) studies that have reported a possible association between prolonged exposure to extremely low frequency (**ELF**) magnetic fields at levels higher than typical and increased rates of childhood leukaemia.

Typical values of magnetic fields measured near powerlines and substations are listed in Table 10

Table 10 - Typical values of magnetic fields measured near powerlines and substations

Source	Location of measure	Range of measurement (mG)	Reference
Substation	At substation fence	1 – 8	ARPANSA (Ref 17)
Transmission line (high voltage powerlines)	Directly underneath	10 – 200	ARPANSA (Ref 17)
Transmission line (high voltage powerlines)	At edge of easement	2 - 50	ARPANSA (Ref 17)
33 kV underground cable	At one metre above ground level	10	Ref 18
33 kV underground cable	20 m from source	Indistinguishable from background magnetic field	
The Battery – assume same as substation (conservative)	Outside battery enclosure	1 – 8	ARPANSA (17)

These values can be compared with typical values of magnetic fields in household appliances in Table 11 (Ref 17).

Table 11 - Typical values of magnetic fields (ARPANSA)

Source	Location of measure	Range of measurement (mG)
Electric stove	at normal user distance	2 - 30
Refrigerator	at normal user distance	2 - 5
Electric kettle	at normal user distance	2 – 50
Hair dryer	at normal user distance	10 - 70

Since late 2015, ARPANSA has adopted the international guideline published by ICNIRP in 2010. The *Reference Levels* set out in the guideline are derived from the levels at which interactions with the central nervous system are established, with a safety factor applied and a further adjustment to simplify compliance measurement. It should be noted that these criteria are independent of duration of exposure.

Table 12 - ICNIRP Guideline Reference Levels (General Public)

Parameter	Reference Level
Electric Field	5,000 Volts per metre (**V/m**)
Magnetic Field	2,000 milligauss (mG)

Given the inconclusive nature of the science regarding EMF at levels commonly associated with electrical equipment and human health, it is widely considered that a prudent approach is the most appropriate response under the circumstances. Prudent Avoidance is a precautionary concept developed to address the possibility of health effects from prolonged exposure to field levels much lower than those for which effects have been established.

Consequence ranking	Level 3: Medical treatment, temporary impairment assuming temporary and short-term occupation of Project locations and AGLM strategies for management of EMF are adhered to

Risk management strategy and likelihood:

The magnitude of the EMF at a location is inversely proportional to the distance from the current carrying elements. Increasing the distance between the conductor and people is a valid approach to managing EMF levels. The location siting of HV/MV equipment is in remote areas and exposure to personnel is short duration in nature (transient) as all permanently occupied buildings are located well away from HV/MV plant and equipment. There will also be no permanently occupied buildings as part of the Battery.

Equipment and systems would be designed and tested to comply with international standards and guidelines, including balancing phases and minimising residual current.

The equipment layout and orientation would be optimised to ensure minimal EMF generation.

There is incidental shielding (i.e. the Battery enclosure, switch room).

Warning signs would be placed within the site and surrounds.

The design of the Project elements would consider EMF risks and any necessary buffer areas to future land uses scenario options currently being explored across the sites.

Potential exposure to EMF would be considered for AGLM Staff and contractors as part of health and safety management practices.

Likelihood ranking	Level 1: Rare, provided the applicable criteria, including Prudent Avoidance, are adhered to (and assuming temporary and short-term occupation of Project locations)

Risk and ALARP evaluation:

Given the remote location of the Battery and the associated decoupling works, the Project would not have an impact on off-site sensitive receptors.

The Project may alter the EMF on the site and the potential exposure to EMF would be considered for AGLM Staff and contractors as part of health and safety management practices. However, given the siting of HV/MV equipment in remote areas and given also that exposure to personnel is short duration in nature (transient)

as all permanently occupied buildings are located well away from HV/MV plant and equipment, EMF created from the Project is not likely to exceed the ICNIRP occupational exposure reference level.
Provided the applicable criteria, including Prudent Avoidance, are adhered to, the risk of EMF would be considered to be managed ALARP.

Risk ranking	Low
ALARP justified, provided the applicable criteria, including Prudent Avoidance, are adhered to and that all permanently occupied buildings are located well away from HV/MV plant and equipment	Yes

5.2.9 Natural hazards (bushfire, water/flooding, lightning, earthquake) causes a hazardous incident

Scenario number in Table 8 and Table 9: #'s 14, 17, 18 and 19
Hazardous event: The potential for natural hazards such as bushfire, water/flooding, lightning, and earthquake to have an impact on the Project and cause a hazardous event
Consequences (immediate and ultimate): Potential damage to infrastructure that can lead to the initiation of one of the fire, hazardous exposure or pollution incidents

Consequence ranking	Level 4: Serious injury or fatality.

Risk management strategy and likelihood: The main strategies against a bushfire event are (1) not to initiate a bushfire, through implementation of AGLM protocols and practices, e.g. training, permits etc.) and (2) ensuring that a bushfire does not threaten infrastructure (e.g. through Bushfire emergency response system in place and training of construction workers dealing with bushfire risk and establishment of Fire Management and Emergency Response Plans) and by establishing and maintaining an appropriate APZ. For further details, refer to Appendix 3. Lightning risk is managed through earthing of electrical equipment incl HV equipment and conveyor, and lightning protection mast (at the substations). Flooding and water ingress are managed through design, including IP rating of enclosures (the Battery, switch rooms, transformers, electrical connections etc.), siting of plant and equipment in relation to flood levels and establishment of a spillway and drainage and containment. Earthquake zone checks were done as per Power Station design in the late 1960s with no known change since that time. The risk of seismic activity is to be integrated into the design for this Project.

Likelihood ranking	Level 1: Rare

Risk and ALARP evaluation:
Codes and Standards (including establishment of APZ) are available to ensure that the risk of natural hazards such as from bush fires, lightning, flooding, and earthquakes can be managed to ALARP.

Risk ranking	Moderate
ALARP justified, provided Codes and Standards (including establishment of APZ) are adhered to, the risk of natural hazards such as from bush fires, lightning, flooding, and earthquakes can be managed to ALARP	Yes

5.2.10 Security breach causes a hazardous incident

Scenario number in Table 8 and Table 9: # 15
Hazardous event: Security breach has a potential to lead to serious damage of plant and equipment which could result in an initiation of a hazardous incident scenario covered in all other scenarios covered in this PHA (refer events #s 1-14, 17)
Consequences (immediate and ultimate): Apart from personnel hazard and asset damage, a security breach may lead to the initiation of incidents resulting in fire, release of corrosives and environmentally pollutant material, bush fire etc. (refer events #s 1-14, 17)

Consequence ranking	Level 4: Serious injury or fatality.

Risk management strategy and likelihood:
The site operates under a security protocol. The Project components are located in secured areas. The Battery is likely to be located within a double secure fenced area. Impact protection from vehicles is provided in the form of bollards or other equivalent measures. There are security cameras installed at the lime softening plant where the ferric chloride tanks are being replaced. During construction, the areas will be manned and temporary fences will be installed.

Likelihood ranking	Level 1: Rare

Risk and ALARP evaluation:
Security risk is being managed to ALARP.

Risk ranking	Moderate
ALARP justified provided AGLM protocols are in place	Yes

5.2.11 Onsite and off-site traffic impact causes hazardous incident

Scenario number in Table 8 and Table 9: # 20	
Hazardous event: Onsite and off-site traffic hazard leads to serious damage of plant which results in the initiation of a hazardous incident scenario covered in other scenarios	
Consequences (immediate and ultimate): On-site traffic impact against or involving Project infrastructure may lead to the initiation of incidents resulting in fire, release of corrosives and environmentally pollutant material, bushfire etc. (refer events #s 1-14, 17). Off-site traffic incident when transporting the Li-ion batteries may lead to fire and subsequent release of heat radiation and toxic combustion products from construction material. The risk of a release of significant amounts of pollutant liquids from Li-ion batteries during off-site transport is Low.	
Consequence ranking	Level 4: Serious injury or fatality.
Risk management strategy and likelihood: Prevention and protection include reduced speed limits on site and mandatory site inductions for all personnel; warning signs (including to watch out for wildlife). The fences at the battery area and at the HV/MV areas also provide some (limited) protection. Transport of Li-ion batteries is under Australian Code for the Transport of Dangerous Goods by Road & Rail.	
Likelihood ranking	Level 1: Rare provided onsite speed limits and off-site requirements for Heavy Vehicle and for DG transport are adhered to, and any required impact protection is installed
Risk and ALARP evaluation: Provided speed limits are adhered to, and any required impact protection measures are installed during the design phase of this project, the risk of a vehicle having an impact on Project components resulting in a major consequence is moderate and can be managed ALARP.	
Risk ranking	Moderate
ALARP justified Rare provided onsite speed limits and off-site requirements for Heavy Vehicle and for DG transport are adhered to, and any required impact protection is installed	Yes

5.2.12 Wildlife interaction with live plant causes hazardous incident

Scenario number in Table 8 and Table 9: # 21
Hazardous event: Wildlife interaction with live plant leads to serious damage of plant which results in the initiation of a hazardous incident scenario covered in other scenarios

Consequences (immediate and ultimate):

Damage to plant, downtime and potential fire depending on level of damage.

