7.0 Traffic and transport

This chapter summarises the assessment of potential traffic and transport impacts arising from the construction and operation of the project, as detailed in the Traffic and Transport Assessment in **Appendix D**. The traffic and transport impacts of the project would primarily be confined to the construction stage. A qualitative assessment was completed to determine likely broad scale impacts to local roads, public transport, active transport networks and parking, and to identify management issues requiring further consideration during detailed design and construction planning to minimise traffic and transport impacts.

7.1 Assessment methodology

7.1.1 Statutory context, policy and guidelines

This assessment has taken into consideration the following legislation and guidelines:

- *Roads Act 1993* which outlines the consent requirements for undertaking works in, on or over a public road;
- *Electricity Supply Act 1995* which outlines the need for relevant local councils to be notified of the works and for any comments to be considered by TransGrid;
- *Traffic control at work sites manual* (Roads and Maritime Services (Roads and Maritime), 2018) which contains guidance on traffic control plans and provides guidance on traffic lane dimensions; and
- *Road Design Part 3: Geometric Design* (Austroads, 2016) which provides guidance for road design and outlines requirements for lane widths.

This statutory framework is discussed in detail in **Appendix D**.

7.1.2 Study area

The study area for the traffic and transport assessment is the project area. The project area includes the location of operational infrastructure and construction work sites for:

- the transmission cable route (including the entire road reserve[1] of roads traversed);
- special crossings of infrastructure or watercourses;
- substation sites requiring upgrades (noting that all works would be contained within the existing site boundaries); and
- construction laydown areas.

The majority of the proposed transmission cable route is within road reserves, with small sections through private property, public parks/recreational areas and industrial areas.

7.1.3 Approach and methodology

7.1.3.1 Transmission cable route

A high level qualitative assessment was undertaken to identify potential impacts on traffic and transport as a result of the project and to outline the traffic management approach required for construction activities along the transmission cable route on a road by road basis. As the majority of construction activities for the transmission cable circuit would occur within road reserves, these activities, while temporary, have the potential to impact local vehicle, public and active transport networks.

[1] Road reserve is defined as the area comprising roads, footpaths, nature strips and public transport infrastructure (including indented bus bays, bus shelters and bus stop signage).

The methodology for the assessment included:

- development of assumptions for maximum widths of work sites during three key construction activities: trenching and excavation, excavation and establishment of joint bays, and cable pulling and jointing;
- identifying the minimum required widths for traffic lanes to maintain either uninterrupted two-way traffic flow or two-way traffic flow (under shuttle working conditions[2]), using the *Traffic control at work sites manual* (Roads and Maritime, 2018) and *Road Design Part 3: Geometric Design* (Austroads, 2016). In addition, the threshold for the road width before a diversion is required was identified. Assumptions were also determined for roads with and without bus routes;
- using the assumptions for the maximum widths of work sites and the minimum widths required for traffic lanes during construction, a set of assumptions were developed for the minimum road widths for two possible traffic management approaches, including:
    - traffic flow maintained (lane closures that will permit two way traffic flow under either uninterrupted or shuttle working conditions);
    - diversion required; and
- considering the potential length of the work site required to complete the construction activity to understand the impact on the capacity of the road network at that location. The assumptions and lengths of the proposed work sites for the three key construction activities are described in **Appendix D**.

A detailed assessment of work site specific impacts and mitigation measures for individual roads will be developed at a later date as the required information to complete a detailed assessment (e.g. the proposed design showing the exact location of the transmission cable circuit and joint bays within the road reserve and the construction method at each work site) would only be available during the detailed design stage. The identified impacts, constraints, design criteria and management requirements would form the basis for detailed design and construction planning, which would include quantitative site assessments (including traffic counts, where required) to confirm and refine traffic control and management measures at the confirmed work site locations.

The width of road required for kerbside works would be less than if the transmission cable circuit were to be installed away from the kerbside (refer to **Figure 7-1** and **Figure 7-2**). As such, construction activities would ideally be undertaken along the kerbside to maximise the available road space for vehicles to pass the work site. There may be a requirement for trenches to be excavated away from the kerbside (i.e. non-kerbside construction). In this case, traffic may be able to pass along both sides of the work site.

[2] A traffic scenario whereby part of the roadway is closed, and a single lane is used alternatively by traffic in each direction.

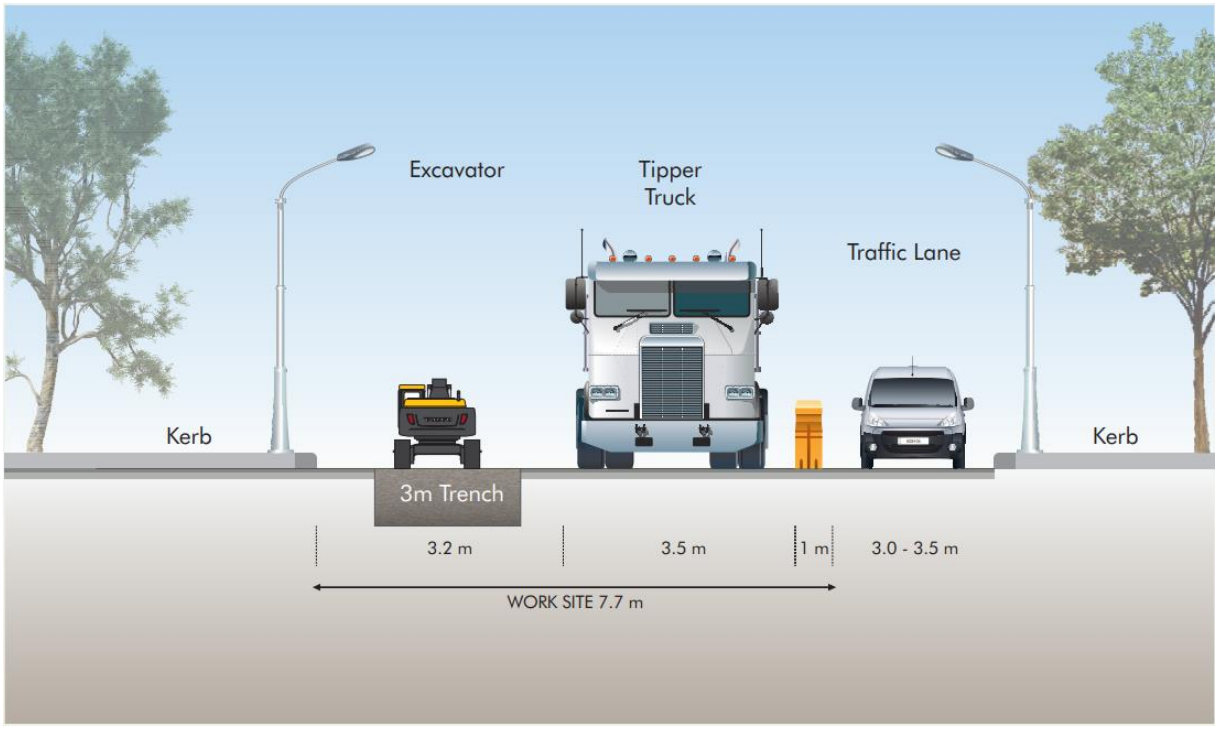


Figure 7-1 Schematic description of the kerbside trenching and excavation construction methodology
Note: This schematic description shows traffic flow maintained under shuttle working conditions. To maintain uninterrupted traffic flow an additional traffic lane would be required. The Roads and Maritime (2018) *Traffic control at work sites manual* explains that current Australian practice is to provide a minimum single lane width through or past a work site of 3 metres at traffic speeds up to 60 kilometres/hour and 3.5 metres at higher speeds.

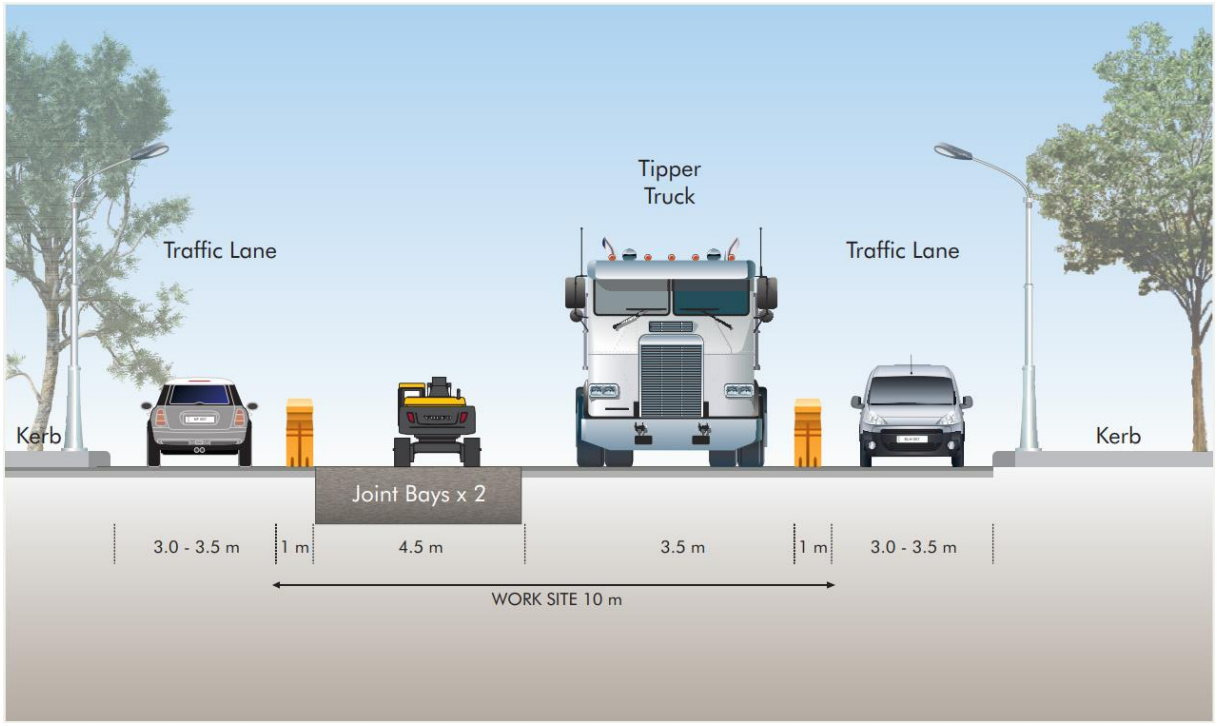


Figure 7-2 Schematic description of the non-kerbside excavation and establishment of joint bays construction methodology
Note: This schematic description shows maintenance of uninterrupted traffic flow with a lane on either side of the work site.

7.1.3.2 Substation upgrade works and construction laydown areas

A high level qualitative assessment of the substation upgrade works and construction laydown areas was undertaken for the project. This is due to the low traffic generation numbers for each substation and construction laydown area, where traffic modelling would not be sensitive to traffic volume increases of this scale. The works are proposed to be undertaken fully within the existing substation site or proposed construction laydown area, which would be located off-road, and as such are not expected to significantly impact the road, public transport or active transport networks.

7.1.3.3 Underboring

Underboring activities at special crossings would generate some disruption to local access and vehicle movements, especially where send or receive pits are located within the road reserve. However, the scale and duration of activities (i.e. generally involving an excavation for up to 10 weeks) is similar to the impacts assessed for the excavation and establishment of joint bays scenario and therefore underboring has not been assessed separately. The mitigation measures identified for the project regarding managing property access, diversions and road/lane closures, are therefore applicable to underboring activities.

7.1.4 Construction Traffic Management Plans

Once the detailed design is completed, a Construction Traffic Management Plan (CTMP) will be prepared for the project. The CTMP will outline the process to manage traffic around the work sites and construction laydown areas. This would typically include traffic modelling (where required) to assess the impacts of any proposed lane closures and/or traffic diversions, and in turn confirm the traffic management approach. The CTMP will also be supported by Traffic Control Plans (TCPs) for each work site identifying how the work site and traffic management devices will be laid out.

7.2 Existing environment

7.2.1 Road network

A road index of the roads along the transmission cable route is provided in Annexure B of the Traffic and Transport Assessment (refer to **Appendix D**). This includes an inventory of the road characteristics including road widths, speed limits, parking and bus stops.

Publicly available traffic count data was only available for a small number of the roads along the transmission cable route and traffic counts at segments of the network have not been undertaken at this stage of the assessment. This would be undertaken during detailed design and construction planning, where needed, in order for any potential impacts to network performance arising from lane closures or diversions to be assessed.

Primarily, the road network along the transmission cable route is made up of the following types of roads:

- arterial roads (state): the state road network forms the primary network of principal traffic carrying and linking routes for the movement of people and goods within the urban centres of Sydney, Newcastle, Wollongong and Central Coast, and throughout NSW. Arterial roads are controlled by Roads and Maritime;
- sub arterial roads (regional): regional roads comprise the secondary road network. They provide for travel between smaller towns and districts and perform a sub arterial function within major urban centres. Sub arterial roads are controlled by either council or Roads and Maritime and the Transport Management Centre (TMC); and
- local roads: local roads serve local or neighbourhood facilities and their primary purpose is to provide for local circulation and access to property, provide connection to the state and regional roads, and support the living environment in which they are located. Local roads are generally controlled by the local council.

A list of the road types per precinct and how they may be impacted is provided in **Table 7-5**.

7.2.1.1 Signalised intersections

All of the signalised intersections along the transmission cable route are managed by Roads and Maritime and the TMC. A list of signalised intersections along the transmission cable route is presented in **Table 7-1**.

Table 7-1 List of signalised intersections along the transmission cable route

Precinct	Signalised intersections
1	William Holmes Drive/Rookwood Road Rookwood Road/Muir Road Muir Road/Worth Street Muir Road/Hume Highway
2	Rawson Road/Waterloo Road Wangee Road/Punchbowl Road
3	Seventh Avenue/Fifth Avenue Centennial Street/Sydenham Road
4	Illawarra Road/Addison Road/Agar Street Addison Road/Enmore Road Enmore Road/Llewellyn Street Llewellyn Street/Edgeware Road/Alice Street Edgeware Road midblock crossing
5	May Street/Princes Highway

7.2.2 Public transport corridors

The project would involve work being undertaken along some public transport corridors, specifically along bus routes and in the vicinity of rail and light rail infrastructure.

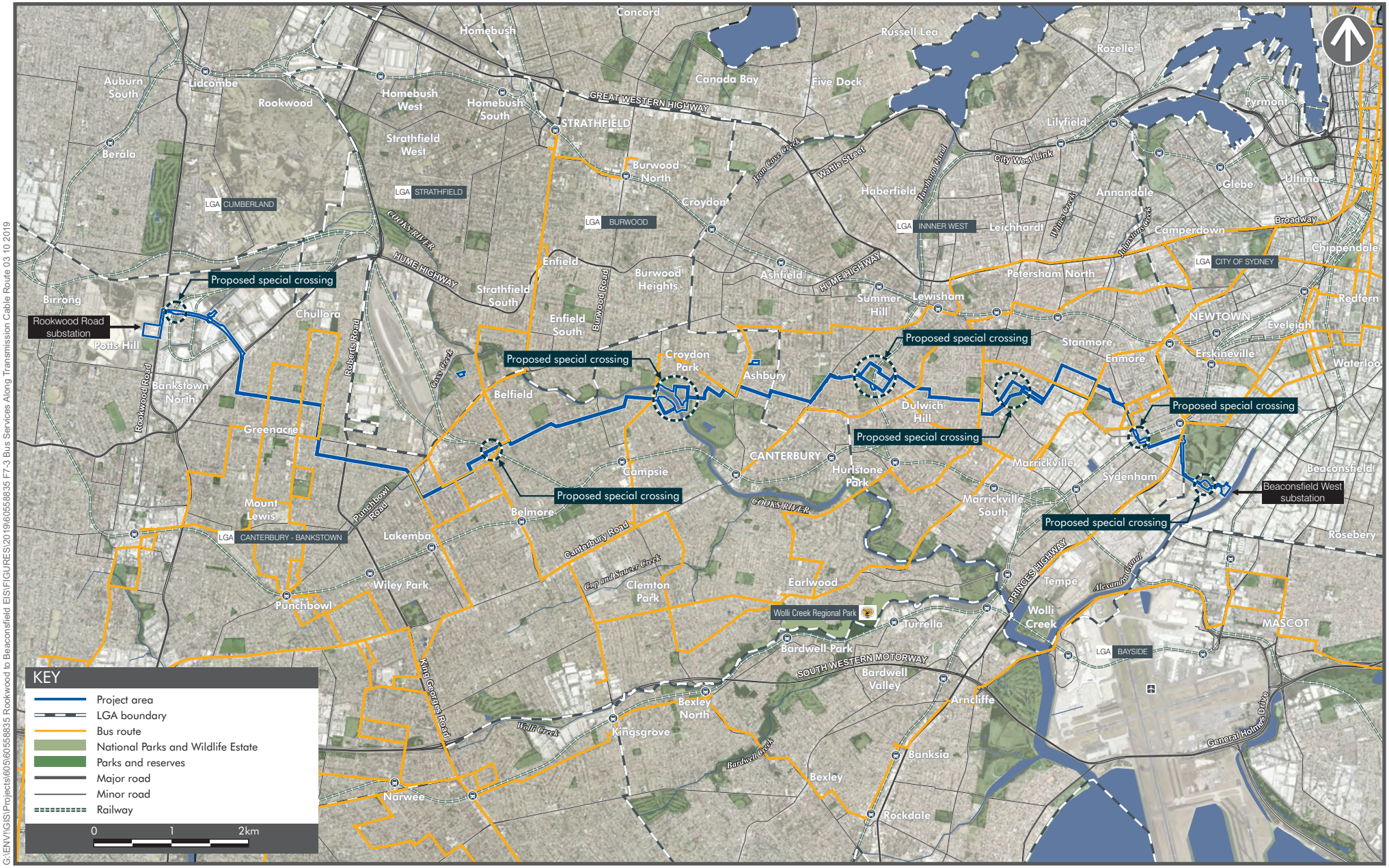
7.2.2.1 Bus routes

There are a number of bus services that utilise streets that may be impacted by the transmission cable route. These are shown in **Table 7-2**.

Table 7-2 Bus services operating along streets impacted by the transmission cable route

Bus routes		
• L23	• 410	• 450
• M30	• 412	• 491
• M92	• 413	• 913
• N40	• 415	• 914
• 308	• 422	• 925
• 352	• 423	• 939
• 355	• 426	• 941
• 406	• 428	• 942

These bus routes provide local and regional connectivity across Sydney, which include key commuter routes, accessibility to services and local amenity. These bus routes are presented in **Figure 7-3**.



G:\ENV\GIS\Projects\605\60558835 Rookwood to Beaconsfield EIS\FIGURES\2019\60558835 F7-3 Bus Services Along Transmission Cable Route 03 10 2019

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BUS ROUTES NEAR THE PROJECT AREA

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Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 7-3

7.2.2.2 Rail and light rail route

Rail and light rail services would not be impacted by underground trenching works for the transmission cable circuit. However, there are occasions where the transmission cable circuit would cross rail or light rail lines in the form of above ground cable bridges or underbores. The locations investigated for these special crossings are presented in **Table 7-4**.

Table 7-3 Rail and light rail special crossing locations investigated along the transmission cable route

Railway	Light rail
• Carter Street and Walker Street (near the Enfield Intermodal freight line • Bedwin Road – T3, T4 and T8 passenger lines	• Terry Road – L1 passenger line • Constitution Road – L1 passenger line

7.2.3 Cycle network

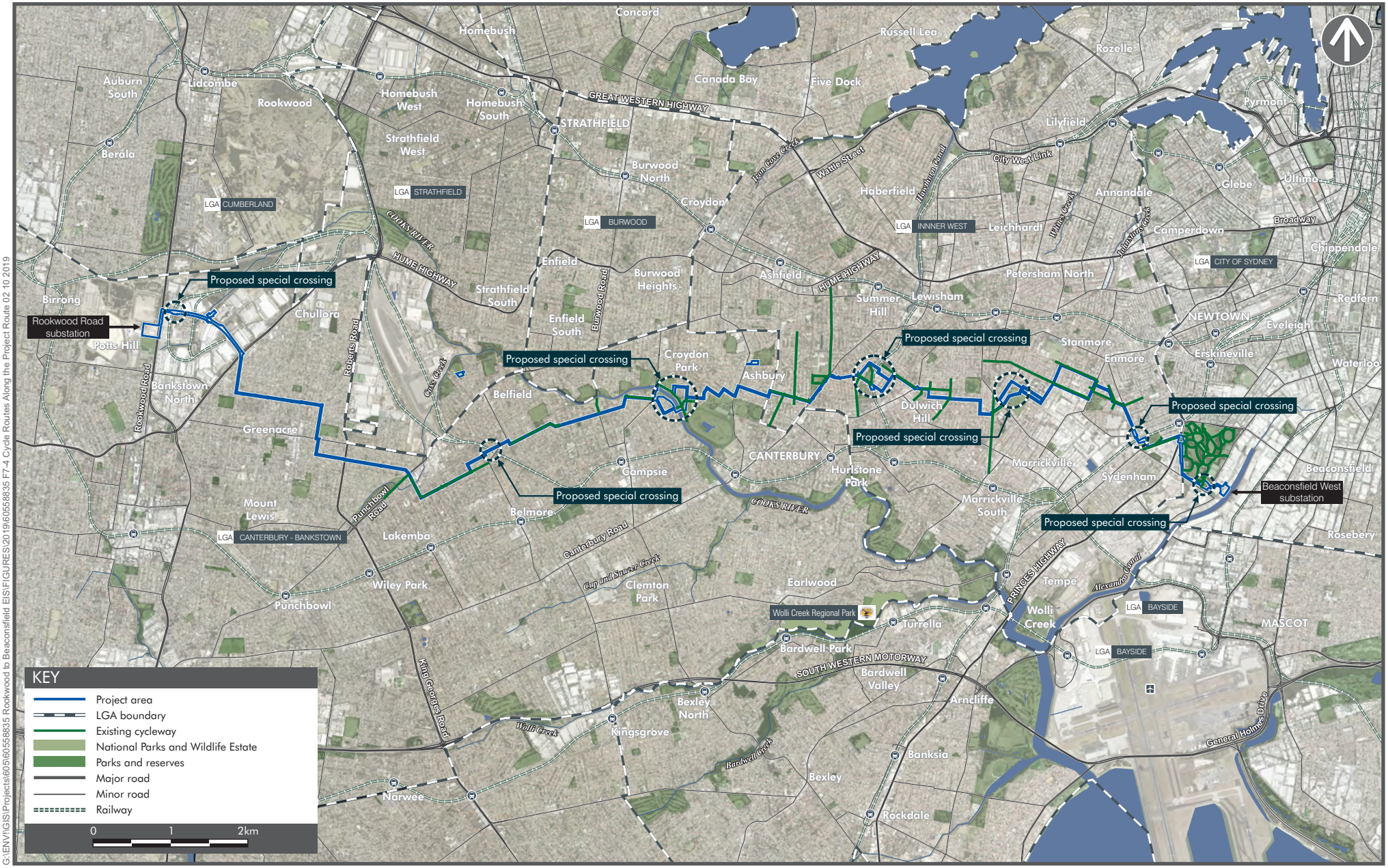
The transmission cable route crosses along some sections of the road network identified by Roads and Maritime as cycle routes. The cycle network is generally managed by local authorities. Roads and Maritime classifies cycleways into bicycle friendly roads (ranging between low, moderate and high difficulty roads), on-road cycle lanes and off-road shared paths as defined on the Roads and Maritime cycleway finder[3]. Roads along the transmission cable route that are part of the Roads and Maritime cycleways are outlined in **Table 7-4** and shown in **Figure 7-4**.

Table 7-4 Impacted roads on the Local Authority Cycleways Network

Cycleway type	Roads forming part of the Local Authority Cycleways Network
Bicycle friendly roads	• Punchbowl Road near Wangee Road (high difficulty) • Wangee Road between Punchbowl Road and Yangoora Road (moderate difficulty) • Yangoora Road between Wangee Road and Neale Street (low, moderate and high difficulty) • Omaha Street between Bruce Avenue and First Avenue (moderate difficulty) • Fifth Avenue north of Seventh Avenue (moderate difficulty) • Byron Street west of Brighton Avenue (low difficulty) • Hanks Street between Holden Street and Old Canterbury Road (low and moderate difficulty) • Pigott Street between Denison Road and New Canterbury Road (moderate difficulty) • Herbert Street between Seaview Street and Fairfowl Street (moderate difficulty) • Wardell Road near Pile Street (moderate difficulty) • Centennial Street between Petersham Road and Sydenham Road (moderate difficulty) • Newington Road between Agar Street and Enmore Road (low difficulty) • Enmore Road between Newington Road and Scouller Street (moderate difficulty) • Addison Road between Agar Street and Enmore Road (moderate difficulty) • Enmore Road between Llewellyn Street and Scouller Street (moderate difficulty) • Juliett Street between Scouller Street and Llewellyn Street (moderate difficulty) • Llewellyn Street between Juliett Street and Edgeware Road (moderate difficulty) • May Street from east of Bedwin Road to Applebee Street (low difficulty)

[3] http://www.rms.nsw.gov.au/maps/cycleway_finder

Cycleway type	Roads forming part of the Local Authority Cycleways Network
On-road cycle lanes	• None
Off-road shared paths	• Cooks River Cycleway. The Cooks River cycleway is a 30-kilometre-long shared use path for cyclists and pedestrians that is generally aligned with the Cooks River. The western terminus of the cycleway is in Settlers' Park, Ryde, while the south-eastern terminus is in Botany Bay at Kyeemagh: – a shared path linking Lindsay Street to Harmony Street across the Cooks River through Lees Park; and – a shared path from Croydon Avenue near Croydon Park, which runs along the northern side of the Cooks River and links to Lees Park. • Arlington Light Rail Station (The Greenway) • May Street between Campbell Street and Applebee Street • multiple paths through Sydney Park



G:\ENVIGIS\Projects\605\60558835 Rookwood to Beaconsfield EIS\FIGURES\2019\60558835 F7-4 Cycle Routes Along the Project Route 02 10 2019

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CYCLE ROUTES IN THE VICINITY OF THE TRANSMISSION CABLE ROUTE

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Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

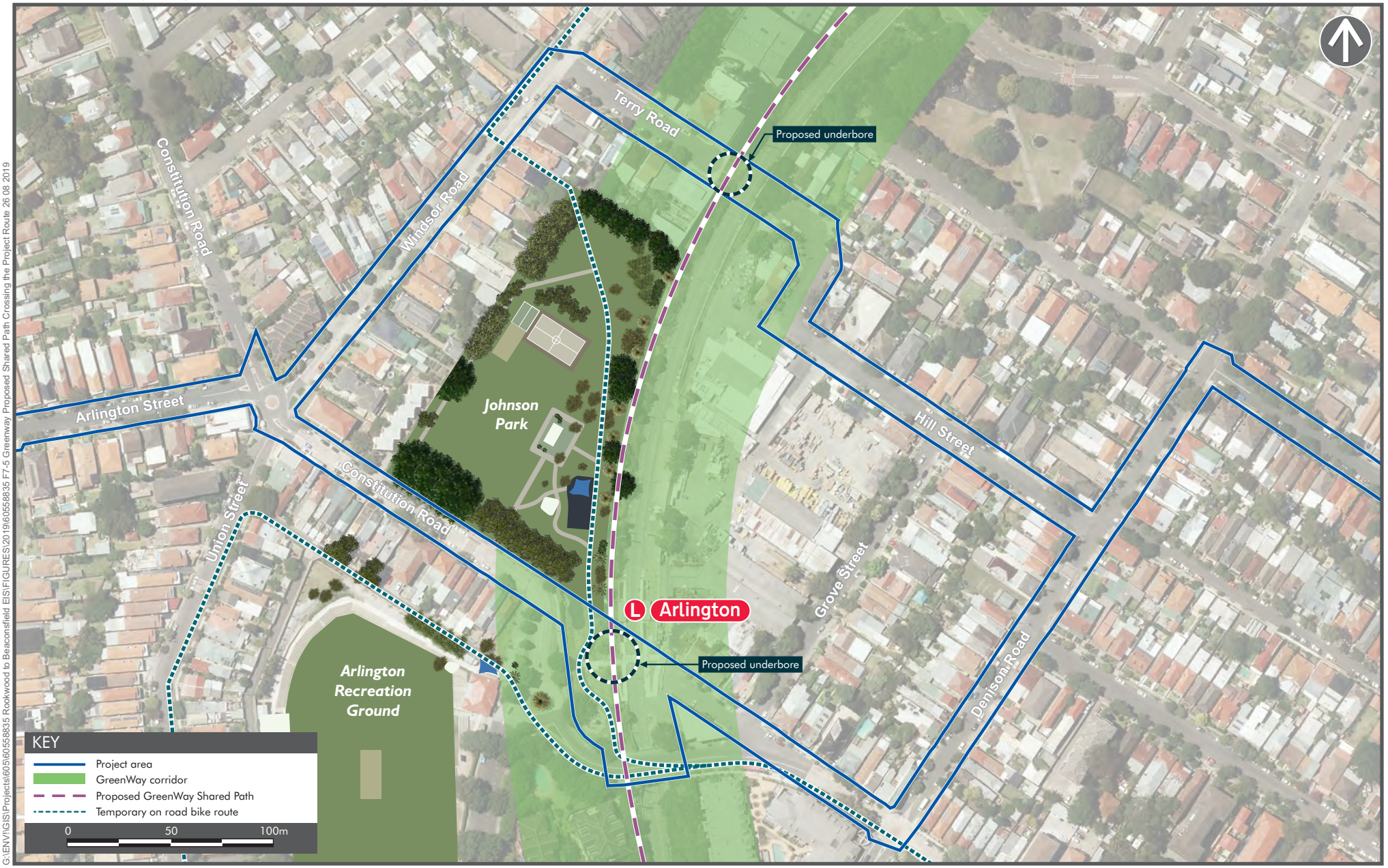
FIGURE 7-4

7.2.4 The Greenway – Cooks River to Iron Cove

The Greenway is an urban green corridor in Sydney's inner west. It is a bush corridor and hub for community arts and groups, bush care, walking and cycling and features bike paths and foreshore walks, cultural and historical sites, cafes and a range of parks, playgrounds and sporting facilities. The Greenway corridor follows the Inner West light rail corridor and Hawthorne Canal and runs from Iron Cove in the north to the Cooks River in the south, and there is currently an existing shared walking/cycle path that runs from Iron Cove to the rail bridge west of Lewisham station. The route to the Cooks River is then completed via a combination of shared paths and on-road bike routes. An existing shared walking/cycle path is provided at Johnson Park, near Arlington Light Rail Station, which crosses the project area at Constitution Road and travels along Windsor Road.

There are proposals for a new Greenway shared path along the entirety of The Greenway corridor between Iron Cove and the Cooks River (refer to **Figure 7-5**). The proposed shared path would cross the project area at Constitution Road and Terry Road.

The Greenway Master Plan was adopted by Inner West Council on 14 August 2018 and includes proposals for $57 million of works to be implemented over the long term. High priority works are anticipated to be completed by 2022 and may overlap with the anticipated construction of the project.



G:\ENVIGIS\Projects\605\60558835 Rookwood to Beaconsfield EIS\FIGURES\2019\60558835 F7-5 Greenway Proposed Shared Path Crossing the Project Route 26 08 2019

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GREENWAY PROPOSED SHARED PATH CROSSING THE PROJECT ROUTE

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Note: The project area is confined to the roadway reserve with the exception of parks and existing substations

Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018), Inner West Council (www.greenway.org.au, 2019)

FIGURE 7-5

7.3 Assessment of potential impacts

This section focuses on the assessment of potential impacts on the road including bus, rail, bicycle and pedestrian networks from the construction of the project. Potential impacts of construction traffic generated by the project and the potential for traffic impacts during project operation are also addressed. The traffic and transport assessment is based on a worst case which assumes a double circuit trench with conduits arranged in a flat formation along the entire route as this would occupy a larger area of roadway than for a trefoil conduit arrangement (further details on cable arrangements are provided in **Chapter 4 Project description**).

7.3.1 Transmission cable route

7.3.1.1 Road network

The assumptions outlined in **Appendix D** compared the required width of a work site and area required to maintain traffic flow was compared with the existing width of individual roads to determine if traffic flow can be maintained around a work site or if a diversion route would be required.

Potential lane closures and/or diversions for both kerbside and non-kerbside construction scenarios was assessed for trenching and excavation, excavation and establishment of joint bays and cable pulling and jointing construction activities.

Where the project is crossing a road, it is expected that construction works can be undertaken in stages. As such, traffic flow would be maintained.

7.3.1.1.1 Trenching and excavation – kerbside work site traffic management approach

The proposed traffic management approach for each road along the route is presented in **Table 7-5** for trenching and excavation construction activities. The table indicates that traffic flow is maintained on all state roads, with diversions required on some sections of the regional and local road network. The information presented is based on the kerbside scenario only, which is intended to reflect a realistic assessment of the likely traffic management approach (assuming there are no technical constraints in the roadway).

Table 7-5 Summary of traffic management approach for each road along the transmission cable route

Precinct	Road name	Classification	Minimum road width (m)	Traffic management approach for trenching and excavation
Precinct 1	William Holmes Street	Local Road	9	Diversions required
	Rookwood Road	State Road 190	23	Traffic flow maintained
	Muir Road	Local Road	20	Traffic flow maintained
	Hume Highway*	State Road 2	23	Traffic flow maintained
Precinct 2	Hillcrest Avenue	Local Road	11	Diversions required
	Rawson Road (between Hillcrest Avenue and Waterloo Road)	Local Road	10.5	Diversions required
	Waterloo Road*	Regional Road 7118	12	Traffic flow maintained
	Rawson Road (between Waterloo Road and Maiden Street)	Local Road	10	Diversions required
	Maiden Street	Local Road	9	Diversions required
	Juno Parade (between Maiden Street and Acacia Avenue)	State Road 636	12.5	Traffic flow maintained
	Acacia Avenue	Local Road	10.5	Diversions required
	Wangee Road (between Acacia Avenue and Roberts Road)	Local Road	9.5	Diversions required
	Roberts Road*	State Road 200	24	Traffic flow maintained
	Wangee Road (between Roberts Road and Skyline Street)	Local Road	10.5	Diversions required
	Wangee Road (between Skyline Street and Punchbowl Road)	Local Road	10.5	Diversions required
	Punchbowl Road*	State Road 549	19.5	Traffic flow maintained
	Wangee Road (between Punchbowl Road and Yangoora Road)	Local Road	12	Traffic flow maintained
	Yangoora Road (between Wangee Road and Neale Street)	Local Road	9.5	Diversions required
	Neale Street	Local Road	10.5	Diversions required
	Lucerne Street (between Neale Street and Knox Street)	Local Road	11.5	Traffic flow maintained
	Knox Street	Local Road	12	Traffic flow maintained
	Walker Street (east of Knox Street)	Local Road	9	Diversions required
	Carter Street (west of Burwood Road)	Local Road	11	Traffic flow maintained
	Burwood Road (between Carter Street and Bruce Avenue)	Regional Road 7047	11	Diversions required
	Bruce Avenue*	Local Road	12.5	Traffic flow maintained
	Omaha Street (between Bruce Avenue and First Avenue)	Local Road	12	Traffic flow maintained

Precinct	Road name	Classification	Minimum road width (m)	Traffic management approach for trenching and excavation
	Seventh Avenue (between First Avenue and Fifth Avenue)	Local Road	10.5	Diversions required
	Fifth Avenue*	Regional Road 7067	12	Traffic flow maintained
	Seventh Avenue (between Fifth Avenue and Beamish Street)	Local Road	10.5	Diversions required
	Beamish Street	Local Road	10.5	Diversions required
	Byron Street (between Beamish Street and Brighton Avenue)	Local Road	10.5	Diversions required
Precinct 3	Option 2: Croydon Avenue (east of Dunstan Street)	Local Road	18	Traffic flow maintained
	Option 2: Dunstan Street (between Croydon Avenue and Hay Street)	Local Road	12.5	Traffic flow maintained
	Option 2: Hay Street	Local Road	12	Traffic flow maintained
	Option 1: Cowper Street (between Brighton Avenue and Lindsay Street)	Local Road	12	Traffic flow maintained
	Option 1: Lindsay Street	Local Road	12	Traffic flow maintained
	Harmony Street (between Hay Street and Malleny Street)	Local Road	12.5	Traffic flow maintained
	Malleny Street	Local Road	12.5	Traffic flow maintained
	Cheviot Street (between Malleny Street and Roslyn Street)	Local Road	12.5	Traffic flow maintained
	Roslyn Street (between Cheviot Street and King Street)	Local Road	12	Traffic flow maintained
	King Street	Regional Road 2040	12	Traffic flow maintained
	Second Street (between King Street and Holden Street)	Local Road	10	Diversions required
	Holden Street	Local Road	12	Traffic flow maintained
	Hanks Street (between Holden Street and Old Canterbury Road)	Local Road	12	Traffic flow maintained
	Old Canterbury Road	State Road 652	12.5	Traffic flow maintained
	Arlington Street (between Old Canterbury Road and Constitution Road)	Local Road	10	Diversions required
	Option 4b: Constitution Road (between Windsor Road and west of the rail corridor)	Local Road	9	Diversions required
	Option 4a: Windsor Road	Local Road	10	Diversions required
	Option 4a: Terry Road (between Windsor Road and west of the rail corridor)	Local Road	12.5	Traffic flow maintained
	Option 4b: Constitution Road (East of the rail corridor and west of Grove Street)	Local Road	10	Diversions required

Precinct	Road name	Classification	Minimum road width (m)	Traffic management approach for trenching and excavation
	Option 4b: Constitution Road (between Grove Street and Denison Road)	Local Road	10	Diversions required
	Option 4b: Denison Road (between Constitution Road and Hill Street)	Local Road	10	Diversions required
	Option 4a: Hill Street (east of the rail corridor and west of Denison Road)	Local Road	9	Diversions required
	Denison Road	Local Road	10	Diversions required
	Pigott Street (between Denison Road and New Canterbury Road)	Local Road	9.5	Diversions required
	New Canterbury Road*	State Road 167	12.5	Traffic flow maintained
	Herbert Street (between New Canterbury Road and Fairfowl Street)	Local Road	12	Traffic flow maintained
	Fairfowl Street	Local Road	5.5	Diversions required
	Pile Street (between Fairfowl Street and Livingstone Road)	Local Road	12	Traffic flow maintained
	Livingstone Road	Local Road	12.5	Traffic flow maintained
	Hawkhurst Street	Local Road	12.5	Traffic flow maintained
	Centennial Street	Local Road	8	Diversions required
	Sydenham Road	State Road 664	12.5	Traffic flow maintained
	Option 5b: Neville Street (between Sydenham Road and Surrey Street)	Local Road	7	Diversions required
	Option 5b: Surrey Street	Local Road	7	Diversions required
	Option 5b: Charles Street	Local Road	12.5	Traffic flow maintained
	Option 5a: Centennial Street (east of Sydenham Road)	Local Road	12.5	Traffic flow maintained
	Option 5a: Amy Street (south of Horton Street)	Local Road	12.5	Traffic flow maintained
	Option 5a: Horton Street	Local Road	12.5	Traffic flow maintained
	Option 5a: Illawarra Road (between Horton Street and Charles Street)	Local Road	9	Diversions required
Precinct 4	Illawarra Road (north of Charles Street)	Local Road	9	Diversions required
	Option 6b: Addison Road	Regional Road 7018	10.5	Traffic flow maintained
	Option 6a: Agar Street	Local Road	9	Diversions required
	Option 6a: Newington Road (between Agar Street and Enmore Road)	Local Road	6.5	Diversions required

Precinct	Road name	Classification	Minimum road width (m)	Traffic management approach for trenching and excavation
	Option 6b: Enmore Road (between Newington Road and Scouller Street)	Regional Road 2021	13	Traffic flow maintained
	Option 6b: Addison Road	Regional Road 7018	10.5	Diversions required
	Option 6b: Enmore Road (between Addison Road and Scouller Street)	Regional Road 2021	12.5	Traffic flow maintained
	Scouller Street	Local Road	12.5	Traffic flow maintained
	Juliett Street	Local Road	12	Traffic flow maintained
	Llewellyn Street	Regional Road 7018	12	Traffic flow maintained
	Edgeware Road (between Llewellyn Street and south of Darley Street)	Regional Road 7017	12	Traffic flow maintained
Precinct 5	May Street (west of Campbell Street to Princes Highway)	Regional Road 2099	12[1]	Traffic flow maintained
	Princes Highway*	State Road 1	21	Traffic flow maintained
	Barwon Park Road	Local Road	12.5	Traffic flow maintained
	Euston Road*	Local Road	12	Traffic flow maintained
	Burrows Road	Local Road	12	Traffic flow maintained

Notes:
1 The width of the western end of May Street near Bedwin Road is currently under construction. At the time of preparation of this report, it is unknown what the final width of the road will be at this location. As such, the narrowest road width of May Street, excluding the construction zone has been taken for the purpose of this assessment.
* The transmission cable route only crosses these roads. The crossing works would be done in stages to maintain traffic flow.

