Review of Environmental Factors
Macquarie Subtransmission Substation

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0.1	7/12/2018	Draft for tender
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1.0	7/3/19	Final version

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Glossary

Term	Meaning
Aboriginal heritage	Any: • deposit, object, place or material evidence (including remains of Aboriginal people) relating to Aboriginal habitation; or • places having particular or special significance to Aboriginal people in accordance with Aboriginal culture and traditions, and which has been declared by the Minister to be protected under the NPW Act, EPBC Act, or Aboriginal and Torres Strait Islander Heritage Protection Act 1984.
AHIP	Aboriginal Heritage Impact Permit
ASS	Acid sulfate soils: are naturally occurring sediments and soils containing iron sulphides (principally pyrite) and/or their precursors or oxidation products. This includes Actual and Potential acid sulfate soils. Both can be found within the same soil profile.
Blue Book	*Managing Urban Stormwater - Soils and Construction* (Landcom, 2004)
BCA	*Building Code of Australia* (Australian Building Codes Board, 2016): is Volumes One and Two of the National Construction Code (NCC) which is an initiative of the Council of Australian Governments developed to incorporate all on-site construction requirements into a single code. The BCA is produced and maintained by the Australian Building Codes Board on behalf of the Australian Government and State and Territory Governments. The BCA has been given the status of building regulations by all States and Territories.
BC Act	*Biodiversity Conservation Act 2016*
CEMP	construction environmental management plan
Classified road	The *Roads Act 1993* provides for roads to be classified as Freeways, Controlled Access Roads, Tollways, Highways, Main Roads, Secondary Roads, Tourist Roads, Transitways and State Works.
Climate Change	Describes both changed average climatic conditions, such as increased temperature and lower average rainfall, as well as changes in the patterns of extreme events, including increased frequency and intensity of storms.
CPESC	Certified Professional in Erosion and Sediment Control
CNVIA	Construction Noise and Vibration Impact Assessment
dB(A)	decibels (A) weighted
Determining authority	Minister or public authority and, in relation to any activity, means the Minister or public authority by or on whose behalf the activity is or is to be carried out or any Minister or public authority whose approval is required in order to enable the activity to be carried out. *Note: In practice, this will mean either the Minister, the local Council, Ausgrid (when self-determining works under Part 5), or other public authority from whom Ausgrid requires concurrence.*
DG	Ausgrid's distribution guideline
Easement	A collection of rights allowing an entity to undertake certain activities on land owned by another person. Easements acquired by Ausgrid are created by a lease, a transfer granting easement, an instrument registered with a deposited plan, or by acquisition.

EIS	environmental impact statement
ELF	extremely low frequency
Emergency works	Works for the purpose of maintaining or restoring infrastructure facilities or equipment in order to ensure public safety or to protect buildings or the environment due to: • a sudden natural event, including a storm, flood, tree fall, bush fire, land slip or coastal inundation, or • accident, equipment failure or structural collapse, or • damage caused by vandalism or arson, provided the works involve no greater disturbance to soil or vegetation than necessary and are carried out in accordance with all applicable requirements of the Blue Book.
EMF	Electric and Magnetic Fields: are part of the natural environment and are also produced wherever electricity or electrical equipment is in use. Power lines, electrical wiring, household appliances and electrical equipment all produce EMF. The electric field is proportional to the voltage and remains constant. The magnetic field is proportional to the load and varies continually depending on the time of day, week and year. As electric fields are naturally shielded, the electricity network generally contributes very little to the electrical fields measured inside a home or office building. For this reason most discussion on EMF usually focuses on magnetic fields.
ENA	Energy Networks Australia
Environmental impact	Any change in the environment whether adverse or beneficial, wholly or partially resulting from the development and use of land. The environment includes: • ecosystems and their constituent parts, including people and communities; and • natural and physical resources; and • the qualities and characteristics of locations, places and areas; and • heritage values of places; and • the social, economic and cultural aspects of these things.
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW). Provides the legislative framework for land use planning and development assessment in NSW.
EP&A Regulations	*Environmental Planning and Assessment Regulation 2000*
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth). Provides for the protection of the environment, especially matters of national environmental significance, and provides a national assessment and approvals process.
EPI	Environmental Planning Instruments: made under Part 3 of the EP&A Act.
ES Act	*Electricity Supply Act 1995* (NSW)
ESCP	erosion and sediment control plan
ESD	Ecologically sustainable development: is development which uses, conserves and enhances the resources of the community so that ecological processes on which life depends, are maintained and the total quality of life, now and in the future, can be increased.

Flood liable land	Land that is susceptible to flooding by the probable maximum flood event, identified in accordance with the principles set out in the manual entitled *Floodplain Development Manual: the management of flood liable land* (NSW Government, 2005). Such land is commonly identified in Local Environmental Plans or Development Control Plans.
GHG	greenhouse gas
GIS	gas insulated switchgear
Hz	Hertz
IARC	International Agency for Research on Cancer
ICNG	*Interim Construction Noise Guideline (DECC, 2009)*
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IECA	International Erosion Control Association
ISO	International Organization for Standardization
kg	Kilogram
kV	Kilovolts
LALC	Local Aboriginal Land Council
LEP	Local Environmental Plan: a type of EPI made under Part 3 of the EP&A Act.
LGA	Local Government Area
Local heritage item	A place, building, work, relic, tree, moveable object, precinct, archaeological site or Aboriginal object that is: • identified as a heritage item (or by a similar description) in a local or regional environmental plan; or • an item of local heritage significance, as defined by the *Heritage Act 1977*, that is the subject of an interim heritage order in force under that Act; • or is listed as an item of local heritage significance in the State Heritage Inventory under that Act. Local heritage significance means significance to an area in relation to the historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic value of the item.A place, building, work, relic, tree, archaeological site or Aboriginal object that is identified as a heritage item (or by a similar description) in a local or regional environmental plan; or an item of local heritage significance, as defined by the *Heritage Act 1977*, that is the subject of an interim heritage order in force under that Act or is listed as an item of local heritage significance in the State Heritage Inventory under that Act.
m	metre
m^2	metres squared
mG	milligauss
MVA	mega volt amps
NES	national environmental significance
NER	National Electricity Rules
Non-Aboriginal heritage	Any deposit, object or material evidence which relates to the settlement of NSW, not being Aboriginal settlement, with local or state significance under the *Heritage Act 1977*.
NPI	*Noise Policy for Industry* (EPA, 2017)

NPW Act	*National Parks and Wildlife Act 1974*
OEH	Office of Environment and Heritage
OEMP	operation environmental management plan
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
PPS	parallel plate separator
PVC	polyvinyl chloride
Principal contractor	The *Work Health and Safety Regulation 2017* defines a principal contractor as a person conducting a business or undertaking (PCBU – the term that includes employers) that commissions a construction project. A construction project can only have one principal contractor at any specific time. A principal contractor with management or control of a workplace must: • manage risks associated with the construction work • secure the workplace so unauthorised persons cannot enter comply with all safe work method statement (SWMS) requirements for high risk construction work. Work Cover defines a principal contractor as a person conducting a business or undertaking (PCBU – the new term that includes employers) that commissions a construction project. A construction project can only have one principal contractor at any specific time. A principal contractor with management or control of a workplace must: • manage risks associated with the construction work • secure the workplace so unauthorised persons cannot enter • comply with all safe work method statement (SWMS) requirements for high risk construction work.
Proponent	The person proposing to carry out the activity, and includes any person taken to be the proponent of the activity by virtue of section 110B of the EP&A Act.
REF	review of environmental factors
RMS	Roads and Maritime Services
Road	Includes the airspace above the surface of the road, the soil beneath the surface of the road and any bridge, tunnel, causeway, road-ferry, ford or other work or structure forming part of the road. The road reserve is inclusive of the carriageway and the footpath.
SEPP	State Environmental Planning Policy: a type of EIP made under Part 3 of the EP&A Act.
Infrastructure SEPP	*State Environmental Planning Policy (Infrastructure) 2007*
SF_6	Sulphur hexafluoride
SHR	State Heritage Register
SSD	State Significant Development
SSI	State Significant Infrastructure
STS	Subtransmission Substation
SWMP	soil and water management plan
TCP	traffic control plan
TMP	traffic management plan
TPZ	Tree Protection Zone: the radius of the TPZ equals 12 times the diameter of the trunk at 1.4m above the ground. For palms and ferns, the TPZ radius should not be less than 1m outside the drip zone.

TSB	thermally stable backfill (also referred to as fluidised thermal backfill)
Vibration	Mechanical oscillations about an equilibrium point. Vibration can be caused by many different external sources, including industrial, construction and transportation activities. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time).
WH&S	Workplace Health & Safety
ZS	zone substation

Executive summary

The proposal

This Review of Environmental Factors (REF) assesses the proposal to construct, operate and maintain a 132/33kV subtransmission substation (STS) at 17-21 Waterloo Road, Macquarie Park (refer to Figure 1-1). The proposed site is located on the same property as the existing Macquarie Park 132/11kV zone substation (ZS).

The substation works would include the design, construct, electrical fit out and commissioning of a two transformer, 132/33kV STS within a single building, housing indoor 33kV switchgear and a control room, giving firm capacity of 140MVA.

The works also require the installation of an interconnecting 132kV feeder between the existing Macquarie Park ZS and the new Macquarie STS, as well as installing banks of 33kV conduits from the new Macquarie STS to the road / property boundary.

Construction of the proposal would be expected to commence in the first half of 2019 with commissioning expected to be completed by 2021, subject to assessment and approval.

Related projects subject to separate environmental impact assessments include site excavation and remediation works, 132kV feeder connections and new 33kV and 11kV supplies to Ausgrid's customers. Works have commenced on bulk excavation of fill to remediate cover over existing underground 11kV cables and construction of a retaining wall.

Background and need

Significant development in the Macquarie Park area in recent years has meant that Macquarie Park ZS is fast approaching capacity. Ausgrid has received a number of major connection applications in the Macquarie Park area. Macquarie Park ZS has insufficient capacity to connect these large anticipated customer loads to the Ausgrid 11kV network. These anticipated loads are significant and would require an increase in capacity in the area for them to be supplied.

Under the National Electricity Rules (NER) Ausgrid is required to enable connection of customers to the electricity distribution network.

Proposal alternatives

The design and location of the proposal resulted from an options investigation. Ausgrid undertakes a holistic approach to considering alternative proposals which consider alterations to various substations and powerlines to achieve the best outcome for the network. These included:

1. Construction of a new 132/33kV STS on the existing Macquarie Park ZS site, with expansion capability

2. Construction of a new 132/33kV STS on a new site adjacent to the existing Macquarie Park ZS site, with expansion capability

3. Construction of a new 132/33kV STS on the existing Macquarie Park ZS site, without expansion capability

4. Construction of a new 132/33kV STS and 33/11kV ZS at Macquarie University

5. Installation of a 3rd 132/11kV transformer at Top Ryde ZS, and 11kV load transfers to facilitate connection of the large customers at 11kV

Option 3 above was selected as the preferred option due to a number of benefits which are detailed in section 3. This option provides the most cost-effective, practical and recommended approach to meet the customer load and timing requirements. Following the selection of the chosen site this REF has assessed the proposal to ascertain whether there is likely to be a significant affect upon the environment to meet the requirements of section 5.5 of the *Environmental Planning and Assessment Act 1979* and clause 228 of the *Environmental Planning and Assessment Regulation 2000*. Proposal alternatives are described in section 3.

Statutory planning and legislation

This review of environmental factors has been prepared in accordance with Part 5 of the *Environmental Planning and Assessment Act 1979* and clause 228 of the Environmental Planning and Assessment Regulation 2000. Additional key legislation includes the *State Environmental Planning Policy (Infrastructure) 2007*, *Electricity Supply Act 1995* and *Protection of the Environment Operations Act 1997*.

Other approvals required for the proposal include s138 consent for working in Roads and Maritime Service classified road and approval from Council and Sydney Water for working in proximity to stormwater and sewer lines.

Further information on the legislation applicable to this proposal is in section 4 and the consultation undertaken is in section 2.

Environmental impact assessment

This review of environmental factors investigates the potential environmental impacts associated with the construction, operation and maintenance of the Macquarie STS proposal.

Key issues associated with the proposal were identified as noise, electric and magnetic fields (EMF) and contamination. A number of specialist assessments were undertaken to assist in assessing the environmental impacts (section 5).

Mitigation measures have been identified to address the impacts and to minimise any residual issues.

Proposal justification and conclusions

The proposal is driven by ongoing demand for electricity in the area. Supply reliability would be reduced if the proposal was not constructed. This work would help maintain a reliable supply of electricity, hence meeting Ausgrid's obligations in terms of safety, reliability, quality and continuity of supply.

On the basis of this review of environmental factors, it is concluded that the proposal:

- is not likely to significantly affect the environment (including critical habitat) or threatened species, populations or ecological communities, or their habitats
- is not on land that is, or is a part of, critical habitat or a wilderness area
- is not likely to have a significant impact on matters of national environmental significance, or a significant impact on the environment (for actions on Commonwealth land) or a significant impact on the environment on Commonwealth land (for actions outside Commonwealth land).

In making these conclusions, consideration of environmental significance was made with regard to clause 228 of the *Environmental Planning and Assessment Regulation 2000* and *Is an EIS Required? Best Practice Guidelines for Part 5 of the Environmental Planning and Assessment Act 1979*[1].

1 Introduction

1.1 Purpose of the review of environmental factors

The purpose of this REF is to assess the potential environmental impacts of the proposal and determine appropriate mitigation measures to reduce those impacts. The findings of this REF would be considered when assessing:

- whether the proposal is likely to have a significant impact on the environment and therefore the necessity for an environmental impact statement as described under section 112 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)
- the significance of any impact on threatened species as defined by the *Biodiversity Conservation Act 2016* and the requirement for a species impact statement (SIS) or apply the Biodiversity Offsets Scheme
- the potential for the proposal to significantly impact a matter of national environmental significance or Commonwealth land and the need to make a referral to the Commonwealth Minister for the Environment in accordance with the Commonwealth *Environment Protection and Biodiversity Conservation Act (*EPBC Act).

Ausgrid's determination of the proposal under Part 5 of the EP&A Act would be prepared separately to this REF.

1.2 The proposal

This REF assesses the proposal to construct, operate and maintain a132/33kV STS at 17-21 Waterloo Road, Macquarie Park (Refer to Figure 1-1). The proposed site is located on the same property as the existing Macquarie Park 132/11kV ZS.

The substation works would include the design, construct, electrical fit out and commissioning of a two transformer, 132/33kV STS within a single building, housing indoor 33kV switchgear and a control room, giving firm capacity of 140MVA.

The works also require the installation of an interconnecting 132kV feeder between the existing Macquarie Park ZS and the new Macquarie STS, as well as installing banks of 33kV conduits from the new Macquarie STS to the road / property boundary.

1.2.1 Proposal location

The proposal is located on the same property as the existing Macquarie Park 132/11kV ZS at 17-21 Waterloo Road, Macquarie Park and within the City of Ryde Local Government Area (LGA) shown in Figure 1-1. The Ausgrid owned property is approximately 200m long and 140m long on the shortest side and 60m wide, giving a total area of approximately 11,540m².

Land title information is provided in Appendix A. Figure 1-2 shows the proposal location within Ausgrid's network area.

Figure 1-1: Proposed location of the new Macquarie STS.

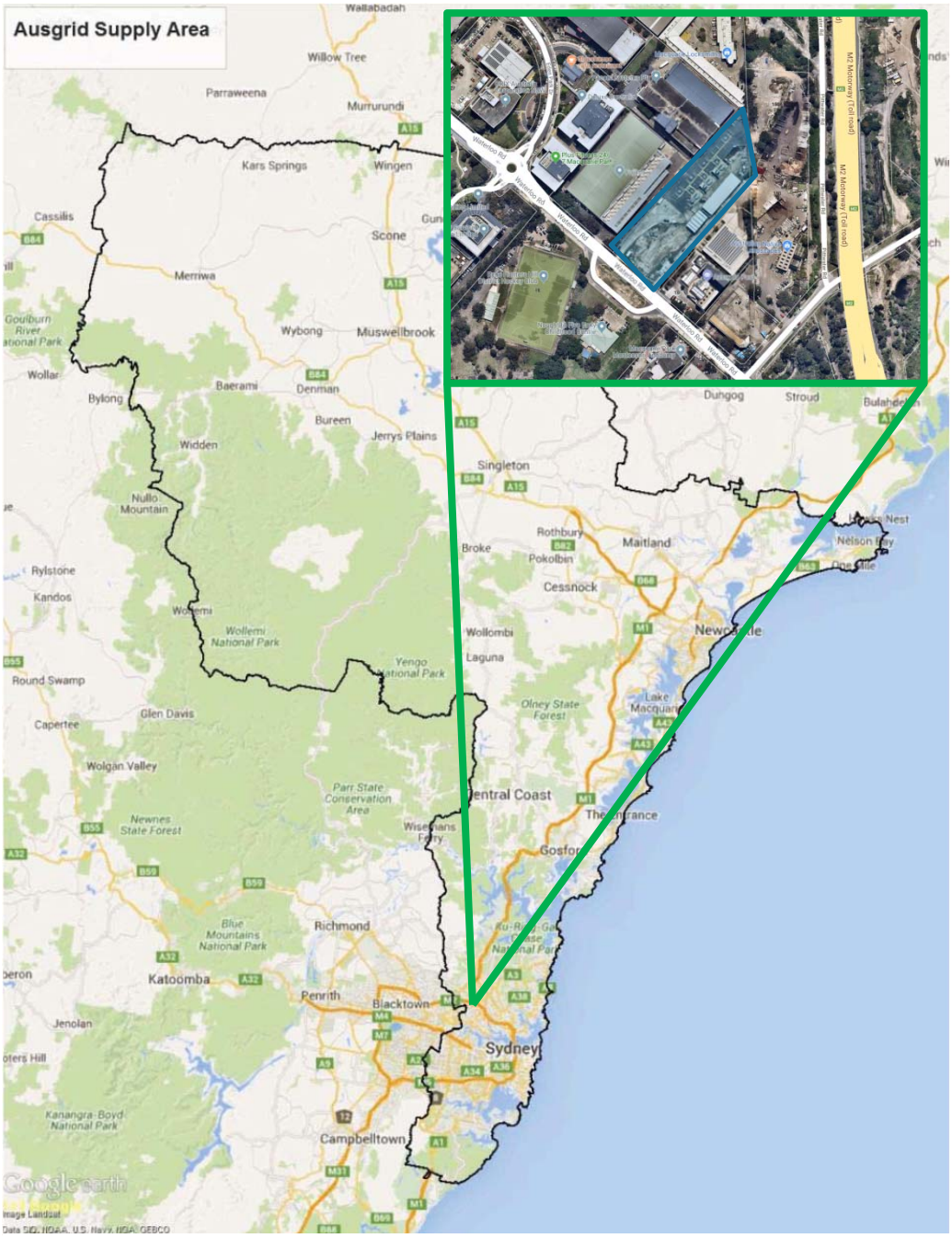


Figure 1-2: Proposed location within Ausgrid's network area

1.2.2 Proposal objectives

The objective of the proposal is to construct, operate and maintain a 132/33kV STS to meet customer supply requirements in the Macquarie Park area. This meets Ausgrid's licensing requirements to provide a satisfactory standard of supply to consumers and cater for forecast future load growth.

Other objectives of the proposal are to:

- comply with relevant laws and standards
- meet Ausgrid's duty of care
- meet Ausgrid's obligations to plan for and supply reliable electricity

- maximise social, economic and environmental benefits
- minimise environmental, social and cultural impacts.

1.3 Background and need

Significant development in the Macquarie Park area in recent years has meant that Macquarie Park ZS is fast approaching capacity. Ausgrid has received a number of major connection applications in the Macquarie Park area. Macquarie Park ZS has insufficient capacity to connect these large anticipated customer loads to the Ausgrid 11kV network. These anticipated loads are significant and would require an increase in capacity in the area for them to be supplied.

Under the NER Ausgrid is required to enable connection of customers to the electricity distribution network.

Consequences of not constructing the Macquarie STS can include:

- inability to supply customers
- damage to the network or consumer equipment
- an increased risk of injury to staff
- a reduction in supply reliability.

1.4 Related projects

Ausgrid projects typically have related projects and flow on activities due to the interconnected nature of the network. These related projects would be subject to separate environmental impact assessments due to factors such as differences in funding, construction timeframes and design.

The following projects associated with the proposal would be assessed separately under the relevant provisions of the EP&A Act once feeder routes are finalised:

- Bulk excavation of fill to remediate cover over existing underground 11kV cables and construction of a retaining wall
- the Macquarie STS 132kV connection works
- 33kV and 11kV customer feeder connections from the site

Known material cumulative impacts associated with these related projects are addressed in section 5.17.

1.5 Study area

The study area is the environment that could be directly or indirectly affected by the proposal. For the purpose of this REF, the study area is defined as the proposed substation site including the existing ZS (the size is dependent on the issue being assessed).

Some potential impacts do not have clear physical boundaries. These are assessed on a broader scale and include land use, climate change, air quality, hydrology, waste disposal, fauna (including migratory birds), visual aesthetics, social and economic impacts.

The proposal site and surrounds are described in section 5.1. Figure 1-3 shows the boundary of the study area for direct impacts assessed in this REF.

Figure 1-3: Aerial view of proposal study area

1.6 Description of the proposal

1.6.1 Overview

This REF assesses the proposal to construct, operate and maintain a132/33kV STS at 17-21 Waterloo Road, Macquarie Park (Refer to Figure 1-1). The proposed site is located on the same property as the existing Macquarie Park 132/11kV ZS.

The substation works would include the design, construct, electrical fit out and commissioning of a two transformer, 132/33kV STS within a single building, housing indoor 33kV switchgear and a control room, giving firm capacity of 140MVA.

The works also require the installation of an interconnecting 132kV feeder between the existing Macquarie Park ZS and the new Macquarie STS, as well as installing banks of 33kV conduits from the new Macquarie STS to the road / property boundary.

The following sections details the physical structures (section 1.7), construction activities (section 1.8) and operation and maintenance activities (section 1.9) associated with the proposal. Figure 1-4 shows the proposed site plan including the indicative location of key components and ancillary facilities.

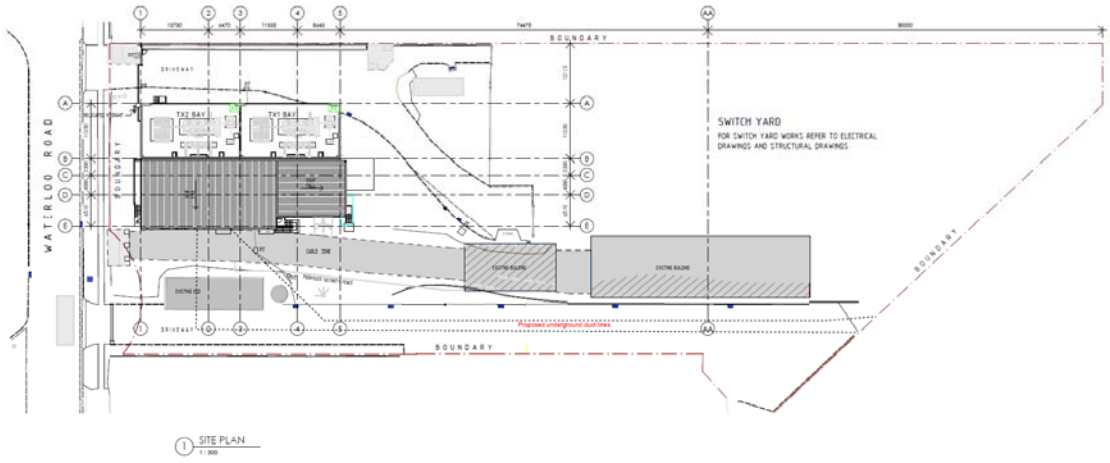


Figure 1-4 Indicative layout of the proposed Macquarie STS

1.6.2 Design

A copy of the conceptual design plans and drawings are contained within in Appendix A. It should be noted that the designs are accurate at the time of printing; however some changes may be made to the final design either prior to, or during construction. These changes are generally of a minor nature which would not materially affect the outcome of this environmental assessment. If there are significant changes, the impacts would be reassessed unless the modification would reduce the overall environmental impact.

1.6.3 Easements

Easements, leases, licences and rights of way / carriageway over land are established to protect the future security and tenure of Ausgrid's assets including substations and distribution lines of all voltages, both overhead and underground.

Section 53 of the *Electricity Supply* (ES) Act details the protection of certain electricity works which are not protected by easements.

The STS would be wholly within the Ausgrid owned properties on Waterloo Road, Macquarie Park. As such an easement would not be required to construct, operate or maintain the Macquarie STS.

1.7 Physical structures

1.7.1 Building layout/structure

The new substation building would be constructed to have a design life of 50 years. The building would sit perpendicular to Waterloo Road and consist of a cable marshalling area (basement) built into the sloped ground and a main equipment floor above it. The maximum wall height to the eave line of the highest point of the building would be approximately 6.5m. The highest point of the roof would be approximately 8m. The transformer bays would be located adjacent to the building with separation walls 8m high. These heights are measured from the ground level of the existing Macquarie Park ZS.

The substation building would be a neutral contemporary design to fit in with the surrounding environment.

The substation building would have a footprint of approximately 14m (parallel to Waterloo Road) by 40m and would consist of the following:

- 132kV switchroom and associated basement
- combined 33kV switchroom and control room with associated basement
- 132kV and 33kV switchgear
- associated control and protection equipment
- batteries and associated chargers that would be stored in compact vertical racking
- oil containment
- other substation equipment
- amenities

1.7.2 Electrical equipment

The substation would include two open transformer bays along the north western side of the new substation building. The two transformer bays would house 132/33kV, 120MVA (140MVA emergency) oil filled transformers with associated cabling and support steelwork. Transformer bays would be approximately 11m by 20m each and constructed of concrete bases with pre-cast concrete wall surrounds on the three sides. The existing transformer roadway along the north western boundary of the substation site would be widened to accommodate both substations.

The indoor 132kV and 33kV switchrooms and control room would be located on the southern boundary of the site. The new building (not including the transformer bays) would have the approximate dimension of 40m and 14m. All information remains subject to the detailed design.

Lightning rods may be required to protect the substation from lightning strike. The requirement for lightning rods would be determined during the detailed design stage.

Concrete plinths and foundations would be constructed for the new transformers and switchgear elements.

The earthing system is an essential part of providing a safe working environment within the substation as well as correct protection. The earthing system would be integrated in the building design and would extend 1m from the building and substation fencing within Ausgrid's property subject to confirmation in the detailed design. The earth rods may be drilled to a depth of approximately 15m, subject to confirmation in the detailed design.

The earthing system would be interconnected with the existing Macquarie Park ZS.

1.7.3 Overhead power lines

In order to supply electricity to the new STS, a new overhead 132kV power line connection is proposed. These associated works would form part of another environmental impact assessment.

1.7.4 Underground cables

There would be four conduit banks for 33kV cables installed from the new substation to the road / property boundary.

33kV cables are typically arranged in a six way configuration with a width of approximately 1.3m and a depth of 1.4m. Spare communications conduits would also be installed. The exact configuration of the cables would be determined in the detailed design stage.

1.7.5 Utilities

The existing electrical infrastructure consists of a mixture of overhead and underground 132kV, 11kV and low voltage power lines running along Waterloo Road. There are also underground electrical assets running throughout the property of the existing ZS.

The following utilities are located off the Waterloo Road frontage:

- A minor gas main, approximately 3m off the property boundary below the footpath.
- An optical fibre cable, approximately 4m off the property boundary below the footpath.
- A minor water main, approximately 5m off the property boundary located in the grass verge between the footpath and the road.
- A minor sewer pipe, approximately 8m off the property boundary below Waterloo Road.
- A minor water main, approximately 13m off the property boundary below Waterloo Road.
- A stormwater pipe, approximately 17m off the property boundary below Waterloo Road on the far side of the road from the building.
- An optical fibre cable, approximately 17m off the property boundary below Waterloo Road on the far side of the road from the building.

- A Telstra copper cable, approximately 19m off the property boundary on the far side of Waterloo Road from the building, in the grass verge.

1.7.6 Lighting

Flood lights would be provided within the outdoor areas for use during night works (emergency works only). The proposed control building would have separate lighting for night purposes, which would only be used when required for temporary out of hour's works. All lighting would comply with Australian standards[2].

1.7.7 Fencing and signage

The site boundary of the substation and the internal transformer bays would be clearly defined and fenced according to Ausgrid's security fencing design standards.

A new masonry wall would be constructed along the north-west boundary at a height of 4m above the transformer roadway. A set of security gates would be installed across the transformer roadway.

New substation security fencing would need to be installed to the south east of the new building, extending to the existing ZS with vehicle and personnel access gates.

Signage would be required for construction and operation of the proposed substation. During construction signage would be displayed in accordance with Workplace Health & Safety (WH&S) regulations for construction sites. This would include warning and protective equipment signs.

During the operational life of the substation warning signs would be put in place and gates padlocked at all times except when in immediate use. Standard signs include High Voltage – Keep Out", "Authorised Personnel Only", "Trespassers will be Prosecuted", "Protective Equipment must be Worn" and an Ausgrid Logo Sign for identification of the substation.

1.7.8 Access and parking

During operation, all site access would be via Waterloo Road. There would be provision for vehicle parking within the boundary. Entrance gates would be established at the substation site to allow vehicles to enter and exit the site.

Reasonable areas would be provided for maintenance and testing vehicles to access the indoor control rooms for testing and maintenance purposes.

Delivery and removal of transformers to and from the site would be via the existing transformer roadway accessed from Waterloo Road. Transformers are large units in excess of 50 tonnes and are required to be delivered by large specially configured trucks. Access to the transformer roadway for a low loader from Waterloo Road would require the closure of a section of this road. Any road closures would require the appropriate approvals. Delivery of a transformer would only occur during the construction of the substation and at the end of the equipment life span (estimated 20-50 years) or as a result of equipment failure.

1.7.9 Oil containment

The oil containment system would control oil in the event of a major failure of the oil filled transformers and any incidental spills and/or leaks during operation of the

substation. The system is designed to capture oil from the substation transformer bunded areas and a section of the roadway and discharge treated water to the local stormwater system.

The system is designed with a reinforced concrete bunded area around the transformers which complies with Australian standards[3]. The proposed oil containment system would be a parallel plate separator designed to service all transformer bays.

1.7.10 Stormwater

The site drainage system comprises pits and pipes which would collect water from sealed surfaces within the transformer roadway and from the roof of the substation building and would be diverted to the local stormwater system.

The detailed stormwater plan is in Appendix A.

1.7.11 Noise barriers

No permanent noise barriers are required to be installed as part of the works. Refer to section 5.4 for further details.

1.7.12 Fire protection

The fire protection system would consist of fire monitoring, detection and protection systems for the entire facility. This would include suitably rated fire doors, fire proofing, fire stopping, portable fire protection equipment and/or hydrant stands.

Refer to section 5.11 for further details.

1.7.13 Landscaping

Landscaping would be undertaken in accordance with the plan prepared as part of the detailed design.

The surfaces of the property would be covered in concrete driveways, concrete footpaths, grass or a layer of blue metal to provide a series impedance layer for earthing requirements.

1.8 Construction activities

The precise construction methodology would be determined at the post-contract stage of the proposal. The works would be undertaken by a contractor, selected after a competitive tendering process as a construction package, who would be responsible for planning all construction processes, including scheduling and overall timing of works. The specifications included in the competitive tendering process would include a requirement to comply with the scope and mitigation measures detailed in this REF. The mitigation measures detailed in this REF must be included in the contractor Construction Environmental Management Plan (CEMP).

The anticipated sequence of works for the proposal would include:

- survey work
- establishing structures such as fencing and hoarding
- installing pre-construction mitigation measures, such as erosion, sediment and water quality controls, fencing sensitive areas

- relocating utilities, services and signage
- establishing temporary construction facilities
- clearing vegetation within the substation footprint and for the construction compound
- saw cutting to remove / recycle concrete or asphalt pavement
- establishing a construction compound and stockpile sites bulk earthworks
- erecting retaining walls and installing drainage
- pile driving
- constructing an access road that would become the transformer roadway
- constructing parking areas
- constructing foundations
- constructing transformer bays
- constructing a combined switchroom and main control room
- installing an oil containment system
- excavating cable trenches and joint bays
- laying conduit / cable and backfilling
- equipment delivery
- pulling cables through conduits
- storing and stockpiling equipment
- dewatering
- jointing
- testing and commissioning
- reinstating roads or pavements
- landscaping
- restoring the site (including general site clean-up and removing site compounds, temporary construction facilities' and temporary environmental controls).

1.8.1 Construction access, parking, site compounds and stockpiles

During construction, access to the proposed site would be from Waterloo Road. Protection measures would be placed at the entrance to reduce the potential for tracking onto the roadways.

A dilapidation survey would be undertaken as part of the CEMP in order to assess the current state of adjacent properties.

The south corner of the property would likely be used as the site compound during construction. Construction materials, any additional portable buildings containing meal rooms, offices and amenities would most likely be positioned in this location however, other suitable areas may be utilised.

A portion of this land may be suitable for parking of vehicles in order that the impact on street parking for the nearby residents and businesses is minimised.

Prior to the commencement of works, a dilapidation survey would be undertaken for all nearby Council assets and public infrastructure, e.g. kerbs, footpaths, fences. This would likely be in the form of digital photographs.

Reinstatement of the affected areas would be undertaken in consultation with the relevant authority (e.g. Council, Roads and Maritime Services (RMS)).

1.8.2 Construction fencing

Temporary construction fencing would be placed around the construction site to secure the site during construction. During construction signage would be displayed in

accordance with WH&S regulations for construction sites. This would include danger and protective equipment signs.

1.8.3 Bulk excavation works

Excavation works are required for the cable basement. Based on approximated dimensions, the estimated combined volume of material to be excavated is approximately 3,000 cubic metres of soil. The amount of excavations required would be determined during detailed design and the works would be performed during construction.

1.8.4 Installation of overhead power lines

In order to supply electricity to the new STS a new overhead 132kV power line connection is proposed. This power line would create a new connection to the existing transmission lines running along Plassey Road to the north east of the substation site. It is anticipated this overhead power line would enter the site via Waterloo Road. These associated works would form part of another environmental assessment.

1.8.5 Installation of underground cables

The trench for installation of the 33kV cables would typically be 1.4m deep and 1.3m wide and the conduits would also be placed in a six way arrangement.

Once each segment of trench is completed it would be backfilled and a new excavation opened for the next segment of the route.

The ends of the conduits would be excavated / exposed and the cables would be then pulled through the conduits, connected, backfilled and commissioned onto the network.

Thermally stable backfill (TSB) would be placed around the cables to provide a good operating environment, then covered with sand or soil excavated from the trench alignment (depending on whether works are in the road or verge).

Temporary road reinstatement would take place shortly after the trench has been backfilled in order to minimise any environmental or traffic impacts. Long term reinstatement would be undertaken at a later date.

1.8.6 Installation of underground to overhead transition pole

The overhead 132kV powerline is expected to connect to the STS via an external wall bushing. This would be determined during detailed design. .

1.8.7 Vegetation clearing

All vegetation within the substation footprint would be cleared to enable unimpeded access to the site for the bulk excavation equipment.

1.8.8 Temporary utilities

A temporary supply would be installed during construction to supply electricity to the construction. The type of connection would be determined during the detailed design stage.

1.8.9 Installation of temporary environmental controls

Temporary environmental controls would be installed during the construction phase to mitigate potential environmental issues identified in section 5. Temporary controls for the proposal to mitigate such issues as noise and sediment would be installed where appropriate. These controls would be removed once construction is complete.

1.8.10 Timing and working hours

Construction of the proposal would be expected to commence in the first half of 2019 with commissioning expected to be completed by the end of 2021, subject to assessment and approval. The works would be broken into three main phases: investigation works, civil construction and electrical fit out.

Works that would generate audible noise at any sensitive receiver would be undertaken between 7am and 6pm Monday to Friday and 8am and 1pm on Saturday. Audible works outside these hours may be undertaken where the following requirements are met:

- the works are emergency works, unplanned or unavoidable and the affected residents have been notified as far as reasonably practicable; or
- the works fall into one of the following categories and the affected residents are provided with a notification letter at least five days prior to the works:
    - the delivery of oversized plant or structures that cannot be undertaken during standard hours
    - maintenance and repair of essential public infrastructure that is unable to occur during standard hours
    - public infrastructure works that shorten the length of the construction phase and are supported by the affected community (this would require community consultation)
    - it is a requirement of a regulatory authority
    - where there is a demonstrated and justified need to operate outside the recommended standard operating hours and this is supported by Ausgrid's Project Manager, Community Relations Section and Manager Environmental Services.

1.8.11 Resources and equipment

There would be approximately 5-40 staff employed during the construction phase. Ongoing maintenance requirements during operation would be undertaken by Ausgrid field personnel and contractors.

The following equipment may be used on site but is not limited to:

- piling rig (continuous flight or impact)
- large rock breaking equipment
- large and small excavators
- concrete form work
- crane
- truck mounted borer
- truck mounted augers and cranes
- backhoe
- trucks for material transport including soil, concrete and cable
- elevated work platforms
- saw cutting machine with vacuum and transport utility

- grader
- cable winch (for high voltage)
- portable / roller compactor
- compressor
- traffic control vehicles
- fire suppression
- power generator
- construction fencing
- street sweeper vehicles
- dust suppression vehicles
- water tankers
- skip bins
- tipper
- ladders
- scaffolding
- site and compound sheds
- temporary construction facilities
- associated minor construction equipment.
- pollution prevention equipment.

The following materials may be required for the proposal but is not limited to:

- concrete piles, footings and pre-cast panel walls
- asphaltic concrete
- bricks and mortar
- various metals for reinforcement and structural steel, balustrades, fencing, signage, roof sheeting, fire suppression system, ventilation panels, electrical equipment, earth grid, electricity and communications conductors
- doors and windows including hardware
- downpipes, guttering and plumbing supplies
- paint
- lighting and fittings
- wall and floor tiling
- vinyl flooring
- plasterboard
- concrete / metal / timber poles
- conduits
- gantry crane
- strip drains
- Polythene membrane
- lourve screen
- Colour bond cladding
- laminate
- imported soil for engineered fill and topsoil
- blue metal gravel / crushed rock
- landscape supplies
- retaining walls
- energy sources such as fuel and oils
- pollution prevention materials
- TSB
- cables
- communication cables
- concrete and reinforcement.

1.9 Operation and maintenance requirements

Once the STS is constructed, periodic maintenance would be required consisting of regular attendance on site by small work groups utilising light vehicles and small to medium plant.

The site would not accommodate staff and/or contractors on a permanent basis; however, access would be undertaken at any time for irregular short duration works,

such as to identify defects and hazards such as damaged components, vandalism, degraded access tracks and reduced safety clearances.

No regular collection of waste is required. All wastes generated during the operational phase on site would be minimal and managed on an 'as required' basis.

The substation building has been designed to be low maintenance, for example:

- A combination of in-situ and pre-cast concrete panels, have been chosen for the façade to reduce the maintenance requirements over the life of the substation.
- Operational systems including passive oil separation systems and security systems are monitored and controlled remotely.

Likely maintenance and operation activities associated with the substation include, but not limited to:

- vegetation trimming to maintain electrical safety clearances and asset protection zone;
- general landscape maintenance;
- fire detection and suppression system inspection and maintenance;
- general building, fence and roadway maintenance;
- access track maintenance;
- stormwater and oil containment system inspection and maintenance;
- regular maintenance of electrical equipment;
- fence maintenance and repair;
- unplanned fault and breakdown repairs;
- insulator and conductor repair;
- underground cables and conduit repairs and maintenance;
- pole replacement; and
- staff attendance for routine inspection, operation and maintenance activities.

2 Consultation

2.1 Overview

Consultation defines the processes Ausgrid uses to seek views or provide information about our works and seek community feedback. Consultation can include a range of communication activities such as notification to community members and relevant authorities, community information displays, individual contact with residents and meetings with community and authority representatives where feedback is invited. These activities are designed to ensure Ausgrid is aware of potential issues so essential electricity upgrades can be conducted with minimal impact on the local community.

The consultation undertaken as a part of this REF meets the Code of Practice for Authorised Network Operators.

Consultation spans the entire proposal from the initial concept stage through to construction and as the new infrastructure is brought into service.

2.2 Statutory notification requirements

Under the *Electricity Supply Act 1995* (NSW) (ES Act), Ausgrid is required to undertake 40 days notification to the local Council for proposed works (other than routine repairs or maintenance works) so that Council has an opportunity to comment on the proposal.

Submissions received under the ES Act from the relevant local Council and Ausgrid's response are summarised in Table 2-1.

Under the *State Environmental Planning Policy (Infrastructure) 2007 (*Infrastructure SEPP), Ausgrid is the determining authority for electricity developments under Part 5 of the EP&A Act. While the work undertaken does not require Council consent, the Infrastructure SEPP requires Ausgrid to undertake 21 days notification to Council where works involve a substation or may impact upon Council infrastructure, the community or local heritage items. Works involving a substation also require 21 days notification to occupiers adjoining that land. In some instances, other public authorities need to be notified (see Table 2-2).

Under the Infrastructure SEPP and ES Act, the stakeholders listed in Table 2-1 were consulted about the proposal and asked to provide comment. The submissions received to date are summarised in Table 2-1.

Specific licences, permits and approvals that require consultation are outlined in Table 4-1.

Table 2-1: Statutory consultation responses

Table 2-1 - Statutory consultation responses

Submission No.	Respondent	Notification requirement	Comments raised	Ausgrid's response
Ausgrid met with the City of Ryde Council in June 2018 to introduce the project and discuss the proposed works. While no formal submission was received from Council in response to the statutory notifications, Council provided more information relating to flood zones, easements and drainage networks. Further feedback was provided directly to the project team and is recorded below. Ausgrid will continue to consult with Council through all stages of the project.				

Submission No.	Respondent	Notification requirement	Comments raised	Ausgrid's response
1.	City of Ryde Council	ES Act & Infrastructure SEPP – consultation Meeting with City of Ryde Council held 5-June-2018	Council expressed concerns regarding possibility of a replica of Macquarie Park ZS open yard layout for STS.	Ausgrid advised the STS would be an indoor/indoor style substation utilising gas insulated switchgear (GIS) equipment.
			Council requested the STS building be treated with architectural details on facades to add visual interest and minimise visual impacts on public domain.	Ausgrid acknowledged this request and noted architectural treatments would be considered in its detailed design.
			Council noted it had future road dedication plans for area and noted the areas Development Control Plan (DCP) showed future goals for new road dedications.	Ausgrid agreed to consult further regarding opportunities for new road dedications in the surrounding area.
			Council noted Department of Planning had a Master Plan covering the area.	

Submission No.	Respondent	Notification requirement	Comments raised	Ausgrid's response
2.	City of Ryde Council	ES Act & Infrastructure SEPP Statutory Notice Letter issued 12 July 2018	Interim advice from Council Planners provided, including map of environmental constrictions showing: - Flood zones - Council drainage - Easements and Rights of Way Two potentially sensitive neighbours identified.	Ausgrid considered information provided and scheduled follow up meeting on 26 September 2018. Potentially sensitive neighbouring properties included in later project consultation.
3.	City of Ryde Council	ES Act & Infrastructure SEPP – Statutory Notice Update Letter issued 1 Nov 2018	No feedback received	

2.3 Community consultation

2.3.1 Planning

Ausgrid has involved the community in the detailed planning of the proposal.

The new substation would be constructed on land owned by Ausgrid at 17-21 Waterloo Road, Macquarie Park. This site is adjacent to the existing Macquarie Park zone substation.

The site faces Waterloo Road and is in an area dominated by facilities used for commercial activities including Australia Post Distribution Centre, a Data Centre, Australian Native Landscapes (Bulk horticultural and landscaping products). A hotel is located at 6 Waterloo Road and on the opposite side of the road is a day care centre.

Adjacent to the day care centre is the Ryde Hunters Hill District Hockey Centre and playing fields.

Ryde Council has been briefed on the project and preliminary comments from the relevant officers are being considered as part of the planning process. Council's DCP for the area has also been taken into consideration.

The area is currently the subject of a Master Planning process by Planning NSW. Ausgrid has contacted the relevant people and provided information on the proposal.

Adjoining land occupiers will be notified of the substation proposal and given opportunity to provide a submission.

Community engagement activities undertaken to date for this proposal include:

- Engaging with Members of Parliament in the area where the substation could be built.
- Initial community newsletter - distributed to 400 properties around the substation site in September 2018 to introduce the proposal.
- Statutory notifications delivered to properties adjoining the substation site in December 2018.
- Door knocking of surrounding properties to introduce the proposal to the local community and let them know about upcoming works at the site. Letters were left where occupants were not home.
- A toll free 1800 information line has been established and an email address made available for people wanting more information on the proposal or to ask questions or to raise issues during construction.
- Ausgrid has a dedicated project information page on its website.
- The REF will be placed on public exhibition for community comment and submissions before the project is assessed for construction approval.