Consequence ranking	Level 4: Serious injury or fatality.

Risk management strategy and likelihood:

The risk management strategy for this Project is to keep wildlife out of live plant e.g. through a fenced area at the Battery and at the HV/MV areas forming part of the decoupling works, and locked buildings e.g. substation.

Likelihood ranking	Level 1: Rare

Risk and ALARP evaluation:

The risk of damage to Project infrastructure from wildlife is well known and understood by the employees and contractors and can be managed to ALARP.

Risk ranking	Moderate
ALARP justified	Yes

6 CONCLUSION AND RECOMMENDATIONS

6.1 OVERVIEW OF RISK ASSESSMENT RESULTS

The hazard and risk assessment found that the risk profile for the Project, as per the definition by AGLM, is consistently between *Moderate* and *Low* risk with no *High* or *Very High* risks. The Project can be managed in accordance with the established risk criteria and in accordance with ALARP principles. Most hazards can be prevented by employing a combination of common measures, including following all applicable AS/NZ Standards, separation distances and setbacks, physical protection and control systems measures. Mitigation measures are also available to reduce the severity of the hazards should they occur, including specific secondary containment and the Battery operational training.

The potential exists for the Battery to initiate a bushfire in the surrounding bush and grasslands. This presents the only potential impact to society from the Project and, provided an APZ is established and maintained, this risk is low. The available land is large and the Battery site can be laid out such that sufficient separation between the Battery and external boundaries can be achieved in order to minimise off-site risk. With application of the risk management measures detailed in this report and an effective fire management plan, there is a low risk to society of a Battery initiated fire event, and low risks to the environment.

Given the remote location of the Project, it is unlikely that it would have an impact on off-site human population The Project may alter the EMF on the site and potential exposure to EMF would need to be considered for AGLM staff and contractors as part of health and safety management ensuring that the risk of EMF exposure is Low and managed to ALARP principles. The Project risks would be considered in any future development of surrounding lands by AGLM or third parties as part of the approval process for those projects. However, the Project is not considered likely to restrict the types of development compatible with current zoning or likely future uses of AGLM lands from a hazard and risk point of view.

Environmental pollution is possible in the event of a rupture or major spill from the brine return pipeline(s), from overfilling an emergency diesel generator, and potentially (subject to detailed design) from a failure to contain pollutants at the Battery. If a spill is not contained, there is a potential to affect off-site sensitive receptors including in the form of threatened vegetation and fauna. Measures to prevent a leak from occurring and for secondary containment will be addressed in the detailed design phase for the Project, and the likelihood of a significant loss of containment event associated with this Project (Level 4) must be designed to Rare in accordance with AGL's Risk Management and Assessment Standard.

Provided the commitment for safety and environmental protection and the recommendations in this PHA are adhered to, the risk profile for the Project is consistently within the Low or Moderate risk ranking and ALARP can be established.

An overview of the risks associated with the Project is provided in Table 13. This table also includes a brief summary of the ALARP condition – more details are provided under each hazardous event in Section 4 and in the detailed Hazard Identification Word Diagram in Appendix 3.

Table 13 – Overview of risks assessment results and ALARP conditions

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
Fire and pollution at the Battery as initiated by internal or external event (scenarios 1, 2, 3, 4 and 14)	Codes and Standards provide clear guidance as to how to prevent and protect against a fault in the battery escalating into a fire at the enclosure. Provided these requirements are met the risk at each individual battery is managed ALARP. Further, provided the minimum separation distances within the Battery and between the Battery and external boundaries is sufficient, as determined during detailed design in agreement with the Battery manufacturer, the Fire Rescue NSW (**FRNSW**) and RFS, and in accordance with the requirements in Codes and Standards, the risk associated with the Battery can be managed ALARP. Onsite hazardous effects are possible in case of a battery fire, and the possibility of generation of toxic gas and toxic combustion products should be considered in design to allow for safe evacuation and in any emergency response. Environmental pollution is possible from a failure to contain cooling water and oils at the Battery, and the identification and secondary containment of a spill should be considered in detailed design. Environmental pollution from run-off of fire-fighting medium is also possible and should be taken into account in emergency response. If large amounts of fire-fighting medium are to be applied during a fire-fighting operation, then the containment of such fire-fighting medium must be included in the design of the Battery. The DPIE generally requires the containment of 90 minutes of fire-fighting medium – this timeframe should be verified during the detailed design process.	Moderate risk and conforms to ALARP provided requirements in Codes and Standards are adhered to (e.g. AS 5139, AS 1940 and international Codes e.g. US NFPA 855) and the minimum separation distances between Battery infrastructure and APZ are established and maintained

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
Fire and pollution at the Medium Voltage (**MV**) and High Voltage (**HV**) infrastructure (scenarios 2 5, 7, 8)	Provided the requirements under the Australian Standards and AGLM management practices for HV and MV infrastructure are adhered to, and a formal APZ established, the risk associated with environmental pollution and fire at the MV and HV infrastructure associated with the decoupling works can be managed ALARP.	Moderate risk and conforms to ALARP provided the requirements in Australian Standards (including AS 2067 and AS 1940), AGLM management practices are adhered to and APZ is established and maintained
Fire and/or generation of dust at the MA1B conveyor (scenario 9)	Provided the requirements under the Australian Standards and management practices in place by AGLM, including rigorous management of change and hazard identification, are adhered to, it is unlikely that this hazardous event would affect areas off the site.	Low risk and conforms to ALARP provided AS 1755 and AGLM controls and risk management practices in place
Fire or pollution at the waste storage area or at the emergency diesel generators (scenarios 12 and 13)	With the upgraded bunding, runoff management and installation of new roofing of the waste storage area, the risk associated with this storage area and with the emergency diesel generators is managed ALARP provided the relevant requirements in AS1940 *Storage and handling of flammable and combustible liquids* are met. If the emergency diesel generators are to be fed directly from the fuel farm, it is likely that automatic and independent cut-off of diesel generator filling will need to be installed. The distance from the site boundary is well in excess of 10 metres and it is unlikely that a fire in the waste storage area or at the diesel generators would have effects off-site (Ref 6). Notwithstanding, the need for active firefighting at the waste storage area should be determined in detailed design.	Low to Moderate risk and conforms to ALARP provided the requirements in Australian Standard AS 1940 and AGLM management practices for change management are adhered to and that automatic and independent cut-off of diesel generator filling is installed

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
Environmental pollution and/or hazardous exposure from loss of containment of ferric chloride at the Lime Softening Plant (scenario 11)	With the upgraded ferric chloride tanks as well as any additional equipment and provided the requirements under AS 3780 for the storage and handling of corrosive liquids are adhered to, the risk associated with the ferric chloride storage is managed ALARP.	Low risk and conforms to ALARP with AS 3780 and AGLM controls in place
Environmental pollution and/or hazardous exposure from loss of containment of brine from the new pipeline(s) (scenario 10)	Detailed design would need to be verified to ensure that the risk of environmental pollution from a release from the brine pipelines is managed to ALARP and that the likelihood of a substantial release (Level 4) is reduced to Rare as per AGLM risk assessment methodology. This is likely to include the need for secondary containment and automatic shut-off of brine feed once the desired level is met.	Moderate risk provided the maximum credible spill of brine can be safely contained
Exposure to hazardous effects of EMF (scenario 15)	The design of the Project elements would consider EMF risks as well as any necessary buffer areas and proposed changes to future land use scenarios (other than electricity generation) would be explored. Given the remote location of the Project, it is unlikely that the Project would have an impact on off-site sensitive receptors. The Project may alter the EMF on the site and the potential exposure to EMF should be considered for AGLM staff and contractors as part of health and safety management practices.	Low risk and conforms to ALARP provided the applicable criteria, including Prudent Avoidance, are followed and that all permanently occupied buildings are located well away from HV/MV plant and equipment

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
	Provided the applicable criteria, including Prudent Avoidance, are adhered to, the risk of EMF can be managed ALARP.	
Natural hazards (bushfire, water/flooding, lightning, earthquake) causes a hazardous incident (scenarios 14, 17, 18, 19)	Codes and Standards are available to ensure that the risk of natural hazards such as those from bushfires, lightning, flooding, and earthquakes can be managed to ALARP.	Low risk and conforms to ALARP provided the applicable Codes and Standards are followed, including an APZ established
Security breach (scenario 16)	The site operates under a strict security protocol and only approved staff/contractors are permitted to enter the site. The main project components are generally located in secure fenced areas, with the Battery located within a double secure fenced area, except lakeside. Impact protection from vehicles will need to be provided in the form of bollards or other equivalent measures. There are security cameras monitoring the site 24 hours a day. During construction, the areas would be manned and temporary fences would be installed.	Low risk and conforms to ALARP
Onsite and off-site traffic impact causes hazardous incident (scenario 20)	Provided on-site requirement, including reduced speed limits are adhered to, and any required impact protection installed during the design phase of this project, the on-site risk of a vehicle impact on plant and equipment is low and can be managed ALARP. With reference to the findings in the Traffic and Transport Assessment in the EIS, and provided the requirements under the Australian Code for the Transport of Dangerous Goods by Road & Rail are adhered to, the risk of off-site transport of Dangerous Goods (**DGs**), including of the Li-ion batteries, is Low and can be managed ALARP.	Moderate risk and conforms to ALARP provided onsite and off-site requirements for Heavy Vehicle and for DG transport are adhered to, and any required impact protection is installed