The assumptions used represent a conservative or worst case assessment, which considered the narrowest 'pinch-point' along each road, the typical maximum width of a work site, and the required available space for vehicles to pass (including buses where the work site is located along a bus route). As there is a degree of conservatism built into the assessment, the actual impacts from the project on the road network are expected to be less than those presented below. As a conservative assessment, the outcome of the assessment also assumed buses would not be diverted. A summary of the percentage of local, regional and state roads where traffic flow is likely to be maintained or where diversions may be required are illustrated in **Figure 7-6**.

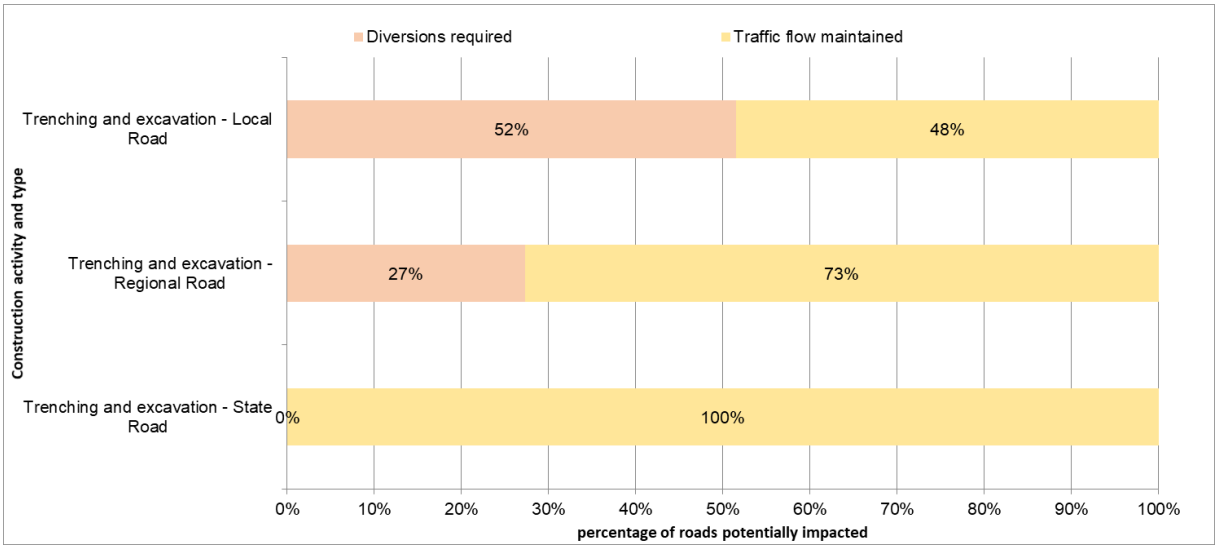


Figure 7-6 Summary of traffic management approaches during trenching and excavation

7.3.1.2 Trenching and excavation – non-kerbside work site traffic management approach

At locations where the trenching and excavation cannot be completed at the kerbside, the non-kerbside construction methodology would be used. Under this scenario, the work site would likely be located close to the centre of the carriageway, and if possible, traffic would be diverted along either side of the work site. This would only be possible on roads that are between 14.7 and 15.7 metres wide, as a minimum. The majority of the roads along the route are narrower than this, and therefore it is probable that for a flat conduit arrangement, more diversions would be required than those presented in **Table 7-5**.However, the non-kerbside scenario would only apply at locations where kerbside construction is not feasible.

7.3.1.2.1 Excavation and establishment of joint bays - work site traffic management approach

Joint bays are generally required to connect two sections of transmission cable circuit. It is anticipated that joint bays would be located approximately every 600-800 metres along the transmission cable route and as such not all roads would be impacted by joint bay construction works. The location of the joint bays have not yet been confirmed, and therefore more detailed impacts from the excavation and establishment of joint bays will be assessed during the detailed design stage on a site by site basis.

In summary, the required work site width for this construction activity is wider than for trenching and excavation construction activities. Therefore, it is likely that where joint bays are required along local and regional roads, it is probable that more diversions would be required than those presented in **Table 7-5**. However, as the joint bays would be located approximately every 600-800 metres, the number of roads likely to be impacted would be significantly less.

It is anticipated that where joint bays are required along the state road network, all of these roads along the transmission cable route would be able to maintain traffic flow based on the dimensions presented in **Table 7-5**.

7.3.1.2.2 Cable pulling and jointing - work site traffic management approach

Cable pulling construction activities would occur at joint bays. As the location of the joint bays have not yet been confirmed, a more detailed assessment of impacts of the cable pulling and jointing activities will be assessed during the detailed design stage on a site by site basis.

In summary, the required work site width for this construction activity is narrower than for trenching and excavation construction activities. Therefore, where cable pulling and jointing construction activities are required along local and regional roads, it is probable that less diversions would be required than those presented in **Table 7-5**. In addition, as the joint bays would be located approximately every 600-800 metres, the number of roads likely to be impacted would be significantly less.

It is anticipated that where joint bays are required along the state road network, all of these roads along the transmission cable route would be able to maintain traffic flow based on the dimensions presented in **Table 7-5**.

7.3.1.2.3 Summary of potential impacts on the road network

Table 7-6 categorises the potential impacts resulting from any proposed lane closures and diversions required along the transmission cable route.

Table 7-6 Summary of proposed road and/or lane closures and potential impacts

Traffic management approach	Potential mid-block impacts
Lane closures while retaining a two-way traffic flow arrangement	• reduced network mid-block capacity[4] • delays in travel time • increased traffic queues • temporary loss of on-road parking • reduced speed limits • traffic controllers present on-site • potential for works outside of standard construction hours • delays to property access
Lane closures that reduce traffic flow to shuttle working arrangement that requires traffic control to operate	• temporary loss of on-road parking • reduced speed limits • traffic controllers present on-site • potential for works outside of standard construction hours • delays to property access • traffic queues on either side of the work site • potential diversions of bus routes
Diversion routes	• temporary loss of on-road parking • reduced speed limits • traffic controllers present on-site • potential for works outside of standard construction hours • delays to property access • diversion routes required • possible reduction in network performance along diversion route

Where diversion routes or lane closures are required, these would only be in operation for short sections of the local road network at any one time. This would be confirmed during detailed design and may reduce the proposed number of diversions and roads operating under shuttle working conditions. Should diversion routes be required at locations that experience significant through traffic, this would likely be restricted to outside of standard construction hours or off-peak times to minimise disruption.

Decisions on proposed route diversions would be made in consultation with relevant road authorities and public transport service providers during the detailed design and construction planning stage. Where diversion routes are required for local roads, consultation with residents will be undertaken in

[4] Mid-block capacity refers to traffic volumes on sections of roads between intersections.

accordance with the Community Consultation Framework (CCF) (refer to **Appendix C**), to ensure they are notified of potential impacts.

Local access to properties would be maintained wherever possible. However, where access cannot be maintained, affected landowners/occupants would be given prior notice and an opportunity to discuss solutions for their specific location (refer to **Section 7.3.1.10**)

A quantitative assessment of the likely impacts on network performance has not been undertaken at this stage of the project. This would occur after the detailed design where each work site would be included in the CTMP. The CTMP would outline the proposed methodology for managing traffic flow around the work site and mitigation measures to reduce any potential impacts, including the preparation of a TCP. A detailed assessment of the traffic impacts would be undertaken at this time, which would consider traffic modelling and mid-block capacity assessments (where required) to identify the potential impacts of lane closures and proposed diversion routes.

During construction planning, alternative construction methodologies and traffic management approaches to those outlined in the traffic and transport assessment would be considered to identify additional measures that may reduce traffic impacts. Management and mitigation measures are discussed further in **Section 7.4**.

7.3.1.3 Works at intersections

Works at intersections, including signalised intersections, priority give way intersections and roundabouts would likely require road and/or lane closures. Lane closures would allow the intersection to continue to operate, however at a reduced capacity. Road closures would close the intersection and diversion routes would be required. Resulting potential impacts from works at intersections is summarised in **Table 7-7**.

Table 7-7 Summary of potential impacts resulting from the traffic management approaches

Traffic management approach	Potential intersection impacts
Works at signalised intersections	• Road Occupancy Licence (ROL) application approved by TMC • reduced intersection capacity • increased traffic queues • temporary loss of on-road parking • potential for works outside of standard construction hours • reduced speed limits • delays to property access • traffic controllers present on-site
Works at priority intersections/roundabouts	• intersection closures if roads have multiple access points, with diversion routes required • access maintained at single access points under shuttle working conditions • reduced intersection capacity • increased traffic queues • temporary loss of on-road parking • potential for works outside of standard construction hours • delays to property access • traffic controllers present on-site

Generally, intersections on local roads (priority give way and roundabouts), have lower traffic volumes and are not used heavily during network peak hours. Therefore, impacts can generally be managed through traffic management and diversion routes and the impacts are not predicted to be significant.

Works at signalised intersections represent a more complex management approach as signalised intersections have capacity constraints and impacts could therefore be more significant. Signalised intersections are managed by the TMC and would require consultation to schedule works outside of peak network operations, which is generally outside of standard construction hours. Therefore, works

at signalised intersections are likely to be restricted to outside of standard working hours, which would reduce the number of road users likely to be affected and avoid impacts to peak time network performance.

7.3.1.4 Bus routes

The majority of the bus routes would continue to operate uninterrupted with minor temporary amendments to the location of the bus stops when the construction works are near a bus stop. However, some bus routes may need to be diverted due to instances where roads are too narrow for a bus to pass when construction works are in progress.

Potential impacts from a temporary bus stop relocation and/or bus route diversion could include increased walking distance to a bus stop, temporary changes to timetables and increased journey time. The extent and significance of the impacts of relocating a bus stop will depend on how far each bus stop needs to be relocated (which is currently not confirmed and will be determined during detailed design in consultation with the relevant bus operators).

Table 7-8 presents the roads that contain bus stops and the likely impact to the bus route during trenching and excavation. In all cases, consultation with Transport for NSW (TfNSW) and the bus operators would be required in advance to ensure the successful diversion of routes and relocation of bus stops as and when required in accordance with the construction program.

Where possible, diversion routes for buses will be signposted to reduce the impacts on bus services. It is noted that impacts would be temporary and existing arrangements (including bus stop locations) would be reinstated upon completion of site-specific construction activities.

TransGrid would work with TfNSW and bus operators to ensure that sufficient lead time and comprehensive public notification, regarding changes to bus stops and services, and alternative arrangements are in place to minimise disruption and provide smooth transitions during changes and when original arrangements are reinstated.

Table 7-8 Summary of potential impacts along bus routes

Precinct	Street name	Bus routes	Trenching and excavation
Precinct 1	Rookwood Road	M92	Relocate bus stop
	Muir Road	925	Relocate bus stop
	Hume Highway	925	Relocate bus stop
Precinct 2	Hillcrest Avenue	913, 941	Divert bus route
	Maiden Street	941	Divert bus route
	Rawson Road (between Waterloo Road and Maiden Street)	941	Divert bus route
	Wangee Road (between Acacia Avenue and Roberts Road)	914	Divert bus route
	Yangoora Road (between Wangee Road and Neale Street)	450	Divert bus route
	Burwood Road (between Carter Street and Bruce Avenue)	415	Relocate bus stop
	Seventh Avenue (between First Avenue and Fifth Avenue)	942	Relocate bus stop
	Seventh Avenue (between Fifth Avenue and Beamish Street)	410, 942	Divert bus route
Precinct 3	Roslyn Street (between Cheviot Street and King Street)	413	Relocate bus stop
	King Street	413, 491	Relocate bus stop
	Old Canterbury Road	406	Relocate bus stop
	Livingstone Road	412, 428	Relocate bus stop
	Centennial Street	428	Relocate bus stop
Precinct 4	Enmore Road	355, 423, 426, 428, M30, N40 L23	Relocate bus stop

Precinct	Street name	Bus routes	Trenching and excavation
	Addison Road	428	Divert bus route
	Edgeware Road (between Llewellyn Street and south of Darley Street)	308, 352	Relocate bus stop

7.3.1.5 Rail and light rail

Impacts to rail and light rail services are associated with the construction of special crossings, either via underboring or installation of a cable bridge. Impacts would be minimised through consultation with rail authorities.

Where rail authorities deem that a track shut down is required for the works to be undertaken, it is proposed to align construction works with scheduled rail maintenance days or during the night where possible. As such, it is expected that there would be minimal impacts to rail (passenger or freight) and light rail services.

7.3.1.6 Bicycle routes

7.3.1.6.1 Bicycle-friendly roads

Where the transmission cable route is located along bicycle-friendly roads (which do not have dedicated bicycle lanes), cyclists would follow the same diversion routes as vehicles (if required). As such, it is anticipated that consideration would be given during the diversion route selection process to include bicycle-friendly roads in order to ensure cycling connectivity and safety is maintained. Provided the affected roads remain open for traffic, cyclists would still be able to use these routes, subject to traffic control. However, as with general traffic conditions, there is the potential for increased journey times due to changes in road conditions under traffic control, which may temporarily discourage cyclists from using affected sections of the transmission cable route.

Traffic control measures, including cyclist safety, would be managed through the CTMP.

7.3.1.6.2 Dedicated cycling lanes

Dedicated cycling lanes are generally provided on-carriageway and are signposted and delineated by line-marking. The transmission cable route is not expected to impact any dedicated on-road cycling lanes.

7.3.1.6.3 Separate dedicated cycleways

Separate dedicated cycleways are provided away from the carriageway, where cyclists have priority. These are generally provided as lanes within the carriageway and separated by a median strip, or as shared pedestrian/cycle paths along the footpath. This cycling infrastructure would be managed so that cycle access is maintained at all times by either keeping the cycleway clear of obstruction or providing a diversion route. The sections of the cycleway network likely to be impacted are:

- Cooks River Cycleway at Croydon Park and Lees Park (shared path);
- Johnson Park at Arlington Light Rail Station (temporary path and future Greenway shared path);
- May Street between Campbell Street and Applebee Street (shared path); and
- multiple shared paths through Sydney Park.

The construction period for the southern section of the Greenway shared path from Parramatta Road through Lewisham West and Dulwich Hill is planned for completion in 2021[5]. This may overlap with the anticipated construction of the project. Consultation with Inner West Council would be ongoing during project construction in this location. The project includes two options for underboring in the vicinity of the future Greenway shared path near the light rail corridor. This is at Constitution Road, south of Johnson Park and Terry Road to the north of the park (refer to **Figure 7-5**). Should the Greenway

[5] https://www.greenway.org.au/about

shared path be operational at the time of project construction, temporary diversion of a small section may be required during the 8 - 10 week period required for underboring under the rail corridor, however all efforts would be made to ensure access is maintained by locating the send and receive pits for the underbore away from the shared path. Similarly, should the Greenway shared path not be operational at the time of project construction in this location, construction works are unlikely to impact users of the existing temporary shared path through Johnson Park.

If required, sections of the existing shared path would potentially be closed for up to 8 – 10 weeks but an alternative shared path would be provided. This could be through identifying a suitable diversion along existing roads and providing signposting, or if the alternative route is too onerous in terms of distance or grade for example, a temporary surface may be provided around the work site. However, the shared path would be reinstated after the completion of the construction works. Further detail on the construction management approach would be detailed in the CTMP for the project.

The cycleway on May Street is provided along the southern footpath as a shared pedestrian/cycle path, which is separate from the carriageway. It is anticipated that generally the works would be undertaken within the channels of the carriageway, so it is not expected that this cycleway would be impacted. However, if works are required within the shared path, a diversion route would be signposted for cyclists, which may involve using the carriageway on May Street or an alternative diversion route.

The cycleway through Sydney Park is a dedicated off-road cycleway. Some parts of the cycleway would be impacted during construction but would be reinstated as soon as possible to minimise disruption to the cycleway. However, in all instances an alternative cycle route within the park would be signposted for cyclists with prior warning provided to guide them around work sites. There are multiple cycle routes within the park which allows for internal diversions to occur as the cycle paths would not be closed simultaneously. Further detail on the management arrangements for cyclists at this location would be prepared during the detailed design stage, in consultation with the relevant local council and identified in the CTMP.

7.3.1.7 Pedestrian routes

Where works are required within the footpath, a diversion around the work site would be required. Generally, as stated in the *Guide to Road Design Part 3* (Austroads, 2016), the desirable minimum width of a footpath is 1.2 metres. These widths should be increased where high pedestrian volumes are anticipated, on a shared path, or where the footpath is to cater for people with disabilities. As such, provided that there is a minimum of 1.2 metres along one side of the work site, pedestrians can be diverted while continuing to remain on the footpath. Where this minimum width cannot be achieved, pedestrians would need to be diverted onto the opposite footpath prior to the work site at an appropriate crossing location (generally at a marked pedestrian crossing or at a signalised intersection) or be diverted onto the carriageway. Carriageway diversions would be managed through the CTMP and relevant TCPs prepared to safely allow pedestrians to pass the work site on the carriageway. This would further require road side parking to be prohibited, and part of a traffic lane closed to achieve this. However, pedestrians cannot be diverted on to the carriageway along roads with high speed and/or traffic volumes. Local pedestrian access to properties would be maintained at all times.

Generally, provided adequate traffic management and/or diversion routes are available, the impacts to pedestrians would be negligible as pedestrian routes would be maintained at all times throughout the construction of the project.

7.3.1.8 Car parking

On-road parking along the transmission cable route would need to be temporarily restricted for the duration of works at specific work sites, to ensure that the work site remains clear for construction to occur. Depending on the width of the carriageway, parking on one or both sides of the carriageway may need to be temporarily restricted for the duration of localised works to ensure that there is sufficient width for the work site and for through traffic to pass.

A 20 metre long trench would generally require a work site of between 55-95 metres depending on the speed of the road. Each work site may result in restrictions to on-road parking, however this would be temporary. The duration that a typical work site would be in use depends on the nature of the

construction activity (refer to **Chapter 4 Project description** for the indicative duration for construction activities).

The design of temporary 'no stopping' restrictions would be undertaken during the detailed design stage and mitigation measures outlined in the CTMP. Furthermore, consultation would be undertaken with the relevant road authorities and affected residents.

In addition, the transmission cable route follows a path through the western car park at Sydney Park. The section of the car park to the south of May Street would be closed for the duration of the construction works in this location. The car park contains around 83 car parking spaces, and during construction 19 of these car parking spaces in the area to the north of May Street would be able to remain open provided sufficient access/egress can be managed. The remainder of the car parking spaces would be closed. Alternative parking would still be available at the northern car park, accessed from Sydney Park Road. During works at this location, some users of the car park would need to find alternative parking arrangements potentially adding to the demand for on-road parking on nearby roads. However, impacts would be temporary and existing parking arrangements would be re-instated upon completion of construction works at this location.

7.3.1.9 Road safety

There would be an increase in the number of construction vehicles and multiple work sites along the transmission cable route during the construction program. All traffic management controls implemented along the transmission cable route would be designed and implemented by suitably qualified technicians in accordance with the *Traffic control at work sites manual* (Roads and Maritime, 2018). Furthermore, the proposed traffic management approaches would be subject to the road safety audit process, which would occur during the construction planning stage of the project. A specially trained road safety auditor would provide commentary on the proposed traffic management approach and identify any areas of risk. Therefore, it is not anticipated that the increase in construction vehicle volumes and work sites would have detrimental impacts on road safety.

7.3.1.10 Property and local access

In principle, vehicle access to residences and businesses would be retained throughout construction. However, while driveways of private properties would be avoided wherever possible, it is likely that there will be some disruptions to access during activities such as trenching, joint bay establishment and cable jointing. During trench and joint bay excavations, affected landowners/occupants would be given prior notice about the anticipated access disruptions. Consultation would occur with affected property occupants, in accordance with the CCF (refer to **Appendix C**), to identify appropriate timeframes for restricting access.

When cable jointing is occurring at joint bays near driveways, access to these properties would not be possible. Jointing could take up to three weeks. Affected owners/occupants would be informed and reasonable and reasonable solutions for access to their specific location discussed.

Access for emergency service vehicles would be maintained at all times. Access for waste collection would be arranged with the local waste collection agency. The contractor will relocate bins to a suitable area for collection that is accessible by the waste collection agency and does not obstruct the work site.

7.3.1.11 Night works and off-peak works

Works that could be required outside of standard construction hours are at work sites that contain signalised intersections or along strategic and busy sections of the arterial and sub arterial road network. This would be required if TMC imposes this a requirement, where works are proposed that would impact the performance (especially during peak periods) of its network assets. Working outside of standard construction hours would allow the impacts of the proposed works to be mitigated by working at a time where road network demand is at its lowest, and the impact of lane closures or diversions can be accommodated within the surrounding road network.

Furthermore, should diversion routes be required along strategic local roads that experience significant through traffic, the construction activity would likely be restricted to outside of standard construction hours or off-peak times to minimise disruption. The implementation of proposed diversion routes would be made in consultation with the relevant road authority and other stakeholders as

required. Where diversion routes are required on local roads, consultation with residents will be undertaken in accordance with the CCF, to ensure they are informed of potential impacts. Where access to a property cannot be guaranteed, consultation would be undertaken with affected property occupiers to identify appropriate timeframes for restricting access, or to negotiate an alternative solution.

7.3.2 Construction vehicle traffic generation

7.3.2.1 Vehicle classification

The largest heavy vehicle that would require access to a work site would generally be a 19 metre truck and dog trailer, which would transport spoil from the work site. There would be a variety of different vehicle types used on-site depending on their function, including small and medium rigid vehicles and 10 tonne tipper trucks.

7.3.2.2 Heavy vehicle routes

Generally, heavy vehicles would use the arterial road network to travel to/from the work sites and construction laydown areas and would avoid using local residential roads, where possible. It is likely that heavy vehicles would follow the routes classified as heavy vehicle routes by Roads and Maritime, which includes bus routes, where possible, as these routes are already designed to accommodate the turning paths of heavy vehicles. Detailed turning path analysis would be undertaken when the CTMP is prepared for the project to ensure that the vehicles can complete the required turning movements along the nominated route to/from the work site or construction laydown area. If the desired vehicle type cannot be accommodated on the nominated route, smaller vehicles would be required.

7.3.2.3 Traffic generation

Construction activities would generate a number of vehicle trips across the project area. Standard working hours have been assumed for the duration of works at the various work sites for the purposes of a worst case assessment as they include the peak traffic periods (7:00 am - 9:00 am and 4:00 pm - 6:00 pm during weekdays). The following section describes the forecast construction traffic generation impacts at the work sites, substations and construction laydown areas.

Construction at transmission cable route work site

It is forecast that up to four work sites would be in operation at any time along the route during trenching and excavation and joint bay excavation. Each work site is expected to generate in the region of four light vehicle trips and 24 heavy vehicle trips per day. All heavy vehicle trips (for the transportation of spoil and construction materials) are not expected to occur within the network peak hour and it is therefore assumed that during the network peak hour, only around eight combined light and heavy vehicle trips would be generated. This would represent a trip rate of one trip every seven and a half minutes for each work site. Net traffic volume increases of such a low order are not expected to have a material impact on the operation or performance of the surrounding road network.

Construction works at substations

It is forecast that works could occur simultaneously at each of the three substations, located at Rookwood Road, Beaconsfield West and Sydney South. The forecast traffic generation for each of the work sites is presented in **Table 7-9**.

Table 7-9 Summary of substation trip generation and access/egress driveways

Substation	Number of vehicle trips per day	Driveway location
Rookwood Road	Light vehicles: 3-4 Heavy vehicles: 4	William Holmes Street
Beaconsfield West (site also identified as a construction laydown area)	Light vehicles: 3-4 Heavy vehicles: 12	Burrows Road
Sydney South	Light vehicles: 5-6 Heavy vehicles: 6	Henry Lawson Drive

If the expected daily trip generation occurred during the network peak hour, this would represent a trip rate of one trip every seven and a half minutes at Rookwood Road substation, one trip every four minutes at Beaconsfield West substation, and one trip every five minutes at Sydney South substation. Net traffic volume increases of such a low order are not expected to have a material impact on the operation or performance of the surrounding road network.

Construction works at laydown areas

Five construction laydown areas have been assessed in the project area. It is assumed that they are in operation at the same time, for the duration of the construction period (up to two years). Each construction laydown area is expected to generate in the region of about four light vehicle trips and twelve heavy vehicle trips per day. If the expected daily trip generation occurred during the network peak hour (AM or PM as a worst case scenario and unlikely to occur), this would represent a trip rate of around one trip every four minutes over the network peak hour. Net traffic volume increases of such a low order are not expected to have a material impact on the operation or performance of the surrounding road network.

It is anticipated that the traffic impacts from the traffic generated by construction activities would be able to be accommodated within the surrounding road network, with relatively low traffic volumes expected to be generated by the work sites, substation sites and laydown areas during peak hours. It is noted that the location of the work sites, construction laydown areas and substations are distributed across the project area. Although multiple construction activities are expected to be undertaken simultaneously, the impacts of the construction activities would also be distributed across the network depending on the location of construction.

7.3.2.4 Workforce parking

In general, workers would be encouraged to use public transport to reduce the demand for parking on local roads. Requirements for on-road parking on local roads would be managed by the construction contractor. At the substations, parking for the workforce would generally be made available on-site to ensure impacts to on-road parking are kept to a minimum. As the workforce numbers are small and time spent in any one location along the transmission cable route is temporary, impacts to network performance and surrounding on-road parking are expected to be minimal.

7.3.3 Operation and maintenance

Once construction is complete, the project is likely to have a minimal impact on the traffic network.

Ongoing maintenance of the substations, underground transmission cable circuit, cable bridges and link or sensor boxes would be required during operation. In most cases, only visual inspections would be required along the transmission cable route and at the cable bridges, which would generally only require light vehicles and access to pits installed in footpath areas adjacent to the joint bays. Potential impacts to traffic would be dependent on where the link and sensor boxes are located i.e. if they are within the roadway, some diversions may be required during maintenance activities. If located in the footpath, there may be some detour of pedestrian access. Relevant management measures would be implemented to allow pedestrians to safely pass the work site.

The duration of impacts to access would depend on the nature of the maintenance activities being undertaken i.e. if routine or in response to a major fault, the latter being quite rare. Maintenance crews would utilise appropriate traffic management measures when undertaking work within the road reserve and given the generally infrequent and temporary nature of maintenance works, impacts to traffic and transport are expected to be minimal.

The operation of cable bridges is not expected to have an ongoing impact on railway operations. Inspections of cable bridges would involve maintenance crews and appropriate traffic management measures when undertaking work at the roadside, including barricades to restrict approach by the public as required. If railway possessions are required for maintenance works, these would be undertaken during rail possessions planned by the relevant rail network authority so as to not disrupt rail services. Work within the rail corridors would be planned, coordinated and executed in close consultation with the relevant rail network authority, with all relevant access and safety requirements met.

Operation and maintenance at the substations would be within the existing operating footprint. Any vehicles associated with these works can be accommodated within the substation site. Operation of the project at the substations would not increase the number of vehicles required and as such no additional traffic and transport impacts at the substations have been identified.

Maintenance activities would also be undertaken in accordance with existing TransGrid procedures and management systems.

7.4 Environmental management and mitigation measures

As described previously, further traffic and transport planning would occur as part of detailed design and construction planning to confirm work site-specific diversion/closure requirements and to determine management measures and traffic controls.

Consultation with public transport service providers, such as TfNSW, Sydney Transit Authority (STA), Sydney Trains and Transdev will be undertaken to ensure that bus and train timetables are minimally impacted by the project and temporary changes to public transport arrangements (such as relocation of bus stops) are implemented successfully.

Alternative construction methodology for the transmission cable circuit

The detailed design, in conjunction with the results of the traffic and transport assessment, will identify locations that represent particular pinch points where the construction methodology may need to be amended to allow works to continue at the same time as minimising disruption to the local community.

Such an alternative construction methodology may be considered for work sites that are identified as critical in terms of traffic demand and performance and that have restricted road geometry in which to undertake the construction works. An alternative construction methodology may reduce the width requirements for the work site, which may result in critical sections of the transmission cable route being able to remain open for two-way traffic flow under shuttle conditions, as a best case scenario. It may also be possible to divert bus routes in a way that would allow light vehicles to pass the work site, resulting in the road operating under shuttle working conditions rather than being closed.

7.4.1 Management objectives

The main objective of the proposed management measures is to minimise the impacts that the project would have on road, public transport and active transport networks. As the traffic and transport assessment is informed by assumptions and based on worst case scenarios, there would be opportunities during detailed design and construction planning to identify alternative construction methodologies and traffic management approaches that would further reduce potential traffic impacts.

During the detailed design, a quantitative traffic and transport assessment will be undertaken to assess the impacts on road network performance. Where diversion routes are proposed, the impact of additional traffic using these diversions will be assessed, and the diversion route option that maintains the best network level of service will be selected. Where lane closures are proposed, mid-block capacity assessments will be undertaken to ensure the network can still operate at a satisfactory level of performance. On high-demand routes, where reducing the road capacity would have unsatisfactory impacts on network performance (as determined by the relevant road authority), work would need to be undertaken at a time where the network impact is reduced to a satisfactory level.

7.4.2 Environmental management and mitigation measures

Traffic and transport management measures for the project are listed in **Table 7-10**.

Table 7-10 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
TT1	General traffic impacts	Alternative construction methodologies and traffic management approaches will be considered to identify additional measures that may reduce potential impacts.	Detailed design and construction
TT2	General traffic	A CTMP will be produced for the project that will	Detailed

No.	Impact/issue	Environmental management and mitigation measures	Timing
	impacts	outline the proposed methodology for managing traffic flow around the work sites, traffic assessment, traffic counts, modelling and/or mid-block capacity assessments to confirm measures to be put in place to manage network performance from lane closures and proposed diversion routes. The CTMP will include effective traffic management measures for the proposed work sites to ensure the construction activities can be undertaken in a safe manner. The CTMP will also consider worker parking requirements and the temporary loss of on-road parking. The CTMP will be supported by TCPs.	design and construction
TT3	General traffic impacts	TCPs will be prepared for each work site. The TCP will graphically show the required traffic control at the work site, which will include, for example, lengths of merge/diverge tapers, location of traffic cones, traffic controllers, warning signage and speed limit sign locations, as required. Each TCP will be prepared by a suitably qualified technician in accordance with the *Traffic control at work sites manual* (Roads and Maritime, 2018) and will comply with the requirements of AS1743.3 *Roads Signs - Specifications*.	Detailed design and construction
TT4	Road closures	In the event of road closures, diversion routes will be provided along with an assessment of the likely network performance of the proposed diversion. Where required, demand management measures will be considered in consultation with the relevant roads authorities to reduce traffic on key corridors affected by construction activities for the project, by directing traffic to other appropriate roads. Diversion routes and demand management measures will be documented in the CTMP.	Detailed design and construction
TT5	Active travel impacts	Where feasible, reasonable and safe, impacts on active transport (walking and cycling) modes and routes will be minimised by maintaining access around work sites or providing diversion routes.	Construction
TT6	Vehicle access	Vehicle access to residential and business properties will be maintained at all times, where possible. Where restricting access to properties is required to enable construction works, vehicle access will be restored as soon as possible. Where access to a property cannot be maintained, affected owners/occupants will be informed and feasible and reasonable solutions for access to their specific location discussed.	Construction
TT7	Emergency access	Access for emergency services vehicles will be maintained at all times.	Construction
TT8	Community and stakeholder consultation	TransGrid will engage with relevant stakeholders including Roads and Maritime, TfNSW TMC, public transport service providers (e.g. Sydney Trains, Transdev and the State Transit Authority), waste collection agencies, local councils and local residents and businesses regarding potential traffic and access	Detailed design and construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
		impacts and management options, in accordance with the CCF. TransGrid will work with TfNSW and bus operators to ensure that sufficient lead time and comprehensive public notification is provided, regarding changes to bus stops and services, and that alternative arrangements are in place to minimise disruption during road changes. Consultation regarding the potential overlap of construction works for the project and other adjacent projects will be undertaken during detailed design to ensure that the works are coordinated, where possible.	
TT9	Impacts to bus routes	All diversions of bus routes will be agreed with TfNSW and bus operators prior to the traffic management approach being finalised; and will consider acceptable routes based on the turning paths of these vehicles.	Detailed design and construction
TT10	Construction laydown areas	The construction laydown areas will undergo a detailed design to ensure that access/egress is possible for the nominated construction design vehicle, and to ensure that impacts to the road network are mitigated and managed. This design will be presented within the CTMP for the project.	Detailed design and construction
TT11	Parking	Workers will be encouraged to travel to the work sites using public/active transport where possible. However, some on-road parking may be required at work sites. The CTMP will detail measures to minimise parking impacts to surrounding receivers as far as possible (e.g. not parking near schools/child care centres during drop off and pick up times or not parking close to sensitive land uses with high on-road parking demand, such as hospitals).	Construction

8.0 Noise and vibration

A Construction Noise and Vibration Impact Assessment (CNVIA) has been prepared for the project and is provided in **Appendix E**. This chapter summarises the assessment, including existing background noise levels, construction noise management levels, vibration limits and likely noise and vibration levels at nearby receivers. Environmental management measures have also been proposed, where required, to reduce and manage potential noise and vibration impacts from the project.

The CNVIA was prepared to satisfy the Secretary's Environmental Assessment Requirements (SEARs) issued for the project, as described in **Appendix E**.

8.1 Assessment methodology

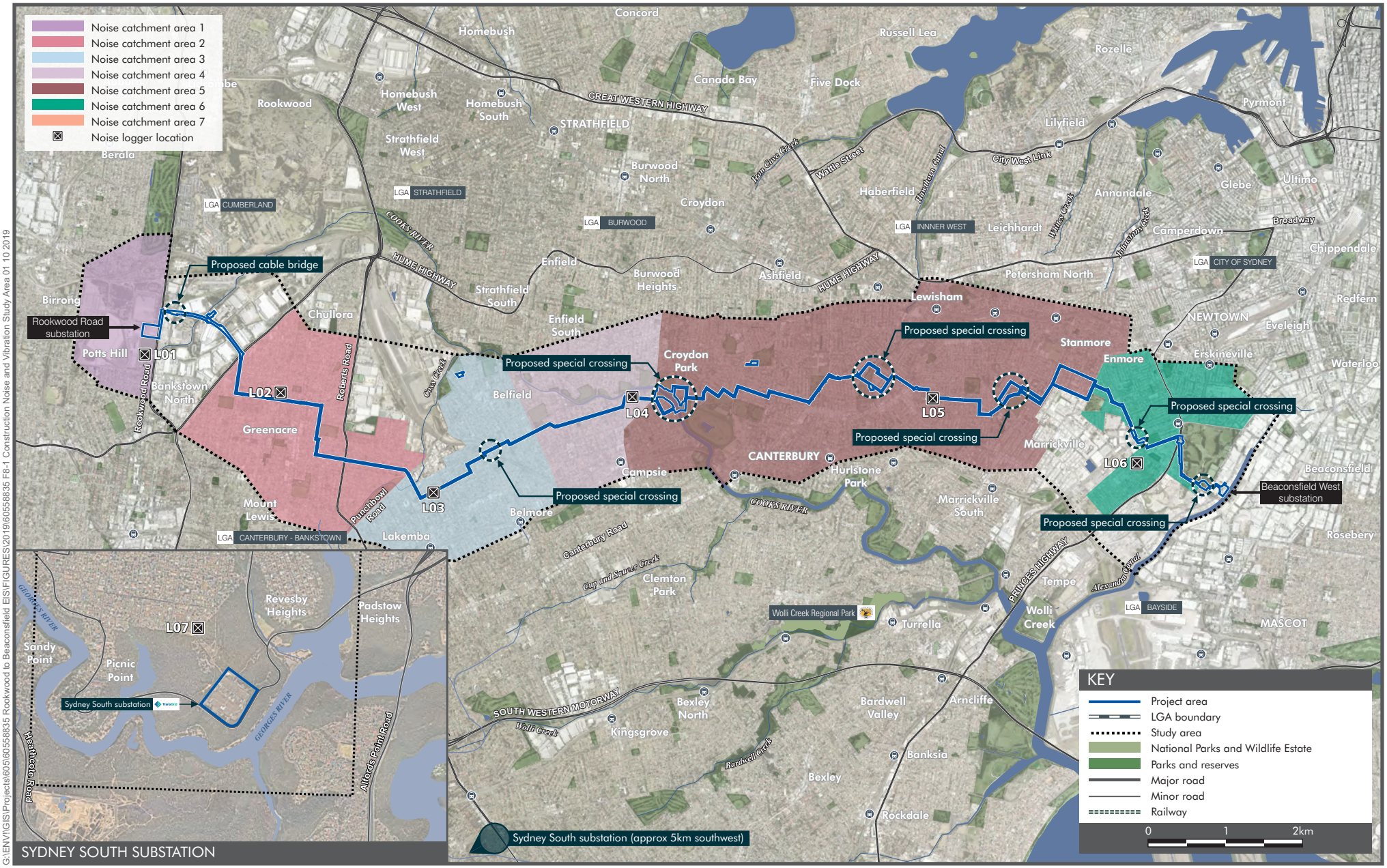
8.1.1 Study area

The study area for the CNVIA comprises a buffer of up to 1,000 metres around the project area. The study area is shown on **Figure 8-1**.