A summary of the issues raised during community consultation to date is contained in Table 2-2

Table 2-2 - Community consultation responses

Submission No.	Respondent	Consultation undertaken	Comments raised	Ausgrid's response
1.	NSW Department of Planning	As per City of Ryde Council's recommendation – emails and phone call correspondence	It is considered of high importance to the team that any works undertaken in the public domain facilitate high quality urban design and amenity outcomes. We recommend that powerline be undergrounded and appropriate treatments applied to the substation to soften the impact. These actions will support the Government vision for Macquarie Park as a productive, attractive and innovative area.	Ausgrid acknowledged the request for consideration of public amenity and will take this feedback on board and will be balancing the need for design functionality and an appropriate façade treatment. Ausgrid provided the justification for considering the overhead feeder options
2.	Neighbouring properties	Door knock Consultation regarding bulk excavation of fill to remediate cover over existing underground 11kV cables and construction of a retaining wall, 7 September 2018	No major concerns were raised. Letters left for property occupants that weren't available to talk.	
3.	Neighbouring properties	Community Newsletter #1 – September 2018	No feedback received.	
		Community Newsletter #2 – January 2019	No submissions received	
4.	Sydney Coordination Office (TfNSW)	Consultation meeting regarding Station Link impacts – 14 September 2018	General discussions regarding Station Link plans and traffic implications	Ausgrid agreed to keep in consultation with Sydney Coordination Office throughout the project works.

Submission No.	Respondent	Consultation undertaken	Comments raised	Ausgrid's response
5	City of Ryde	REF	Council asked for details about exact route & alignment of the 132kV overhead power poles for Macquarie.	Ausgrid shared the drawings and options for the proposed alignment from the tower line to the new Macquarie STS.

2.3.2 Construction

Community engagement activities would continue as the project enters the construction phase.

This would include:

- A dedicated community engagement officer would be part of the project team during construction. This officer would work closely with construction personnel and the community to ensure the community is informed about upcoming works and potential impacts, and to address any construction-related issues as quickly as possible.
- A 24 hour community information line, project email address and web page.
- Co-branded business card with 1800 number and project email. To be carried by supervisors and traffic controllers and provided to stakeholders who need to contact Ausgrid directly.
- Information about project needs, planning, environmental approval documentation and answers to frequently asked questions on Ausgrid's website. This information would be updated as required during the project.
- Notifications to neighbours prior to the start of new work would provide information about the proposed construction activities, timing, work hours and traffic and parking arrangements, as well as details of how to find out more information or raise any issues with the project team.
- Specific notification requirements for any noisy works outside standard construction hours

2.3.3 Aboriginal community

A search of the AHIMS record indicated that the works are not within the buffer of recorded Aboriginal heritage. The site is largely disturbed by past cut and fill activities. The proposal is not likely to harm Aboriginal objects or places. A due diligence assessment and Aboriginal cultural heritage consultation was not required.

3 Investigation of alternatives for the proposal

3.1 Assessing alternative options

As part of developing this proposal, consideration was given to alternative sites, designs, construction and management options.

3.2 Do nothing

The first option considered to address the objectives of this proposal is to refrain from undertaking any further development of the network in the area (do nothing).

Benefits of this option would include reduced capital expenditure and no construction or operation impacts as described in section 5 of this REF.

Under a do nothing scenario Ausgrid would only supply part of the customer's requested load with the existing 11kV spare capacity at Macquarie Park ZS in the absence of a network option. Note this is not a realistic scenario as it is Ausgrid's obligation to process and facilitate customer connection requirements under Section 5.3 in the NER. As the load continues to grow in the area Ausgrid's capacity to supply existing and new customers would be further restricted.

3.3 Demand management

The main driver of this project is the need to provide supply to major connection applications in the Macquarie Park area. It is not considered appropriate to attempt a deferral of the connection date for major customer connections.

These customers have progressed with formal connection applications and confirmed their load requirements and expected connection dates. In particular, these customers are requesting approximately 91MVA by 2021 which is best served with a subtransmission voltage (i.e. 33kV or higher). For this type of customers the load is almost constant and demand management technologies are not realistic as a means of deferring/avoiding network investments.

3.4 Network and site options

Five network alternatives were considered for rectifying supply issues in the Macquarie Park area. Ausgrid undertakes a holistic approach to considering alternative proposals which consider alterations to various substations and powerlines to achieve the best outcome for the network. These included:

1. Construction of a new 132/33kV STS on the existing Macquarie Park ZS site, with expansion capability

2. Construction of a new 132/33kV STS on a new site adjacent to the existing Macquarie Park ZS site, with expansion capability

3. Construction of a new 132/33kV STS on the existing Macquarie Park ZS site, without expansion capability

4. Construction of a new 132/33kV STS and 33/11kV ZS at Macquarie University

5. Installation of a 3rd 132/11kV transformer at Top Ryde ZS, and 11kV load transfers to facilitate connection of the large customers at 11kV

3.5 Chosen option

A feasibility investigation has been completed into subtransmission options to supply the large data centre needs and provide flexibility for future large customer connections and zone capacity. The most cost-effective, practical and recommended approach to meet the customer load and timing requirements was identified as Option 3, being the construction of a 2 x 120MVA transformer STS at the existing zone substation site, without expansion capacity.

Following the selection of the chosen site, Ausgrid prepared this REF to assess the environmental impacts of the proposal and to ascertain whether there would be a significant impact upon the environment to meet the requirements of sections 111 and 112 of the EP&A Act and clause 228 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulations).

4 Environmental legislation

4.1 Environmental Planning and Assessment Act 1979

The EP&A Act is the primary legislation regulating land use planning in NSW. It provides the framework for the development of state and local planning instruments which, through their hierarchy, determine the statutory process for environmental impact assessment. This proposal satisfies the definition of an activity under Part 5 of the EP&A Act since it:

- may be carried out without development consent
- is not exempt development
- would be carried out by a determining authority or requires the approval of a determining authority.

Under Part 5 of the EP&A Act, activities require a determining authority to take into account all matters affecting or likely to affect the environment by the proposed activity. As Ausgrid is an authorised network operator under the *Electricity Network Assets (Authorised Transactions) Act 2015*, where it is carrying out development for the purposes of an electricity transmission or distribution network (within the meaning of State Environmental Planning Policy (Infrastructure) 2007) to be operated by the authorised network operator, Ausgrid is prescribed as a public authority under r277 of the *Environmental Planning and Assessment Regulation 2000*.

Environmental Planning Instruments (EPIs) are legal documents that regulate land use and development, including the type of assessment process required. EPI is the generic term used to describe SEPPs and LEPs. As of 1 July 2009, regional environmental plans (REPs) are no longer part of the hierarchy of EPIs in NSW. All existing REPs are now deemed SEPPs.

The following EPIs that apply to the proposal area were considered:

- SEPP – Infrastructure
- SEPP – Major Development
- SEPP – State and Regional Development
- SEPP 19 – Bushland in Urban Areas
- SEPP 55 – Remediation of Land
- Ryde Local Environmental Plan (LEP) 2014

4.2 State Environmental Planning Policy (Infrastructure) 2007

Subject to certain exemptions, the Infrastructure SEPP allows development for the purpose of an electricity transmission or distribution network to be carried out by or on behalf of an electricity supply authority or public authority without development consent on any land.

Having regard to the Coastal Management SEPP, this proposal falls within the scope of the Infrastructure SEPP as an activity permissible without development consent. Consultation requirements under the Infrastructure SEPP are addressed in section 2.

4.3 State Environmental Planning Policy (Coastal Management) 2018

State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP) will exclude the application of the Infrastructure SEPP for some developments which are located on land identified as “coastal wetlands” or “littoral rainforest”, or development which is coastal protection works. . There are no “coastal wetlands” or “littoral rainforest” located near the area of the proposal, nor is the land identified as a proximity area for coastal wetlands or littoral rainforest. As such the proposal would not impact upon land captured by the Coastal Management SEPP.

4.4 Vegetation Clearing SEPPs

State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017 (Vegetation SEPP) requires certain approvals from either Council or the Native Vegetation Panel prior to clearing of certain vegetation. Clause 8 provides that authority to clear vegetation is not required under this Policy if it is clearing of a kind that is authorised under section 60O of the *Local Land Services Act 2013* (LLS Act). As this proposal is authorised under s60O(b)(ii) of the LLS Act, being [an activity carried out by a determining authority within the meaning of Part 5 of that Act after compliance with that Part], consent under the Vegetation SEPP is not required.

State Environmental Planning Policy No 19—Bushland in Urban Areas (Bushland SEPP) applies where works are proposed on urban land which is bushland zoned or reserved for public open space purposes, or adjacent to such land.

4.5 State Environmental Planning Policy (State and Regional Development) 2011

The *SEPP (State and Regional Development) 2011* declares certain development to be State Significant Development (SSD) and State Significant Infrastructure (SSI), including Critical SSI. Applications for SSD and SSI must be accompanied by an Environmental Impact Statement (EIS).

The proposal is not a type of development listed in the schedules of the *SEPP (State and Regional Development) 2011* as being SSD or SSI. The proposal would not have a significant impact on the environment (refer to section 6) and therefore does not require an EIS and as such would not be considered SSI.

On this basis, the *SEPP (State and Regional Development) 2011* is not applicable to the proposal and it can be assessed under Part 5 of the EP&A Act through the operation of the Infrastructure SEPP.

4.6 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act prescribes the Commonwealth’s role in environmental assessment, biodiversity conservation and the management of protected species, populations and communities and heritage items. The approval of the Commonwealth Minister for the Environment is required for the following controlled actions:

- an action that may have a significant impact on matters of national environmental significance (NES)

- actions that are likely to have a significant impact on the environment of Commonwealth land
- actions taken on a Commonwealth land that are likely to have a significant impact on the environment anywhere.

The EPBC Act lists nine matters of NES which must be addressed when assessing the impacts of a proposal. An assessment of how the proposal may impact on matters of NES is provided in Secion 6.2.

The assessment of the proposal's impact on matters of NES and the environment of Commonwealth land found that there is unlikely to be a significant impact on relevant matters of national environmental significance. Accordingly, the proposal has not been referred to Commonwealth Department of Environment.

4.7 Electricity Supply Act 1995

The ES Act sets out the licensing regime on Ausgrid and provides a framework for the development and maintenance of electricity infrastructure. The ES Act allows Ausgrid to trim and remove trees, carry out works on public roads and acquire land.

The ES Act also requires that works (other than routine repairs or maintenance works) must not be undertaken without a minimum of 40 days consultation with relevant local Councils. Any submission must be considered by Ausgrid. Consultation requirements under the ES Act are addressed in section 2.

4.8 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) provides a framework for the licensing of certain activities and is administered by the Environmental Protection Agency (EPA) (the statutory authority of Office of Environment and Heritage (OEH)). Under the POEO Act, the EPA is the Appropriate Regulatory Authority for Ausgrid.

Schedule 1 of the POEO Act lists activities that require an Environment Protection Licence to operate. The need for a licence would be evaluated and sought prior to the commencement of construction, once a detailed construction method has been finalised. Refer to section 4 for licences that may be required for the proposal. Regardless of whether a licence is required, during construction and operation of the proposal Ausgrid must ensure that:

- works do not pollute the environment
- waste is classified, handled, transported and disposed in accordance with EPA guidelines
- environmental incidents involving actual or potential harm to human health or the environment are reported to OEH.

4.9 Biodiversity Conservation Act 2016

Section 1.7 of the EP&A Act provides that the Act is subject to the provisions of Part 7 of the *Biodiversity Conservation Act 2016* (BC Act) and Part 7A of the *Fisheries Management Act 1994* (FM Act). The BC Act and FM Act contain additional requirements with respect to assessments, consents and approvals under the EP&A Act, concerning certain terrestrial and aquatic environments.

Where an activity being assessed under Part 5 is likely to significantly affect threatened species, s 7.8 of the BC Act requires that a species impact statement, or biodiversity development assessment report must be prepared by the proponent. Where there are other likely significant effects on the environment, then an environmental impact statement would instead be required.

With respect to a development being assessed under Part 5, s 7.2 of the BC Act provides that development or an activity is likely to significantly affect threatened species if:

- it is likely to significantly affect threatened species or ecological communities, or their habitats, or
- it is carried out in a declared area of outstanding biodiversity value.

Section 7.3 of the BC Act lists a number of factors to be considered in determining whether the proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats. This includes, for example, whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

The Schedules to the BC Act prescribe the following lists of specifies, ecological communities, and other matters relevant to this determination:

- Threatened species;
- Threatened ecological communities;
- Extinct species, species extinct in the wild and collapsed ecological communities;
- Key threatening processes;
- Protected animals; and
- Protected plants.

A desktop assessment indicated that no threatened flora or fauna species, population or ecological community would be affected by the proposal.

4.10 Summary of legislative requirements

Additional pieces of environmental legislation that could apply to Ausgrid's network area were considered in the preparation of this REF, including:

- *Biodiversity Conservation Act 2016* (NSW)
- *Coastal Management Act 2016* (NSW)
- *Crown Lands Act 2016* (NSW)
- *Fisheries Management Act 1994* (NSW)
- *Forestry Act 2012* (NSW)
- *Heritage Act 1977* (NSW)
- *Hunter Water Act 1991* (NSW)
- *Local Land Services Act 2013* (NSW)
- *Coal Mine Subsidence Compensation Act 2017* (NSW)
- *National Greenhouse and Energy Reporting Act 2007* (NSW)
- *National Parks and Wildlife Act 1974* (NSW)

- *Native Title Act 1993* (Commonwealth)
- *Biosecurity Act 2015* (NSW)
- *Roads Act 1993* (NSW)
- *Rural Fires Act 1997* (NSW)
- *Water Act 1912* (NSW)
- *Water Management Act 2000* (NSW)
- *Water NSW Act 2014*
- *Wilderness Act 1987* (NSW).

Specific licences, permits, approvals and notifications required for the construction, maintenance and operation of the proposal are outlined in Table 4-1.

Table 4-1: Summary of legislative requirements

Legislation	Authority	Requirement	Comment	Responsibility
Contaminated Land Management Act 1997	OEH	**Notification:** under s. 60, by a person whose activities have contaminated land or a landowner whose land has been contaminated is required to notify OEH when they become aware of the contamination.	If contamination is discovered during the contamination investigation or construction, the duty to report would be determined.	Ausgrid/Principal Contractor
EP&A Regulation	Ausgrid	**Consideration:** under cl. 228, of the factors to take into account concerning the impact on an activity on the environment.	This REF has considered factors under cl. 228 in section 6.1.	Ausgrid / Principal Contractor
ES Act	Local Council	**Notification:** under s.45, of 40 days' notice for the proposed electricity works.	Notification was given on 12 July 2018.	Ausgrid
Infrastructure SEPP	Local Council	**Notification:** under s. 13-15, 21 days' notice for substantial impact on Council related infrastructure and local heritage or works in flood liable land that will change flood patterns other than to a minor extent.	Notice was given at the same time as the ES Act notification – 12 July 2018.	Ausgrid
Infrastructure SEPP	Adjoining land occupiers	**Notification:** under s. 42, 21 days' notice for works involving new or existing substations.	Notification was given on 7 December 2018.	Ausgrid
National Greenhouse and Energy Reporting Act 2007	Clean Energy Regulator (Commonwealth)	**Reporting:** under s. 19 a registered corporation is required to report information on energy production, energy consumption and the amount of greenhouse gas emissions for the facilities under their operational control on an annual basis by 31 October following the financial year for which they are reporting.	Reporting would be undertaken by 31 October each year.	Ausgrid /Contractor
POEO Act	OEH	**General:** under s. 120, no 'dirty water' discharge into a stormwater drain.	Water management is addressed in section 5.6.	Ausgrid / Contractor
POEO (Waste Regulation) 2005	OEH	**General:** under cl. 24, Ausgrid must track transportation of certain waste.	Waste management is addressed in section 5.9.	Contractor

Legislation	Authority	Requirement	Comment	Responsibility
Roads Act 1993	RMS	**Approval:** under s. 138, for road work on a Classified Road.	Approval for the crossing of / temporary closure / connection to Waterloo Road is to be obtained.	Contractor
Water Act 1912	OEH	**Permit**: under s. 113, to extract groundwater via any type of bore, well or excavation.	The need for a permit would be obtained prior to construction / would be evaluated as part of preparation of the CEMP.	Contractor

5 Environmental assessment

This section describes the existing environment of the study area and assesses the potential impacts of the proposal during construction, maintenance and operation. This section also prescribes the specific mitigation measures necessary to manage and control environmental impacts which consist of:

- specific mitigation measures prescribed in this REF (to be implemented during the design, construction, operation phases of the proposal or in combination)
- controls detailed in Ausgrid's NS 174C Environmental Handbook for Construction and Maintenance.

Where there is an inconsistency, the proposal specific mitigation measures would prevail. Only specific mitigation measures are included in this REF, where required to minimise potential impacts.

Once the detailed construction methodology is known, the principal construction contractor would be responsible for developing further mitigation measures as required to meet both legislative requirements and the commitments in this REF. Section 7 outlines the requirements for preparing the CEMP.

5.1 Land use

5.1.1 Existing environment

The proposal is located within the City of Ryde LGA. The proposed substation location is zoned B3 – Commercial Core and B7 – Business Park under Ryde LEP 2014. The land adjacent to the proposed works area comprises commercial properties with an early childhood establishment located on Waterloo Road across the road from the proposed substation.

The objectives of the B3 – Commercial Core zoning are to:

- provide a wide range of retail, business, office, entertainment, community and other suitable land uses that serve the needs of the local and wider community
- encourage appropriate employment opportunities in accessible locations
- maximise public transport patronage and encourage walking and cycling

The objectives of the B7 – Business Park zoning are to:

- provide a range of office and light industrial uses
- encourage employment opportunities
- enable other land uses that provide facilities or services to meet the day to day needs of workers in the area

The proposed substation site is currently owned by Ausgrid.

A tenure assessment was undertaken to determine if the proposed works are located on Crown land that is not public road or reserve as defined by s. 45 of the *Electricity Supply Act 1995*. The substation site is on land owned by Ausgrid.

Other utilities in the area are described in section 1.7.5.

5.1.2 Potential impacts

The proposal is consistent with the current surrounding land use. The proposal is also consistent with the objectives and land use zoning of the LEP. No potential impacts have been identified. The proposal consists of installing a new facility on the same property as the existing Macquarie Park ZS.

Short term impacts on the surrounding land use during the construction phase of the proposal would include increased traffic intensity (section 5.15), noise (section 5.4) and visual (section 5.14) impacts.

Once constructed, the proposal would not restrict access to educational or commercial properties. The proposal would have the benefit of facilitating both existing and future surrounding land uses in the region by providing a reliable supply from the electricity network.

5.1.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-1.

Table 5-1: Land use mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Consult with affected stakeholders about the proposal.	✓	✓	
Provide information via a free call 1800 number, email address and Ausgrid's website for people wanting more information.	✓	✓	
The substation building would be a neutral contemporary design to fit in with the surrounding environment	✓		
The substation would be designed and constructed to facilitate future 33kV customer connections. This will reduce the number of times excavation is required for customer connections and hence minimise future impact on local land uses.	✓	✓	

5.1.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to land use for reasons including:

- construction related impacts would be minor, localised and short-term
- a reliable supply of electricity would allow existing land uses to continue
- the substation building would be a neutral contemporary design to fit in with the surrounding environment
- mitigation measures outlined in section 5.1.3 would readily manage potential impacts.

5.2 Climate change

5.2.1 Existing environment

Climate change describes both changed average climatic conditions, such as increased temperature and lower average rainfall, as well as changes in the patterns of extreme events, including increased frequency and intensity of storms.

Greenhouse gas (GHG) emissions are defined by the GHG Protocol[4] and international standards[5] as scope 1 (direct emissions), scope 2 (indirect emissions from the consumption of purchased energy) and scope 3 (other indirect emissions).

The proposal is not located in low-lying areas near coastal locations.

5.2.2 Potential impacts

A risk assessment[6] of predicted climate change impacts on power infrastructure and the assets and services that they provide, considered the following climate change scenarios:

- higher average temperatures
- more frequent occurrence of extreme temperatures (days over 35 °C)
- lower average rainfall
- more intense extreme rainfall events
- increased lightning strikes
- higher evapo-transpiration
- higher sea level and storm surge events
- more frequent extreme fire danger days.

The risk assessment showed that the key risks to power infrastructure would include extreme events, accelerated degradation of materials and structures, and resource demand pressures. In relation to the proposal, it is expected that the likely impact of extreme weather events would be low. This is because the substation building would be enclosed and the feeders would enter and leave the substation via underground cables, which would protect the substation equipment from extreme events.

Similarly, impacts related to the accelerated degradation of materials and structures would be low, as most of the electrical equipment and cables would be enclosed or underground. However, any exposed equipment and structures would be covered by specified epoxy paint and/or be of galvanised steel to reduce or eliminate accelerated degradation. The potential risk to underground cables due to groundwater levels creating a more saline environment is expected to be low given that the underground cables are sealed in polyvinyl chloride (PVC) casing.

Current climate predictions anticipate that extreme heatwaves would increase in frequency and intensity, potentially generating an increase in electricity demand for air conditioning at the same time as the efficiency of the transmission is reduced by up to 30% due to high temperatures[7]. This increased demand has the potential to place pressure on the resource supplied and increase capacity constraints and maintenance requirements. Therefore, the new supply infrastructure would have a greater ability to withstand the increased pressure on the supply network.

Greenhouse gas emissions

Scope 1 emissions are direct GHG emissions produced from sources within the boundary of the proposal and as a result of the proposal's activities. Emissions arising from the construction of the proposal include those from vehicles and machinery used for materials delivery and handling, excavation, rehabilitation works, waste transport and general construction activities. The major contributor would be the consumption of fuel by transport vehicles.

The proposed substation is designed to minimise the amount of mechanical ventilation required for heating or cooling in the substation, thus eliminating the need for refrigerants. Natural air flow ventilation would be utilised in all areas of the substation with the exception of the switchgear and control room, transformer bay, cable basement, lunch room and the toilets, which would utilise mechanical ventilation for exhaust only.

The control building would house GIS technology which utilises sulphur hexafluoride (SF_6), a known GHG. SF_6 was selected due to its excellent insulation properties and more compact design that requires fewer raw materials. The quantitative contribution of SF_6 to global warming is below 0.1% with respect to the other manmade GHGs[7].

There is the potential for unintentional discharge of SF_6 during maintenance of the GIS. The total amount of SF_6 within the substation would be approximately 540kg, however the largest compartment would contain approximately 74kg. If losses were to occur it is likely that they would occur from one compartment only and not all 540kg would be lost.

During operation, all electrical equipment would be monitored and maintained to reduce the likelihood of any leaks and to maximise the operating efficiency of the substation. This would include the installation of gas density meters on each compartment to detect a drop in pressure. These meters would send an alarm if the pressure drops below a pre-set level which would allow action to be taken to rectify the leak. This (and handling of SF_6 in accordance with appropriate guidelines) would ensure that losses of SF_6 to the atmosphere are minimised, which would reduce its impact on atmospheric GHG concentrations.

Ausgrid's assets are subject to regular maintenance and monitoring to ensure all equipment is operating effectively. Minimal staff would be required to attend the asset thus limiting associated vehicle use and scope 1 emissions.

Under the *National Greenhouse and Energy Reporting Act 2007*, Ausgrid is required to report information on energy production, energy consumption and the amount of greenhouse gas emissions for the facilities under their operational control on an annual basis by 31 October following the financial year for which they are reporting.

Scope 2 emissions are GHG emissions generated from the production of electricity, heat or steam that a proposal consumes, but which is physically produced by another facility. These emissions would arise primarily from the consumption of electricity through network losses when the proposal is in operation. Electrical losses are an inevitable consequence of the transmission of electricity through the transmission and distribution network, and the energy consumed in these losses must be generated by power stations. This energy is sourced from the Australian electricity market, which is primarily supplied from coal-fired power stations that emit GHGs.

The proposal would not result in a change in the capacity of the network and hence in scope 2 GHG emissions.

Scope 3 emissions are those GHG generated in the wider economy that are related to a proposal but are physically produced by another facility. The main source of scope 3 emissions related to this proposal is from power stations supplying the National Electricity Market (currently predominantly coal fired) that supply the electricity retailers who sell power to customers in the area supplied by this proposal. The power stations supply electricity from a variety of generation sources with varying emission levels. The end user can influence the level of scope 3 emissions by the amount of electricity they consume and by selecting to receive green power.

The proposal would not result in a change in the capacity of the network and hence in scope 3 GHG emissions.

Since 2003, all electricity retailers in NSW have been governed by licence conditions that require them to reduce greenhouse emissions arising from the energy they sell in NSW. This *Greenhouse Gas Abatement Scheme*[8] is a compulsory legal framework under the ES Act that requires the retailers to take actions to reduce emissions through a range of measures in order to meet a benchmark level set by the NSW government. The benchmark currently applicable is 5% below the Kyoto baseline year of 1990, on a per capita basis.

All electricity retailers who would utilise the proposal to transport electricity to customers are bound by this regulatory framework. The framework provides a robust, market based means to manage scope 3 emissions to the level determined to be appropriate by the NSW government. It should be noted that any effort to reduce emissions from electricity usage supplied by NSW electricity retailers outside this framework would be accompanied by a reduced requirement on the retailers themselves, and no net reduction would result.

Sea level rise

Under clause 228(2)(p) of the EP&A Regulation, Ausgrid is required to consider any impact on coastal processes and hazards, including those under projected climate change conditions. The NSW Government acknowledges that increased sea levels will have significant medium to long-term social, economic and environmental impacts for development located in the coastal zone. However the proposal is not within the coastal zone.

5.2.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-2.

Table 5-2: Climate change mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Report information on energy production, energy consumption and the amount of greenhouse gas emissions to the Clean Energy Regulator for the facilities on an annual basis by 31 October the following year.			✓

Mitigation measures	Implementation of mitigation measures		
The climatic conditions to which the plant, equipment and the major substation shall be exposed are detailed in: • AS/NZS 1170 Structural design actions • AS 2067 Substations and high voltage installations exceeding 1kV A.C. • Bureau of Meteorology Climate maps for the “Annual Rainfall”, “Minimum Temperatures” and “Maximum Temperatures” in New South Wales • Engineers Australia “Australian Rainfall and Runoff – A Guide to Flood Estimation” • NS185 Major Substations Building Design Standard • NS186 Major Substations Civil Works Design Standard	✓		
Materials sourced from local suppliers were cost effective and no impact on engineering properties.	✓	✓	
Fluorescent tube lighting and water efficient appliances would be installed to reduce electricity use during operation.	✓	✓	✓
Recycled materials considered and used where cost effective and no impact on engineering properties.	✓	✓	
All plant and equipment would be turned off when not in use.		✓	✓

5.2.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to climate change for reasons including:

- construction related impacts would be minor and short-term
- Ausgrid designs its network to comply with network standards and relevant Australian Standards
- in the context of existing GHG, the proposal would result in an insignificant increase to GHG emissions
- the substation has been designed to eliminate the need for refrigerants
- installation of gas density meters and handling of SF6 to avoid losses into the atmosphere
- issues such as electricity demand and location of existing electricity infrastructure have been considered in selecting the proposed substation site and feeder route; and
- mitigation measures outlined in section 5.2.3 would readily manage potential impacts.

5.3 Electric and magnetic fields

5.3.1 Existing environment

EMFs are part of the natural environment and are present in the atmosphere and static magnetic fields are created by the Earth's core. EMF is also produced wherever electricity or electrical equipment is in use. Power lines, electrical wiring, household appliances and electrical equipment all produce EMF. Power-frequency EMF (also known as extremely low frequency or extremely low frequency (ELF) EMFs) has a frequency of 50 Hertz (Hz).

An electric field is a region where electric charges experience an invisible force. The strength of this force is related to the voltage, or the pressure which forces electricity along wires. Electric fields can be present in any appliance plugged into a power point which is switched on. Even if the appliance itself is turned off, an electric field will be present if the power point is on.

Electric fields are strongest close to their source, and their strength diminishes rapidly as we move away from the source Electric fields are shielded by most objects, including trees, buildings and human skin.

A magnetic field is a region where magnetic materials experience an invisible force produced by the flow of electricity, commonly known as current. The strength of a magnetic field depends on the size of the current (measure in amps), and decreases rapidly with increasing distance from the source. While electric fields are blocked by many common materials, this is not the case with magnetic fields.

Ausgrid's existing sources of EMF in the area include 132kV Feeders 92A and 92B and many 11kV feeders. Given the underground arrangement of the existing and proposed feeders, the magnetic field exposure at the site is likely to be dominated by sources from the distribution network.

In terms of exposure within the home, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) advise that:

> *Magnetic fields within homes can vary at different locations and also over time. The actual strength of the field at a given location depends upon the number and kinds of sources and their distance from the location of measurement. Typical values measured in areas away from electrical appliances are of the order of 0.1 - 2mG.*

Typical magnetic field measurements and ranges associated with various appliances and feeders are shown in Table 5-3.

Table 5-3: Magnetic field measurements and ranges associated with various appliances and feeders

Magnetic Field Source	Range of Measurement (in milligauss (mG))
Electric Stove	2-30
Computer Screen	2-20
Television Screen	0.2-2
Electric Blanket	5-30
Hairdryer	10-70

Magnetic Field Source	Range of Measurement (in milligauss (mG))
Refrigerator	2-5
Electric Toaster	2-10
Electric Kettle	2-10
Electric Fan	0.2-2
Street Distribution Line (directly underneath)	2-20
HV Transmission Overhead Line (directly underneath)	10-200

Source: Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), Measuring magnetic fields.

5.3.2 Potential impacts

The question of EMF and health has been the subject of a significant amount of research since the 1970's. This large body of scientific research includes both epidemiological (population) and laboratory (at both a cellular and an organism level) studies.

Research into EMF and health is a complex area involving many disciplines, from biology, physics and chemistry to medicine, biophysics and epidemiology.

EMF at levels well above the recognised international exposure guidelines can cause both synaptic effects perceived as magneto-phosphenes in the sensitive retinal tissue (magnetic fields) and micro-shocks (electric fields). The exposure guidelines are in place to protect against these biological effects.

No single study considered in isolation will provide a meaningful answer to the question of whether or not EMF can cause or contribute to adverse health effects. In order to make an informed conclusion from all of the research, it is necessary to consider the science in its totality. Over the years, governments and regulatory agencies around the world have commissioned many independent scientific review panels to provide such overall assessments.

As part of the Health and Aging Portfolio, Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a Federal Government agency charged with the responsibility for protecting the health and safety of people, and the environment, from EMF.

ARPANSA[9] advises that:

> *"The scientific evidence does not establish that exposure to ELF EMF found around the home, the office or near powerlines and other electrical sources is a hazard to human health"*
>
> *"The scientific evidence does not establish that exposure to the electric and magnetic fields found around the home, the office or near powerlines causes health effects. However, there are some epidemiological (population) studies that have reported a possible association between prolonged exposure to ELF magnetic fields at levels higher than typical and increased rates of childhood leukaemia. Other research including studies on cells and animals has not confirmed these results. On balance, the evidence related to childhood leukaemia is not strong; however people should be aware of the issue in order to make informed decisions."*

These findings are consistent with the views of other credible public health authorities. For example, the World Health Organization (WHO)[10] advises that:

> *"Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."*

Similarly, the U.S. National Cancer Institute concludes that:

> *"Currently, researchers conclude that there is little evidence that exposure to ELF-EMFs from power lines causes leukaemia, brain tumors, or any other cancers in children."*
>
> *"No mechanism by which ELF-EMFs could cause cancer has been identified. Unlike high-energy (ionizing) radiation, ELF-EMFs are low energy and non-ionizing and cannot damage DNA or cells directly."*
>
> *"Studies of animals exposed to ELF-EMFs have not provided any indications that ELF-EMF exposure is associated with cancer, and no mechanism has been identified by which such fields could cause cancer."*

Health Canada, the Canadian national public health authority advises that:

> *"There have been many studies on the possible health effects from exposure to EMFs at ELFs. While it is known that EMFs can cause weak electric currents to flow through the human body, the intensity of these currents is too low to cause any known health effects. Some studies have suggested a possible link between exposure to ELF magnetic fields and certain types of childhood cancer, but at present this association is not established."*
>
> *"The International Agency for Research on Cancer (IARC) has classified ELF magnetic fields as "possibly carcinogenic to humans". The IARC classification of ELF magnetic fields reflects the fact that some limited evidence exists that ELF magnetic fields might be a risk factor for childhood leukaemia. However, the vast majority of scientific research to date does not support a link between ELF magnetic field exposure and human cancers. At present, the evidence of a possible link between ELF magnetic field exposure and cancer risk is far from conclusive and more research is needed to clarify this "possible" link."*

International Commission On Non-Ionizing Radiation Protection - 2010[11]

> *"It is the view of ICNIRP that the currently existing scientific evidence that prolonged exposure to low frequency magnetic fields is causally related with an increased risk of childhood leukaemia is too weak to form the basis for exposure guidelines. In particular, if the relationship is not causal, then no benefit to health will accrue from reducing exposure."*

EMF health guidelines

The two internationally recognised exposure guidelines are International Commission on Non-Ionizing Radiation Protection (ICNIRP) and IEEE.

- ICNIRP 2010.
- International Committee on Electromagnetic Safety, Institute of Electrical and Electronics Engineers (IEEE) in the USA 2002.

ARPANSA's advice[12] is that "The ICNIRP ELF guidelines are consistent with ARPANSA's understanding of the scientific basis for the protection of people from exposure to ELF EMF."

The following table, Table 5-1 summarise the magnetic field exposure Reference Levels for IEEE and ICNIRP.

Table 5-4: Magnetic field Reference Levels at 50Hz for IEEE and ICNIRP

	IEEE 2002	ICNIRP 2010
GENERAL PUBLIC		
Exposure general	Not specified	200 μT*
Exposure to head and torso	904 μT	Not specified
Exposure to arms and legs	75,800 μT	Not specified
OCCUPATIONAL		
Exposure general	Not specified	1,000 uT*
Exposure to head and torso	2,710 μT	Not specified
Exposure to arms and legs	75,800 μT	Not specified

Prudent avoidance

Since the late 1980s, many reviews of the scientific literature have been published by authoritative bodies. There have also been a number of Inquiries such as those by Sir Harry Gibbs in NSW18[13] and Professor Hedley Peach in Victoria19[14]. These reviews and inquiries have consistently found that:

- adverse health effects have not been established.
- the possibility cannot be ruled out.
- if there is a risk, it is more likely to be associated with the magnetic field than the electric field.

Both Sir Harry Gibbs and Professor Peach recommended a policy of prudent avoidance, which Sir Harry Gibbs described in the following terms:

> *"…. [doing] whatever can be done without undue inconvenience and at modest expense to avert the possible risk …"*

Prudent avoidance does not mean there is an established risk that needs to be avoided. It means that if there is uncertainty, then there are certain types of avoidance (no cost / very low cost measures) that could be prudent. These recommendations have been adopted by the Energy Networks Association (ENA) and other electricity transmission and distribution businesses

Energy Network Australia position

The ENA is the peak national body for Australia's energy networks. ENA represents gas and electricity distribution, and electricity transmission businesses in Australia on a range of national energy policy issues.

ENA is committed to taking a leadership role on relevant environmental issues including power frequency EMFs. ENA and its members are committed to the health and safety of the community, including their own employees.

ENA's position is that adverse health effects from EMFs have not been established based on findings of science reviews conducted by credible authorities. ENA recognises that that some members of the public nonetheless continue to have concerns about EMFs and is committed to addressing it by the implementation of appropriate policies and practices.

ENA is committed to a responsible resolution of the issue where government, the community and the electricity supply industry have reached public policy consensus consistent with the science.

Policy statement

1. ENA recommends to its members that they design and operate their electricity generation, transmission and distribution systems in compliance with recognised international EMF exposure guidelines and to continue following an approach consistent with the concept of prudent avoidance.
2. ENA will closely monitor engineering and scientific research, including reviews by scientific panels, policy and exposure guideline developments, and overseas policy development, especially with regard to the precautionary approach.
3. ENA will communicate with all stakeholders including assisting its members in conducting community and employee education programs, distributing information material including newsletters, brochures, booklets and the like, liaising with the media and responding to enquiries from members of the public.
4. ENA will cooperate with any bodies established by governments in Australia to investigate and report about power frequency electric and magnetic fields.

Magnetic field calculations

A specialist EMF assessment was undertaken for the proposal (Appendix B).

The predicted contribution of the STS to the magnetic field environment at the site boundaries is a small fraction of the ICNIRP Guideline Reference Level of 2000mG. The contribution to the existing magnetic field environment along the various boundaries is summarised in Table 5-5.

Table 5-5: Contribution to the existing magnetic field environment along the boundaries

	Eastern boundary	**South-eastern boundary**	**Waterloo Road boundary**	**North-western boundary (existing)**
Typical range (short term)	0.5-2mG	2-5mG	10mG	1-18mG
Typical range (long term)	0.5-2mG	<10mG	N/A	1-18mG
Highest value (short term)	2mG	5mG	72mG (existing)	18mG
Highest value (long term)	10mG	20mG	76mG	18mG

Based in the short and long terms, the highest period magnetic field contribution of the proposed STS is less than 4% of the Guideline Reference Level and of the same order as at present.

Cumulative impact

Adding magnetic fields from multiple sources is a complex and dynamic exercise. In the residential environment there are a multitude of sources such as existing powerlines, service lines, household wiring, appliances and water pipes. Each of these sources has a unique magnetic field profile which changes over time depending on the nature of the source and load it is carrying. This is further complicated by the fact that magnetic fields are vectors which have direction as well as size.

While attempting to define the exact field at a particular point in time is therefore problematic, it can be shown that the addition of two magnetic fields with random orientation is slightly less than the root-sum-of squares. In practice this means that one field has to be only slightly larger than the other to dominate the average result. For example, if one field is half the size of the other field, it makes only a 10% difference to the total.

Cumulative impact considerations do not change the conclusions that the project would comply with relevant guidelines and the principles of prudent avoidance.

5.3.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-6.

Table 5-6: EMF mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Implement no costs and very low measures to reduce magnetic field exposure, including where relevant: • using multicore cables or trefoil single core cables • placing neutral conductors with associated phase conductors • balancing loads across phases • avoiding phase by phase grouping of cables in parallel circuits • locating cable trays away from adjoining uses • orientating equipment to locate LV side further from adjoining uses.	✓	✓	
Specialist report recommendations: • locate main substation equipment well within the site boundaries • install compact gas-insulated switchgear for the 132kV side of the substation • using a vertical configuration for the incoming 132kV line	✓ ✓ ✓	✓ ✓ ✓	

5.3.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to EMF for reasons including:

- the proposal would meet all relevant International health guidelines, including the, ICNIRP Guideline, and IEEE Standard
- Ausgrid is proposing a number of mitigation measures (outlined in section 5.3.3) which would substantially reduce the magnetic field exposure
- the proposed mitigation measures are consistent with the prudent avoidance and precautionary policies and advice of the ENA, ARPANSA and WHO

5.4 Noise and vibration

5.4.1 Existing environment

The normal day time noise and vibration environment near the proposed substation site is primarily influenced by road traffic on Waterloo Road and Sherringhams Nursery on Wicks Road.

The existing environment is characterised by a mix of commercial receivers. A child care centre and a hockey centre are located across the street from the substation.

An assessment of existing ambient noise levels was undertaken by consultants Day Design. Noise levels were taken in proximity to the study area to characterise the background noise environment at nearest potential noise affected receivers and establish representative construction noise management levels for the proposal (refer to Figure 5-1).

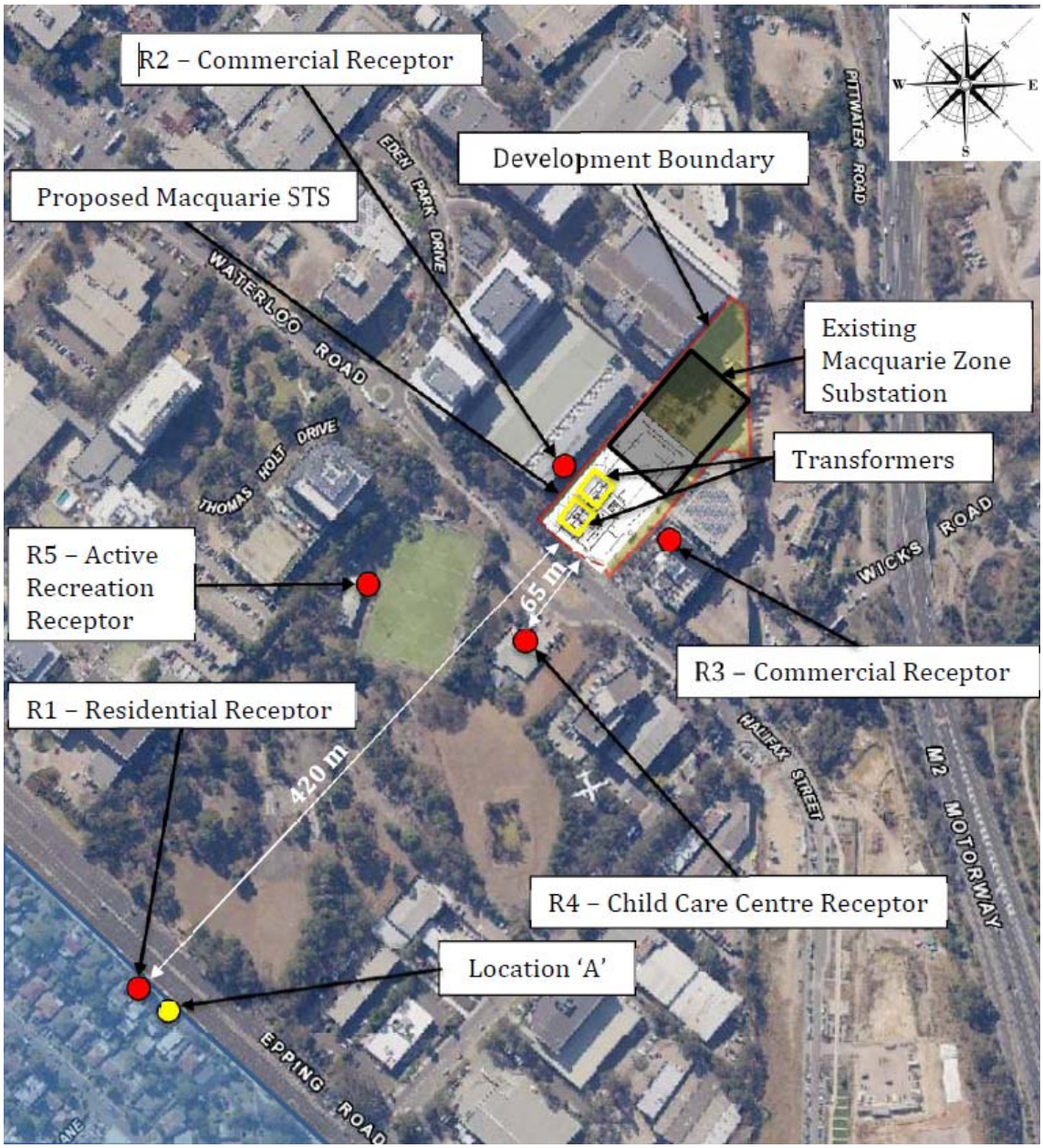


Figure 5-1: Background noise monitoring locations

5.4.2 Potential impacts

Noise during construction

The *Interim Construction Noise Guideline (DECC, 2009)* (ICNG)[15] outlines that a quantitative assessment must be undertaken where works are likely to affect an individual or sensitive land use for more than three weeks in total.

A specialist Construction Noise and Vibration Impact Assessment (CNVIA) was undertaken for the proposed construction works. The following activities were undertaken as part of the CNVIA:

- attended and unattended noise monitoring at locations indicative of noise sensitive receivers
- establishment of project specific airborne noise construction goals based on monitored existing noise levels

- prediction of construction noise levels from proposed construction works
- recommendation of environmental noise control options/management practices.

Noise impacts predicted are representative of peak noise generating construction works without implementation of any mitigation measures. As works progress, nearest receivers are anticipated to be less impacted by construction noise as the plant and equipment used during the electrical fit out of the substation have lower noise levels and various mitigation measures would be implemented.

Construction noise is managed in accordance with the EPA ICNG, which provides management objectives for construction noise at non-residential land uses. The ICNG airborne noise goals are to be applied to assess noise impacts and determine the requirement for the reasonable and feasible management of construction noise to minimise potential for disturbance.

Site specific construction noise management levels, as shown in Table 5-7, have been established adopting the measured background noise levels and the ICNG corrections for the time of construction work.

Table 5-7: Adopted Construction Noise Management Levels for Residential Receivers

Residential Receivers	**Construction Noise Management Level (NML) – dB(A)**		
	Daytime 7am – 6pm	**Evening 6pm – 10pm**	**Night 10pm – 7am**
Surrounding Residences	61	60	47

Noise modelling of the construction activities and comparison with the NML's has been undertaken for the different items of equipment. The construction of Macquarie STS would utilise various items of heavy vehicles associated with the construction and transportation of materials and equipment by large trucks. See Tables 5-8 to 5-11.