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary / concept design, assuming existing and recommended controls in place)
Wildlife interaction with live plant causes hazardous incident (scenario 21)	The risk of wildlife damage to plant and equipment is well known and understood by AGLM and contractors therefore can be managed to ALARP.	Moderate risk and conforms to ALARP

6.2 RECOMMENDATIONS

The following recommendations are made as part of this PHA:

1. A detailed bushfire threat assessment is conducted for the Project, including establishment of an APZ, in consultation with the Rural Fire Service (**RFS**);

2. The separation distance between infrastructure within the Battery is determined in accordance with Codes and Standards and manufacturer's recommendations so that the preferred strategy of allowing a fire in one battery enclosure or inverter to burn without the risk of propagating to other infrastructure can be maintained without the need for external firefighting;

3. The separation distance within the Battery is determined in accordance with Codes and Standards and manufacturer's recommendations to allow safe escape in case of a fire;

4. All relevant requirements in the new AS5139 (2019) are adhered to at the Battery. Adherence to requirements in international standards are also considered, for example to the US NFPA 855 (2020) Code. Further, consider procurement of a battery system that is certified to UL 1642, UL 1973, IEC 61427-2 and IEC62619;

5. The need for active firefighting requirements at the Battery and at the waste storage area is determined in consultation with RFS and the DPIE, e.g. in the form of fire water tanks and connections to the RFS. Detailed fire fighting response and any need for fire water containment should be assessed and reported (e.g. in the format of a Fire Safety Study) post development approval, for review by the DPIE, NSWFR and the RFS;

6. The health and safety associated with EMF on the site and the potential exposure to EMF are considered for AGLM staff and contractors as part of AGLM's obligations for their health and wellbeing under the WHS Regulations;

7. Measures to prevent a leak from occurring at the brine pipeline, the emergency diesel generators and at the Battery, and for secondary containment should a leak occur, is addressed in the detailed design phase for the Project. The likelihood of a significant loss of containment event associated with this Project (Level 4) will be designed to Rare in accordance with AGL's Risk Management and Assessment Standard;

8. The register of commitment (Appendix 1 of the PHA) is integrated into the management for the Project. This includes integration of 84 individual commitments, including for the design, installation and maintenance of the Battery automatic shutdown system on exceedance of

safe limits; installation of deflagration venting and fire protection inside the battery enclosures; design of the brine pipeline, waste oil facility, emergency diesel generators and the Battery such that the risk of pollution from a release is reduced to ALARP; installation of protective barriers, including at the transformers; and application of a rigorous and formal management of change process for the Project, including detailed hazard identification and risk assessment processes.

7 REFERENCES

1 NSW Department of Planning and Infrastructure*, Hazardous Industry Planning Advisory Paper No 6, Hazard analysis,* 2011

2 Department of Planning and Infrastructure, *Multi-level Risk Assessment*, 2011

3 NSW Rural Fire Service, https://www.rfs.nsw.gov.au/plan-and-prepare/building-in-a-bush-fire-area/planning-for-bush-fire-protection/bush-fire-prone-land/check-bfpl

4 *Manifest for Hazardous Chemicals, Bayswater Power Station*, version 5, 3 May 2020

5 NSW Government, State Environmental Planning Policy No 33 - *Hazardous and Offensive Development,* 1992

6 Hazardous and Offensive Development Application Guidelines *Applying SEPP 33*, State of New South Wales through the Department of Planning, 2011

7 *Planning for Bushfire Protection*, NSW Rural Fire Service, November 2011

8 AS/NZS 5139:2019, *Electrical installations — Safety of battery systems for use with power conversion equipment*

9 AS / IEC 62619 Safety requirements for secondary lithium cells and batteries, for use in industrial applications

10 NFPA 855-2020 *Standard for the Installation of Stationary Energy Storage Systems*, (US) National Fire Protection Association, 2002

11 Bushfire Risk Management Plan, AusGrid, March 2017

12 *Australian Dangerous Goods Code, 2020*, Edition 7.7, National Transport Commission, 2020

13 *Safety Data Sheet for ferric chloride solution*, Substance No: 000033756801, IXOM, 02 December 2019

14 Blum A, Long T, *Hazard Assessment of Lithium Ion Battery Energy Storage Systems*, Fire Protection Research Foundation (an affiliate of NFPA), February 2016

15 UL 9540A *Test Method for Evaluated Thermal Runaway Fire Propagation in Battery Energy Storage Systems*

16 NSW Department of Planning and Infrastructure*, Hazardous Industry Planning Advisory Paper No 2, Fire safety,* 2011

17 ARPANSA website December 2020:
https://www.arpansa.gov.au/understanding-radiation/radiation-sources/more-radiation-sources/measuring-magnetic-fields

18 https://www.emfs.info/sources/overhead/specific/33-kv/

19 Ditch B, Zeng D, *Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems*, FM Global, June 2019

Appendix 1

Register of Commitments

Preliminary Hazard Analysis for Liddell Battery and Bayswater Ancillary Works, NSW

Appendix 1 – Register of commitments

Type of safeguard	Element	Register of commitments: Preventative and protective safeguards
Prevention	General - applies to all elements of the Project	1. All equipment and systems designed & tested to comply with the relevant national / international standards and guidelines 2. Equipment to be procured from reliable and internationally recognised supplier with proven track-record 3. Battery to be procured from supplier with no thermal runaways 4. Equipment installed by contractors following AGL's internal requirements for contractor management, permits, control of modifications etc. 5. All installation and maintenance to be performed by trained personnel using SWMS 6. Induction of all personnel prior to works commencing 7. Electrical isolation protocol will be in place during construction and installation (PTW) 8. Hot work permits will be in place during construction and installation (PTW) 9. Bushfire Management Plan in place 10. Training of personnel for preventing and dealing with bushfire risk 11. Preventative maintenance practices in place including maintenance schedules and calibration of equipment, instruments and sensors 12. Impact barriers installed as required to prevent damage from vehicles, heavy machinery etc. 13. Warning signs etc. installed as per Code and Standards requirements including DG signage 14. Earthing of electrical equipment including HV equipment and conveyor 15. Lightning protection mast installed (Substations) 16. Switch rooms and the Battery are housed in dedicated enclosure(s) which will be constructed in accordance to relevant standards and above flood level

Type of safeguard	Element	Register of commitments: Preventative and protective safeguards
Prevention	Specific to the brine return pipeline	17. Hydraulic testing of installation 18. Control of pipeline including management of pressure, temperature, flow to be determined in detailed design 19. Prevention of vehicular impact 20. Vegetation maintenance of pipeline corridor(s)
Prevention	Specific to waste storage area and the emergency diesel generators	21. Appropriate DG (and other) signs on containers for easy identification 22. No incompatible material allowed (e.g. no strong acids near flammable or combustible material) – managed using appropriately located signage 23. Upgraded bunding sized to AS 1940 requirement to contain maximum stored volume, runoff management and roofing will minimise risk of run-off of pollutant from waste storage area 24. Relatively small containers at the waste storage area (largest is likely to be IBCs) and maximum approx. 20kL storage volume
Prevention	Specific to EMF	25. Optimising equipment layout and orientation to ensure minimal EMF generation 26. Balancing phases and minimising residual current 27. Location siting of HV/MV equipment in remote areas - Exposure to personnel is short duration in nature (transient) as all permanently occupied buildings are located well away from HV/MV plant and equipment 28. Incidental shielding (i.e. the Battery building/enclosure, switch room) 29. Warning signs 30. Exposure to EMF considered for AGLM Staff and contractors as part of health and safety management practices
Prevention	Security measures	31. The entire site is secured, the Battery will be located within a secure fenced area. Impact protection from vehicles e.g. in the form of guard posts or other equivalent measures where relevant 32. Security cameras are installed at the lime softening plant (ferric chloride) 33. Onsite security protocols

Type of safeguard	Element	Register of commitments: Preventative and protective safeguards
		34. Warning signs 35. During construction, the areas will be manned and temporary fences will be installed
Detection and shut-off	General - applies to all elements of the Project	36. Inspection rounds formally established 37. Thermography and other Non-Destructive Testing (**NDT**) as per scheduled maintenance to identify precursor of malfunction 38. Alarms available to provide hazard warning on operations upset conditions. Control room attended 100% of the time in normal operation (most likely this will be the AGLM Control Room in Melbourne, with communication to personnel at Bayswater, as required).
Detection and shut-off	Specific to the battery	39. Battery Management System (BMS) including voltage control, charge/ discharge current control and temperature monitoring to battery manufacturer's specifications 40. Automatic safety shut-off function in case of safe limits exceeded 41. HVAC system installed if required (may be water cooled) 42. Secondary detection in enclosure (e.g. smoke / heat), with information transferred to the BESS control room so that, if there is a fire/ smoke/ high temperature the module is isolated with associated shut-downs
Detection and shut-off	Specific to the brine return pipeline and the emergency generators	43. Control of plant including management of pressure, temperature, flow, level etc. 44. Closure of shut-off valves (automatic or manually remote activated) upon detection of major leak and rupture of pipeline(s) (to be defined in detailed design). Shut off valves also stop the decant basin from draining 45. Need for automatic and independent shut-off valves and secondary containment at the emergency diesel generators to be determined in detailed design