8.1.2 Approach and methodology

A quantitative noise assessment, based on 'reasonable' worst case construction scenarios, has been carried out. The approach for the CNVIA was to:

- identify the noise and vibration sensitive receivers likely to be affected by construction noise and vibration;
- establish the existing background noise levels in the vicinity of the project using unattended and attended noise monitoring;
- establish construction noise management levels (NMLs) based on background noise levels and vibration limits applicable to the project, in accordance with the relevant guidelines and policies listed in **Section 8.1.3**;
- predict noise levels from typical worst case construction scenarios using a noise model;
- identify the likely impact from airborne construction noise levels at nearby residential and other sensitive receivers, by comparing the predicted noise level against the NMLs, during construction of the project;
- predict vibration levels and identify potential impacts from construction vibration;
- identify the likely noise impacts generated by additional construction traffic on public roads during construction of the project;
- recommend environmental management and mitigation measures where necessary to reduce and manage construction noise and vibration impacts from the project; and
- address the SEARs relevant to noise and vibration.



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CONSTRUCTION NOISE AND VIBRATION ASSESSMENT STUDY AREA

Powering Sydneys Future

Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
The noise catchment areas group receivers which have a similar noise environment together and are focussed on noise sensitive land uses such as residential areas
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 8-1

8.1.2.1 Modelling

In order to assess airborne noise impacts during construction, a noise model was created and used to determine the likely noise levels during each construction noise scenario at noise sensitive receivers. The model considered project specific construction scenarios and equipment to identify potential construction noise levels at identified residential and non-residential receivers.

A number of construction activities are proposed for the project as outlined in **Chapter 4 Project description**. The CNVIA considered these activities and developed nine construction noise scenarios which are summarised in **Table 8-1**. The construction noise scenarios are considered to represent the noisiest activities likely to occur during the works. Other activities such as cable jointing would also occur, however these are considered to be less noisy than those listed in **Table 8-1**.

Excavation and establishment of joint bays, and cable pulling, are two of the scenarios modelled in the CNVIA. It should be noted that the location of joint bays have not been determined at this stage therefore modelling has been completed at indicative discrete locations along the length of the transmission cable route.

The equipment and respective sound power levels for each scenario are detailed in **Appendix E**. Each construction scenario was modelled separately, and all equipment was assumed to be operating simultaneously during each construction stage, unless otherwise noted[1].

Differences between predicted and measured noise levels are expected due to variations in instantaneous operating conditions and also the location of the plant/equipment. The acoustic shielding calculated in the model due to fixed building structures would also vary as the construction equipment moves around a particular work site. For most construction scenarios, it is expected that the construction noise levels would frequently be lower than predicted, as the noise levels presented in the CNVIA are based on the noisiest activities likely to occur and assumes equipment operating simultaneously, which would not occur at all times in practice.

The noise levels predicted by the model for each noise catchment area (NCA) and associated noise sensitive receivers, were assessed against the NMLs for standard construction hours and outside of standard construction hours for daytime, evening and night-time (refer to **Table 8-2** for a description of these hours).

As trucks used for spoil haulage and waste management would be operating primarily on roads to and from work sites (i.e. outside of work sites[2]), noise from truck movements has not been modelled as a scenario but has been assessed as part of noise from construction traffic (refer to **Section 8.3.3**).

[1] For the CNVIA it has been assumed that when the diamond saw is in use the chainsaw is not, i.e. the diamond saw and chainsaw are not in use simultaneously.
[2] A specific section of the project area for carrying out project construction activities such as trenching and excavation, establishment of a joint bay or a special crossing. The work site would be fenced off from public access and may include associated activities such as traffic management measures.

Table 8-1 Construction noise scenarios and scheduling

Scenario	Location	Timing	Duration	Description
Site preparation	Work site	Standard construction hours and outside of standard construction hours (night-time) for construction works within major road reserves and through signalised intersections[3][4].	Up to one week.	Short term works to clear the project area where required, including implementing traffic management and establishing environmental controls and ancillary facilities.

[3] Night-works have been modelled within the following state and regional road reserves:

i. Rookwood Road
ii. Hume Highway crossing
iii. Waterloo Road crossing
iv. Juno Parade (between Maiden Street and Acacia Avenue)
v. Roberts Road crossing
vi. Punchbowl Road crossing
vii. Burwood Road (between Carter Street and Bruce Avenue)
viii. Fifth Avenue crossing
ix. Brighton Avenue crossing
x. Old Canterbury Road
xi. New Canterbury Road crossing
xii. Sydenham Road crossing
xiii. Addison Road (between Illawarra Road and Enmore Road)
xiv. Enmore Road (between Newington Road and Addison Road)
xv. Llewellyn Street (between Lynch Lane and Edgeware Road)
xvi. Edgeware Road (between Llewellyn Street and south of Darley Street)
xvii. May Street (west of Campbell Street to Princes Highway)
xviii. Princes Highway crossing.

[4] Night-works have been modelled at the following signalised intersections including 100 m before and after the intersection along the alignment:

i. William Holmes Drive/Rookwood Road
ii. Rookwood Road/Muir Road
iii. Muir Road/Worth Street
iv. Muir Road/Hume Highway
v. Rawson Road/Waterloo Road
vi. Wangee Road/Punchbowl Road
vii. Seventh Avenue/Fifth Avenue
viii. Centennial Street/Sydenham Road
ix. Illawarra Road/Addison Road/Agar Street
x. Addison Road/Enmore Road
xi. Enmore Road/Llewellyn Street

Scenario	Location	Timing	Duration	Description
Trenching and excavation	Transmission cable route	Standard construction hours and outside of standard construction hours (night-time) for construction works within major road reserves and through signalised intersections[3, 4].	Average rate of trenching of 20 metres per day. Each section between the joint bays may take up to eight weeks to complete.	Linear progressive works. May occur at multiple locations along the transmission cable route at one time. Steel plates may be used to temporarily cover trenches.
Excavation and construction of joint bays	Transmission cable route, one joint bay every 600-800 metres	Standard construction hours[5].	Up to five weeks to establish each joint bay, including excavation.	Works to be undertaken at discrete locations along the transmission cable route[6].
Special crossing - Cable bridges	• Muir Road, Chullora • Cooks River, Campsie/Croydon Park • Bedwin Road, St Peters	Standard construction hours and outside of standard construction hours (night-time).	Up to 10 weeks for each crossing (but not continuous).	Works to be undertaken at up to three discrete locations.
Special crossing - Underboring	• Enfield Intermodal, Belfield • Cooks River, Campsie/Croydon Park • Arlington Light Rail Station, Dulwich Hill • Amy Street, Marrickville • Sydney Park, Alexandria	Standard construction hours and outside of standard construction hours (night-time).	Up to 10 weeks for each crossing (but not continuous).	Works to be undertaken at up to five discrete locations.

xii. Llewellyn Street/Edgeware Road/Alice Street
xiii. Edgeware Road midblock crossing
xiv. May Street/Princes Highway

[5] Joint bays would generally be located outside of major road reserves where possible, therefore it is assumed that night works would not be required for the excavation and construction of cable joint bays. However, it is anticipated that night works may be required by the relevant traffic management authority for two locations along regionally classified roads (May Street and Edgeware Road).

[6] Joint bay locations would be determined during detailed design.

Scenario	Location	Timing	Duration	Description
Cable pulling	Transmission cable route, between two adjacent joint bays for one cable pull	Standard construction hours and outside of standard construction hours (night-time).	Up to two weeks for each section.	Works to be undertaken at discrete locations along the transmission cable route. May occur at multiple locations along the transmission cable route at one time.
Construction laydown areas	• 12 Muir Road, Chullora • Cooke Park, Belfield • Peace Park, Ashbury • Camdenville Park, St Peters • Beaconsfield West substation, Alexandria	Standard construction hours and outside of standard construction hours (including night-time).	Duration of the project, estimated to be around 24 months.	Primarily for construction plant parking, storage of equipment and deliveries, and spoil stockpiling. Stockpiling is expected to occur for around 15 months.
Restoration of road surfaces	Transmission cable route	Standard construction hours and outside of standard construction hours (including night-time) for construction works within major road reserves and through signalised intersections[3, 4].	Between 3-5 weeks per section.	Linear progressive works. May occur at multiple locations along the transmission cable route at one time.
Substation upgrade works	Rookwood Road, Beaconsfield West and Sydney South substations	Standard construction hours and outside of standard construction hours (including night-time).	Rookwood Road: 4-6 months Beaconsfield West: 6-9 months Sydney South: 6-9 months.	Upgrade works at substation.
Spoil and waste management[7]	Roads surrounding the transmission cable route	Standard construction hours and outside of standard construction hours (including night-time).	Duration of the project, estimated to be around 24 months.	Trucks would be used to transport spoil during the trenching and conduit installation works, joint bay construction, construction of special crossings and restoration of road surfaces. Trucks would use both local and arterial roads.

[7] The spoil and waste management construction noise scenario has not been modelled as it effectively comprises construction traffic movements, which have been assessed separately (refer to **Section 8.3.3**)

8.1.3 Statutory context, policy and guidelines

The relevant legislation, policies and guidelines for the assessment of noise and vibration in NSW that have been considered during the preparation of the CNVIA include:

- *Interim Construction Noise Guideline* (ICNG), Department of Environment and Climate Change (DECC), 2009;
- *Assessing Vibration: A Technical Guideline* (AVATG), Department of Environment and Conservation (DEC), 2006;
- *NSW Road Noise Policy* (RNP), Department of Environment, Climate Change and Water (DECCW), 2011;
- *Noise Policy for Industry* (NPfI), Environment Protection Authority (EPA), 2017c;
- German Standard DIN 4150: *Part 3 1999 Structural Vibration in Buildings - Effects on Structures*, 1999;
- British Standard 6472: Part 1 2008 *Evaluation of Human Exposure to Vibration in Buildings*, 2008;
- Australian Standard AS 2436-2010, *Guide to noise and vibration control on construction, demolition and maintenance sites*, 2010;
- Australian Standard AS 1055.1-1997 – *Acoustics – Description and measurement of environmental noise, Part 1: General procedures*, 1997; and
- UK Department for Environment, Food and Rural Affairs (DEFRA) *Update of noise database for prediction of noise on construction and open sites*, 2006.

8.1.3.1 Interim Construction Noise Guideline

The ICNG is a NSW Government document that identifies ways to manage impacts of construction noise on residences and other noise sensitive land uses. It is the principal guideline for the assessment and management of construction noise in NSW and is used to establish construction NMLs and provides guidance for management measures.

Where an exceedance of the NMLs is predicted, the ICNG advises that receivers can be considered 'noise affected' and the proponent should apply all feasible and reasonable work practices to minimise the noise impact. The proponent should also inform all potentially impacted residents of the nature of the works to be carried out, the expected noise level and duration, as well as provide contact details to facilitate feedback from affected residents during construction.

The ICNG also states that during recommended standard construction hours, where construction noise levels reach 75 A Weighted decibels (dB(A))[8] at residences, residential receivers can be considered as 'highly noise affected' and the proponent may be required to consider restricting hours of very noisy works (such as rock breaking or road cutting) to provide respite periods. In this assessment, receivers are considered as 'highly noise affected' where noise levels are 75 dB(A) or above, regardless of the time of day. Respite periods could be a negotiated outcome with highly noise affected receivers, taking into account times identified by the community when they are less sensitive to noise, or considering whether the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

The ICNG defines what is considered to be feasible and reasonable as follows:

- **Feasible:** "A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements".

[8] The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1kHz and 4 kHz) which the human ear is most sensitive to and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).

- **Reasonable:** "Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure".

A description of ICNG standard hours and NMLs is provided in **Table 8-2**. The NML is based on the rating background level (RBL), which is the overall background noise level measured (DECC, 2009).

Table 8-2 ICNG residential noise management levels

Time of day	NML, LAeq,15min, dB(A)[1]	How to apply
Recommended standard hours: Monday to Friday: 7:00 am to 6:00 pm; Saturday: 8:00 am to 1:00 pm; and 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 $L_{Aeq\ (15\ min)}$[2] is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level; and • the proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise: • where 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: - 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; and - 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.

Source: based on Table 2, page 12 of the ICNG (DECC, 2009)

Notes:

1 Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

2 $L_{Aeq(15min)}$ is defined by the ICNG as 'the A-weighted equivalent continuous (energy average) A-weighted sound pressure level of the construction works under consideration over a 15-minute period and excludes other noise sources such as industry, road, rail and the community".

Work that is proposed outside of standard construction hours, as defined in the ICNG, generally requires strong justification to the relevant authorities. Construction would need to be undertaken outside of standard construction hours (including night works) for reasons of safety, traffic management and utility constraints. Further to the above as required by the ICNG, where the $L_{Aeq(15min)}$ noise levels exceed 75 dB(A) at the same receiver, respite measures would need to be considered.

Sleep disturbance guidelines

The ICNG requires a sleep disturbance analysis to be completed where construction works are planned to extend over more than two consecutive nights. The ICNG makes reference to the NSW *Environment Criteria for Road Traffic Noise* (NSW EPA, 1999) (ECRTN), now superseded by the *Road Noise Policy* (DECCW, 2011) (RNP), for guidance in assessing the potential for sleep disturbance.

The CNVIA considered the guidance in the RNP and advice from the NSW EPA and determined both a *sleep disturbance screening level* and *awakening reaction level* for the project. The sleep disturbance screening level is intended as a guide to identify the likelihood of sleep disturbance. While it is not a firm criterion to be met, where the criterion is met sleep disturbance is not likely. When the screening criterion is not met, a more detailed analysis is required, to consider the likelihood of awakening reactions and the number of times this may happen during the night-time period. The guidance provided in the RNP for assessing the potential for sleep disturbance recommends that to minimise the risk of sleep disturbance during the night-time period (10.00 pm to 7.00 am), the $L_{A1(1\ min),}$ noise level outside a bedroom window should not exceed the $L_{A90\ (15\ minute)}$ background noise level by more than 15 dB.

The awakening reaction level is the level that is likely to cause people to wake up. The RNP states that “Maximum internal noise levels below 50 to 55 dB(A) are unlikely to cause awakening reactions”. Therefore, given that an open window provides around 10 dB in noise attenuation from outside to inside, external noise levels of 60 to 65 dB(A) are unlikely to result in awakening reactions. Noise levels above 65 dB(A) may cause awakening and have been adopted as the awakening reaction level for the project.

Construction traffic noise criteria

Noise from construction traffic on public roads is not covered by the ICNG. However, the ICNG does refer to the ECRTN, now superseded by the RNP, for the assessment of noise arising from construction traffic on public roads.

To assess noise impacts from construction traffic in accordance with the RNP, an initial screening test should be undertaken by evaluating whether existing road traffic noise levels would increase by more than 2 dB(A). Where the predicted noise increase is 2 dB(A) or less, then no further assessment is required. The RNP states that an “increase in up to 2 dB(A) represents a minor impact that is considered barely perceptible to the average person”. However, where the predicted noise level increase is greater than 2 dB(A), and the predicted road traffic noise level exceeds the road category specific criterion in the RNP, then noise mitigation should be considered for those receivers affected. The RNP does not require assessment of noise impact to commercial or industrial receivers.

8.1.3.2 Construction vibration guidelines

Vibration criteria are set primarily according to whether the particular project activities are continuous in nature or intermittent, whether they occur during the daytime or night-time and the type of receiver to be assessed, e.g. industrial, commercial or residential. The effects of vibration in buildings can be divided into the following categories:

- those in which the occupants or users of the building are inconvenienced or possibly disturbed, i.e. human disturbance or discomfort; and
- those in which building damage may occur.

Therefore, vibration levels at sensitive receiver locations must be controlled so as to prevent discomfort and regenerated noise, and in some extreme cases, structural damage. The relevant standards and guidelines utilised for the assessment of construction vibration for the project are:

- structural damage: German Standard DIN 4150 – *Part 3 – Structural Vibration in Buildings – Effects on Structures* (DIN 4150); and
- human comfort (tactile vibration): *Assessing Vibration: A Technical Guideline* (AVATG)[9].

The CNVIA details the structural damage safe limits based on DIN 4150 for building vibration and, based on the AVATG, the preferred and maximum vibration dose values for intermittent vibration. This data was then used to determine safe working distances for jack hammers and rock breakers from off-site project receivers.

8.2 Existing environment

8.2.1 Noise sensitive receivers

The CNVIA assessed the potential construction noise impacts on sensitive receivers. Noise sensitive receivers for the project include people within noise sensitive land uses, as defined by the ICNG, being:

- residential areas;
- educational establishments;
- hospitals;
- places of worship;
- active recreational areas;
- passive recreational areas; and
- community centres.

Commercial and industrial receivers are generally not considered noise sensitive, however some may comprise specific uses which are considered noise sensitive. For example, child care centres, aged care and theatres (when in use) are considered noise sensitive receivers. Where a number of commercial and industrial receivers are located together and are not considered sensitive, they have not been included in a NCA; however they have still been assessed (refer to **Section 8.2.2**).

8.2.2 Noise catchment areas

To assist in determining noise criteria for noise sensitive receivers near the project, NCAs were identified. NCAs were determined by reviewing existing land use and identifying groups of noise sensitive receivers which are likely to be exposed to a similar existing noise environment. A description of these NCAs and their location is shown in **Table 8-3** and **Figure 8-1**.

1. This document is based upon the guidelines contained in British Standard 6472:1992, *Evaluation of human exposure to vibration in buildings (1-80 Hz)*. This British Standard was superseded in 2008 with BS 6472-1:2008 *Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting* and the 1992 version of the Standard was withdrawn. However, the NSW EPA still requires vibration to be assessed in accordance with the 1992 version of the Standard at this time.

Table 8-3 Noise catchment areas and description

NCA	Description of noise catchment areas
1	Includes mainly low density residential properties within Yagoona, Potts Hill and Regents Park. This is also adjacent to industrial properties within Potts Hill and Chullora.
2	Includes mainly low density residential properties within Greenacre but also includes some high and medium density residential properties. Bordered by industrial properties to the northwest and northeast. Greenacre town centre is located in the centre of the NCA and includes Greenacre Area Community Centre. Other non-residential noise sensitive receivers include St John Vianney Catholic Church, St John Vianney Catholic Primary School, Good Shepherd Church Sydney Full Gospel Church, Greenacre Public School, Banksia Road Public School, Greenacre Montessori Academy Child Care Centre, Playtime Child Care Centre, Tiny Tots Kindergarten, Funtime Child Care Centre, Kindy Academy Child Care Centre, Mickey's World Child Care Centre, Alnoori Muslim School, Al Sadiq College, Liberty Church of Christ, KU Karingal Preschool, Holy Saviour Primary School and Wangee Road Child Care Centre.
3	Includes mainly medium and high density residential properties within Lakemba, Belmore and Belfield. The Enfield Intermodal Terminal is located to the northwest. Other non-residential noise sensitive receivers include St Michael's Catholic Primary School, Belfield Uniting Church, Church of St Michael the Archangel, St Andrews Anglican Church, Lakemba Mosque, Hanaro Presbyterian Church, Saint Therese Catholic Church, St Therese's Catholic Primary School, three Care for Kindies child care centres, Hamden Park Public School, Canterbury Vale School, Colonial Preschool Child Care Centre, Embassy Church, Belmore North Public School and Star Academy Kids Learning Centre.
4	Includes a mix of low, medium and high density residential properties within Croydon Park and Campsie. Other non-residential noise sensitive receivers include Love of Learning Child Care Centre and Little Learning School Child Care Centre, Oz Education Child Care Centre, Harcourt Public School and Croydon Park Baptist Church.
5	Includes mainly low density residential properties within Campsie, Croydon Park, Ashbury, Canterbury, Ashfield, Hurlstone Park, Dulwich Hill, Lewisham, Marrickville and Stanmore with some medium and high density residential properties. Other non-residential noise sensitive receivers include child care centres, Sydney Private Hospital, Bethel Nursing Home, Ashbury Public School, Summer Hill Aged Care Services Nursing Home, Woodstock Child Care Centre, Summer Hill Public School, St Patrick's Catholic Primary School and Trinity Grammar School, Summer Hill Children's Centre, St Patrick's Catholic Church, Lewisham Public School, Christian Brothers' High School Lewisham, Newington College, Petersham Primary School, Addison Road Early Learning Centre, Learn & Laughter Early Learning Centre, Enmore Road Early Learning Centre, Canaan Presbyterian Church, Petersham Baptist Church and Marrickville Kingdom Hall of Jehovah's Witnesses, St Francis Xavier Catholic School, Canterbury Public School, and Croydon Park Public School.
6	Includes mainly low density residential properties within Enmore, Newtown, Erskineville and St Peters but also includes some medium and high density residential properties. Industrial properties are located to the west and east. Sydney airport is located to the south. Other non-residential noise sensitive receivers include Camdenville Public School, St Pius Catholic Primary School, St Peters Public School, Only About Children Child Care Centre and St Pius Enmore Catholic Church.
7	Includes mainly low density residential properties within Picnic Point, Revesby Heights and Alfords Point.

8.2.3 Existing background noise levels

Long term noise monitoring was undertaken within each NCA to determine existing background noise levels. One noise logger was placed within each NCA at a representative location. The loggers measured continuous noise levels over the monitoring periods. Based on the noise logger data, the L_{A1}, L_{A90} and L_{Aeq} levels of each representative noise logger location were then determined.

The L_{A1} is indicative of the maximum noise levels due to individual noise events such as the pass-by of a heavy vehicle.

The L_{A90} noise level is the level exceeded for 90% of the monitoring period and is considered to be the background level. The L_{A90} noise levels were analysed to determine a single assessment background level (ABL) for each day, evening and night-time period in accordance with the *Noise Policy for Industry* (NPfI) (NSW EPA, 2017b), for each monitoring location. The background noise level or rating background level (RBL) representing the day, evening and night-time periods is based on the median of individual ABLs determined over the entire monitoring period.

The L_{Aeq} level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels. The L_{Aeq} level represents the existing ambient noise levels selected for each day, evening and night-time period.

Table 8-4 presents individual RBLs and the existing L_{Aeq} ambient noise levels selected for each day, evening and night-time period for the NCAs, determined in accordance with the NPfI.

In accordance with the NPfI:

- day is defined as:
  - 7:00 am to 6:00 pm Monday to Saturday;
  - 8:00 am to 6:00 pm Sundays and public holidays;
- evening is defined as:
  - 6:00 pm to 10:00 pm Monday to Sunday and public holidays;
- night-time is defined as:
  - 10:00 pm to 7:00 am, Monday to Saturday; and
  - 10:00 pm to 8:00 am Sundays and public holidays.

Table 8-4 Unattended noise measurement results in dB(A) for all NCAs

NCA	RBL L_{A90} dB(A)			Log Average L_{Aeq} dB(A)		
	Day[1]	Evening[1]	Night[1]	Day[1]	Evening[1]	Night[1]
NCA 1	45	45[2]	39	63	58	52
NCA 2	38	38[2]	35	53	50	45
NCA 3	40	40[2]	38	59	57	53
NCA 4	33	33[2]	32	54	45	44
NCA 5	34	34[2]	30	58	57	48
NCA 6	42	42[2]	35	61	60	56
NCA 7	30[3]	30[2]	30[3]	49	45	40

Notes:
1 In accordance with the NPfI.
2 Where measured evening RBLs are higher than daytime RBLs, Evening RBLs adjusted to the same as the daytime RBL in accordance with the NPfI (INP application notes).
3 Where the rating background level is found to be less than 30 dB(A), then it is set to 30 dB(A) in accordance with the NPfI.

The existing acoustic environment is primarily dominated by traffic noise at all NCAs and is typical of an urban environment. In addition, NCA 1 and NCA 2 experience some industrial noise, NCA 6 experiences some aircraft noise and NCA 7 is also characterised by fauna noises.

8.2.4 Construction noise management levels

The construction NMLs were determined based on the results of the noise monitoring and in accordance with the ICNG. **Table 8-5** presents the actual NMLs for this project that are applicable at the noise sensitive receivers throughout the study area. **Table 8-6** presents the NMLs applicable to other noise sensitive receivers, such as educational facilities and places of worship and commercial receivers as recommended by the ICNG. Hotels have been considered as a residential land use rather than a commercial land use. This provides a conservative assumption as the residential NML is more stringent than that which would be applied to a commercial receiver.

The first group of NMLs presented in **Table 8-5** and **Table 8-6** are for standard daytime construction hours. Standard construction hours for the project are:

- Monday to Friday 7:00 am to 6:00 pm (daytime);
- Saturday 8:00 am to 1:00 pm (daytime); and
- no work on Sundays and public holidays.

However, construction would also need to be undertaken outside of standard construction hours (including night works). It is likely that construction works within major road reserves (e.g. Rookwood Road), those in the vicinity of signalised intersections, or those activities that need to proceed continuously (such as cable jointing), would need to be conducted outside of standard daytime construction hours for safety and traffic management reasons or to meet the requirements of government agencies. Some works at the substation sites may also need to be undertaken outside of standard construction hours due to outage constraints on the existing infrastructure (i.e. the need to maintain power supply to customers).

Cable bridges and underboring at rail corridors would be timed with other rail works to limit disruption to freight and/or passenger rail services. These works could be undertaken outside of standard construction hours including at night time or over weekends, subject to approval of the relevant rail authority.

Table 8-5 and **Table 8-6** also present NMLs for outside of standard construction hours. Outside of standard construction hours for the project are defined as:

- Daytime:
  - Saturday from 7:00 am to 8:00 am and 1:00 pm to 6:00 pm;
  - Sundays and public holidays 8:00 am to 6:00 pm;
- Evening:
  - seven days a week and public holidays 6:00 pm to 10:00 pm;
- Night-time:
  - Monday to Saturday 10:00 pm to 7:00 am; and
  - Sundays and public holidays 10:00 pm to 8:00 am.

Table 8-5 Construction noise management levels – residential receivers

NCA	Period	RBL, L_{A90} dB(A)	Standard construction hours NMLs, $L_{Aeq,15min}$, dB(A)	Outside of standard construction hours NMLs, $L_{Aeq,15min}$, dB(A)
1	Day	45	55	50
	Evening	45	-	50
	Night	39	-	44
2	Day	38	48	43
	Evening	38	-	43
	Night	35	-	40
3	Day	40	40	45
	Evening	40	-	45
	Night	38	-	43
4	Day	33	43	38
	Evening	33	-	38
	Night	32	-	37
5	Day	34	44	39
	Evening	34	-	39

NCA	Period	RBL, L_{A90} dB(A)	Standard construction hours NMLs, $L_{Aeq,15min}$, dB(A)	Outside of standard construction hours NMLs, $L_{Aeq,15min}$, dB(A)
	Night	30	-	35
6	Day	42	52	47
	Evening	42	-	47
	Night	35	-	40
7	Day	30	40	35
	Evening	30	-	35
	Night	30	-	35

Table 8-6 Construction noise management levels – Other receivers

Land use	NMLs, $L_{Aeq,15min}$ (applies when properties are being used)	
	External noise level (dB(A))	Internal noise level (dB(A))
Commercial premises (including offices, retail outlets)	70	-
Industrial premises	75	-
Medical	55[1]	45
Classrooms at schools and other educational institutions	55[1]	45
Places of worship	55[1]	45
Active recreation areas	65	-
Community centres	55[1]	45[2]

Notes:
1 External noise level NMLs are based upon a 10 dB loss through an open window
2 Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS2107 for specific uses.

8.2.5 Sleep disturbance criteria

Based on the measured background noise levels during the night, the sleep disturbance criteria for the nearest noise sensitive residential receivers have been determined and are presented in **Table 8-7**. As part of the assessment, the predicted maximum noise levels have been compared against the screening criteria. If the screening criteria is exceeded the maximum noise levels are then compared against the awakening reaction criteria.

Table 8-7 Sleep disturbance criteria

NCA	Background noise level (L_{A90}), dB(A)	Sleep disturbance screening level $L_{A1(1\ minute)}$, dB(A)[1]	Awakening reaction $L_{A1(1\ minute)}$, dB(A)[2]
1	39	54	65
2	35	50	65
3	38	53	65
4	32	47	65
5	30	45	65
6	35	50	65
7	30	45	65

Notes:
1 Based on RBL + 15 dB(A), external level.
2 External $L_{A1(1\ min)}$ level, based upon a maximum internal noise level of 55dB(A) and a 10dB loss through an open window.

8.3 Assessment of potential construction impacts

8.3.1 Construction airborne noise assessment

Construction noise levels at the identified residential and non-residential sensitive receivers have been assessed against the NMLs for standard construction hours and outside of standard construction hours as outlined in **Section 8.2.4**. Outside of standard construction hours (at night-time) is considered to be the worst case scenario as it has the lowest NMLs.

8.3.1.1 Residential receivers

Based on the sound power levels of the equipment likely to be used in each construction noise scenario, the highest noise levels are likely to be generated by the following construction noise scenarios:

- site preparation;
- trenching and excavation;
- excavation of joint bays;
- special crossings;
- cable pulling; and
- restoration of road surfaces.

Key high noise generating equipment, based on sound power levels, includes jackhammers, diamond saws, rock breakers and piling rigs.

The predicted numbers of exceedances of the NMLs at residential receivers due to construction works during both standard construction hours and works outside of standard construction hours (night-time) are shown in **Table 8-8**. The numbers of receivers presented in this table are split into four categories:

- 1-10 dB exceedance - a noticeable exceedance of the NML;
- 11-20 dB exceedance – a clearly audible exceedance of the NML;
- greater than 20 dB exceedance – an intrusive exceedance of the NML; and
- greater than 75 dB(A) – highly affected receivers.

The following sections summarises the potential airborne noise impacts for each of the construction noise scenarios for residential receivers along the transmission cable route and near the construction laydown areas and substations.

Site preparation

Site preparation works are likely to be completed in a period of up to one week at any one work site. Sensitive receivers near to the site preparation works would experience elevated noise levels during these works. Approximately 16,000 receivers during works outside of standard construction hours and 13,000 receivers during standard construction hours across the project area may experience noise levels above the noise management levels and 2,000 receivers may be highly noise affected (experience noise levels above 75 dB(A)).

Trenching and excavation

The trenching and excavation works are expected to progress at an average rate of around 20 metres per day. Receivers would generally be affected for around eight weeks. The predicted noise levels for these scenarios represent the worst case noise levels as this is where the works come closest to each receiver.

Approximately 21,500 receivers during works outside of standard construction hours and 16,500 receivers during standard construction hours across the project area may experience noise levels above the NMLs and around 2,000 receivers may be highly noise affected. However, at any one receiver, construction noise levels would slowly increase as the works approach the receiver (around four weeks), would remain fairly constant while the works are directly in front of the receiver (around four days) and would then slowly decrease again as the works move away (around four weeks).

Therefore, the number of receivers affected at any one point in time would be much lower than stated above. For example, at a receiver located along the road where trenching and excavation is taking place, noise levels are expected to:

- increase by about 30 dB over the NML over a period of up to four weeks;
- remain above 75 dB(A) for about four days as the works are directly in front of the receiver; and
- decrease to the NML over a period of up to four weeks as the works move away.

An example of this change is shown diagrammatically in **Figure 8-2** and in **Appendix E**.

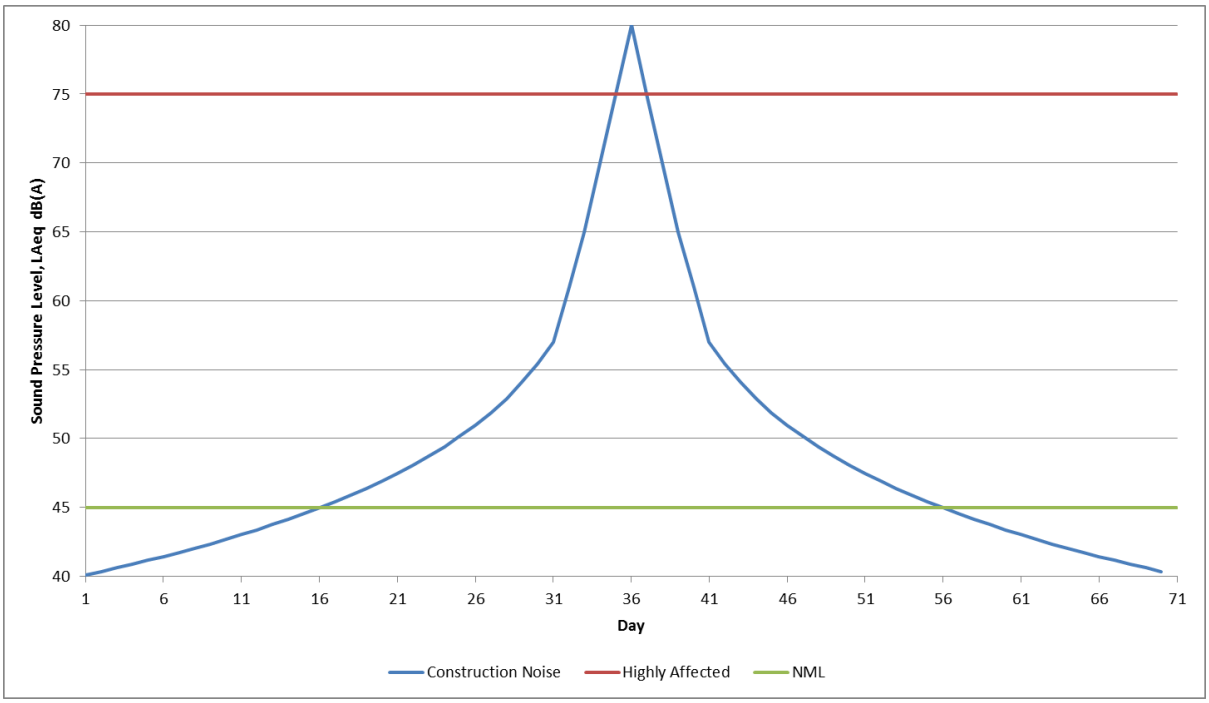

Figure 8-2 Variation in $L_{Aeq(15min)}$ noise level as works progress

Excavation and construction of joint bays

Excavation and construction of each joint bay is likely to take up to five weeks. Noise sensitive receivers around the joint bays would experience construction noise during these works. Approximately 8,000 receivers during standard construction hours across the project area may experience noise levels above the NMLs and 138 receivers may be highly noise affected across the entire project. It is noted that joint bay works were modelled at discrete locations along the entire transmission cable route, therefore the actual number of affected receivers may differ from those reported above, depending on the final location of the joint bays. The actual joint bay locations would be determined during detailed design and the number of receivers affected would be re-evaluated.

Special crossings

Special crossings are likely to be completed in a period of up to 10 weeks at each crossing, however works would be staged and not continuous over the 10 week period. Sensitive receivers near the special crossings would also experience construction noise during these works. Approximately 12,000 receivers at night and 4,000 receivers during standard construction hours across the project area may experience noise levels above the NMLs and 31 receivers may be highly noise affected.

Cable pulling

Cable pulling is likely to be completed in a period of up to two weeks per cable section. Noise sensitive receivers near the cable pulling would also experience construction noise during these works. Approximately 14,500 receivers at night and 5,000 receivers during standard construction hours across the project area may experience noise levels above the NMLs and 86 receivers may be highly noise affected. As noted above, the location of joint bays is not yet confirmed and therefore the actual

number of affected receivers may differ from those reported above, depending on the final location of the joint bays. The actual joint bay locations would be determined during detailed design and the number of receivers affected would be re-evaluated.

Construction laydown areas

Laydown areas would be used for the majority of the overall construction period, with impacts expected to occur for up to 24 months. For work in the construction laydown areas, noise levels are predicted to exceed the NMLs at approximately 1,000 residential receivers at night and 220 receivers during standard construction hours for all construction laydown sites in total across all NCAs, however no receivers are expected to be highly noise affected. Stockpiling activities would also be undertaken for around 15 months. Stockpiling would be undertaken during the daytime and the night-time. Other general laydown activities would not be continuous with activities mainly occurring at the start and end of shifts with some movement in and out of the areas mid-shift to support construction activities along the transmission cable route. Therefore, when stockpiling activities are not ongoing there would be periods of no noise within the construction laydown area.

Restoration of road surfaces

The surface restoration works are progressive works and the overall duration of the activity is expected to be three to five weeks per section. Approximately 19,500 receivers at night and 17,000 receivers during standard construction hours across the project area may experience noise levels above the NMLs and 2,500 receivers may be highly noise affected. For surface restoration works, noise levels of greater than 75 dB(A) may be experienced for around three days.

Works at Rookwood Road, Beaconsfield West and Sydney South substations

Noise sensitive receivers near the Rookwood Road, Beaconsfield West or Sydney South substations would experience construction noise. Substation works are likely to be completed in a period of up to six months for the Rookwood Road substation and up to nine months for the Beaconsfield West and South Sydney substations. Approximately 670 receivers at night (32 in NCA 1, 2 in NCA 6 and 637 in NCA 7) and 80 receivers in NCA 7 only during standard construction hours, may experience noise levels above the NMLs, however no receivers are expected to be highly noise affected during standard construction hours.

Results from the noise modelling are presented as noise contour layers over aerial maps in **Appendix E**.