Table 5-8: Construction Leq Sound Power Levels and Predicted Noise Level at R1

	Construction activity	Sound Power Level, dBA	Predicted Leq, 15 minute Noise Level dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
Standard Construction Hours	Mobile Crane (20T)	110	53	66	Yes
	20 to 30 Tonne Truck	105	48	66	Yes
	Excavator	100	43	66	Yes
	Generator	100	42	66	Yes
Non-Standard Construction Hours – Day	Mobile Crane (20T)	110	53	61	Yes
	20 to 30 Tonne Truck	105	48	61	Yes
	Excavator	100	43	61	Yes
	Generator	100	42	61	Yes
Non-Standard Construction Hours – Evening	Mobile Crane (20T)	110	53	60	Yes
	20 to 30 Tonne Truck	105	48	60	Yes
	Excavator	100	43	60	Yes
	Generator	100	42	60	Yes
Non-Standard Construction Hours – Night	Mobile Crane (20T)	110	**53**	47	**No**
	20 to 30 Tonne Truck	105	48	47	Yes
	Excavator	100	43	47	Yes
	Generator	100	42	47	Yes

Table 5-9: Construction Leq Sound Power Levels and Predicted Noise Level at R2

Construction activity	Sound Power Level, dBA	Predicted Leq, 15 minute Noise Level dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
Mobile Crane (20T)	110	70	70	Yes
20 to 30 Tonne Truck	105	65	70	Yes
Excavator	100	60	70	Yes
Generator	100	60	70	Yes

Table 5-10: Construction Leq Sound Power Levels and Predicted Noise Level at R3

Construction activity	Sound Power Level, dBA	Predicted Leq, 15 minute Noise Level dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
Mobile Crane (20T)	1108	71	70	Yes
20 to 30 Tonne Truck	105	66	70	Yes
Excavator	100	61	70	Yes
Generator	100	61	70	Yes

Table 5-11: Construction Leq Sound Power Levels and Predicted Noise Level at R4

Construction activity	Sound Power Level, dBA	Predicted Leq, 15 minute Noise Level dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
Mobile Crane (20T)	110	**69**	55	**No**
20 to 30 Tonne Truck	105	**64**	55	**No**
Excavator	100	**59**	55	**No**
Generator	100	**58**	55	**No**

Table 5-12: Construction Leq Sound Power Levels and Predicted Noise Level at R5

Construction activity	Sound Power Level, dBA	Predicted Leq, 15 minute Noise Level dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
Mobile Crane (20T)	110	**71**	65	**No**
20 to 30 Tonne Truck	105	**66**	65	**No**
Excavator	100	61	65	Yes
Generator	100	61	65	Yes

With the installation of noise control barriers all predicted Leq, 15 minutes would be considered compliant excepting the Mobile Crane (20T) and at R4 and R5. Refer further to Annexure B.

A number of mitigation measures were recommended and these are reproduced in section 5.4.3.

Vibration during construction

The EPA published the *Assessing Vibration: a technical guideline* in February 2016. This guideline is based on the British Standard BS6472:1992 *Evaluation of human exposure to vibration in buildings* (1 Hz to 80 Hz). The guideline presents the preferred maximum vibration values for use in assessing human response to vibration and provides recommendations for measurement and evaluation techniques.

The British Standard BS7385-2:1993 *Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration* provides guide values for transient vibration relating to cosmetic damage. See Table 5-13 below. It is recommended that the vibration level outside of the adjacent residential buildings not exceed these values from the construction activities.

Table 5-13: Criteria for Operational Noise Emissions to Sensitive Receivers

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Residential	15 mm / s at 4 Hz increasing to 20 mm / s at 15 Hz	20 mm / s at 15 Hz increasing to 50 mm / s at 40 Hz and above

It is considered that an overall peak particle velocity of 15 mm / s at the boundaries would comply with the recommended values of the EPA's *NSW Noise Policy for Industry (2017)* (NPI).

A number of mitigation measures were recommended and these are reproduced in section 5.4.3.

Noise and vibration during operation

A specialist noise assessment was undertaken for operation of the substation.

The noise limits for the operational noise emissions from the proposed STS are derived from the NPI. The NPI provides criteria for the assessment of noise impacts associated with Industrial activities. It aims to balance the need for industrial activity with the desire for quiet within the community. The processed results of the unattended noise monitoring have been used to generate project specific noise criteria in accordance with NPI principles. The project specific noise levels are the most stringent of the Intrusive and Amenity criteria and are shown in Table 5-14.

Table 5-14: Predicted Leq Noise Levels at Nearby Receptors

Receptor Location	Predicted Leq, 15 minute Noise Level, dBA (No Load – Full Load)	Acceptable Noise Level, dBA	Compliance (Yes/No)
R1 – Residential	10-16	47 (night)	Yes
R2 – Commercial	50-56	63	Yes
R3 – Commercial	28-34	63	Yes
R4 – Child care Centre	23-29	33 (Indoor) 53 (Outdoor)	Yes
R5 – Active Recreation	25-31	53	Yes

Prediction of operational noise impacts from the proposed STS has been undertaken through the use of the Infobyte Noise Monitors iM4 #120, which is a Type 1 precision environmental noise monitor meeting all the applicable requirements of AS1259. The noise impacts from all 2 transformers operating concurrently at the nearest residential receivers are detailed in this report.

The report concluded that the proposal would comply with the NSW NPI (Appendix C) provided noise control measures as indicated in the substation design are implemented. The main control measure required to ensure compliance is that the transformers bays are fully enclosed with brick walls. A number of mitigation measures were recommended and these are reproduced in section 5.4.3.

Impacts to the noise and vibration environment are likely to be associated with construction activities associated with the proposal and not during operation.

5.4.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-15.

Table 5-15: Noise and vibration mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	**Construction**	**Operation**
Comply with sections 4.2 of NS 174C Environmental Handbook or Construction Noise and Vibration Management Plan (NVMP) where required (see below for the requirements of a NVMP).		✓	
All workers to be made aware of the presence of sensitive receivers in the area and the need to avoid impacts.		✓	
Provide at least four clear business days' notice (but not more than 14 days') to affected receivers prior to starting work unless it is emergency works or it is discussed with the affected receivers face-to-face. Include the following information in notification letters: • a description of the works and why they are being undertaken • details of the works that would be noisy • work hours and expected duration • what is being done to minimise the impacts (e.g. respite periods) 24 hour contact number.	✓	✓	
On-going consultation is required with affected sensitive receivers (especially the child care across the road)		✓	
No high impact activities after 11 pm. (High impact activities include saw cutting, vibratory rolling, grinding, rock cutting, rock breaking, jack hammering, underboring/ directional drilling and impact piling).		✓	
Plan the site layout to minimise movements that would activate audible reversing and movement alarms.		✓	
Provide respite periods for affected receivers: • one hour respite after every three consecutive hours of high impact activities • one day respite after every three consecutive days of high impact activities.		✓	
Do not affect a receiver for more than two nights in a one week period.		✓	
Due to unavoidable work requirements or due to a regulatory licence requirement (e.g. RMS) out of hours and/or night works may be required.		✓	

Mitigation measures	Implementation of mitigation measures		
Where the ROL stipulates out of hours work the works must meet the requirements of NS 174C Environmental Handbook, out of hours work criteria or a site specific noise management plan.		✓	
Ensure measures are implemented as per the design.	✓	✓	
Develop and Comply with a NVMP where works are likely to exceed three weeks in duration at one location or a certain receiver or cause offensive noise within a sensitive area or night time pile driving / rock breaking would be required. The NVMP must be in accordance with the Interim Construction Noise Guidelines (NSW DECC, 2009).	✓	✓	

Works would be undertaken between 7am and 6pm Monday to Friday and 8am and 1pm on Saturday. Between 7am and 8am on Saturdays, works that are inaudible to the nearest residential premises are allowed. Audible works may be undertaken outside of these hours if:
• the works are emergency works AND the affected residents have been notified as far as reasonably practicable; OR
• the works fall into one of the following categories AND the affected residents are provided with a notification letter at least four clear business days prior to the works:
  • the delivery of oversized plant or structures that require special approval
  • maintenance and repair of essential public infrastructure that is unable to occur during standard hours
  • public infrastructure works that shorten the length of the work and are supported by the affected community (this would require community consultation).
		✓	

For out of hours work, consider notifying local Council.		✓	
Provide information via a free call 1800 number, email address and Ausgrid's website for people wanting more information.	✓	✓	
Provide signage outside the worksite detailing who is undertaking the works and a 24 hour contact number.		✓	
Have a documented complaints process, including an escalation procedure so that if a complainant is not satisfied there is a clear path to follow		✓	

Mitigation measures	Implementation of mitigation measures		
Keep a register of any complaints, including details of the complaint such as date, time, person receiving complaint, complainant's contact number, person referred to, description of the complaint, time of verbal response and timeframe for written response where appropriate.		✓	
Undertake condition reports of structures within 5m of vibration generating works.		✓	
Refer operational noise enquires to Ausgrid Environmental Services.			✓
Comply with recommendations in Appendix C where practicable	✓	✓	

5.4.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to noise and vibration for reasons including:

- the construction would be temporary and transitory
- based on the results of the assessment, in a worst case scenario, predicted construction noise impacts could trigger the adopted NMLs, during standard construction hours at the assessment locations. Mitigation measures as detailed in Appendix C (specialist report) would be implemented throughout the works where practicable.
- potential vibration impacts would comply with the OEH *Assessing Vibration: A Technical Guidelines* (2006)
- the proposal would comply with the NSW NPI (Appendix C) provided noise control measures as indicated in the substation design are implemented. The main control measure required to ensure compliance is that the transformers bays are fully enclosed with brick walls.
- mitigation measures outlined in section 5.4.3 would readily manage potential impacts.

5.5 Air quality

5.5.1 Existing environment

No ambient air quality monitoring has been undertaken specifically for the proposal, however OEH operates a comprehensive air quality monitoring network comprising sites throughout the State, with particular focus on the main population centres of Sydney, the lower Hunter and the Illawarra. The closest monitoring site to the proposal is at Macquarie University Sport Fields – Culloden Road, approximately 3km north west of the study area. Monitoring data and meteorological data was utilised for the air quality modelling and assessment.

Key air pollutants as identified under the National Environment Protection Measure for Ambient Air Quality include: carbon monoxide, nitrogen dioxide, lead, sulphur dioxide, photochemical smog and fine particles. Photochemical smog (as ozone) and, to a lesser extent, fine particles remain significant issues in NSW.

Air pollution includes emission of odours, smoke, fuel or any other substances to the air. There are many substances in the air which may impair human health as well as the health of plants and animals, or reduce visibility. Impacts from pollutants are governed by the intensity of pollutant discharges, type of discharges and the prevalent weather conditions.

The existing (background) air quality environment is highly influenced by the urban and industrial activities occurring in the vicinity of the proposal. Influences of existing air quality include emissions from construction activities, transportation, commercial operations and domestic activities.

5.5.2 Potential impacts

Direct potential impacts from the proposal to the local air quality would be limited to dust and emissions from vehicles, plant and equipment generated during the construction and to a lesser extent the operational phases.

Exhaust emissions are likely to include nitrogen oxides, carbon monoxide, sulphur oxides, hydrocarbons and total suspended particulates. All equipment would be fitted with approved exhaust systems and maintained to keep vehicle exhaust emissions within accepted standards.

Activities that may generate dust include wind erosion of exposed surfaces, movement of topsoil during excavations and disturbance of stockpiles, movement of vehicles and equipment, trenching, boring, clearing vegetation, saw cutting, rock breaking and site preparation works.

Ausgrid's internal guidelines require an erosion and sediment control plan (ESCP) or soil and water management plan (SWMP) for construction works where soil disturbance is greater than 250m^2. The ESCP must be produced in accordance with the 'Blue Book'[16]. The site would be inspected for compliance with the ESCP during the construction phase. During the operational phase works would comply with the erosion and sediment control measures detailed in section 2.2 of NS 174C Environmental Handbook.

Impacts to air quality would be predominantly associated with construction activities. A number of mitigation measures (described in section 5.5.3) would be implemented to ensure the amount of dust and emissions generated is minimal and would not affect the surrounding environment.

5.5.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-16.

Table 5-16: Air quality mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with sections 2.1 Erosion and sediment control and 2.2 Air of NS 174C Environmental Handbook		✓	
All workers to be made aware of the presence of sensitive receivers in the area and the need to avoid impacts.		✓	

Mitigation measures	Implementation of mitigation measures		
Use water sprays to dampen (but not saturate) disturbed surfaces and stockpiles, at material transfer points and during construction.		✓	
Visually monitor dust levels during works. If dust is leaving site, causing a safety issue or complaints are received suspend works and consider mitigation options and/or substitute with an alternate process.		✓	
Restrict traffic movement and vehicle speeds over disturbed areas and unsealed roads.		✓	
Stabilise long term stockpiles by covering, or with soil binders such as polyvinyl acetate (PVA) or latex sprays.		✓	
Prepare and comply with a site specific ESCP when disturbing more than 250m2 at any one time. The ESCP must be prepared in accordance with Managing Urban Stormwater – Soils and Construction (NSW Landcom, 2004), the 'Blue Book'. The ESCP would form part of the CEMP prepared prior to construction. The ESCP / SWMP must be prepared by a suitably qualified person (i.e. who has completed an International Erosion Control Association (IECA) endorsed course or passed the examination for Certified Professional in Erosion and Sediment Control (CPESC)) in accordance with Managing Urban Stormwater – Soils and Construction.		✓	
Do not leave vehicles or equipment idling when they are not needed.		✓	✓
Handle SF6 and other gases in accordance with approved work practices.		✓	✓
Install erosion and sediment controls in accordance with the site specific ESCP		✓	

5.5.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to air quality for reasons including:

- construction related impacts would be minor, localised and short-term
- once in operation, the proposal would have no impact on air quality
- mitigation measures outlined in section 5.5.3 would readily manage potential impacts.

5.6 Hydrology

5.6.1 Existing environment

The closest waterway to the proposal is Porters Creek located approximately 600m to the north east of the site. This creek leads to Lane Cover River.

Prior to finalisation of the detailed design of the substation a groundwater investigation is required to identify quality, depths and directions of flow.

5.6.2 Potential impacts

Bulk earthworks would cause considerable surface disturbance to the works area during the initial phases of construction, creating potential for erosion and sedimentation of waterways. During and after wet weather, dewatering may be required to allow work to continue. Onsite treatment of the water would be undertaken to remove sediment from the water. In the case of incursion of groundwater in the basement, groundwater would be tested for water quality and if it satisfies the adopted criteria, it would be discharged to drainage channel/stormwater drain. A water management plan would be required as part of the CEMP for these works.

Minor amounts of soil would be stockpiled on site. The stockpiles would be covered when not in use and would be protected with sediment fencing.

At the conclusion of earthworks all exposed soil surfaces would be stabilised. This would ensure that there would be no long term erosion or sediment impact. Where possible this stabilisation would happen progressively during construction.

The construction works would involve vegetation removal within the existing site which is not within a riparian corridor. This vegetation removal would result in areas of exposed soil material that would be prone to erosion in a rainfall event. However, due to the proposal size, duration of works and the natural topography constraints it is proposed to implement temporary sediment control measures on site to minimise any impacts from additional sediments entering the surrounding environment.

The substation footprint would take up approximately 10 % of the total site. In order to ameliorate the potential stormwater impacts, a new onsite detention tank to capture stormwater run-off from the substation building, designed in accordance with Ryde City Council requirements, has been included.

Prior to finalisation of the detailed design of the substation a groundwater investigation is required to identify quality, depths and directions of flow. If groundwater is likely to be intercepted and require dewatering a licence under the *Water Act 1912* or *Water Management Act 2000* may be required. This licence would not be required during the operation of the proposal. The proposal has been designed so that the groundwater would not be impacted by works.

Water quality in the study area may be affected by spills of hydraulic oil and fuels from equipment or vehicles. Quantities of these products would be kept to a minimum and would be stored in a suitably bunded and covered area. Adequate storage and refuelling controls would be installed to mitigate impacts. Plant and equipment would also be maintained to minimise the potential for leakages.

The proposal includes 2 transformers which would each contain 48,000 litres of oil. The design of the substation includes reinforced concrete bunds around the transformers in accordance with Australian Standard 1940-2004 (refer to section 5.6). The oil containment system is designed to contain 110% of the oil from the largest transformer plus an allowance for 20 minutes of firefighting liquid. Stormwater from these areas would be directed to an oil separator and containment structure for oil removal before being directed to the stormwater system.

A passive oil separation system would be located adjacent to each transformer within the transformer bund, specifically for each bunded transformer bay only. The existing transformer roadway would not drain through this system. Shut off valves on the

stormwater pits in the transformer roadway would be closed during any activities involving oil on the roadway. All stormwater on site drains through the onsite detention tanks and ultimately to stormwater. The passive oil separation system would form part of Ausgrid's standard oil containment maintenance program, be pumped out and taken off-site by a tanker for suitable disposal as required. These systems would ensure the risk of contamination of the site and surrounding waters during operation is minimised.

5.6.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-17.

Table 5-17: Hydrology quality mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with sections 2.1 Erosion and sediment control, 2.3 Oil fuel and chemicals and 2.2 Water discharge of NS 174C Environmental Handbook.		✓	
Prepare and comply with a site specific ESCP when disturbing more than 250m2 at any one time. The ESCP must be prepared in accordance with Managing Urban Stormwater – Soils and Construction (NSW Landcom, 2004), the 'Blue Book'. The ESCP would form part of the CEMP prepared prior to construction. The ESCP/SWMP must be prepared by a suitably qualified person (i.e. who has completed an IECA endorsed course or passed the examination for CPESC) in accordance with Managing Urban Stormwater – Soils and Construction		✓	
Maintain sediment controls, especially during periods of rainfall.		✓	
Prior to finalisation of the detailed design of the substation a groundwater investigation is required to identify quality, depths and directions of flow.	✓	✓	
Remove temporary erosion and sediment controls as the site is stabilised or rehabilitation is complete		✓	
Stockpiles must be located away from roadways, gutters, drains, slopes, concentrated flow paths and channels.		✓	
Stabilise disturbed areas promptly, this may include progressive rehabilitation		✓	✓
Contain slurry using a wet-vac.		✓	
Organise a licensed taker to remove the water if the relevant discharge criteria cannot be met.		✓	✓
Prepare and comply with a site specific water management plan.	✓	✓	✓
Non-domestic discharges to sewer must be in accordance with a permit from the relevant water supply authority.		✓	✓
Prior to construction, outline the location of access routes, compound sites, construction boundaries, and exclusion zones on detailed designs, clearly staked and marked onsite.		✓	

Mitigation measures	Implementation of mitigation measures		
Stabilise the main access road during construction to minimise the tracking of sediment onto Waterloo Road.		✓	
If dewatering of groundwater is required during construction, works would cease and additional testing would be undertaken to develop a Water Quality Management Plan.		✓	
If dewatering of groundwater is required during construction, obtain a licence under the *Water Act 1912* from OEH.		✓	
Comply with the water quality discharge criteria of NS 174C Environmental Handbook.		✓	✓
Design, construct and operate an oil separation system in accordance with Ausgrid's Network Standard 189 and 190.	✓	✓	
Provide a secure and bunded area for the storage of fuel, oil or chemicals. This area would be imperviously bunded with a capacity to contain not less than 110% of the volume of the largest container.	✓	✓	
Prior to construction, nominate and sign post a plant refueling area.		✓	
Regularly inspect and maintain the oil containment system in accordance with relevant Ausgrid Network Standards.			✓
Store oil in a bund unless it is temporary storage.		✓	✓
Ensure a spill kit is readily available and workers and know how to use it.		✓	✓

5.6.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to hydrology for reasons including:

- construction related impacts would be minor, localised and short-term
- once in operation, the proposal would have no impact on hydrology
- potential flood impacts would comply with the NSW Government *Floodplain Development Manual: the management of flood liable land* (2005)
- potential hydrology impacts would comply with the Blue Book
- mitigation measures outlined in section 5.6.3 would readily manage potential impacts.

5.7 Geology and soil

5.7.1 Existing environment

The Geological Series Sheet for Sydney[17] indicates that the site is underlain by Ashfield Shale from the Wianamatta Group of Triassic Age. Ashfield Shale generally

comprises shale and74laminate and is often deeply weathered forming clays of medium to high plasticity with poor drainage properties.

A limited preliminary geotechnical investigation was carried out by Douglas Partners on the site (Appendix D). Seven bore holes were completed. The general subsurface conditions may be broadly summarised as follows:

- Fill material to a depth of approximately RL46.0
- Residual Clay material to a depth of RL45.7m
- Sandstone till bore limit

The proposed development area has plan dimensions of approximately 25m (parallel to Waterloo Road) by 40m. The western part of the site is relatively flat, with a gradual slope down to the south and east. To the east the ground surface slopes towards a small car parking area and a concrete driveway (refer Plate 2). The provided site survey drawing indicates that surface levels within the development footprint vary between RL49.9m to RL47.0m (north-west to south-east corners, respectively).

The proposed work area is not within a mine subsidence area.

A review of the NSW Acid Sulfate Soil Risk Map for Prospect/Parramatta River (Reference 2) indicates that the site is not located within an area of known acid sulfate soil risk.

5.7.2 Potential impacts

The construction of the proposal would cause some minor soil instability. There would be more than 250m^2 of soil disturbed at any one time, therefore an ESCP must be prepared by the principal contractor prior to the commencement of works. The ESCP must be prepared by a suitably qualified person (i.e. who has completed an IECA endorsed course or passed the examination for CPESC) in accordance with *Managing Urban Stormwater – Soils and Construction*[18].

Soil testing would occur prior to earthworks to determine the nature of the excavated material, presence of acid sulfate soils (ASS) and how excavated material would be reused or disposed of according to the NSW *Waste Classification Guidelines*[19].

5.7.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-18.

Table 5-18: Geology and soil mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with section 2.1 Erosion and sediment control of NS 174C Environmental Handbook.		✓	
All workers to be made aware of the presence of sensitive areas and the need to avoid impacts.		✓	
An in depth Geotechnical, Contamination and Waste Classification must be prepared prior to the finalisation of detailed design.	✓		

Mitigation measures	Implementation of mitigation measures		
Prepare and comply with a site specific ESCP when disturbing more than 250m^2 at any one time. The ESCP must be prepared in accordance with Managing Urban Stormwater – Soils and Construction (NSW Landcom, 2004), the 'Blue Book'. The ESCP would form part of the CEMP prepared prior to construction. The ESCP/SWMP must be prepared by a suitably qualified person (i.e. who has completed an IECA endorsed course or passed the examination for CPESC) in accordance with *Managing Urban Stormwater – Soils and Construction*.	✓	✓	

5.7.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to geology and soil for reasons including:

- the construction would be temporary, localised, short term and transitory
- reinstatement works would stabilise the proposed route once construction is complete
- once in operation, the proposal would have no more than a minor impact on geology and soil
- mitigation measures outlined in section 5.7.3 would readily manage potential impacts.

5.8 Contamination

5.8.1 Existing environment

A desktop assessment of the study area showed the existing environment is a mixture of land zoned B3 – Commercial Core and B7 – Business Park under Ryde LEP 2014. The land adjacent to the proposed works area comprises commercial properties with an educational establishment located across the road on Waterloo Road. The site is not listed on Council or OEH's contaminated land register.

Soil testing would occur prior to earthworks to determine the nature of the excavated material, presence of ASS and how excavated material would be reused or disposed of according to the NSW *Waste Classification Guidelines*[20].

5.8.2 Potential impacts

Soil testing would occur prior to earthworks to determine the nature of the excavated material, presence of ASS and how excavated material would be reused or disposed of according to the NSW *Waste Classification Guidelines*[21].

Results from trial hole investigations would be used to ensure excavated spoil is appropriately classified and managed with respect to waste management requirements.

If asbestos is encountered in soil or old conduits or joint bays during construction, the works would cease, access restricted and the asbestos managed and disposed of in

accordance with the POEO Act, NUS211 Working with Asbestos Products and NSW EPA Waste Classification Guidelines, 2014.

Soil quality may be affected by spills of hydraulic oil and fuels from equipment or vehicles. However the extent would be localised and appropriate controls would minimise the potential for contamination to occur. Quantities of these products would be kept to a minimum and would be stored in a suitably bunded and covered area. Adequate storage and refuelling controls would be installed to mitigate impacts. Plant and equipment would also need to be maintained to minimise the potential for leakages. Any accidentally contaminated soil would be excavated, stockpiled, chemically classified for disposal and transported to an appropriately licensed waste facility.

5.8.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-19.

Table 5-19: Contamination mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with section 5 Contamination of NS 174C Environmental Handbook.		✓	
All workers to be made aware of the presence of sensitive areas and the need to avoid impacts.		✓	
Soil testing would occur prior to earthworks to determine the nature of the excavated material, presence of ASS and how excavated material would be reused or disposed of according to the NSW EPA Waste Classification Guidelines.	✓	✓	
Toolbox talk is to include a discussion of the potential contamination at the site.		✓	
Segregate suspected contaminated spoil from clean spoil to reduce disposal costs, prevent cross-contamination of waste streams, and maximise potential for reuse of appropriate excavated materials (e.g. VENM).		✓	
Undertake testing to determine the waste classification and subsequent storage, transport, tracking, licensing and disposal requirements.	✓	✓	
Provide a secure and bunded area for the storage of fuel, oil or chemicals. This area would be imperviously bunded with a capacity to contain not less than 110% of the volume of the largest container.		✓	✓
Temporarily store excavated known or suspected contaminated spoil in a covered, lined/ sealed skip or bulk storage bag or sealed container on-site for classification prior to disposal off site. Where there are site restrictions for on-site storage, store offsite. If storing more than 5 tonnes of spoil, use a licensed storage facility. There may also be a requirement for having a licence to transport the spoil.		✓	

Mitigation measures	Implementation of mitigation measures		
If you think that you have found contamination, you must stop work immediately, restrict access and notify: • your supervisor • Ausgrid's Environmental Services • your local safety advisor for WHS requirements.		✓	
Any person handling the waste is trained in handling Scheduled Chemicals and methods of containing Scheduled Chemical spills, and wears Personal Protective Equipment (PPE).		✓	✓
All packages / storage containers are clearly labelled and maintained in good order.		✓	✓
Where more than 50kg but less than 1 tonne is stored, ensure that: There is a clearly defined storage area with conspicuous warning notices identifying the area. The storage area is constructed to prevent discharge in the external environment. For soil this can be satisfied by storing in a lined and covered bin.		✓	✓
Engage an AS1 licensed contractor to manage asbestos impacted fill in accordance with Work Cover NSW (2008).		✓	
Provide a secure, lockable and floored area for the storage of fuel, oil or chemicals. This area would be imperviously bunded with a capacity to contain not less than 110% of the volume of the largest container.		✓	✓
Prior to construction, nominate and sign post a plant refueling area.		✓	
Comply with NS 156 when working near or around underground cables.		✓	✓
If asbestos is encountered in soil or old conduits or joint bays during construction, the works would cease, access restricted and the asbestos managed and disposed of in accordance with NS 211 Working with Asbestos Products and NSW EPA Waste Classification Guidelines.		✓	✓

5.8.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to contamination for reasons including:

- Soil testing would occur prior to earthworks to determine the nature of the excavated material, presence of ASS and how excavated material would be reused or disposed of according to the NSW EPA Waste Classification Guidelines.
- the contamination would be managed in accordance with relevant OEH contamination guidelines
- mitigation measures outlined in section 5.8.3 would readily manage potential impacts.

5.9 Waste

5.9.1 Existing environment

The existing substation is unmanned and only generates small amounts of waste such as oil absorbent pads, green waste, general waste and light globes.

5.9.2 Potential impacts

The proposal may generate various types of waste, some would be reused or recycled while others would require disposal. Most waste would be generated during the construction phase. Waste likely to require disposal includes:

- bitumen, concrete and asphalt as a result of removal of existing hard surfaces
- excavated earth material that is unsuitable for re-use
- waste oils, liquids and fuels from maintenance of construction plant and equipment
- wastes from site compounds (including sewage waste, putrescible waste etc.)
- building waste (packaging material, scrap metal, plastic wrapping, cardboard)
- excess building materials that can't be reused
- vegetation from clearing activities
- cable and conduit off-cuts
- timber cable drums
- timber pallets
- redundant equipment
- other general construction waste.

Soil testing, would occur prior to earthworks to determine the nature of the excavated material, presence of ASS and how excavated material would be reused or disposed of according to the NSW *Waste Classification Guidelines*[22]. Put waste class information in

Any soil suspected of being contaminated would be stored and sampled separately then disposed to an appropriately licensed waste facility (refer to section 5.9.3).

During operation of the proposal, waste generation would be minimal.

5.9.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-20.

Table 5-20: Waste mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with section 5.3 Waste management of NS 174C Environmental Handbook.		✓	✓
All workers to be made aware of the presence of sensitive areas and the need to avoid impacts.		✓	✓

Mitigation measures	Implementation of mitigation measures		
Prior to construction, prepare a Waste Management Plan (WMP) which contains a list of expected wastes, their volume and their planned reuse, disposal or recycling.	✓	✓	
Soil testing, would occur prior to earthworks to determine the nature of the excavated material, presence of ASS and how excavated material would be reused or disposed of according to the NSW *Waste Classification Guidelines*[23]. If the works require the disturbance of >50m^3 at any one time, then an ASS management plan would be required.		✓	
Segregate and label waste to improve recycling opportunities, avoid cross contamination and reduce disposal costs.		✓	
Where possible, reuse or recycle or return to the supplier wastes including metal components, transformer oil, spoil and packaging.		✓	✓
Reuse VENM and ENM where options are available. Ensure that: • a valid waste classification certificate is available and • the reuse meets the conditions of the planning approval for that site.		✓	
Where more than 50kg but less than 1 tonne of Scheduled Chemical Waste (SCW) is stored, ensure that: • there is a clearly defined storage area with conspicuous warning notices • the storage area is constructed to prevent discharge into the external environment. This can be satisfied by storing in a plastic lined and covered bin • an adequate supply of PPE, clean-up material and equipment must be available in a secure external location from the storage area.		✓	✓
Where more than 1 tonne of SCW is stored: • a licence is required to store the waste. • comply with the conditions of the licence • perform monthly inspections for unauthorised entry or leakage and keep a log at the storage area containing details and reports of inspections.		✓	✓

Mitigation measures	Implementation of mitigation measures		
When transporting SCW with a concentration of more than 50mg/kg, personnel accompanying the vehicle must: • be trained in methods of containing spilled scheduled chemicals • be provided with adequate personal protective equipment, clean up material and equipment to deal with any spill • notify the EPA of any spill.		✓	✓
A transport licence or waste tracking is not required to transport oil (liquid or hazardous waste) in Ausgrid vehicles between Ausgrid locations (e.g. from the substation to a depot). A licence for storage of liquid or hazardous waste of greater than 5 tonnes is required. If these licensing thresholds are breached ensure storage is on a licensed Ausgrid depot. If liquid or hazardous waste is to be transported by non-Ausgrid vehicles the appropriate licences must be in place. The waste oil must be disposed of to a facility licensed to accept Liquid and, or hazardous waste. Ausgrid employees must manage the waste oil in accordance with Ausgrid's waste licence and additional requirements outlined in EG120 Waste Guidelines.		✓	✓
Ensure a spill kit is readily available and workers and know how to use it.		✓	✓

5.9.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to waste for reasons including:

- all waste would be re-used or managed in accordance with the NSW EPA Waste Classification Guidelines.
- mitigation measures outlined in section 5.9.3 would readily manage potential impacts.

5.10 Flora and fauna

5.10.1 Existing environment

The existing flora and fauna environment of the proposed site consists of cleared land and grass. There is a street tree on the Waterloo Road boundary.

A desktop assessment was undertaken for the study area. A review of OEH's Atlas of NSW Wildlife Database and the Commonwealth Department of Environment *Protected Matters Search Tool* to identify threatened species, populations, communities and migratory species likely to occur within the study area.

The review indicates no threatened species have previously been recorded near (within 1 km of) the site.

No noxious weeds listed under the *Noxious Weeds Act 1993* were identified on site.

5.10.2 Potential impacts

The proposal requires the removal of grass prior to the construction of the substation.

Noise impacts

While the construction phases of the proposal (along with its ancillary activities) may cause temporary disturbance to animals, the impacts from noise emissions are likely to be localised close to the proposal (up to 100m) and are not likely to have a significant, long-term, impact on wildlife populations.

Fragmentation and connectivity

Habitat fragmentation through the clearing of vegetation can increase the isolation of remnant vegetation and create barriers to the movements of small and sedentary fauna such as ground dwelling mammals, reptiles, amphibians and small birds. Furthermore habitat fragmentation can create barriers to the movement of pollinator vectors, such as insects, and thereby affecting the life cycle of both common and threatened flora.

Construction of the proposal would not result in additional fragmentation or any edge effects.

Weeds

The proposal site is predominantly grass. The risk of weeds being spread as a result of this development is negligible.

5.10.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-21.

Table 5-21: Flora and fauna mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with section 6 Ecology of NS 174C Environmental Handbook.		✓	
There is to be no works within the sensitive root zone (SRZ) of a tree without the advice of an arborist.		✓	
Where cables must be laid within any tree protection zone (TPZ), minimise the extent impacted and for significant encroachments, underbore/ directional drill at least 600 mm beneath the ground surface, or if excavating, hand dig or use an air knife.		✓	
Keep storage areas, stockpiles, vehicle parking, and access tracks clear of the TPZ.		✓	✓
Vegetation to be retained must be identified and protected to prevent damage from workers and machinery and remain in place for the duration of construction work.		✓	

Mitigation measures	Implementation of mitigation measures		
Where works could inadvertently harm adjacent tree, implement measures to protect the TPZ and the vegetation.		✓	
Trench or excavate outside the SRZ.		✓	
For unplanned encroachments within the TPZ: 1. Prior to site establishment, prepare a TPZ plan to show TPZ limits (based on 12 times diameter of tree at 1.4m height) and trench alignment. 2. Prior to site establishment, mark out TPZ limits in the field where access allows using spray paint and seek concurrence from Ausgrid's ESU 3. Prior to site establishment, include the TPZ plan in relevant work instructions. 4. Prior to construction, provide the TPZ plan to Ausgrid's ESU advising they would be notified where any un-planned works would encroach on the TPZ. 5. Provide tool box construction restrictions and approval process for works within the TPZ to construction crews. 6. Generate a hold point where the TPZ is to be compromised via construction works (trenching, access or storage of materials), until written advice is received from Ausgrid's ESU that planned controls are sufficient to release the hold point.		✓	
Contact local wildlife rescue organisations for the rescue or care of native wildlife (refer to section 11 of NS 174C Environmental Handbook)		✓	✓
Clear the minimum amount of vegetation necessary and consider replacement planting.		✓	
No importing mulch from other sites.		✓	✓
Provide an escape route for fauna if trenches or pits would be open extended periods (e.g. log or stick)		✓	
Keep storage areas, stockpiles, vehicle parking, and access tracks clear of the TPZ.	✓	✓	
Where cables must be laid within the TPZ, minimise the extent impacted and for significant encroachments, underbore/ directional drill at least 600 mm beneath the ground surface, or if excavating, hand dig or use an air knife.	✓	✓	
Vegetation to be retained must be identified and protected to prevent damage from workers and machinery and remain in place for the duration of construction work.		✓	
Ensure vegetation and trenching reinstatement is undertaken to minimise visual impacts.	✓	✓	

5.10.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to flora and fauna for reasons including:

- no significant impact to any matters of NES is expected (refer to Table 6-2and a referral to the Commonwealth Department of Environment is not required
- mitigation measures outlined in section 5.10.3 would readily manage potential impacts.

5.11 Bush fire

5.11.1 Existing environment

The proposal is not within land mapped as a bush fire prone land.

The site is in an urban setting surrounded predominantly by commercial properties and cleared land with isolated patches vegetation.

5.11.2 Potential impacts

The risk of causing a bush fire is primarily associated with construction and maintenance activities, not the inherent nature of the proposed infrastructure. The main risks constitute:

- undertaking various kinds of ‘hot work’ where naked flames are used, such as welding, use of blowtorches, angle-grinding and use of gas torches for shrinking heat shrink components
- use of machinery with the potential to generate sparks, such as jack hammers, rock saws and angle grinders.

Ausgrid’s distribution guideline (DG) DG 33 Hot Work During Total Fire Bans restricts hot works during total fire bans and require risk assessments and precautions to be put in place to minimise the risk of causing a bush fire. These precautions would apply to construction and maintenance for the life of the proposal.

Ausgrid’s design and performance standards require the application of passive fire protection to its substation which in some instances is over and above the minimum requirements of relevant statutory regulations given the unique risks of substations. Passive fire mitigation design involves the application of a fire rating to fire barrier/fire separation walls, the provision of adequate separation distances or a combination thereof.

In accordance with the Building Code of Australia (BCA) requirements, active fire protection systems would be incorporated into the building where required. Active fire extinguishing systems such as sprinklers and deluge systems aim at reducing the damage to burning equipment by reducing or eliminating any fire or smoke damage to the substation and equipment.

This requirement has been integrated into the proposed design and assessed during the design stages of the proposal. The result of this design process is a development which exceeds the minimum requirements of relevant statutory regulations.

5.11.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-22.

Table 5-22: Bush fire mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with section 6.4 Total fire bans of NS 174C Environmental Handbook.		✓	
All workers to be made aware of sensitive areas and the need to avoid impacts.		✓	
Design the substation to address both passive and active fire protection systems, including: • specification of fire ratings in the building design • application of active fire protection controls as required by the BCA • provision for access and emergency egress in accordance with the relevant statutory regulations	✓		

5.11.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to bush fire risk for reasons including:

- the proposal is not located within bush fire prone land
- mitigation measures outlined in section 5.11.3 would readily manage potential impacts.

5.12 Aboriginal heritage

5.12.1 Existing environment

The proposal is located in an area administered by Metropolitan Local Aboriginal Land Council (LALC).

The study area is on developed land that has previously been disturbed. Previous disturbance has occurred over part of/the whole area as a result of construction of roads, trails and tracks, construction of buildings or structures, installation of utilities, clearing of vegetation and modification of the ground surface is clear and observable.

With regard to landscape features, the study area is not located within 200m of waters, within a sand dune system, on a ridge top, ridge line or headland; within 200m below or above a cliff face; or within 20m of or in a cave, rock shelter, or a cave mouth. In addition, there are no old growth trees in the vicinity of the site.

A desktop assessment of OEH's Aboriginal Heritage Information Management System (AHIMS) and the Commonwealth Department of Environment Protected Matters Search Tool revealed zero Aboriginal sites/objects have previously been recorded in proximity to the proposal site. The nearest recorded Aboriginal artefact is located approximately 700m to the north east of the proposal.

5.12.2 Potential impacts

The proposal would not impact on any known Aboriginal object. The proposal clearing landscaping and no disturbance to the ground surface in areas previously undisturbed. There are no landscape features that indicate the presence of Aboriginal objects.

The location of registered artefacts is generally isolated to areas of potential developments and hence the result of investigations for development or rezoning applications. The presence of registered artefacts does not indicate the significance of sites in regional context, nor reflect the absence of artefacts in other locations. The mapping of registered sites is often misleading and infers the absence of artefacts in other areas, when in fact it reflects an absence of detailed investigations.

Therefore consideration of the potential for Aboriginal objects to be in the area of the proposal is required regardless of whether the database searches indicate known Aboriginal objects. Aboriginal objects are often associated with particular landscape features as a result of Aboriginal people's use of those features in their everyday lives and for traditional cultural activities. The proposal is not located near landscape features such as are rock shelters, sand dunes, waterways, waterholes, old growth trees and wetlands.

Notwithstanding, if potential heritage is identified during works, the works would cease, access restricted and the Environmental Officer contacted to investigate.

Given the proposal would not impact on any known Aboriginal sites, is not located on undisturbed land, does not comprise any sensitive landscape features and visual inspection did not reveal any new objects, the probability of objects occurring in the area of the proposed activity is low and it was concluded that a more detailed investigation (and an Aboriginal Heritage Impact Permit (AHIP) application) was not required.

5.12.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-23.

Table 5-23: Aboriginal heritage mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with section 7.1 Aboriginal heritage of NS 174C Environmental Handbook.		✓	
Stop work immediately and restrict access if potential Aboriginal heritage is discovered. Notify the Supervisor and Ausgrid Environmental Services. Environmental Services will contact the regulator if required. Ausgrid employees should contact Ausgrid Environmental Services on 9394 6659.		✓	✓

5.12.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to Aboriginal heritage for reasons including:

- the proposal would not impact any known Aboriginal sites, is not located on undisturbed land, does not comprise any sensitive landscape features and a visual inspection did not reveal any new objects
- there are no known Aboriginal objects in the project area
- the proposal would not impact any known Aboriginal sites
- mitigation measures outlined in section 5.12.3 would readily manage potential impacts.

5.13 Non-Aboriginal heritage

5.13.1 Existing environment

A desktop assessment was conducted using the Australian Heritage Database[24], NSW State Heritage Inventory[25] and the City of Ryde Local Environmental Plan. The results of these searches were that there are no Commonwealth or State or Local Heritage listed items in the study area.

The closest non-Aboriginal heritage item identified is the Macquarie Park Cemetery and Crematorium, see Figure 5-2.

5.13.2 Potential impacts

The proposal is located adjacent to an existing substation site that has been previously disturbed. Due to the previous disturbance and the proposal's location adjacent to the existing substation, it is not expected that non-Aboriginal heritage would be found or impacted during construction.

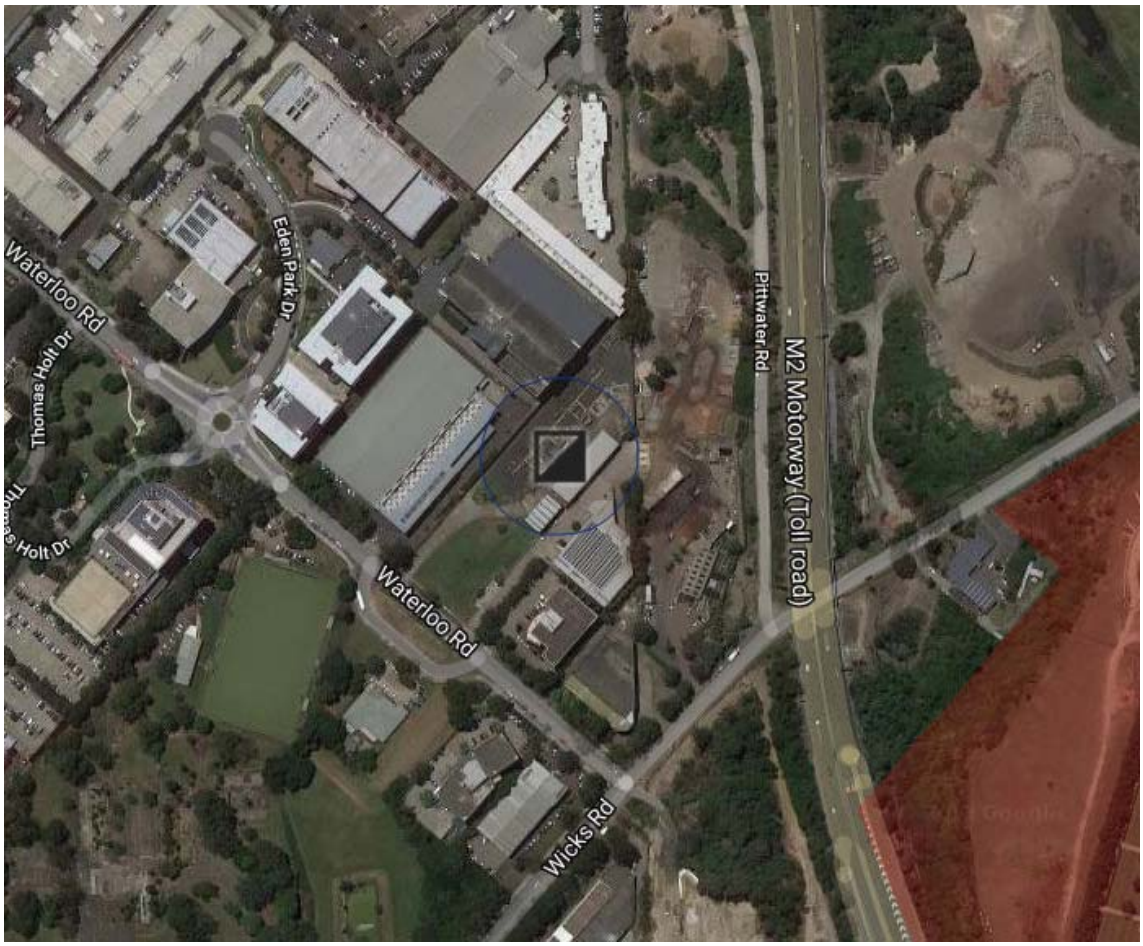


Figure 5-2: Non-Aboriginal heritage items

5.13.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-24.