Type of safeguard	Element	Register of commitments: Preventative and protective safeguards
Detection and shut-off	Specific to the conveyor MA1B	46. Automatic shut down on vibration, bearing temperature, overspeed, etc. 47. Manual local shut down through use of trip wire 48. Manually remote initiated shut down from control room
Detection and shut-off	Specific to the ferric chloride tanks	49. Control of plant including management of pressure, temperature, flow, level 50. Automatic shut down on excessive level 51. Manual local shut down using Emergency Shut Down buttons 52. Manually remote initiated shut down from control room 53. Operator and/or tanker driver attendance during unloading 54. Dangerous Goods training, Induction etc. for people involved in transfer operation 55. Clear signage at tanker unloading bay and on the storage tank
Protection and limitation to prevent escalation	General - applies to all elements of the Project	56. Warning signs (electrical hazards, arc flash) 57. Separation distances established between each element of the Project (including between infrastructure at the Battery) to minimise risk of escalation in accordance with Codes and Standards and manufacturer's recommendations 58. Separation distances to the surrounding bushland established in accordance with *Planning for Bush Fire Protection* and *AS3959 Construction of buildings in bushfire prone areas* (this includes establishment of an appropriate APZ) 59. Vegetation management within the APZ to be scheduled as a maintenance task 60. Security protocol for the site; fencing at the Battery
Protection and limitation to prevent escalation	Specific to the Battery	61. The Battery housed in a dedicated enclosure with appropriate fire rating (minimum 1 hour). Only restricted personnel allowed 62. Visible annunciation fitted to the battery enclosure to indicate potentially hazardous conditions associated with the Battery (e.g. at entry door and inside the enclosure to allow escape)

Type of safeguard	Element	Register of commitments: Preventative and protective safeguards
		63. Battery enclosure venting to reduce concentrations inside enclosure as per requirements in Codes and Standards 64. Explosion venting or venting of toxic or flammable gases, if required, as per Codes and Standards and in accordance with manufacturer's instructions 65. Battery fire protection system inside and outside of the enclosure to Standard requirements 66. Escape from battery enclosure an escape through the Battery in accordance with Code requirement (note: Code stipulates that any toxic combustion products or gas released from other fault conditions will be evacuated from the enclosure such that people will be able to escape from the enclosure and not be exposed at adjacent egress routes (during the time deemed necessary to evacuate from that area))
Protection and limitation to prevent escalation	Specific to the Decoupling works	67. Management System including voltage control, charge/discharge current control and temperature monitoring. Automatic safety shut-off function in case of exceeding safe limits as per AS2067. 68. Protective walls, barriers or solid covers as per AS2067 requirements 69. Use of appropriate PPE for flash hazard 70. Smoke and heat detectors 71. Fire protection system (enclosure) - fire suppression system to be determined during design e.g. deluge initiated through fusible link / fusible bulb or other, fire extinguisher(s) 72. Use of appropriate PPE 73. Key locked cabinets and electrical rooms
Protection and limitation to prevent escalation	Specific to the conveyor (MA1B)	74. Need for electrical Hazardous Area classification to be determined in detailed design 75. Dust suppression system installed. Deluge sprays over coal area to minimise dust generation 76. Containment basin under the conveyor ensures loss of coal can be captured and recovered 77. Camera surveillance to control room

Type of safeguard	Element	Register of commitments: Preventative and protective safeguards
Protection and limitation to prevent escalation	Specific to the brine return pipeline	78. Secondary containment, curbing or bunding to be determined in detailed design to ensure the maximum credible spill is contained and the likelihood of a spill is minimised
Protection and limitation to prevent escalation	Specific to the ferric chloride tanks	*79.* Upgraded ferric chloride tanks and associated bund designed to the latest relevant requirements in AS 3780 *The storage and handling of corrosive substances* 80. Unloading bay, with any spill captured as per AS3780 requirements 81. PPE as per SDS 82. Safety shower / eye wash station with alarm to control room if activated
Overall	Management	83. The risk of seismic activity is to be integrated into the design for this Project 84. MA1B project will follow rigorous Management of Change process

Appendix 2

AGL Risk Matrix

Preliminary Hazard Analysis for Liddell Battery and Bayswater Ancillary Works, NSW

Planager
Risk Management Consulting

Appendix 2 – AGL's Risk Matrix

Likelihood	Level 1 (0.5)	Level 2 (1.0)	Level 3 (1.5)	Level 4 (4)	Level 5 (5)
Almost Certain (5)	2.5 Moderate	5 High	7.5 High	20 Extreme	25 Extreme
Likely (4)	2 Moderate	4 Moderate	6 High	16 Very High	20 Extreme
Possible (3)	1.5 Low	3 Moderate	4.5 High	12 Very High	15 Very High
Unlikely (2)	1 Low	2 Moderate	3 Moderate	8 High	10 High
Rare (1)	0.5 Low	1 Low	1.5 Low	4 Moderate	5 High

Consequence

	Likelihood Description		
Score	**Complexity**	**Susceptibility/ Exposure**	**Probability**
5	**Training:** highly specialist training/ education, years of knowledge required **Technology:** highly/significantly advanced **Interdependencies:** extreme inter dependencies	**Susceptibility:** extreme **Employee impact:** large number of people involved **Processes:** new/recently implemented, significant changes, new system, untried processes	The risk is **almost certain** to happen (> 50%) in any one year
4	**Training:** advanced training, education and specialist knowledge required **Technology:** moderately advanced **Interdependencies:** significant number of variables and interrelated tasks	**Susceptibility:** high **Employee impact:** many people involved **Processes:** a lot of changes to systems and procedures, item is aging	The risk is **likely** to happen (between 10- 50%) in any one year
3	**Training:** high level skill required, usually secondary studies necessary, detailed knowledge needed	**Susceptibility:** moderate **Employee impact:** quite a few people involved	The risk **may happen** (between 1-10%) in any one year
2	Training: basic but can be quickly mastered by most people **Technology:** not complex **Interdependencies:** few variations or steps involved	**Susceptibility:** low **Employee impact:** small group of people involved **Processes:** minimal changes to systems and procedures, good audit trail	The risk is **unlikely** to happen (between 0.01- 1%) in any one year
1	**Training:** straight forward **Technology:** low or not applicable **Interdependencies:** singular tasks or steps	**Susceptibility:** minimal **Employee impact:** minimal group of people involved **Processes:** negligible change to systems and procedures, excellent audit trail, very well tried and tested, extremely well known and understood	There is a **rare** chance the risk will happen (<0.01%)

		Consequence Definitions (only Environment and Health & Safety shown)	
Score	**Descriptor**	**Environment**	**Health & Safety**
0.5	**Level 1**	**Event:** single minor event with negligible short-term environmental impact. No history of event. **Area:** No impact beyond AGLM's operational area.	**Workplace safety:** Injury or illness requiring no treatment OR first aid treatment on site. Health: Negligible and reversible health effects **Lost time:** Immediate return to work after treatment.
1	**Level 2**	**Event:** small scale and short-term environmental impact. Event has occurred previously. **Area:** localised area affected, no impact beyond AGLM's operational area.	**Workplace safety:** Injury or illness that requires off site medical treatment. **Health:** Temporary and reversible health effects of some concern. **Lost time:** Return to work within the same or next rostered shift. Return to the same role.
1.5	**Level 3**	**Event:** moderate short to medium term environmental impact. **Area:** minor impact extending beyond AGLM's operational area which is contained, and short term clean up.	**Workplace safety:** Injury or illness requiring off site medical treatment for temporary impairment. **Health:** Reversible health effects (temporary impairment). **Lost Time:** Unable to return to same or next shift and / or rehabilitation required to return to alternate role.
4	**Level 4**	**Event:** significant medium- term impact on important (listed or protected) environment/habitat. **Area:** multiple or localised area affected and extends beyond AGLM's operational areas which is contained medium term clean up.	**Workplace safety:** Injury or illness that results in a serious injury (permanent impairment) or fatality. **Health:** Irreversible health effects (permanent impairment). **Lost Time:** Unable to return to work.
5	**Level 5**	**Event:** long term impact on important (listed or protected environment/ habitat). **Area:** multiple or localised area affected and significantly extends beyond AGLM's operational areas which is uncontained and long term clean up.	**Workplace safety:** Injury or illness that results in >1 fatality or permanently impairs >1 person's life. **Health:** Irreversible and permanent health effects impacting >1 individual. **Lost Time:** Unable to return to work.