Table 8-8 Number of residential buildings where noise levels may exceed NMLs for all construction scenarios during daytime and night-time hours

NCA	Scenario	Number of residential buildings where noise levels may exceed NMLs across the project area						
		Standard construction hours			Outside of standard construction hours (night)			Highly affected, > 75 dB(A)
		1-10 dB	11-20 dB	> 20 dB	1-10 dB	11-20 dB	> 20 dB	
NCA1	Site preparation	0	0	0	46	1	0	0
	Trenching and excavation	1	0	0	118	5	0	0
	Excavation and construction of cable joint bays	1	0	0	-	-	-	0
	Special crossings	0	0	0	0	0	0	0
	Cable pulling	0	0	0	31	0	0	0
	Construction laydown	0	0	0	0	0	0	0
	Restoration of road surfaces	1	0	0	83	1	0	0
	Rookwood Road substation works	0	0	0	32	0	0	0
NCA2	Site preparation	1,225	507	415	2,334	415	161	336
	Trenching and excavation	1,647	669	475	3,160	707	225	386
	Excavation and construction of cable joint bays	999	121	48	-	-	-	26
	Special crossings	0	0	0	0	0	0	0
	Cable pulling	507	70	39	2,190	324	84	18
	Construction laydown	0	0	0	0	0	0	0
	Restoration of road surfaces	1,513	631	446	2,955	586	198	366
NCA3	Site preparation	700	184	248	678	126	51	232
	Trenching and excavation	838	300	269	1,145	183	70	248
	Excavation and construction of cable joint bays	339	54	30	-	-	-	22
	Special crossings	145	24	11	540	83	23	4

NCA	Scenario	Number of residential buildings where noise levels may exceed NMLs across the project area						
		Standard construction hours			Outside of standard construction hours (night)			Highly affected, > 75 dB(A)
		1-10 dB	11-20 dB	> 20 dB	1-10 dB	11-20 dB	> 20 dB	
	Cable pulling	177	36	22	837	102	43	16
	Construction laydown	56	0	0	186	29	0	0
	Restoration of road surfaces	764	276	261	980	159	64	242
NCA4	Site preparation	989	326	270	1,833	166	106	176
	Trenching and excavation	1,560	427	354	2,506	350	138	190
	Excavation and construction of cable joint bays	830	193	65	-	-	-	20
	Special crossings	240	13	0	1,202	54	9	0
	Cable pulling	563	128	44	1,161	302	104	13
	Construction laydown	0	0	0	3	0	0	0
	Restoration of road surfaces	1,492	404	345	2,286	245	131	191
NCA5	Site preparation	4,026	1,751	1,581	6,156	1,551	549	1,130
	Trenching and excavation	5,178	2,105	1,965	7,648	2,648	762	1,196
	Excavation and construction of cable joint bays	3,862	716	219	-	-	-	62
	Special crossings	2,832	362	80	6,835	2,460	369	25
	Cable pulling	2,497	417	156	5,998	2,118	487	35
	Construction laydown	103	42	0	448	95	36	0
	Restoration of road surfaces	5,571	2,262	2,216	7,164	2,186	679	1,468
NCA6	Site preparation	338	91	161	1,143	292	191	152
	Trenching and excavation	429	140	173	1,343	470	241	167
	Excavation and construction of cable joint bays	204	19	14	-	-	-	8

NCA	Scenario	Number of residential buildings where noise levels may exceed NMLs across the project area						
		Standard construction hours			Outside of standard construction hours (night)			Highly affected, > 75 dB(A)
		1-10 dB	11-20 dB	> 20 dB	1-10 dB	11-20 dB	> 20 dB	
	Special crossings	31	3	2	575	50	5	2
	Cable pulling	114	16	6	689	146	24	4
	Construction laydown	19	0	0	263	22	0	0
	Restoration of road surfaces	466	162	222	1,283	390	221	221
	Beaconsfield West substation works	0	0	0	2	0	0	0
NCA7	Sydney South substation works	80	0	0	613	24	0	0

Summary of construction airborne noise impacts on residential receivers

A large number of residential receivers have been identified in the CNVIA as being likely to hear a noticeable level of noise from the construction works during standard construction hours.

The CNVIA indicated that works outside of standard construction hours are likely to have a greater potential impact on sensitive receivers. Construction would need to be undertaken outside of standard construction hours for safety and traffic management reasons, outage constraints on the existing infrastructure (i.e. the need to maintain power supply to customers), to comply with relevant licence or approval conditions (e.g. road occupancy licences) or to meet the requirements of government agencies.

It can be expected that there may be differences between the predicted and actual noise levels experienced during construction due to variations in instantaneous operating conditions and also the location of plant and equipment. For most construction scenarios, it is expected that the construction noise levels would frequently be lower than predicted, as the noise levels presented in the CNVIA are based on the noisiest activities likely to occur (i.e. the worst case).

Potential impacts identified would be temporary in nature ranging from around 8-10 weeks per section for trenching and excavation and joint bay activities, up to 10 non-continuous weeks for special crossings, around 3-5 weeks per section for road surface restoration activities, about 4-9 months for substation upgrade works and around 24 months for construction laydown areas. For the trenching and excavation works, receivers may generally be affected for around eight weeks. Furthermore, at any one receiver, construction noise levels would slowly increase as the works approach the receiver, would then remain fairly constant for a few days while the works are close to the receiver and would then slowly decrease again as the works move away. However, for road surface restoration works, receivers may be affected for about 3-5 weeks. Although construction laydown areas are of the longest duration, noise impacts would be variable throughout the day and night.

A Construction Noise and Vibration Management Plan (CNVMP) will be developed for the project before construction works begin. The CNVMP will include reasonable and feasible safeguards to manage the noise emissions from the work sites. These measures are outlined in **Section 8.4**.

8.3.1.2 Other receivers

The numbers of non-residential noise sensitive receivers where noise levels are expected to exceed the NMLs during standard construction hours are shown in **Table 8-9**. Around 550 non-residential receivers are predicted to be affected in total at some point during the following activities; however more than 50% of the NML exceedances are expected to be less than 10 dB:

- site preparation;
- trenching and excavation;
- excavation of joint bays;
- special crossings; and
- restoration of road surfaces.

The highest impacts are expected during trenching and excavation. Noise levels at around 550 non-residential receivers are expected to exceed the NMLs during these works. However, this is over the full extent of the project area and most receivers would only be affected for a short period of time.

The impacts of works around cable joint bays which includes joint bay construction and cable pulling, would affect fewer receivers due to their discrete locations (in comparison to trenching and excavation works along the entire transmission cable route).

Construction noise levels at the following non-residential noise sensitive receivers are expected to exceed the NML at times:

- Little Angels Long Day Care Centre;
- Funtime Child Care;
- Fantastic Kids Family Day Care;
- Toddlers Ink Childcare;
- St John Vianney Catholic Primary School;
- St John Vianney Catholic Church;
- Lakemba Mosque;
- St Michael's Catholic Primary School;
- Church of St Michael the Archangel;
- Woodstock Child Care Centre;
- Goodstart Early Learning Ashfield;
- Sydney Private Hospital;
- Yeo Park Infants School;
- Ashfield Early Learning Centre;
- Summer Hill Public School;
- Christian Brothers' High School Lewisham;
- Lewisham Public School;
- Greek Orthodox Community Child Care Centre;
- Addison Road Child Care Centre;
- Newington College;
- Enmore Children's Centre;
- St Pius Catholic Primary School;
- Catholic Parish of Our Lady of The Southern Cross;
- St Pius Enmore Catholic Church;
- Only About Children Enmore; and
- Camdenville Public School.

Table 8-9 Number of non-residential sensitive receivers where noise levels exceed the NMLs

Scenario	Number of other buildings where noise levels exceed the NMLs across the project area		
	1-10 dB	11-20 dB	> 20 dB
Site preparation	251	96	92
Trenching and excavation	302	138	107
Excavation and construction of cable joint bays	159	50	21
Special crossings	141	23	54
Cable pulling	110	23	18
Construction laydown	10	2	0
Restoration of road surfaces	286	124	103
Rookwood Road and Beaconsfield West substation works	0	0	0
Sydney South substation	0	0	0

Note that the impacts identified in **Table 8-9** apply when the properties are in use, i.e. during school hours or religious services.

8.3.1.3 Cumulative construction noise impacts

While most construction activities are expected to occur at separate times and locations, it is possible that noisy construction activities for the project may occur at the same time in close proximity to each other. These may include works at the substations, trenching and excavation, special crossings, and excavation and construction of joint bays. In these cases, it is possible that predicted noise levels may increase by up to 3 dB(A) and there is potential that this would increase the number of receivers where noise levels would be exceeded by more than 20 dB above the NMLs. Cumulative noise impacts from concurrent project activities would be managed through the implementation of the measures described in **Section 8.4**.

8.3.2 Sleep disturbance assessment

The predicted $L_{A1(1\ min)}$ noise levels, presented in **Table 8-10** indicate that the awakening reaction criteria may be exceeded during night-time construction works (where this is required). Where the awakening reaction criterion is exceeded, consideration would be given to reasonable and feasible mitigation measures as summarised in **Section 8.4**.

The following sections summarises the potential sleep disturbance impacts for each of the construction noise scenarios for residential receivers in the project area.

8.3.2.1 Site preparation

Noise levels at approximately 1,200 residential receivers in total along the entire transmission cable route are predicted to potentially exceed the awakening reaction criteria for site preparation works, if undertaken during the night-time period. Site preparation works are likely to be completed in a period of up to one week at any one site.

8.3.2.2 Trenching and excavation

Noise levels at approximately 1,400 residential receivers in total along the entire transmission cable route are predicted to exceed the awakening reaction criteria for the trenching and excavation during the construction period. However, as this scenario progresses linearly along the transmission cable route, it is expected that noise levels at up to 250 residential receivers at any one time may exceed the awakening reaction criteria. The highest impacts are expected during road surface/pavement cutting. These impacts are expected at receivers within NCAs 2, 3, 4, 5 and 6.

8.3.2.3 Special crossings

Noise levels at approximately 580 residential receivers in total (for all special crossings collectively) are predicted to exceed the awakening reaction criteria for the special crossing scenario. Special crossings are likely to be completed in a period of up to 10 weeks at each crossing location; however, works would be staged and not continuous over the 10 week period. These impacts are expected at receivers within NCAs 3 to 6.

8.3.2.4 Cable pulling

Noise levels at approximately 750 residential receivers in total along the entire transmission cable route are predicted to exceed the awakening reaction criteria for the cable pulling scenario. These impacts are expected at receivers within NCAs 2 to 6. Cable pulling is likely to be completed in a period of up to two weeks per section. As noted above, the location of joint bays is not yet confirmed and therefore the actual number of affected receivers may differ from those reported above, depending on the final location of the joint bays. The actual joint bay locations would be determined during detailed design and the number of receivers affected would be re-evaluated.

8.3.2.5 Construction laydown areas

Noise levels at approximately 39 residential receivers in total are predicted to exceed the awakening reaction criteria, for the construction laydown scenario. The laydown areas are likely to be in use for up to 24 months, with stockpiling activities occurring for 15 months. These impacts are expected at receivers in NCAs 3 and 5.

8.3.2.6 Restoration of road surfaces

Noise levels at approximately 1,100 residential receivers in total along the entire transmission cable route are predicted to exceed the awakening reaction criteria for the restoration of road surfaces scenario. However, as this scenario progresses linearly along the transmission cable route, it is expected that approximately 100 residential receivers at any one time would exceed the awakening reaction criteria. These impacts are expected in NCAs 2, 3, 4, 5 and 6.

8.3.2.7 Works at Rookwood Road, Beaconsfield West and Sydney South substations

Noise levels from substation works are not expected to exceed the awakening reaction criteria at any noise sensitive receivers.

Table 8-10 Number of residential buildings where noise levels may exceed sleep disturbance and awakening reaction levels for construction scenarios potentially occurring at night

NCA	Scenario	Number of residential buildings where noise levels may exceed the sleep disturbance screening level and/or the awakening reaction level	
		Sleep disturbance screening level $L_{A1(1\ minute)}$, dB(A)	Awakening reaction level $L_{A1(1\ minute)}$, dB(A)
NCA1	Site preparation	28	0
	Trenching and excavation	47	0
	Excavation and construction of cable joint bays	-[1]	-[1]
	Special crossings	0	0
	Cable pulling	15	0
	Construction laydown	0	0
	Restoration of road surfaces	28	0
	Rookwood Road substation works	7	0
NCA2	Site preparation	2,124	225
	Trenching and excavation	2,910	277
	Excavation and construction of cable joint bays	-[1]	-[1]
	Special crossings	0	0
	Cable pulling	1,996	124
	Construction laydown	0	0
	Restoration of road surfaces	2,124	225
NCA3	Site preparation	568	120
	Trenching and excavation	855	151
	Excavation and construction of cable joint bays	-[1]	-[1]
	Special crossings	787	106
	Cable pulling	640	93

NCA	Scenario	Number of residential buildings where noise levels may exceed the sleep disturbance screening level and/or the awakening reaction level	
		Sleep disturbance screening level $L_{A1(1\ minute)}$, dB(A)	Awakening reaction level $L_{A1(1\ minute)}$, dB(A)
	Construction laydown	154	16
	Restoration of road surfaces	568	120
NCA4	Site preparation	1,451	106
	Trenching and excavation	2,105	131
	Excavation and construction of cable joint bays	-[1]	-[1]
	Special crossings	1,567	11
	Cable pulling	1,245	104
	Construction laydown	0	0
	Restoration of road surfaces	1,451	106
NCA5	Site preparation	6,839	443
	Trenching and excavation	8,256	549
	Excavation and construction of cable joint bays	-[1]	-[1]
	Special crossings	10,702	442
	Cable pulling	7,411	368
	Construction laydown	392	23
	Restoration of road surfaces	6,839	443
NCA6	Site preparation	1,323	269
	Trenching and excavation	1,626	308
	Excavation and construction of cable joint bays	-[1]	-[1]
	Special crossings	749	24
	Cable pulling	648	55

NCA	Scenario	Number of residential buildings where noise levels may exceed the sleep disturbance screening level and/or the awakening reaction level	
		Sleep disturbance screening level $L_{A1(1\ minute)}$, dB(A)	Awakening reaction level $L_{A1(1\ minute)}$, dB(A)
	Construction laydown	179	0
	Restoration of road surfaces	1,323	269
	Beaconsfield West substation works	0	0
NCA7	Sydney South substation works	80	0

Notes:

1 These works are not proposed to be undertaken outside of standard hours therefore modelling for sleep disturbance has not been undertaken.

The scenarios considered above represent 'reasonable worst case scenarios' based on the assumed location of plant and the number of plant operating concurrently. Therefore, the numbers of affected receivers are considered to be conservative. The actual number of affected receivers is expected to be lower than those predicted. In addition, all construction scenarios, with the exception of the excavation and construction of joint bays, have been assessed as being delivered during standard construction hours and outside of standard construction hours, in certain locations. The requirement for works to be completed outside of standard construction hours would be at the discretion of the relevant road authorities. Therefore, the impacts are unlikely to be as extensive as have been modelled and reported.

A range of management measures have been recommended to reduce the noise impacts. These measures include consideration of respite periods, noise monitoring, choice of equipment and plant, scheduling of works, stationary noise shields and community consultation with affected receivers to achieve negotiated outcomes. Noise management measures would be documented in a Construction Noise and Vibration Management Plan (CNVMP) for the project, which would include an Out-of-hours Protocol to detail specific procedures and consultation measures for affected receivers to manage works outside of standard construction hours. Further information is provided in **Section 8.4**.

8.3.3 Assessment of noise from construction traffic on public roads

The maximum construction traffic movements are anticipated to be:

- 12 heavy vehicle deliveries/spoil removal (24 movements) and up to two light vehicles (four movements) per work site per day, noting that four work sites may be operating concurrently at multiple locations along the transmission cable route;
- five heavy vehicle movements (10 movements) and up to six light vehicles (12 movements) per special crossing site;
- six heavy vehicles (12 movements) and up to two light vehicles (four movements) per construction laydown area;
- two heavy vehicles (four movements) and up to two light vehicles (four movements) at Rookwood Road and Beaconsfield West substations, per day; and
- three heavy vehicles (six movements) and up to three light vehicles (six movements) at the Sydney South substation per day.

In order for construction traffic to generate an increase in noise levels of greater than 2 dB, existing traffic levels along construction traffic routes would need to increase by around 60%. For arterial roads, noise level increases due to project related construction traffic are expected to be less than 2 dB during the day and night-time periods, given existing high levels of traffic on these roads. Therefore, the potential noise impact is considered barely perceptible and no further assessment is required, in accordance with the RNP.

Local roads vary in existing traffic volumes and generally accommodate less through traffic than arterial roads. It is expected that some local roads may experience noise level increases greater than 2 dB during daytime and night-time hours due to construction traffic from the project, where existing traffic volumes are considerably low. In these instances, it is expected that the overall road traffic noise levels would comply with the $L_{Aeq(1hr)}$ noise levels for local roads under the RNP. Therefore, no consideration of noise mitigation is required in accordance with the RNP.

The majority of the truck movements would be associated with transmission cable route activities (trenching, special crossings and joint bay excavation) and so noise impacts on local roads are expected to be limited to a short duration (up to 10 weeks). Truck movements would occur at any time throughout the work shift, but would not be continuous, i.e. there would be times when no trucks are travelling to or from work sites.

8.3.4 Construction vibration assessment

Vibration intensive works may include the use of jack hammers and rock breakers. The minimum working distances for these items of equipment from off-site receivers are shown in **Table 8-11**. These distances indicate the minimum separation distances where no adverse impacts from vibration intensive works (i.e. works which use vibration intensive equipment such as jack hammers, piling rigs

and rock breakers) are likely in terms of human comfort or cosmetic damage to buildings/structures. It is noted that the minimum working distances can vary from site to site depending on ground conditions etc. To account for this the minimum working distances presented in **Table 8-11** are typically conservative in order to cover most sites and ground conditions.

Table 8-11 Minimum working distances of vibration intensive equipment to be used during the project

Plant	Rating/description	Cosmetic damage – residential/ commercial, m	Cosmetic damage – heritage, m	Human comfort – residential, m
Jack hammer	Hand-held	1 (nominal)	1 (nominal)	Avoid contact with structure
Hydraulic hammer (rock breaker)	300 kg – 5-12 t excavator	2	4	7
	900 kg – 12-18 t excavator	7	12	23
	1600 kg – 18-34 t excavator	22	34	73
Piling rig	Hammer – 12 t down force	15	24	50

Based on the indicative construction activities assessed for the project, some works may occur within the minimum working distances for human comfort and cosmetic damage of residential/commercial buildings and heritage listed items. Works undertaken within the human comfort minimum working distances may cause some people to experience annoyance and concern for cosmetic damage to buildings. Receivers located within the minimum distances for human comfort would be notified of the potential impacts as part of the notification of highly noise affected receivers.

Works undertaken within minimum working distances for cosmetic damage have the potential to cause damage to buildings, if appropriate mitigation measures are not employed. Where vibration-intensive works are required within the identified minimum working distances, mitigation measures to control excessive vibration would be implemented as outlined in **Section 8.4**.

These measures would include undertaking attended vibration measurements at work sites when work commences to determine site specific minimum working distances and pre- and post-construction building condition surveys. Vibration measurements would be made progressively working out from the minimum working distances identified in **Table 8-11** to determine site specific working distances that vibration-intensive works can be undertaken without causing structural/cosmetic damage to buildings and heritage items. Detailed information on vibration transmission would be measured to allow site specific safe working distances to be determined.

Potential impacts on heritage items due to vibration (in relation to impacts to heritage significance) are assessed in the Historical Heritage Impact Assessment in **Appendix J** and summarised in **Chapter 15 Non-Aboriginal heritage**.

8.4 Environmental management and mitigation measures

The CNVIA identified a large number of residential and non-residential receivers which would likely be impacted by the construction of the project. The greatest impacts were identified to occur at night-time, outside of standard construction hours.

The CNVIA presents a worst case assessment and therefore there may be differences between the predicted and actual noise levels experienced during construction. For most construction activities, it is expected that the construction noise levels would frequently be lower than predicted.

This scale of noise impact is not uncommon for linear projects undertaken in metropolitan areas. For these types of projects community consultation is a key mitigation measure. A Community Consultation Framework (refer to **Appendix C**) has been developed for the project and outlines a community consultation framework for construction noise and vibration management. The following sections outline the consultation and other management measures which would be implemented to reduce the potential noise and vibration impacts on sensitive receivers.

8.4.1 Management objectives

The objective for managing construction noise is to minimise noise and vibration impacts. Minimising noise impacts has been considered throughout the planning and assessment phase and will continue to be a consideration for the construction. During construction, noise and vibration impacts would be minimised by identifying and applying 'feasible' and 'reasonable' measures in accordance with the ICNG.

A feasible measure is one that is capable of being put into practice. A reasonable measure is one where the overall benefits outweigh the adverse social, economic and environmental costs of the measure. When determining measures consideration is given to the:

- level of noise impact;
- benefits of the mitigation;
- cost effectiveness of the mitigation; and
- community views.

8.4.2 Environmental management and mitigation measures

Table 8-12 presents proposed noise and vibration mitigation measures. These are based upon standard mitigation measures contained within the ICNG.

Table 8-12 Noise and vibration mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
NV1	CNVMP	A CNVMP will be developed as part of the CEMP for the project and will include reasonable and feasible safeguards to manage the noise emissions from construction and manage any complaints which may be received. The CNVMP will include the following: • identification of nearby residences and other sensitive land uses; • description of approved hours of work; • description and identification of all construction activities, including construction work sites, equipment and duration; • description of work practices (generic and specific) which will be applied to minimise noise and vibration; • a complaints handling process; • noise and vibration monitoring procedures; • overview of community consultation/notification required (see NV2); and • the Out-of-hours Protocol developed for the project.	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
NV2	Community consultation/ notification	Residents and other sensitive receivers impacted by noise and/or vibration from the proposed works which is expected to exceed the NML (as defined in **Table 8-5** and **Table 8-6**) and/or the vibration criteria (as summarised in Table 5-6 and Table 5-7 of **Appendix E**) will be notified at least seven days prior to the commencement of the particular activity. The information provided to the residents and other sensitive receivers impacted will include: • programmed times and locations of construction work; • the hours of proposed works; • construction noise and vibration impact predictions; and • construction noise and vibration mitigation measures to be implemented. Community consultation regarding construction noise and vibration is further detailed in the Community Consultation Framework in **Appendix C**.	Construction
NV3	Site inductions	All project personnel, contractors and subcontractors will undergo an environmental induction. The induction will at least include: • all project specific and relevant standard noise and vibration mitigation measures; • relevant licence and approval conditions; • permissible hours of work; • any limitations on high noise generating activities (e.g. use of jack hammering, rock breaking, piling rigs and diamond saws); • locations of nearest sensitive receivers; • construction employee parking areas; • designated loading/unloading areas and procedures; • site opening/closing times (including deliveries); • behavioural practices such as limiting the use of loud stereos/radios on-site and not dropping materials from height or metal items; • public complaints handling procedures; and • environmental incident management procedures.	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
NV4	Out-of-hours Protocol	Where feasible and reasonable, construction will be carried out during standard construction hours. However, given that some works would be undertaken outside of standard construction hours an 'Out-of-hours Protocol' will be prepared as part of the CNVMP. This will evaluate the potential noise impacts of specific out-of-hours works and recommend appropriate mitigations measures such as: • community consultation with highly noise affected receivers; • procedures to determine negotiated outcomes in consultation with affected receivers (e.g. construction scheduling during sensitive periods such as exams where construction is in the vicinity of schools); • specific mitigation measures such as respite periods; and • a monitoring program.	Construction
NV5	Respite periods for works during standard construction hours	Respite periods during standard construction hours will be identified in consultation with affected receivers. Respite options will be considered when sensitive receivers are within the minimum working distances for vibration intensive works or are highly noise affected receivers (experiencing noise levels above 75 dB(A)). Respite options will include consideration of amendments to work schedules. Vibration intensive or high noise generating equipment will be used in continuous blocks, not exceeding three hours each, with a minimum respite period of one hour between each block.	Construction
NV6	Respite periods for works outside of standard construction hours	The need to consider respite periods will be triggered where the $L_{Aeq(15min)}$ noise levels exceed 75 dB(A) at the same receiver after midnight for more than three consecutive nights. Where this level is exceeded, respite periods will be considered in accordance with the Out-of-hours Protocol (refer to NV4).	Construction
NV7	Construction hours and scheduling	Where feasible and reasonable, construction will be carried out during standard construction hours. Where required to be completed outside of standard construction hours, in proximity to sensitive receivers, works generating high noise and/or vibration levels (including the use of rock breakers and diamond saws) will be scheduled during less sensitive time periods.	Construction
NV8	Noise monitoring	A noise monitoring program will be implemented for the duration of the works in accordance with the CNVMP and will focus on the use of high noise generating plant (e.g. jack hammering, rock breaking, piling rigs and diamond saws) and works outside of standard construction hours.	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
NV9	Equipment selection and placement	Equipment selection will consider potential noise and vibration impacts and quieter equipment and/or construction methods will be used where feasible and reasonable. Plant and equipment will: • have an operating sound power level of no more than those listed in **Annexure E**; • be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse noise and vibration impacts; • be fitted with non-tonal reversing beepers (or an equivalent mechanism); • be throttled down or shut down when not in use; and • minimise noise through: - use of residential grade mufflers; - use of damped hammers such as 'City' Model Rammer Hammers; and - silencing air parking brakes. High noise generating plant will: • be located so that the offset distance between the plant and adjacent sensitive receivers is maximised as far as possible; and • be directed away from sensitive receivers, where possible to do so.	Detailed design and construction
NV10	Construction traffic	Potential noise impacts from construction vehicles will be minimised through the following: • traffic flow, parking and loading/unloading areas will be planned to minimise reversing movements within the work sites and at construction laydown areas; • loading and unloading of materials/deliveries will occur as far as possible from sensitive receivers; • shielding loading/unloading areas if close to sensitive receivers, where feasible (i.e. breaking the line of site between the area and the receiver); • fitting delivery vehicles with straps rather than chains for unloading, wherever possible; • selecting construction laydown area access points and roads as far away as possible from sensitive receivers; • locating delivery and haulage routes away from sensitive receivers, where possible; • scheduling deliveries during less sensitive times, where possible; • limiting the speed of vehicles; • restricting the use of engine compression brakes; and • maximising the storage capacity of construction laydown areas to reduce the need for truck movements during sensitive times (between midnight and 7:00 am).	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
NV11	Steel road plates	The use of road plates will be minimised, where possible. Where required to be used, the plates will be installed in a manner that minimises the potential for displacement by traffic loading and minimises any height difference with the adjacent road surface in order to reduce the potential for impact noise generation from tyres traversing the plates.	Construction
NV12	Stationary noise sources	Low noise emitting plant and equipment (such as those with built-in shielding and mufflers) will be used wherever possible. Noise generating plant at work sites (such as compressors and generators) will be directed away from and situated furthest away from sensitive receivers, where practicable. Machinery that is not in use will be switched off.	Construction
NV13	Shield sensitive receivers	Structures will be used to shield residential receivers from noise such as use of hoarding/noise curtains, where practicable, at construction laydown areas and special crossing work sites.	Construction
NV14	Building condition surveys and vibration monitoring	If vibration intensive equipment is to be used within the minimum working distances for cosmetic damage, then it is recommended that a different construction method with lower source vibration levels is used where feasible and reasonable. Where work within the minimum working distances for cosmetic damage is planned to occur: • attended vibration measurements will be undertaken at the work site when work commences, to determine site specific minimum working distances. As a precaution, where practicable, these measurements will be made at distances outside the minimum working distances to ensure no structural damage occurs and will provide detailed information regarding the transmission of vibration to allow site specific safe working distances to be determined; and • for listed heritage items and houses within heritage conservation areas, building conditions surveys will be undertaken. The survey will document the structural condition of these buildings/structures before construction commences and after construction is complete to identify any impacts on historical buildings/structures as a result of the project construction. Building condition surveys will be scheduled in consultation with property owners. Vibration intensive work will not proceed within the minimum working distances (recommended or site specific) unless a permanent vibration monitoring system is installed to warn operators when vibration levels are approaching the peak particle velocity objectives as outlined in DIN 4150. For work scheduled to occur near a building, within the minimum working distance for human comfort but outside the minimum working distance for cosmetic damage, the affected receivers will be notified.	Construction

9.0 Air quality

This chapter provides an overview of the pollutants of concern for the project. It also summarises the assessment of potential impacts of the project on air quality and the proposed management and mitigation measures to mitigate impacts, as detailed in the Air Quality Impact Assessment in **Appendix F**.

9.1 Assessment methodology

9.1.1 Particulate matter and dust

During construction, the primary pollutant of concern for the project would be particulate matter and deposited dust. Dust in the form of particulate matter (dust suspended in the air) and deposited dust (dust settled on surfaces) would be generated during any activities that result in the physical disturbance of soil. Activities with the greatest potential to generate dust include those requiring excavation such as trenching and the construction of joint bays. Dust generation would generally be higher as the quantity of soil disturbed increases, when the soil is dry, or during windy conditions.

Particulate matter refers to the many types and sizes of particles suspended in the air we breathe. Particulate matter is often classified according to the following sizes:

- total suspended particulates (TSP) - particles with an aerodynamic diameter of less than or equal to 30 micrometres (µm); and
- particles with an aerodynamic diameter less than or equal to 10 µm (referred to as PM_{10}).

Particulate matter would be emitted from a number of construction activities including disturbance of soil and rock, movement of plant on exposed areas of earth, movement of fill materials and wind-blown dust from exposed surfaces.

Particles with a diameter of less than 2.5 µm (referred to as $PM_{2.5}$) are typically associated with combustion processes, and are only produced in very small amounts by mechanical disturbance of materials such as excavation. $PM_{2.5}$ was therefore not assessed further.

Deposited dust (dust soiling) refers to dust particles of all sizes that have settled on exposed surfaces. Deposited dust causes aesthetic impacts associated with coarse particles settling on surfaces, which causes soiling and discolouration.

In NSW, air quality criteria are specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Approved Methods) (NSW EPA, 2017a) and represent maximum allowable pollution levels at sensitive receptors. The assessment criteria relevant to dust emissions for the project are presented in **Table 9-1**.

Table 9-1 NSW EPA impact assessment criteria for pollutants of potential concern

Pollutant	Averaging period	Concentration/ Rate
Particles as PM_{10}	24 hours	50 µg/m^3
	Annual	25 µg/m^3
Total Suspended Particulates (TSP)	Annual	90 µg/m^3
Deposited dust (dust soiling)	Annual	2 g/m^2/month[a] 4 g/m^2/month[b]

Notes:
a Maximum increase in deposited dust level.
b Maximum total deposited dust level.

The SEARs reference the NSW Approved Methods with respect to air quality impact assessment. The modelling and assessment methodology outlined in the Approved Methods apply to stationary industrial sources. The project is not a stationary industrial emission source and air quality impacts associated with the project would be confined almost entirely to the construction phase. Moreover, the majority of construction activities would occur in a progressive linear manner, with the exception of the construction laydown areas, special crossings and substation works, with receptors likely exposed to relatively short periods of construction at any given point along the transmission cable route. The

construction laydown areas, cable bridges and substation works would occur at stationary locations; however, dust-generating activities at these locations would not be as intensive as along the transmission cable route. The excavation of the launch and receive underbore pits would be the highest dust generating stage of underboring and is expected to take up to a week. Given this, quantitative modelling under the Approved Methods was not considered applicable to the project. Air quality impacts associated with the project have been assessed qualitatively, based on a risk-based approach focusing on construction emissions and standard mitigation measures to minimise amenity and nuisance impacts at surrounding receptors. Relevant air pollutant criteria and the general approach to assessment (e.g. background air quality and meteorology) have been applied consistent with the Approved Methods.

The assessment of potential dust impacts resulting from the construction of the project was based on the methodology described in the UK Institute of Air Quality Management (IAQM) guideline, *Guidance on the assessment of dust from demolition and construction Version 1.1* (IAQM, 2014). This guideline focuses on the risk of dust soiling (equivalent to dust deposition) and human health impacts focusing on PM_{10}. The larger fraction of TSP (> 10 µm) tends to fall out of suspension quickly as deposited dust. The finer size fraction of TSP (< 10 µm) are effectively PM_{10}. Based on this, the TSP emissions are generally accounted for when focusing only on deposited dust and PM_{10}. In addition, assessment of TSP is generally concerned with impacts to amenity, whereas the assessment of PM_{10} is usually more concerned with health impacts. Based on this, TSP is not strictly considered in the IAQM methodology and therefore was not considered further. The risk of dust deposition (hereafter referred to as dust soiling as per the IAQM guideline) and human health impacts resulting from the generation of PM_{10} on surrounding areas was determined based on the scale of activities and proximity to sensitive receptors.

The IAQM method uses a four-step process to assess dust impacts:

- Step 1: Screening based on distance to nearest sensitive receptors. If any sensitive receptors are within a certain distance, then continuing on to Step 2 is required:
    - the IAQM method recommends further assessment of dust impacts for construction works where sensitive receptors are located closer than:
        - 350 metres from the boundary of a site;
        - 50 metres from the route used by construction vehicles on public roads up to 500 metres from a site entrance;
- Step 2: Assess risk of dust impacts from project activities based on:
    - scale and nature of the works, which determines the potential dust emission magnitude;
    - sensitivity of the surrounding area;
- Step 3: Determine site-specific mitigation for dust-emitting activities; and
- Step 4: Reassess risk of dust impacts after mitigation has been considered.

An assessment of dust impacts during construction is presented in **Section 9.3**.

9.1.2 Odour

There is the potential that landfill gas (LFG) may be encountered during excavation activities (for trenching and underboring) in Arlington Oval (Precinct 3), Marrickville Park (Precinct 3), Henson Park (Precinct 3), Camdenville Park (Precinct 5) and Sydney Park (Precinct 5). The transmission cable route option passes within 20 to 50 meters of both Arlington Oval and Marrickville Park. Arlington Oval, Marrickville Park and Henson Park are formerly filled brick pits, however, the potential presence and extent of LFG at these locations is currently unknown. There is also potential for LFG to be present at the construction laydown areas at Cooke Park (Precinct 2) and Peace Park (Precinct 3).

Landfill gas is primarily composed of methane and carbon dioxide, which are not odorous compounds and are not covered by environmental air quality criteria in NSW as priority pollutants. Emissions of methane and carbon dioxide have therefore not been considered further in this assessment. However, LFG typically contains small amounts of other compounds, such as hydrogen sulfide, which can be

odorous, even at low concentrations. Odour from hydrogen sulfide therefore has the potential to impact on nearby receptors if LFG is encountered during excavation activities.

Odour impacts from industry are usually assessed in NSW in accordance with *Technical framework: Assessment and management of odour from stationary sources in NSW* (Department of Environment and Conservation NSW, 2006). However, the Technical Framework applies to new or modified stationary odour sources. The odour source of concern for the project is legacy LFG, which the project does not contribute to. As such, the framework is not considered relevant to the assessment of potential odour impacts from the project. Potential odour impacts due to LFG have been assessed qualitatively, focusing on likely risks of encountering LFG, and appropriate odour management measures to minimise impacts at nearby sensitive receptors, should LFG be encountered.

Odour impacts typically manifest as annoyance, which is described as the negative reaction that a person may experience when exposed to an unpleasant odour. Continued annoyance may impact health by causing a build-up of stress.

Odour concentration is measured in terms of odour units (OU). An odour assessment criterion of 2 OU was adopted for this assessment based on the urban nature of the project area and surrounds in accordance with NSW EPA's odour assessment criteria for complex mixtures of odorous air pollutants (NSW EPA, 2017a).

9.1.3 Combustion emissions

A small number of mobile plant and light vehicles would be required to undertake construction of the project and operational maintenance. It is unlikely that more than one or two mobile plant would be operational at any given time near any given receptor, and as such combustion emissions (e.g. $PM_{2.5}$, nitrogen dioxide, carbon monoxide) from plant are not expected to be significant and are unlikely to impact on surrounding sensitive receptors. Combustion emissions due to mobile plant and other vehicles were therefore not included in this assessment. However, as a precautionary measure standard mitigation measures for combustion emissions have been identified and included.

9.1.4 Study area

For the purpose of the air quality impact assessment, the study area comprises a 350 metre buffer around the project area, which includes the transmission cable route, construction laydown areas and substations.

9.2 Existing environment

9.2.1 Sensitive receptors

There are a large number of sensitive receptors[1] along the length of the transmission cable route, including private residences, commercial businesses, and community facilities including schools, childcare centres, healthcare providers and parks. Many of these receptors are located within about 20 metres of the project area and as a result are likely to be impacted due to their proximity. Only minor impacts are expected at receptors beyond this distance, or at receptors shielded from the works by other buildings. However, all receptors within 350 meters have been considered for the purpose of the air quality impact assessment, as specified in the IAQM guideline.

The Sydney South substation is located in bushland on a bend of the Georges River at Picnic Point. There are no sensitive receptors within 350 metres of works to be undertaken at the substation.

A summary of the approximate number of sensitive receptors within the study area by construction precinct are presented in **Table 9-2**.

[1] Sensitive receptors include residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres, passive recreation areas (including outdoor grounds used for teaching), active recreation areas (including parks and sports grounds), commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, retail spaces and industrial premises).

Table 9-2 Summary of sensitive receptors by precinct

Precincts and Sydney South substation	Approximate number of sensitive receptors within the study area
Precinct 1	~50 mostly commercial
Precinct 2	>100 mostly residential[1]
Precinct 3	>100 mostly residential[1]
Precinct 4	>100 mostly residential[1]
Precinct 5	>100 mixed residential and commercial[1]
Sydney South substation	None

Note:
1 The highest number of receptors category is listed as >100 in the IAQM guideline.

9.2.2 Terrain and land use

Terrain along the transmission cable route and at Rookwood and Beaconsfield West substations is largely flat and regular in nature, without deep valleys or prominent peaks that could strongly influence local meteorology such as wind speed and direction. Land use along the transmission cable route is a combination of medium-density residential, commercial, and public use parkland. Air flow would be most affected by taller buildings that block winds particularly in areas where there are continuous buildings on both sides of the road. This creates an urban canyon effect wherein air flow would be affected and would increase the overall air pollution concentration at street level.

The construction laydown areas are all located within about one kilometre from the transmission cable route and share similar terrain and land use features to the transmission cable route, i.e. mostly flat. They are located primarily in parks and vacant space and are surrounded by a mix of residential and commercial land use. Wind flow would be slightly less affected compared with the transmission cable route, due to the open parkland and generally lower buildings surrounding the parks.

The Sydney South substation is located on a hill above the Georges River at an elevation of about 55 metres above sea level (mASL). The area surrounding the substation is hilly with the Georges River Valley running west to east to the immediate south of the substation. Winds are likely to be directed along the flow of the Georges River Valley. The substation is completely surrounded by forest with the nearest residential areas around 500 metres away.

Arlington Oval, Marrickville Park, Henson Park and two of the construction laydown areas (Cooke Park and Peace Park) are formerly filled brick pits. In a 2012 survey conducted by GHD, methane was detected in high concentrations in boreholes in Camdenville Park, indicating the presence of LFG (GHD, 2013). No methane (the major LFG constituent) was detected in an LFG screening program undertaken at six locations in Sydney Park wherein one location is within the project area located near the Sydney Park car park adjacent to Princes Highway (Douglas Partners, 2017). Negligible detections of carbon dioxide were identified during the screening program, suggesting that LFG could be present. No landfilling activities have been undertaken however for more than 30 years in this park.