Table 5-24: Non-Aboriginal heritage mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with section 7.2 Non-Aboriginal heritage of NS 174C Environmental Handbook.		✓	
All works to cease if potential heritage is discovered. Access should be restricted and Supervisor notified to ensure regulator is contacted. Ausgrid employees should contact Ausgrid Environmental Services on 9394 6659.		✓	✓

5.13.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to non-Aboriginal heritage for reasons including:

- the proposal would not affect known non-Aboriginal heritage items

- mitigation measures outlined in section 5.13.3 would readily manage potential impacts.

5.14 Visual and aesthetics

5.14.1 Existing environment

The existing visual environment of the proposed substation consists of:

- urban and educational, industrial, commercial, or infrastructure
- medium density of existing development
- existing infrastructure in the area

Figure 5-3 shows the proposed site and existing visual environment. The photographs show land use adjacent to the proposal.

Figure 5-3: Existing visual environment

5.14.2 Potential impacts

Potential visual impact may be determined through visual sensitivity of the site and the magnitude of changes. The site has a low visual sensitivity. Visual modifications as a result of the proposal would include:

- erection of a substation building with a floor area of 560m^2 and maximum building height of approximately 8m
- limited vegetation clearing
- light spillage onto surrounding properties
- new fire separation walls
- security fence including pedestrian and vehicle gates
- short term construction activities.

The proposal would be visible from:

- land and road users on Waterloo Road

Short term visual impact

The construction phase of the proposal would have a visual impact on local views due to the presence of construction fencing, plant and equipment, exposed soil and grass. The impact would vary throughout construction, with the building construction stage likely to be most visually prominent. As construction impacts would be short term and the adjoining stakeholders would be consulted about the works, the overall impact during construction is not expected to be significant. Disturbed areas would be reinstated as soon as practicable to further ameliorate short term visual impact.

Long term visual impact

Figure 5-4 shows an artist's conceptual impression of the proposed STS prepared by Kann Finch architects. A number of mitigation measures were recommended and these are reproduced in section 5.14.3.

Figure 5-4: Conceptual artist's impression of the STS

The substation building would be a neutral contemporary design to fit in with the surrounding environment.

Building form, character and position was designed to limit visual impact for the surrounding community. Furthermore, the substation design would include indoor switch gear which reduces the footprint of the proposal. A selection of colours and materials sympathetic to the location would provide a positive visual treatment. It is not considered that these works would result in any transformation of the locality

Once constructed, the proposal would not restrict access to recreational space, commercial or industrial development, residential development or water supply catchment. The proposal would require minimal maintenance, reducing the need for plant and equipment to access the site. Maintenance work would form part of Ausgrid's existing maintenance program.

5.14.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-25.

Table 5-25: Visual mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Consult with affected stakeholders about the proposal.	✓	✓	
Reinstate the roadways post works to a suitable condition.		✓	
Clear the minimum amount of vegetation necessary		✓	
Locate the proposal adjacent to the existing Macquarie Park ZS on Ausgrid property	✓		
Construct an indoor switchroom with a contemporary design in keeping with the locality	✓		

Mitigation measures	Implementation of mitigation measures		
Use the compound area on the existing ZS site as the staging area	✓	✓	

5.14.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to visual and aesthetic value for reasons including:

- the minimum amount of vegetation would be cleared as possible
- the proposal would generally be located within Ausgrid property adjacent to the existing Macquarie Park ZS which contains existing electrical infrastructure
- the proposed would be generally located within the pre-disturbed areas
- incorporation of screening opportunities (structural)
- the building is architect designed with appropriate profile, colours and materials to suit the area
- mitigation measures outlined in section 5.14.3 would readily manage potential impacts.

5.15 Traffic and access

5.15.1 Existing environment

The proposal would be accessed from Waterloo Road.

The existing driveway would be used where possible as a staging area to provide safe movement of vehicles and equipment off the road.

Transport in the region is heavily reliant on the road network for private vehicle usage and public transport in the form of buses, trains and commercial vehicles. Any impacts on the road network in the region are quickly amplified with the high volumes of traffic which utilise the road network daily.

Traffic on Waterloo Road is very heavy during peak times and remains busy at off peak periods. The southern side of Waterloo Road are utilised for car parking during business hours. Paved footpaths are located on either side of Waterloo Road. Overall, traffic surrounding the proposed site is dominated by commercial vehicle movements.

5.15.2 Potential impacts

During construction approximately up to 15 vehicles would be required any one time. Vehicles associated with the proposal would mainly include light vehicles and heavier vehicles such as tipper trucks, flat-bed trucks, concrete trucks and cranes. Heavy vehicles at the site are expected to cause some minor disruption to local roads. Construction would also result in temporary changes to traffic arrangements in local roads. Portions of some roads would need to be blocked and access may change or be reduced to some buildings for short periods of time.

Where major road disruption would occur, a traffic management plan (TMP) would be prepared in accordance with the RMS Manual *Traffic Control at Work Sites*[26] and would be implemented during construction. The TMP would also include allocated areas for staff parking.

A traffic control plan (TCP) which shows the traffic control arrangements for the proposed site would be prepared in accordance with Australian Standard 1742.3. The TCP consists of a diagram showing temporary signs and devices arranged to warn traffic and guide it around, past or if necessary through the proposed site.

Measures would be employed to minimise traffic disruption. The construction would be undertaken by those experienced in such activities along traffic routes. Any disruption, however, cannot be fully avoided, but can be minimised through timing the work to avoid peak traffic flows.

There would be some localised disruption to the community around the immediate work site (delivery of construction equipment and materials) in terms of a reduction in pedestrian access and disruption to vehicular traffic and parking during construction works. Any inconvenience to pedestrians during construction or maintenance would be minimised by ensuring that there is an alternative route. Additionally, residents, public authorities and commercial organisations would be notified via a letterbox drop of upcoming works.

During operation, the site would only be visited by vehicles on an intermittent basis for general maintenance purposes.

5.15.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-26.

Table 5-26: Traffic and access mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Comply with section 4.2 Noise and vibration of NS 174C Environmental Handbook.		✓	
Access works from Waterloo Road to the proposed STS must comply with the RMS consent conditions under section 138 of the Roads Act		✓	
Where works are proposed on a classified road, consent is required under section 138(1) of the Roads Act 1993. To apply for a section 138 consent, write to RMS for classified state roads or the relevant local Council for classified regional roads to request approval, providing a description of the work and including a plan showing the extent of the works. Ausgrid employees should use the relevant templates from Appendix 1 of Ausgrid's Procedure to Seek Consent Under Section 138 of the Roads Act. An ROL must be obtained from RMS if traffic is impacted during the works.		✓	
Prepare and implement a Traffic Management Plan in accordance with RMS and / or Council requirements.		✓	
Prior to construction, prepare a TCP in accordance with the Australian Standard 1742.3		✓	

Mitigation measures	Implementation of mitigation measures		
The TMP and /or TCP must consider the cumulative impact of construction traffic movements from other Ausgrid and non-Ausgrid works.		✓	
All potentially affected residents and businesses are to be provided with 48 hours' notice of any access changes to properties. Where residents and businesses are directly affected by the work, for example their access is restricted, one week notice must be given.		✓	
Reinstate roads post works in consultation with Council/RMS.		✓	

5.15.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to traffic and access for reasons including:

- the construction period is temporary, localised and short term
- all works affecting Waterloo Road would be undertaken in accordance with a TMP or TCP
- given the small number of vehicles expected to be used during construction, it is unlikely to result in a significant increase in traffic in the area during construction
- where possible vehicles can be parked within the boundary of the existing Ausgrid property which would reduce the amount street parking during construction.
- once in operation, the proposal would have minimal impact on the local traffic
- mitigation measures outlined in section 5.15.3 would readily manage potential impact.

5.16 Social and economic

5.16.1 Existing environment

The proposal is located within the suburb of Macquarie Park within the City of Ryde LGA. Land use within the area is characterised by a mix of educational, commercial and Business Park.

The site for the Macquarie STS is adjacent to the existing Macquarie Park ZS.

5.16.2 Potential impact

The proposal would increase the reliability of electrical supply, resulting in a positive impact on the community.

By reducing the probability of power shortages and failure, the proposal is reducing the associated economic risks, including damages and productivity losses resulting from short term interruption of commercial activities.

Construction projects such as this proposal create opportunities for suppliers, contractors and consultants which creates flow on benefits for local communities.

Discretionary spending by civil contractors during the construction period would benefit the local region.

Short term impacts on the community during the construction phase of the proposal include increased traffic intensity, altered traffic conditions, maintaining access to properties and noise. Security issues have been a major consideration throughout the design phase of the proposal. The substation would be maintained and operated in a safe manner at all times. This would include the provision of high security fencing and signage as outlined in section 1.7.7.

Due to the small scale of the works, the socio-economic impacts of the proposal would be considered to be localised.

5.16.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-27.

Table 5-27: Social and economic mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
EMF, noise, visual and traffic mitigation measures (sections 5.3.3, 5.4.3, 5.14.3 and 5.15.3 would reduce potential impacts on the surrounding community.	✓	✓	✓
The site was chosen as it is next door to the existing substation, keeping with the land use surrounding it.	✓		

5.16.4 Conclusion

The proposal is not likely to significantly affect the environment in relation to social or economic impacts for reasons including:

- construction related impacts would be minor, localised and short-term
- once in operation, the small scale of the works means any the socio-economic impacts of the proposal would be localised
- a more reliable electricity supply reduces associated economic risks such as damages and productivity losses resulting from short term interruption of commercial activities
- mitigation measures outlined in section 5.16.3 would readily manage potential impacts.

5.17 Cumulative impact

5.17.1 Existing environment

Cumulative impacts may be experienced due to the interaction of elements within the proposal, or with other existing or proposed developments within the locality. Where possible, the cumulative impact associated with the proposal has been incorporated into the assessments within this REF.

Ausgrid projects typically have related projects and flow on activities due to the interconnected nature of the network (refer to section 1.4). Other Ausgrid activities with potentially cumulative impacts include:

- Macquarie STS 132kV connection
- Macquarie STS 33kV feeder connections to connecting customers
- Macquarie Park ZS maintenance activities

Other non-Ausgrid activities with potentially cumulative impacts include:

- Sydney Metro Northwest
- Redevelopment of neighbouring properties

5.17.2 Potential impact

The potential impact due to the interaction of elements within the proposal, or with other existing or proposed developments within the locality is summarised in Table 5-28.

Table 5-28: Summary of cumulative impacts

Potential impact	Other activities with cumulative impacts	Contribution to overall impact	REF section
Noise	Construction noise from activities listed in section 5.4.2. Operational noise from activities listed in section 5.4.2.	Council was consulted in relation to other development in the area. Council submissions have been given due consideration (see section 2.2). Noise impacts during the construction phase would be localised, short term and staged along the separate sections of the proposal.	5.4
EMF	Existing 132kV, 11kV and 415V power lines. Existing substations. Proposed 132kV, 33kV, 11kV and 415V power lines.	As specialist EMF assessment would be completed during the detailed design stage. Council was consulted in relation to other development in the area. Council submissions have been given due consideration (see section 2.2).	5.3
Traffic	Traffic from activities listed in section 5.15.2	Council was consulted in relation to other development in the area. Council submissions have been given due consideration (see section 2). The TMP and / or TCP would consider the cumulative impact of construction traffic movements.	5.15
Flora and fauna	Flora and fauna impacts from activities listed in section 5.10.2.	Council was consulted in relation to other development in the area. Council submissions have been given due consideration (see section 2).	5.10

Potential impact	Other activities with cumulative impacts	Contribution to overall impact	REF section
Visual	Visual impacts from activities listed in section 5.14	Council was consulted in relation to other development in the area. Council submissions have been given due consideration (see section 2). Activities listed in section 5.14.2 would not materially alter the outcome of the visual assessment in 5.14.2.	5.14
Resources	Materials as listed in section 1.8.11 are required for the proposal.	These materials are not currently in short supply, and it is not anticipated that the proposal would substantially increase the demand on these resources. The proposal would not have a major impact on the demand on resources.	5.9

5.17.3 Environmental mitigation measures

Mitigation measures for all phases of the proposal are summarised in Table 5-29.

Table 5-29: Cumulative impacts mitigation measures

Mitigation measures	Implementation of mitigation measures		
	Design	Construction	Operation
Notify Ausgrid's Community Relations section prior to commencing construction works.		✓	

5.17.4 Conclusion

The proposal is not likely to have significant cumulative impacts for reasons including:

- the localised extent of potential impacts during construction and operational phases
- mitigation measures outlined in section 5.17.3 would readily manage potential impacts.

6 Consideration of environmental factors

6.1 Clause 228 factors

In accordance with clause 228 of the EP&A Regulations, the following factors in Table 6-1 were considered for the proposal.

Table 6-1: Consideration of clause 228 factors

Clause 228 factors	REF section giving consideration to the factors
Impact on a community	2 Consultation, 5.1 Land use, 5.3 Electric and magnetic fields, 5.4 Noise and vibration, 5.14 Visual and aesthetics, 5.15 Traffic and access and 5.16 Social and economic
Transformation of a locality	5 Environmental assessment
Impact on the ecosystem of the locality	5.10 Flora and fauna, 5.11 Bush fire and 6.3.3 Biodiversity
Reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality	5 Environmental assessment
Effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations	5 Environmental assessment
Impact on the habitat of protected fauna	5.10 Flora and fauna
Endangering any species of animal, plant or other form of life, whether living on land, in water or in the air	5.10 Flora and fauna
Long-term effects on the environment	5 Environmental assessment
Degradation of the quality of the environment	5.7 Geology and soil
Risk to the safety of the environment	5.8 Contamination and 6.3.1 Precautionary principle
Reduction in the range of beneficial uses of the environment	5.1 Land use
Pollution of the environment	5.6 Hydrology and 5.8 Contamination
Environmental problems associated with the disposal of waste	5.9 Waste
Increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply	1.8.11 Resources and equipment and 6.3.4 Improved valuation of resources
Cumulative environmental effect with other existing or likely future activities	5.17 Cumulative impact
Impact on coastal processes and coastal hazards, including those under projected climate change conditions	5.2 Climate Change

6.2 Matters of national environmental significance

In accordance with the EPBC Act, the following matters of NES were considered for the proposal[27].

Table 6-2: Consideration of Matters of NES

Matters of NES	Comment	Likely impact
World Heritage Properties	No world heritage properties would be potentially affected by the proposal (the nearest property is the Cockatoo Island Convict site which is approximately 7.5km to the south east).	Nil
National Heritage Places	No national heritage places would be potentially affected by the proposal (the nearest property is the Cockatoo Island Convict site which is approximately 7.5km to the south east).	Nil
Wetlands of International Importance	No wetlands of international importance would be potentially affected by the proposal.	Nil
Commonwealth listed Threatened Species and Ecological Communities	No threatened species, populations or ecological communities listed within Commonwealth (or State) legislation would be potentially affected by the proposal.	Nil
Commonwealth listed Migratory Species	No migratory species would be potentially affected by the proposal.	Nil
Nuclear Action	The proposal would not result in any nuclear action nor would it require any nuclear action to be undertaken.	Nil
Commonwealth Marine Areas	No Commonwealth marine areas would be potentially affected by the proposal.	Nil
Great Barrier Reef Marine Park	The Great Barrier Reef Marine Park would not be affected by the proposal as it is not located within Ausgrid's network area.	Nil
Water resources in relation to coal seam gas development and large coal mining development	Water resources would not be affected by the proposal as it does not involve coal seam gas or coal mining development.	Nil

6.3 Ecologically sustainable development

The proposal has been assessed against the following four principles of ecologically sustainable development (ESD) as listed in the *Protection of the Environment Administration Act 1991* (NSW) adopted by s. 1.3(b) of the EP&A Act.

6.3.1 Precautionary principle

The precautionary principles (s. 6 (2) (a)) states that:

'If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation'.

For the precautionary principle to be applicable two pre-conditions must be satisfied; "first it is not necessary that serious or irreversible environmental damage has actually occurred – it is the threat of such damage that is required. Secondly, the environmental damage threatened must attain the threshold of being serious or irreversible".[28]

When the precautionary principle applies, measures taken must be proportionate to the level of threat. In assessing the level of threat and determining a proportional response, Ausgrid is guided by the relevant regulators and health authorities who are charged with the responsibility for providing such advice.

Potential health effects associated with EMF are discussion in section 5.3.

A range of specialist environmental investigations, including Noise , EMF and Contamination have been undertaken during the preparation of this REF to ensure that the potential environmental impacts are understood with a degree of certainty. The design for the proposal has evolved to avoid environmental impacts where practical and mitigation measures have been recommended to minimise adverse impacts.

The proposal is therefore considered to be consistent with the precautionary principle.

6.3.2 Inter-generational equity

The principle of inter-generational equity (s. 6 (2) (b)) states that:

'The present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.'

The key objective of the proposal is to improve electricity supply and reliability, catering for future demand for the benefit of future generations. The proposal would not result in any impacts that are likely to impact on the health, diversity or productivity of the environment for future generations.

Potential health effects associated with EMF are discussed in section 5.3.

The proposal is considered to be consistent with the principle of inter-generational equity.

6.3.3 Biodiversity

The principle of biological diversity and ecological integrity (s. 6 (2) (c)) states that:

'Conservation of biological diversity and ecological integrity should be a fundamental consideration.'

A flora and fauna assessment was not undertaken as the property contains only exotic lawn. The proposal's potential impact on the biological diversity and ecological integrity of the study area is considered minimal to negligible

The proposal is considered to be consistent with the principle of biological diversity.

6.3.4 Improved valuation of resources

The principle of improved valuation of environmental resources (s. 6 (2) (d)) states that:

'Environmental factors should be included in the valuation of assets and services.'

This principle explains that those who generate pollution and waste should bear the cost of containment, avoidance and abatement; the users of goods and services should pay prices based on the full life cycle of costs; and environmental goals should be pursued in the most cost effective way.

All costs associated with the containment, avoidance and abatement of pollution have been factored into the design of this proposal and Ausgrid's operations generally.

The proposal is considered to be consistent with the principle of improved valuation of environmental resources.

7 Environmental management plan

7.1 Construction environmental management plan

A CEMP outlines the environmental objectives of a proposal, the environmental construction mitigation measures to be implemented, the timing of implementation, responsibilities for implementation and management, and a review process to determine the effectiveness of the strategies.

Once the construction methodology is known, the principal construction contractor would be responsible for developing a CEMP that addresses the scope of works to be undertaken, including site specific, measurable and achievable actions to the CEMP and the preparation of any appropriate work methods or sub plans.

The CEMP documents all the procedures and processes necessary to ensure that all personnel comply with:

- legislative requirements and relevant non-statutory policies
- specific environmental construction mitigation measures described in section 5 of this REF
- requirements outlined in any relevant approvals, permits or licences, or requirements of any relevant stakeholders / landowners.
- NS 174C Environmental Handbook.

The CEMP would typically:

- establish environmental goals and objectives
- detail the conditions of approval
- list actions, timing and responsibilities for implementation that arise from the construction mitigation measures recommended in this REF
- detail statutory requirements
- provide a framework for reporting on relevant matters on an ongoing basis
- detail training requirements for personnel in environmental awareness and best practice environmental management system
- detail emergency procedures, including contact names and corrective actions
- detail process surveillance and auditing procedures
- list complaint handling procedures
- detail quality assurance procedures.

The CEMP would be submitted to Ausgrid to be reviewed by an Environmental Officer prior to the commencement of any site works for an adequacy review to determine that the CEMP effectively addresses the scope of works to be undertaken, addresses the objectives described above and generally meets the requirements outlined in the *Guideline for the Preparation of Environmental Management Plans*[29].

No works covered by this REF would be permitted to commence until a suitable CEMP is prepared and reviewed as adequate by Ausgrid.

It is also noted that the CEMP would be a working document and would be amended and continually improved over time. This would occur when there is a change in scope, during the review process or when processes or strategies are found to be inadequate to mitigate potential environmental harm.

If an activity falls outside the scope of the REF (as defined by section 1.6) or if the mitigation measures outlined in section 5 cannot be implemented, then an additional approval would be required. The activity is not permitted to continue without an appropriate environmental assessment under the EP&A Act.

7.1.1 Implementation

The principal construction contractor would be responsible for implementing these controls during construction.

All personnel working on the proposal must be aware of their environmental obligations, responsibilities and have received the necessary training to meet the environmental obligations associated with their duties, as specified in the CEMP. Site induction training would be undertaken for all personnel to highlight sensitive work areas, explain the requirements of the CEMP, outline an individual's responsibilities and inform all personnel of emergency response procedures. Documented evidence of such training would be available before commencing work on-site.

Prior to works commencing:

- emergency procedures would be displayed in a prominent position within the site working area
- a person would be allocated for the dissemination of general information on the site operations. A contact person and contact numbers would be identified for receiving comments or complaints from the community
- a register for complaints would be established and maintained for the full duration of the work. The register would record details of complaints, complainant contact information and action taken to address complaints.

Auditing of the construction would be undertaken in accordance with the relevant international and Australian standards[30] to establish whether the Contractor is conducting activities in accordance with their current CEMP and whether the CEMP is an effective tool to control adverse environmental impacts. Recommendations regarding improvements to the CEMP must be incorporated as soon as practicable.

An Environmental Officer would be appointed to the proposal. The Environmental Officer has the authority to stop works if it is deemed necessary to mitigate potential environmental harm.

7.1.2 Compliance

The contractor is required to have an auditing and inspection schedule. Ausgrid may undertake audits to ensure the CEMP is being implemented appropriately.

At the conclusion of the construction phase of the proposal, Ausgrid in collaboration with the principal contractor, must record how and whether the conditions and measures in the REF and CEMP were observed. The documentation must be sufficient to enable a reasonable person who reads the documentation to understand, without reference to any extrinsic material, whether the conditions and measures in question were observed, and the nature of and reasons for any non-compliance.

7.2 Operation environmental management plan

An operation environmental management plan (OEMP) may be required to minimise the potential environmental impacts from operational and maintenance activities conducted as a result of the proposal.

Usually it would be the case that Ausgrid network standards, operating procedures and environmental guidelines would be sufficient to fulfil the requirements of an OEMP

However, where current Ausgrid network standards, operating procedures and environmental guidelines do not address specific requirements of the REF or a licence, permit or approval of a regulatory authority a specific OEMP may be required to be prepared. The specific OEMP would allow for operational and maintenance procedures and activities post construction to be consistent with the environmental outcomes stipulated in the REF.

The need for OEMP has been assessed as part of this REF and a specific OEMP is not required.

7.3 Environmental mitigation measures

CEMP requirements for all phases of the proposal are summarised in Table 7-1: requirements.

Table 7-1: CEMP requirements

Mitigation measures	**Implementation of mitigation measures**		
	Design	**Construction**	**Operation**
Prepare CEMP		✓	
Review CEMP for adequacy by Ausgrid		✓	
At the conclusion of the construction phase of the proposal, the Contractor must record how and whether the conditions and measures in the REF and CEMP were observed.		✓	

Additionally, through the outcomes of the auditing process, Ausgrid will also generally implement as part of its broader processes any learnings which are identified through the auditing process in order to ensure its continuous improvement for future proposals.

8 Certification

The new Macquarie STS REF assesses the potential impacts of the proposal to construct, operate and maintain a new 132/33kV STS adjacent to the existing Macquarie Park ZS on Waterloo Road, Macquarie Park.

Ausgrid is an authorised network operator under the *Electricity Network Assets (Authorised Transactions) Act 2015* (ENA Act). Under section 41 of the ENA Act and clause 277(5) of the *Environmental Planning and Assessment Regulation 2000.* development by or on behalf of Ausgrid for the purpose of an electricity transmission or distribution network (within the meaning of State Environmental Planning Policy (Infrastructure) 2007) constitutes the carrying out of that development by the authorised network operator as an electricity supply authority and public authority. As such, Ausgrid is a determining authority as defined in the EP&A Act. The proposal satisfies the definition of an activity under the EP&A Act, and as such, Ausgrid as a proponent and determining authority, must assess and consider the environmental impacts of the proposal before determining whether to proceed.

This REF examines and takes into account to the fullest extent possible all matters affecting or likely to affect the environment as a result of the proposed activities outlined in the section 1.6. This REF fulfils the requirements of section 5.5 of the EP&A Act and clause 228 of the EP&A Regulation, which sets out environmental factors to be considered in making the assessment.

On the basis of this REF, it is concluded that the proposal:

- is not likely to significantly affect the environment (including critical habitat) or threatened species, populations or ecological communities, or their habitats
- is not on land that is part of critical habitat
- is not likely to have a significant impact on matters of NES, or a significant impact on the environment (for actions on Commonwealth land) or a significant impact on the environment on Commonwealth land (for actions outside Commonwealth land).

In making these conclusions, consideration of environmental significance was made with regard to clause 228 of the EP&A Regulations, *Is an EIS Required? Best Practice Guidelines for Part 5 of the Environmental Planning and Assessment Act 1979*[1].

REF preparer:

I certify that I have prepared the contents of this REF and, to the best of my knowledge, it is in accordance with the Code approved under clause 244K of the *Environmental Planning and Assessment Regulation 2000*, and the information it contains is neither false nor misleading.

Signature:

Name: Annette Comerford

Title: Environmental officer

Company: Ausgrid

Date: 25/2/19

REF reviewer:

I certify that I have reviewed the contents of this REF and, to the best of my knowledge, it is in accordance with the Code approved under clause 244K of the *Environmental Planning and Assessment Regulation 2000*, and the information it contains is neither false nor misleading.

Signature:

Name: BARO WHITTARD

Title: S/Environmental Officer (Acting)

Company: Ausgrid

Date: 26/02/19

Project manager acceptance:

I accept the description of the proposal outlined in section 1.6 as true and accurate and I commit to the implementation of the mitigation measures outlined in section 5.

Signature:

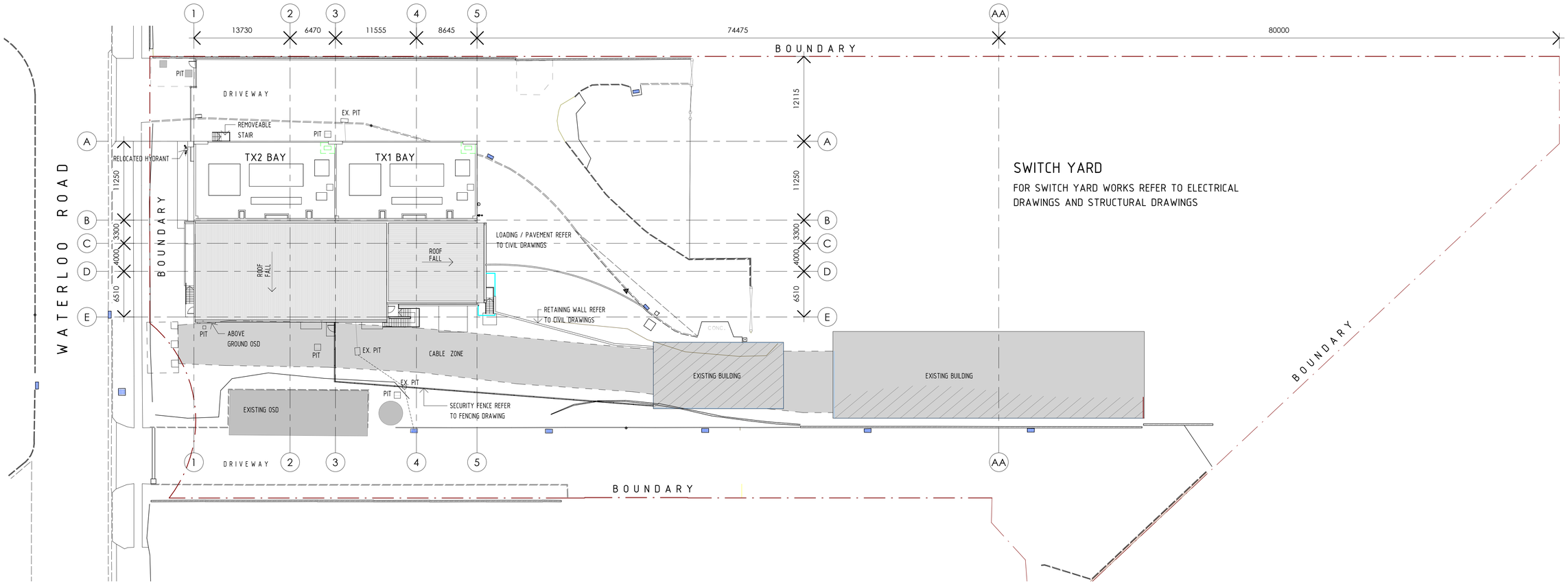
Name: Dominic Nakhle

Title: Project Manager (Acting)

Company: Ausgrid

Date: 27/2/19

Appendix A Design Drawings and Land Title



1 SITE PLAN
1 : 300

NORTH

Scale 1: 300

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DO NOT SCALE from this drawing use given dimensions only check all dimensions on the job prior to commencement of shop drawing of fabrication. Any discripancies are to be reffered to the Architect/Engineer/Designer prior to commencement of work.

NOT FOR CONSTRUCTION

AMENDMENTS

CAD DRAWING DO NOT MANUALLY AMEND

AMD	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY
0	30/11/18	INITIAL ISSUE				

Architects :
KANNFINCH
Kann Finch Group Pty Ltd 50 Carrington St Sydney NSW 2000
ACN 139 614 798 Tel +61 2 9299 4111 www.kannfinch.com
Nominated Architect: Stephen Jamison NSW ARB Reg No 5108

ASSOCIATED DRAWINGS

Ausgrid
570 George Street
SYDNEY NSW 2000

ISSUED FOR
TENDER

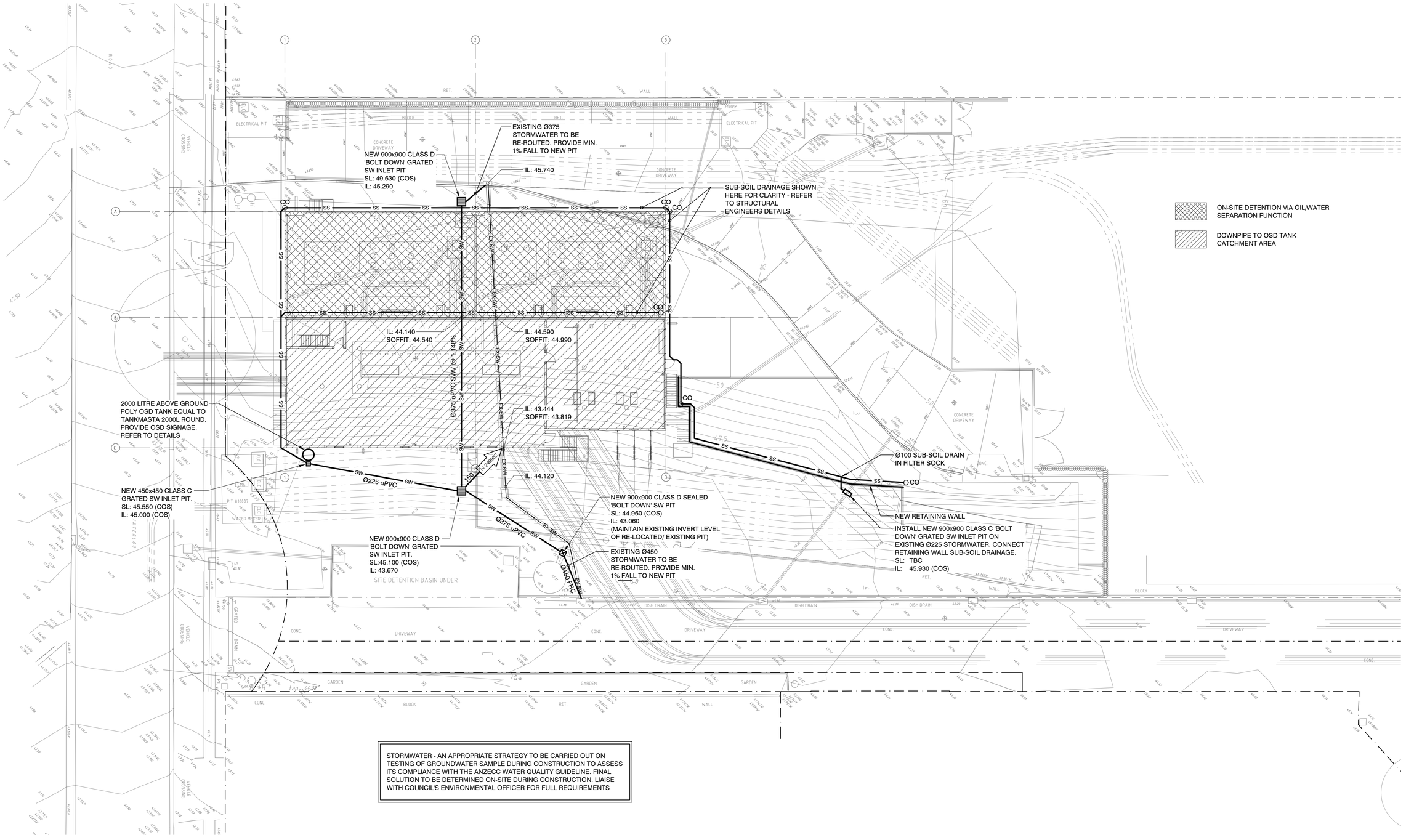
SCALE	1 : 300
DESIGNED	AC
DRAWN	AC
CHECKED	JG
APPROVED	JG
DATE	11/2018
TRIM REF	-
PROJECT NUMBER	6660

TS 37500 MACQUARIE STS
NEW BUILDING AND ASSOCIATED CIVIL WOKRS

SITE PLAN

DRAWING No. 249929 | SHEET | AMD 0 | SIZE A1

7/12/2018 9:44:40 AM :Plot Date



Scale 1:100

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DO NOT SCALE from this drawing use given dimensions only check all dimensions on the job prior to commencement of shop drawing of fabrication. Any discripancies are to be reffered to the Architect/Engineer/Designer prior to commencement of work.

AMENDMENTS

CAD DRAWING DO NOT MANUALLY AMEND AMENDMENTS

AMD	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY
0	29.11.18	INITIAL ISSUE	J.C.	H.M.	B.M.	D.W.

marline BUILDING SERVICES ENGINEERS
MECHANICAL . ELECTRICAL . HYDRAULIC . FIRE . ENERGY
P (02) 4925 9300
mail@marline.com.au
www.marline.com.au
ABN 49 612 456 381
MARLINE NEWCASTLE PTY LTD
Unit 4 239 King Street
Newcastle NSW 2300
ACN 612 456 381

MN10632

ASSOCIATED DRAWINGS

Ausgrid
570 George Street
SYDNEY NSW 2000

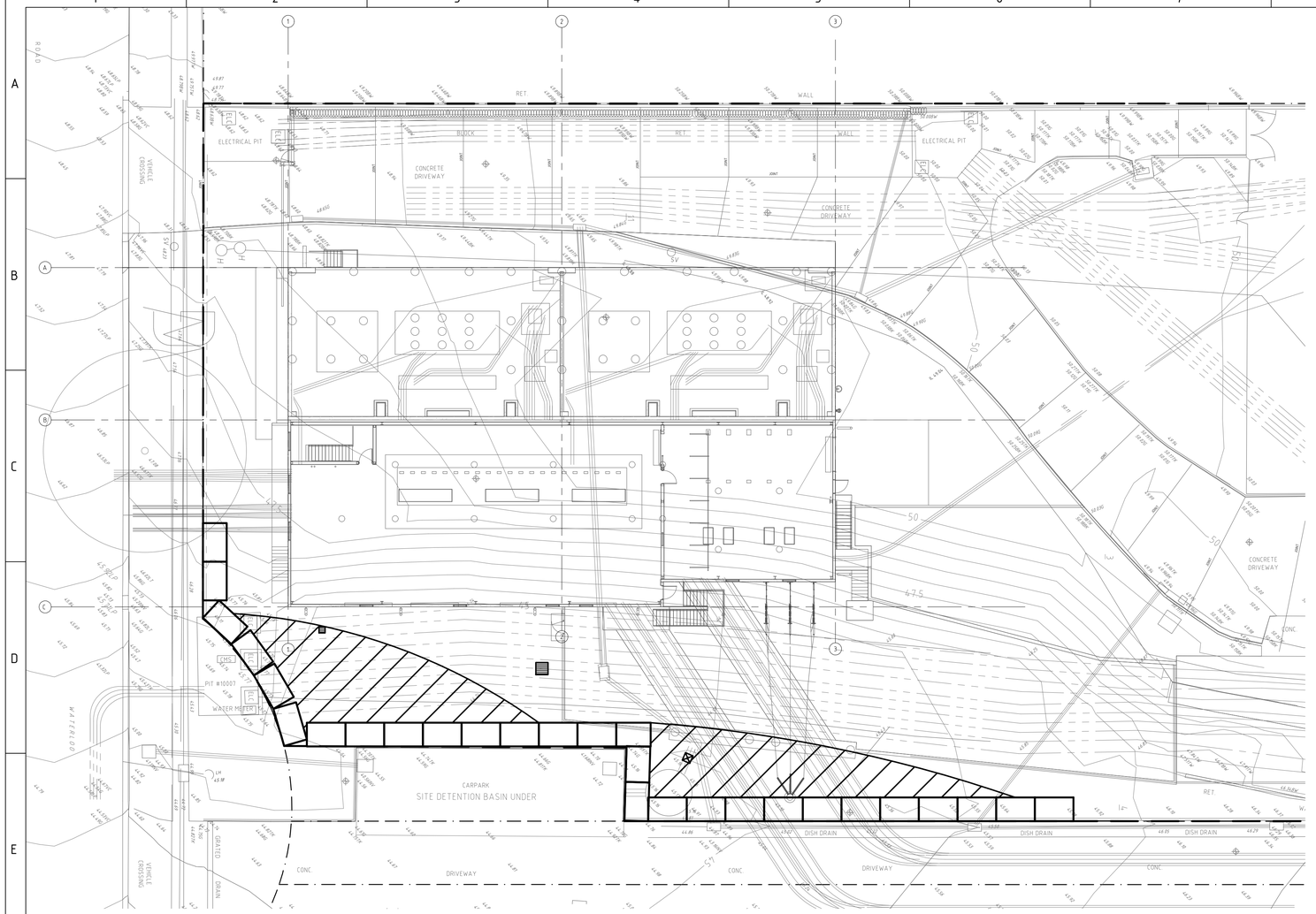
ISSUED FOR
–

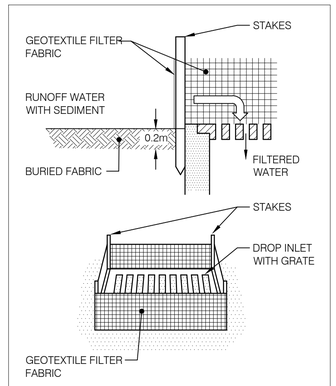
SCALE	N.T.S.
DESIGNED	H.M.
DRAWN	J.C.
CHECKED	B.MAHER
APPROVED	D.WHITE
DATE	OCTOBER 2018
TRIM REF	
PROJECT NUMBER	

TS 37500 MACQUARIE STS

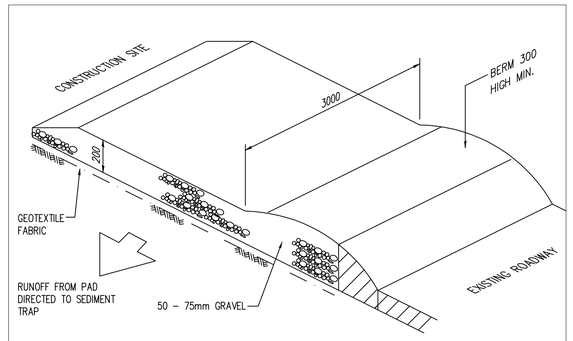
STORMWATER SERVICES
SITE STORMWATER LAYOUT

DRAWING No. 249968 | SHEET 1 | AMD 0 | SIZE A1



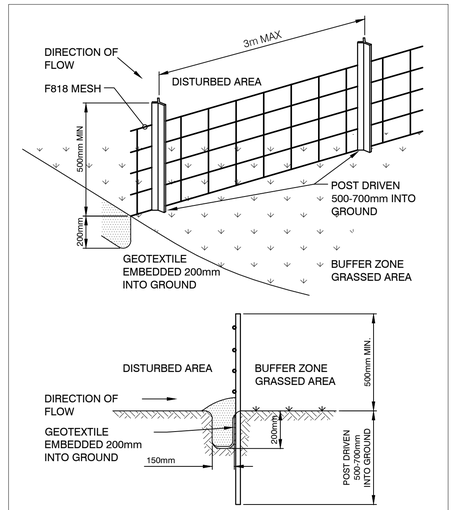


GEOTEXTILE FILTER FABRIC DROP INLET SEDIMENT TRAP

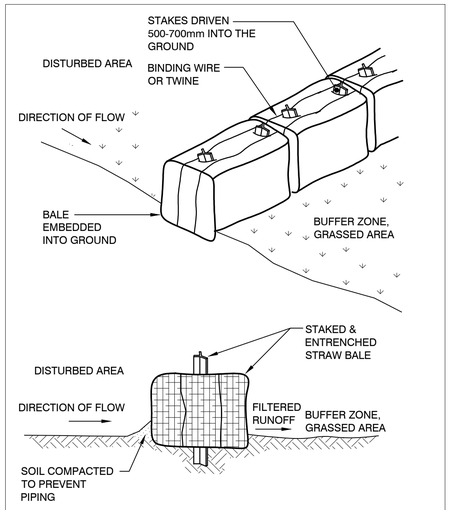


RUBBLE CROSSING

FOR USE AT ALL TRUCK/CONSTRUCTION VEHICLE ENTRY POINTS TO THE SITE.



GEOFABRIC LINED "SILT" FENCE



STRAW BALE SEDIMENT FENCE

SOIL AND WATER MANAGEMENT PLAN

1. INTRODUCTION

This plan defines the soil and water management work for erosion control and stormwater disposal, and it shall form part of the building requirements for this project.

Erosion and sediment control measure are to be implemented on the site. These works are to be maintained and /or varied as specified during the contract period unless the are they protect is rehabilitated.

2. LEGISLATION

The Clean Water Act, 1970, as amended, prohibits a person polluting any water as defined under the Art. No solid, liquid or gaseous matter is to be placed in a position where it is likely to fall, descend, be washed, be blown or percolate into unconfined surface water, a natural or artificial watercourse, drain, channel or gutter used to convey rainwater, stormwater, floodwater, or unpolluted water.

The Act is enforced under the Environment Offenses and Penalties Act, 1989 with stiff penalties for offenses ranging from "on the spot" infringement notices to fines for corporations and fines and/or imprisonment for individuals.

The contractor shall make all site workers and subcontractors aware of their responsibilities to minimise the potential for soil erosion and pollution to downslope lands and waters.

3. MANAGEMENT PLAN

A soil and water management plan has been prepared. The contractor shall undertake these works prior to any clearing, bulk earthworks and excavation for services. Installation shall begin with the fencing and shall progress upslope in a way which mitigates erosion and controls sediment even whilst this stage is being implemented.

works should be undertaken in the following sequence to minimise soil erosion hazard on the site.

a. Install security site provisions.
b. Locate the chain wire and hessian screen fencing.
c. Provide silt retention with sediment fence.
d. Install gravel driveway ramp.
e. Install Stormwater drainage work.
f. Undertake contract works.
e. Rehabilitate and maintain all disturbed lands within 20 working days after final land shaping.

4. CHAIN WIRE FENCING & HESSIAN SCREEN

A 1800 high chain wire fence with pedestrian and vehicular gate is to be erected around the contractor's site area perimeter.

Supply hessian cloth and fix to the fence and all gates on the windward side for their full height using 1.25mm wire ties at max 900mm centres both horizontally and vertically. Allow for overlapping, trimming around backstay and for interruptions on paired gates and at gate posts.

Hessian cloth shall be maintained in effective condition for the full period of the contract work.

Repair or replace torn sections when required or as directed by the Superintendent. Retie hessian as before specified where it comes adrift from the fence or gates and when repairing or replacing cloth section.

5. HAY BALES

Form a filter wall at the lower corner of the construction site.

all accumulated siltation at the hay bales shall be removed off the site when 30% of the hay bale height is covered with silt.

6. STORMWATER DRAINAGE PITS

All grated pit covers on the stormwater drawing shall be provided with a geotextile filter inlet as shown on the drawing. The filter fabric shall be maintained in effective and clean condition for the period of the contract work.

No sediment shall pass from the stormwater drainage pits on the site to the Council's stormwater pipes.

7. STOCKPILES

Stockpiles are not to be located within 2 metres of hazard areas.

Dust from any stockpiles shall not enter the adjoining property.

All excavation and stockpiles shall be covered or treated so that no dust causes a nuisance.