Appendix 3

Hazard Identification Word Diagram

Preliminary Hazard Analysis for Liddell Battery and Bayswater Ancillary Works, NSW

Appendix 3 – Hazard Identification Word Diagram

Workshop

A workshop was held online over one half day on 9 November 2020 in the format of a Microsoft Teams Meeting. The workshop team included representatives with appropriate project design and development knowledge, planning and environmental support. The workshop team is presented in Table A3.1.

Table A3.1 - Hazard identification workshop team

Name	Company	Title / Role
Arianna Henty	AGL Energy Ltd	Lands and Approvals Manager
Matthew Parkinson	AGL Macquarie	Manager Environment and Approvals
Neil Cooke	AGL Energy Ltd	Senior Manager Power Development
Todd Fuller	AGL Energy Ltd	Lands and Approvals Coordinator
Karin Nilsson	Planager Pty Ltd	Risk Engineering Specialist, Hazard identification workshop lead

Hazard identification word diagram

Details of the hazardous events, causes, consequences and controls are presented in the *Hazard identification word diagram* in Table A3.1 below.

Table A3.1 – Hazardous incidents word diagram

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
Battery storage (The Battery)			
1) Thermal runaway in the Battery and generation of toxic vapours *i.e. generation of excessive heat inside or outside the cell which keeps on generating more and more heat* *The chemical reactions inside the cell in turn generate additional heat until there are no reactive agents left in the cell*	Elevated temperature (e.g. external fire from bush fire – see event 14) Surrounding infrastructure failure[1] including BMS failure, HVAC failure, or from adjacent HV infrastructure Faulty battery causing electrical failure (faulty manufacture or design; short circuit, excessive current/voltage) Imbalanced charge across cells Mechanical failure (internal cell defect, damage, crush/ penetration/ puncture)	Fire in the battery cell, generation of heat Generation of toxic gases and combustion products Fire hazard can evolve to deflagration Possible escalation to the enclosure, and potentially escalation to the entire Battery Possible injury/fatality from heat generation and exposure to toxic combustion products Environmental pollution from firefighting medium	<u>Prevention:</u> Equipment and systems designed and tested to comply with the relevant international standards and guidelines (refer Section 2.6.3) Selection of battery cell chemistry to minimise runaway. Equipment to be procured from supplier with proven track-record and with no thermal runaways having occurred to-date Equipment installed by reputable contractors following AGL Contractor HSE Management Standard, permits, control of modifications etc. Installation and maintenance by trained personnel Installation would occur in accordance with the Principal Contractors HSEMS/safe systems of work using SWMS. Induction of all personnel prior to work <u>Detection and automatic shut-down:</u> Battery Management System (BMS) including voltage control, charge/ discharge current control and temperature monitoring to battery manufacturer's specifications. Automatic safety shut-off function in case of safe limits exceeded HVAC system Thermography as per scheduled maintenance to identify precursor of malfunction Secondary fire detection in enclosure (smoke / heat), with information transferred to the BESS control room. Circuit breakers fitted at the cell, rack, and cabinet level so that, if there is a fire/ smoke/ high temperature the module is isolated. The Fire Safety Panel in the BESS control

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			room has indications of each 'fire circuit' to allow identification of the fire/ smoke/ high temperature and associated shut-downs Protection and limitation to prevent escalation: Explosion venting or venting of toxic or flammable gases, as required, as per Codes and Standards and in accordance with manufacturer's instructions, Section 2.6.3 The Battery housed in dedicated enclosure with minimum 1 hour fire rating. Only restricted personnel allowed Separation distance between batteries to minimise risk of escalation in accordance with Codes and Standards, Section 2.6.3. Fire barrier ratings on enclosure, battery capacity segregated into smaller building blocks Minimising generation of toxic combustion products and flammable hydrogen Battery enclosure venting to reduce build-up of toxic or flammable concentrations inside the enclosure as per requirements in Codes and Standards, Section 2.6.3 Battery is located in open area to minimise risk of accumulation / ingress of toxic combustion products Emergency response Battery fire protection system inside outside and the enclosure to Standard requirements (Section 2.6.3) Visible annunciation will be fitted to the enclosure to indicate potentially hazardous conditions associated with the ESS (e.g. at entry door and inside the enclosure to allow escape) Escape from enclosure in accordance with Code requirement (e.g. BCA). As per Code requirements, any toxic combustion products or gas released from other fault conditions will

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			be evacuated from the enclosure such that people will be able to escape from the enclosure and not be exposed at adjacent egress routes (during the time deemed necessary to evacuate from that area) Activation of local emergency shutdown (ESD button) Fire Management Plan and Emergency Response Plan will be updated. External assistance for firefighting (FRNSW & RFS) APZ will be defined to prevent escalation to nearby bushland
2) Loss of containment of pollutant material from the Battery	Mechanical failure/ damage to battery, e.g. from drop, impact Abnormal heating/ elevated temperature as a result of the thermal runaway scenario in #1 above	Release of pollutant material – environmental pollution if not contained Possible injury from exposure to irritant material	Prevention Equipment and systems designed and tested to comply with the relevant international standards and guidelines, (see Section 2.6.3) Equipment installed by reputable contractors following AGL Contractor HSE Management Standard, permits, control of modifications etc. Installation and maintenance by trained personnel Installation would occur in accordance with the Principal Contractors HSEMS/safe systems of work using SWMS. Induction of all personnel prior to work Design of cooling system prevents release of cooling water. Low toxicity / irritation Detection and automatic shut-down Battery Management System (BMS) including voltage control, charge/discharge current control and temperature monitoring in compliance with relevant standards and guidelines. Automatic safety shut-off function in case of safe limits exceeded. HVAC system if required (may be water cooled) Protection Battery housed in dedicated enclosure(s). Only restricted personnel allowed

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			PPE and Safety shower / Eye wash station <u>Emergency response</u> Spill clean-up using dry absorbent material and activation of PIRMP Activation of emergency shutdown (ESD button) Emergency Response Plan to be updated
3) Electrical fault inside the Battery causing fire	Connection fault causing short circuit	Heat, possibly fire Arc flash may result in fires and pressure waves Toxic combustion products Burns, injury and/or fatality Exposure to intense light and noise Propagation to adjacent infrastructure	<u>Prevention:</u> Equipment and systems designed and tested to comply with the relevant international standards and guidelines (see Section 2.6.3) Equipment to be procured from supplier with proven track-record Equipment installed by reputable contractors following AGL Contractor HSE Management Standard, permits, control of modifications etc. Installation and maintenance by trained personnel Installation would occur in accordance with the Principal Contractors HSEMS/safe systems of work using SWMS. Induction of all personnel prior to work <u>Detection and automatic shut-down:</u> BMS including voltage control, charge/discharge current control and temperature monitoring. Auto safety shut-off function in case of exceeding safe limits. HVAC system if required (may be water cooled) Preventative maintenance and condition monitoring including thermography <u>Protection and limitation to prevent escalation:</u> The Battery housed in dedicated enclosure. Only restricted personnel allowed

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			Separation distance between batteries to minimise risk of escalation in accordance with Codes and Standards, Section 2.6.3 Minimising generation of toxic combustion products Battery enclosure venting to reduce build-up of toxic or flammable concentrations inside the enclosure as per requirements in Codes and Standards, Section 2.6.3 The Battery is located in open area to minimise risk of accumulation / ingress of toxic combustion products Emergency response The Battery fire protection system inside outside and the enclosure to Standard requirements (refer Section 2.6.3) Visible annunciation will be fitted to the enclosure to indicate potentially hazardous conditions associated with the ESS (e.g. at entry door and inside the enclosure to allow escape) Escape from enclosure in accordance with Code requirement (e.g. BCA). As per Code requirements, any toxic combustion products or gas released from other fault conditions evacuated such that people will be able to escape from the enclosure and not be exposed at adjacent egress routes (during the time deemed necessary to evacuate from that area) Activation of local emergency shutdown (ESD button) Fire Management Plan and Emergency Response Plan will be updated. External assistance for firefighting (FRNSW & RFS) APZ will be defined to prevent escalation to nearby bushland

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
4) Exposure to voltage (at Battery - inverters, cables etc.) *Battery in itself is relatively low voltage (33 kV)*	Short circuit or electrical connection failure e.g. due to: - faulty equipment, - incorrect installation, - incorrect maintenance / human error during maintenance, - safety device / circuit compromised, - battery casing / enclosure damage	Injury / fatality (potential initiation of events #s 1, 2 and 3 above)	<u>Prevention:</u> Installation and maintenance by trained personnel using SWMS. Induction of all personnel prior to work Equipment and systems designed and tested to comply with the relevant international standards and guidelines (see Section 2.6.3) Equipment installed by reputable contractors following AGL Contractor HSE Management Standard, permits, control of modifications etc. Installation and maintenance by trained personnel Installation would occur in accordance with the Principal Contractors HSEMS/safe systems of work using SWMS. Induction of all personnel prior to work Warning signs (electrical hazards, arc flash) All relevant standards and requirements by asset owners will be met <u>Detection and automatic shut-down:</u> BMS fault detection and safety shut-off HVAC system Preventative maintenance and condition monitoring including thermography <u>Protection and limitation:</u> The Battery is housed in dedicated enclosure. Only restricted personnel allowed. Key locked cabinets and electrical rooms. Use of appropriate PPE <u>Emergency response</u> Activation of local emergency shutdown (ESD button) Emergency Response Plan will be updated