9.2.3 Meteorology

The nearest meteorological weather stations operated by the Bureau of Meteorology (BoM) are at:

- Canterbury Park Racecourse, less than 200 metres from the project area in Precinct 3; and
- Holsworthy Control Range; approximately 8 kilometres west of the Sydney South substation.

Wind characteristics measured at the Canterbury Park Racecourse are generally considered to be representative of winds across the project area. Typically, summer afternoons would be most favourable to rapid dispersion of air pollutants due to strong winds and a low percentage of calm conditions. Winter mornings would be least favourable to the dispersion of air pollutants due to the lower wind speeds and higher percentage of calm conditions. Winds at Sydney South substation are expected to be consistent with both Holsworthy Control Range and Canterbury Park Racecourse, as all sites are located in the Sydney basin.

9.2.4 Existing air quality

The NSW Office of Environment and Heritage (OEH) operate three air quality monitoring stations in close proximity to the project which monitor particulate matter concentrations. These monitoring stations are located at:

- Rozelle (around 3.5 kilometres to the north of the project area) – predominately residential;
- Chullora (immediately adjacent to the western end of the project area) – mixed residential/commercial; and
- Earlwood (about 2 kilometres to the south of the project area) – predominately residential.

No OEH monitoring station is located near Sydney South substation. The Chullora monitoring station is the closest, approximately 10 kilometres to the north of the substation. Particulate concentrations at Sydney South substation are likely to be similar to those monitored at Rozelle, Chullora and Earlwood as concentrations throughout the Sydney Basin are typically similar. The data presented below can therefore be considered representative of concentrations along the transmission cable route including at Sydney South substation.

A summary of PM_{10} monitoring data for the period 2013 to 2018 at Rozelle, Chullora and Earlwood are presented in **Table 9-3**. Observations from the monitoring stations identified:

- exceedances of the 24-hour NSW EPA criterion at all three sites in 2013, 2015, 2016, 2017 and 2018. The highest 24-hour PM_{10} concentrations measured at three stations in 2018 were all recorded on 22 November 2018 when a state wide dust storm occurred (NSW OEH, 2018);
- no exceedances of the annual average NSW EPA criterion at any of the sites across all six years. The highest annual average PM_{10} concentration of 21.9 µg/m^3 was measured in 2018 at Chullora; and
- the study area can be subject to elevated short-term particulate impacts, for example when smoke from bushfires and/or hazard reduction burn events affects the Sydney basin.

Table 9-3 Summary of existing PM_{10} concentrations at nearby air quality monitoring stations

Averaging period	NSW EPA impact assessment criteria	Year	PM_{10} concentration (µg/m^3)		
			Rozelle	Chullora	Earlwood
Maximum 24-hour average	50	2013	58.5	69.4	63.1
		2014	43.8	40.0	45.2
		2015	60.3	64.6	66.5
		2016	58.8	63.5	42.9
		2017	54.1	63.0	59.8
		2018	88.3	90.7	86.5
Annual average	25	2013	18.3	18.3	19.9
		2014	17.9	18.1	18.3
		2015	16.7	17.5	17.2
		2016	16.8	18.1	17.6
		2017	18.1	20.1	18.0
		2018	18.5	21.9	19.8

9.3 Assessment of potential impacts

9.3.1 Selection of emissions scenarios

To assess the potential magnitude of dust emissions from the construction of the project, a worst case dust emission scenario was defined (detail around the worst case scenario can be found in **Appendix F**). This was determined to be the construction of the transmission cable circuit as this project component had the highest estimated volumes of earthworks, construction and trackout (trucks and other vehicles moving materials to and from work sites).

The construction activities that would produce the most dust in relation to the transmission cable route would be trenching and excavation for conduit installation, excavation of pits for underboring and excavation and establishment of joint bays, including associated stockpiling. Excavation volumes along the length of the transmission cable route are expected to be essentially identical, and as such the dust emission scenario was developed as a generic case which could be applied across the entire transmission cable route.

As the proposed upgrade works at the substation sites and use of the construction laydown areas would be of a much smaller scale than construction of the transmission cable circuit, the worst case dust emission scenario described for the transmission cable route was applied conservatively to these other components of the project.

9.3.2 Construction dust assessment

The IAQM four-step assessment, as described in **Section 9.1.1**, was applied to the worst case dust emission scenario and is summarised below.

Step 1 (the screening assessment) identified that there are a number of sensitive receptors located within 350 metres of the project (except for receptors near Sydney South substation which are located more than 350 metres away). Given the number of sensitive receptors, further assessment was necessary.

Step 2 (risk assessment) involves applying a risk assessment tool to unmitigated construction dust emissions to define the magnitude of the emission (Step 2A) and the sensitivity of the area (Step 2B), and then combining these in a risk matrix (Step 2C) to determine an overall risk of dust impacts. The dust emission magnitude for earthworks, construction and trackout were determined based on the IAQM guidance. Overall dust emission magnitudes were small, mostly due to the relatively small volumes of work to be undertaken – refer to **Table 9-4**.

Table 9-4 Maximum dust emission magnitudes for the worst case dust emissions scenario in accordance with IAQM guidance

Construction activity	Potential dust emission magnitude	Justification
Demolition	Nil	• no demolition activities proposed
Earthworks	Medium	• total site area ~8,280 m^2 (does not include construction laydown areas where no earthworks would be undertaken) • <5 heavy earth moving vehicles at any one time: 1 x excavator and 1 x backhoe/front-end loader, <3 spoil trucks at any given time at each work site • to bunds, or bunds <4 metres in height • total material excavated approximately 44,700 tonnes • most surplus excavated material to be trucked from site immediately without stockpiling • stockpiling of excavated material at selected construction laydown areas, up to 522 m^3/day

Construction activity	Potential dust emission magnitude	Justification
Construction	Small	• total construction volume <25,000 m^3 • no on-site crushing or concrete batching • cable bridges would be pre-built using precast sections
Trackout	Medium	• up to 48 outward heavy vehicle movements per day for the transmission cable route • unpaved road length <50 metres

The sensitivity of the project area to dust soiling and human health impacts due to PM_{10} was determined to be 'High' for dust soiling and 'Medium' for human health impacts. Further detail on the factors that influenced these sensitively ratings (including the risk matrix) can be found in **Appendix F** and are summarised in **Table 9-5**.

Table 9-5 Sensitivity of the area in accordance with IAQM guidance

Potential impact	Sensitivity of the area	Justification
Dust soiling	High	• receptor sensitivity: High (residences) • number of receptors: >100 per 1,800 metre length of transmission cable route • distance from source: <20 metre of transmission cable route area
Human health (PM_{10})	Medium	• receptor sensitivity: High (residences) • annual average background PM_{10} concentration: <24 µg/m^3 • number of receptors: >100 per 1,800 metre length of transmission cable route • distance from source: <20 metre of transmission cable route area

The risk of dust impacts on sensitive receptors as a result of the worst case dust emission scenario was assigned according to the IAQM risk matrix, in terms of dust emission magnitude and sensitivity of the area and is summarised in **Table 9-6**.

Table 9-6 Summary of worst case without mitigation

Potential impact	Risk of dust impacts on sensitive receptors – Without mitigation		
	Earthworks	Construction	Trackout
Dust soiling	Medium	Low	Medium
Human health (PM_{10})	Medium	Low	Low

The qualitative air quality risk assessment determined that the project poses a Medium Risk of dust soiling and a 'Medium' risk of human health impacts, across the project area, excluding at Sydney South substation.

Step 3 (management strategies) is informed by the outcomes of the risk assessment. A high or medium-level risk rating means that suitable management measures must be implemented during construction to minimise nuisance/noticeable dust impacts. As the outcomes of the risk assessment indicated a 'Medium' risk of dust soiling and a 'Medium' risk of human health impacts, suitable management measures would need to be implemented – refer to **Section 9.4**.

Step 4 (reassessment) is applied to determine whether there are significant residual impacts arising from the project even after mitigation measures are implemented. Based on qualitative analysis, it was considered that the project would not have any significant residual impacts related to dust soiling and human health impacts as it involves standard construction methodologies for an urban linear construction project and would involve the implementation of well-established mitigation measures that are proven to manage dust impacts in typical construction activities such as those proposed for the project.

9.3.3 Construction odour assessment

As noted in **Section 9.1.2**, there is potential for LFG to be encountered during excavation at several locations throughout the project area. Should LFG be encountered, odorous constituents of the gas may disperse from the excavation towards nearby sensitive receptors. LFG may impact receptors causing annoyance and potential for stress if the annoyance is ongoing.

Previous studies have identified the presence of LFG constituents (methane and/or carbon dioxide) at Camdenville Park and Sydney Park, further assessment of these locations is presented in **Section 9.3.3.1** and **Section 9.3.3.2**.

The presence and extent of LFG at Arlington Oval, Marrickville Park and Henson Park are unknown and require further assessment. Assessment would need to be undertaken prior to the commencement of construction as part of site investigations. Site investigations would include assessment for the presence and risk of subsurface landfill gas by sampling ground gas following the *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases* (NSW EPA, 2012).

Two of the construction laydown areas, Cooke Park (Precinct 2) and Peace Park (Precinct 3) may also contain potential former landfills and were identified as having potential for LFG. Only minor ground disturbance is proposed at Cooke and Peace Park and therefore it is unlikely that LFG would be encountered. Given this, no further assessment of potential odour impacts was undertaken for these construction laydown areas.

Although odour impacts are not considered likely, precautionary measures would be adopted. LFG would be monitored to assess the presence of odour by means of a portable LFG analyser during excavation works at any locations that may potentially have LFG, to allow for early on-site detection.

9.3.3.1 Camdenville Park

In a 2012 survey conducted by GHD, methane was detected in high concentrations in boreholes in Camdenville Park, indicating the presence of LFG (GHD, 2013). However, the bulk of the high detections were concentrated along the northern and eastern boundaries of the park, away from the transmission cable route. Detections of methane near the transmission cable route were typically below the NSW EPA subsurface monitoring criterion, however, while methane is non-odorous, its presence suggests that other odorous components of LFG may also be present in concentrations above their respective odour thresholds.

The investigation of air flow rates in monitored bores (GHD, 2013) indicated that migration of LFG through the subsoil is unlikely and that should a pocket of LFG be encountered during excavation, further infiltration of LFG from surrounding areas is also unlikely. Additionally, trenching would be undertaken at a rate of about 20 metres per day meaning that any given 20 metre section would be excavated and covered again within a day. Potential odour impacts due to LFG would therefore be short-term in duration and it is not likely to lead to continued annoyance and potential stress to sensitive receptors. Despite the short-term nature of impacts, as a precautionary measure, management measures for potential odour impacts would be implemented during construction activities in Camdenville Park – refer to **Section 9.4**.

9.3.3.2 Sydney Park

LFG investigations undertaken by Douglas Partners in 2017 detected no methane (a major constituent of LFG) during screening at six locations in Sydney Park wherein one location is within the project area located near the Sydney Park car park adjacent to Princes Highway. Negligible detections of carbon dioxide were identified during the screening program, suggesting that LFG could be present. No landfilling activities have been undertaken however for more than 30 years in the park (Douglas Partners, 2017). Refer to **Figure 9-1** for the known extent of the historical landfill.

If LFG is encountered during excavations in Sydney Park, it is most likely to be in the southern or western side of the park where the transmission cable route passes through or alongside areas of the historic landfill. However, LFG can migrate underground and there is also potential for LFG to be encountered at the location of the underboring pits near the wetland. Excavation works involved with trenching and underboring would both be deep enough to potentially encounter LFG, should it be present.

Based on the age of the landfill material in Sydney Park, the lack of methane detected during the LFG investigation, and the short duration of excavation works (for both trenching and underboring), the likelihood of encountering significant pockets of LFG during excavation activities in Sydney Park is considered to be low and therefore it is unlikely that significant odour impacts will arise.

Should any LFG be encountered, it is not likely to be widespread (based on the non-detection of methane in the 2017 investigation), and any odour emissions would be short-term in duration and not likely to lead to continued annoyance and potential stress to sensitive receivers. As a precautionary measure, management measures for short-term odour impacts would be implemented during excavation activities (trenching and underboring) in Sydney Park – refer to **Section 9.4**.

G:\ENV\GIS\Projects\605\60558835 Rockwood to Beaconsfield EIS\FIGURES\2019\60558835 F9.1 Project Area and Approximate Locations of Landfill 01 10 2019

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PROJECT AREA AND APPROXIMATE LOCATIONS OF LANDFILL IN SYDNEY PARK

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

FIGURE 9-1

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Douglas Partners (2017), Nearmap (2018)

9.3.4 Operational impacts

All ground surfaces disturbed during construction would be returned to a condition similar to their original state (or as agreed with relevant road authority or local council) post-construction. Based on this, air quality emissions are not anticipated during operation of the project except possibly during maintenance activities or emergency works along the transmission cable route or at the substations through vehicle related emissions, which would be infrequent and minor and potential discovery of LFG. As noted in **Chapter 16 Soils and contamination**, LFG could potentially migrate into link and sensor pits in the vicinity of Camdenville Park and Sydney Park. Workers accessing the pits for maintenance may be exposed to vapours and/or create a potentially explosive atmosphere for both workers and surrounding members of the public. Should maintenance work require excavation, it is likely to be limited in extent and therefore the dust emission magnitude would be less than that described in **Section 9.3.2** for construction activities. Potential impacts would be managed in accordance with TransGrid's Environmental Management System which sets out relevant procedures and measures to be implemented.

As recent investigations have found very low to negligible detections of LFG, no odour emissions are anticipated during operation of the project.

9.4 Environmental management and mitigation measures

Management of air quality throughout the construction of the project would be undertaken with the aim of reducing impacts on nearby sensitive receptors in accordance with the IAQM guideline. The main objective of the air quality management measures would be to minimise dust and odour emissions to maintain amenity at nearby sensitive receptors. The secondary objective would be to ensure that no complaints regarding air quality issues are received for the duration of the project.

Performance of air quality management measures would be assessed through a combination of visual monitoring and development of a complaints register. No visible dust or detectable odour migrating off-site and no dust or odour related complaints would indicate successful achievement of the management objectives.

A range of air quality management strategies and mitigation measures have been identified for the project and are detailed in **Table 9-7**.

Table 9-7 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
AQ1	General dust and odour impacts	An Air Quality Management Plan (AQMP) will be prepared for the project as part of the project's Construction Environmental Management Plan (CEMP). The AQMP will identify the measures to be undertaken during construction of the project and document the complaints management process.	Construction
AQ2	Dry surfaces	Regularly water all exposed surfaces at construction laydown areas (excluding stockpiles) or special crossing work sites when conditions are dry and dusty, through the use of water sprays, sprinkler systems, a water cart or other suitable methods. Frequency would be determined by how quickly the surface dries out again, with higher frequency watering required on hot, dry, windy days.	Construction
AQ3	Adverse weather	On days where forecast weather conditions (e.g. high winds) may result in high dust emissions, dust generating work activities may need to be rescheduled or modified. The forecast weather conditions will be included in daily tool box talks and construction planning.	Construction
AQ4	Stockpiles	Spoil stockpiles will be covered.	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
AQ5	Drop heights	Minimise drop heights from excavators when placing spoil into trucks or onto stockpiles to reduce the potential for dust generation.	Construction
AQ6	Exposed surfaces	Progressively rehabilitate exposed areas at work sites to limit dust generation.	Construction
AQ7	Generation of dust from vehicles and plant	Ensure that all vehicles transporting spoil, rock, other materials or waste, are covered when entering or exiting the work site.	Construction
AQ8	Generation of dust from vehicles and plant	Vehicles and plant will be free of excessive soil, where required, to reduce soil tracking onto public roadways.	Construction
AQ9	Generation of dust from vehicles and plant	Provide stabilised site access (where existing site is unsealed) and access points as required.	Construction
AQ10	Generation of dust from vehicles and plant	Construction vehicles and mobile plant will use designated haulage and access routes, where practicable, and traffic speeds at work sites will be restricted to limit the generation of dust from vehicle movements.	Construction
AQ11	Migration of dust off-site	If dust is seen to be migrating off-site, the source of the dust will be identified and additional management and mitigation measures implemented (such as rescheduling the works or water spraying), where required.	Construction
AQ12	Landfill gas	Site-specific landfill gas management plans will be prepared for works at locations with landfill gas (including Camdenville Park and Sydney Park) prior to any trenching and excavation. Further site investigations will be undertaken within the project area closest to Arlington Oval and Marrickville Park and where the project traverses Henson Park, in accordance with the *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases* (NSW EPA, 2012), to assess the presence and risk of landfill gas. If landfill gas is detected, a site-specific landfill gas management plan will be developed for any excavation works in these areas (also refer to CT9). The plans will be prepared by a suitably qualified landfill gas management specialist. The management plans will include mitigation measures to prevent human health exposure and explosive risks posed by landfill gas and nuisance odours from exposed leachate or landfill wastes. The plans will detail the type and frequency of monitoring required during the works and will outline the triggers that could stop works or require a step up in controls. Controls may include the use of odour suppressant mists and foams, and other measures deemed suitable for the local conditions of the site.	Detailed design and construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
AQ13	Plant exhaust emissions	Construction vehicles and mobile plant will be maintained in good working condition. Engines will be switched off when not in use.	Construction

Notes:
1 H2S is typically odorous at concentrations much lower than 1 ppm. However, 1 ppm is a typical limit of detection for portable LFG analysers. Concentrations lower than 1 ppm are therefore not easily measurable on a continuous basis.
2 An OCE is essentially a tent that is maintained under negative pressure with all air within the tent vented via a single vent stack. Controlling emissions through a single vent stack allows for better dispersion of potential odour and reduces the risk of impacts.

10.0 Electric and magnetic fields

This chapter provides an overview of the findings from a study into the electric and magnetic fields (EMF) that would be produced during the operation of the project and a summary of the health science research related to EMF.

10.1 Overview of EMF

EMF exists wherever electric current flows such as in overhead powerlines, underground transmission cables, substations, residential wiring and electrical appliances (e.g. toasters, televisions, hair-dryers and computers). Electricity is widely used in modern life, which means EMF is all around us and exists wherever electricity is used.

The electric field component is associated with the voltage. The higher the voltage, the higher the electric field. Electric fields are strongest closest to the source but reduce quickly with distance. The level of electric fields is measured in thousands of volts per metre (kV/m). In addition, most materials act as a total or partial barrier to electric fields.

Magnetic fields are produced by the flow of an electric current. The higher the current (measured in amps), the greater the magnetic field. The strength of magnetic fields is measured in milliGauss (mG). Like electric fields, magnetic fields are highest closest to the source but also reduce quickly with distance. The magnetic field strength resulting from an electrical installation varies with the electrical load current and is affected by several factors including the total electrical load, and the layout and arrangements of the conductors (which comprises the core of the cable).

The project would include electrical cables[1] primarily buried within roadways and located around 900 millimetres below the ground surface, with the conductor fully contained within a metallic sheath and the electric field component contained within the cable. The electric fields that would be generated by the operation of the transmission cable circuit would therefore be fully shielded and were not considered further in the EMF study for the project. The study therefore focused on the magnetic fields associated with the project.

10.2 Standards, guidelines and policies

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a Federal Government body whose responsibilities include protecting the health and safety of people, and the environment, from Extremely Low Frequency (ELF) EMF. ARPANSA have adopted the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2010 *Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz)* for application in Australia.

The ICNIRP guideline outlines reference levels for assessing compliance of human exposure to magnetic fields. The ICNIRP guidelines are consistent with ARPANSA's recommendations for the protection of the general public and workers from exposure to ELF EMF[2] (ARPANSA, n.d.). The main source of ELF EMF is from artificial sources, usually related to the production, distribution and use of electricity at a frequency of 50 Hz (which is the frequency the electricity network in Australia operates at).

These reference levels for magnetic field exposure have been adopted for the assessment of magnetic fields likely to be generated by the project.

A summary of the ICNIRP (2010) 50 Hz magnetic field reference levels for the general public[3] and workers (occupational level) is provided below:

[1] Three cables comprise a single circuit.
[2] References to ELF EMF as quoted from ARPANSA are used interchangeably with the terms 'ELF magnetic fields' or 'magnetic fields' throughout this chapter.
[3] The general public is defined as individuals of all ages and of differing health statuses, which may include particularly vulnerable groups or individuals, and who may have no knowledge of or control over their exposure to EMF. Note that a foetus is defined as a member of the general public, regardless of exposure scenario, and is subject to the general public restrictions (ICNIRP 2010).

- general public – 2,000 mG; and
- occupational – 10,000 mG.

As stated in ICNIRP (2010), compliance with the reference levels may not necessarily preclude interference with, or effects on, medical devices such as metallic prostheses, cardiac pacemakers, implanted defibrillators and cochlear implants.

For persons wearing active implantable medical devices (AIMDs), which include pacemakers and implantable defibrillators, the most relevant standard is considered to be European Standard EN 50527-1 (2016) *Procedure for the Assessment of the Exposure to Electromagnetic Fields of Workers Bearing Active Implantable Medical Devices – Part 1: General*. In practice, this means the AIMDs need to be designed with an immunity up to the general public reference level (as stated above). However, older type AIMDs (prior to 1999) may only have been designed and manufactured with immunity up to 1,000 mG. This is therefore a conservative limit that the project will aim to meet.

For persons wearing a hearing aid or cochlear implant there is the standard risk of 50 Hz magnetic field noise occurring, which would not damage the devices or the ear. While modern AIMDs are expected to be designed with consideration of the current published ICNIRP reference levels for general public exposure, due to differences between manufacturers and countries of origin, it is recommended that any concerned persons consult with their physician.

10.3 Magnetic fields and human health

The potential impacts of magnetic field exposure on human health have been the subject of research conducted over the past 40 years. A number of comprehensive reviews of the body of scientific research have been undertaken to assess the potential health effects of exposure to magnetic fields. These reviews include those published by the World Health Organisation (WHO) (2007) and ICNIRP (2010). A summary of the potential health effects identified in these reviews are discussed below in **Section 10.3.1** and **Section 10.3.2**.

As no risk to human health has been established from long-term exposure, those responsible for the health guidelines do not consider the evidence sufficient to warrant (or provide a scientific basis for) the development of low level long-term exposure limits.

While no risk to human health has been established from long-term magnetic field exposure, TransGrid has adopted an approach of 'prudent avoidance' in accordance with good industry practice, guidance from Energy Networks Associations (ENA) and reference to WHO guidance. 'Prudent avoidance' is generally accepted as implementing precautionary measures by adopting practical measures, at modest cost and without undue inconvenience, to reduce people's prolonged exposure to elevated magnetic fields.

The WHO indicates that precautionary measures are warranted, but only very low-cost measures can be justified.

The practice of prudent avoidance has been adopted by the ENA and most Australian power utilities, including TransGrid. In accordance with the latest advice, the ENA EMF Handbook[4], states:

- *"Prudent Avoidance does not mean that 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"*; and
- *"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."*

10.3.1 Established effects

ICNIRP (2010) and the WHO (2007) have reported that short-term (i.e. instantaneous) exposure to magnetic field levels above the ICNIRP reference levels set out in the guidelines are associated with

[4] Energy Networks Association (2016), EMF Management Handbook

established health effects such as direct stimulation of nerve and muscle tissue and induction of retinal phosphenes[5].

The ICNIRP (2010) exposure guideline and reference levels discussed in **Section 10.2** have been set to protect against these established biological effects.

10.3.2 Prolonged exposure

Following 40 years of research, countless laboratory and animal studies have not been able to establish any causal relationship between prolonged (i.e. long-term) exposure to low level magnetic fields (i.e. at levels below the ICNIRP reference levels for human exposure) and adverse health effects. It is important to note that ARPANSA has stated that:

- "*There is no established evidence that ELF EMF is associated with long term health effects*";
- "*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*"; and
- "*There is no established evidence that the exposure to magnetic fields from powerlines, substations, transformers or other electrical sources, regardless of the proximity, causes any health effects*".

There is some epidemiological research indicating an association between prolonged exposure to higher than normal magnetic fields and increased rates of childhood leukaemia, however, the WHO (2007) has noted that this epidemiological evidence is weakened by:

- potential selection bias;
- there are no accepted biophysical mechanisms that would indicate that low-level exposure leads to cancer development; and
- animal studies, for the most part, have been negative.

Other potential health effects associated with long-term exposure have been studied including other childhood cancers, cancers in adults, depression, suicide, cardiovascular disorders, reproductive dysfunction, developmental disorders and neurodegenerative disease, amongst others. The WHO (2007) identified that the scientific evidence supporting these other health effects is much weaker (or not at all) than for childhood leukaemia.

ICNIRP (2010) concluded that for long-term magnetic field exposure:

- available data does not indicate an effect on the neuroendocrine system in a way that would have an adverse impact on human health;
- there is no evidence for an association with Alzheimer's disease or cardiovascular disease; and
- the evidence for an association with developmental and reproductive effects is very weak.

A recent review by the European Commission (2015) similarly concluded that overall, existing studies do not provide convincing evidence for a causal relationship between magnetic field exposure and self-reported symptoms. It also concluded that recent results show no evidence of magnetic fields affecting the reproductive function in humans or adverse pregnancy outcomes.

The WHO (2007) noted that "*there are uncertainties about the existence of chronic effects, because of the limited evidence for a link between exposure to ELF magnetic fields and childhood leukaemia. Therefore, the use of precautionary approaches is warranted. However, it is not recommended that 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*."

[5] Phosphenes are a phenomenon characterised by the experience of seeing light without light actually entering the eye. This may be perceived as the faint flickering of light in the periphery of the visual field (commonly referred to as 'seeing stars'). Phosphenes can be caused by magnetic field stimulation of the retina (i.e. the sensory membrane that lines the inner surface of the back of the eyeball).

10.4 Assessment methodology

A study was undertaken to predict the magnetic fields likely to be generated during the operation of the project. This involved:

- undertaking a desktop review of cable ratings and circuit loadings;
- calculating the magnetic field levels for the project based on:
  - typical trench arrangements;
  - typical cable configurations;
  - indicative location of cable joint bays and cable bridges;
  - reference points for where people are expected to experience the highest fields;
  - maximum and time weighted average operating conditions;
- consideration of cumulative impacts with the operation of a future 330kV transmission cable circuit; and
- identification of prudent avoidance measures.

Based on the design information currently available, the magnetic field contributions associated with the project were assessed against the ICNIRP reference levels identified in **Section 10.2**.

Key aspects of the study approach and methodology are discussed in more detail in the following sections.

10.4.1 Cable rating and circuit loading

Under normal circumstances, the circuit loading will vary substantially between a daily minimum and a daily maximum at times of peak demand over the duration of each day. Loadings will also vary seasonally during the year, generally reaching a peak in either summer or winter. Consistent with the approach reported by the WHO (2007) to assess long-term exposure, the approach which considers daily and seasonal variations is to calculate the time weighted average (TWA).

The load profile for the proposed transmission cables is expected to be similar to an existing TransGrid 330kV cable supplying inner Sydney (i.e. Cable 41 which presently supplies Beaconsfield West substation). The median daily TWA 2017/2018 load profile for the existing Cable 41 has been calculated to be 71% (taken as a percentage of the maximum loading over a 12 month period) during normal operating conditions.

The expected peak circuit loading during normal operating conditions for the proposed transmission cable circuit would be 480 MVA (or 840 Amps), which is based on the Ausgrid 2016 forecast for the 2023/2024 summer based on demand forecasts. This forecast load is consistent with (slightly lower) than the Ausgrid 2018 revised forecasts for the 2028/2029 summer peak. Therefore, 480MVA is considered to be a conservative prediction for input to calculations of the magnetic field generation by the project.

A TWA of 71% was therefore assessed for a forecast single circuit loading of 480 MVA for a long-term exposure scenario.

During rare periods of abnormal system configuration, the cables may need to operate up to their maximum emergency rating of 900 MVA (1,575 Amps) during peak times, for up to three days. This peak value has been used to assess compliance against the ICNIRP (2010) magnetic field reference levels and AIMD interference level.

10.4.2 Trench arrangement and cable configuration

The proposed transmission cable route was modelled and assessed for a typical single circuit in either a flat or trefoil configuration. In the flat formation, the conduits are laid side by side in the trench whereas in the trefoil formation, they are arranged in a triangular form. The proposed transmission cable circuit would not have the same trench arrangement and cable configuration along the entire route due to constraints in some sections of the route, such as where the road reserve is too narrow or where space in the roadway is limited by other services and utilities.

10.4.3 Joint bays and cable bridges

The expected increased spacing between the three individual transmission cables (or cable phases) within joint bays would increase the magnetic field contribution at these locations by approximately 50% directly above the joint bay. However, the increase is somewhat offset directly above the cables by the increased depth of the cables within the joint bays, where a depth of approximately 1.1 metres to the top of conduits is anticipated.

For the cable bridges which are publicly accessible, the magnetic field exposure to the general public would be higher than along trenched sections of the cable route, however will not exceed 1000mG to avoid interference with AIMD. This is due to the comparatively shallower cover over the conduits in the bridge structure.

10.4.4 Reference points

The primary reference points for calculations of magnetic fields should be in the locations where people are expected to spend prolonged periods of time. The magnetic field levels out to 20 metres from the edge of the trench have therefore been calculated.

The proposed transmission cable circuit would be installed in roadways for the majority of the route. The highest magnetic field levels are expected to occur directly above the cable trenches, where people would only be temporarily located for short durations of time (i.e. passing vehicles, pedestrians and cyclists).

10.4.5 Cumulative impacts

Section 10.5 identifies other electrical infrastructure in the project area that could interact with the proposed transmission cable circuit. Magnetic fields from different sources are generally of random orientation and phase. This means that the magnetic fields from different sources are not additive. The largest magnetic field from a single source therefore usually dominates. An electrical asset with the greatest current would be the largest single source.

The cumulative impact from the operation of the future second 330 kV transmission cable circuit has not been assessed and would be assessed as part of the approval process for the operation of the future cable circuit.

10.5 Existing environment

The proposed transmission cable route is located within an extensively developed urban area that is primarily residential land with areas of industrial and commercial development. As a result, the majority of the transmission cable route is proposed to be installed in road reserves alongside existing low voltage (LV) customer supplies and medium voltage (MV) electricity distribution lines[6,7]. LV and MV do not necessarily have a lower magnetic field contribution at receivers as magnetic fields are proportional to the current and proximity to receivers rather than the voltage level.

A number of existing high voltage (HV) underground and overhead transmission lines[8] have also been identified along the transmission cable route, including an overhead transmission line crossing Rawson Road at 55 Rawson Road within Precinct 2 and another overhead transmission line within Mildura Reserve, on the western bank of the Cooks River within Precinct 3. Each of these existing electrical services will have a resultant EMF that is typically a maximum at each service's centreline, decreasing as the radial distance from the centreline is increased.

Rookwood Road, Beaconsfield West and Sydney South substations house a range of operational electrical infrastructure including transformers, buildings housing gas insulated switchgear, reactors, a control building and ancillary infrastructure, each a source of EMF.

[6] Low voltage is considered to be less than 1 kilovolts (kV). Medium voltage is typically 11 kV alternating current $_{(AC)}$ or 33 kV_{AC} and high voltage is typically 132 kV_{AC} for the electrical utilities encountered in these areas.
[7] These distribution lines are existing utilities operated by providers other than TransGrid.
[8] These transmissions lines are existing utilities operated by providers other than TransGrid.

The ENA EMF Handbook provides a summary of typical magnetic field levels that may be encountered day to day at residences and other facilities. These levels, presented in **Table 10-1**, are also reported in the ARPANSA *Measuring Magnetic Fields Fact Sheet.*

Table 10-1 Typical magnetic field levels encountered in daily life

Location	Source	Typical magnetic field (mG)
Home[1]	Television	0.2 – 2
	Pedestal fan	0.2 – 2
	Refrigerator	2 – 5
	Electric kettle	2 – 10
	Toaster	2 – 10
	Electric stove	2 – 30
	Electric blanket	5 – 30
	Hairdryer	10 – 70
Office[1]	Personal computer/laptop	2 – 20
Public streets/neighbourhoods	Directly under an overhead LV or MV distribution line	2 – 30
	10 metres away from an overhead LV or MV distribution line	0.5 – 10
	Directly under an overhead HV transmission line	10 – 200
	At the edge of an overhead HV transmission line easement	2 – 50

Notes:
1 Sourced from the ARPANSA Fact Sheet – *Measuring Magnetic Fields* (2016). The range of typical magnetic field levels associated with common household/office appliances are measured at a normal user distances. Levels of magnetic fields may vary from the range of measurements shown.

10.6 Assessment of potential impacts

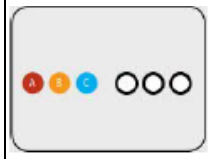
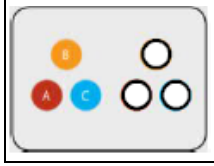
10.6.1 Magnetic fields generated by the transmission cable circuit

This section provides the magnetic fields predicted to result from the operation of the transmission cable circuit. During construction, the transmission cable circuit would not be energised (i.e. would not be operational) and would therefore not generate a magnetic field.

Table 10-2 presents the predicted time weighted average magnetic fields that would be generated during operation of the proposed transmission cable circuit for different typical cable arrangements (i.e. flat or trefoil formation). The results presented in **Table 10-2** are for a straight section of trenching along the route, where a nominal 900 millimetres depth of cover over the trench has been assessed. The magnetic field level is calculated in each arrangement directly above the cable trench where any people would only be temporarily present for short durations of time. Predictions of the magnetic field with increasing horizontal distance from the edge of the trench (up to 20 metres away) are also calculated.

The calculated TWA results presented in **Table 10-2** show that the cable arrangement of a single flat circuit has magnetic field level of 221 mG directly above the trench, which is well below the ICNIRP reference levels of 2,000 mG for general public exposure or 1,000 mG for older type AIMDs. The results for the trefoil arrangement are even lower, with 155mG predicted directly above the trench.

Table 10-2 Predicted TWA magnetic field levels generated by the operation of the transmission cable circuit

Phasing arrangements		Directly above (mG)	Magnetic field (mG) at offset distance (m) from edge of trench															
			0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+12	+14	+16	+18	+20
	Single circuit, flat formation	**221**	159	98	61	41	28	21	14	13	11	9	8	6	4	3	3	2
	Single circuit, trefoil formation	**155**	115	77	50	33	23	17	13	10	8	7	6	4	3	3	2	2

10.6.1.1 Magnetic fields generated at joint bays

The single circuit flat formation cable configuration has been modelled for the joint bay scenario and the results show that the magnetic field is 50% higher directly above the joint bay compared to directly over a typical trench. While higher than for the trench, the magnetic field levels in and around joint bays would still be below the ICNIRP reference levels of 2,000 mG for general public exposure and 1,000 mG for older type AIMDs.

10.6.1.2 Magnetic fields generated at cable bridges

While public exposure to relatively higher levels of magnetic fields would occur at cable bridges, only the proposed cable bridge at the Bedwin Road rail crossing at St Peters may be accessible to the public. Public access is not being considered at the proposed cable bridges at Muir Road and the Cooks River.

Exposure to magnetic fields by members of the public traversing the Bedwin Road cable bridge would be transient in nature. TransGrid is investigating this option in conjunction with Inner West Council and Transport for NSW (formerly the Roads and Maritime Services Motorways Division), as it presents an opportunity to improve active transport connectivity across the rail corridor. The average magnetic field levels generated directly above the cable bridges would be higher than the levels directly above sections of underground cables in the roadway or parks/reserves due to the shallower depths of the cables in the bridge structure. The cable bridges would typically only have a covering of around 600 millimetres compared to underground cables in roadways or parks/reserves which would have a minimum of 900 millimetres of cover. However, the magnetic field levels directly above the cable bridges would still be under 2,000 mG for general public exposure and 1,000 mG for older type AIMDs, and exposure is expected to be only transient in nature.

10.6.2 Magnetic fields generated during emergency operation

During rare periods of abnormal system configuration when the cables may need to operate up to their emergency rating of 900 MVA, the magnetic field levels in and around publicly accessible areas of the transmission cable circuit would still be below the ICNIRP reference levels of 2,000 mG for general public exposure and 1,000 mG for older type AIMDs.

10.6.3 Magnetic fields generated by the substations

The Rookwood Road, Beaconsfield West and Sydney South substations currently house a range of operational electrical infrastructure, each generating a magnetic field. The project would only result in localised changes to the magnetic fields in the immediate vicinity of the new cable equipment within the substations. Therefore, no significant changes to the magnetic field environment are predicted within the substation boundary.

10.6.4 Potential cumulative impacts

Assessing cumulative magnetic fields from multiple sources is a complex exercise as each source has a unique magnetic field profile which changes over time depending on the nature of the source and the load it is carrying. In practice, the dominant source will influence the cumulative magnetic field. In a residential environment, it can be expected that the proposed transmission cable circuit would be the dominant source.

Existing HV underground and overhead transmission lines, MV distribution lines and cables and LV customer supplies have been identified along the proposed transmission cable route. In cases where the transmission cable circuit would be in the vicinity of existing overhead electricity distribution and transmission lines, the cumulative levels are not expected to exceed the reference levels.

The cumulative impact therefore does not affect the conclusions that the magnetic field levels along the proposed transmission cable route would comply with the ICNIRP reference levels for public and occupational exposure.

While the cumulative impact of the future second 330kV transmission cable circuit has not been assessed, in general, the operation of two circuits in one trench would result in a lower magnetic field due to the cancellation effect created between the cables. The magnitude of this reduction would be influenced by the cable arrangement with a trefoil arrangement usually resulting in a larger reduction than a flat formation.

10.6.5 Summary of impacts

Based on the predicted magnetic field levels for the transmission cable circuit, across various trench and cable arrangements, and a comparison with the ICNIRP reference levels for human exposure, the project magnetic fields would be well within the reference levels for the general public and occupational exposure.

The actual magnetic field levels generated by the project will vary depending on the depth of cover and the spacing between the cable phases for the single circuit as well as between the two circuits when the future second transmission cable circuit commences operation (should it be required). Localised increased magnetic field effects would also be generated at joint bays (due to an increased separation between cable phases), and at cable bridges (due to a reduced depth of cover over the conduits).

However, considering all these variables, the magnetic fields at publicly accessible areas directly above the trench, and at the horizontal offset levels (measured as distance from the edge of the trench) are not expected to reach the ICNIRP reference levels for human exposure or the older type AIMDs immunity level of 1,000 mG during normal and emergency operating conditions.

10.7 Environmental management and mitigation measures

While no risk to human health has been established from long-term magnetic field exposure, TransGrid has adopted an approach of 'prudent avoidance' in accordance with good industry practice.