8. MATERIAL RECEPTORS

Provide acceptable reception for concrete and motor slurries, paints, acid washing, light-weight waste material and litter. Empty as necessary and dispose in an acceptable manner.

9. EXISTING SERVICES

All existing services shall be identified and protected against damage as defined in the specification.

10. MAINTENANCE

All sediment and erosion control measures shall be maintained in satisfactory working order throughout the area which they protect is rehabilitated.

The contractor shall inspect the site weekly to ensure that:

a. Control measure operate effectively and to initiate repairs or maintenance as required.
b. Spilled material is removed from hazard areas including likely areas of concentrated or high velocity flows such as spoon drains, gutters, paved areas and driveways.
c. Sediment is removed from settling basins when 30% capacity is trapped in the setting zone. All collected sediment is to be removed to areas where further pollution to downslope lands and waters is unlikely.
d. Hay bales or filter materials are clean and have been reinstated or replaced to maintain effective performance.
e. No gravel, silt or rubbish is deposited in the Council gutter or outside the site area.

All devices are to be inspected after each storm for structural damage or clogging by silt or other debris and to make prompt repairs or replacement.

11. SITE REHABILITATION

Rehabilitate all disturbed areas and restore the site as shown on the landscape plan and to the satisfactory of the Council.

Where grasses are sown, a complete NPK fertiliser shall be applied at a rate of 300gms/10m . Fertilising and watering shall be as directed by the Superintendent for Contract.

Rehabilitate land as soon as possible. Disturbed areas which are likely to remain unattended for more than 60 days shall be restored with sown annual grasses.

12. FINAL SITE LANDSCAPING

Final site landscaping is to be undertaken as soon as possible in any precinct after building activities surrounding the building are completed.

13. REINSTATEMENT

Remove all construction material used in these soil and water control measures from the site when they cease to perform effectively and are replaced, or are no longer required.

Reinstate the finished ground level around the works after it is determined that the areas they protect are satisfactorily rehabilitated.

14. LOG BOOK RECORD

ON site supervisor shall keep a log book recording.

a. all rainfall.
b. date of the erection and dismantle of soil and water retaining fencing.
c. all other maintenance work undertaken on erosion of pollution control measures.

This log book is to be kept on the building site and shall be made available to an officer of the E.P.A. or Department of Housing upon request.

Scale 1:100

0 1000 2000 5000 10000

DO NOT SCALE from this drawing use given dimensions only check all dimensions on the job prior to commencement of shop drawing of fabrication. Any discripancies are to be reffered to the Architect/Engineer/Designer prior to commencement of work.

AMENDMENTS

AMD	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY
0	29.11.18	INITIAL ISSUE	J.C.	H.M.	B.M.	D.W.

CAD DRAWING DO NOT MANUALLY AMEND AMENDMENTS

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ACN 612 456 381
MN10632

ASSOCIATED DRAWINGS

Ausgrid
570 George Street
SYDNEY NSW 2000

ISSUED FOR
–

SCALE	N.T.S.
DESIGNED	H.M.
DRAWN	J.C.
CHECKED	B.MAHER
APPROVED	D.WHITE
DATE	OCTOBER 2018
TRIM REF	
PROJECT NUMBER	

TS 37500 MACQUARIE STS

STORMWATER SERVICES
EROSION & SEDIMENT CONTROL LAYOUT

DRAWING No. 249969 | SHEET 1 | AMD 0 | SIZE A1

NEW SOUTH WALES LAND REGISTRY SERVICES - TITLE SEARCH

FOLIO: 1/1006960

SEARCH DATE	TIME	EDITION NO	DATE
4/12/2018	9:21 AM	6	28/2/2017

LAND

LOT 1 IN DEPOSITED PLAN 1006960
AT NORTH RYDE
LOCAL GOVERNMENT AREA RYDE
PARISH OF HUNTERS HILL COUNTY OF CUMBERLAND
TITLE DIAGRAM DP1006960

FIRST SCHEDULE

ALPHA DISTRIBUTION MINISTERIAL HOLDING CORPORATION (CN AK971571)

SECOND SCHEDULE (6 NOTIFICATIONS)

1 LAND EXCLUDES MINERALS AND IS SUBJECT TO RESERVATIONS AND CONDITIONS IN FAVOUR OF THE CROWN - SEE CROWN GRANT(S)
2 DP844951 EASEMENT TO DRAIN WATER 1.5 METRE(S) WIDE APPURTENANT TO THE PART SHOWN SO BENEFITED IN THE TITLE DIAGRAM
3 DP1006960 RIGHT OF ACCESS 10 METRE(S) WIDE AND VARIABLE AFFECTING THE PART(S) SHOWN SO BURDENED IN THE TITLE DIAGRAM
4 DP1006960 EASEMENT FOR SERVICES 1.95 & 2 METRE(S) WIDE AFFECTING THE PART(S) SHOWN SO BURDENED IN THE TITLE DIAGRAM
5 AA340404 POSITIVE COVENANT
6 AK971351 LEASE TO BLUE ASSET PARTNER PTY LTD, ERIC ALPHA ASSET CORPORATION 1 PTY LTD, ERIC ALPHA ASSET CORPORATION 2 PTY LTD, ERIC ALPHA ASSET CORPORATION 3 PTY LTD & ERIC ALPHA ASSET CORPORATION 4 PTY LTD EXPIRES: 30/11/2115. OPTION OF RENEWAL: 99 YEARS.
AK971352 LEASE OF LEASE AK971351 TO BLUE OP PARTNER PTY LTD, ERIC ALPHA OPERATOR CORPORATION 1 PTY LTD, ERIC ALPHA OPERATOR CORPORATION 2 PTY LTD, ERIC ALPHA OPERATOR CORPORATION 3 PTY LTD & ERIC ALPHA OPERATOR CORPORATION 4 PTY LTD EXPIRES: 29/11/2115.
AK971502 MORTGAGE OF LEASE AK971351 TO ANZ FIDUCIARY SERVICES PTY LTD

NOTATIONS

END OF PAGE 1 - CONTINUED OVER

NOTATIONS (CONTINUED)

UNREGISTERED DEALINGS: NIL

*** END OF SEARCH ***

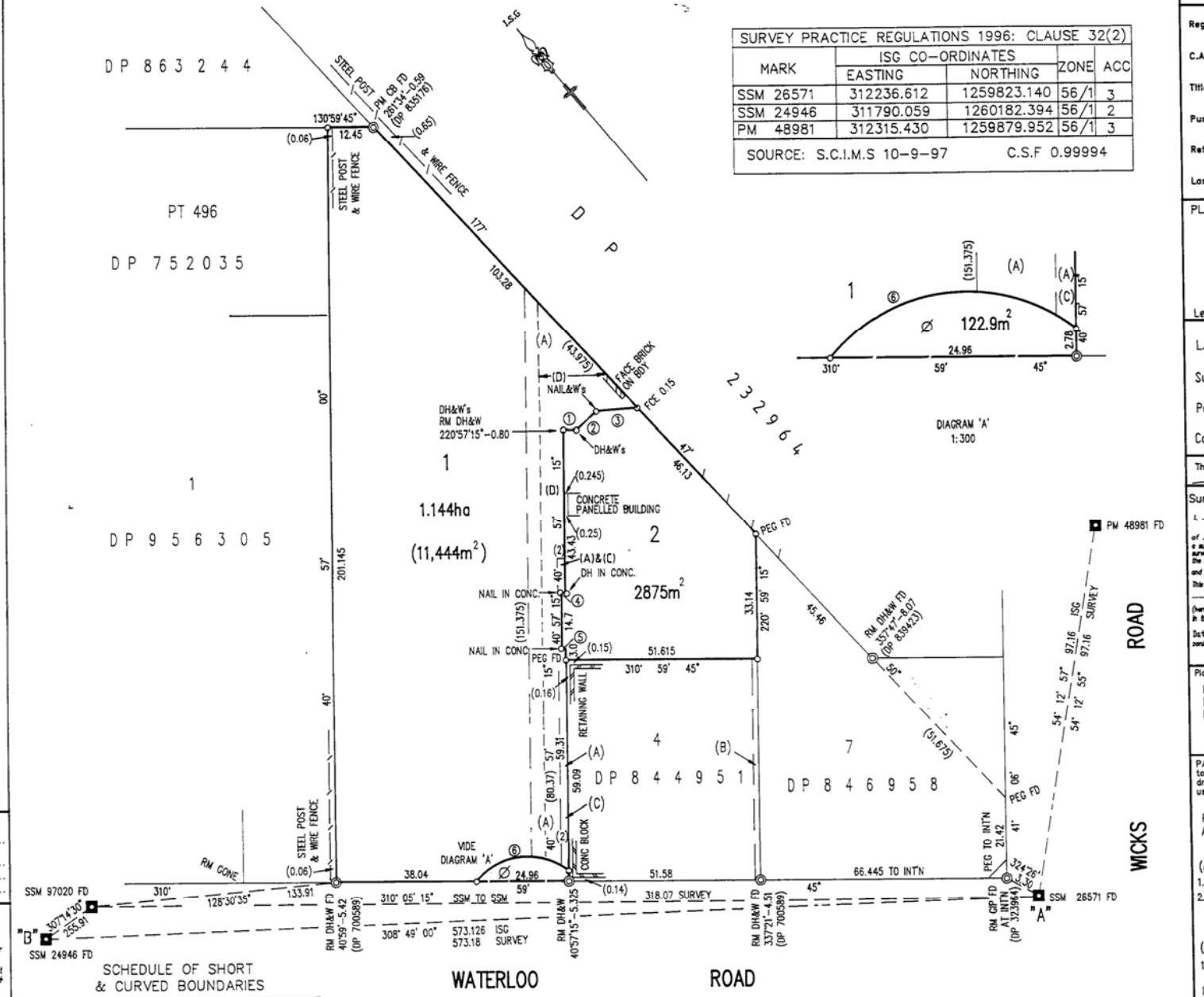
PLAN FORM 2 — Plan Drawing only to appear in this space

DP1006960

SIGNATURE AND SEALS ONLY.

P.C. RIVETT.
TINA RIVETT

SURVEY PRACTICE REGULATIONS 1996: CLAUSE 32(2)				
MARK	ISG CO-ORDINATES		ZONE	ACC
	EASTING	NORTHING		
SSM 26571	312236.612	1259823.140	56/1	3
SSM 24946	311790.059	1260182.394	56/1	2
PM 48981	312315.430	1259879.952	56/1	3
SOURCE: S.C.I.M.S 10-9-97		C.S.F 0.99994		



Ø ROAD WIDENING

(A) RIGHT OF ACCESS 10.0 WIDE AND VARIABLE
(B) EASEMENT TO DRAIN WATER 1.5 WIDE (VIDE DP 844951)
(C) EASEMENT FOR SERVICES 1.95 & 2.0 WIDE
(D) BENEFITED BY EASEMENT TO DRAIN WATER 1.5 WIDE (DP 844951)

SCHEDULE OF SHORT & CURVED BOUNDARIES

No	BEARING	CHORD	ARC	RADIUS
1	132°15'	3.53		
2	88°31'	7.2		
3	126°39'	11.27		
4	130°57'	0.05		
5	310°57'	0.05		
6	124°38'05	25.11	27.79	18

Crown Lands Office Approval

PLAN APPROVED ..... Authorised Officer
Land District .....
Paper No. .....
Field Book ..... pages .....

Council's Certificate

I hereby certify that –
(a) the requirements of the Local Government Act, 1919 (other than the requirements for the registration of plans), and
*(b) the requirements of †Part 3 Division 2 of the Water Board Act 1987, or †Part 5 Division 7 of the Hunter Water Board (Corporatisation) Act 1991.
have been complied with by the applicant in relation to the proposed Subdivision (insert "new road", "subdivision" or "consolidated lot") set out herein
Subdivision No. 541H
Date 13/9/1999
(Signature) R Mogle
General Manager/Authorised Person
Council File No. 645/1999

*This part of certificate to be deleted where the application is only for a consolidated lot or the opening of a new road or where the land to be subdivided is wholly outside the areas of operations of the Water Board and the Hunter Water Corporation Ltd.
†Delete if inapplicable.

SURVEYOR'S REFERENCE: 23577DP"CHECKLIST"

Registered: 7-10-1999
C.A.: SEE CERTIFICATE
Title System: TORRENS
Purpose: SUBDIVISION
Ref. Map: U0952-21*, U0960-83*
Last Plan: DP 844951

PLAN OF SUBDIVISION OF LOTS 1, 2 AND 3 DP 844951

Lengths are in metres. Reduction Ratio 1:800

L.G.A.: RYDE
Suburb/Locality: NORTH RYDE
Parish: HUNTERS HILL
County: CUMBERLAND

This is sheet 1 of my plan in + sheets. (Delete if inapplicable).

Survey Certificate Surveyors (Practice) Regulation 1996
I, DAMIAN JOSEPH MAGUIRE
MICHAEL LOCKLEY AND ASSOCIATES
of PO BOX 229 GLADESVILLE NSW 2111
a surveyor registered under the surveyors Act 1929, hereby certify that the survey represented in this plan is accurate, has been made in accordance with the Surveyors (Practice) Regulation 1996
and was completed on 5-08-99
This survey relates to .....
(here specify the land actually surveyed, or specify any land shown in the plan that is not the subject of the survey)
Datum Line: 'A'-'B'
zoning: Suburban/Country (Signature) .....
Surveyor registered under the Surveyors Act 1929

Plans used in preparation of survey/compilation
DP 863244
DP 846958
DP 866302

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PURSUANT TO SEC 88B OF THE CONVEYANCING ACT 1919 AS AMENDED, IT IS INTENDED TO:

(A) CREATE:
1. RIGHT OF ACCESS 10.0 WIDE AND VARIABLE
2. EASEMENT FOR SERVICES 1.95 & 2.0 WIDE

(B) RELEASE:
1. RIGHT OF WAY 6.0 WIDE - DP 844951

IT IS INTENED TO DEDIACTE THE AREA MARKED ROAD WIDENING TO THE PUBLIC AS PUBLIC ROAD

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 Table of mm 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390

M P D

WARNING: CREASING OR FOLDING WILL LEAD TO REJECTION

Appendix B EMF Assessment

Macquarie Park 132/33kV STS

EMF Assessment

Ausgrid

Reference: 504590

Revision: 2

2019-01-09

aurecon

Bringing ideas to life

Document control record

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Title		Title	

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1 Project Overview

1.1 Background

It is understood that Ausgrid has received a number of major Connection Applications in the Macquarie Park area and that these loads will require significant subtransmission capacity to be provided. Accordingly, Ausgrid proposes to construct a 132/33kV subtransmission substation (STS) on Ausgrid property, adjacent to the existing Macquarie Park 132/11kV Zone Substation (ZS) at 17-21 Waterloo Road, Macquarie Park. The existing ZS, which is at the northern end of the property, will be retained and the STS will be established at the southern (Waterloo Road) end. The project will also involve the installation of 6 outgoing 33kV feeders, and 6 spare conduits to Waterloo Road, together with a further 12 spare conduits along a shared driveway (on Ausgrid property) away from Waterloo Road, along with some 132kV feeder rearrangements at the site.

In connection with these works, Aurecon has been engaged to conduct an independent assessment of the predicted EMF at the boundaries of the Ausgrid site. It is understood that the results of this assessment will be used by Ausgrid to inform their overall environmental assessment of the project.

1.2 Scope

The scope of Aurecon's assessment is to encompass the following:

- Provide a brief description of the EMF health issue.
- Perform calculations to predict the magnetic field levels at 1m above ground level (as per the relevant standard) at the site boundaries, both shortly after commissioning and under ultimate loading conditions.
- Undertake an assessment of the compliance of the proposed works with the relevant national and international EMF guidelines (ICNIRP 2010).
- Undertake an assessment of compliance of the proposed design against precautionary and prudent avoidance principles as defined in the relevant literature.
- Prepare a report documenting the above.

1.3 Site Description

The site of the proposed STS is shown (highlighted in blue) in Figure 1-1. The existing ZS can also be seen, edged with a dotted blue line.

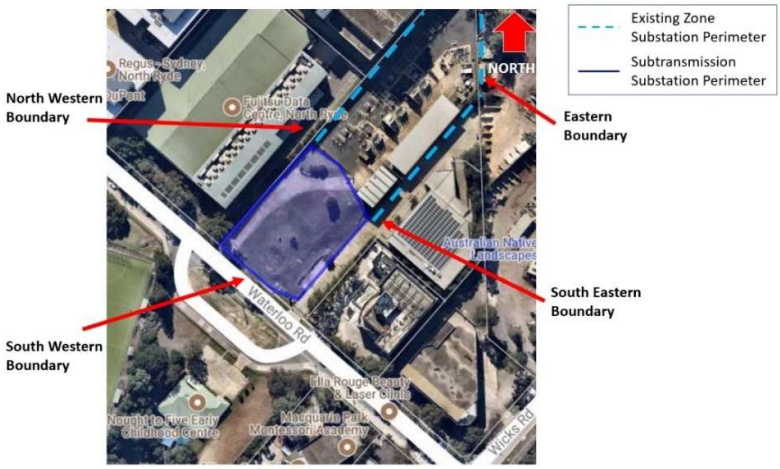

Figure 1-1: Site of Macquarie Park STS

1.4 Approach

In undertaking the assignment, Aurecon has adopted the following approach:

- Perused relevant background information supplied by Ausgrid, including single line diagrams, details of the substation layout, detailed cable routes including their trench section details and cable specifications, loading forecasts and other relevant technical details.
- Measured the existing magnetic fields along the site boundaries.
- Performed calculations to predict the contribution of the proposed works to the magnetic fields at the boundaries of the site, 1m above ground (in accordance with the relevant standard), both after commissioning and under ultimate loading conditions.
- Reviewed compliance of the proposed design against relevant EMF guidelines
- Reviewed the proposed design, including any proposed or potential magnetic field mitigation options, against relevant precautionary and prudent avoidance principles.

2 Overview of Electric and Magnetic Fields

2.1 General description

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.

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

Further detail on electric and magnetic fields can be found in Appendix A.

2.2 Electric and magnetic field / health issue

The possibility of adverse health effects due to the EMFs associated with electrical equipment has been the subject of extensive research throughout the world for more than 40 years. To date, while adverse health effects have not been established, the possibility that they may exist cannot be ruled out. In the context of the present assignment, it should be noted that underground cables produce no external electric field and, accordingly, only the magnetic field component of EMF associated with underground cables requires assessment. Further discussion of the EMF/health issue can be found in Appendix B.

2.3 Health guidelines

Since late 2015, the relevant Australian regulator, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), has adopted the international guideline published by the International Commission on Non-Ionising Radiation Protection (ICNIRP) in 2010. Details of the current guideline “Reference Levels” for electric and magnetic field exposure can be found in Appendix C.

These “Reference Levels” have been used as the principal assessment criteria for this assignment and are reproduced in Table 2-1. It should be noted that these criteria are independent of duration of exposure.

Table 2-1: ICNIRP Guideline Reference Levels (General Public)

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

2.4 Prudent avoidance

Given the inconclusive nature of the science regarding EMF and human health, it is widely considered that a prudent approach is the most appropriate response under the circumstances. Under this approach, subject to modest cost and reasonable practicality, the owners of electric power infrastructure should design their facilities to reduce the intensity of the fields they generate in frequented areas. Further general discussion on this subject can be found in Appendix D and the implications for this project are discussed in Section 5.2.

3 Input information and aspects of field predictions

3.1 Input information

The input data required for the calculations on which this assessment is based has been supplied by Ausgrid and is summarised below.

- Design drawings for the proposed STS and associated feeders.
- Details of typical daily load currents in the existing and proposed 11, 33 and 132kV feeders, shortly after commissioning and in the long term.
- Relevant electrical data regarding the various underground cables and the proposed 132kV overhead connection.
- Detailed cross sections showing the dimensions and phasing of each different section of 11, 33 and 132kV cable or overhead line within and/or leaving the STS site.
- Details of the existing and proposed incoming and outgoing 132kV, 33kV and 11kV feeder locations in the immediately vicinity of the substation.

3.2 Assumptions for modelling

In undertaking this EMF assessment, the modellers have made the following assumptions in consultation with Ausgrid:

- The existing Zone Substation is already fully loaded and this is not expected to increase in the future.
- Where the phasing arrangement is not available, it is reasonable to assume a conservative phasing arrangement for modelling purposes.
- The initial loading on the first tranche of outgoing 33kV feeders has been estimated in consultation with the designers (Stowe), based on the customer loads immediately before commissioning of the STS.
- The STS provides for future outgoing 33kV feeders, exiting either via Waterloo Road or via the shared laneway on the south-eastern side. As these routes influence different boundaries, the modelling for the “ultimate load” case for the Waterloo Road boundary assumes that the future feeders exit via Waterloo Road and the modelling for the “ultimate load” case for the south-eastern boundary assumes that the future feeders exit via the shared laneway.

3.3 Magnetic field dependence on load

Being related to the equipment voltage, electric fields, where they exist, are relatively stable over time, whereas the magnetic fields from electrical equipment depend on the loadings at the time. As this assignment involves multiple feeders, both existing and proposed, in proximity to one another, their interaction will influence the resulting fields. Accordingly, in characterising the magnetic fields at the

boundaries of the STS, it is necessary to make practical assumptions regarding the loadings on the various items of equipment at the time.

This approach has been followed in our modelling calculations, with the loadings in the existing and proposed feeders being assumed to be the time-weighted average[1] values, as advised by Ausgrid. These loadings are summarised below.

Table 3-1: Line loadings used for modelling

Feeder	2020 Load (Amps)	Ultimate Load (Amps)
132kV Cable 92AX	117	117
132kV Cable 92AY	117	117
132kV Overhead 92B	109	604
33kV Customer 1	87	394
33kV Customer 2	65	131
33kV Customer 2	65	262
33kV Customer 1	87	394
33kV Customer 2	65	131
33kV Customer 2	65	262
33kV Future	0	420
33kV Future	0	420

4 Field characterisation

4.1 Site measurements

The existing magnetic fields around the site boundaries were measured between 1130 and 1300 on 18th November, 2018.

The magnetic field measurements were undertaken using an Emdex 2 magnetic field meter, in conjunction with an Enertech linear data acquisition system "LINDA", at a height of 0.9 metres above ground, as dictated by the (US) equipment used. Prior to undertaking the measurements, the instrument used was checked using a purpose-built National Electricity "Emdex 2 Functional Test Unit" and found to be within the specified levels of accuracy.

At the time of the measurements, the load on the ZS was approximately equal to the time weighted average values advised by Ausgrid.

4.1.1 Eastern boundary

A total of 80 measurements were made. All were quite low, ranging from 0.3mG at the northern end to 2 towards the southern end.

[1] *Time weighted average values are selected as this parameter has frequently been used in epidemiological health studies associated with magnetic fields.*

4.1.2 South-eastern boundary

A total of 140 measurements were made. Due to traffic and obstructions in the Australia Post area of the shared driveway, the measurements were made along the inner (NW) edge of the driveway and would have overstated the influence of the substation. The majority were 1mG or less, except for the section immediately adjacent to the 11kV cable basement, where fields between 3 and 7mG were recorded. These could be expected to fall to 1 or 2mG at the actual property boundary.

4.1.3 Waterloo Road boundary

A total of 100 measurements were made. A localised peak of 65mG was observed where the 132kV cables enter the site. The fields along the remainder of the boundary were 5mG or less.

4.1.4 North-western boundary

A total of 180 measurements were made. Readings ranged from 0.3mG at the NE end to 18mG at the Waterloo Road end The dominant sources of the measured fields were the Zone substation, particularly the busbars (up to 13mG), and the incoming 132kV cables. The influence of the outgoing 11kV cables towards the Waterloo Road end was minor. An unidentified source (14mG) was observed approximately 75 metres from the Waterloo Road boundary. As no source was evident within the Ausgrid property, it is likely that the source was associated with the adjacent Fujitsu facility.

4.2 Modelling

Based on the available design and loading information, the magnetic field contribution of the proposed STS and relevant existing feeders has been modelled using in-house software, which applies well established engineering formulae and has been extensively validated against other software packages and field testing. The modelling has covered the four STS site boundaries, with two cases having been modelled, namely, shortly after commissioning of the STS and a long term (“ultimate”) condition.

The electric field contribution of the proposed section of overhead 132kV line entering the STS has also been modelled.

In all cases, the fields have been calculated at a height of 1m above ground, in accordance with international practice (Ref B-1).

4.3 Magnetic field results

The results obtained from the magnetic field modelling are shown in the following sections, in the form of profiles along the respective boundaries.

4.3.1 Eastern Boundary

The calculated magnetic field along the Eastern boundary is shown in Figure 4-1. The lower curve is shortly after commissioning and the upper curve is the long-term case, with the STS fully loaded and includes future 33kV feeders which may ultimately leave the STS via a different route. The influence of the possible future 33kV feeders can be seen towards the right hand end of Figure 4-1. Should these feeders leave the substation via the Waterloo Road alternative, the long term magnetic field will remain as shown by the lower curve.

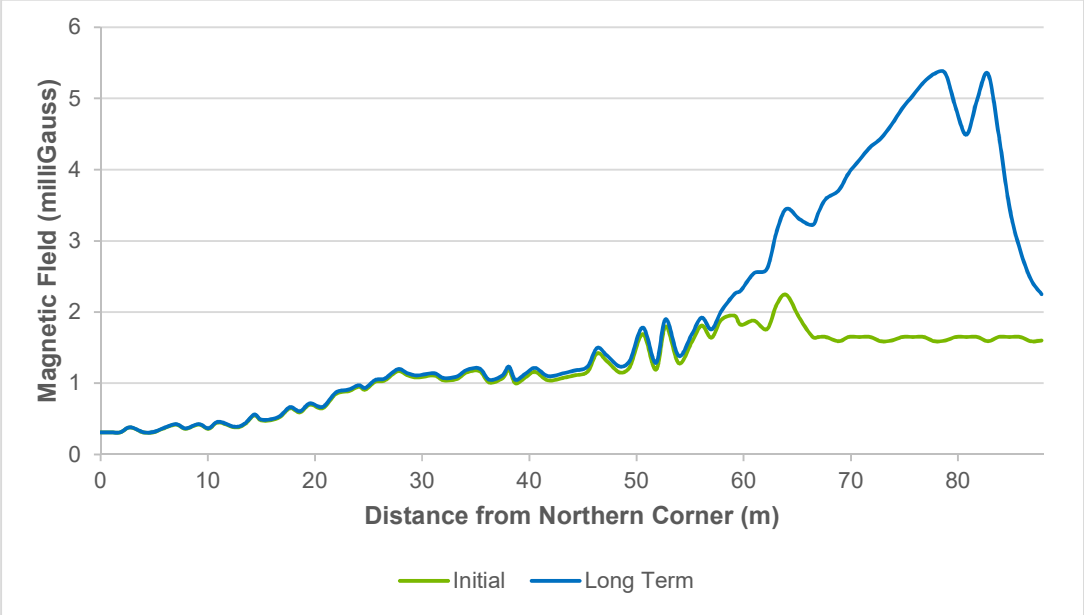

Figure 4-1: Calculated Magnetic Field Profile along Eastern Boundary

It can be seen from Figure 4-1 that in the short term, the magnetic field along the Eastern boundary of the site is less than 2mG. In the longer term, in the event that the future feeders exit the site via the shared driveway, the field above those cables will be up to 5.4mG. Otherwise, the long term magnetic fields will be similar to the short-term fields.

4.3.2 South-Eastern Boundary

The calculated magnetic field along the south-eastern boundary is shown in Figure 4-2. The lower curve is shortly after commissioning and the upper curve is the long-term case with the STS fully loaded and includes future 33kV feeders which may ultimately leave the STS via a different route.

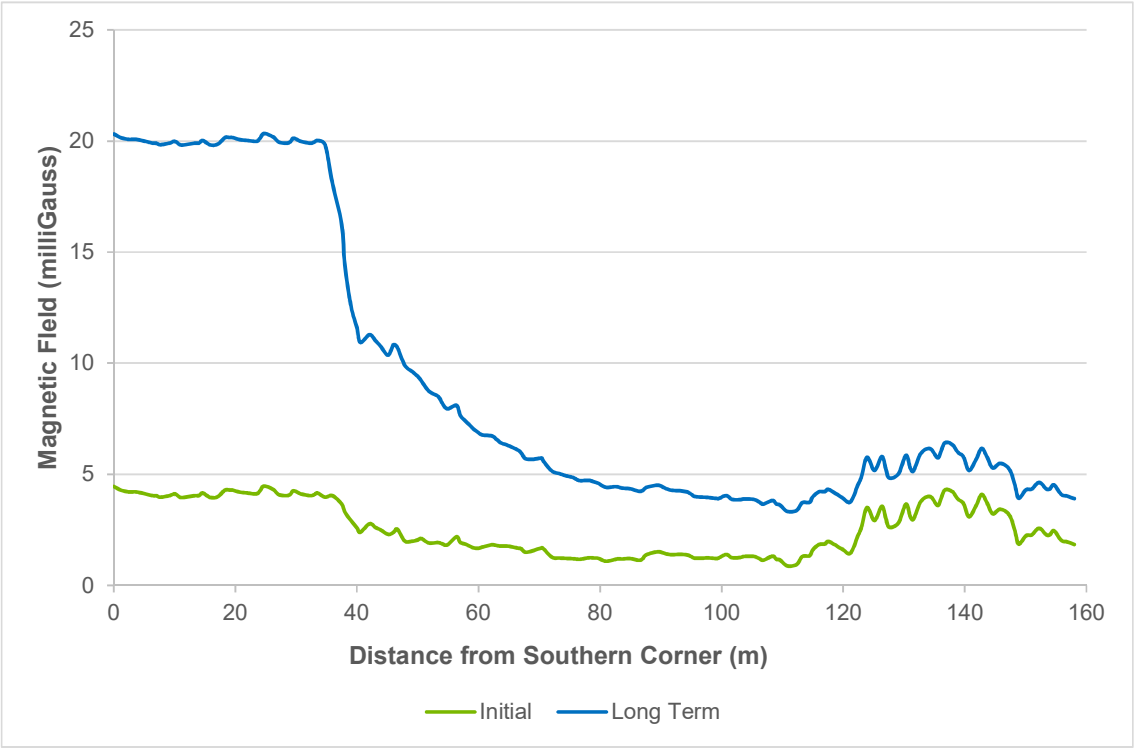

Figure 4-2: Calculated Magnetic Field Profile along South-Eastern Boundary

It can be seen from Figure 4-2 that the magnetic field along the south-eastern boundary of the STS, shortly after commissioning, is less than 5mG.

In the long term, the field at the Waterloo Road end will increase to 20mG, due to the increased current in the incoming 132kV overhead line. The influence of the possible future 33kV feeders can be seen for the northern section of the boundary but is only of the order of 2mG. In the event of these feeders exiting via Waterloo Road, the long term field in the northern part of this boundary will remain as shown by the lower curve.

4.3.3 South-Western (Waterloo Road) Boundary

The calculated magnetic field along the south-western (Waterloo Road) boundary, is shown in Figure 4-3. The lower curve is shortly after commissioning and the upper curve is the long-term case with the STS fully loaded and includes future 33kV feeders which may ultimately leave the STS via a different route. The influence of the various groups of feeders entering and exiting the site is readily visible, with the existing 132kV cables being the most significant source[2].

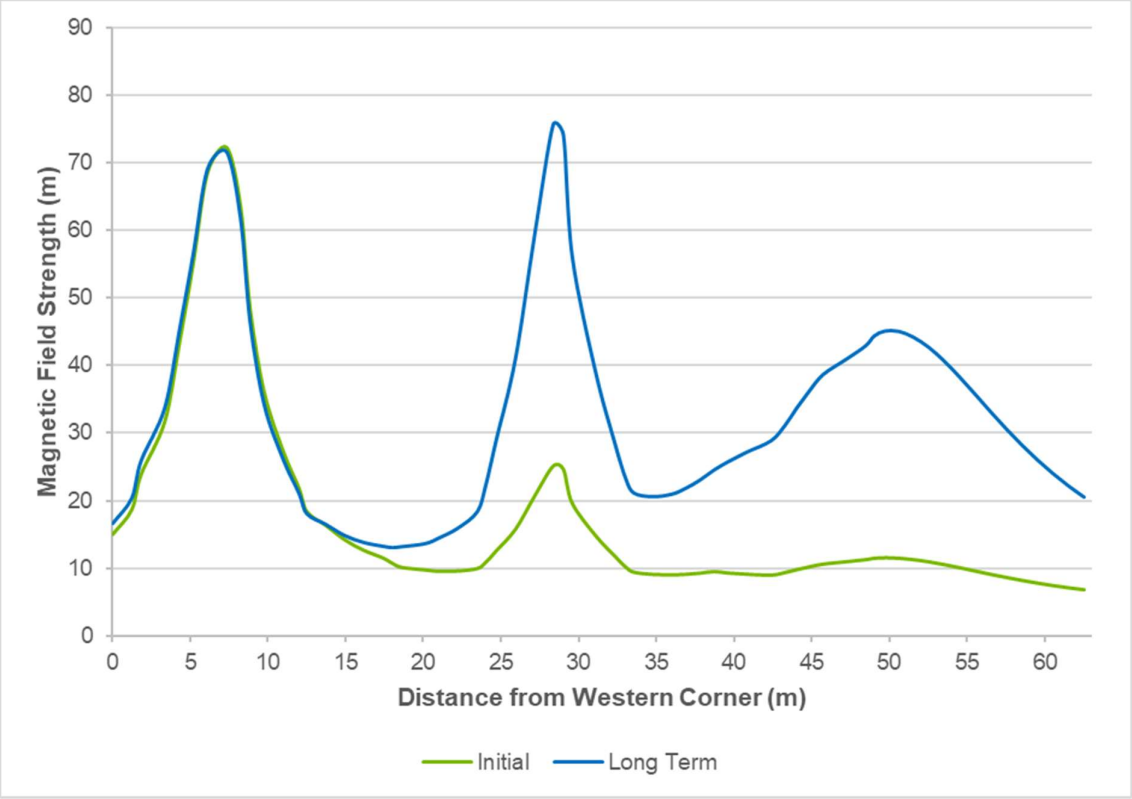

Figure 4-3: Calculated Magnetic Field Profile along South-Western (Waterloo Road) Boundary

It can be seen from Figure 4-3 that, in the short term, the magnetic field along the south-western (Waterloo Road) boundary, is generally about 10mG, rising to 72mG above the incoming 132kV cables (existing) and 25mG above the outgoing 33kV cables. In the long term, the field will tend to be dominated by the peaks associated with the incoming 132kV cables (unchanged), the outgoing 33kV cables (up to 76mG) and the 132kV overhead line (up to 45mG).

The influence of the outgoing 11kV cables and the possible future 33kV cables is relatively minor and not readily discernible in Figure 4-3.

[2] *The fields above the existing 132kV cables are based on site measurements at a time when the loading approximated the time weighted average loading. Due to uncertainty as to the actual cable installation details, the measured values were considered to give a fairer representation of the actual situation.*

4.3.4 North-Western Boundary

The predicted magnetic fields along the north-western boundary are shown in Figure 4-4. As this boundary is substantially remote from the proposed STS infrastructure, field levels are not expected to change appreciably from the present values.

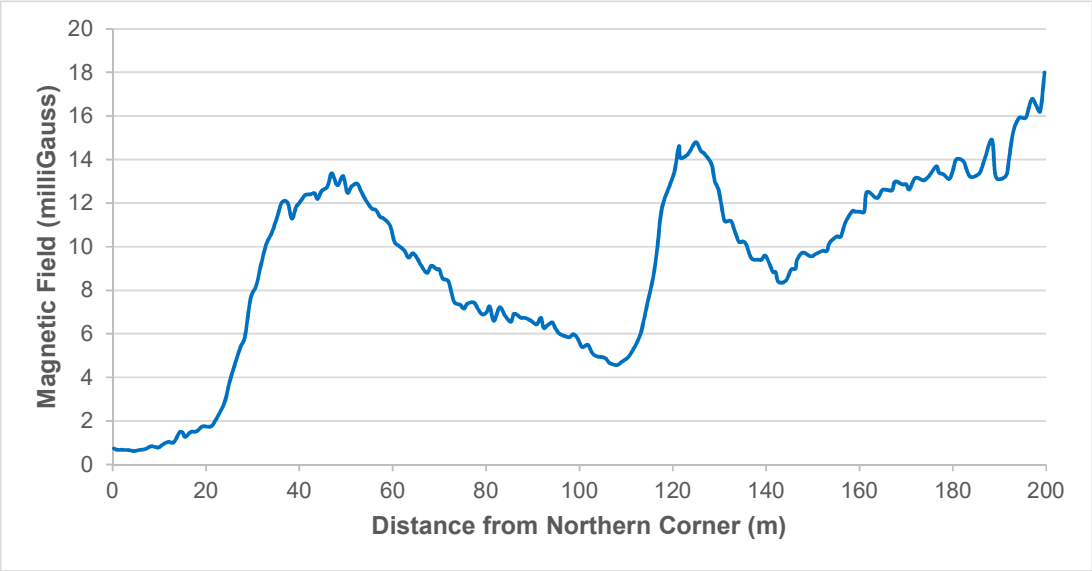

Figure 4-4: Magnetic Field Profile along North-Western Boundary

It can be seen from Figure 4-4 that the magnetic field along the north-western boundary ranges from 0.3mG at the NE end to 18mG at the Waterloo Road end. The influence of the Zone substation, particularly the busbars (up to 13mG), can be seen towards the northern end. The other major contributing source is the incoming 132kV cables. The influence of the outgoing 11kV cables towards the Waterloo Road end is minor. The source of the 14mG peak approximately 120 metres from the northern corner is thought to be external, possibly associated with the adjacent Fujitsu facility.

4.4 Magnetic fields experienced in everyday life

In considering the fact that the magnetic fields along the boundaries of the proposed ZSS are unlikely to be experienced by people, other than intermittently and with the highest fields being quite localised, it is important to recognise that life in the modern world involves moving from one source of magnetic fields to another. To put this into perspective, the Energy Networks Association has published a series of typical magnetic field levels associated with particular appliances and infrastructure at normal user distance. These are set out in Table 4-1.

Table 4-1: ELF Magnetic Field Levels Associated with Appliances and Infrastructure (source: Energy Networks Association)

	Typical Measurement (mG)	Range of Measurements (mG)
Electric Stove	6	2 – 30
Refrigerator	2	2 – 5
Electric Kettle	3	2 – 10
Toaster	3	2 – 10
Television	1	0.2 – 2
Personal Computer	5	2 – 20
Electric Blanket	20	5 – 30

	Typical Measurement (mG)	Range of Measurements (mG)
Hair Dryer	25	10 – 70
Pedestal Fan	1	0.2 – 2
Substation - Substation Fence	 5	 1 – 8
Distribution Line - Under Line - 10m Away	 10	 2 – 30 0.5 – 10
Transmission Line - Under Line - Edge of Easement	 20 10	 10 – 200 2 – 50

From the above range of fields, it can be seen that the predicted magnetic field contributions along the boundaries of the proposed STS are within the range of fields commonly encountered in everyday life. The fields above the (existing) 132kV cables and proposed 33kV cables are within the range normally associated with such cables or their overhead equivalents.

4.5 Electric field results

The only asset likely to produce electric field at the substation boundary is the incoming 132kV overhead feeder 92B and, accordingly, the electric field beneath it has been modelled. The results are shown in Figure 4-5 in the form of a profile indicating the electric fields along a line at right angles to the proposed overhead line.

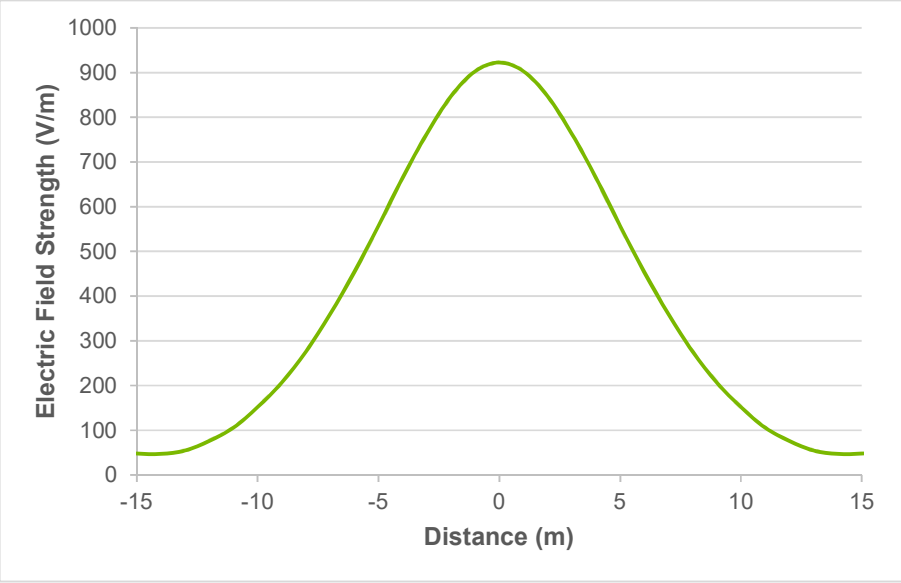

Figure 4-5: Calculated Electric Field Profile beneath incoming 132kV Feeder 92B

It can be seen from Figure 4-5 that the electric field beneath the proposed incoming 132kV overhead line is predicted to be 900 Volts/metre directly under it, decreasing to a negligible level at a distance of 10 metres.

4.6 Commentary on calculated fields

As **magnetic fields** are dependent on the load current in the source, which can vary from time to time, the actual values can differ from those calculated. At times of infrequent high load or emergency conditions, the contributions of the infrastructure modelled in this assessment could be 2-3 times higher than those reported. However, such occasions would be rare and of short duration.

In practice, the **electric fields** are likely to be considerably lower than the calculated values, due to the effects of the shielding provided by trees along the south-eastern boundary.

5 Compliance with EMF guidelines and prudent avoidance principles

5.1 Compliance with health guidelines

5.1.1 Magnetic fields

The combined contribution of the Substations to the magnetic field environment at the site boundaries is a small fraction of the ICNIRP Guideline Reference Level of 2000mG. The contribution to the existing magnetic field environment along the various boundaries is summarised in Table 5-1.

Table 5-1: Contribution to the existing magnetic field environment along the boundaries

	Eastern Boundary	South-Eastern Boundary	Waterloo Road Boundary	North-Western Bndry (existing)
Typical range (short term)	0.5-2mG	2-5mG	10mG	1-18mG
Typical range (long term)	0.5-2mG	Less than 10mG	N/A	1-18mG
Highest value (short term)	2mG	5mG	72mG (existing)	18mG
Highest value (long term)	10mG	20mG	76mG	18mG

Both in the short and long terms, the highest predicted magnetic field contribution of the proposed STS is less than 4% of the Guideline Reference Level and of the same order as at present.

5.1.2 Electric fields

The only source of electric fields will be the overhead 132kV line entering the site from Waterloo Road. The field directly under the line is predicted to be 900Volts per metre, which is less than 20% of the ICNIRP Guideline Reference Level. This will diminish to a negligible level within 10 metres. The field at the south-eastern boundary will be negligible.

5.2 Assessment against prudent avoidance principles

As noted in Section 2.4, given the inconclusive nature of the science, it is considered that a prudent/precautionary approach continues to be the most appropriate response in the circumstances. Under this approach, the operators of electricity infrastructure should design their facilities to reduce the intensity of the magnetic fields they generate, and locate them to minimise the fields that people, especially children, encounter over prolonged periods, provided this can be readily achieved without undue inconvenience and at reasonable expense, and be consistent with good engineering and risk minimisation practice.

In this context, it is noted that:

- The main substation equipment is located well within the site boundaries, thereby minimising its external influence.
- The use of compact gas-insulated switchgear for the 132kV side of the substation is a low-field option.
- The vertical configuration which has been selected for the incoming 132kV line is a low-field option.

The most significant source of magnetic fields associated with the proposed STS will be the outgoing 33kV feeders at the Waterloo Road boundary, particularly in the long term. The peak field is still less than 4% of the ICNIRP Guideline Reference Level and comparable to the existing field from the incoming 132kV cables.

As noted in Appendix D, an objective of Prudent Avoidance is to minimise the fields that people, especially children, encounter over prolonged periods. As the Waterloo Road boundary involves only transitory exposure for passing pedestrians, there is no prolonged exposure and no further measures to reduce magnetic fields along that boundary are warranted.

6 Conclusions

Based on Aurecon's modelling of the electric and magnetic fields likely to be associated with the proposed Subtransmission Substation, the following conclusions may be drawn.

6.1 Magnetic fields

Both in the short and long terms, the highest predicted magnetic field contribution of the proposed STS is less than 4% of the Guideline Reference Level and of the same order as at present.

6.2 Electric fields

The only source of electric fields will be the overhead 132kV line entering the site from Waterloo Road. The field directly under the line is predicted to be 900Volts per metre, which is less than 20% of the ICNIRP Guideline Reference Level. This will diminish to a negligible level within 10 metres. The field at the south-eastern boundary will be negligible.