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
330/33 kV station transformers (x2) and transformer compound; cables to connect the transformers and connection to the TransGrid switchyard			
5) Arc flash in HV/MV cable reticulation network, substation or transformers *Note: An arc produced by flow of electrical current through ionized air after initial flashover or short circuit, resulting in a flash that can cause significant heating and burn injuries to occur. 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.*	Connection of opposite electrical poles due to (e.g.): - incorrect procedure used during installation/ maintenance, - faulty equipment (e.g. corrosion on conductors), - equipment instead too close to each other or insulation damage	Arc blasts and resulting heat, may result in fires and pressure waves leading to burns, injury and/or fatality Potential propagation to adjacent infrastructure (e.g. oil storages) and domino effects and further fire, release of toxic combustion products Exposure to intense light and noise	<u>Prevention</u> Equipment and systems designed and tested to comply with the relevant international standards and guidelines, (see Section 2.6.3) Equipment procured from reputable supplier and installed by reputable contractors following AGLM's internal requirements for contractor management Equipment installed by reputable contractors following AGL Contractor HSE Management Standard, permits, control of modifications etc. Installation and maintenance by trained personnel Installation would occur in accordance with the Principal Contractors HSEMS/safe systems of work using SWMS. Induction of all personnel prior to work Maintenance and isolation procedure (e.g. deenergize equipment) used. Preventative maintenance (insulation) Warning signs (arc flash boundary) <u>Detection:</u> Preventative maintenance and condition monitoring including thermography Current limiting devices and shut-offs (trips) as per AS2067 <u>Protection</u> Protective barriers or solid covers as per AS2067 requirements Use of appropriate PPE for flash hazard <u>Emergency response</u> Emergency Response Plan. External assistance for firefighting (FRNSW & RFS)

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			APZ to be defined in detailed design to prevent escalation to nearby bushland
6) Exposure to voltage (MV and HV cable reticulation network, substation, transformers	Short circuit or electrical connection failure e.g. due to: - faulty equipment, - incorrect installation, - incorrect maintenance / human error during maintenance, - safety device / circuit compromised	Electrocution, injury and/or fatality Fire, generation of heat Generation of toxic combustion products Possible escalation to the enclosure / building, and potentially to the escalation to the entire Battery (refer to event #1 above) Possible injury/fatality from heat generation and exposure to toxic combustion products	Prevention Equipment and systems designed and tested as per Codes and Standards (Section 2.6.3) Equipment will be procured from reputable supplier and installed by reputable contractors following AGLM's internal requirements for contractor management All relevant standards and requirements by asset owners will be met Installation and maintenance by trained personnel. Procedures and instructions incl. SWMS. Electrical isolation protocol (PTW) Fault detection and safety shutoff Warning signs (electrical hazards, arc flash) Detection Preventative maintenance and condition monitoring including thermography Smoke and heat detectors Detection: Current limiting devices and shut-offs (trips) as per AS2067 Protection Fire protection system (enclosure/building), fire extinguisher(s) Use of appropriate PPE Key locked cabinets and electrical rooms Emergency response Emergency exit lighting

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			Emergency Response Plan. External assistance for firefighting (FRNSW & RFS)
7) Fire or pollution at the transformers	Transformer oil leak Faulty equipment including breakdown of insulators Arc flash or other incident initiates further fire External fire, e.g. bushfire, adjacent infrastructure[1] *1) Prevention and protection against impact from bush fire and failure in surrounding facilities are detailed in the individual scenarios for these events*	Fire in switchyard and escalation to switch room Release of toxic combustion products Injury/fatality Asset damage Potential environmental pollution if spill is not contained Interruption in power supply, loss of production, financial effect	<u>Prevention</u> Equipment and systems designed and tested as per Codes and Standards (Section 2.6.3) Equipment will be procured from reputable supplier and installed by reputable contractors following AGLM's internal requirements for contractor management All relevant standards and requirements by asset owners will be met Power Control Units and transformers are located in designated area Installation, operations and maintenance by trained personnel in accordance with procedures and instructions including SWMS Preventative maintenance and condition monitoring (e.g. insulation, replacement of faulty equipment) including oil analysis as per maintenance schedule and continuous online monitoring of a number of parameters of the transformer (with alarm if safe limits are exceeded, for operator response). Regular visual inspection. <u>Detection</u> Preventative maintenance and condition monitoring including thermography Smoke and heat detectors <u>Protection</u> Fire resistant barriers (walls) to be installed in accordance with AS 2607 <u>Emergency response</u> Activation of emergency shutdown (ESD button)

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			Fire suppression system to be determined during design e.g. deluge initiated through fusible link / fusible bulb or other Fire Management Plan Emergency Response Plan External assistance for firefighting (FRNSW & RFS) APZ to be defined in detailed design to prevent escalation to nearby bushland
8) Switch room fire	Equipment failure e.g. fault in design, connection fault Arc flash Vandalism External fire, e.g. bushfire, adjacent Infrastructure[1] *1) Prevention and protection against impact from bush fire and failure in surrounding facilities are detailed in the individual scenarios for these events*	- Fire in substation and escalation to switchyard - Release of toxic combustion products - Injury/fatality - Asset damage - Interruption in power supply	<u>Prevention</u> Equipment and systems will be designed and tested to comply with the relevant standards and codes (Section 2.6.3) Equipment will be procured from reputable supplier All relevant standards and requirements by asset owners will be met Power Control Units and transformers are located in designated areas Installation, operations and maintenance by trained personnel (e.g. reputable third party) in accordance with relevant procedures and SWMS Preventative maintenance (e.g. insulation, replacement of faulty equipment) Electrical switch-in & switch-out protocol (pad lock) Circuit breakers Substation is locked and located in designated area Security fence and controlled access <u>Detection and automatic shut-down:</u> Preventative maintenance and condition monitoring including thermography

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			Management System including voltage control, charge/discharge current control and temperature monitoring. Automatic safety shut-off function in case of exceeding safe limits. HVAC system Thermography to be carried out as per scheduled maintenance to identify precursor of malfunction <u>Emergency response</u> Activation of emergency shutdown (ESD button) Fire Management Plan Emergency Response Plan External assistance for firefighting (FRNSW & RFS) APZ to be defined in detailed design to prevent escalation to nearby bushland
Bayswater Ancillary Works (BAW)			
9) Maloperation of modified conveyor MA1B	Failure of control (speed, weight) Equipment failure including wear and tear, fluid coupling fire Increased vibration Belt misaligned or excessive tension on belt Fire in coal	Increased generation of dust with environmental consequences (air pollution) Fire in conveyor, heat radiation of toxic combustion products (belt) Structural damage Potential for injury and fatality	<u>Prevention</u> Conveyor to comply with the most recent editions of the AS1755 *Conveyors—Safety* requirements which details the safety measures and personal protective measures, in particular in relation to conveyor control and motor drive isolation General maintenance schedules including calibration of sensors Need for electrical Hazardous Area classification to be determined in detailed design <u>Protection</u> Automatic shut down on vibration, bearing temperature, overspeed, etc. Manual local shut down through use of trip wire

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
	Structural failure	Potential for spillage and environmental damage if failure leads to major loss of containment of coal which is not contained Potential for fire (possibly for dust explosion) if significant flammable dusts are ignited	Manually remote initiated shut down from control room Toxic combustion products likely to be naturally dispersed as not confined Dust suppression system Containment basin under the conveyor ensures loss of coal can be captured and recovered Detection Camera surveillance to control room Control room attended 100% of the time in normal operation. Alarms in control room on operations upset conditions Emergency response Deluge sprays over coal area to minimise dust generation Initiation of the PIRMP
10) Loss of containment of brine from the new pipeline/s for use to return brine from the Brine Concentrator Decant Basin to the Brine Concentrator	Equipment failure including wear and tear Failure of control (pressure, temperature, flow, level) Impact by vehicles Damage by vegetation / trees / roots etc.	Potential for spillage and environmental damage if failure leads to major loss of containment of brine which is not contained Pollution to ground Injury if exposure occurs	Prevention Hydraulic testing at installation Control of pipeline including management of pressure, temperature, flow to be determined in detailed design General maintenance schedules including visual inspection and calibration of sensors Prevention of vehicular impact, e.g. pipeline goes under the road Vegetation maintenance of corridors

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
Approx. 2.5 -3kkm pipeline(s) with some underground for roadways			Detection and automatic shut-off: Closure of shut-off valves (automatic or manually remote activated) upon detection of major leak and rupture of pipeline (to be defined in detailed design). Shut off valves also stop the decant basin from draining. Protection The decant basin is located at a low point on site to collect the brine and feed the brine to the pipeline. The basin itself is lined is contained by embankments within a relatively flat area with no creeks or water ways Existing built settling basins/ponds available to collect spills. Secondary containment, curbing or bunding to be determined in detailed design PPE as per SDS Emergency response Initiation of the PIRMP
11) Loss of containment of ferric chloride (aqueous solution) from new polyethylene tanks and associated piping	Mechanical failure, damage to packaging / vessel etc. Loss of containment during unloading from tanker to the storage tank due to line failure, valve failure, operational error, drive away.	Potential for spillage and environmental damage if failure leads to major loss of containment of ferric chloride which is not contained Injury if exposure occurs (Reaction with incompatible materials is not considered a	Prevention Control of plant including management of pressure, temperature, flow, level General maintenance schedules including calibration of sensors Operator and/or tanker driver attendance during unloading Dangerous Goods training, Induction etc. for people involved in transfer operation Clear signage at tanker unloading bay and on the storage tank Protection Automatic shut down on excessive level