Taking a prudent avoidance approach includes designing and siting electricity infrastructure to reduce long-term public exposure to electric and magnetic fields. TransGrid will continue to consider the following during the project design development, which is consistent with the prudent avoidance/precautionary principles outlined in the ENA EMF Handbook:

- maximise cable separation to property boundaries, in particular normally occupied buildings (such as businesses and residences) by locating the cable in the centre of the roadway where practical;
- optimise the trench cross-section (i.e. the conduit arrangement with the trench) to maximise the cancellation of magnetic fields by adopting a trefoil cable arrangement where practical; and
- maximise the magnetic field cancellation effect, such as by reducing the spacing between individual cable phases as far as technically practical through the use of thermally engineered backfill along the route and installing field cancellation measures at non-typical trench configuration locations, such as joint bays, where practical.

In addition to the above prudent avoidance measures that will be implemented during detailed design, a number of general mitigation measures have been identified as outlined in **Table 10-3**.

Table 10-3 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
EMF1	Generation of magnetic fields	A revised EMF calculation will be undertaken once the final cable details are known to ensure consistency with the initial assessment undertaken and to confirm that magnetic field levels for the project are still below the ICNIRP reference levels for human exposure.	Detailed design
EMF2	Generation of magnetic fields	The project will operate within the limits set in the *International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to EMF* (ICNIRP, 2010).	Operation
EMF 3	Verification of magnetic fields	Within six months of operations commencing, magnetic field levels will be measured at selected locations close to receptors along the transmission cable route to verify that levels are below the ICNIRP reference levels.	Operation

11.0 Hazards and risks

This chapter provides an overview of the potential hazards and risks to public safety that may occur during construction and operation of the project and the measures that would be implemented to minimise these potential hazards and risks. Potential hazards and risks associated with electric and magnetic fields are discussed in **Chapter 10 Electric and magnetic fields** while an overview of potential human health risks is provided in **Chapter 21 Social and economic**.

11.1 Assessment methodology

A qualitative assessment of hazards and risks to public safety has been undertaken using the following methodology:

- identification of existing hazards across the project area;
- identification of potential hazards resulting from the construction and operation of the project;
- review of existing background information for the existing substations; and
- identification of controls required to minimise the likelihood of hazardous events.

The following policies, guidelines and legislation have been reviewed to inform the assessment of hazards and risks:

- *Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz)* (International Commission on Non-Ionizing Radiation Protection, 2010);
- *Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard* Analysis (NSW Department of Planning, 2011);
- *Multi-Level Risk Assessment* (NSW Department of Planning, 2011);
- *Work Health and Safety Act 2011*; and
- *Planning for Bushfire Protection* (NSW Rural Fire Service, 2006).

11.2 Existing environment

Existing hazards and risks across the project area include:

- below and above ground utilities present within the road reserve, substations and private and public properties, including, but not limited to electricity, water, gas and telecommunications;
- traffic hazards associated with the movement of vehicles along existing roads;
- railway hazards associated with the rail corridors that the project crosses;
- electrical safety hazards at the existing substations (Rookwood Road, Beaconsfield West and Sydney South);
- vehicle, plant and equipment hazards within existing substations, such as vehicle movements and emissions in battery rooms;
- storage of hazardous materials and dangerous goods at the existing substation sites; and
- bushfire risk.

11.2.1 TransGrid management systems

TransGrid's existing health, safety and environmental management systems would be implemented during construction and operation of the project. Management of health, safety and environmental aspects would be as per the relevant procedures that form part of these management systems.

In addition, TransGrid operates under a number of operational management systems which are applied to manage hazards and risks at existing substations and other infrastructure assets, including site-specific management systems and asset management plans.

11.2.1.1 Site-specific management systems

A site-specific Emergency Response Manual is implemented at the existing Beaconsfield West, Rookwood Road and Sydney South substations. The manuals contain the following necessary information:

- relevant internal and external contact details and lines of communication;
- response procedures in the event of an emergency. These procedures outline the actions and responsibilities in case of fire, site injuries, security threats, oil spills, gas leaks and site evacuations; and
- internal and external notification requirements including to relevant government agencies and the community (where appropriate).

If required, these manuals would be updated to reflect the changed conditions and additional requirements that may arise as a result of the project.

11.2.1.2 Asset management plans

TransGrid has existing asset management plans operating across different sites and infrastructure. These plans comprise procedures for the safe operation and management of underground cables and substations. These management plans would be implemented for the project.

11.2.2 Bushfire risk

The transmission cable route, construction laydown areas and the Rookwood Road and Beaconsfield West substations are not located within a bushfire prone area, as identified by the NSW Rural Fire Service.

The Sydney South substation in Picnic Point is surrounded by bushland and is located within a designated bushfire prone area.

11.3 Assessment of potential construction impacts

Hazards and risks to public safety associated with construction of the project can be categorised into the following:

- storage, handling and transport of hazardous materials and dangerous goods;
- amenity impacts;
- traffic and transport hazards;
- below and above ground utilities and electrical safety;
- bushfire risk; and
- underboring risks.

The potential impacts associated with these hazards and risks are discussed in the following sections.

11.3.1 Storage, handling and transport of hazardous materials and dangerous goods

Hazardous materials and dangerous goods include substances that can pose a significant risk to health and safety if not managed correctly. This includes substances such as flammable liquids and chemicals used during construction.

While the project would not involve the storage of hazardous materials during construction, it would require the daily refuelling of mobile plant and static machinery (such as excavators, pumps, backhoes and drilling machines) needed within the project area. Refuelling of plant and equipment would be carried out by mobile tanker, dispensing directly into the items of plant being refuelled. Refuelling would be undertaken at least 100 metres from the nearest watercourse. Other vehicles such as staff vehicles would be taken off-site for refuelling. The mobile tanker would be parked at a construction laydown area when not in use. Spill kits and Work Method Statements would be in place during refuelling activities.

Safety Data Sheets (SDS) would accompany all hazardous materials and dangerous goods transported to work sites. The SDS provides guidance on the safe handling, transport and storage of the substance as well as first aid treatment information.

The transport, storage, handling and use of hazardous substances would be undertaken in accordance with the NSW *Dangerous Goods (Road and Rail Transport) Act 2008*, NSW *Work Health and Safety Act 2011*, the Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission, 2017) and other relevant Australian Standards.

Spills and leaks of hazardous materials from construction vehicles and plant, has the potential to impact the local community through a discharge into the atmosphere, ground or into nearby watercourses. Appropriate spill containment measures would be implemented to reduce the potential for a spill and leaks to impact off-site receivers. Accidental spills or leaks would be managed by protocols outlined in the Construction Soil and Water Management Plan (CSWMP) which would include quick response times and the use of spill kits to contain and capture contaminated water. Industry standard measures are proposed to manage the risks of spills and leaks, as summarised in **Chapter 16 Soils and contamination**.

As discussed further in **Chapter 16 Soils and contamination**, there is also a potential for contaminated material such as acid sulfate soils or asbestos to be present within the project area, due to historical land uses. Excavation and trenching may result in the exposure of these contaminants, which may be mobilised via wind or rain into the surrounding environment, if not managed appropriately, and indirectly impact local community members who come into contact with it.

If contaminated material is encountered during construction works, it would be managed in accordance with the management and mitigation measures outlined in **Chapter 16 Soils and contamination** and **Chapter 19 Waste management** as well as relevant legislation and Australian Standards.

11.3.2 Amenity impacts

The project may result in indirect impacts to the health of local community members as a result of amenity impacts related to noise and vibration. If works are not managed appropriately, it could also result in reduced air quality from dust. Noise and vibration generated by night works may cause sleep disturbance which could have associated health and wellbeing effects on residents. Dust generated may pose a risk to those already suffering from respiratory conditions such as asthma. Amenity impacts have the potential to manifest as annoyance, which is described as the negative reaction that a person may experience. Continued annoyance may impact health by causing a build-up of stress.

Risks to human health associated with noise and vibration and air quality impacts would be managed via the effective implementation of the mitigation measures presented in **Section 8.4** and **Section 9.4**. Amenity impacts that may arise during construction are discussed further in **Chapter 21 Social and economic**.

11.3.3 Traffic and transport hazards

The construction of the transmission cable circuit would largely be confined to road reserves. As a result, these works and the associated truck and other vehicle movements, if not managed appropriately, have the potential to result in vehicle, pedestrian and cyclist collisions either due to direct collision with construction vehicles/equipment, or as a result of changed traffic conditions. Construction works at the substations and the use of construction laydown areas would temporarily increase the number of vehicles in these areas, which if not managed appropriately, would also have the potential to result in vehicle, pedestrian and cyclist collisions from direct collision with construction vehicles.

Traffic hazards would be managed through the preparation and implementation a Construction Traffic Management Plan (CTMP), with related Traffic Control Plans (TCPs) for each work site, construction laydown area and substation. The CTMP would be used to manage access to residences/businesses, the closure of lanes and roads and detours for pedestrians and cyclists. The CTMP would include measures to make the public aware of changes in road conditions such as erecting warning signs and having traffic controllers on-site. Road or lane changes would be shown graphically on the TCPs.

Construction of special crossings within rail corridors would be undertaken during rail possessions planned by the relevant rail network authority, wherever possible, and are not likely to pose any risk to public safety. Work within the rail corridors would be planned, coordinated and executed in close consultation with the relevant rail network authority, with all access and safety requirements met.

Chapter 7 Traffic and transport describes the potential traffic and transport impacts and proposed management measures for the project in more detail.

11.3.4 Utilities and electrical safety

There are a number of underground services within the project area, and excavation works would need to be undertaken in proximity to these services. Risks to underground utilities and services include possible punctures/ruptures from excavation plant. Ruptures/punctures of any underground services may lead to the temporary disruption of that service and may also result in risks to public safety as a result of flooding in the event of a burst water pipe, fire from a fuel pipeline leak, or an explosion in the event that a gas pipeline is impacted.

In addition, utilities which have not properly been identified prior to works commencing may result in project delays associated with implementing appropriate protection/support measures or potential utility relocation (if required) or service disruption caused by damaging a utility.

The development of the concept design, including the alignment of the transmission cable route, has taken into consideration other existing utilities within the road reserve in order to minimise impacts on these services. Investigations into the exact location of utilities are ongoing along the transmission cable route. TransGrid has undertaken ground penetrating radar testing, potholing and slit trenching, with the results used to inform development of the project design and further investigations would be carried during detailed design. The exact alignment within the road reserve will continue to be refined during detailed design to avoid significant impacts on utilities.

The potential for risks to both underground services and to public safety as a result of damaging utilities would be minimised via:

- undertaking utility service checks such as Dial-Before-You-Dig (DBYD) and consulting with the relevant service infrastructure providers prior to the commencement of excavation;
- undertaking service and utility identification works (for example, non-destructive excavation methods) to expose buried services prior to use of an excavator);
- protection of utilities prior to any excavation works being undertaken in proximity to the utility, where required;
- identifying the required distance to be maintained between the proposed transmission cable circuit and other services, ensuring compliance with relevant design criteria; and
- identifying opportunities to retain utilities in-situ with relevant protection and/or support measures to ensure services are not struck or disrupted while undertaking trenching activities.

All relevant utility service providers along the transmission cable route would be contacted regarding the necessary construction service relocation requirements. The need for major service relocation has been avoided through design, however, consultation with relevant asset owners would continue throughout construction.

Utilities would be supported and/or protected as required to avoid damage and subsequent disruption of services. Support/protection measures include temporary mechanical props to support the utilities in situ while excavating and installing the new cable trench. Utilities would also be protected by encasing in timber and metal covers, where required, to ensure these services are not impacted during construction.

Above ground utilities would be identified prior to commencing construction work. If works are to be conducted within the vicinity of overhead utilities then measures such as isolating the hazard from workers and implementation of engineering controls, restricted plant movement and/or administrative controls, and warning signs would be applied.

The upgrade works at the existing substations have the potential to generate electrical safety risks. These risks would be managed by conducting works in accordance with existing TransGrid management systems and relevant Safe Work Australia guidelines.

11.3.5 Bushfire risk

The transmission cable route, construction laydown areas and the Rookwood Road and Beaconsfield West substations are not located within a bushfire prone area, as identified by the NSW Rural Fire Service. Considering the urban nature of the project area, risks to public safety as a result of the interference of bushfires with the construction of the transmission cable circuit and cable bridges and upgrade works at these two substations is not anticipated.

The Sydney South substation in Picnic Point is surrounded by bushland and is located within a designated bushfire prone area. In the event that a fire occurs within the Sydney South substation, it would be contained to the site; therefore, there is a low risk of causing a bushfire. Mitigation measures for construction works at the Sydney South substation would include restricting hot works (such as welding or other activities generating heat or sparks) on days of declared catastrophic fire danger. In the unlikely event that a fire on-site results in a bushfire, this would be managed in accordance with the Emergency Response Manual for the site.

11.3.6 Underboring risks

Underboring construction methods for installing the conduits carry the risk of subsidence and/or frac-out.

Soil settlement could occur during and after construction, mainly as a result of soil loss during underboring. Significant soil loss would present as settlement on the surface during construction and can lead to subsidence (i.e. the caving in of the ground), whereas minor soil loss may not appear at all. This risk is more associated with the thrust boring method than horizontal direction drilling (HDD) due to the relatively larger cross sectional area (diameter) of the bore.

Frac-out is the release of drill slurry at the ground surface due to a build-up of pressure in the bore. where the drill slurry reaches the surface through an underground pathway such as a fault line, fissure in the rock, tree root or underground utility/ service. There is a risk of this occurring during HDD. The potential impacts of frac-out are dependent on where the frac-out has occurred and the amount of drill slurry released into the environment. For example, should frac-out occur away from a waterway, the likelihood of impact would be low as the drill slurry could be cleaned up with no harm to sensitive receivers, however should the frac-out occur near a waterway (for example, the Cooks River) the drill slurry could potentially enter the waterway and impact aquatic flora and fauna. It considered that this impact would be low due to the existing poor water quality of the catchments and waterways within proximity of the project (i.e. elevated levels of heavy metals, pH, turbidity and nutrients) (refer to **Chapter 17 Surface water and flooding**). The HDD contractor would have a contingency plan in place to manage frac-out in the event it occurs to minimise any impacts to the environment and nearby sensitive receivers.

11.4 Assessment of potential operational impacts

Potential hazards and risks associated with project operation can be categorised into the following:

- electrical safety;
- bushfire risk;
- electric and magnetic fields;
- traffic and transport; and
- storage, handling and transport of hazardous materials and dangerous goods.

The potential impacts associated with these hazards and risks are discussed in the following sections.

11.4.1 Electrical safety

Considering the majority of the transmission cable route would be located within road reserves and other public areas, there is a risk that other activities being undertaken in proximity may impact on the

transmission cable circuit, resulting in electrical safety risks. Risks which are relevant to underground transmission cables and cable bridges include:

- infringement of electrical safety clearances e.g. due to excavation activity or tree root growth;
- electrical induction due to parallel conducting materials e.g. electricity cables in close proximity to each other;
- fault conditions due to lightning or bushfire;
- failure of bridge structures or cables due to third party vehicle or plant impact; and
- transfer of dangerous voltages off-easement, e.g. by services installed within the easement area.

The State Environmental Planning Policy (Infrastructure) 2007 (ISEPP) contains clauses to help manage risks associated with development near electrical utilities. Section 45 requires notification to the electrical supply authority prior to determining a development application - this provides an opportunity for the assessment of potential safety risks.

The consent authority must take into consideration the response from the electrical supply authority prior to determining an application. In accordance with these provisions, following the construction of the project any development proposed in proximity to the project that triggers Section 45 of ISEPP would require notification to TransGrid by the consent authority.

In addition to Section 45, Section 44 lists specific requirements for development with 10 metres of the centreline of defined electricity supply corridors within the City of Sydney Local Government Area (LGA). For these corridors, Section 44 requires the consent authority to notify the electrical supply authority and take into consideration the response.

The proponent will apply to have the project listed as an electrical supply corridor under Section 44 of the ISEPP. If the project is listed, then any development within 10 metres of the corridor would be required to satisfy the requirements of Section 44 of the ISEPP.

In addition, where easements are established for sections of the transmission cable route, risks would be managed via the easement restrictions and the implementation of the *TransGrid Easement Guidelines – Third Party Development*[1].

The transmission cable circuit easement will be registered on DBYD prior to construction commencing. Future development near or in the easement would require consent from TransGrid to ensure that potential risks have been assessed and mitigated prior to development consent being granted.

To minimise the risks of accidental damage during excavation works by third parties, conduit installation would include laying polymeric covers and warning tape at various levels over the conduits, marked with appropriate warnings. Warning tape would also be placed on top of the engineered backfill material, which will be placed over the conduits to further convey appropriate warnings. These warnings would notify other parties of the presence of the cable in the event of exposure through excavation. Once restoration activities have been completed in the cable trenches, surface cable markers would be installed along the transmission cable route to give warning of the presence of the cable and the need to make enquiries before digging.

Furthermore, the DBYD service allows users to enquire about utilities present within an area of interest. The enquiry is submitted into the DBYD system and the registered members are notified. Registered members respond directly to the enquiry about the presence (or absence) and location of their assets within the enquiry boundary. For NSW/ACT TransGrid is a registered member. Using the DBYD service aims to prevent damage and disruption and minimise safety risks of encountering utilities during excavation.

Operation of the project within the substations is not expected to materially change the existing electrical safety risks of the substations. These are already operating substations and as such have existing management procedures in place to manage electrical safety risks.

[1] https://www.transgrid.com.au/being-responsible/public-safety/living-and-working-with-powerlines/Documents/Easement%20guidelines%20for%20third%20party%20developers.pdf

11.4.2 Bushfire risk

As discussed in **Section 11.3.5**, the transmission cable route, construction laydown areas and the Rookwood Road and Beaconsfield West substations are not located within a bushfire prone area and considering the urban nature of the project area, risks to public safety as a result of the interference of bushfires with the operation of the transmission cable circuit and cable bridges are not anticipated.

The Sydney South substation in Picnic Point is surrounded by bushland and is located within a designated bushfire prone area. The operation of the project within the Sydney South substation would not introduce new bushfire risks as the site is an existing substation and the operation of the project would be consistent with the exiting use. Bushfire risk at the Sydney South substation would be managed by the Emergency Response Manual for the site.

11.4.3 Electric and magnetic fields

The transmission cables would create electric and magnetic fields (EMF) during operation. The potential impacts of EMF from the project are discussed in **Chapter 10 Electric and magnetic fields**.

11.4.4 Traffic and transport

Ongoing maintenance of the substations, underground transmission cable circuit, cable bridges and link or sensor boxes would be required during operation. In most cases, only visual inspections would be required along the transmission cable route and at the cable bridges, which would not have any impact on existing traffic conditions.

Potential disruptions to road users and the community are dependent on where the link and sensor boxes are located i.e. if they are within the roadway, some closure of lanes may be required. If located in the footpath, there may be some detour of pedestrian access. The duration of impacts to access would depend on the nature of the maintenance activities being undertaken i.e. if routine or in response to a major fault, the latter being quite rare. Maintenance crews would utilise appropriate traffic management measures when undertaking work within the road reserve.

The operation of cable bridges is not expected to have an ongoing impact on railway operations. If railway possessions are required for maintenance works, these would be undertaken during rail possessions planned by the relevant rail network authority. Work within the rail corridors would be planned, coordinated and executed in close consultation with the relevant rail network authority, with all relevant access and safety requirements met.

Operation of the project at the substations would not increase the number of vehicles required and as such no additional traffic and transport hazards at the substations have been identified.

Maintenance activities would also be undertaken in accordance with existing TransGrid procedures and management systems.

11.4.5 Storage, handling and transport of hazardous materials and dangerous goods

As discussed in **Section 11.3.1**, the inadequate storage, handling and transport of hazardous materials and dangerous goods may result in impacts to the surrounding environment and community as a result of leaks and spills or from potential fires if the material is flammable. Hazardous materials and dangerous goods may be transported, stored and used during maintenance activities; however, these are expected to be in minor quantities.

The transport, storage, handling and use of hazardous substances would be undertaken in accordance with the NSW Dangerous Goods (Road and *Rail Transport) Act 2008*, *Work Health and Safety Act 2011*, the Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission, 2017) and other relevant Australian Standards.

While the existing substation sites do house hazardous materials and dangerous goods, the expected volumes and management of these is not expected to change as a result of the project.

11.5 Environmental management and mitigation measures

Environmental management and mitigation measures relating to potential hazards and risks are outlined in **Table 11-1**.

Measures to manage potential human health impacts resulting from exposure to EMF, amenity impacts associated with noise and vibration and dust generation and odour and contaminated materials are addressed in the relevant chapters of the Environmental Impact Statement (EIS); being **Chapter 10 Electric and magnetic fields**, **Chapter 21 Social and economic, Chapter 8 Noise and vibration, Chapter 9 Air quality,** and **Chapter 16 Soils and contamination**.

Table 11-1 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
HR1	General	General hazard and risk management measures for construction of different project components (such as underground cables, special crossings and construction laydown areas) will be included within the Construction Environmental Management Plan (CEMP), including: • details of the environmental hazards and risks associated with different construction activities; • procedures to comply with legislative and industry standard requirements; • Work Method Statements; • emergency procedures for unplanned events; and • training for relevant personnel (including subcontractors) and site inductions.	Construction
HR2	Traffic hazards during construction	Traffic hazards will be managed through the preparation and implementation of a CTMP. The CTMP will manage access to residences/businesses, the closure of lanes and roads and detours for pedestrians and cyclists. The CTMP will also include measures to make the public aware of changes in road conditions such as erecting warning signs and having traffic controllers on-site. Refer to additional measures in **Chapter 7 Traffic and transport**.	Construction
HR3	Disruption of rail network	Construction and maintenance of the cable bridges within heavy rail and light rail corridors will be undertaken during rail possessions planned by the relevant rail network authority or as otherwise agreed with the rail authority.	Construction and operation
HR4	Transportation of hazardous materials	Hazardous materials will be transported, stored and used in accordance with: • *Work Health and Safety Act 2011 (NSW);* • *Dangerous Goods (Road and Rail Transport) Act 2008* (NSW); • Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission, 2017); and • relevant Australian Standards. SDSs will accompany all dangerous goods transported to work sites.	Construction and operation
HR5	Spills and leaks of hazardous materials	Hazardous material procedures (including procedures for storage, transport and disposal of hazardous materials, spill prevention and management and the	Construction and operation

No.	Impact/issue	Environmental management and mitigation measures	Timing
		refuelling and maintenance of vehicles/equipment) will be developed and implemented as part of the CEMP, to minimise potential for impacts associated with chemical spills and leaks. Any captured water which is not of a suitable quality for discharge will be disposed of at an appropriately licenced waste facility.	
HR6	Unauthorised access	All work sites and construction laydown areas will include some form of delineation, barrier/perimeter fencing and signage notifying unauthorised persons not to enter and of the potential hazards at the site.	Construction
HR7	Underground utilities	Minimise public safety risks such as flooding and fire/explosions from damaging underground utilities by: • undertaking DBYD enquiries and consulting with relevant service infrastructure providers, prior to commencement of construction; • undertaking service and utility identification works; • employing non-destructive excavation methods to expose buried services prior to excavation where works are required in close proximity to the utility and there is a high risk of striking that utility; and • protecting utilities prior to any excavation works being undertaken in proximity to the utility where required.	Construction
HR8	Bushfire risks	Restrict hot works (such as welding or other activities generating heat or sparks) on days of declared catastrophic fire danger at the Sydney South substation.	Construction
HR9	Electrical safety	During construction, appropriate warning in the form of surface markers and subsurface tape will be installed along the transmission cable route to warn third parties conducting excavations in the area of the presence of the cable circuit. The cable circuit will also be registered on DBYD prior to construction commencing.	Construction
HR10	Emergency response	If required, the site-specific Emergency Response Manual for the Rookwood Road, Beaconsfield West and Sydney South substations will be updated to reflect the changed conditions and additional requirements that may arise as a result of the project.	Operation
HR11	Hazards during operation	Maintenance crews will undertake maintenance and repair work in accordance with the requirements of TransGrid's existing Environmental Management System.	Operation

No.	Impact/issue	Environmental management and mitigation measures	Timing
HR12	Subsidence and/or frac-out during underboring	The risk of subsidence and/or frac-out will be minimised during underboring by: • designing the depth of the underbore around local geotechnical conditions; • appointing a suitably qualified and experienced drilling contractor; and • ensuring contingency plans are in place to deal with drilling fluid in the event of a frac-out.	Detailed design and construction
HR13	Frac-out during underboring	Modelling of underbores will be undertaken to determine the risk of frac-out. This would include a geological evaluation and construction risk assessment. Proposed construction methods will be evaluated to determine the lowest risk method.	Detailed design
HR14	Ground settlement during underboring	For underboring under rail corridors, a geotechnical settlement analysis will be undertaken to meet the requirements of the relevant rail authority for determining the risk of settlement.	Detailed design

12.0 Visual amenity

This chapter provides an overview of the potential landscape character and visual impacts from the construction and operation of the project and outlines proposed management and mitigation measures. The Landscape Character and Visual Impact Assessment (LCVIA) report included in **Appendix G** provides further detail on the existing environment and the assessment of potential landscape character and visual impacts.

12.1 Assessment methodology

12.1.1 Study area

The study area for the LCVIA is a two kilometre wide corridor offset one kilometre from either side of the transmission cable route (refer to **Figure 12-1**). This encapsulates the project area and enough of the surrounding landscape to capture both landscape and visual impacts of the project. Construction laydown areas that fall outside this two kilometre wide corridor have also been included in the assessment.

As the proposed upgrades at the Sydney South substation would not be seen from public viewpoints such as walking tracks, the potential changes in visual amenity are considered to be negligible and as such the works at this substation have been excluded from this assessment.

12.1.2 Approach and methodology

The LCVIA was undertaken using methodology informed by the Roads and Maritime Services (2013) *Environmental Impact Assessment Practice Note – Guideline for Landscape Character and Visual Impact Assessment*, which is a method widely accepted by NSW government authorities and the *Guidelines for Landscape and Visual Impact Assessment* (Landscape Institute and Institute for Environmental Management, 2013).

The LCVIA assessed impacts to both the landscape character and views (visual impacts). The landscape character assessment determines the impact of a project on the overall character of an area, including built, natural and cultural aspects of the landscape. In order to assess impacts on the landscape character, landscape character zones (LCZ) were determined to group areas sharing broadly the same characteristics or spatial qualities. The impact of the project on each LCZ within the study area is considered, rather than the impact at any one location, e.g. if the impact on recreational open space was being considered (which would be one LCZ unit), the impact on the overall character of open space within the entire study area would be assessed, rather than the impact of the project on an individual park/recreational area.

The visual impact assessment defines the day-to-day visual effects of a project on receptors (refer to **Section 12.2.3** for a description of receptors). To determine the potential impacts, Observer Locations (OLs) were identified, which are locations with a representative view of the project area.

Broadly, the methodology for assessing landscape character and visual impacts of the project has involved a desktop analysis to identify existing environmental conditions, undertaking visual inspections at multiple locations within the study area, production of visual simulations to show what operational infrastructure may look like from public viewpoints, assessment of the significance of potential impacts and identifying reasonable and feasible mitigation measures to minimise potential impacts. Further details on the methodology are provided in **Appendix G**.

12.1.2.1 Assessment of impacts

The impact of the project on landscape character and visual impact comprises an analysis of sensitivity, of either the landscape itself or the receptor seeing the view subject to change, and an assessment of the magnitude of change on that LCZ or view. The factors that determine the sensitivity of receptors and magnitude of change is described in **Table 12-1**.

Table 12-1 Summary of factors that determine sensitivity and magnitude

Sensitivity	Magnitude
Landscape character	
The sensitivity of a landscape is based on the extent to which it can accept change of a type and scale without adverse impacts upon its character or value. Sensitivity is based on: • inherent landscape value, e.g. its condition, perceptual qualities, and cultural importance; and • likely congruency of the proposed change, (i.e. the extent to which the project may 'fit' or be 'absorbed' into the landscape), e.g. in relation to line, colour, texture, form and scale.	The magnitude of change of landscape character depends on factors such as the extent of: • loss, change or addition of any feature or element; • change to the landscape itself or one nearby that affects its character; and • the quality of the project design and potential mitigation measures, if adopted.
Visual	
The sensitivity of visual receptors and views would be dependent on: • location and context of the viewpoint; • expectations and activity of the receptor; • type and number of receptors; • importance of the view; and • typical duration of viewing. The most sensitive receptors may include: • users of outdoor recreational facilities; • communities where the project has the potential to result in changes in the landscape setting or valued views enjoyed by the community; and • owners and occupiers of residences with views affected by the project.	The magnitude of change on a view would depend on factors such as: • the extent of visibility of the change; • the scale, size and character of the project elements; • the degree of obstruction of existing features; • the degree of contrast with the existing view; • the quality of the project design and any mitigation measures recommended, if adopted; • angle of existing view; • the potential and typical duration of view; and • distance from the project. The magnitude of change can therefore range from a total view loss or significant change in the view (High), to no change (Negligible).

The resulting sensitivity and magnitude ratings are then combined to generate an overall impact rating using the impact grading matrix in **Table 12-2**. The impact rating does not include a value judgement regarding the nature of the change (i.e. whether the change is a positive or negative impact on the landscape character or on the views seen by receptors).

Table 12-2 Landscape character and visual impact grading matrix

		Magnitude			
		High	**Moderate**	**Low**	**Negligible**
Sensitivity	**High**	High	High - Moderate	Moderate	Negligible
	Moderate	High - Moderate	Moderate	Moderate - Low	Negligible
	Low	Moderate	Moderate - Low	Low	Negligible
	Negligible	Negligible	Negligible	Negligible	Negligible

12.1.2.2 Night lighting assumptions

Construction hours for the project are described in **Chapter 4 Project description** and in Section 2.5 of **Appendix G**. The following represent 'worst case scenario' assumptions for night lighting in the project area for the purposes of the LCVIA:

- transmissions cable route:
  - all road reserves situated along the transmission cable route may at some point require night lighting during the construction period;
  - night lighting in road reserves would comprise low, temporary flood lighting to illuminate areas of construction activity;
- construction laydown areas:
  - all construction laydown areas would be lit at night for the entire construction period (up to two years);
  - lighting would comprise high flood lighting positioned around the perimeter of the construction laydown areas, and pointing into the compound; and
  - fencing around construction laydown areas would generally comprise temporary mesh fencing covered with shade cloth, or painted timber hoarding or similar, where required.

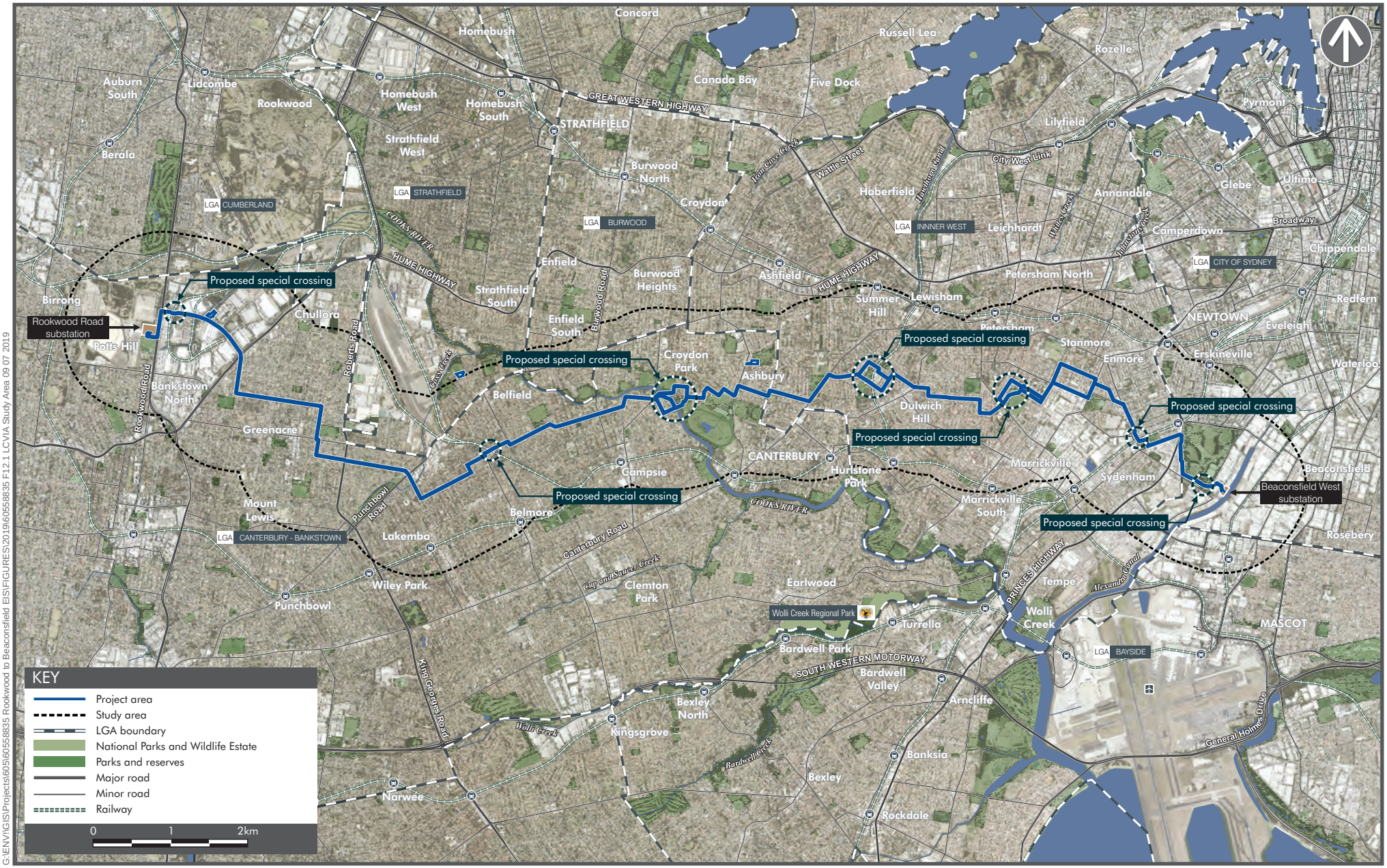
12.1.2.3 Tree removal assumptions

The project would avoid the removal of trees wherever feasible and reasonable however as a worst case scenario the LCVIA has assumed that along the transmission cable route, street trees along roadways would be removed down one verge to accommodate the transmission cable circuit within the road reserve. It is anticipated that between 2-5% of trees within the project area may be removed. Opportunities to retain trees would be further investigated during detailed design and construction.

Tree removal and replacement (including species choice) would be dependent on the position of the transmission cable circuit within the road reserve. Where the transmission cable circuit passes within the middle of the roadway (i.e. avoiding the road verges), trees would be less affected by the project. Where trees are required to be removed, a tree replanting strategy/landscape plan would be developed in consultation with the relevant council. Similar species would be replanted (where feasible) and where this is not possible, suitable trees for specific local conditions would be determined. The Arboricultural Impact Assessment undertaken for the project (included in **Appendix O**) describes the trees identified within the project area based on the current concept design.

12.1.2.4 Assessment of cumulative impacts

The LCVIA considered the likely cumulative landscape character and visual impacts of other developments and the project on the surrounding environment. The assessment of cumulative impacts is summarised in **Chapter 22 Cumulative impacts**.



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LANDSCAPE CHARACTER AND VISUAL IMPACT ASSESSMENT STUDY AREA

Powering Sydney's Future

Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and special crossings
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 12-1

12.2 Existing environment

12.2.1 Built form, land use and character

The transmission cable route is divided into five construction precincts, as described in detail in **Chapter 4 Project description**. The key land use and built form character of development adjoining the transmission cable route within each of these construction precincts is discussed in the following sections.

The following sections note heritage values in the relevant construction precincts. Refer to the Historical Heritage Impact Assessment in **Appendix J** for a list of heritage items and heritage conservation areas (HCAs) in proximity to the project area.

12.2.1.1 Precinct 1

Rookwood Road substation and Chullora Industrial Estate to Hume Highway

This construction precinct has an industrial land use and built form character, consistent with its industrial zoning. This construction precinct comprises the existing substation facility on Rookwood Road and industrial properties on the eastern side of Rookwood Road. The transmission cable route runs along Muir Road within the Chullora Industrial Estate, which features large floor plate warehousing/light industrial premises with extensive hard surface areas and at-grade parking areas, with street tree plantings along the median of Muir Road, mainly comprising Hills Figs.

There are no HCAs adjoining the transmission cable route in this construction precinct. The Potts Hill Reservoirs 1 and 2, which adjoin the transmission cable route on the western side of Rookwood Road, are items of State and local significance listed in the Bankstown Local Environmental Plan (LEP).

12.2.1.2 Precinct 2

Hume Highway to Cooks River Crossing (Brighton Avenue)

This construction precinct has a low density residential land use and built form character with a small light industrial area along Punchbowl Road, consistent with the zoning pattern. The predominant built form is detached housing, one and two storeys in height, on lots with an area around 500 square metres. Dwellings generally date from around the 1970s onwards and are built from a range of materials including fibreboard and rendered brick.

The low density residential development is interspersed with pockets of other land uses which are complementary to the residential character. This includes a sports field (Allum Park) in Maiden Street and a small mixed use local centre at the intersection of Hillcrest Avenue and Rawson Road which features a row of one and two storey shop top premises. There are small groups of local shops throughout this construction precinct. Along Seventh Avenue and Byron Street, dwelling densities increase, with two to three storey walk-up apartments and attached dwellings, although detached housing is still the most common building type.

Street tree planting contributes to the overall character of the residential areas within this construction precinct, particularly to the west of Punchbowl Road.

The street trees on Fifth Avenue are locally listed heritage items titled ‘Inter war street trees’. The transmission cable route crosses Fifth Avenue at the intersection with Seventh Avenue. No other HCAs or heritage items are within proximity of the transmission cable route in this construction precinct.

12.2.1.3 Precinct 3

Brighton Avenue (near Mildura Reserve) to Henson Park

This construction precinct has a low density residential land use and built form character with medium density pockets around the local and neighbourhood centres. The predominant building form is detached housing, one or two storeys in height. The character of this construction precinct is similar to that of Precinct 2.

The medium density dwellings throughout this construction precinct are typically located along larger roads and near transport hubs such as the Arlington Light Rail Station. The transmission cable route

passes several sports fields and open spaces including Gough Reserve, Yeo Park, Arlington Recreation Reserve and Marrickville Park.

Streets in this construction precinct are typically wide with small street trees along the verges contributing to the character of the construction precinct.

The Ashbury Conservation Area encompasses the western most portion of the transmission cable route in this construction precinct. Other HCAs and heritage items adjoining the transmission cable route include:

- Canterbury Park Racecourse;
- Service Avenue Conservation Area;
- Yeo Park (public reserve);
- The Abergeldie Estate Conservation Area;
- The Boulevarde Conservation Area;
- Dulwich Hill Conservation Area; and
- Henson Park.