6.3 Prudent avoidance

In the context of Prudent Avoidance, it is noted that:

- The main substation equipment is located well within the site boundaries, thereby minimising its external influence.
- The use of compact gas-insulated switchgear for the 132kV side of the substation is a low-field option.
- The vertical configuration which has been selected for the incoming 132kV line is a low-field option.

Further measures to reduce magnetic fields along the site boundaries are not warranted.

Appendices

Appendix A

General description of electric and magnetic fields

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

An **electric field** is a region where electric charges experience an invisible force. The strength of this force is related to the voltage, or pressure, which forces electricity along wires. Electric fields are strongest closest to their source, and their strength diminishes rapidly with distance from the source, in much the same way as the warmth of a fire decreases with distance. Many common materials – such as brickwork or metal – block electric fields, so they are readily shielded and, for all practical purposes, do not penetrate buildings. They are also shielded by human skin, such that the electric field inside a human body will be at least 100,000 times less than the external field. (Ref A-1) Being related to voltage, the electric fields associated with HV aerial lines and electrical substations remain relatively constant over time, except where the operating voltage changes.

A **magnetic field** is a region where magnetic materials experience an invisible force produced by the flow of electricity (known as electric current and measured in Amperes). The strength of a magnetic field depends on the size of the current and decreases as distance from the source increases. The magnetic field strength resulting from an electrical installation varies continually with time and is affected by a number of factors including:

- The total electric load
- The size and nature of the equipment
- The design of the equipment
- The layout and electrical configuration of the equipment and its interaction with other equipment

While electric fields are blocked by common materials, this is not the case with magnetic fields. This is why locating equipment in enclosures or underground will eliminate any external electric field but not the magnetic field.

Alternating electric and magnetic fields are produced by any electric wiring or equipment carrying alternating current (AC). This current does not flow steadily in one direction but oscillates backwards and forwards at a frequency[3] of 50Hz and hence the fields produced by AC systems oscillate at the same frequency. This frequency falls into a range referred to as **extremely low frequency** (ELF), so the electric and magnetic fields are referred to as ELF fields.

Electromagnetic Radiation

It is not uncommon for the electric and magnetic fields (EMF) associated with electrical equipment to be confused with electromagnetic radiation (EMR). The fact that, in many jurisdictions, agencies which regulate the various forms of EMR are also involved in the setting of guidelines/standards for EMF tends to add to this confusion.

Electromagnetic radiation is a term we use to describe the movement of electromagnetic energy through the propagation of a wave. This wave, which moves at the speed of light in a vacuum, is composed of electric and magnetic waves which oscillate (vibrate) in phase with, and perpendicular to, each other. This is in contrast to EMF, where the electric and magnetic components are essentially independent of one another.

Electromagnetic radiation is classified into several types according to the frequency of its wave; these types include (in order of increasing frequency): radio waves, microwaves, terahertz radiation, infra-red radiation,

[3] *Frequency is a measure of the number of times per second a wave oscillates or vibrates. The most common unit of measurement of frequency is the Hertz (Hz) where 1 Hz is equal to 1 cycle per second.*

visible light[4], ultraviolet radiation, X-rays and gamma rays. Whereas EMR causes energy to be radiated outwards from its source e.g. light from the sun or radio-frequency signals from a television transmitter, EMFs cause energy to be transferred along electric wires.

In the context of the EMF/health issue, the distinction between EMF and EMR is addressed by the New Zealand Ministry of Health in its public information booklet "Electric and Magnetic Fields and Your Health" (Ref A-2) as follows:

"The electric and magnetic fields around power lines and electrical appliances are not a form of radiation. The word "radiation" is a very broad term, but generally refers to the propagation of energy away from some source. For example, light is a form of radiation, emitted by the sun and light bulbs. ELF fields do not travel away from their source, but are fixed in place around it. They do not propagate energy away from their source. They bear no relationship, in their physical nature or effects on the body, to true forms of radiation such as x-rays or microwaves."

References

A-1. World Health Organisation: Environmental Health Criteria Vol. 238: Extremely low frequency fields. (2007).

A-2. New Zealand Ministry of Health: Electric and Magnetic Fields and Your Health. (2008).

[4] *Visible light is a group (spectrum) of frequencies which can be sensed by the eyes of humans and various other creatures.*

Appendix B
Overview of EMF health issue

Research into EMFs and health is a complex area involving many scientific disciplines – from biology, physics and chemistry to medicine, biophysics and epidemiology. Many of the health issues of interest to researchers are quite rare. In this context, it is well accepted by scientists that no study considered in isolation will provide a meaningful answer to the question of whether or not EMFs can contribute to adverse health effects. In order to make an informed conclusion from all of the research, it is necessary to consider the science in its totality. Over the years, governments and regulatory agencies around the world have commissioned independent scientific review panels to provide such overall assessments.

Extremely Low Frequency (ELF) Fields

The possibility of adverse health effects due to the EMFs associated with extremely low frequency electrical equipment has been the subject of extensive research throughout the world. To date, while adverse health effects have not been established, the possibility that they may exist cannot be ruled out.

While EMFs involve both electric and magnetic components, electric fields are relatively constant over time, are readily shielded and, in the health context, are generally no longer associated with the same level of interest as magnetic fields. Nevertheless, high electric field strengths, such as those associated with high voltage equipment in major substations can approach a level at which "nuisance shocks" can occur and this phenomenon needs to be managed. Magnetic fields are not readily shielded, are more ubiquitous and remain the subject of some debate. Accordingly, much of the remainder of this section is directed towards magnetic fields.

The most recent scientific reviews by authoritative bodies are reassuring for most potential health issues. However, statistical associations[5] between prolonged exposure to elevated magnetic fields and childhood leukaemia have persisted. This led the International Agency for Research on Cancer (IARC) (Ref. B-2) in 2002 to classify magnetic fields as a "possible carcinogen" [6].

The fact that, despite over 30 years of laboratory research, no mechanism for an effect has been established, lends weight to the possibility that the observed statistical associations reflect some factor other than a causal relationship. This point is made in the 2001 report of the UK National Radiological Protection Board's (NRPB) Advisory Group, chaired by eminent epidemiologist, the late Sir Richard Doll (Ref. B-3)

> *"in the absence of clear evidence of a carcinogenic effect in adults, or of a plausible explanation from experiments on animals or isolated cells, the evidence is currently not strong enough to justify a firm conclusion that such fields cause leukaemia in children" (page 164)*

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4 It should be noted that a statistical association does not necessarily reflect a cause and effect relationship.

[5] IARC publishes authoritative independent assessment by international experts of the carcinogenic risks posed to humans by a variety of agents, mixtures and exposures. These agents, mixtures and exposures are categorised into 5 groups, namely:

- *Group 1 – the agent is carcinogenic to humans – 118 agents are included in the group, including asbestos, tobacco and ultraviolet radiation*
- *Group 2A – the agent is probably carcinogenic – 79 agents have been included in this group, including diesel engine exhaust, creosotes and PCBs*
- *Group 2B – the agent is possibly carcinogenic to humans – 290 agents have been included in this group, including coffee, gasoline, lead, nickel, petrol engine exhaust and extremely low frequency magnetic fields*
- *Group 3 – the agent is not classifiable as to carcinogenicity – 501 agents have been included in this group, including caffeine, coal dust, extremely low frequency electric fields and static electric and magnetic fields*
- *B-2. National Radiological Protection Board, (UK), ELF Electromagnetic Fields and the Risk of Cancer, Report of an Advisory Group on Non-Ionising Radiation, Chairman, Sir Richard Doll, NRPB Vol. 12 No. 1, 2001.*
- *Group 4 – the agent is probably not carcinogenic to humans – only 1 agent (caprolactam) has been included in this group.*

References

B-1. The Institute of Electrical and Electronics Engineers, Inc, IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields From AC Power Lines, Submission to the NSW Government, 1995.

B-2. World Health Organisation, International Agency for Research on Cancer, Lyon, France: IARC Monographs on the evaluation of carcinogenic risks to humans. Non-Ionising Radiation Part 1: Static and Extremely Low Frequency (ELF) Electric and Magnetic Fields. (2001)

B-3. National Radiological Protection Board, (UK), ELF Electromagnetic Fields and the Risk of Cancer, Report of an Advisory Group on Non-Ionising Radiation, Chairman, Sir Richard Doll, NRPB Vol. 12 No. 1, 2001.

Appendix C
Health guidelines

Health Guidelines for Extremely Low Frequency Electric and Magnetic Fields

The World Health Organisation recognises two international EMF/Health guidelines:

- the Guidelines for Limiting Exposure to Time-varying Electric and Magnetic Fields (1Hz to 100kHz) produced by the International Commission on Non-Ionising Radiation Protection (ICNIRP) Ref C-1), and
- the, IEEE Standard C95.1, produced by the International Committee on Electromagnetic Safety, Institute of Electrical and Electronics Engineers (IEEE) in the USA.

In July 2015, the relevant Australian regulator (ARPANSA) officially adopted the more conservative of the above two, the ICNIRP 2010 Guidelines, in full, stating:

> *"The ICNIRP ELF guidelines are consistent with ARPANSA's understanding of the scientific basis for the protection of the general public (including the foetus) and workers from exposure to ELF EMF." (Ref. C-2)*

In line with the regulator's advice, AJJV has applied the current international ICNIRP guideline reference levels to this assessment.

The reference levels for both electric and magnetic fields contained in the current ICNIRP guidelines are summarised in the table below

Health Guideline Reference Levels

Parameter	ICNIRP 2010 Reference Levels
Electric Fields – General Public	5kV/m
Electric Fields – Occupational	10kV/m
Magnetic Fields – General Public	2,000mG
Magnetic Fields – Occupational	10,000mG

In applying the guidelines, it is to be noted that, unlike earlier versions, the various limits are now independent of duration of exposure.

In applying the ICNIRP Guideline, it is also important to recognise that the numerical limits, e.g. 2,000mG, are based on established health effects. In ICNIRP's fact sheet on the guidelines (Ref. C-3), it notes that:

> *"It is the view of ICNIRP that the currently existing scientific evidence that prolonged exposure to low frequency magnetic fields is causally related with an increased risk of childhood leukaemia is too weak to form the basis for exposure guidelines. Thus, the perception of surface electric charge, the direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes are the only well-established adverse effects and serve as the basis for guidance."*

Being based on established biological effects (which occur at field levels much higher than those normally encountered in the vicinity of electrical equipment), the (numerical) exposure limits in the guidelines and standards cannot be said to define safe limits for possible health effects, should these exist, from magnetic fields at levels normally encountered in the vicinity of electrical equipment.

It is in this context that precautionary measures for ELF magnetic fields such as "Prudent Avoidance" have arisen (see Attachment D).

References

C-1 International Commission on Non-Ionising Radiation Protection (2010: Guidelines for Limiting Exposure to Time-varying Electric and Magnetic Fields (1Hz to 100kHz): Health Physics 99(6):818-836; (2010).

C-2 ARPANSA: Extremely Low Frequency Electric and Magnetic Fields – 2015, accessed 10 May 2016.

C-3. ICNIRP Fact Sheet on the guidelines for limiting exposure to time-varying electric, and magnetic fields (1Hz-100kHz) published in Health Physics 99(6): 818-836; 2010, accessed 10 May 2016, < http://www.icnirp.org/cms/upload/publications/ICNIRPFactSheetLF.pdf>.

Appendix D
Prudent avoidance

Extremely Low Frequency Magnetic Fields

Regarding the potential health effects from ELF magnetic fields, while compliance with the relevant guideline is important in protecting people from established health effects, it does not necessarily address possible health effects, should they exist, from fields at levels normally encountered in the vicinity of electrical equipment. The possibility of such effects has been comprehensively studied over several decades worldwide but, to this day, there is no clear understanding of how ELF electric or magnetic fields at low levels could pose a threat to human health.

Since the late 1980s, many reviews of the scientific literature have been published by authoritative bodies. There have also been several inquiries such as those by Sir Harry Gibbs in NSW (Ref. D-1) and Professor Hedley Peach in Victoria (Ref. D-2). These reviews and inquiries have consistently found that:

- Adverse health effects have not been established
- The possibility cannot be ruled out
- If there is a risk, it is more likely to be associated with the magnetic field than the electric field

Both Sir Harry Gibbs and Professor Peach recommended a policy of prudence or prudent avoidance, which Sir Harry Gibbs described in the following terms:

> *"… [doing] whatever can be done without undue inconvenience and at modest expense to avert the possible risk …"*

In 1999, the (US) National Institute of Environmental and Health Sciences (NIEHS) (Ref. D-3) found:

> *"In summary, the NIEHS believes that there is weak evidence for possible health effects from ELF-EMF exposures, and until stronger evidence changes this opinion, inexpensive and safe reductions in exposure should be encouraged." (page 38)*

The practice of 'prudent avoidance' has been adopted by the (Australian) Energy Networks Association (ENA) and most Australian power utilities, including Ausgrid.

The World Health Organisation has also addressed the notion of prudence or precaution on several occasions, including in its 2007 publication Extremely low frequency fields. Environmental Health Criteria, Vol. 238 (Ref. D-4), which states:

> *"…the use of precautionary approaches is warranted. However, it is not recommended that the limit values in exposure guidelines be reduced to some arbitrary level in the name of precaution. Such practice undermines the scientific foundation on which the limits are based and is likely to be an expensive and not necessarily effective way of providing protection."*

It also states:

> *"Provided that the health, social and economic benefits of electric power are not compromised, implementing very low-cost precautionary procedures to reduce exposure is reasonable and warranted."*

Given the inconclusive nature of the science, it is considered that a prudent approach continues to be the most appropriate response in the circumstances. Under this approach, subject to modest cost and reasonable convenience, power utilities and transport authorities should design their facilities to reduce the intensity of the fields they generate, and locate them to minimise the fields that people, especially children, encounter over prolonged periods. While these measures are prudent, it cannot be said that they are essential or that they will result in any benefit.

In the Australian context, ENA's position, as adopted in their EMF Management Handbook (Ref. D-5), states:

> *"Prudent avoidance does not mean there is an established risk that needs to be avoided. It means that if there is uncertainty, then there are certain types of avoidance (no cost / very low cost measures) that could be prudent."*

It also states:

> *"Both prudent avoidance and the precautionary approach involve implementing no cost and very low cost measures that reduce exposure while not unduly compromising other issues."*

References

D-1. Gibbs, Sir Harry, Chairman, Inquiry into Community Needs and High Voltage Transmission Line Development, Submission to the NSW Government, February, 1991.

D-2. Peach HG, Bonwick WJ and Wyse T (1992). Report of the Panel on Electromagnetic Fields and Health to the Victorian Government (Peach Panel Report). Melbourne, Victoria: September, 1992.

D-3. National Institute of Environmental Health Sciences, National Institutes of Health, (USA), NIEHS report on health effects from exposure to power-line frequency electric and magnetic fields, NIH Publication No. 99-4493, 1999.

D-4. World Health Organisation: Environmental Health Criteria Vol. 238: Extremely low frequency fields. (2007).

D-5. Energy Networks Association: EMF Management Handbook. (2016).

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Appendix C Construction and Operation Noise and Vibration Impact Assessment

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Acoustic Assessment

Proposed Macquarie Subtransmission Substation, 17-21 Waterloo Road, Macquarie Park, NSW

REPORT No
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Prepared For:
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TABLES

1.0 CONSULTING BRIEF

Day Design Pty Ltd was engaged by Ausgrid to assess the environmental noise impact from the operation of a new subtransmission substation (designated Macquarie STS), located at 17-21 Waterloo Road, Macquarie Park, NSW.

The Macquarie STS will consist of two 120MVA, 132kV/33kV/11kV transformers and two 200/75 kVA, 11kV/433V/240V auxiliary transformers.

An assessment of the noise impact from the construction of the Macquarie STS was also carried out. This commission involves the following:

Scope of Work:

- Inspect the site and environs.
- Measure the background noise levels at critical locations and times.
- Establish acceptable noise level criterion.
- Quantify noise emissions from the subtransmission substation.
- Quantify noise emissions from the construction works associated with the installation of subtransmission substation.
- Calculate the level of noise emission, taking into account building envelope transmission loss, screen walls and distance attenuation.
- Prepare a site plan identifying the development and nearby noise sensitive locations.
- Provide recommendations for noise control (if necessary).
- Prepare an Environmental Noise Assessment Report.

2.0 PROJECT DESCRIPTION AND SUMMARY OF FINDINGS

A new subtransmission substation (Macquarie STS) is proposed to be constructed at 17-21 Waterloo Road, Macquarie Park comprising of two 120MVA, 132kV/33kV/11kV transformers and two 200/75 kVA, 11kV/433V/240V auxiliary transformers.

The Macquarie STS will be located on the south-western side of the lot adjacent to an existing Ausgrid 132/11kV zone substation. The site is immediately adjacent to commercial premises to the east and west. Located to the south west, across Waterloo Road, are a child care centre and sporting club approximately 65 m and 50 m away respectively. Beyond the child care centre and sporting club, across Epping Road, the nearest potentially affected residential premises is located approximately 420 m away from the proposed substation in North Ryde. The site and surrounding environs is shown in Figure 1 on the following page.

The substation will operate 24 hours a day, 7 days a week.

The transformers convert high voltage electricity to 33kV supply electricity and typically generate a low frequency 'hum' at 100 Hz. The noise levels from the proposed subtransmission substation have been calculated at the nearest effected property boundary.

The installation of the subtransmission substation will require construction works to be carried out including heavy vehicles and machinery. The majority of the construction works will occur during business hours. The EPA's *Interim Construction Noise Guideline* has been used to assess the construction noise impact of the proposed works to surrounding receptors.

Acceptable intrusive noise levels from the noise generated by the transformers to surrounding premises are based on the requirements within the *Environmental Operations (Noise Control) Regulation* and the *Environmental Protection Authority's* (EPA) *Noise Policy for Industry* (NPI) *2017*.

The nearest affected receptors are given in Table 1 below and are shown in Figure 1. The noise levels from the proposed transformers and the associated construction works at Macquarie STS have been calculated and will meet the EPA's NPI.

Table 1 Noise Sensitive Receptors

Receptor and Type	Address	Distance From Site (Direction)
R1 – Residential	82 Epping Road	420 m (south-west)
R2 – Commercial	23-25 Waterloo Road	25 m (west)
R3 – Commercial	9-13 Waterloo Road	50 m (east)
R4 – Child Care Centre	16 Waterloo Road	65 m (south-west)
R5 – Active Recreation	18 Waterloo Road	50 m (south-west)

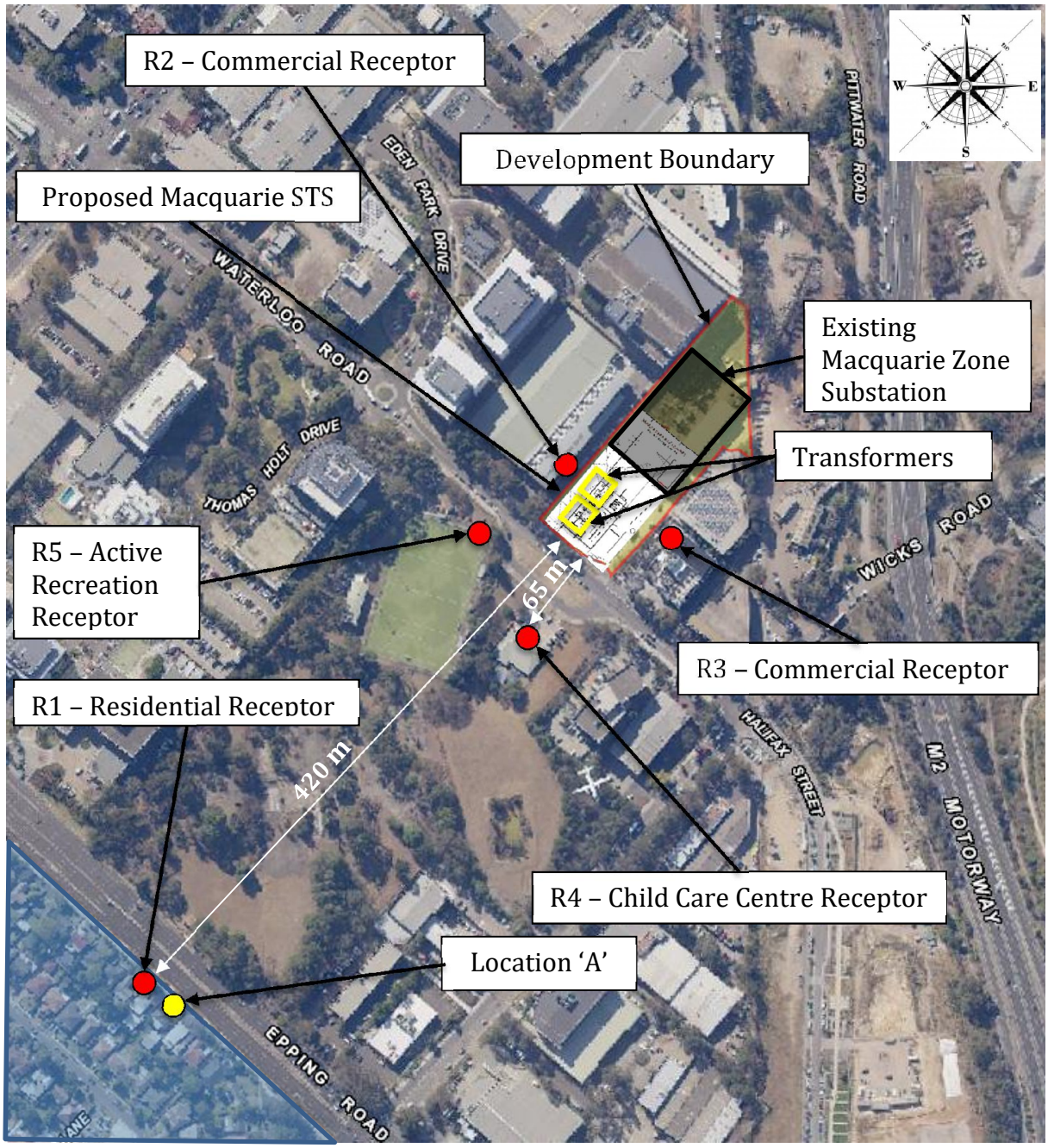


Figure 1 – Site Map, Macquarie STS

3.0 NOISE SURVEY INSTRUMENTATION

Noise level measurements and analysis were made with instrumentation as follows in Table 2:

Table 2 Noise Instrumentation

Description	Model No.	Serial No.
Infobyte Noise Logger (Type 1)	iM4	120
Condenser Microphone 0.5" diameter	MK 250	15361

An environmental noise logger is used to continuously monitor ambient noise levels and provide information on the statistical distribution of noise during an extended period of time. The Infobyte Noise Monitors iM4 #120 is a Type 1 precision environmental noise monitor meeting all the applicable requirements of AS1259 for an integrating-averaging sound level meters.

All instrument systems had been laboratory calibrated using instrumentation traceable to Australian National Standards and certified within the last two years thus conforming to Australian Standards. The measurement system was also field calibrated prior to and after noise surveys. Calibration drift was found to be less than 1 dB during unattended measurements. No adjustments for instrument drift during the measurement period were warranted.

4.0 MEASURED AMBIENT NOISE LEVELS

In order to assess the severity of a possible environmental noise problem in a residential area it is necessary to measure the ambient background noise level at the times and locations of worst possible annoyance. The lower the background noise level, the more perceptible the intrusive noise becomes and the more potentially annoying.

The ambient L_{90} background noise level is a statistical measure of the sound pressure level that is exceeded for 90% of the measuring period (typically 15 minutes).

The Rating Background Level (RBL) is defined by the NSW EPA as the median value of the (lower) tenth percentile of L_{90} ambient background noise levels for day, evening or night periods, measured over a number of days during the proposed days and times of operation.

The places with the greatest potential to be affected by noise annoyance are the nearest residential, commercial, private recreation and child care premises shown in Figure 1 above. The times of worst annoyance will be during the night for residences and non-peak hour operating times for the remaining premises, typically when ambient noise is at its lowest.

A noise logger was placed at 78 Epping Road, North Ryde from 1 November 2018 to 12 November 2018 to determine the Rating Background Level for the nearest effected residences. This location is shown on Figure 1 as Location 'A'.

The measured noise levels are presented in the attached Appendix A and also in Table 3 below.

Table 3 Rating Background Level

Noise Measurement Location	Time Period	Rating Background Level	Existing L_{eq} Level
Location 'A' – 78 Epping Road, North Ryde	Day (7 am to 6 pm)	**56 dBA**	**68 dBA**
	Evening (6 pm to 10 pm)	**55 dBA**	**67 dBA**
	Night (10 pm to 7 am)	**42 dBA**	**64 dBA**

Meteorological conditions during the testing typically consisted of clear skies with temperature of 11 to 37°C. Atmospheric conditions were ideal for noise monitoring. Noise measurements were therefore considered reliable and typical for the receptor area. Rain affected data has been removed from the assessment period.

The ambient noise survey at Location 'A' is attached as Appendix A.

5.0 ACCEPTABLE NOISE LEVELS

5.1 NSW Industrial Noise Policy

The Environment Protection Authority (EPA) published their NSW Noise Policy for Industry (NPI) in October 2017. The NPI is specifically aimed at assessing noise from industrial noise sources scheduled under the Protection of the Environment Operations Act 1997 (POEO, 1997).

The Macquarie STS is not a 'scheduled premises' under the Protection of the Environment Operations Act 1997 as it is not required to hold a licence under that Act for operations at the site. However, the NPI provides a useful framework to assess noise emission from non-scheduled premises, whether that premises produces intrusive or non-intrusive noise.

While the NPI is not strictly applicable to this site, as the site is not scheduled, in the absence of other relevant standards the limits set out in the NPI will be used as a guide in determining whether the level of noise is considered intrusive or not.

5.2 Residential Receptor Intrusiveness Criteria

The EPA states in Section 2.3 of the NPI that the L_{eq} level of noise intrusion from broad-band industrial noise sources may be up to 5 dB above the L_{90} background noise level at the receptor without being considered intrusive.

The L_{90} Rating Background Level at Location 'A' was 56 dBA during the day, 55 dBA during the evening and 42 dBA during the night.

Therefore the acceptable L_{eq} noise intrusiveness criteria in this area is:

- (56 + 5 =) **61 dBA** during the day.
- (55 + 5 =) **60 dBA** during the evening.
- (42 + 5 =) **47 dBA** at night.

5.3 Residential Amenity Criterion

Depending on the type of area in which the noise is being made, there is a certain reasonable expectancy for noise amenity. Table 4 below is based on Table 2.2 in the NPI. It provides a schedule of recommended L_{eq} industrial noise levels that under normal circumstances should not be exceeded. If successive developments occur near a residential area, each one allowing a criterion of background noise level plus 5 dB, the ambient noise level will gradually creep higher.

Table 4 Amenity Criteria

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Acceptable Recommended L_{eq} Noise Level, dBA
Residence	Suburban	Day	60
		Evening	50
		Night	45
Commercial premises	All	When in use	65
Active Recreation	All	When in use	55
School classroom – Internal	All	Noisiest 1-hour period when in use	35

The project amenity noise level for industrial developments is equal to the recommended amenity noise levels given in Table 4 minus 5 dB.

The L_{Aeq} is determined over a 15-minute period for the project intrusiveness noise level and over an assessment period (day, evening and night) for the project amenity noise level. This leads to the situation where, because of the different averaging periods, the same numerical value does not necessarily represent the same amount of noise heard by a person for different time periods. To standardise the time periods for the intrusiveness and amenity noise levels, the *NPI* assumes that the $\mathbf{L_{Aeq,15min}}$ will be taken to be equal to the $\mathbf{L_{Aeq,\,period}}$ **+ 3 decibels (dB)**.

Compliance with the amenity criteria will limit ambient noise creep. Wherever the existing L_{eq} noise level from industrial noise sources approaches or exceeds the amenity criteria at a critical receptor location, the intrusive L_{eq} noise from the noise source in question must be reduced to a level that may be as much as 10 dB below the existing L_{eq} industrial noise level.

Additionally, for cases where the level of road traffic noise is high enough to make noise from an industrial source effectively inaudible, the project amenity noise level may be derived from the $\mathbf{L_{Aeq,\,period\,(traffic)}}$ **- 15 decibels (dB)**.

The high traffic project amenity noise level only applies if traffic noise is identified as the dominant noise source at the site, the existing traffic noise level measured is 10 dB or more above the recommended amenity noise level and traffic noise is highly unlikely to decrease in the future.

The L_{Aeq} Noise Level at Location 'A' was 68 dBA during the day, 67 dBA during the evening and 64 dBA during the night. With all the above information considered the residential amenity criterion is given by the following:

- (60 – 5 + 3 =) **58 dBA** during the day.
- (67 – 15 + 3 =) **55 dBA** during the evening.
- (64 – 15 + 3 =) **52 dBA** at night.

5.4 Commercial Receptor Amenity Criterion

The allowable L_{eq} intrusive level at nearby noise sensitive locations on commercial premises is (65 -5 + 3 =) **63 dBA** as derived from Table 4 above.

5.5 Active Recreation Amenity Criterion

The allowable L_{eq} intrusive level at nearby noise sensitive locations on active recreational areas is (55 -5 + 3 =) **53 dBA** as derived from Table 4 above.

5.6 Child Care Centre Amenity Criterion

The allowable L_{eq} intrusive level at nearby noise sensitive locations at school classroom premises is (35 -5 +3 =) **33 dBA** in indoor areas and (55 -5 + 3 =) **53 dBA** in outdoor areas as derived from Table 4 above.

5.7 Modifying Factors

Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level.

Fact Sheet C of the NPI provides modifying factor corrections to account for the additional annoyance where applicable. The modifying factor corrections are to be applied to the measured or predicted source noise level, at the receiver location, prior to comparison with the project specific noise criterion detailed above.

The modifying factor corrections from Fact Sheet C of the NPI are applied only to external measurements or predicted noise levels.

Where a complaint is made regarding transformer noise, the character of the intrusive noise typically contains tonal components and significant low frequency content. The relevant section of Table C1 and C2 of Fact Sheet C, regarding tonality and low frequency noise, is reproduced in Tables 5 to 7.

Table 5 NSW Noise Policy for Industry – Table C1: Modifying Factor Corrections

Factor	Assessment/ Measurement	When To Apply	Correction[1]	Comments
Tonal Noise	One-third octave band analysis using the objective method for assessing the audibility of tones in noise	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: · 5dB or more if the centre frequency of the band containing the tone is in the range 500Hz-10kHz · 8dB or more if the centre frequency of the band containing the tone is in the range 160Hz-400Hz · 15dB or more if the centre frequency of the band containing the tone is in the range 25Hz-160Hz	5 dB	Third octave measurements should be undertaken using unweighted or Z-weighted measurements. Note: Narrow-band analysis using the reference method in ISO1996:2:2007, Annex C, may be required by the consent/regulatory authority where it appears that a tone is not being adequately identified, e.g. where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands

[1] *Corrections to be added to the measure or predicted levels, except in the case of duration where the adjustment is to be made to the criterion.*

Table 6 NSW Noise Policy for Industry – Table C1: Modifying Factor Corrections

Factor	Assessment/ Measurement	When To Apply	Correction	Comments
Low Frequency Noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements in the range 10-160Hz	Measure/assess source contribution C- and A-weighted Leq,T levels over same time period. Correction must be applied where the C minus A level is 15dB or more and: Where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5dB and cannot be mitigated a 2dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period Where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB and cannot be mitigated/predicted A-weighted levels applies for the evening/night period and a 5dB(A) positive adjustment applies for the day time period.	2 or 5 dB[2]	A difference of 15 dB or more between C- and A-weighted measurements identifies the potential for an unbalanced spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse (2011) for DEFRA fluctuating low-frequency noise criteria with corrections to reflect external assessment locations.

Table 7 NSW Noise Policy for Industry – Table C2: One-third octave low-frequency noise thresholds

Hz/dB(Z)	One-third octave $L_{Zeq,\ 15\ min}$ threshold level												
Frequency (Hz)	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
dB(Z)	92	89	86	77	69	61	54	50	50	48	48	46	44

2 Where a source emits tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low-frequency range, that is, below 160Hz.

5.8 EPA Construction Noise Guideline

The NSW Environmental Protection Authority published the *Interim Construction Noise Guideline* in July 2009. The guideline has been developed to focus on applying a range of work practices most suited to minimise construction noise impacts, rather than focusing only on achieving numerical noise levels. While some noise from construction sites is inevitable, the aim of the Guideline is to protect the majority of residences and other sensitive land uses from noise pollution most of the time.

Normal construction hours are defined by the EPA as follows:

- 7:00 am to 6:00 pm Monday to Friday
- 8:00 am to 1:00 pm Saturday, and
- No work on Sunday or Public Holidays.

The Guideline is designed to employ a series of work practices to minimise construction noise at nearby residential premises instead of setting specific noise goals. The Guideline presents to ways of assessing construction noise impacts; the quantitative method and the qualitative method.

Quantitative Assessment Method

The *Interim Construction Noise Guideline* details a quantitative method generally suited to longer term construction projects and involves predicting noise levels from the construction phase and comparing them with noise management levels given in the guideline. The noise levels provided for residences in Table 2 of the guideline, is extracted as Table 8 below.

Table 8 Noise at Residences using Quantitative Assessment

Time of day	Management level L_{Aeq} (15 min)	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. · Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level · The proponent should also inform all potentially impacted residents of the nature of the works to be carried out, the expected noise levels and duration, as well as contact details.

Table 8 Noise at Residences using Quantitative Assessment (con't)

Time of day	Management level L_{Aeq} (15 min)	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Highly noise affected 75 dB(A)	The highly affected noise level represents the point above which there may be a strong community reaction to noise. · Where the noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences) 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	· A strong justification would typically be required for works outside the recommended standard hours. · The proponent should apply all feasible and reasonable work practices to meet the noise affected level. · Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

The noise levels provided for non-residential land uses in Table 3 of the guideline, is extracted as Table 9 below.

Table 9 Noise at Non-residential Land Uses using Quantitative Assessment

Land Use	Management level L_{Aeq} (15 min)
Classrooms at schools and other educational institution	45 dBA (internal) 55 dBA (external)
Active recreation areas	65 dBA (external)
Commercial (offices, retail outlets)	70 dBA (external)

5.9 Qualitative Assessment Method

The Interim Construction Noise Guideline details a qualitative assessment method for construction noise that may be applied for short term construction works that are likely to affect nearby residential premises for less than 3 weeks. This method of assessment is simplified in a manner to identify potential noise sources and manage them through reasonable and feasible means.

5.10 EPA Vibration Guideline

The NSW Environmental Protection Authority published the Assessing Vibration: a technical *guideline* in February 2006. This guideline is based on the British Standard BS6472:1992 *Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*.

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. The guideline considers vibration from construction activities as Intermittent Vibration. Table 2.4 of the guideline sets out limits for Vibration Dose Values to assess intermittent vibration and is extracted in Table 10 below for residential receptor locations.

Table 10 Vibration Dose Values (VDV) from Construction Activities

Receptor Location	Preferred value ($m/s^{1.75}$)	Maximum value ($m/s^{1.75}$)
Residences – Day-time	0.20	0.40
– Night-time	0.13	0.26

The British Standard BS7385-2:1993 *Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration* provides guide values for transient vibration relating to cosmetic damage, extracted in Table 11 below for residential buildings. We recommend that the vibration level outside any nearby residential buildings not exceed these values from the construction activities.

Table 11 Transient Vibration Guide Values for Cosmetic Damage

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Residential	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

In our opinion, an overall peak particle velocity of **15 mm/s** at the boundaries will comply with the recommended values in Table 5 and is an acceptable criterion for intermittent vibration to prevent cosmetic damage to the adjacent buildings.

5.11 Project Specific Noise Criteria

When all the above factors are considered, we find that the most stringent noise criterion during operation of the substation is:

Operation

- **58 dBA for broadband noise sources** during the day,
- **55 dBA for broadband noise sources** in the evening,
- **47 dBA for broadband noise sources** at night.

In addition, the following criteria also apply at non-residential areas:

- **63 dBA at nearby commercial premises,**
- **53 dBA at nearby active recreation areas,**
- **33 dBA internally and 53 dBA externally at nearby child care premises.**

Construction

During construction of Macquarie STS we find the most stringent noise criterion is:

- At residences:
  - **66 dBA** for **broadband construction noise** during standard construction hours,
  - **61 dBA** for **broadband construction noise** during day-time, non-standard construction hours,
  - **60 dBA** for **broadband construction noise** during the evening,
  - **47 dBA** for **broadband construction noise** during the night.
- **70 dBA externally at nearby commercial premises,**
- **65 dBA externally at nearby active recreation areas,**
- **55 dBA externally at nearby child care premises.**

These criteria apply at the most-affected point on or within the property boundary. For upper floors, the noise is assessed outside the nearest window.

6.0 NOISE EMISSION DURING OPERATION

The main sources of noise from the proposed Macquarie Park Subtransmission Substation are the two 120MVA, 132kV/33kV/11kV transformers and two 200/75 kVA, 11kV/433V/240V auxiliary transformers that will operate continually throughout the day and night. The transformer noise level does not change appreciably from the day to the night and therefore the predicted noise level at night will be the worst-case scenario.

Fire blast walls of 8 m height are proposed on the north-east, south-east and south-west side of each main transformer as shown in Appendix B.

6.1 Measured Sound Power Levels

Ausgrid has proposed transformers with sound power level specifications from the manufacturer as follows:

- Main Transformers – maximum sound power level at 77 dBA, no load;
- Auxiliary Transformers – maximum sound power level of 55 dBA, no load.

Noise surveys have been carried out by Day Design at a number of Substations around Sydney, to determine the level and character of high voltage transformers. Manufacturer's data was also used to determine the overall sound power level of the proposed transformers.

Typical sound power level data has been used for the proposed transformers at no load. A schedule of the no load sound power levels are given in Table 12 below.

Table 12 Transformer L_{eq} Sound Power Levels

Description	**dBA**	**Sound Power Levels (dB) at Third Octave Band Centre Frequencies (Hz)**						
		50	100	200	400	800	1k6	3k15
		63	125	250	500	1k	2k	4k
		80	160	315	630	1k25	2k5	5k
Primary Transformer, 132/11kV, 120 MVA, (No load - Energised)	**77**	57	79	79	70	63	56	44
		52	61	71	66	60	54	39
		60	64	82	68	60	49	35
Auxiliary Transformer, 132/11kV, 45 MVA, (No load - Energised)	**55**	61	62	57	52	47	45	39
		58	54	53	48	46	43	38
		56	52	60	47	44	41	35

6.2 Predicted Noise Emission

Knowing the sound power level of a noise source (see Table 12 above), the sound pressure level (as measured with a sound level meter) can be calculated at a remote location using suitable formulae to account for distance losses, sound barriers, etc.

Fire blast walls, of 8 m height, are proposed to be constructed on the north-east, south-east and south-west of each main transformer. This barrier has been included in the noise emission calculations. The location of the transformer bay and its proximity to the surrounding location is provided in drawings attached as Appendix B.

The calculated level of noise generated by the transformer substation at each receptor is shown in Table 13 below and graphically in Appendix C.

Table 13 Predicted L_{eq} Noise Levels at Nearby Receptors

Receptor Location	Predicted $L_{eq,\ 15\ minute}$ Noise Level, dBA (No Load - Full Load)	Acceptable Noise Level, dBA	Compliance (Yes/No)
R1 – Residential	**10-16**	**47 (night)**	**Yes**
R2 – Commercial	**50-56**	**63**	**Yes**
R3 – Commercial	**28-34**	**63**	**Yes**
R4 – Child Care Centre	**23-29**	**33 (Indoor)** **53 (Outdoor)**	**Yes**
R5 – Active Recreation	**25-31**	**53**	**Yes**

The predicted levels of noise for the proposed Macquarie STS will meet the noise criteria at all residential, commercial, child care and active recreation premises.

7.0 NOISE EMISSION DURING CONSTRUCTION

The construction of Macquarie STS will utilise various items of heavy vehicles associated with the construction and transportation of materials and equipment by large trucks.

The earthworks required will use a variety of heavy construction equipment, including a loader, excavator and trucks. The construction phase will also utilise concrete trucks and a crane.

Noise level data for the machinery to be used in this project was gathered from a number of sources, including previous projects and equipment manufacturer's technical specifications. Noise levels were then selected that were typical of the best available machinery in each category. Machinery should be chosen to comply with the noise levels shown below and should be well maintained and operated to comply with the Environment Protection Authority "best management practice" (BMP).

If the noise from any one item of equipment is suspected to be excessive, it is possible to check compliance with the above industry standards by measurement of the sound pressure level at a distance of approximately 7 metres in a free field. The measured sound pressure level at this distance should be approximately 25 dBA less than the sound power levels listed in Table 14.

Noise criteria and noise emission are always stated and measured in decibels of sound pressure level (L_p), which varies with distance (D) and weather conditions. Machinery noise ratings in this report are expressed in decibels of sound power level (L_w), which are absolute and independent of distance. If the sound power level is known, the sound pressure level at a distance (D) can be calculated by the formula: $L_p = L_w - 10\log(D) - 8$.

The various construction activities, including vehicles and equipment used during the construction of Macquarie STS are listed in Table 14 below. Table 14 also details the sound power level (dBA), predicted sound level at each receptor (dBA), acceptable noise level at each receptor, and a statement of compliance for each noise receptor.

Table 14 Construction L_{eq} Sound Power Levels and Predicted Noise Level at R1

Construction Activity	Sound Power Level, dBA	Predicted $L_{eq,\ 15\ minute}$ Noise Level, dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
Standard Construction Hours				
· Mobile Crane (20T)	110	53	66	Yes
· 20 to 30 Tonne Truck	105	48	66	Yes
· Excavator	100	43	66	Yes
· Generator	100	42	66	Yes
Non-Standard Construction Hours - Day				
· Mobile Crane (20T)	110	53	61	Yes
· 20 to 30 Tonne Truck	105	48	61	Yes
· Excavator	100	43	61	Yes
· Generator	100	42	61	Yes
Non-Standard Construction Hours - Evening				
· Mobile Crane (20T)	110	53	60	Yes
· 20 to 30 Tonne Truck	105	48	60	Yes
· Excavator	100	43	60	Yes
· Generator	100	42	60	Yes
Non-Standard Construction Hours - Night				
· Mobile Crane (20T)	110	**53**	47	**No**
· 20 to 30 Tonne Truck	105	48	47	Yes*
· Excavator	100	43	47	Yes
· Generator	100	42	47	Yes

* A predicted exceedance of up to 2 dBA is considered acceptable in accordance with the NSW Noise Policy for Industry, Chapter 4, Table 4.1 – Significance of residual noise impacts.

Table 15 Construction L_{eq} Sound Power Levels and Predicted Noise Level at R2

Construction Activity	Sound Power Level, dBA	Predicted $L_{eq,\ 15\ minute}$ Noise Level, dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
· Mobile Crane (20T)	110	70	70	Yes
· 20 to 30 Tonne Truck	105	65	70	Yes
· Excavator	100	60	70	Yes
· Generator	100	60	70	Yes

Table 16 Construction L_{eq} Sound Power Levels and Predicted Noise Level at R3

Construction Activity	Sound Power Level, dBA	Predicted $L_{eq,\ 15\ minute}$ Noise Level, dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
· Mobile Crane (20T)	110	71	70	Yes*
· 20 to 30 Tonne Truck	105	66	70	Yes
· Excavator	100	61	70	Yes
· Generator	100	61	70	Yes

Table 17 Construction L_{eq} Sound Power Levels and Predicted Noise Level at R4

Construction Activity	Sound Power Level, dBA	Predicted $L_{eq,\ 15\ minute}$ Noise Level, dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
· Mobile Crane (20T)	110	**69**	55	**No**
· 20 to 30 Tonne Truck	105	**64**	55	**No**
· Excavator	100	**59**	55	**No**
· Generator	100	**58**	55	**No**

* A predicted exceedance of up to 2 dBA is considered acceptable in accordance with the NSW Noise Policy for Industry, Chapter 4, Table 4.1 – Significance of residual noise impacts.

Table 18 Construction L_{eq} Sound Power Levels and Predicted Noise Level at R5

Construction Activity	Sound Power Level, dBA	Predicted $L_{eq,\ 15\ minute}$ Noise Level, dBA	Acceptable Noise Level, dBA	Compliance (Yes/No)
· Mobile Crane (20T)	110	**71**	65	**No**
· 20 to 30 Tonne Truck	105	**66**	65	**No**
· Excavator	100	61	65	Yes
· Generator	100	61	65	Yes

It is proposed to use a large crane (150-200 tonne) for the installation of the transformers. This will occur for only one day per transformer. The noise level during use of this crane is expected to be up to 10 dB higher than for the 20 tonne mobile crane used throughout construction. We recommend installation of the transformers be carried out during the hours recommended in Section 8.3.