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
Ferric chloride aq. Solution is a DG Class 8 (PG III) corrosive substances. It is not combustible in its aqueous form.	Loss of containment during transfer from storage to water treatment. Human error. Overfill of tank(s).	credible consequence as no incompatible materials located in the vicinity)	Manual local shut down using Emergency Shut Down buttons Manually remote initiated shut down from control room Upgraded ferric chloride tanks and associated bund will be designed to the latest relevant requirements in AS 3780 *The storage and handling of corrosive substances* Unloading bay, with any spill captured as per AS3780 requirements PPE as per SDS Safety shower / eye wash station with alarm to control room if activated Emergency response Initiation of the PIRMP Spill kits available on tanker unloading bay
12) Fire or pollution at waste storage area for hydrocarbons, oils, greases *Although this event is screened out using the SEPP33 methodology (refer to Section 3.2)*	Damage to container (drum, IBC etc.) including from wear and tear, impact Heat radiation from nearby plant	Loss of containment of environmental pollutant to ground. Local pollution to ground. If spill is allowed to run off, potential for environmental pollution May result in fire if ignited with subsequent damage, heat radiation and toxic combustion products	Prevention Impact prevention to be determined General audits / tours of the area Containers to be appropriately for easy identification No incompatible material allowed (e.g. no strong acids near flammable or combustible material) – managed using appropriately located signage Protection Upgraded bunding, runoff management and roofing to minimise risk of run-off of pollutant from new waste storage area to contain maximum volume of stored material PPE as per SDS

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
this event has been retained here in order to present the risk management features associated		Injury if exposure occurs	<u>Limitation</u> Relatively small containers (largest is likely to be IBCs) and maximum approx.. 20kL storage volume Distance to boundary in excess of 10m <u>Emergency response</u> Initiation of the PIRMP Spill kits available Firefighting equipment available in the local area
13) Fire or pollution at the new emergency diesel generators	Loss of containment during unloading from truck or during filling from fuel storage	Loss of containment of environmental pollutant to ground. Local pollution to ground. If spill is allowed to run off, e.g. into creek, potential for environmental pollution May result in fire if ignited with subsequent damage, heat radiation and toxic combustion products Injury if exposure occurs	<u>Prevention</u> Impact prevention to be determined General audits / tours of the area Need for automatic and independent shut-off valves to be determined in detailed design <u>Protection</u> Secondary containment as per AS 1940 PPE as per SDS <u>Limitation</u> Distance to boundary in excess of 10m <u>Emergency response</u> Initiation of the PIRMP Spill kits available Firefighting equipment available in the local area

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
Site wide			
14) Bushfire	Encroachment of off-site bushfire onto the Battery or other parts of the Project Escalated event from a fire associated with new plant and equipment. Ignition source may come from faults in electrical equipment; mechanical energy from hot work during operation or construction of Project; mechanical crashes, human (failure to follow procedures and requirements; arson/ sabotage; uncontrolled smoking) etc.	Injury/fatality Asset damage Potential initiation of thermal runaway in the Battery (refer scenario #1)	<u>Prevention</u> Safeguards during construction to include: - Control of hot works such as welding - Bushfire emergency response system in place - Training of construction workers dealing with bushfire risk. Installation, operations and maintenance by trained personnel (e.g. reputable third party) in accordance with relevant procedures, PTW and SWMS APZ to be determined during detailed bushfire threat assessment. Location for the Project, including for the Battery and electrical installation forming part of decoupling works, provide flexibility and optionality with respect to the establishment of the APZ Vegetation management within the APZ to be scheduled as maintenance task All electrical installation to be maintained as per events #1 to #8 <u>Protection</u> APZ will provide defendable boundary for firefighting Fire Management Plan and Emergency Response Plan Cooling water supply on-site External assistance for firefighting (FRNSW & RFS)

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
15) Exposure to electric and magnetic fields at MV cable reticulation network, Substation, the Battery and Transformers	Electric and magnetic fields generated during operations of power generation equipment	High level exposure may affect function of the nervous system. Personnel injury and ill health	<u>Prevention</u> Equipment and systems will be designed and tested to comply with international standards and guidelines. Optimising equipment layout and orientation to minimise EMF generation Balancing phases and minimising residual current <u>Limitation</u> Location siting (including separation distance) in remote area Incidental shielding (i.e. Battery enclosure, switch room) Exposure to personnel is short duration in nature (transient) as all permanently occupied buildings are located well away from HV/MV plant and equipment Warning signs

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
16) Security breach	Unauthorised personnel access	Asset damage Hazard to unauthorised person (e.g. electrocution) Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire etc. (refer events #s 1-14, 17)	Project infrastructures are located in secure fenced areas[11]. Batteries located within as double secure fenced area. Impact protection from vehicles e.g. in the form of guard posts or other Security cameras at the ferric chloride area Onsite security protocol Warning signs During construction, the areas will be manned and temporary fences will be installed
17) Lightning strike	Lightning storm	Injury/fatality Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire etc. (refer events #s 1-14, 17)- Asset damage	Earthing of electrical equipment incl HV equipment and conveyor Lightning protection mast (Substations)

11 Exception are the brine pipeline(s) and the conveyor which are within Bayswater PS but traverse outside of secured fenced area – however, these are inside farm fenced area

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
18) Water ingress	Flood / Water ingress	Electrical fault/short circuit Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire etc. (refer events #s 1-14, 17) Injury/fatality Asset damage	- Location siting (i.e. outside of flood prone area) - Switch rooms and the Battery are housed in dedicated enclosures constructed in accordance to relevant standards and above flood level - Drainage and containment system e.g. at new brine pipeline(s), refer event #10
19) Earthquake or land subsidence causes structural failure of plant and equipment	Land subsidence, earthquake	Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire etc. (refer events #s 1-14, 17) Personnel injury from electrical energy	<u>Prevention</u> No known land subsidence issues in this area Earthquake zone checks were done as per Power Station design in the late 1960s with no know change since that time Earthquake requirements for the Battery in accordance with Australian Standard requirements AS5139-2019 <u>Emergency response</u> As per Emergency Response Plan and PIRMP

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
20) Onsite or off-site vehicular traffic impact e.g. due to wildlife interaction or failure to comply with speed restrictions	Impact with vehicle / collision	Subsequent impact on infrastructure causing damage, fire, electrocution Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire etc. (refer events #s 1-14, 17)	<u>Prevention</u> Warning signs on-site to watch out for wild life Induction for all persons coming on site Speed limits on and off site Fenced area at battery area and HV/MV areas prevents wildlife accessing these areas Dangerous Goods drivers and requirements to adhere to the Australian Code for the Transport of Dangerous Goods by Road & Rail <u>Protection</u> Spill kit carried by transport company as per DG requirements <u>Emergency response</u> PIRMP
21) Wildlife interaction with live plans causes damage	Wildlife access to live plant	Damage to plant, downtime Potential fire depending on level of damage	<u>Prevention</u> Fenced area at battery area and HV/MV areas prevents wildlife accessing these areas Locked substation