12.2.1.4 Precinct 4

Henson Park (Illawarra Road) to Camdenville Park

To the south of the transmission cable route, this construction precinct has commercial, light industrial and bulky goods retailing land use, with residential development less common. Buildings generally feature limited setbacks to the street, with heights of two to three storeys. There are some street trees but there is little other vegetation and therefore this is not a significant contributor to the character of this part of the transmission cable route.

To the north of the transmission cable route, residential development predominates within this precinct, with a grid road network featuring many narrow streets lined with street trees (e.g. Newington Road).

These areas comprise predominantly Victorian era attached and detached dwellings on small blocks with small setbacks to the street, with significant vegetation on private properties and mature street trees contributing significantly to the character. Other uses include schools such as Newington College and St Pius Catholic Primary School, which comprise large educational institutions on extensive school grounds.

Enmore Park is within the vicinity of the transmission cable route in this construction precinct. It is a significant area of public open space, with mature trees and extensive green space. Opposite this park to the west and north, land use and built form character is predominantly Victorian terrace housing and cottages. Properties in Llewellyn Street and Scouller Street to the north of the park are within the Llewellyn Estate HCA. A mix of mature and young street trees add to the character of this area.

12.2.1.5 Precinct 5

Bedwin Road Rail Bridge to Beaconsfield West substation

Immediately east of the rail bridge, the land use and built form character is mixed, with a range of light industrial, commercial and residential properties along the proposed transmission cable route, with limited setbacks from the street and scattered street trees. Two parks are also located within the construction precinct, which include Camdenville Park and Sydney Park. Sydney Park provides extensive green space with mature tree planting.

A part of the precinct to the south of Sydney Park is currently under construction as part of the WestConnex New M5 project and the local area is therefore experiencing a transition in land use.

The property on the western side of Bedwin Road adjoining the transmission cable route, immediately south of the rail bridge, is a local heritage item known as the Waugh and Josephson industrial buildings. Camdenville Park is within the Goodsell Estate HCA. The heritage character of this part of

the construction precinct is reinforced further by the group of terrace houses in May Street adjoining the park, which are local heritage items.

Sydney Park is a regionally significant area of public open space, and the largest area of public open space within the project area. It has a high quality landscape character with extensive mature tree planting, and a heritage item in the northwest part of the park, known as the 'former brickworks group'. The last section of the proposed transmission cable route between Sydney Park and the Beaconsfield West substation has a light industrial built form and character. Large industrial buildings line Burrows Road with a consistent scale and setback, and intermittent native street trees line the road corridors.

12.2.2 Landscape character zones

Five LCZs were identified within the study area:

- LCZ 1: Recreational Open Space (refer **Figure 12-2**);
- LCZ 2: Infrastructure Corridor (refer **Figure 12-3**);
- LCZ 3: Mixed Residential Development (refer **Figure 12-4**);
- LCZ 4: Industrial Development (refer **Figure 12-5**); and
- LCZ 5: Commercial Development (refer **Figure 12-6**).

Overall, the landscape surrounding the project area predominantly comprises Mixed Residential Development (LCZ 3), mostly comprising low density residential lots with detached dwellings. A few large areas of Industrial Development (LCZ 4) are located at Bankstown/Chullora, Greenacre, Marrickville/Sydenham and St Peters. Recreational areas comprise linear areas along creek corridors and isolated parks. The largest linear area of Recreational Open Space (LCZ 1) is associated with the Cooks River (Precincts 2 and 3), and the largest isolated park is Sydney Park (Precinct 5), while the Canterbury Racecourse and Canterbury Park are also large recreational areas, although the racecourse is privately owned land. Other isolated parks of different sizes are scattered throughout the Mixed Residential Development (LCZ 3). Infrastructure Corridor (LCZ 2) is predominantly made up of road and rail corridors, but with a large area in Precinct 1 associated with Sydney Water infrastructure. Commercial Development (LCZ 5) is generally clustered along major roads.

Appendix G summarises the existing environment of each LCZ in more detail. Refer to **Figure 12-7** for the location of landscape character zones in relation to the study area.

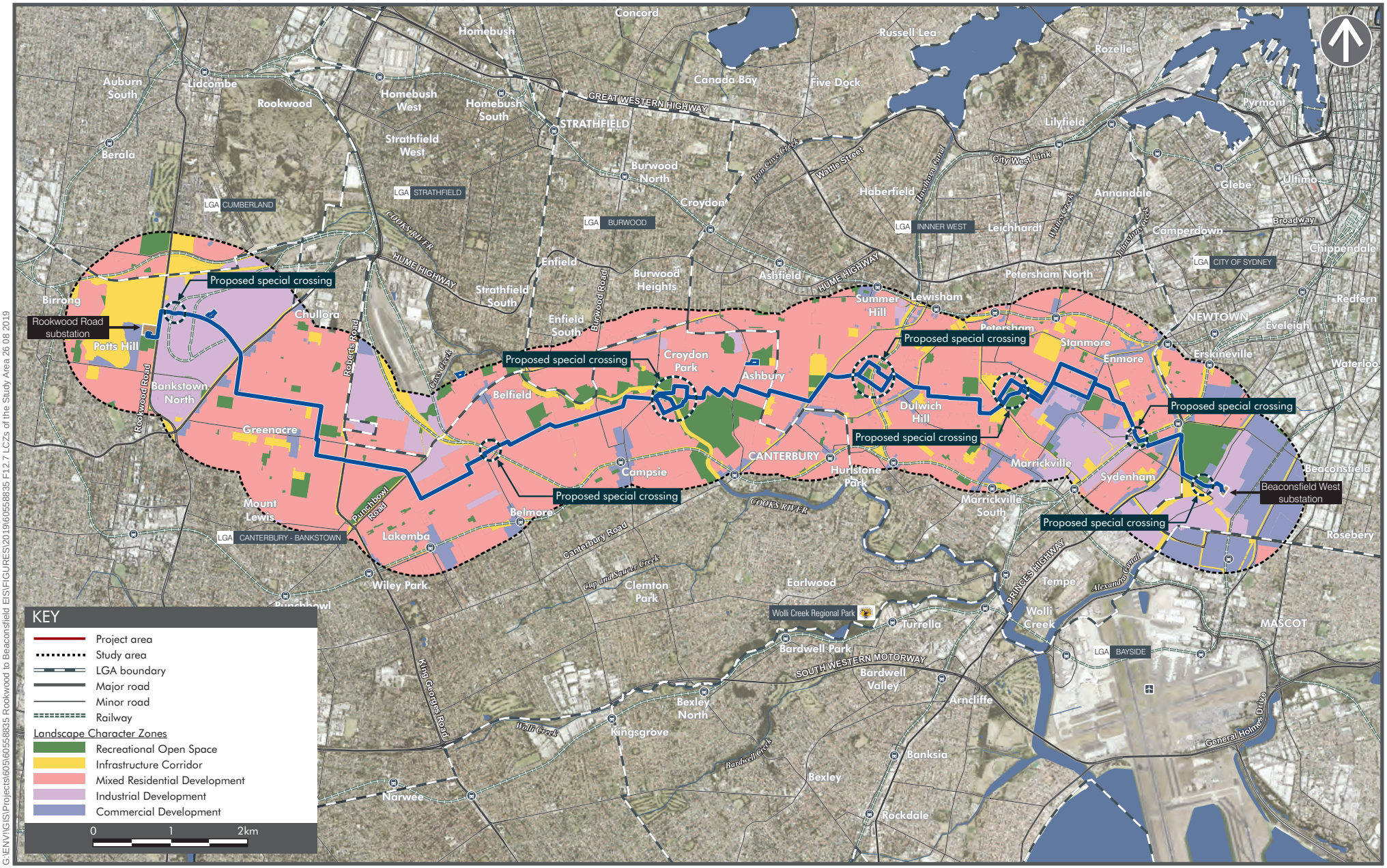
Figure 12-2 Example of Recreational Open Space (LCZ1). A series of wetlands with fringing vegetation and lookouts within Sydney Park

Figure 12-3 Example of Infrastructure Corridor (LCZ2). Typical rail crossing at Muir Road, Chullora

Figure 12-4 Example of Mixed Residential Development (LCZ3). Narrow streets with large, mature street trees and on-street parking are typical of the inner west

Figure 12-5 Example of Industrial Development (LCZ4). Large scale buildings with some landscaping along the street edge within the Chullora Industrial Park in Precinct 1

Figure 12-6 Example of Commercial Development (LCZ5). Built form is often attached and directly addresses the streets, with limited or no landscaping (Livingstone Road, Petersham)



G:\ENVIGIS\Projects\605\60558835 Rookwood to Beaconsfield EIS\FIGURES\2019\60558835 F12.7 LCZs of the Study Area 26 08 2019

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LANDSCAPE CHARACTER ZONES OF THE STUDY AREA

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Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations

Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 12-7

12.2.3 Visual impact receptors

The visual catchment of the study area comprises the following receptors:

- residents of homes including low density single residences, and multi-storey apartment blocks;
- employees and customers of businesses including cafes and restaurants, and businesses along major roads and in industrial areas;
- students and teachers at schools and childcare facilities;
- worshipers and visitors to religious and cultural centres;
- recreational receptors in parks; and
- travellers (vehicles, pedestrians and cyclists) on roads.

12.2.4 Summary of views

In this section the visibility of the project is discussed during construction and operation. **Appendix G** provides more detail on the existing views of each OL.

The majority of the project is linear in nature, along a proposed 20 kilometre transmission cable route, with three construction laydown areas located along the transmission cable route and two located close by (the furthest being about one kilometre from the transmission cable route). For the purpose of this assessment, the project is divided into the construction of the transmission cable circuit (including joint bays and special crossings), which includes linear works; and the use of construction laydown areas and substation sites, which are contained to specific locations.

The proposed transmission cable route is located predominantly within road reserves, with up to three cable bridge crossings potentially required. Underboring is proposed at other locations where the transmission cable route is required to cross features including watercourses or rail corridors. Within the road reserve, the visibility of the construction activity would generally be localised, with views to the works limited to the built form on either side of the road, and along the road itself. The roads within the study area are predominantly flat to gently undulating. There are no areas where significant views to the surrounding landscape (or views back from the surrounding landscape) are seen from a vantage point.

Built form within the study area predominantly comprises low density residential housing (both attached and detached), with some industrial complexes to the west and some higher residential apartment blocks scattered along the transmission cable route.

There are few areas where views to the project area are not contained by the built form on either side of the road reserve. This typically occurs where the transmission cable route passes directly next to open space, such as Allum Park in Greenacre, Gough Reserve and Yeo Park in Hurlstone Park, Enmore Park in Enmore, Camdenville Park in St Peters and Sydney Park in Alexandria. Within these parks the visibility of the project area is limited by vegetation and landform.

Visibility of the proposed cable bridges, which would be located adjacent to existing bridges and would cross rail corridors or watercourses, would vary with each location. Views to bridges are sometimes limited by the visual containment of the crossing point, e.g. where a road bridge crosses a rail corridor the bridge deck is visible to traffic passing over it. However, views to the bridge from below (i.e. from within the rail corridor) are limited by the difference in grade between the rail corridor and the surrounding landscape and by fringing vegetation along the rail corridor which screens views into the corridor. Views to the crossing structures would be most accessible where public open spaces are associated with the bridges, e.g. at the crossing of the Cooks River in Campsie/Croydon Park and at Camdenville Park, St Peters.

Views to the construction laydown areas would vary with each location and are described in **Table 12-3**.

Table 12-3 Views to construction laydown areas

Construction laydown area	Description of views to the site
Muir Road, Chullora	Reasonably open, with views available into the construction laydown area from two sides (the access path to the Freshwater Wetlands to the northwest and the former TAFE Chullora Campus to the southeast), although the side fronting Muir Road is bordered by a tall black metal fence with mature street trees and some vegetation.
Cooke Park, Belfield	Large park with one side open to Chisolm Street to the east and Madeline Street to the west, with the southern and western boundaries predominantly bordered by back fences of properties, and one side bounded by the Cooks River. Views into the park from Chisolm Street are limited by large tree plantings along the boundary.
Peace Park, Ashbury	The park is visually open to Trevenar Street along one edge, but the location of the construction laydown area is positioned away from the street frontage and more contained by landform, built form and planting. Views into the park can be seen from Trevenar Street and from the rear property boundaries of homes backing onto the park.
Camdenville Park, St Peters	Visually contained by the rail corridor and localised mounding along the northern boundary. Views into the park are available from May Street and Council Street and distant views into the park are seen from the Bedwin Road rail bridge over the rail corridor to the west of the park.
Beaconsfield West substation, Alexandria	Visually contained within the high walls of the substation and between other substation infrastructure. Some views may be available from the eastern side of Alexandra Canal, but typically these are from private properties and not publicly accessible areas.

12.3 Assessment of potential impacts

The following sections provide a high level summary of the outcomes of the LCVIA and the potential impacts on landscape character and visual impacts. Sensitivity of the LCZ and visual receptors and the magnitude of change were determined based on the methodology provided in **Table 12-1**. Further detail on the existing landscape character and views, the sensitivity of the receptors and the magnitude of change is provided in **Appendix G**.

The changes to the LCZ and visual receptors have been summarised by grouping the following project activities:

- transmission cable route:
  - construction works would have visual elements including:
    - presence of workers, vehicles, plant, equipment, materials and traffic management;
    - excavations for trenches, joint bays and underboring launch and receive pits;
    - tents or demountable buildings over joint bays during cable jointing;
    - vegetation clearance (where required);
    - night lighting;
  - operational impacts of the transmission cable circuit would be minor as the roads and parks would be rehabilitated following construction. Any routine maintenance would be infrequent and temporary. Visual elements that may remain visible include:
    - reduced vegetation density due to clearing, where required (the feasibility of replacement planting would be investigated during detailed design);

    - minor infrastructure such as link and sensor boxes and cable markers, which are considered visually unobtrusive;

- cable bridges:
    - construction of a cable bridge would include the following visual elements:
        - presence of workers, vehicles, plant, equipment, materials and traffic management;
        - excavation for bridge piers;
        - vegetation clearance (where required);
        - night lighting;
    - during operation there would be views of the new cable bridges and reduced vegetation density due to clearing, where required the feasibility of replacement planting would be investigated during detailed design;
- construction laydown areas:
    - during construction, changes at construction laydown areas would include:
        - presence of workers, vehicles, plant, equipment and materials and site offices;
        - night lighting;
    - there are no further changes at these locations during operation as these sites would be returned to their original pre-construction state;
- Rookwood Road and Beaconsfield West substations:
    - construction works at the substations would include the following visual elements:
        - presence of workers, vehicles, plant, equipment, materials and traffic management;
        - excavation for conduit installation or other infrastructure, vegetation clearance (where required);
        - night lighting; and
    - during operation there would be no views of the changes inside the substation from publicly accessible locations. Where feasible (i.e. no impact on the safe operation of the substation), any removed trees would be replaced.

12.3.1 Potential impacts on landscape character

An assessment of the potential impact on landscape character within each LCZ is summarised in **Table 12-4**. This includes the route options and alternative construction methods proposed at the Cooks River, Dulwich Hill light rail corridor, Henson Park and Marrickville (refer to **Figure 12-8** to **Figure 12-11** and a detailed description of these options in **Chapter 4 Project description**).

Table 12-4 Landscape character impact assessment

LCZ	Sensitivity	Changes due to project	Magnitude	Impact rating	Overall assessment
LCZ 1: Recreational Open space	High	**Construction impact assessment**			
		Construction activity associated with: • the transmission cable route (such as site preparation, tree removal, trenching, underboring, installation of cable bridges, conduit installation and construction of joint bays, erection of tents or demountable buildings during cable jointing and road restoration); and • construction laydown areas.	High	High	The impact on landscape character during construction would be High. The construction of the project would result in a significant change in landscape character which would affect many recreational open space areas throughout the LCZ within the study area. This is due to the length of the transmission cable route traversing Camdenville Park and Sydney Park and the use of multiple public open spaces as construction laydown areas. The visual character and activity of construction within open space would be atypical of the existing character of these areas. However, the construction period would be short-term, with areas affected by construction activity being reinstated to their original condition (or as otherwise agreed with the relevant authority). The length of time that changes due to construction activity would be observed would vary from location to location. Open space areas affected by construction laydown areas would experience these changes potentially over the entire construction period (up to two years); while other areas affected by construction would only experience changes over a shorter period (e.g. where conduits are installed, or a cable bridge constructed).
		Operation impact assessment			
		• Changes associated with cable bridges: - Cooks River and cycleway near Lindsay Street at Campsie (this is one of three crossing options at this location); and - Bedwin Road, St Peters.	Low	Moderate	The impact during operation would be Moderate. While there would be permanent changes, they largely result from the cable bridges which would be installed adjacent to an existing bridge, rather than a new element within the landscape. The impact rating is the result of the High sensitivity of the LCZ rather than the magnitude of the change, which was assessed as Low.

LCZ	Sensitivity	Changes due to project	Magnitude	Impact rating	Overall assessment
LCZ 2: Infrastructure Corridor	Low	**Construction impact assessment**			
		Construction activities associated with: • the transmission cable route (such as site preparation, tree removal, trenching, underboring, installation of cable bridges, conduit installation and construction of joint bays, erection of tents or demountable buildings during cable jointing, and road restoration); and • construction laydown areas.	Moderate	Moderate to Low	The impact during construction would be Moderate to Low. While areas of the infrastructure corridor that are affected by the project construction activity are limited to a small number of main road reserves (passing over several rail corridors), these portions of road/rail are small areas compared to the overall area of the LCZ within the study area.
		Operation impact assessment			
		• Changes associated with cable bridges at: - Muir Road, Chullora; and - Bedwin Road, St Peters.	Moderate	Moderate to Low	The impact during operation is Moderate to Low, considering the visual 'fit' of the cable bridges within infrastructure corridors as both are typically utilitarian in character. Where trees are required to be removed during construction, an appropriate tree replanting strategy/landscape plan would be developed in consultation with the relevant council (i.e. replanting similar species of trees where feasible and where this is not possible selecting suitable trees for specific local conditions).

LCZ	Sensitivity	Changes due to project	Magnitude	Impact rating	Overall assessment
LCZ 3: Mixed Residential Development	Moderate	**Construction impact assessment**			
		Construction activity associated with: • the transmission cable route (such as site preparation, tree removal, trenching, underboring, installation of cable bridges, conduit installation and construction of joint bays, erection of tents or demountable buildings during cable jointing and restoration of road surfaces); and • construction laydown areas.	Moderate	Moderate	The impact during construction would be Moderate. The changes are either contained to road reserves or to scattered construction laydown areas. The project area makes up only a very small proportion of the overall LCZ within the study area, and while there may be instances of change to the character of the immediate area surrounding the project, the impact on the overall character of the LCZ is limited. While construction along the transmission cable route would be new and atypical of the character of this LCZ, this activity would be temporary, which limits the magnitude rating. The construction laydown areas would potentially be visible for longer periods of time (up to two years) but would be visually contained within another LCZ (LCZ 1: Recreational Open Space).
		Operation impact assessment			
		• Changes associated with cable bridges at: - Cooks River at Campsie; and - Bedwin Road, St Peters.	Moderate	Moderate	The impact during operation would be Moderate. The road would be restored along the transmission cable route following construction e.g. road pavement and footpaths reinstated. However, the potential loss of street trees within this LCZ would be a source of change in character, as street trees are typically important elements within residential streetscapes. The cable bridges would be permanent operational infrastructure. While these comprise a new element within the landscape, when within or adjacent to this LCZ, they are positioned adjacent to an existing bridge which would reduce the impact of these structures on the local and overall character of the LCZ.

LCZ	Sensitivity	Changes due to project	Magnitude	Impact rating	Overall assessment
LCZ 4: Industrial Development	Low	**Construction impact assessment**			
		Construction activity associated with: • the transmission cable route (such as site preparation, tree removal, trenching, underboring, installation of cable bridges, conduit installation and construction of joint bays, erection of tents or demountable buildings during cable jointing and road restoration); • construction laydown areas; and • substation upgrades.	Low	Low	Overall, the impact during construction would be Low, given the low sensitivity and magnitude ratings of the LCZ. The LCZ has a low sensitivity due to its utilitarian character, where developments are designed for functionality rather than aesthetic appeal. The sensitivity of the LCZ is somewhat dependent on the ability of this LCZ to visually accept the proposed changes. While construction activity would be a new element where they occur within the LCZ, they are not particularly out of character. Furthermore, the project would be limited to a very small proportion of this LCZ and therefore would only locally affect landscape character, leaving a majority of the LCZ unchanged.
		Operation impact assessment			
		• Changes associated with cable bridges at: - Muir Road, Chullora; and - Bedwin Road, St Peters.	Low	Low	The impact during operation would be Low. Due to the utilitarian character of the LCZ, it has a high tolerance to changes of similar character, such as infrastructure projects. The two cable bridges situated within the LCZ would be built adjacent to existing bridges, thereby helping the new structures visually recede into the landscape. The potential loss of trees within this LCZ would be the most visible change, and although the project would only pass through the LCZ in limited places, the loss of trees (if required) would locally alter the landscape character where it occurs. Tree replacement (where possible) would reduce this change, and over time reduce the local impact.

LCZ	Sensitivity	Changes due to project	Magnitude	Impact rating	Overall assessment
LCZ 5: Commercial Development	Moderate	**Construction impact assessment**			
		Construction activity associated with: • the transmission cable circuit substations (such as site preparation, tree removal, trenching, underboring, conduit installation and construction of joint bays, erection of tents or demountable buildings during cable jointing and road restoration); • construction laydown areas; and • substation upgrades.	Moderate	Moderate	The impact during construction would be Moderate. There are only a few areas of this LCZ within the overall study area. The project typically affects these areas because local commercial centres are often positioned along main roads, along which the transmission cable route would pass. While these areas are not particularly sensitive due to the visual containment of the landscape by built form, the local centres are typically small, therefore the project would affect whole areas of the LCZ where it traverses them. Overall, this LCZ is not typically picturesque, but it does have areas where it is more sensitive due to the presence of HCAs and heritage items.
		Operation impact assessment			
		• No changes expected during operation.	Negligible	Negligible	The impact during operation would be Negligible. No changes would occur to the overall streetscape with limited (if any) trees proposed to be removed during construction.

12.3.1.1 Summary of landscape character impacts

Overall, the project would have the greatest impact on landscape character during the construction period, as much of the construction activity is uncharacteristic of the LCZs within the study area. This is particularly true within the most sensitive LCZ (Recreational Open Space (LCZ 1)), where there is a high scenic quality to the landscape and where construction work (including night lighting) would be atypical within the LCZ. However, the construction period is short-term (up to two years) and in most cases the impact on landscape character is reduced during operation. The work sites make up only a very small proportion of the overall LCZs within the study area, and although in some instances they may change the character of the immediate area surrounding the project, the impact on the overall character of the LCZs are limited.

The greatest potential impact of the project on landscape character during operation would be associated with the potential removal of street trees during construction, which in some areas would alter the character of the LCZ to varying degrees, depending on the size and character of the individual LCZs and the number, area and type of trees to be removed. Where possible, suitable replacement trees would be planted, which would assist in reducing the potential impacts of the project. Cable bridges would also permanently change the landscape; however, as there are up to three proposed, and they would be adjacent to existing bridges, the cable bridges would not change the landscape character of the LCZs.

12.3.2 Potential visual impacts

An assessment of the potential visual impact on each OL is summarised in **Table 12-5**. **Figure 12-8** to **Figure 12-11** shows the OLs in relation to the project area.

The following visuals have also been provided:

- the existing view and a visual simulation of the proposed cable bridge at Muir Road from OL3 are provided in **Figure 12-12** and **Figure 12-13** respectively;
- the existing view and a visual simulation of the proposed cable bridge option over the Cooks River from OL11B are provided in **Figure 12-14** and **Figure 12-15** respectively;
- the existing view and a visual simulation of the proposed cable bridge at Bedwin Road from OL24 are provided in **Figure 12-16** and **Figure 12-17** respectively; and
- the existing view and a visual simulation of the proposed cable bridge at Bedwin Road from OL25 are provided in **Figure 12-18** and **Figure 12-19** respectively. A close up visualisation over the proposed cable bridge with the cage structure is provided in **Figure 12-20**.

G:\ENV\GIS\Projects\605\60558835 Rookwood to Beaconsfield EIS\FIGURES\2019\60558835 F12.8 Study Area and Observer Locations - Map 1 01 10 2019

AECOM Imagine it. Delivered. TransGrid

OBSERVER LOCATIONS - MAP 1

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 12-8

G:\ENV\GIS\Projects\605\60558835 Rookwood to Beaconsfield EIS\FIGURES\2019\60558835 F12.9 Study Are and Observer Locations - Map 2 01 10 2019

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OBSERVER LOCATIONS - MAP 2

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 12-9

G:\ENV\GIS\Projects\605\60558835 Rookwood to Beaconsfield EIS\FIGURES\2019\60558835 12.10 Study Area and Observer Locations - Map 3 01 10 2019

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OBSERVER LOCATIONS - MAP 3

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 12-10

G:\ENV\GIS\Projects\605\60558835 Rookwood to Beaconsfield EIS\FIGURES\2019\60558835 F12.11 Study Area and Observer Locations - Map 4 01 10 2019

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OBSERVER LOCATIONS - MAP 4

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 12-11

Table 12-5 Visual impact assessment – construction and operational impacts

			Construction impact assessment			Operation impact assessment		
Precinct	**OL**	**Sensitivity**	**Changes to the view**	**Magnitude**	**Impact rating**	**Changes to the view**	**Magnitude**	**Impact rating**
1	OL 1: Rookwood Road substation, Potts Hill	Low	• Construction works at the Rookwood Road substation • Construction of the transmission cable circuit • Potential night work lighting	Moderate	Moderate to Low	• Limited changes due to new infrastructure • Potential markers of the transmission cable circuit and reduced vegetation density	Low	Low
1	OL 2: Muir Road rail overpass, Chullora	Low	• Construction of a cable bridge • Potential night work lighting	Moderate	Moderate to Low	• New cable bridge (refer to **Figure 12-13**) • Potential markers of the transmission cable route and reduced vegetation density	Moderate	Moderate - Low
1	OL 3: Muir Road construction laydown area, Chullora	Low	• Construction of the transmission cable circuit • Establishment and use as a construction laydown area • Flood lit at night	Moderate	Moderate to Low	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Low
2	OL 4: Allum Park, Greenacre	High	• Construction of the transmission cable circuit	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
2	OL 5: Lakemba Mosque, Lakemba	High	• Construction of the transmission cable circuit	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate

			Construction impact assessment			Operation impact assessment		
Precinct	**OL**	**Sensitivity**	**Changes to the view**	**Magnitude**	**Impact rating**	**Changes to the view**	**Magnitude**	**Impact rating**
2	OL 6: Yangoora Road, Lakemba	High	• Construction of the transmission cable circuit	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
2	OL 7: Carter Street, Belfield	High	• Construction of the transmission cable circuit including underboring works • Potential night work lighting	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
2	OL 8: Cooke Park construction laydown area, Belfield	High	• Establishment and use as a construction laydown area • Flood lit at night	High	High	• No changes expected during operation	Negligible	Negligible
2	OL 9: Rudd Park, Belfield	High	• Construction of the transmission cable circuit	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate

			Construction impact assessment			Operation impact assessment		
Precinct	**OL**	**Sensitivity**	**Changes to the view**	**Magnitude**	**Impact rating**	**Changes to the view**	**Magnitude**	**Impact rating**
3	OL 10: Cowper Street Playground, Campsie – All cable transmission route options (refer to **Figure 12-9**)	High	• Construction of the transmission cable circuit • Underboring for Option 2 • Potential night work lighting Options 2 and 3 would result in changes to views within Mildura Reserve north of the playground, while Option 1 would change the views within the Cowper Street road reserve.	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density Options 2 and 3 would have similar changes to the view, with the potential loss of trees within the reserve being the greatest change due to the project, although most of the trees within the reserve are juvenile. The reserve would be returned to its pre-construction state on completion of the project. Option 1 would also result in the potential removal of trees within Cowper Street, which would be seen from the road verge and playground.	Low	Moderate
3	OL 11A: Croydon Avenue, Croydon Park (refer to **Figure 12-9**)	High	• Construction of the transmission cable circuit including underboring works • Potential night work lighting	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate

			Construction impact assessment			Operation impact assessment		
Precinct	**OL**	**Sensitivity**	**Changes to the view**	**Magnitude**	**Impact rating**	**Changes to the view**	**Magnitude**	**Impact rating**
3	OL 11B: Lindsay Street, Campsie – Underboring option (refer to **Figure 12-9**)	High	• Construction of the transmission cable circuit • Underboring works for Option 1 or 3 • Potential night work lighting Option 3 would introduce trenching and excavation within the open space of Mildura Reserve south of the Cooks River while Option 1 would introduce these elements within the Lindsay Street road corridor.	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
3	OL 11B: Lindsay Street, Campsie – Cable bridge option (refer to **Figure 12-9**)	High	• Construction of a cable bridge for Option 1 or 3 • Potential night work lighting	High	High	• New cable bridge • Potential for reduced vegetation density	Moderate	High to Moderate

			Construction impact assessment			Operation impact assessment		
Precinct	**OL**	**Sensitivity**	**Changes to the view**	**Magnitude**	**Impact rating**	**Changes to the view**	**Magnitude**	**Impact rating**
3	OL 12: Harmony Street Playground, Croydon Park – Option 1 and 2 (refer to **Figure 12-9**)	High	• Construction of the transmission cable circuit • Potential views of construction of a cable bridge or underboring works • Potential night work lighting These changes would be seen along Harmony Street for Option 2, and both along the street and within Lees Park for Option 1.	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
3	OL 13: Cheviot Street, Ashbury	High	• Construction of the transmission cable circuit	High	High	• Potential markers of the transmission cable circuit • Potential removal of mature and unique trees which are an important element of the street. If replaced, the replacement trees would take a long time to meet the size and quality of the existing trees	Moderate	High to Moderate

			Construction impact assessment			Operation impact assessment		
Precinct	**OL**	**Sensitivity**	**Changes to the view**	**Magnitude**	**Impact rating**	**Changes to the view**	**Magnitude**	**Impact rating**
3	OL 14: Second Street, Ashbury	High	• Construction of the transmission cable circuit	High	High	• Potential markers of the transmission cable circuit • Potential removal of mature and unique trees which are an important element of the street. If replaced, the replacement trees would take a long time to meet the size and quality of the existing trees	Moderate	High to Moderate
3	OL 15: Peace Park construction laydown area, Ashbury	High	• Establishment and use as a construction laydown area; and • Flood lit at night.	High	High	• No changes expected during operation	Negligible	Negligible
3	OL 16: Old Canterbury Road, Hurlstone Park	High	• Construction of the transmission cable circuit	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
3	OL 17: Sideways Deli Café, Dulwich Hill (Options 1 and 2) (refer to **Figure 12-10**)	High	• Construction of the transmission cable circuit The changes to the view as a result of Options 1 and 2 would be similar, but with more construction activity viewed in close proximity to Option 2 as the route passes closer to the café on Constitution Road.	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate

			Construction impact assessment			Operation impact assessment		
Precinct	**OL**	**Sensitivity**	**Changes to the view**	**Magnitude**	**Impact rating**	**Changes to the view**	**Magnitude**	**Impact rating**
3	OL 18A: Terry Road, Dulwich Hill (refer to **Figure 12-10**)	High	• Construction of the transmission cable circuit including underboring works • Potential night work lighting	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
3	OL 18B: Arlington Light Rail Station, Dulwich Hill (refer to **Figure 12-10**)	High	• Construction of the transmission cable circuit including underboring works • Potential night work lighting	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
3	OL 19: 370 New Canterbury Road, Dulwich Hill	High	• Construction of the transmission cable circuit • Night work lighting	Moderate	Moderate to High	• Potential markers of the transmission cable circuit	Negligible	Negligible
3	OL 20: Marrickville High School, Marrickville	High	• Construction of the transmission cable circuit	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
3	OL 21: Amy Street Playground, Marrickville	High	• Construction of the transmission cable circuit including underboring works • Potential night work lighting	High	High	• Potential markers of the transmission cable circuit	Negligible	Negligible
3	OL 22: Charles Street, Marrickville	High	• Construction of the transmission cable circuit	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate

			Construction impact assessment			Operation impact assessment		
Precinct	**OL**	**Sensitivity**	**Changes to the view**	**Magnitude**	**Impact rating**	**Changes to the view**	**Magnitude**	**Impact rating**
4	OL 23: Enmore Park, Enmore	High	• Construction of the transmission cable circuit • Potential night work lighting	Moderate	Moderate to High	• Potential markers of the transmission cable circuit and reduced vegetation density	Low	Moderate
5	OL 24: Edgeware Road, St Peters	High	• Construction of a cable bridge • Night work lighting	High	High	• New cable bridge (refer to **Figure 12-17**); and • Potential markers of the transmission cable circuit reduced vegetation density	High	High
5	OL 25: Camdenville Park, St Peters	High	• Construction of the transmission cable circuit • Construction of a cable bridge • Establishment and use as a construction laydown area • Flood lit at night	High	High	• New cable bridge (refer to **Figure 12-19** and **Figure 12-20**) • Potential markers of the transmission cable circuit and reduced vegetation density	Moderate	High to Moderate
5	OL 26: 53 Barwon Park Road, St Peters	High	• Construction of the transmission cable circuit • Potential night work lighting	High	High	• Potential markers of the transmission cable circuit and reduced vegetation density • Potential removal of street trees would potentially allow street lighting to illuminate greater distances along the road	Moderate	High to Moderate

			Construction impact assessment			Operation impact assessment		
Precinct	**OL**	**Sensitivity**	**Changes to the view**	**Magnitude**	**Impact rating**	**Changes to the view**	**Magnitude**	**Impact rating**
5	OL 27: Sydney Park, Alexandria	High	• Construction of the transmission cable circuit • Night work lighting	High	High	• No changes expected during operation • Potential markers of the transmission cable circuit may remain but would not be visually prominent	Negligible	Negligible
5	OL 28: 2-34 Campbell Road, St Peters	High	• Construction of the transmission cable circuit • Night work lighting	High	High	• No changes expected during operation • Potential markers of the transmission cable circuit may remain but would not be visually prominent	Negligible	Negligible
5	OL 29: Driveway, Euston Road, St Peters	Moderate	• Construction of the transmission cable circuit • Potential night work lighting	High	High to Moderate	• No changes expected during operation • Potential markers of the transmission cable circuit may remain but would not be visually prominent	Negligible	Negligible
5	OL 30: Beaconsfield West substation, Alexandria	Low	• Construction works at the Beaconsfield West substation • Light spill from substation night work	Low	Low	• Limited changes due to potential markers of the transmission cable circuit	Negligible to Low	Negligible to Low

Figure 12-12 The existing view from the footpath looking east along Muir Road

Figure 12-13 Visual simulation showing the proposed cable bridge spanning the rail corridor at Muir Road

Figure 12-14 The existing view from the maintenance access point to Mildura Reserve on the northern edge of the cul-de-sac on Lindsay Street, looking southeast along the mangroves lining Cooks River

Figure 12-15 Visual simulation showing the proposed cable bridge crossing the Cooks River from the cul-de-sac on Lindsay Street (noting underbore is preferred option in this location subject to technical feasibility)

Figure 12-16 The existing view from the eastern kerb of Edgeware Road, looking west at the Bedwin Road rail bridge

Figure 12-17 Visual simulation showing the proposed cable bridge crossing as viewed from the eastern kerb of Edgeware Road

Figure 12-18 The existing view from Camdenville Park to the existing Bedwin Road rail bridge

Figure 12-19 Visual simulation showing the proposed cable bridge over the Bedwin Road rail corridor as viewed from Camdenville Park

Figure 12-20 Close up visualisation of the cable bridge over Bedwin Road with cage structure

12.3.2.1 Summary of visual impacts

Overall, the most sensitive OLs are those that are associated with public open space, i.e. public parks and reserves. The magnitude of change to views within and from these areas would be most affected when a construction laydown area is positioned within a park, as the character, land use and change in view to and within the park would be significantly different. However, as per the assessment of landscape character, the changes during the construction phase of the project are short-term, and in most cases the visual impact rating is reduced during operation, in many cases to Low.

The most sensitive residential OLs are located within those areas in or adjacent to HCAs, which are often listed due to the street trees within the streetscapes. Removal of trees within these areas would have a higher visual impact due to the reliance on these trees for streetscape character and aesthetic quality of the areas. Typically, street trees in these areas are mature, and replacement trees would take a long time to visually replace those removed.

The greatest potential operational impacts on views are due to the possible removal of street trees during construction and the installation of cable bridges. Where tree removal is required, this would affect views in almost all streets the transmission cable route passes, with the character of the streetscape of some streets with mature street trees or within HCAs more significantly affected than others (as described above). Opportunities to retain trees would be investigated during detailed design and construction. Tree replacement and augmentation planting within affected road reserves (where feasible) may, over time, reduce the visual impact of tree removal, although the speed at which the view would be improved depends on the growth rate of the tree species and the maturity (pot size) of the street trees replanted.

12.4 Environmental management and mitigation measures

12.4.1 Management objectives

Objectives for the management of project impacts would continue to be investigated throughout the development of the project design to identity further opportunities to minimise any adverse impacts generated by the project.

Management objectives for landscape character and visual impacts include:

- maintain or improve the landscape character and visual amenity of HCAs and public open space;
- minimise tree removal;
- select designs and materials for temporary or permanent infrastructure that integrate with the surrounding landscape; and
- restore areas to their previous condition where feasible.

12.4.2 Environmental management and mitigation measures

Table 12-6 outlines a number of mitigation measures to reduce the impact of the project construction and operation on the landscape character and visual amenity of the project area.