8.0 NOISE CONTROL RECOMMENDATIONS

The predicted level of noise emission from the construction activities is in excess of the noise management levels established in Section 5.11 of this report. Therefore, we recommend the following noise controls to minimise the noise impact from all construction activities.

8.1 Temporary Sound Barriers

Temporary construction barriers should be erected on the north-western and south-western boundaries of the site throughout the duration of the construction of the Macquarie STS. The barriers may be 19 mm ply or a flexible construction barrier which may be fixed to standard construction fences. The height of the barriers should be minimum:

- 1.8 m on the south-western boundary, and
- 1.8 m on the north-western boundary.

Appendix B displays the location of each barrier on the site.

8.2 Acoustic Enclosures

Constructing acoustical enclosures around items of mobile plant such as generators, air compressors is recommended where extended use for long periods of time is expected.

8.3 Scheduled Use of the Crane

The use of the proposed mobile crane generally meets the noise level criteria set out in Section 5.10 during standard construction hours at Receptors R1 to R3. The predicted noise level at Receptors R4 and R5 exceed the noise criteria by up to 14 dB during the daytime.

Two options are provided to mitigate the noise impact.

- **Consult and notify** - Provide to the affected receptor at R4, ahead of time, the periods when the crane is scheduled to be used.
- **Operate crane outside of standard construction hours** – Scheduling all use of the crane outside of standard construction hours, but not at night, where possible will allow compliance to all nearby affected receptors. The recommended hours to operate the crane include:
    - Monday to Friday – 6 pm to 10 pm,
    - Saturday – 8 am to 10 pm, and
    - Sunday –8 am to 10 pm.

Provided the above recommendations are met the noise emissions from the construction of the Macquarie STS will be minimised in accordance with the NSW Environmental Protection Authority's requirements.

8.4 Noise Management Controls

The following noise management controls are derived from, or are in accordance with recommendations given in Australian Standard AS2436:2010 and the EPA's *Interim Construction Noise Guideline*.

Periods of Respite

We recommend that noisy construction activities only operate for 2 to 3 hours at a time.

Work Practices

We recommend that workers and contractors be trained in work practices to minimise noise emission such as the following:

1. Avoid dropping materials from a height.
2. Avoid shouting and talking loudly outdoors.
3. Avoid the use of radios outdoors that can be heard at the boundary of residences.
4. Turn off equipment when not being used.

Heavy Vehicles and Staff Vehicles

1. Keep truck drivers informed of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (for example, minimising the use of engine brakes, and no extended periods of engine idling).
2. Optimise the number of vehicle trips to and from the site – movements can be organised to amalgamate loads rather than using a number of vehicles with smaller loads.
3. Contractor parking areas should be located as far from residential receiver locations as practicable.

Community Relations

1. A Community Liaison Officer is to be appointed by the contractor prior to the commencement of any works;
2. The officer will approach all potentially affected residents prior to the commencement of any works as an initial introduction and provide his or her contact details;
3. The officer will explain the project, duration of works, potentially noisy periods as well as determine any particularly sensitive receivers or sensitive time periods and schedule works accordingly, as far as reasonably practical;
4. A contact number will be provided for any residents to call with complaints or queries.

Once works commence, communication with the community should be maintained by the officer. Communication should be maintained via a range of media including, for example, continued individual contact, letter box drops or a clearly visible notice board at the site office or on construction site boundaries.

Consultation and cooperation between the contractor and the neighbours and the removal of uncertainty and rumour can help to reduce adverse reaction to noise.

Managing a Noise Complaint

The Liaison Officer should receive and manage noise complaints.

All complaints should be treated promptly and with courtesy.

Should a justified noise complaint not be resolved, noise monitoring may be carried out at the affected receptor location and appropriate measures be taken to reduce the noise emission as far as reasonably practicable.

Where it is not practicable to stop the noise, or reduce the noise, a full explanation of the event taking place, the reason for the noise and times when it will stop should be given to the complainant.

The following guidelines are recommended in Section 6 of the *Interim Construction Noise Guideline* to manage a noise complaint:

1. Provide a readily accessible contact point, for example, through a 24 hour toll-free information and complaints line.
2. Give complaints a fair hearing.
3. Have a documented complaints process, including an escalation procedure so that if a complainant is not satisfied there is a clear path to follow.
4. Call back as soon as possible to keep people informed of action to be taken to address noise problems. Call back at night-time only if requested by the complainant to avoid further disturbance.
5. Provide a quick response to complaints, with complaint handling staff having both a good knowledge of the project and ready access to information.
6. Implement all feasible and reasonable measures to address the source of complaint.
7. Keep a register of any complaints, including details of the complaint such as date, time, person receiving complaint, complainant's contact number, person referred to, description of the complaint, work area (for larger projects), time of verbal response and timeframe for written response where appropriate.

8.5 Construction Disclaimer

Recommendations made in this report are intended to resolve acoustical problems only. We make no claims of expertise in other areas of building construction and therefore the recommended noise controls should be implemented into the building design in consultation with other specialists to ensure they meet the structural, fire or other aspects of construction.

We encourage clients to check with us before using materials or equipment that are alternative to those specified in our Acoustical Report.

9.0 CONCLUSION

The level of noise emitted by two 120MVA, 132kV/33kV/11kV transformers and two 200/75 kVA, 11kV/433V/240V auxiliary transformer proposed to be located at Macquarie STS, 17 - 21 Waterloo Road, Macquarie Park, NSW has been assessed at all residential, commercial, child care and active recreational locations.

The predicted noise levels from the proposed transformers at the new Macquarie STS will meet the noise criteria set out in NSW NPI at all nearby receptor locations provided that the transformer bays are constructed as detailed in Appendix B.

Provided the recommendations made in Section 8 of this report are implemented, the level of noise from the construction works for the installation of the Macquarie STS will be minimized in accordance with the NSW Environmental Protection Authority's requirements as detailed in Section 5 of this Report

Stephen Gauld, BE (Mechanical), MEngSc (Noise and Vibration), MIEAust, MAAS
Principal Acoustical Consultant
for and on behalf of Day Design Pty Ltd

AAAC MEMBERSHIP

Day Design Pty Ltd is a member company of the Association of Australasian Acoustical Consultants, and the work herein reported has been performed in accordance with the terms of membership.

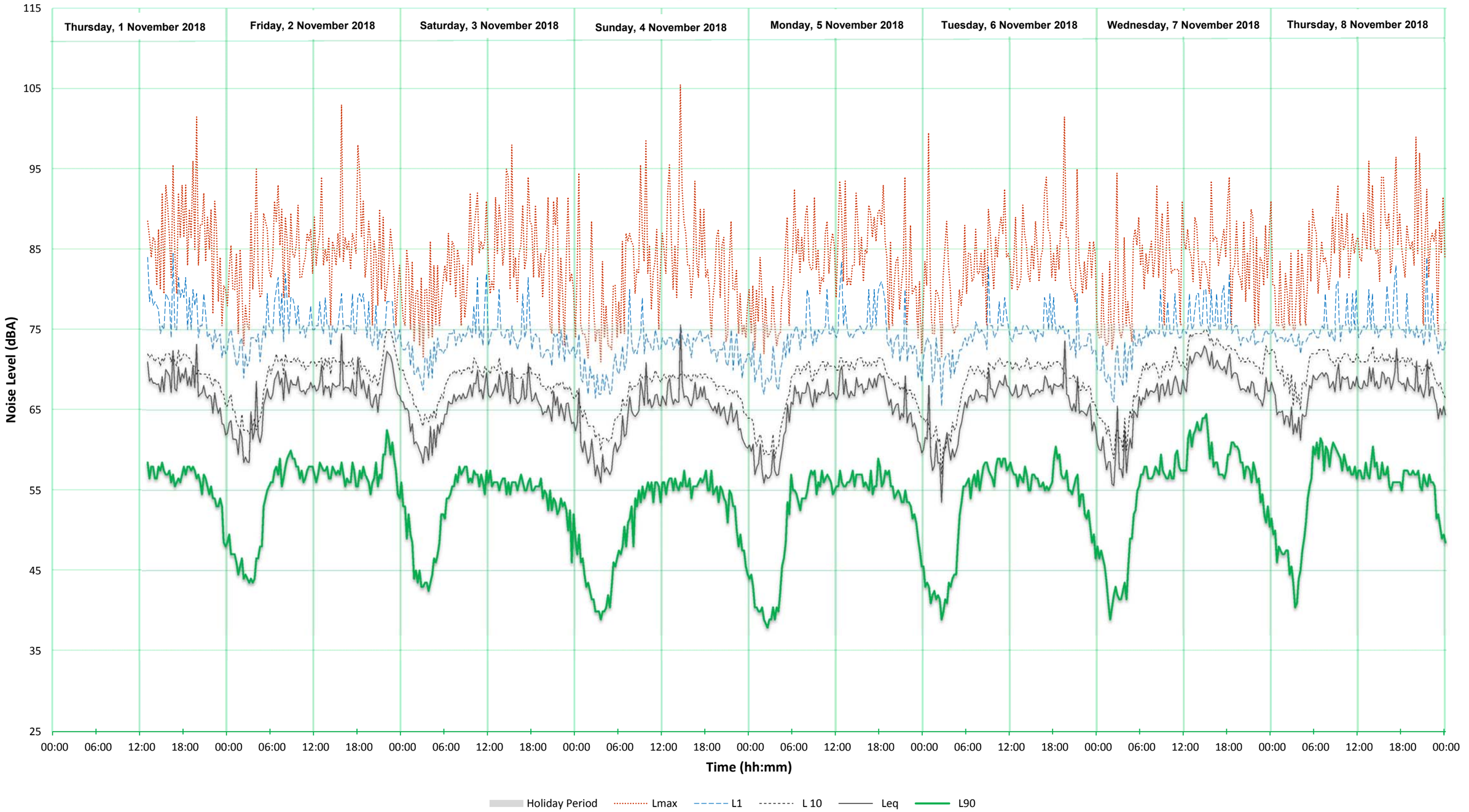
Attachments:

- Appendix A – Ambient Noise Survey
- Appendix B – Site Layout
- Appendix C – Operational Noise Contours
- AC108-1 to 4 – Glossary of Acoustical Terms

AMBIENT NOISE SURVEY

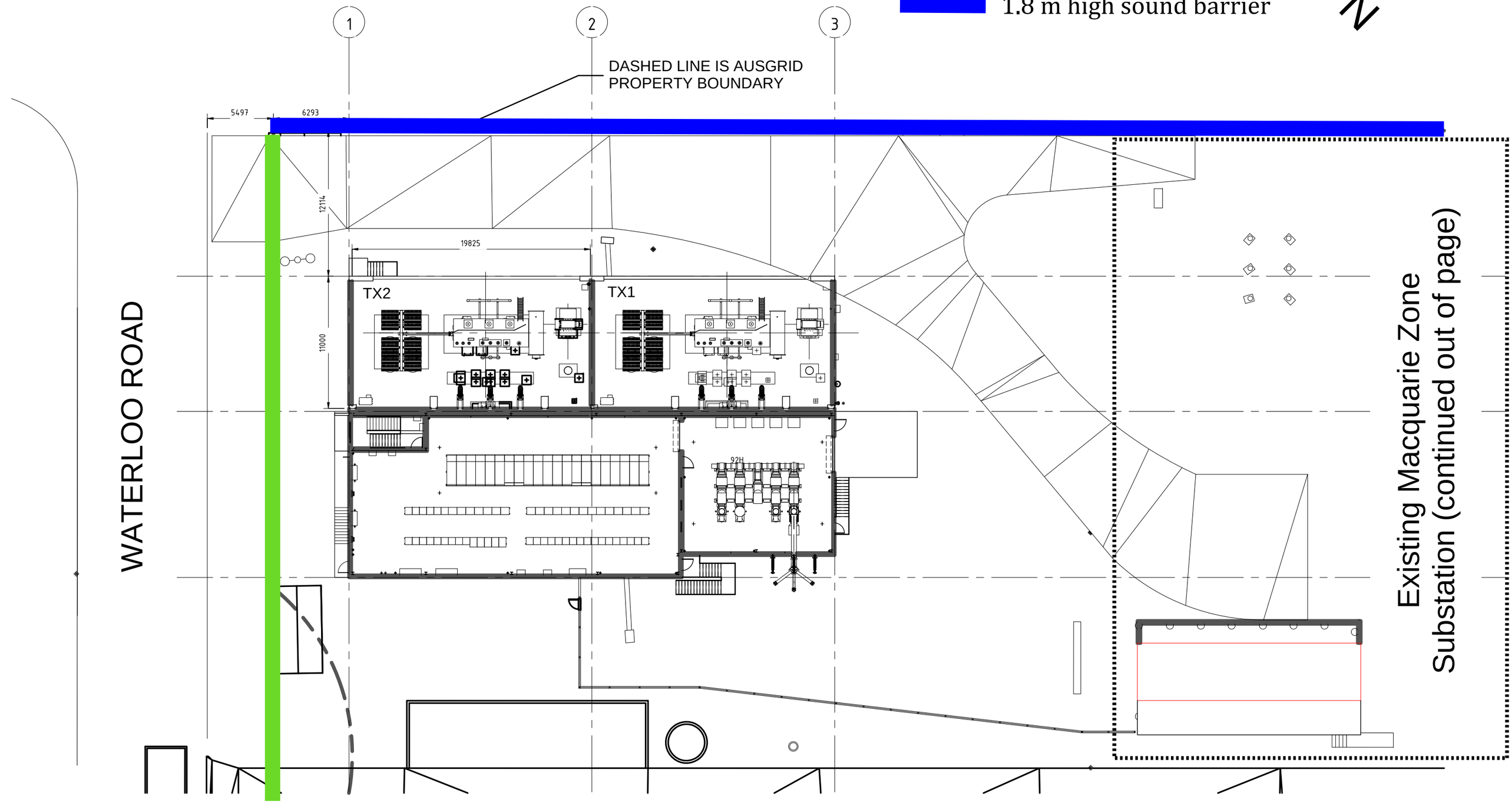
6639-1
Appendix A

Located at 78 Epping Road, Macquarie Park, NSW



Attachment B: Proposed 132/33 kV Subtransisission Substation, Macquarie STS, Site Layout

1.8 m high sound barrier
1.8 m high sound barrier



WORK IN PROGRESS
FOR INFORMATION

Macquarie Park Subtransmission Substation

Noise Level Prediction Contour Map

Appendix C

Noise levels dB(A)

	< 10
10 <=	< 15
15 <=	< 20
20 <=	< 25
25 <=	< 30
30 <=	< 35
35 <=	< 40
40 <=	< 45
45 <=	< 50
50 <=	< 55
55 <=	< 60
60 <=	< 65
65 <=	< 70
70 <=	

Signs and symbols

- Point source
- Plane source
- Residential Building
- Industrial Building
- Noise Barrier Wall

Date: 30 Nov 18

Length Scale 1:2500

0 12.525 50 75 100 m

DAY DESIGN PTY LTD
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Appendix D Preliminary Geotechnical Investigation

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Assessment

Proposed 132/33 kV Substation
21 Waterloo Road, Macquarie Park

Prepared for
Ausgrid

Project 86471.00
August 2018

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

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Revision 0	1	0	Paul Hurst, Ausgrid

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		8 August 2018
Reviewer		8/8/2018

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Douglas Partners
Geotechnics / Environment / Groundwater

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Report on Geotechnical Assessment
Proposed 132/33 kV Substation
21 Waterloo Road, Macquarie Park

1. Introduction

This report presents the results of a geotechnical assessment undertaken for a proposed 132/33kV Substation to be constructed adjacent to an existing substation at 21 Waterloo Road, Macquarie Park. The investigation was commissioned in an email dated 28 June 2018 by Mr Paul Hurst of Ausgrid and was undertaken in accordance with Douglas Partners Pty Ltd (DP) proposal SYD180586 dated 22 June 2018.

The proposed substation footprint is between Waterloo Road and an existing operational substation to the north-east.

It is understood that the proposed development will include:

- shallow excavations for a transformer yard, with 2 transformer bays;
- shallow excavations for a control room, on the northern side of the development footprint;
- excavations for a single-level cable basement below a switchroom, with the basement floor level understood to be no deeper than RL45.5 m, relative to the Australian Height Datum (m AHD);
- shallow excavations for cable trenches, to link into an existing 11 kV cable pit (south-west of the proposed substation); and
- construction of a 132/33 kV switchroom over the cable basement footprint, and construction of the control room, with the switchroom and control room proposed to have a design floor level of approximately RL49.5 m.

Site investigation (including hand augered and machine drilled boreholes) was carried out to provide detailed sub-surface information on the depth to rock within the development footprint, and to obtain soil and rock samples for logging, testing and waste classification purposes. The objective of the geotechnical assessment is to confirm the site geotechnical model.

The investigation included borehole drilling, installation of a standpipe piezometer, and laboratory testing of selected groundwater, soil and rock samples. The field work was conducted in conjunction with a Preliminary Site Investigation and Limited Stage 2 Contamination Investigation, and Preliminary Waste Classification, which are both reported separately (DP reports 86471.01.R.001.Rev0 and 86471.01.R.002.Rev0, dated August 2018).

The details of the field work and laboratory testing are presented in this report, together with comments and recommendations relating to design and construction practice.

2. Previous Investigations

Documents supplied indicate that previous geotechnical and environmental site investigations were completed at the site in 1997 and 2000 by Jeffery and Katauskas Pty Ltd (J&K), and in 2000 by Environmental Investigation Services Pty Ltd (EIS: a division of J&K) and Golder Associates Pty Ltd (Golder). It is noted that the drilling results from the 1997 geotechnical investigation were included as an appendix within the J&K report prepared for Enerserve (Report reference 15400SLrpt, dated 9 September 2000).

The previous geotechnical and environmental investigations completed for the wider substation development site are understood to have included a total of 19 boreholes by J&K (including three boreholes cored into the underlying rock: Boreholes 1, 3 and 7), 5 boreholes by EIS, and 22 test pits by Golder. The boreholes and test pits completed in close proximity to the proposed substation development footprint are shown on Drawing 1.

The 2000 J&K report Section 3.1 indicates that previous cut and fill earthworks at the site resulted in a 'benched' profile, with temporary batters ranging up to 4 m high and grades of around 1(H):1(V). Excavations for a cable trench, a pit with sloping side batters, and exposed sandstone which were noted on several of the J&K test location plans (e.g. Figure 7) were not observed during the current field work. It is assumed that the "3m deep pit" shown on the Golder site plan was for the cable pit excavation, which is located adjacent to the southern property boundary along Waterloo Road.

It is understood that two trenches have recently been excavated by Ausgrid (to about 3 m depth), using non-destructive digging (NDD) methods, to expose the buried high voltage cables. The locations of both trenches are shown on Drawing 1. It is assumed that these trenches were terminated within the filling, with logs for these trenches not available at the time of reporting. It is noted that logs for five boreholes completed by EIS were not included in their report (i.e. Boreholes BH A to BH E), and that the log for test pit TP17 was omitted from the Golder report.

The Golder test pits (excavated with a trailer-mounted backhoe) generally reached refusal to the backhoe bucket at or up to 0.3 m below the top of sandstone. The 2000 J&K report Section 3.4 notes that the Golder logs were for "environmental investigation purposes and therefore they do not show the detail that would be expected with geotechnical logging", that the Golder test pit logs "did not have any surface reduced levels", and that the Golder test location plan is "not to scale and therefore the locations of these test pits can only be approximated".

3. Site Description and Geology

The site, identified as Lot 1 in DP 1006960, includes an existing, active substation (Macquarie Park Substation, ZN 8000), with street address 21 Waterloo Road, Macquarie Park. Industrial and commercial properties are located adjacent to the site. A review of aerial imagery indicates that the site was developed into a substation around 2003.

The proposed substation footprint is within a grass-covered area, on the eastern side of an existing concrete driveway and locked access gate and south-west of the existing substation control room and live transformer yards (refer Plate 1 in Appendix C). It is understood that this area was filled to the current surface levels using site-won materials, after completion of the previous geotechnical reports

(i.e. after the year 2000), with these filling materials placed over existing filling materials, which are inferred to also have been sourced from the site.

The proposed development area has plan dimensions of approximately 25 m (parallel to Waterloo Road) by 40 m. The western part of the site is relatively flat, with a gradual slope down to the south and east. To the east the ground surface slopes towards a small car parking area and a concrete driveway (refer Plate 2). The provided site survey drawing indicates that surface levels within the development footprint vary between RL49.9 m to RL47.0 m (north-west to south-east corners, respectively).

A buried stormwater service transects the proposed footprint, with a buried fire hydrant pipe adjacent to the north-western corner of the development footprint.

Reference to the Sydney 1:100 000 Geological Series Sheet (Geological Survey of NSW: Reference 1) indicates that the site is underlain by Hawkesbury Sandstone of Triassic age, which typically comprises medium to coarse grained quartz sandstone, very minor shale and laminite lenses.

A review of the NSW Acid Sulfate Soil Risk Map for Prospect/Parramatta River (Reference 2) indicates that the site is not located within an area of known acid sulfate soil risk.

4. Field Work Methods

The field work was undertaken over two days between 10 and 11 July 2018, and included:

- scanning for buried services using a scanning sub-contractor;
- excavation using non-destructive digging (NDD) techniques of two 'L'-shaped test trenches adjacent to proposed machine-drilled borehole locations;
- reinstatement of the NDD trenches using certified clean sand backfilling, compacted in layers using hand compaction equipment (i.e. 'wacker packer');
- excavation of five hand augered boreholes HA1 to HA5, to depths of 0.4 – 0.6 m;
- drilling of two boreholes (BH01 and BH02) using a track-mounted drilling rig, to depths of 7.33 m and 7.0 m (respectively);
- installation of a standpipe piezometer within Borehole BH01, screened within the sandstone (refer to borehole log for well construction details);
- groundwater observations during NDD excavations and drilling;
- sampling of soils during drilling for geotechnical, contamination and waste classification purposes;
- measurement of the groundwater level and developing of the groundwater well on 17 July 2018; and
- measurement of the groundwater level and sampling of the groundwater well on 24 July 2018.

The two machine-drilled boreholes were advanced within the soils and the upper 0.3 m to 0.7 m of the underlying extremely low to very low strength sandstone using auger drilling methods, with both boreholes deepened into the underlying extremely low and higher strength rock using NMLC diamond

core drilling techniques. The boreholes drilled using hand tools encountered shallow refusal on coarse inclusions within the filling, such as gravel, cobbles and boulders (0.4 m to 0.6 m total drilled depths).

Logging of the soil and rock materials within the boreholes was undertaken in general accordance with Australian Standard AS 1726 - 2017 (Reference 3), with observations made during NDD excavation utilised to supplement observations made during borehole drilling.

All field work was carried out under the full-time supervision of a geotechnical engineer. Co-ordinates and surface levels of the test locations were obtained using a high-precision differential GPS, and checked using measurements relative to surveyed site features. The inferred accuracy of the co-ordinates is 0.1 m in both plan and elevation. The positions of the boreholes, and the scaled locations of previous boreholes and test pits from the 1997 and 2000 site investigations, are shown on Drawing 1, Appendix B.

Further details of the methods and procedures employed in the investigation are presented in the attached Notes About This Report.

5. Field Work Results

The subsurface conditions encountered in the boreholes are presented on the attached borehole logs in Appendix D, along with standard notes defining the descriptive terms and the classification methods used, and core photographs from boreholes BH01 and BH02. Site photographs are presented in Appendix C. A cross-section through the development footprint is presented as Drawing 2, in Appendix B.

The subsurface conditions encountered in the boreholes can be summarised as:

FILLING: silty clay topsoil with some rootlets (0.1 m thick), over silty clay, sandy clay and clay filling with concrete and brick fragments, and cobbles and boulders of sandstone and siltstone, to 3.5 m depth (elevation of RL46.0 m to RL46.9 m), damp to moist, generally firm to stiff (inclusive of filling placed after the completion of the previous geotechnical site investigations in the year 2000); over

RESIDUAL CLAY: stiff, brown, slightly silty clay with trace ironstone gravel, damp, 0.3 m thick (to an elevation of RL45.7 m, possibly filling: encountered at the base of a former pit shown on Drawing 7 of the J&K report); over

SANDSTONE: extremely low to very low strength, medium grained sandstone, becoming high strength and moderately weathered within 0.95 m below the top of rock. It is noted that intervals of extremely low and low strength sandstone (0.4 – 0.6 m thick) were encountered within both cored boreholes.

It is understood that records of earthworks compaction and/or density testing records for the filling material were not available at the time of reporting. The variability of the encountered materials suggests that the filling material across the site is “uncontrolled filling”, in that it has not been placed and compacted with Level 1 earthworks inspections and testing, as defined in Australian Standard AS 3798 – 2007 “Guidelines on earthworks for commercial and residential developments” (Reference 4).

The surface levels and depths at which various materials were encountered in the current boreholes during the investigation are summarised in Table 1. Depths of various materials from selected historical site investigations (assuming surface levels for previous investigations are within about 0.3 m below the current ground surface levels) are summarised in Table 2. Details for Bore E and Test Pit TP17 are not included in Table 2, as no investigation logs were included in the various supplied reports.

Table 1: Borehole Surface levels and Summary of Subsurface Profile

Borehole	Surface RL (m AHD)	Top of Residual Clay		Top of Weathered Sandstone	
		Depth (m)	RL (AHD)	Depth (m)	RL (AHD)
BH01	49.5	3.5	46.0	3.8	45.7
BH02	49.6	ne	ne	2.7	46.9
HA1	48.5	> 0.4	< 48.1	ne	ne
HA2	47.6	> 0.55	< 47.0	ne	ne
HA3	49.7	> 0.5	< 49.2	ne	ne
HA4	48.2	> 0.6	< 47.6	ne	ne
HA5	49.6	> 0.4	< 49.2	ne	ne

Notes: “ne” indicates Not Encountered

Table 2: Summary of Historical Site Investigation Data

Historical Test Location	Historical Surface Level (m AHD)	Top of Residual Clay (m AHD)		Top of Weathered Sandstone (m AHD)		Interpolated Current Surface Level (m AHD)
		Depth (m)	RL (m AHD)	Depth (m)	RL (m AHD)	
TP1	48.5[3]	0.8	47.7[3]	1.4	47.1[3]	48.0
TP2	49.1[3]	1.2	47.9[3]	2.0	47.1[3]	49.3
TP3	50.0[3]	1.5	48.5[3]	2.2	47.8[3]	50.2
TP15	49.7[3]	1.5	45.9[3]	2.4	47.3[3]	49.8
TP16	47.4[3]	0.8	46.6[3]	1.4	46.0[3]	47.5
TP18	49.9[3]	2.4	47.5[3]	3.0	46.9[3]	49.9
TP19	50.0[3]	2.0	48.0[3]	2.6	47.4[3]	50.1
Bore 1	48.5	1.6	46.9	2.0	46.5	48.6
Bore 2	49.7	1.7	48.0	2.3	47.4	49.9
Bore 6	44.5	ne[1]	ne	1.5	43.0	45.0
Bore 7	46.5	0.5	46.0	0.8	45.7	45.4
Bore 201	46.3	ne[1]	ne	0.3	46.0	46.4

Historical Test Location	Historical Surface Level (m AHD)	Top of Residual Clay (m AHD)		Top of Weathered Sandstone (m AHD)		Interpolated Current Surface Level (m AHD)
		Depth (m)	RL (m AHD)	Depth (m)	RL (m AHD)	
Bore 206	50.0	ne[1]	ne	1.4	48.6	50.1
Bore 207	49.8	1.5	48.3	2.5	47.3	50.1
Bore 208	49.7	1.2	48.5	3.3[2]	46.4	49.9
Bore 209	49.1	ne[1]	ne	1.0	48.1	49.4

Notes: (1) "ne" indicates Not Encountered. (2) Extremely low strength bands above this depth within the residual clay. (3) Level inferred.

Groundwater was not observed within the recent boreholes during auger drilling or NDD excavation, and the use of water as a drilling fluid during coring of the rock prevented further groundwater observations. Measurement of the standpipe piezometer installed within Borehole BH01 was completed on 17 July 2018 and 24 July 2018 (i.e. between one and two weeks following installation and development of the piezometer). The water level measurements are presented in Table 3.

Table 3: Groundwater Measurements in Standpipe Piezometer

Borehole	Surface RL (m AHD)	Groundwater Measurements				Stratum Notes for Groundwater
		17 July 2018		24 July 2018		
		Depth (m)	RL (m AHD)	Depth (m)	RL (m AHD)	
BH01	49.5	6.0	43.5	5.0	44.5	Within sandstone. Closely spaced clay seams and rock defects between 5.3 - 5.9 m depth

Only two of the nearby historical site investigations encountered groundwater during auger drilling. The measurements within these two boreholes (Bore 2 and Bore 207) are presented in Table 4.

Table 4: Reported Groundwater Measurements from Historical Boreholes, 13 May 1997

Borehole	Surface RL (m AHD)	Measurements		Groundwater Notes from Borehole Log
		Depth (m)	RL (m AHD)	
Bore 2	49.7	2.6	47.1	Within sandstone. Level measured 3.75 hours following completion of auger drilling, inflow at 4.8 m depth during drilling
Bore 207	49.8	3.6	46.2	Within sandstone. Level measured on completion of the borehole, with inflow at 4.5 m depth during drilling

6. Laboratory Testing

6.1 Rock Core

Laboratory testing was completed on selected rock core specimens from the boreholes for rock strength (Point Load Strength Index: Is_{50}). The results, which are presented on the borehole logs, generally indicate Is_{50} values of 0.3 MPa to 2.3 MPa, indicating rock ranging from medium to high strength classification. To obtain inferred unconfined compressive strengths (UCS) from point load strength test results, a conversion factor of 15 to 20 is often used, indicating a UCS of up to about 46 MPa.

6.2 Soil Samples – Chemical Analysis

Two soil samples selected from the boreholes were submitted for analysis at a chemical laboratory. The analytes included soil aggressiveness to buried concrete and steel elements (pH, electrical conductivity, sulfate and chloride concentration). Further chemical testing was undertaken for a waste classification, which has been reported under separate cover (DP Report 86471.01.R.001.Rev0, dated August 2018), and is not discussed further herein.

The soil aggressivity results are summarised in Table 5, with the laboratory test reports included in Appendix E.

Table 5: Laboratory Test Results for Soil Aggressiveness to Buried Concrete and Steel

Sample ID	Sample Description	Elevation of Sample[1] (RL m)	pH	EC[3] (µS/cm)	Cl [3] (mg/kg)	SO_4 [3] (mg/kg)
BH01, 2.5-2.95 m	Clay (Filling)	47.0	8.9	110	10	43
HA3, 0.5 m	Silty Clay (Filling)	49.2	7.8	28	10	<10

Notes: (1) Elevation quoted is for the 'top' of the samples. (2) EC = Electrical Conductivity, Cl – Chloride, SO_4 = sulfate. (3) Each analyte was tested as a 1:5 mixture of soil:water.

In accordance with AS 2159 - 2009 (Reference 5), the results of the chemical laboratory testing indicate that the filling tested is non-aggressive to buried concrete and steel.

6.3 Soil Samples – Mechanical Analysis

One soil sample collected from Borehole BH02 was tested to determine the compaction properties and California bearing ratio (CBR – 4 day soak) at a NATA-accredited soils laboratory. The results of the testing are summarised in Table 6 below. The laboratory test reports are included in Appendix E.

Table 6: Summary of Compaction Properties, CBR, and Moisture Content

Borehole ID	Depth (m)	Material Description	FMC (%)	OMC (%)	MDD (t/m^3)	Swell (%)	Curing (hr)	CBR (%)	Over size (%)

Borehole ID	Depth (m)	Material Description	FMC (%)	OMC (%)	MDD (t/m^3)	Swell (%)	Curing (hr)	CBR (%)	Over size (%)
BH02	0.5 – 1.5	Sandy clay (Filling)	14.6	11.5	1.91	0.5	172	15	5.7

Notes: FMC = Field Moisture Content, OMC = Optimum Moisture Content, MDD = Maximum Dry Density, CBR = California Bearing Ratio, Oversize = material retained on the 19 mm sieve.

7. Proposed Development

It is understood that the proposed development on the southern part of the existing substation site is to include a transformer yard with two transformer bays, a new 132/33 kV switchroom, and an adjoining control room. The development includes shallow excavations for a single level cable basement beneath the switchroom (basement design floor level understood to be no deeper than RL45.5 m), with a cable trench to link into an existing 11 kV cable pit.

Given the site topography, it is anticipated that excavations for the cable basement will require a 4 m deep excavation to achieve the design floor level, with further deepening of the excavation to accommodate floor slabs and footings.

8. Geotechnical Model

8.1 Historical Geotechnical Model

The historical geotechnical model for the proposed switchroom and transformer yard footprint (based on the J&K report and borehole logs near the proposed development footprint) comprised three geotechnical units, given below in order of increasing depth below the ground surface:

MATERIAL A: Silty clay or sandy clay filling, with sandstone gravel, to depths of between 1 – 2.5 m;

MATERIAL B: Residual silty clay, with bands of iron cementation or extremely weathered sandstone, between 0 – 2.2 m thick; over

MATERIAL C: generally described (e.g. in boreholes 208 and 209) as red-brown and grey to brown, fine to medium grained, extremely low to very low strength sandstone.

8.2 Current Geotechnical Model

Past cut/fill construction activities were noted within a historical geotechnical report (J&K: 2000), with the original site levels having apparently been extensively modified (i.e. topsoil and residual soils almost completely removed). The origin of the filling used to level the site at that time was not included in the report, however, it is likely that site re-profiling utilised site-won material.

Historical and current investigations completed in close proximity to each other (i.e. Borehole BH02 and Test Pit TP15) indicate some variability in the encountered soil profile, however, elevations for the

top of rock are similar. Elsewhere, the elevation of the top of rock as encountered in the current boreholes is similar to the inferred contours for the top of rock presented in Figure 4 of the J&K Report. These contours indicate the elevation of the top of rock reduces in a southerly direction, in a series of broad, shallow 'steps'.

Comparison of historical spot survey levels and surface levels of boreholes with current survey data supplied by Ausgrid indicates that minimal stripping of filling across the site has occurred. Further, the survey data indicates that the surface level within a former pit / excavation within the current development footprint has been raised by about 2.5 m: refer Drawing 2. The origin of the 'new' filling (i.e. post-year 2000) is likely to be from site-won material, sourced from excavations for the substation which was reportedly constructed circa 2003. Descriptions of filling materials placed prior to and after the year 2000 are similar, with the exception that the new filling appears to have an increased relative proportion of sand and demolition rubble (i.e. concrete and brick inclusions). The thickness of filling and residual soils over weathered sandstone appears to decrease towards the southern side of the development footprint.

Based on the current and historical geotechnical information for the site, the current geotechnical model for the proposed development area is considered to comprise three geotechnical units, as follows (in order of increasing depth below the ground surface: refer to Drawing 2 in Appendix B):

UNIT 1: Silty Clay, Sandy Clay and Clay filling (including topsoil), with brick fragments, and cobbles and boulders of sandstone and siltstone, to depths of between 2 – 3.5 m; over

UNIT 2: Clay residual soil with ironstone gravel (up to about 0.5 m thick); over

UNIT 3: Extremely low to very low strength sandstone at depths of between 1.5 – 3.5 m, becoming high strength within 1 m of the top of rock.

The installed standpipe piezometers, and historical groundwater observations, indicate that groundwater seepage flow is occurring within the underlying sandstone, likely from rock defects. Groundwater levels and flow rates are likely to vary over time, depending on downslope drainage and climatic conditions.

9. Comments

9.1 Site Classification

Uncontrolled filling materials were encountered within the boreholes and test pits at the site, interpreted to occur to depths of up to 3.5 m below current surface levels. Based on visual observations and SPT testing, the filling appears to be generally firm to stiff. Some brick and concrete fragments were observed within the filling in five of the seven test locations (i.e. Boreholes BH01, BH02, and HA1 to HA3).

As there is more than 0.4 m of clay filling on the site, the site will be classified as Class P, when assessed in accordance with the requirements of Australian Standard AS 2870 - 2011 "Residential Slabs and Footings" (Reference 6). It is noted that one small tree is present near to the proposed development site, with another small tree within the development footprint.

The Standard does, however, allow for an alternative site classification, provided the site is assessed using engineering principles. Due to the relatively shallow depth to rock, and the proposed design finished levels for the proposed switchroom and cable basement (i.e. at or close to the top of rock), these structures are likely to be founded on weathered sandstone, for a Class A site. Therefore, the site classification in the area of the proposed switchroom is considered to be Class P, with an alternative classification of Class A following site preparation and earthworks.

9.2 Site Preparation and Trafficability

Bulk excavations to around 4 m depth for the cable basement will be within clay and sandy clay filling with cobbles and boulders of sandstone and siltstone (with brick and concrete inclusions), and through a thin layer of residual clay. A limited amount of vertical excavation is expected within extremely low to low strength sandstone near bulk excavation level (BEL: assumed to be at RL45.5 m).

For the construction of pavements and floor slabs the following site preparation measures are recommended:

- Excavate to bulk excavation levels within the pavement and building footprints;
- Remove any vegetation or organic filling and any other deleterious materials below design / bulk excavation levels;
- Where rock is not exposed, test roll the exposed surface using a minimum 12 tonne smooth drum roller in non-vibration mode. The surface should be rolled a minimum of six times with the last two passes observed by an experienced geotechnical engineer to detect any ‘weak spots’, in accordance with the project Specification;
- Any heaving materials identified during test rolling should be removed as directed by the geotechnical engineer; and
- Placement of suitable filling materials up to design levels, and density testing of the compacted layers, should be undertaken in accordance with the project Specification.

Access to the proposed development, such as for concrete trucks and other vehicles, is likely to be via an existing concrete pavement driveway on the western side of the site.

The filling materials are likely to remain trafficable during the construction period under the applied loading of vehicles with tyres, although some rutting / surface damage is to be expected if traversed following periods of prolonged rainfall. It may be difficult for machines to access the eastern side of the site, due to the side slope (approximate grade 4(H):1(V) - refer Photo 4 in Appendix C). It is suggested a layer of crushed rock or recycled concrete working platform at least 300 mm thick be placed and compacted on the upper part of the site to improve all-weather trafficability. Consideration could be given to incorporating this layer of crushed rock or concrete into the final surface layer of the transformer yard.

For support of mobile crane outriggers on filling materials, thicker working platforms comprising compacted crushed rockfill are likely to be required. An assessment of the required platform thickness should be made once mobile crane equipment has been selected. The suitability of the concrete pavement to take mobile crane outrigger loads will also need to be assessed.

9.3 Excavation

9.3.1 Methods

Excavations for the proposed new switchroom, control room and cable basement are expected through silty clay and sandy clay filling (with cobbles and boulders of sandstone and siltstone), and within extremely low to very low strength sandstone (to a maximum of approximately 0.5 m below the top of rock). Minimal excavations are proposed for the transformer yard. Based upon the assumed cable basement BEL of RL45.5 m, the depth of excavation will be up to about 4 m below existing surface levels.

The clay filling materials cannot be expected to stand vertically for any length of time. Clay filling and extremely low to very low strength sandstone is expected to be exposed at the cable basement bulk level. It is noted that existing buried services (e.g. fire-fighting and stormwater services) are within the proposed building footprint, and may need to be re-located.

Excavations for proposed cable trenches (to link into the existing cable trench: a further approximately 2.3 m depth of excavation) are expected through sandy clay filling (with cobbles and boulders of sandstone and siltstone), and then through sand filling (cable trench backfilling). It is anticipated that clay filling will be exposed along most of the trench length, with the thickness of clay filling and the depth to the base of the cable trench reducing towards Waterloo Road.

It is considered that excavation of the filling, including of the cobbles and boulders, can be readily carried out using conventional earthmoving equipment. Some additional allowance should be made for the on-site handling of these large sandstone pieces. Excavations into the underlying extremely low and very low strength sandstone for bulk and detailed excavations, such as for footing excavations or deepening of trenches, are also likely to be readily carried out using conventional earthmoving equipment. Excavation contractors should make their own assessment of likely productivity depending on their equipment capabilities and operator skills.

9.3.2 Vibration Control

The use of rock hammers or ripping of low and higher strength rock, such as may be encountered at the site below an elevation of RL44.8 m, will cause vibrations which, if not controlled, could possibly result in damage to nearby structures and underground services (e.g. closer than 20 m).

It is assumed that the foundation systems of the nearby substation buildings are founded on low and medium strength sandstone. It is suggested that vibrations be provisionally limited to a peak particle velocity (PPV) of 8 mm/s at the ground level of the neighbouring buildings to protect architectural features, and at cable level within identified underground service trenches. This level complies with AS/ISO 2631.2 - 2014 (Reference 7) and is well below the normal building damage threshold level.

It is suggested that the client assess whether the proposed vibration limit will have a serviceability impact on the existing cables nearby. This provisional limit may need to be modified depending on the result of such assessments. A site specific vibration monitoring trial may be required to determine vibration attenuation once excavation plant and methods have been finalised.

9.3.3 Disposal of Excavated Material

Off-site disposal of excavated material will require assessment for re-use or classification in accordance with *Waste Classification Guidelines* (NSW EPA, 2014: Reference 8), prior to disposal to an appropriately licensed landfill or receiving site. This includes filling and virgin excavated natural materials (VENM), such as may be removed from this site.

It is noted that chemical analysis was carried out on selected soil and groundwater samples obtained from boreholes and standpipe piezometers, and that a waste classification has been carried out based on these test results (refer to DP Report 86471.01.R.002.Rev0, dated August 2018). Subject to the recommendations given in that report, further environmental testing may need to be carried out to classify excavated spoil prior to disposal. The type and extent of testing undertaken will depend on the final use or destination of the spoil, and requirements of the receiving site. The results of the environmental testing and waste classification are not further discussed herein.

9.3.4 Groundwater

Groundwater was encountered in the current and previous investigation at depths of 2.6 – 6 m (RL47.1 – 43.5 m). It is likely that the proposed excavation for the cable trenches and cable basement will not intersect the regional groundwater table (within the sandstone), however, intermittent groundwater seepage into the cable basement and footing excavations through the soil at the soil-rock interface below RL44 m, during and after periods of wet weathered, is possible. Some de-watering during construction will probably be required, possibly prior to placing concrete in foundation excavations.

Based on experience, it is anticipated that seepage volumes into the cable basement excavation will be small. If groundwater seepage into the basement is not tolerable then the cable basement will need to be waterproofed.

If some seepage into the basement is tolerable (i.e. the basement designed for drained conditions), it can probably be controlled over the long-term via a sub-floor drainage and collection system for seepage removal and to safeguard against uplift pressures. This could comprise a minimum 100 mm thick, durable, open-graded, crushed rock layer with subsurface drains and sumps. It is normally necessary to incorporate provision for regular flushing and cleaning of iron oxide sludge in the maintenance and design of the sub-floor drainage system.

Groundwater entering excavations and post-construction accumulation of groundwater below the basement floor will need to be disposed of in accordance with the Protection of the Environment Operations Act 1997 (POEO Act). Ultimately, this requires that any water discharged into the natural environment should comply with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council (ANZECC) and Agricultural and Resource Management Council of Australia and New Zealand.

The above water quality guideline criteria include trigger values for pH, turbidity, nutrients, dissolved oxygen and faecal coliforms (unlikely to be present in excavation water). An appropriate strategy would be to carry out testing of groundwater samples during construction to assess its compliance with the ANZECC water quality guidelines. If the tested water quality complies with the guidelines, it can normally be pumped directly into the stormwater system, subject to regulatory and Council approvals, who normally also have limits on dissolved iron. Alternatively, the pumped groundwater seepage

would require on-site treatment such as sedimentation and dosing to improve the quality of water to a sufficient level to comply with the ANZECC requirements before disposal into stormwater, again subject to appropriate approvals. In some circumstances, if groundwater is substantially contaminated, it may be necessary to dispose of it off-site as liquid waste or through the sewer via a trade waste agreement.

9.3.5 Excavation Slopes

It is understood that excavations for the proposed cable basement will be required beneath the footprint of the switchroom, with a transformer yard proposed to be constructed to the west. Based on the supplied buried services drawings ("S23336 Reduced file size.pdf"), services are indicated to occur parallel to and within the Waterloo Road property boundary. On the assumption that the filling soils beneath the transformer yard are not to be excavated, these documents indicate that there will be insufficient space between the proposed buildings and transformer yard (western side), and the buried services along the property boundary (southern side) to enable the excavation faces to be battered to a safe angle during construction and which will therefore need to be supported. Sufficient space will exist on the other two sides of the excavation to enable slope batters to be formed, which will require a mid-height bench with width no less than 1 m.

Suggested temporary and permanent maximum batter slope angles for slopes not exceeding 2 m in height are presented in Table 7.

Table 7: Recommended Temporary and Permanent Maximum Batter Slopes

Material	Batter Slope Ratio (H:V)	
	Short-term (Temporary)	Long-term (Permanent)
Filling, firm to stiff condition	1 : 1	1.5 : 1[a]
Residual Clay, stiff condition	1 : 1	1.5 : 1[a]
Extremely low to very low strength sandstone	0.75 : 1	1 : 1

Notes: (a) 1.5(H):1(V) slope is equivalent to a 34 degree slope, 3(H):1(V) slope if vegetation and maintenance of the batters is required.