Appendix 4

Minimal Footprint of the Battery

Preliminary Hazard Analysis for Liddell Battery and

Bayswater Ancillary Works, NSW

Appendix 4 – Minimal footprint of the Battery

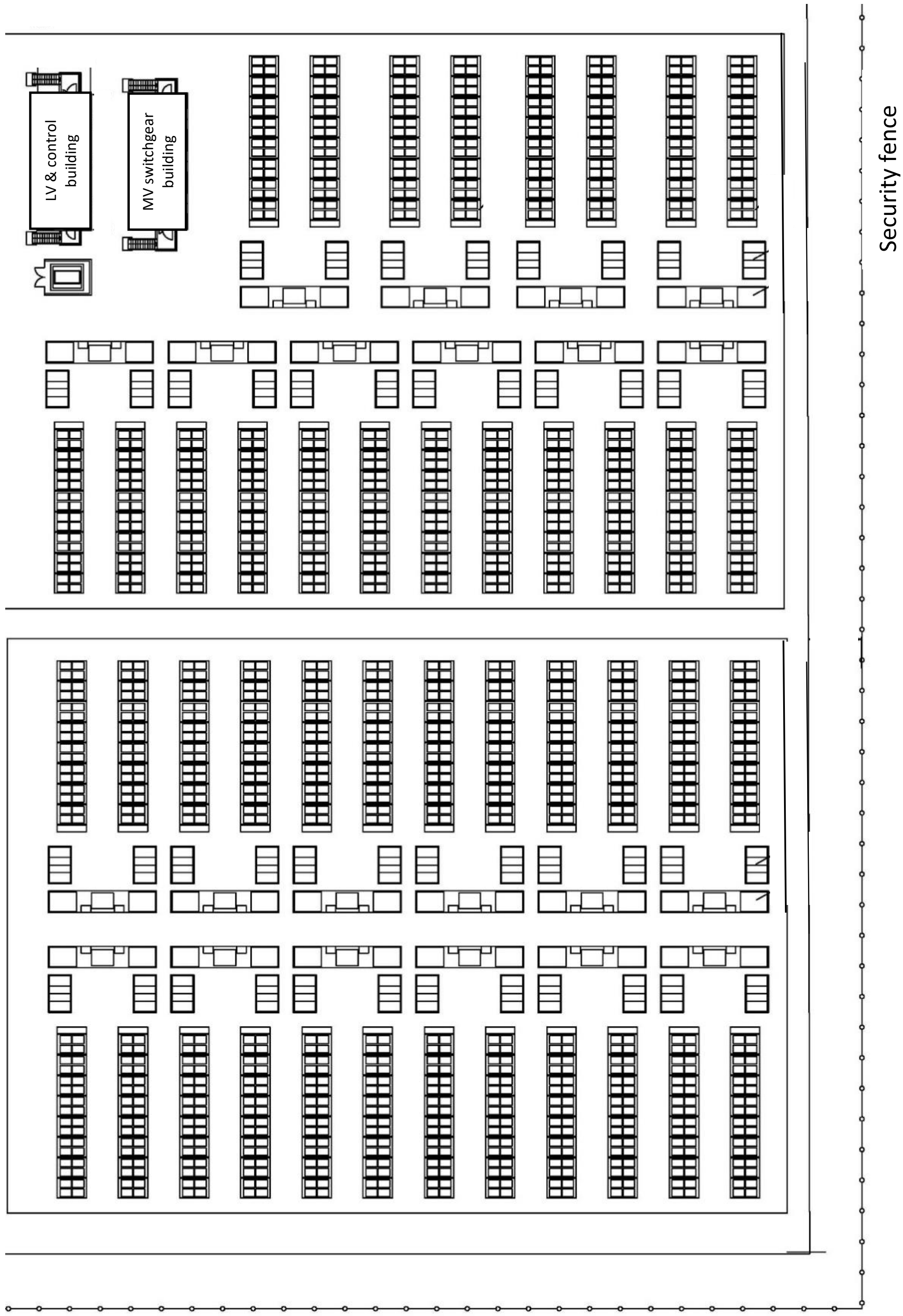
An example configuration of the battery enclosures, inverters and the step-up transformers (630V to 33kV) is provided in the photograph in Figure A4.1.

Figure A4.1 - Example configuration of the Battery

A generic layout of the Battery is provided in Figure A4.2.

- Only two "boxes", with battery enclosures, inverters and the step-up transformers, LV and control building and MV switchgear, are shown.
- These "boxes" would be repeated until the desired capacity of capacity is reached (of 500 MW for a four-hour period or up to 2 GWh).
- A number of LV and controls buildings and MV switch rooms would also be included, as shown diagrammatically on the top left of Figures A4.2 and A4.3 below.
- Additional to this would be the major transformers (four expected), perimeter road, security fence, APZ etc, not shown in the figures.

Figure A4.2 - Generic layout for the Battery



The separation between battery enclosure and between enclosures and other infrastructure within the Battery will be determined during detailed design.

The NFPA 855 (Ref 10) paragraph 4.4.3.3 *Clearance to Exposures* sets the separation distance of 10 feet (about 3 metres) between the battery enclosures and other buildings. This separation distance corresponds the results of the results from the large test data by FM Global in their Research Report in Ref 19 and extrapolating the FM Global test results to the Liddell battery .

Figure A4.3 shows a detail of the generic layout, with the expected dimensions and separation distances included. The 3 metre separation between enclosures has been applied.

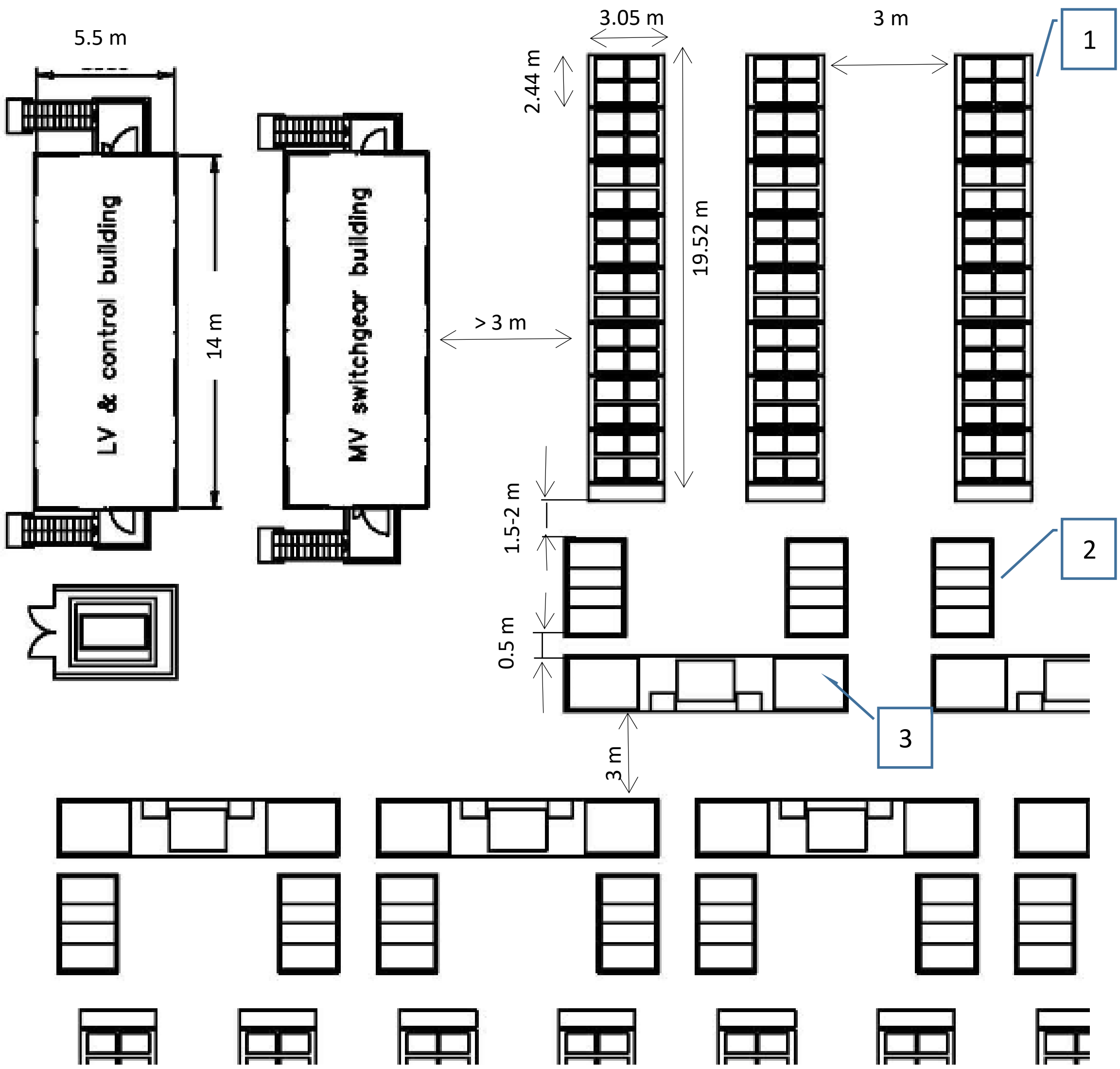
Using the dimensions and separation distances in Figure A4.4, the total footprint for the Battery development would be approximately 4.5 hectares. Additional would be access for operation and maintenance, space for the APZ, security fencing, lighting and internal roads and access / egress ways as well as space for the major transformers.

The total available land is 56 hectares, with the Battery compound expected to occupy approximately 20 hectares, possibly established as smaller parcels within the overall Project footprint.

The actual separation distances between the infrastructure that makes up the Battery will be determined in detailed design, based on the requirements in Codes and Standards and the Battery manufacturer.

The evaluation of the minimum footprint for the Battery conducted as part of this PHA shows that the Battery would fit comfortably within the available land.

Figure A4.3 – Detail of the generic layout for the Battery, with dimensions



Legend:	
1	Battery enclosures located end to end in a string (8 enclosures per string in this example). Dimensions (WxD) mm: 3.05x2.44 per enclosure (for the example of 8 enclosures per string, the dimensions are 3.05x19.52 per string of enclosures). Total of 1335 enclosures, see Table 2 in the body of the report
2	Inverter. Dimensions (WxD) mm: 3.7x2.2. Total of 740 inverters, see Table 2 in the body of the report
3	Transformers (630V to 33kV). Dimensions (WxD) approximately 2.4m x 3m. Total of approx.. 165 transformers (630V-33kV)
Additional:: LV & control building MV switchgear building Major transformers (not shown in the figure)	