Vertical excavations for cable trenches will likely require shoring boxes. Material stockpiles and machinery / equipment should not be stored at the crest of unsupported excavations.

9.4 Excavation Support

9.4.1 General

As insufficient space exists to batter the western and southern sides of the 4 m deep cable basement excavation to the recommended slope angles, the excavation will require both temporary and permanent lateral support, to ensure that excavation stability is maintained.
The shoring / support system considered suitable to retain the soil slope on the western and southern sides of the cable basement is bored concrete soldier piles, with the 'gap' between piles supported

using steel mesh-reinforced shotcrete, with short (i.e. 1 m long) steel soil nails or dowels installed into the filling material, and incorporated into the shotcrete using 'spider plates'.

Geotechnical inspections must be carried out during excavation, with further stabilisation and drainage measures to be implemented as required (e.g. strip drains) to maintain appropriate excavation stability.

9.4.2 Shoring Design and Retaining Walls

Excavation faces retained either temporarily or permanently will be subjected to earth pressures from the ground surface down to the top of medium strength rock, which for the current site is the full excavation depth. Retaining walls are also subjected to earth pressures for their full height.

Material and strength parameters that may be used for preliminary design of excavation support structures and retaining walls (if required) are presented in Table 8 and Table 9. A triangular earth pressure distribution may be adopted on the rear of the shotcrete. Unless positive drainage measures can be incorporated to prevent water pressure build up behind the shoring walls, full hydrostatic head should be allowed for in design while, at the same time, allowing for the soil density to reduce to the buoyant condition.

The values of active earth pressure coefficient, K_a, to be used for estimating soil pressures, are for a level ground surface and a flexible wall allowing for some lateral movement. To minimise movement of adjacent footings, the soil and weathered rock below the foundations should be designed using an "at rest" lateral earth pressure coefficient (K_o) – refer Table 8.

Table 8: Typical Material and Strength Parameters for Excavation Support Structures – Earth Pressures

Material	Bulk Density (γ: kN/m^3)	Coefficient of Active Earth Pressure (K_a)	Coefficient of Earth Pressure at Rest (K_o)	Ultimate Passive Earth Pressure (kPa)
Filling	20	0.3	0.6	-
Residual Clay	20	0.25	0.45	-
Sandstone: EL to VL	22	0.1	0.15	300

Notes: Strength descriptors: EL = Extremely low, VL = Very low

Table 9: Typical Material and Strength Parameters for Excavation Support Structures

Material Type	Effective Friction Angle (φ')	Effective Modulus E' (MPa)	Poisson's Ratio (ν')
Filling (Clay)	25	4	0.35
Residual Clay	25	8	0.35
Sandstone: EL to VL	30	75	0.15

Notes: Strength descriptors: EL = Extremely low, VL = Very low

Design of retaining walls should allow for lateral pressures from surcharge loads above the wall, such as from sloping ground, traffic loading, or arising from construction plant. The ultimate passive pressure given in Table 8 should incorporate a suitable factor of safety to limit deflection.

9.5 Foundations

Based upon the results of the investigations, the following materials are anticipated to be encountered at bulk excavation level:

- Cable basement (BEL: RL45.5 m) – residual clay and extremely low to very low strength sandstone;
- Control room (BEL: RL49.0 m) – clay filling; and
- Transformer yard (BEL: RL49.0 m) – clay filling.

It is recommended that all footings be taken to sandstone, via driven or bored piles for the control room and transformer yard, or shallow pad footings for the switchroom and cable basement. The piles should be socketed into a uniform founding stratum such as low or higher strength sandstone: Borehole BH01 encountered consistent high strength sandstone at a depth of 1.9 m below the “top of rock”. An allowance for temporary steel casing may be required for the bored piles, to prevent the cobbles and boulders from falling into pile holes and creating other challenges. The extremely low to very low strength sandstone stratum could be used for shallow footings (at basement level), with an allowable bearing pressure of 1,000 kPa.

Recommended maximum allowable (and ultimate) bearing pressures, shaft adhesions and modulus values for the rock encountered in boreholes at the site are presented in Table 10. These parameters apply to the design of socketed bored piles, for the support of axial compression loadings. They can be adopted on the assumption that the excavations are clean and free of loose debris, with pile sockets free of smear and adequately roughened immediately prior to concrete placement. For piles driven to refusal on rock, the structural capacity of the piles is likely to govern design.

Table 10: Recommended Design Parameters and Moduli for Foundation Design

Foundation Stratum[1]	Allowable End Bearing (MPa)	Ultimate End Bearing (MPa)	Allowable Shaft Adhesion (kPa)	Ultimate Shaft Adhesion (kPa)	Field Elastic Modulus (MPa)
Sandstone – Extremely low to very low strength	1.0	3.0	75	150	50
Sandstone – Low Strength	3.5	20	350	800	350
Sandstone – High Strength	6.0	60	600	1500	900

Notes: (1) Based on Pells et. al (1998).
(2) Shaft adhesion applicable to the design of bored piles, uncased over the rock socket length, where adequate sidewall cleanliness and roughness are achieved

Foundations proportioned using the allowable parameters would be expected to settle less than 1% of the footing width (or pile diameter) under the applied working load, with differential settlements between adjacent columns expected to be less than half of this value. An experienced geotechnical professional should inspect all bored pile excavations prior to the placement of concrete and steel, to check the adequacy of the foundation material and to undertake spoon testing as appropriate.

Whilst the allowable bearing pressure is not likely to be critical to the design, pile footings taken down into consistent high strength sandstone could potentially be designed for an allowable bearing pressure of 6,000 kPa and possibly up to 12,000 kPa, subject to additional investigation or spoon testing during construction. If higher bearing pressures are used in design, however, then additional testing will be required in the form of cored boreholes and/or spoon testing of footings, to ensure there are no defects beneath footings. Alternatively, if a lower allowable bearing pressure of 3,500 kPa is adopted then testing during construction could be limited to inspection of foundations.

9.6 Materials Re-Use

The provided drawings indicate that placement of filling elsewhere on the site is not proposed as part of the proposed substation development, and that limited additional new areas of pavement are proposed.

The materials anticipated to be excavated from within the building footprint (e.g. clay filling, residual clay and weathered sandstone) are considered to be suitable from a geotechnical perspective for re-use at the site, however, sieving and segregation / stockpiling of the coarse material (e.g. boulders) from the filling is likely to be required. Re-use could be considered for new pavement areas, provided the materials are moisture conditioned prior to compaction, and as general filling for landscaping, although past experience with these materials indicates the potential for low soil fertility. Cross-fall to suitable drainage will be required to prevent saturation, waterlogging and softening of the clay.

Further advice should be sought when further details are known, on issues including placement and test rolling methodologies, required compaction densities and recommended layer thicknesses.

9.7 Floor Slab and Pavement Design Parameters

The floor at basement level can be designed as a slab on ground. The final rock surface (at BEL) should be trimmed and scraped clean of debris, and the stiff residual clay or clay filling (where it occurs at BEL) compacted using a smooth drum roller.

Based upon CBR test results from the filling and on residual clay samples from nearby sites, and allowing for some variability, it is suggested that a design CBR value for the subgrade material and reworked filling material not exceed 5%. If imported material is used to level the site and form subgrade levels, the design CBR value will depend on the type of imported material.

The design CBR value is based on the provision of adequate surface and subsoil drainage to maintain the subgrade as close to the optimum moisture content as possible. Subsoil drainage should be installed adjacent to pavement edges abutting lawns or garden areas.

It will be necessary to provide under-floor drainage to safeguard against uplift pressures if the basement floor and walls are designed for drained conditions. This could comprise a minimum 100 mm thick, durable open-graded crushed rock with subsurface drains and sumps.

9.8 Seismic Design

In accordance with the Earthquake Loading Standard, AS1170.4 – 2007 (Reference 9), the site has a hazard factor (z) of 0.08 and a site sub-soil class of shallow soil (C_e), being underlain by materials with a compressive strength less than 0.8 MPa, and with a surface layer of less than 25 m depth of stiff cohesive soil.

10. References

1. Herbert C., 1983, Sydney 1:100 000 Geological Sheet 9130, 1st edition. Geological Survey of New South Wales, Sydney.
2. The Department of Land and Water Conservation, 1997 (Edition 2). 1:25 000 Acid Sulphate Soil Risk map for Prospect / Parramatta River.
3. Australian Standard AS1726-2017, “Geotechnical Site Investigations”, Standards Australia.
4. Australian Standard AS3798-2007, “Guidelines on Earthworks for commercial and Residential Developments”, March 2007, Standards Australia.
5. Australian Standard AS2159-2009, “Piling – Design and Installation”, third edition, 2009, Standards Australia.
6. Australian Standard AS2870-2011, “Residential Slabs and Footings”, April 2011, Standards Australia.
7. Australian / International Standard AS/ISO 2631.2 – 2014, “Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Vibration in buildings (1 Hz to 80 Hz)”.
8. NSW Environment Protection Authority (EPA), 2014, “Waste Classification Guidelines”.
9. Australian Standard AS1170.4 – 2007, “Structural design actions, Part 4: Earthquake actions in Australia”.

11. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at Macquarie Park Substation, 21 Waterloo Road, Macquarie Park, in accordance with DP’s proposal SYD180586 dated 22 June 2018 and acceptance received from Mr Paul Hurst dated 28 June 2018. The work was carried out under the amended Master Services Agreement – Design and Related Services Panel (Purchase Order Number 4500978730). This report is provided for the exclusive use of Ausgrid for this project only and for the purposes as described in the report. It should not be used by or be relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express

written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached pages and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The scope for work for this report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, with Preliminary Site Investigation and Limited Stage 2 Contamination Investigation, and Preliminary Waste Classification reports produced under separate covers. Should evidence of filling of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such filling may contain contaminants and hazardous building materials.

Asbestos containing material was not detected by observation from boreholes or at the ground surface, at the test locations sampled and analysed. Building demolition materials, such as bricks and concrete fragments, were also located within previous below-ground filling, and these are considered as indicative of the possible presence of hazardous building materials (HBM), including asbestos.

Although the sampling plan adopted for this investigation is considered appropriate to achieve the stated project objectives, there are necessarily parts of the site that have not been sampled and analysed. This is either due to undetected variations in ground conditions or to budget constraints (as discussed above). It is therefore considered possible that HBM, including asbestos, may be present in unobserved or untested parts of the site, between and beyond sampling locations, and hence no warranty can be given that asbestos is not present.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role

respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical / groundwater components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawings

Locality Plan

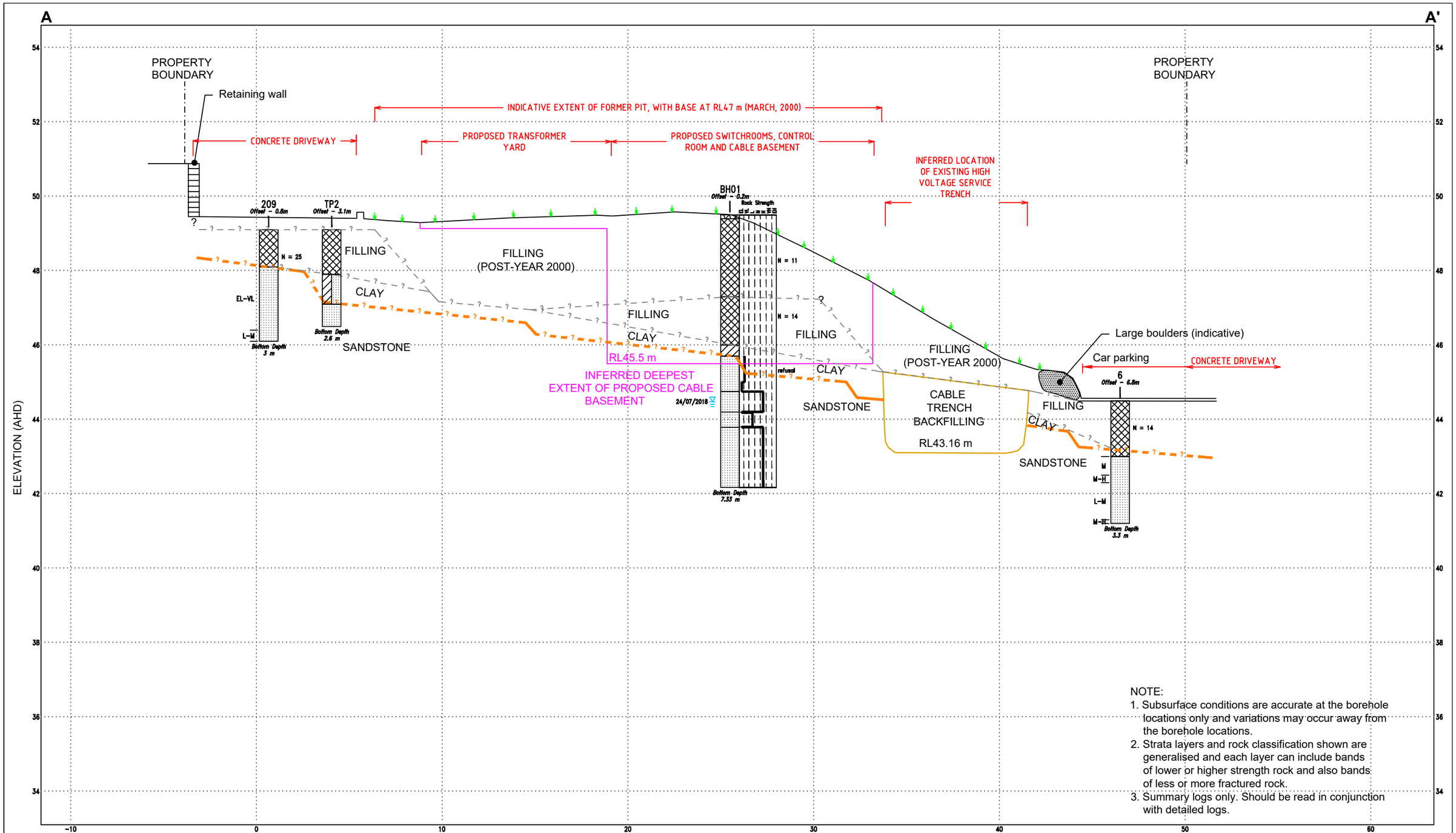
NOTE:
1: Base drawing from Degotardi Smith & Partners Pty Ltd (Dwg S 23336,dated 12.1.2018)
2: Test locations are approximate only and are shown with reference to existing features
3: Survey levels are relative to the Australian Height Datum.

0 1 2 4 6 8 10 15 20 30m
1:300 @ A3

LEGEND

- ▲ Historical test pit (Golders)
- \+ Historical borehole (J&K / EIS)
- Cored borehole
- Hand augered borehole
- NDD trench
- Geotechnical cross-section
- P Standpipe Piezometer

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: AusGrid	TITLE: **Test Location Plan** **Proposed 132/33kV Substation** **21 Waterloo Road, MACQUARIE PARK**	PROJECT No: 86471.00
	OFFICE: Sydney DRAWN BY: PSCH		DRAWING No: 1
	SCALE: 1:300 @ A3 DATE: 4.7.2018		REVISION: 0



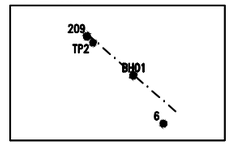
NOTE:
1. Subsurface conditions are accurate at the borehole locations only and variations may occur away from the borehole locations.
2. Strata layers and rock classification shown are generalised and each layer can include bands of lower or higher strength rock and also bands of less or more fractured rock.
3. Summary logs only. Should be read in conjunction with detailed logs.

LEGEND
- Topsoil
- Filling
- Clay
- Sandstone

Notes:
1. Vertical and horizontal scales are not equal
2. Profile of top of rock for an inferred pit based on J&K Report 15400SL Figure 7, dated September 2000.
3. Summarised boreholes and borehole surface levels taken from J&K Report (September 2000).
4. Level of base of existing high voltage cable trench taken from Enerserve Drawing 128302 (Rev1), dated November 2000.

TESTS / OTHER
N - Standard penetration test value
▽ - Water level

SITE MAP



Horizontal Scale (metres)
Vertical Exaggeration = 2.0

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Ausgrid		TITLE: **Geotechnical Cross-Section A-A'**	PROJECT No: 86471.00
OFFICE: Sydney	DRAWN BY: HDS	**Macquarie Park Zone Substation**	DRAWING No: 2
SCALE: 1:200 (H) 1:100 (V) @ A3	DATE: 27.07.2018	**21 Waterloo Road, MACQUARIE PARK**	REVISION: 0

Appendix C

Site Photographs

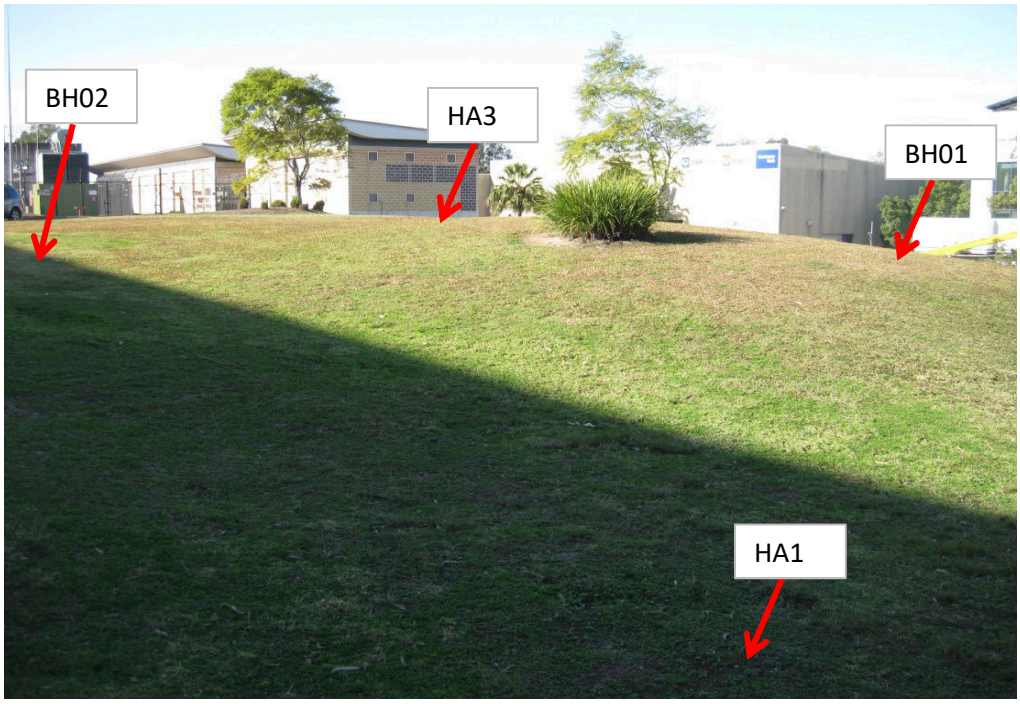


Photo 1 - View north-east towards the existing substation and across the proposed substation footprint. The approximate locations of the tests are indicated as shown.

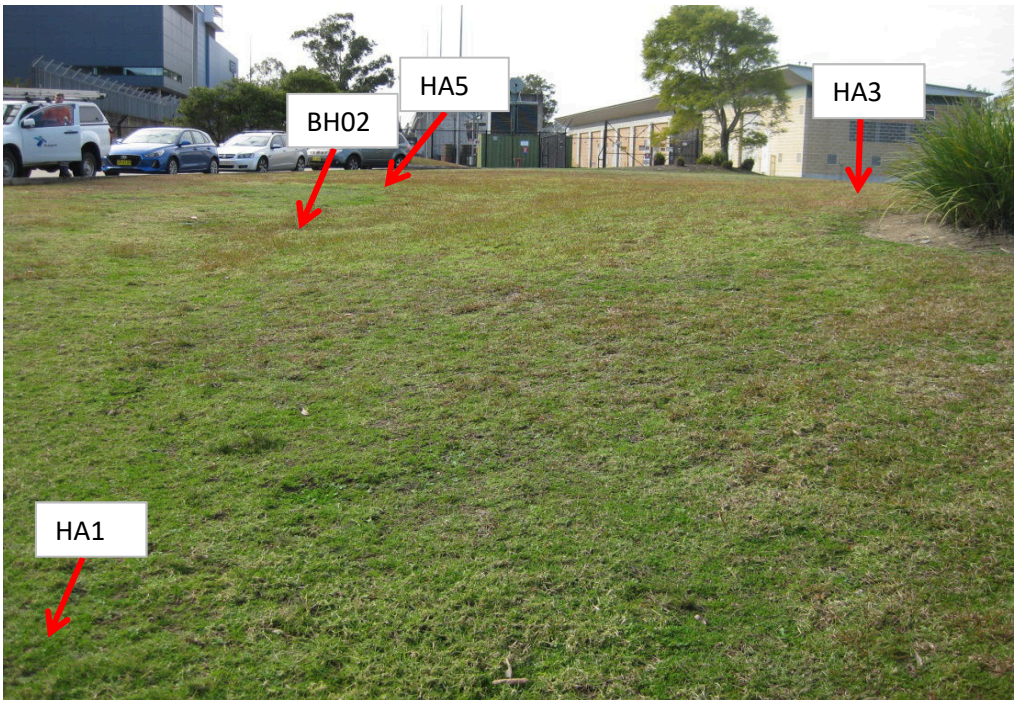


Photo 2 - View north-east towards the existing substation and across the proposed substation footprint. The approximate locations of the tests are indicated as shown.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Geotechnical Assessment** **21 Waterloo Rd, Macquarie Pk**	PROJECT: 86471.00 PLATE No: 1 REV: 0
	CLIENT: Ausgrid	DATE: 31-Jul-18

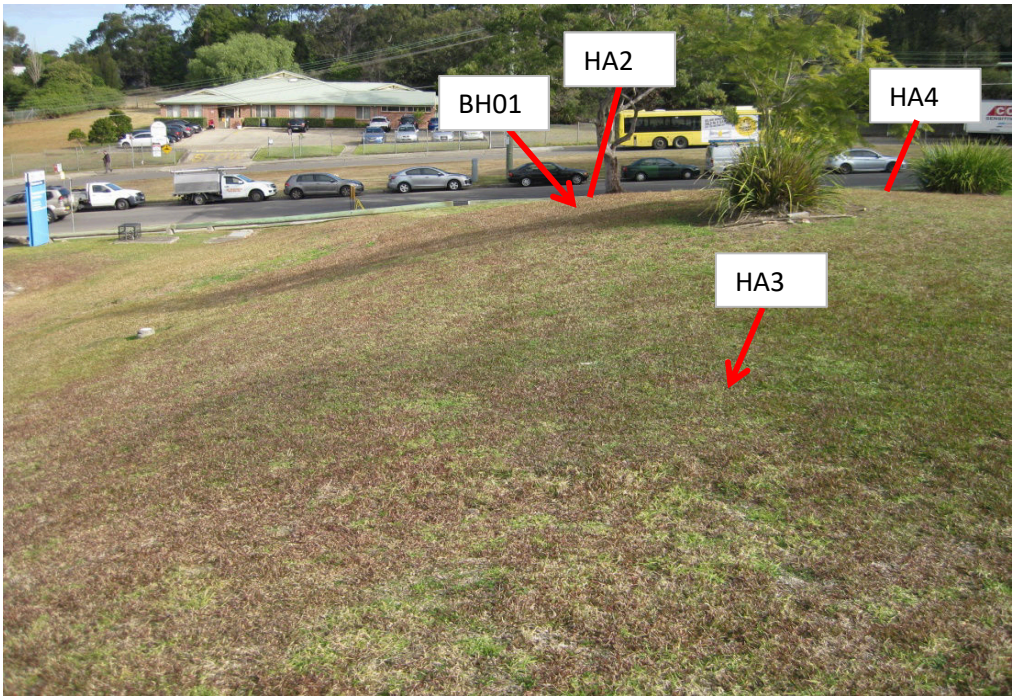


Photo 3 - View south-west across the proposed substation footprint, with Waterloo Road in the background. Approximate locations of test positions are as shown.

Photo 4 - View north-east towards the existing substation buildings, east of the proposed substation footprint.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Geotechnical Assessment** **21 Waterloo Rd, Macquarie Pk**	PROJECT: 86471.00 PLATE No: 2 REV: 0
	CLIENT: Ausgrid	DATE: 31-Jul-18

Appendix D

Field Work Results

Sampling Methods

Douglas Partners

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726-1993, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 2007. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approximate Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and longer sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq 100 \text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Symbols & Abbreviations

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	Lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

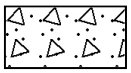
Symbols & Abbreviations

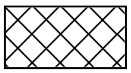
Graphic Symbols for Soil and Rock

General

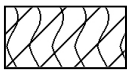

Asphalt

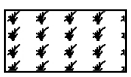

Road base

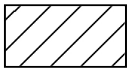

Concrete

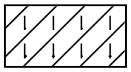

Filling

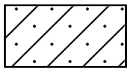
Soils


Topsoil

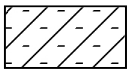

Peat

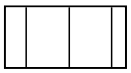

Clay

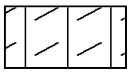

Silty clay

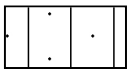

Sandy clay

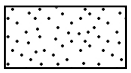

Gravelly clay

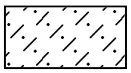

Shaly clay

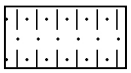

Silt


Clayey silt


Sandy silt

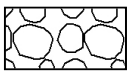

Sand

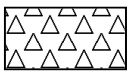

Clayey sand


Silty sand


Gravel

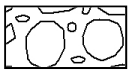

Sandy gravel


Cobbles, boulders

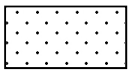

Talus

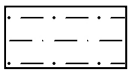
Sedimentary Rocks

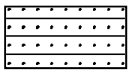

Boulder conglomerate

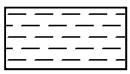

Conglomerate


Conglomeratic sandstone

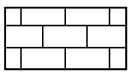

Sandstone


Siltstone

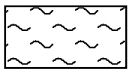

Laminite

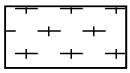

Mudstone, claystone, shale

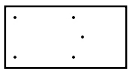

Coal


Limestone

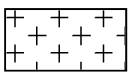
Metamorphic Rocks

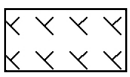

Slate, phyllite, schist

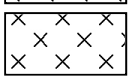

Gneiss

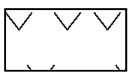

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Macquarie Park Zone Substation
LOCATION: 21 Waterloo Road, Macquarie Park

SURFACE LEVEL: 49.5 AHD
EASTING: 327069
NORTHING: 6259841
DIP/AZIMUTH: 90°/--

BORE No: BH01
PROJECT No: 86471.00
DATE: 11/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low / Very Low / Low / Medium / High / Very High / Ex High)	Water	Fracture Spacing (m) (0.01 / 0.05 / 0.10 / 0.50 / 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
49	0.1	TOPSOIL: dark grey and grey, silty sand topsoil filling, trace clay.							A/E			
		FILLING: brown to dark brown, sandy clay filling, with some sandstone, siltstone, brick and concrete gravel and cobbles, moist, generally in a stiff condition.							A/E			
48	1								A/E*			
									S			3,6,5 N = 11
	2											
47	2.2	FILLING: grey to dark brown, clay filling, with some sandstone and siltstone gravel and cobbles, trace sand, moist, generally in a stiff to very stiff condition.							A/E			
									S			4,3,11 N = 14
	3											
46	3.5	CLAY: stiff, brown, slightly silty clay, with trace ironstone gravel, damp (possibly filling).										
	3.8	SANDSTONE: extremely low to very low strength, extremely weathered, pale grey, medium grained sandstone with ironstone bands.							A/E			
	4								S			16,19,6/60 refusal
45								4.50-4.75m: Cs, 250mm				
	4.75	SANDSTONE: high strength, highly weathered, fractured to slightly fractured, pale grey to red-brown, medium grained sandstone.										PL(A) = 1.2
	5											
	5.3	SANDSTONE: low strength, highly weathered, fractured to slightly fractured, pale grey, medium grained sandstone.						5.30m: Cs, 20mm 5.36m: B, 0-10°, pl, ro, cly co 5.47m: J, 40-50°, pl, ro, cly co				
44	5.71	SANDSTONE: high strength, moderately weathered, slightly fractured to unbroken, pale brown to red-brown, medium grained sandstone.						5.7m: B, 0-10°, pl, ro, cly co 5mm 5.91m: B, 0-10°, ro, cln	C	100	86	PL(A) = 1.8
	6											
43												PL(A) = 1.5
	7											
	7.33	Bore discontinued at 7.33m - Target depth reached.										PL(A) = 1.5
42												

RIG: Hanjin D8 **DRILLER:** BG **LOGGED:** AT **CASING:** HQ to 4.5m

TYPE OF BORING: Solid flight auger to 4.5m, NMLC coring to 7.33m.

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *TR1110718 and TR2110718 taken at 0.9-1.0m.
Standpipe installed, blank 0-4.33m; screen 4.33-7.33m; backfill 0-3.5m; bentonite plug 3.5-4.0m; gravel 4.0-7.33m, gatic cover at surface.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BORE: BH01 PROJECT: MACQUARIE PARK STS AUGUST 2018

4.5m – 7.33m

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Macquarie Park Zone Substation
LOCATION: 21 Waterloo Road, Macquarie Park

SURFACE LEVEL: 49.6 AHD
EASTING: 327066
NORTHING: 6259856
DIP/AZIMUTH: 90°/--

BORE No: BH02
PROJECT No: 86471.00
DATE: 11/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Degree of Weathering	Graphic Log	Rock Strength	Water	Fracture Spacing (m)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
49	0.1	TOPSOIL: dark grey and grey, silty sand topsoil filling, trace clay.							A/E			
		FILLING: brown to dark brown, sandy clay filling, with some sandstone, siltstone, brick and concrete gravels and cobbles, moist, generally in a firm to stiff condition.							A/E			
	1								E*			
									B			
									S			3,2,4 N = 6
48	2											
47	2.7	SANDSTONE: very low strength, highly weathered, red-brown, medium grained sandstone with some ironstone bands.							S			19,20/100 refusal
	3											
	3.24	SANDSTONE: low to medium strength, highly weathered, fractured, pale grey to red-brown, medium grained sandstone with some extremely low strength clay bands.						3.18m: Cs, 20mm 3.5m: B, 0-10°, ro, cln 3.63m: Cs, 25mm 3.9m: Cs, 20mm 4.14m: B, 0-10°, ro, fe stn	C	100	74	PL(A) = 0.27 PL(A) = 0.41
46	4											
	4.4	SANDSTONE: extremely low strength, extremely to highly weathered, highly fractured, pale grey, medium grained sandstone.						4.4m: B, 0-10°, ro, cly vn 4.41m: B, 0-10°, ro, cln 4.56m: B, 0-10°, ro, cln 4.66m: B, 0-10°, ro, cln 4.76m: B, 0-10°, ro, cln 4.83m: B, 0-10°, ro, cln 4.89m: B, 0-10°, ro, cln 4.94m: B, 0-10°, ro, cln				
45	5											
	5.0	SANDSTONE: high strength, moderately weathered, slightly fractured and unbroken, pale brown, medium grained sandstone.						5.39m: Cs, 10mm	C	100	56	PL(A) = 1.2
44	6											PL(A) = 2.3
43	7							6.46m: Cs, 40mm 6.55m: B, 0-10°, ro, cln				
	7.0	Bore discontinued at 7.0m - Target depth reached.										
42												

RIG: Hanjin D8 **DRILLER:** BG **LOGGED:** AT **CASING:** HQ to 3.0m

TYPE OF BORING: Solid flight auger to 3.0m, NMLC coring to 7.0m.

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *TR6110718 and TR7110718 taken at 0.9-1.0m.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BORE: BH02 PROJECT: MACQUARIE PARK STS AUGUST 2018

3.0m – 7.0m

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Macquarie Park Zone Substation
LOCATION: 21 Waterloo Road, Macquarie Park

SURFACE LEVEL: 48.5 AHD
EASTING: 327051
NORTHING: 6259840
DIP/AZIMUTH: 90°/--

BORE No: HA1
PROJECT No: 86471.00
DATE: 11/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
48.4	0.1	TOPSOIL: brown, silty clay topsoil filling, some rootlets.		A/E	0.1				
	0.4	FILLING: brown, silty clay filling, slightly gravelly and sandy, gravels are sub-angular to sub-rounded and fine to coarse igneous, sandstone, siltstone and brick, with some cobbles up to 80mm diameter, damp.		A/E*	0.4				
		Bore discontinued at 0.4m - Hand auger refusal on possible cobble/boulder.							

RIG: Hand tools **DRILLER:** RMM **LOGGED:** RMM **CASING:** None

TYPE OF BORING: Hand auger (100mm diameter) to 0.4m.

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *TR4110718 and TR5110718 taken at 0.4m.

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Macquarie Park Zone Substation
LOCATION: 21 Waterloo Road, Macquarie Park

SURFACE LEVEL: 47.6 AHD
EASTING: 327062
NORTHING: 6259831
DIP/AZIMUTH: 90°/--

BORE No: HA2
PROJECT No: 86471.00
DATE: 11/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
47.6	0.1	TOPSOIL: brown, silty clay topsoil filling, some rootlets.		A/E	0.1				
		FILLING: brown then grey, silty clay filling, slightly gravelly, gravels are sub-angular to sub-rounded and fine to coarse, mostly siltstone with igneous, sandstone and brick, with some siltstone cobbles up to 100mm diameter, damp to humid.		A/E	0.5				
47	0.55	Bore discontinued at 0.55m - Hand auger refusal in gravelly filling.							
46	1								
45	2								
44	3								
43	4								
42	5								
41	6								
40	7								

Dynamic Penetrometer Test (blows per 0mm): 5, 10, 15, 20

RIG: Hand tools **DRILLER:** RMM **LOGGED:** RMM **CASING:** None

TYPE OF BORING: Hand auger (100mm diameter) to 0.55m.

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Macquarie Park Zone Substation
LOCATION: 21 Waterloo Road, Macquarie Park

SURFACE LEVEL: 49.7 AHD
EASTING: 327078
NORTHING: 6259851
DIP/AZIMUTH: 90°/--

BORE No: HA3
PROJECT No: 86471.00
DATE: 11/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
49.6	0.1	TOPSOIL: brown, silty clay topsoil filling, some rootlets.		A/E	0.1				
	0.5	FILLING: brown, silty clay filling, slightly gravelly and sandy, gravels are sub-angular to sub-rounded and fine to coarse, mostly sandstone with some igneous and brick, damp to humid.		A/E	0.5				
		Bore discontinued at 0.5m - Hand auger refusal on possible cobble/boulder.							

RIG: Hand tools **DRILLER:** RMM **LOGGED:** RMM **CASING:** None

TYPE OF BORING: Hand auger (100mm diameter) to 0.5m.

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Macquarie Park Zone Substation
LOCATION: 21 Waterloo Road, Macquarie Park

SURFACE LEVEL: 48.2 AHD
EASTING: 327057
NORTHING: 6259835
DIP/AZIMUTH: 90°/--

BORE No: HA4
PROJECT No: 86471.00
DATE: 11/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
48	0.1	TOPSOIL: brown, silty clay topsoil filling, some rootlets.							
		FILLING: brown then grey, silty clay filling, slightly gravelly, gravels are sub-angular and fine to coarse, mostly siltstone with some sandstone, damp to humid.		A/E	0.5				
	0.6	Bore discontinued at 0.6m - Hand auger refusal in gravelly filling.							
47	1								
46	2								
45	3								
44	4								
43	5								
42	6								
41	7								

Dynamic Penetrometer Test (blows per 0mm): 5, 10, 15, 20

RIG: Hand tools **DRILLER:** RMM **LOGGED:** RMM **CASING:** None

TYPE OF BORING: Hand auger (100mm diameter) to 0.6m.

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Macquarie Park Zone Substation
LOCATION: 21 Waterloo Road, Macquarie Park

SURFACE LEVEL: 49.6 AHD
EASTING: 327073
NORTHING: 6259864
DIP/AZIMUTH: 90°/--

BORE No: HA5
PROJECT No: 86471.00
DATE: 11/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
49.6	0.1	TOPSOIL: brown, silty clay topsoil filling, some rootlets.							
49.2	0.4	FILLING: brown, silty clay filling, slightly gravelly and sandy, gravels are sub-angular to sub-rounded, fine to coarse, mostly sandstone, siltstone and igneous, damp to humid.							
		Bore discontinued at 0.4m - Hand auger refusal in gravelly filling.							

RIG: Hand tools **DRILLER:** RMM **LOGGED:** RMM **CASING:** None

TYPE OF BORING: Hand auger (100mm diameter) to 0.4m.

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Groundwater Field Sheet

Bore Volume = casing volume + filter pack volume
$= \pi h_1 d_2^2/4 + n(\pi h_1 d_1^2/4 - \pi h_2 d_2^2/4)$
Where: $\pi = 3.14$
n = porosity (0.3 for most filter pack material)
h_1 = height of water column
d_1 = diameter of annulus
h_2 = length of filter pack
d_2 = diameter of casing
Bore Vol Normally: 7.2*h

Project and Bore Installation Details	
Bore / Standpipe ID:	~~86471.01~~ BH01
Project Name:	Macquarie Park Substation
Project Number:	86471.01
Site Location:	
Bore GPS Co-ord:	
Installation Date:	11.7.18
GW Level (during drilling):	m bgl
Well Depth:	m bgl
Screened Interval:	m bgl
Contaminants/Comments:	

Bore Development Details	
Date/Time:	
Purged By:	
GW Level (pre-purge):	m bgl
GW Level (post-purge):	m bgl
PSH observed:	Yes / No (interface / visual). Thickness if observed:
Observed Well Depth:	m bgl
Estimated Bore Volume:	L
Total Volume Purged:	(target: no drill mud, min 3 well vol. or dry)
Equipment:	

Micropurge and Sampling Details	
Date/Time:	17/3
Sampled By:	MW
Weather Conditions:	Fine
GW Level (pre-purge):	? or 6.0m (estimated) m bgl Wasn't getting tone from dip meter,
GW Level (post sample):	? m bgl despite it working correctly from other water sources.
PSH observed:	Yes / (No) (interface / visual). Thickness if observed:
Observed Well Depth:	7.04 m bgl
Estimated Bore Volume:	L
Total Volume Purged:	L
Equipment:	Geosub / Bailer

Water Quality Parameters

Time / Volume	DO (mg/L)	EC (µS or mS/cm)	pH	Redox (mV)	Temp (°C)
Stabilisation Criteria (3 readings)	**+/- 0.3 mg/L**	**+/- 3%**	**+/- 0.1**	**+/- 10 mV**	**0.1°C**
12:55	2.30	705 µs	6.17	70	19.3
12:57	2.14	708	6.16	69	19.5
12:59	2.06	706	6.16	67	20.0
Additional Readings Following stabilisation:	DO % Sat	SPC	TDS		
	209ppm				

All readings taken from single bailer in bucket due to insufficient water in well for continuous flow

Sample Details

Sampling Depth (rationale):	6.5 m bgl,
Sample Appearance (e.g. colour, siltiness, odour):	Very silty, no odour
Sample ID:	MW1
QA/QC Samples:	metals, PAH
Sampling Containers and filtration:	Sampling conducted from bailer as couldn't get flow from Geosub.

Appendix E

Laboratory Test Results

Material Test Report

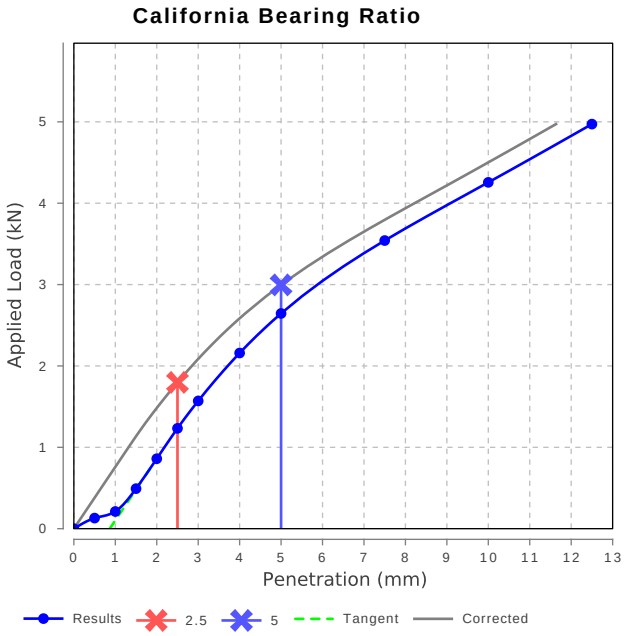
Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Sydney Laboratory
96 Hermitage Road West Ryde NSW 2114
Phone: (02) 9809 0666
Fax: (02) 9809 0666
Email: mick.gref@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Michael Gref
NATA Accredited Laboratory Number: 828

Report Number: **86471.00-1**
Issue Number: 1
Date Issued: 24/07/2018
Client: Ausgrid
Level 1/9-13 Carter Street, Lidcombe NSW 2141
Contact: Paul Hurst
Project Number: 86471.00
Project Name: MACQUARIE PARK Zone Substation
Project Location: Macquarie Park Substation, Macquarie Park
Work Request: 3477
Sample Number: 18-3477A
Date Sampled: 11/07/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **BH02 (0.5 - 1.5m)**
Material: Sandy Clay Filling

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**15**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.91		
Optimum Moisture Content (%)	11.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.90		
Field Moisture Content (%)	14.6		
Moisture Content at Placement (%)	11.6		
Moisture Content Top 30mm (%)	14.2		
Moisture Content Rest of Sample (%)	13.9		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	172		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	5.7		



Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 196123-A

Client Details

Client	Douglas Partners Pty Ltd
Attention	Huw Smith
Address	96 Hermitage Rd, West Ryde, NSW, 2114

Sample Details

Your Reference	**86471.00, Geotech. Investigation, Macquarie Park**
Number of Samples	11 Soil
Date samples received	12/07/2018
Date completed instructions received	12/07/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	20/07/2018
Date of Issue	19/07/2018

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Jacinta Hurst, Laboratory Manager

Soil Aggressivity			
Our Reference		196123-A-2	196123-A-11
Your Reference	UNITS	BH01	HA3
Depth		2.5-2.95	0.5
Date Sampled		11/07/2018	11/07/2018
Type of sample		Soil	Soil
pH 1:5 soil:water	pH Units	8.9	7.8
Electrical Conductivity 1:5 soil:water	µS/cm	110	28
Resistivity by calculation	ohm m	91	360
Chloride, Cl 1:5 soil:water	mg/kg	10	10
Sulphate, SO4 1:5 soil:water	mg/kg	43	<10

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: Soil Aggressivity					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	196123-A-1
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	2	8.9	8.9	0	102	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	2	110	120	9	106	[NT]
Resistivity by calculation	ohm m	0.1	Inorg-002	<0.1	2	91	86	6	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	10	10	0	111	106
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	43	45	5	115	113

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Douglas Partners
Geotechnics | Environment | Groundwater

CHAIN OF CUSTODY DESPATCH SHEET

Project No:	86471.00	**Suburb:**	Macquarie Park	**To:**	Envirolab Services
Project Name:	Geotechnical Investigation	**Order Number**			12 Ashley St Chatswood 2067
Project Manager:	Huw Smith	**Sampler:**	AT/RMM	**Attn:**	Aileen Hie
Emails:	huw.smith@douglaspartners.com.au			**Phone:**	(02) 9910 6200
Date Required:	Same day ☐ 24 hours ☐ 48 hours ☐ 72 hours ☐ Standard ☑			**Email:**	AHie@envirolab.com.au
Prior Storage:	☐ Esky ☑ Fridge ☐ Freezer ☐ Shelved	Do samples contain 'potential' HBM?	Yes ☐ No ☐ (If YES, then handle, transport and store in accordance with FPM HAZID)		

Sample ID	Lab ID	Date Sampled	Sample Type (S - soil, W - water)	Container Type (G - glass, P - plastic)	Analytes: Agressivity											Notes/preservation
BH01/2.5-2.95	2	11.07.18	s	g	×											
HA3/0.5	11	11.07.18	s	g	×											
PQL (S) mg/kg															**ANZECC PQLs req'd for all water analytes** ☐	

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200

Job No: 196123-A

Date Received: 12/7/18
Time Received: 15:30
Received By: MT / YH
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

PQL = practical quantitation limit. If none given, default to Laboratory Method Detection Limit

Lab Report/Reference No: 196123-A

Metals to Analyse:

Total number of samples in container: **Relinquished by:** NLE **Transported to laboratory by:** Bonds

Send Results to: Douglas Partners Pty Ltd **Address:** 96 Hermitage Road West Ryde NSW 2114 **Phone:** (02) 4271 1836 **Fax:** (02) 4271 1897

Signed: 12/7 **Received by:** MT EGL **Date & Time:** 12/7/18 1030

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