Table 12-6 Environmental management and mitigation measures

No.	Issue/impact	Environmental management and mitigation measures	Timing
LV1	Design of construction laydown areas and work sites	Fencing around construction laydown areas and work sites and hoardings (where required) will take into consideration the landscape character of the local environment and proximity of sensitive receptors in selecting suitable materials and designs. Fencing around laydown areas within Heritage Conservation Areas (HCAs) and public open space will prevent visibility of the internal works area.	Detailed design and construction
LV2	Night lighting at construction laydown areas	Night lighting at construction laydown areas will be minimised adjacent to residential properties. Where lighting is required, and a construction laydown area is	Detailed design and construction

No.	Issue/impact	Environmental management and mitigation measures	Timing
		positioned close to residences, lighting will be directed away from residential properties to avoid light spill into properties at night.	
LV3	Cable bridge design	Design principles for the final cable bridge designs will include integration of the structures into the surrounding landscape while meeting safety, technical and operational requirements. Bridges will be designed to reduce visual prominence, including surface treatment which avoids reflective materials.	Detailed design
LV4	Landscaping and rehabilitation	Ground stabilisation, landscaping and rehabilitation at cable bridge crossings will be undertaken once installation of the cable bridge is complete and will be monitored for a period of at least six months.	Construction and operation
LV5	Tree removal and replanting	The project will avoid the removal of trees wherever feasible and reasonable. Where avoidance is not possible, a tree replanting strategy/landscape plan will be developed in consultation with the relevant council. To mitigate the visual impact of tree removal, similar species of trees will be replanted, where feasible. Where this is not possible, suitable trees for specific local conditions will be determined. The suitability of the replacement trees will be confirmed by a qualified arborist, in consultation with TransGrid's cable specialists. Trees will be removed at the time of construction if trenching activities impact tree roots to a point where the tree is no longer viable (as determined by the project arborist). No trees will be removed within the parklands of Sydney Park in Alexandria, along Constitution Road in Dulwich Hill and at the Johnson Park Bushcare site in Dulwich Hill (also refer to **Chapter 13 Biodiversity**).	Construction and operation
LV6	Sydney Park	The final transmission cable circuit alignment will follow Barwon Park Road and existing stormwater infrastructure to avoid impacting established trees within or adjacent to Sydney Park.	Detailed design and construction

13.0 Biodiversity

This chapter provides a summary of the results of the ecological assessment carried out for the project. Further detail is provided in the Biodiversity Development Assessment Report (BDAR) in **Appendix H**, including the key fish habitat assessment in Annexure E of Appendix H, and the arboricultural impact assessment in **Appendix O**. The BDAR and arboricultural impact assessment were prepared by Eco Logical Australia (ELA).

13.1 Assessment methodology

13.1.1 Biodiversity assessment

Section 7.9 of the NSW *Biodiversity Conservation Act 2016* (BC Act) states that an application for State significant infrastructure must be accompanied by a BDAR. The BDAR therefore supports the EIS by identifying and assessing potential biodiversity impacts of the project. The BDAR has been prepared in accordance with the requirements of the Biodiversity Assessment Method (BAM) 2017.

The Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) also requires an assessment of impact significance for developments where Matters of National Environmental Significance (MNES) may be affected. MNES includes threatened species and ecological communities listed in the Act. For the project, the one relevant MNES is the Grey-headed Flying Fox, listed as Vulnerable under the Act. A detailed significance assessment for this threatened species is included in Annexure D of **Appendix H**.

The biodiversity assessment included a desktop search of relevant databases and historical records in order to identify features of the existing environment and threatened biota potentially affected by the project. An assessment of the likelihood of occurrence was made for threatened species, migratory species, and species of local conservation significance as identified from the literature review. Data gathered informed the field surveys undertaken within the project area between March 2018 and July 2018; and May 2019.

Surveys included:

- rapid vegetation validation along the project area for the identification of street trees and planted native and non-native vegetation;
- two vegetation integrity survey (VIS) plots at Mildura Reserve in Campsie to identify Plant Community Types (PCTs) and Threatened Ecological Communities (TECs) within the project area, in accordance with the BAM; and
- identification of potential habitat for threatened fauna species, such as the presence of hollow-bearing trees.

The biodiversity assessment was therefore based on records, as well as presence or absence of suitable habitat, features of the project area, results of field surveys and professional judgement.

An ‘assessment area’ for the biodiversity assessment was defined as the project area plus land within a 1,500 metre buffer of the project area. The use of this broad area allowed impacts within and adjacent to the project area to be assessed.

13.1.2 Key fish habitat assessment

A key fish habitat assessment was undertaken in accordance with the *Fisheries Management Act 1994* (FM Act) to assess the potential impacts on key fish habitat, marine vegetation and threatened species of fish from the proposed special crossing options of the Cooks River at Campsie/Croydon Park. This was the only location within the study area that was identified to potentially contain marine vegetation and key fish habitat (refer to **Figure 13-2**).

The study area includes all the options under consideration at the Cooks River (as described in **Chapter 4 Project description**).

During a site visit in May 2019, the length of the Cooks River within the study area was walked to determine the current condition and extent of riparian and aquatic habitat. The assessment of the riparian habitat considered the extent and condition of native vegetation cover, connectivity, quality, bed and bank stability, habitat diversity, and ability to recover from disturbance. The assessment of the

aquatic habitat examined the quality of aquatic habitats, including aquatic vegetation structure, extent of regeneration, weed infestation, woody debris, fish habitat, patch size and connectivity potential.

13.1.3 Arboricultural assessment

An arboricultural impact assessment was undertaken to identify trees within the project area that would potentially be affected by the project, to assess their current health and condition; and to evaluate the significance of trees within the project area including their retention value.

The arboricultural assessment does not assess the impact of tree removal as the number and location of trees that may need to be removed is subject to:

- further refinement of the project design;
- finalisation of the transmission cable route, including positioning of joint bays and other ancillary infrastructure (link and sensor boxes); and
- determination of the location and distribution of tree roots within the areas to be excavated, to consider impacts on the structural root zone (SRZ)[1] of trees and the tree protection zones (TPZ)[2].

The information in the arboricultural assessment is therefore being used to characterise the existing environment, inform other assessments in the EIS, such as the landscape character and visual impact assessment, and to inform the final transmission cable route.

The tree retention assessment was undertaken in accordance with the Institute of Australian Consulting Arboriculturists (IACA) *Significance of a Tree, Assessment Rating System* (STARS). The tree retention assessment determines the retention value/importance of a tree or group of trees using a combination of environmental, cultural, physical and social values, with values classified as low, medium or high. A tree would be assigned a high retention value if it has good condition and vigour, is listed as a heritage item and has a form typical of the species.

Trees are defined in accordance with *Australian Standard AS 4970-2009 Protection of Trees on Development Sites* as a 'long lived woody perennial plant greater than (or usually greater than) 3 metres in height with one or relatively few main stems or trunks'. This definition was adopted for the arboricultural assessment.

Visual tree inspections within the project area were undertaken between April and July 2018 and in June 2019.

13.1.4 Assumptions, limitations and exclusions

13.1.4.1 Field survey

Physical access to some parts of the project area were not possible for biodiversity surveys due to existing land uses, as outlined below. However, visual observations from adjacent areas was sufficient to inform the biodiversity assessment:

- within the Dulwich Hill Light Rail corridor near Terry Road, Dulwich Hill;
- between an existing construction site and the rail corridor near Camdenville Park, St. Peters; and
- within an industrial estate of Euston Road, Alexandria.

None of the above access restrictions pose significant limitations to the biodiversity assessment.

For the arboricultural impact assessment, it was assumed that no trees would be removed within the construction laydown areas or at existing substation sites. A few individual trees may need to be removed or trimmed to provide access to some of the construction laydown areas. The focus of the arboricultural assessment was on trees along the transmission cable route (including at proposed special crossings).

[1] The SRZ is the area of the root system used for stability, mechanical support and anchorage of the tree. It is critical for the support and stability of the tree and provides the bulk of mechanical support and anchorage. Severance of roots (>50 mm diameter) within the SRZ is generally not recommended as it may lead to the destabilisation and/or decline of the tree.
[2] The TPZ is the optimal combination of crown and root area that requires protection during the construction process. The TPZ is an area that is isolated from the work zone to ensure no disturbance or encroachment occurs into this zone. Tree sensitive construction measures must be implemented if works are to proceed within the TPZ.

13.1.5 Legislative context

The biodiversity assessment has considered the requirements of the following legislation:

- BC Act;
- EPBC Act;
- *Environmental Planning and Assessment Act 1979* (EP&A Act);
- *Biosecurity Act 2015;*
- FM Act; and
- *Water Management Act 2000.*

13.2 Existing environment

This section describes the landscape context of the project area, including landscape features, waterbodies and vegetation present. The project area is within the Sydney Basin region and contains various rivers and streams. Vegetation within the project area is largely modified and disturbed containing exotic plants and planted native tree species. Small areas of native vegetation were identified in Dulwich Hill and Campsie, as discussed below.

13.2.1 Landscape features

In accordance with the BAM, the BDAR is required to identify a number of landscape features such as the Interim Biogeographic Regionalisation for Australia (IBRA) region, IBRA subregion, Mitchell landscape, rivers and streams and extent of native vegetation in the assessment area. The landscape features of the project area are shown in **Figure 13-1** and outlined below.

13.2.1.1 IBRA regions and subregions

The project area falls within the IBRA region and subregions as outlined in **Table 13-1**.

Table 13-1 IBRA region and subregions

IBRA region and subregions		Area within project area (hectares)
IBRA region	Sydney Basin	58.34
IBRA subregion	Pittwater	3.38
	Cumberland	54.96

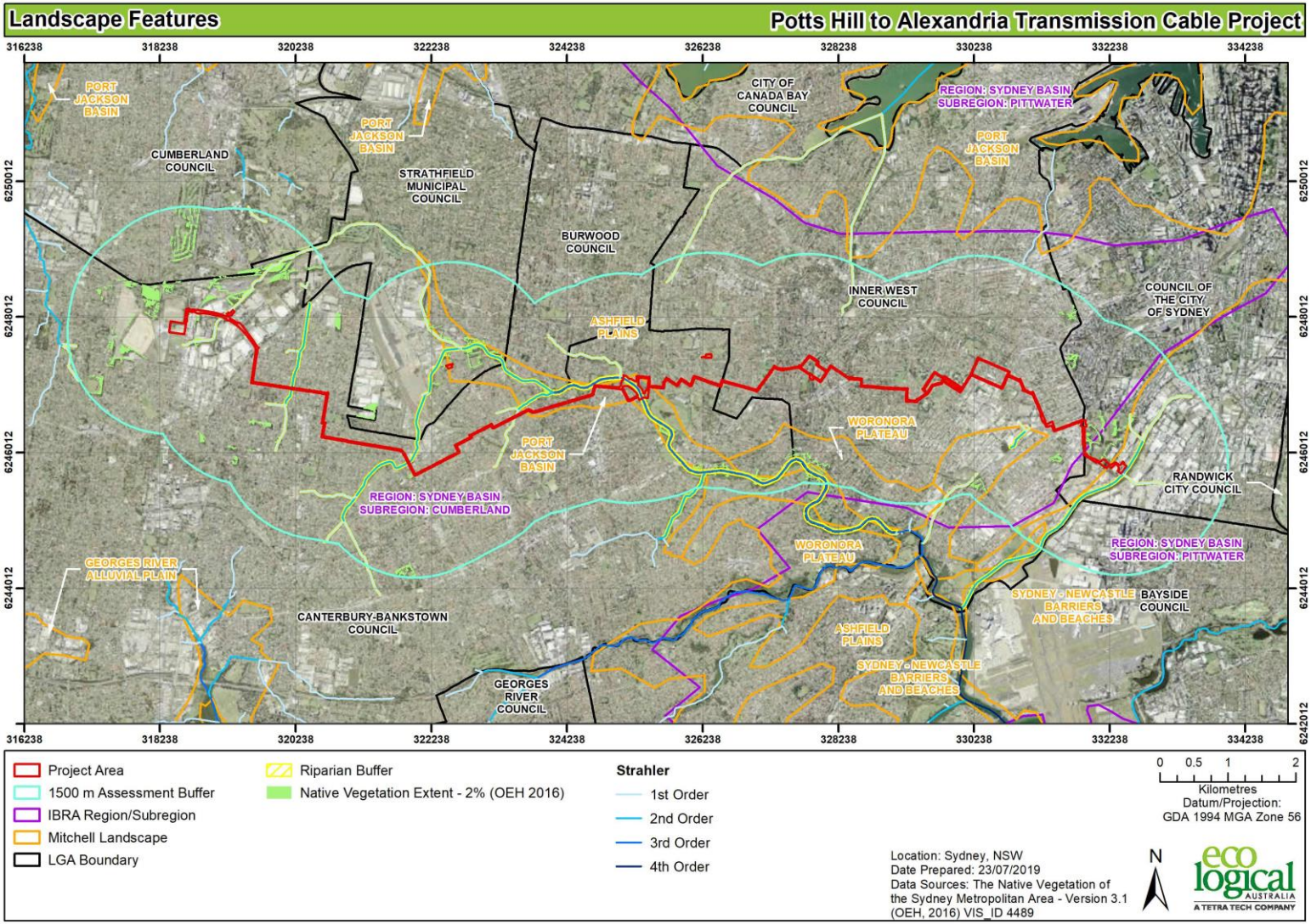


Figure 13-1 Landscape features of the project area

13.2.1.2 Rivers and streams

In accordance with the BAM, rivers and streams within the project area have been categorised by their Strahler stream order and associated riparian buffer distances. The project area contains rivers and streams as outlined in **Table 13-2**. The project area does not contain any natural wetland areas. A waterbody is situated within the project area in Sydney Park, but this is a constructed wetland which does not conform to a PCT identified in the NSW BioNet Vegetation Classification System. It is also noted that this wetland is not listed in the Directory of Important Wetlands of Australia (DIWA) or as coastal wetlands under the State Environmental Planning Policy (Coastal Management) 2018 and has therefore not been included in wetland mapping for the project area.

Table 13-2 Rivers and streams in the project area

Precinct	River/stream	Location	Strahler Stream Order	Riparian buffer (metres) as per Table 14 in the BAM
1	Cooks River	Muir Road	1	10
2	Unnamed	Rawson Road	2	20
2	Unnamed	Omaha Street/Varidel Avenue	1	10
2	Coxs Creek	Wangee Road	2	20
3	Cooks River	Lees Park	3	30

The Cooks River within Precinct 3 is a 3rd order watercourse[3] that is approximately 40 metres wide. The river is subject to tidal influences from Botany Bay and is located in a highly urbanised catchment. During a site inspection, the water within the river was turbid with visibility of less than 0.5 metres, despite there being no rain in the 24 hours prior to the day of the survey. The dominant aquatic vegetation within the study area is *Avicennia marina* (Grey Mangrove). About 7,642 square metres of the mangroves located on the southern bank of Cooks River are considered to be Type 2 key fish habitat as shown in **Figure 13-2**. On the northern bank of the Cooks River there are about 9.5 square metres of isolated mangroves plants.

[3] As per the Natural Resources Access Regulator guidelines (DPI, 2018)

Figure 13-2 Key fish habitat within the project area

13.2.1.3 Vegetation

Ninety-three percent of the vegetation within the project area (9.9 hectares) are urban exotics and natives. The remaining seven percent of vegetation within the project area is classified as the following PCTs as defined by the NSW Bionet Vegetation Classification System:

- Mangrove Forest in the estuaries of the Sydney Basin Bioregion and South East Corner Bioregion, PCT 920 (0.76 hectares); and
- Sydney Turpentine-Grey Ironbark Open Forest on shale in the lower Blue Mountains and Sydney Basin Bioregion, PCT 1281 (0.2 hectares).

These vegetation types are discussed further below.

Urban exotics and natives

The project area is largely modified and disturbed containing exotic plants (including weeds) and native tree species, which are classed as 'urban exotics and natives' by the NSW Office of Environment and Heritage (OEH) (now the Department of Planning, Industry and Environment). Typically, these areas include vegetation such as backyard trees, street trees, gardens and median strips.

Ninety-three percent of vegetation within the project area (around 9.9 hectares) falls under this class of vegetation. Exotic species within the project area include *Lagerstroemia indica* (Crepe Myrtle), *Fraxinus griffithii* (Evergreen Ash), *Pyrus calleryana* (Callery Pear) and *Triadica sebifera* (Chinese Tallow). Native species occurring within the project area predominately comprise landscape plantings and street trees such as *Lophostemon confertus* (Brush Box), *Callistemon viminalis* (weeping Bottlebrush), *Tristaniopsis laurina* (Kanooka), and various *Melaleuca* (Paperbark) and *Eucalyptus* (Eucalypt) species. Many areas have been turned to grassland or lawn. Exotic species in grassland or lawn areas typically include *Cenchrus clandestinum* (Kikuyu), *Cynodon dactylon* (Couch) and *Paspalum dilatatum* (Paspalum).

This vegetation has been validated during the rapid validation survey as 'urban exotics and natives', keeping the class label in line with OEH labelling. Trees within this class have been further assessed for their retention value (refer to **Section 13.2.1.4**).

A typical example of 'urban exotics and natives' within the project area is shown in **Figure 13-3**.

Figure 13-3 Typical example of 'urban exotics and natives' within the project area

PCT 920 Mangrove Forest in the estuaries of the Sydney Basin Bioregion and South East Corner Bioregion

The baseline OEH vegetation mapping data for vegetation (OEH, 2016) identified an area of native vegetation on the southern bank of Cooks River in Campsie as 'Estuarine Mangrove Forest' (refer to **Figure 13-6**). Two BAM survey plots were undertaken in accordance with the BAM methodology. The vegetation has been assigned to PCT 920 'Mangrove Forest in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion' as a best fit PCT. This area of PCT 920 – Mangrove Forest comprises 0.76 hectares.

A typical example of PCT 920 – Mangrove Forest within the project area is shown in **Figure 13-4**.

Figure 13-4 Typical example of PCT 920 – Mangrove Forest within the project area

PCT 1281 Sydney Turpentine-Grey Ironbark Open Forest on shale in the lower Blue Mountains and Sydney Basin Bioregion

During the rapid validation survey, a small area of this native vegetation was identified to occur within the project area at Dulwich Hill, between Terry Road and the Dulwich Hill Light Rail corridor (refer to **Figure 13-7**). The area is associated with the Johnson Park Bushcare site and has been planted with native vegetation. The Johnson Park Bushcare site includes species associated with Sydney Turpentine-Ironbark Forest (STIF), which is also a TEC, listed as Critically Endangered under the BC Act and EPBC Act.

The Johnson Park Bushcare site could not be accessed during the rapid validation survey due to its location within the Dulwich Hill Light Rail corridor, and hence no quantitative survey was undertaken. This PCT therefore was not validated. However, based on distant visual assessment and on a desktop review, this vegetation has been assigned as PCT 1281 'Sydney Turpentine-Grey Ironbark Open Forest on shale in the lower Blue Mountains and Sydney Basin Bioregion (unvalidated)' as a best fit PCT. This area of PCT 1281 – Sydney Turpentine-Grey Ironbark Open Forest comprises 0.2 hectares.

It is considered unlikely that vegetation within the bushcare site would meet the TEC STIF criteria, as the vegetation consists of planted rather than remnant vegetation and lacks a canopy.

An example of PCT 1281 – Sydney Turpentine-Grey Ironbark Open Forest is shown in **Figure 13-5**.

Figure 13-5 Example of PCT 1281 – Sydney Turpentine-Grey Ironbark Open Forest (Source: OEH, 2019)

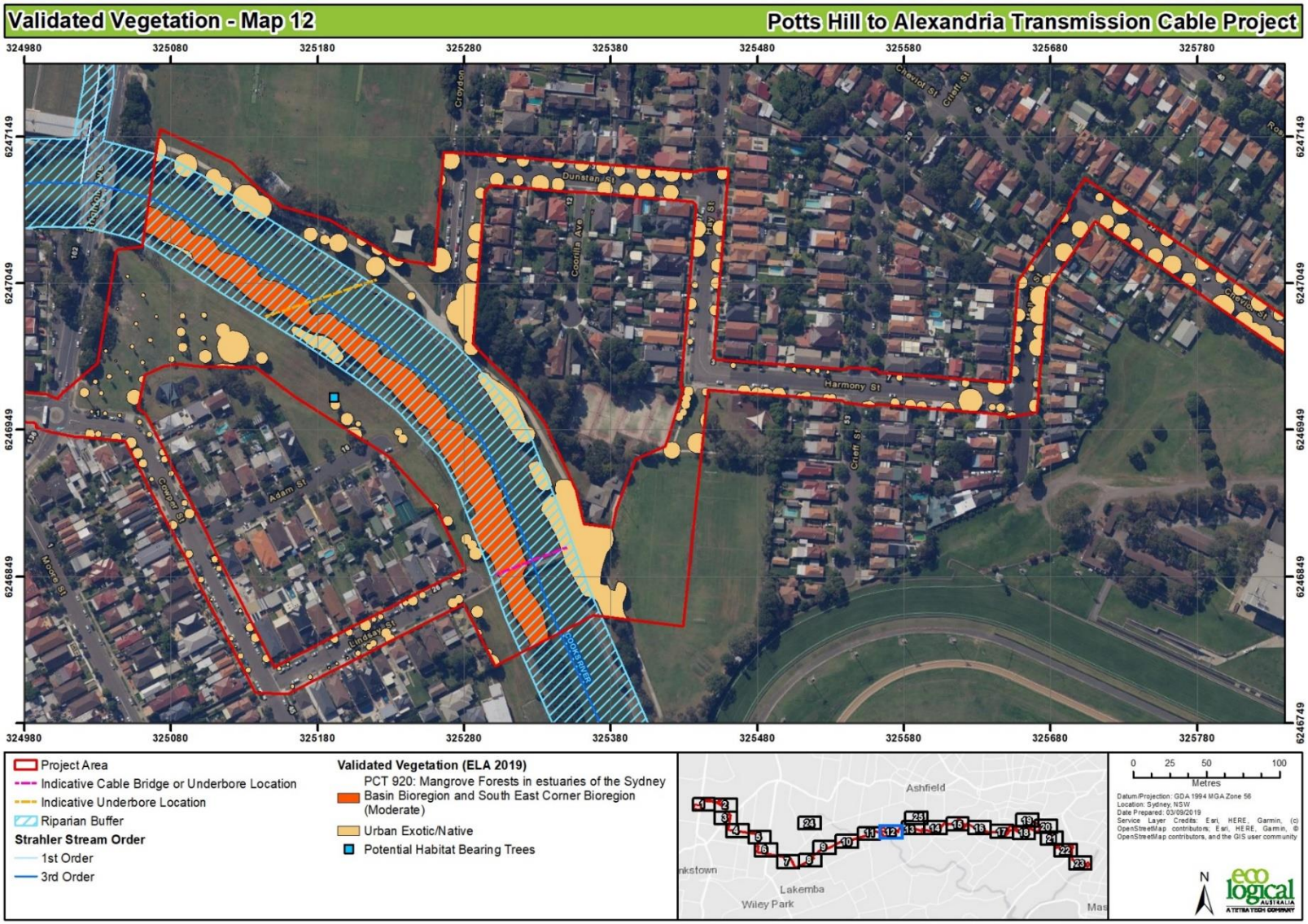


Figure 13-6 Location of PCT 920 – Mangrove Forest

Figure 13-7 **Location of PCT 1281 - Sydney Turpentine-Grey Ironbark Open Forest**

13.2.1.4 Trees

The arboricultural impact assessment identified 2,367 trees (as defined in **Section 13.1.3**) across the project area. Details of the trees are included in Annexure B of the arboricultural impact assessment in **Appendix O** and summarised as follows:

- 104 high retention value trees;
- 1,580 medium retention value trees; and
- 683 low retention value trees.

13.2.2 Threatened species

13.2.2.1 Terrestrial species

The BAM outlines the process for identifying potential threatened flora and fauna species within the project area. Threatened species reliably predicted by PCTs are called 'ecosystem credit species'. Ecosystem credit species were identified based on their association with PCT 920 – Mangrove Forest. Those species which cannot be accurately predicted by PCTs must undergo additional consideration and are called 'species credit species'. Species credit species were predicted based on a 'likelihood of occurrence' assessment performed as part of the BDAR, which was informed by database searches, previous studies and specific habitat features present within the project area. Potential threatened fauna species identified within the project area are listed in **Table 13-3**. An assessment of potential impacts on these species is provided in **Section 13.3.2**.

Table 13-3 Threatened species potentially occurring within the project area

Species name	Common name	BC Act listing status	EPBC Act listing status	Threatened species type
Miniopterus australis (foraging)	Little Bentwing-bat	Vulnerable	Not listed	Ecosystem credit species
Miniopterus schreibersii oceanensis (foraging)	Eastern Bentwing-bat	Vulnerable	Not listed	Ecosystem credit species
Mormopterus norfolkensis (foraging)	Eastern Freetail-bat	Vulnerable	Not listed	Ecosystem credit species
Haliaeetus leucogaster	White-bellied Sea-eagle	Vulnerable	Not Listed	Ecosystem credit species
Pteropus poliocephalus (foraging)	Grey-headed Flying-fox	Vulnerable	Vulnerable	Ecosystem credit species
Myotis Macropus	Southern Myotis	Vulnerable	Not listed	Species credit species

PCT 920 – Mangrove Forest provides potential foraging habitat for ecosystem credit species Grey-headed Flying-fox, Eastern Bentwing-bat, Little Bentwing-bat and White-bellied Sea-eagle.

One species credit species, Southern Myotis, also has potential to occur within this PCT at the Cooks River and was assumed as present. Potential habitat for the Southern Myotis is shown in **Figure 13-8**.

Additionally, non-native vegetation within the project area provides potential foraging habitat for the Grey-headed Flying-fox.

It is considered there is a low potential for roosting habitat for the Eastern Bentwing-bat and Little Bentwing-bat in some of the culverts and stormwater pipes in the project area. Culverts and pipes have not been surveyed for potential habitat, however given that the affected sections of culvert intersected by the project are short and exposed to light, the potential of these structures to provide favourable roosting habitat is considered low.

Refer to **Appendix H** for candidate ecosystem credit species and species credit species which were excluded from the assessment, including the relevant justification for excluding them.

13.2.2.2 Aquatic species

A search of the Commonwealth Protected Matters Search tool, OEH BioNet database and Fisheries Threatened Species distribution maps (Riches et al, 2016) was undertaken. The searches identified two threatened species of fish with potential to be found within the study area. This includes the Black Rockcod (*Epinephelus daemelii*) and the Macquarie Perch (*Macquaria australasica)*. A review of the listed records of threatened species however found no records within five kilometres of the study area and a lack of suitable habitat. It is therefore unlikely that these species would be found within the study area.

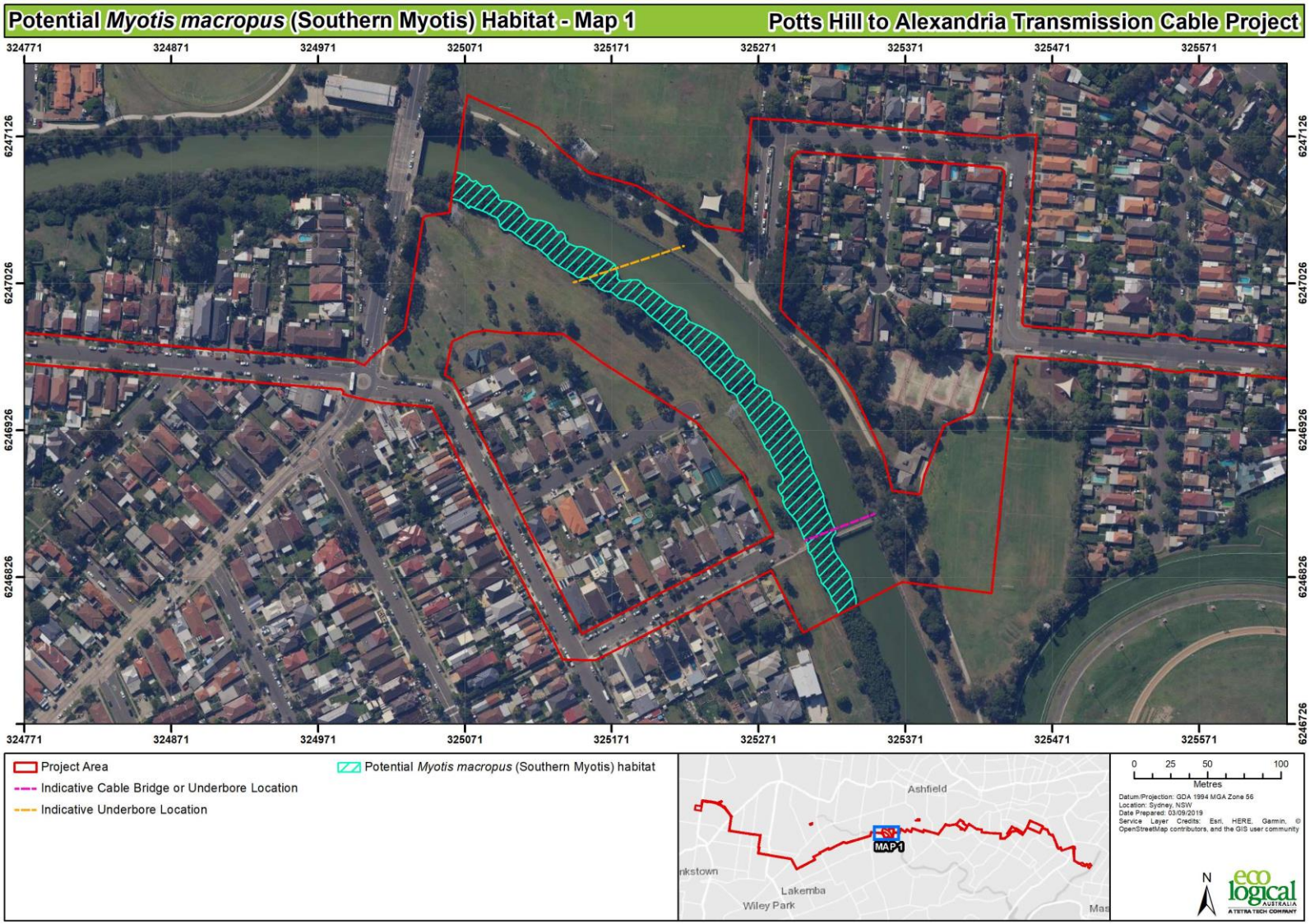


Figure 13-8 **Potential habitat for Southern Myotis within the project area**

13.3 Assessment of potential impacts

This section identifies potential direct and indirect impacts of the project on the biodiversity values in the assessment area and evaluates the significance of potential impacts in accordance with the criteria detailed in **Section 13.1**.

13.3.1 Avoiding and minimising impacts

The project has been located and designed in a way which avoids and minimises impacts on vegetation, habitat and biodiversity in accordance with the BAM as outlined in **Table 13-4**. This information is summarised from Table 16 and Table 17 of the BDAR in **Appendix H**.

Table 13-4 Avoiding and minimising biodiversity impacts

Approach	Justification
Locating the project in areas where there are no biodiversity values.	The project area has been located primarily in areas of low biodiversity value within road reserves, as well as within mown grasslands.
Locating the project in areas where the native vegetation or threatened species habitat is in the poorest condition.	The project area is primarily located in road reserves, where vegetation consists of a mix of exotic and native planted street trees, which are subject to disturbance from edge effects and tree maintenance. 9.9 ha (93%) of vegetation within the project area does not meet the definition of a PCT and is classified as 'urban exotics/natives'. A small area (0.76 ha) of PCT 920 – Mangrove Forest, located within the project area at the Cooks River crossing, is of moderate condition. A small area (0.2ha) of unvalidated PCT 1281- Sydney Turpentine-Grey Ironbark Open Forest on shale in the lower Blue Mountains and Sydney Basin Bioregion, consists of planted native groundcover and shrub vegetation only. The project would avoid clearing PCT 1281 through underboring under the Dulwich Hill Light Rail corridor at Terry Road, should this crossing option be progressed. No TECs have been confirmed within the project area.
Locating the project in areas that avoid habitat for species and vegetation in high threat categories (e.g. an Endangered Ecological Community (EEC) or CEEC), indicated by the biodiversity risk weighting for a species.	There is no habitat in the project area for species listed as Endangered of Critically Endangered. There is habitat within the project area for six species listed as Vulnerable (listed in **Table 13-3**).
Locating the project such that connectivity enabling movement of species and their genetic material between areas of adjacent or nearby habitat is maintained.	There is minimal ecological connectivity within the project area.

Approach	Justification
Reducing the clearing footprint of the project.	The project has been designed to utilise existing utility and services corridors, which are mostly situated within existing road reserves, and public open space consisting of mown lawn areas. The project assesses a worst case of all vegetation within the project area being cleared as it assesses multiple transmission cable routes and special crossing options. This represents a conservative approach. The final area of vegetation to be cleared will be determined once the final route and crossing methods are selected during detailed design. The final area of vegetation to be cleared would be significantly less than the area identified for urban exotic/native vegetation and PCT 920 – Mangrove Forest in the biodiversity assessment for the project. At the Cooks River, the area for mangrove clearing is subject to the special crossing methodology selected (i.e. underbore or cable bridge) – refer to **Section 13.3.2.1**. The project would avoid clearing at the Johnson Park Bushcare site by underboring under the Dulwich Hill Light Rail corridor at Terry Road, should this crossing option be progressed. At the detailed design stage further refinements to the location of project infrastructure would be undertaken to avoid impacting vegetation.
Locating construction laydown areas in areas where: - there are no biodiversity values. - where the native vegetation or threatened species habitat is in the poorest condition (i.e. areas that have a lower vegetation integrity score).	Proposed construction laydown areas would be located within cleared areas of existing substation sites and maintained exotic lawn in mainly public open space. Use of these sites are short-term and the impacted area (lawn in open spaces) would be reinstated following construction.
Locating ancillary facilities in areas that avoid habitat for species and vegetation in high threat status categories (e.g. an EEC or CEEC).	There is no habitat for species listed as Vulnerable, Endangered or Critically Endangered at the construction laydown areas.
Providing structures to enable species and genetic material to move across barriers or hostile gaps.	Not applicable.
Making provision for the demarcation, ecological restoration, rehabilitation and/or ongoing maintenance of retained native vegetation habitat in the project area.	The proposed construction laydown areas and work sites would be temporarily fenced and the impacted areas of lawn in open spaces would be reinstated following construction.

13.3.2 Construction impacts

13.3.2.1 Direct impacts

Potential impacts on threatened fauna

The biodiversity assessment determined that potential habitat for six threatened fauna species (listed under the BC Act and EPBC Act) may be affected through the clearance or disturbance of potential habitat.

The worst-case scenario was assessed in accordance with the BAM requirements which assumes that all vegetation within the project area would be removed. Identified impacts associated with the removal of vegetation included:

- removal of 0.76 hectares of PCT 920 – Mangrove Forest, and associated ecosystem credit species (Grey-headed Flying-fox, Eastern Bentwing-bat; Little Bentwing-bat and White-bellied Sea-eagle) and species credit species (Southern Myotis) habitat;

- removal of 9.9 hectares of urban exotics and natives, and associated urban exotic foraging habitat for Grey-headed Flying Fox; and
- potential impact on culverts and stormwater pipes (through temporary removal or relocation during trenching) and associated impact on potential habitat for Eastern Bentwing-bat and Little Bentwing-bat species.

Additionally, the Grey-headed Flying-fox, Eastern Bentwing-bat and Little Bentwing-bat have been considered under prescribed impacts, which the BAM details as impacts on biodiversity values in addition to or instead of clearing native vegetation. A summary of these prescribed biodiversity impacts is presented in **Table 13-5**. This describes potential impacts on threatened species where non-native vegetation or man-made structures may provide suitable habitat. Further detail is provided in Section 2.2 of the BDAR in **Appendix H**.

As a worst-case impact scenario has been assessed, impacts to vegetation would be less as not all vegetation within the project area would be impacted.

Table 13-5 Prescribed biodiversity impacts

Species or ecological community affected	Prescribed biodiversity impact	Nature, extent and duration of long and short-term impacts	Consequence of the impacts for the local and bioregional persistence
Pteropus poliocephalus (Grey-headed Flying-fox)	Habitat of threatened species associated with non-native vegetation.	As a worst case scenario, around 9.9 hectares of urban exotic/native vegetation would be removed.	The species exists as a dynamic single population which utilises a range of habitats along the Australian east coast. The impacts of removal of non-native vegetation are small relative to the available habitat for this species. The vegetation removal is not likely to result in the long term decrease of the species in the local area or within the bioregion.
Little Bentwing-bat and Eastern Bentwing-bat	Human made structures with potential to be habitat for threatened species or ecological communities.	Trenching for the transmission cable circuit would remove or temporarily relocate sections of several culverts throughout the project area. As the culverts/stormwater pipes would be reinstated, the impact would be short-term.	The consequence of the potential impacts for the local and bioregional persistence of the Little Bentwing-bat and Eastern Bentwing-bat is considered low as a vast amount of equivalent roosting habitat is likely to be present for this species.

Vegetation removal including street trees

As described in **Section 13.2.1.4**, the arboricultural impact assessment identified 2,367 trees in the project area, including 104 of high retention value. While TransGrid is committed to avoiding tree removal wherever feasible and reasonable, some trees would need to be removed during site preparation and excavation works for the transmission cable circuit and special crossings due to resulting impacts on the trees and their roots, and to ensure tree roots do not encroach on the transmission cable circuit once operational.

The number of trees to be removed would be identified once a final alignment for the transmission cable route (including special crossings) is determined during detailed design. However, based on the current concept design, it is estimated that between 2 and 5% (of the trees within the project area would require removal. Following community feedback on the revised route, TransGrid are committed to avoiding tree removal in the parklands at Sydney Park in Alexandria, along Constitution Road in

Dulwich Hill and at the Johnson Park Bushcare site in Dulwich Hill. TransGrid will work with local councils to identify suitable locations for replanting of street trees.

Potential impacts to key fish habitat

As described Annexure E of **Appendix H**, the study area for assessment of impacts to key fish habitat includes all the options under consideration at the Cooks River crossing, the potential impacts on the aquatic and riparian environments are associated with the proposed special crossings. Each special crossing option would have a slightly different footprint for establishment of a work site and cable installation. While the underboring options require a larger work site during construction (up to 800 square metres at the launch pit and up to 100 square metres at the receive pit) than the cable bridge option, the work sites can be offset from the banks whereas construction of the cable bridge embankments would impact both river banks.

The study area includes approximately 7,642 square metres of mangroves, considered to be Type 2 key fish habitat, on the southern bank of the Cooks River and approximately 9.5 square metres on the northern bank where isolated mangrove plants are located (refer to **Figure 13-2**). The main direct impact on key fish habitat as a result of the project would be from the removal/disturbance of mangroves on the southern bank of the river to facilitate the construction of a cable bridge. Depending on the route option and construction method selected, only a portion of the total area of mangroves within the study area would be impacted.

The introduction of temporary or permanent impervious surfaces to a previously vegetated or permeable area would potentially also have a direct impact on in-stream flows, surface water runoff and water quality within the Cooks River.

Any impacts on key fish habitat would be from the special crossing. The focus of the assessment of key fish habitat is therefore on the crossing method i.e. cable bridge or underboring.

Underboring

Direct impacts associated with underboring of the Cooks River relate to decreased river bed stability should the underboring operations not be suitably planned and undertaken, and reduced water quality in the event of an accidental release of drilling fluids. However, these impacts have a low risk of occurring under normal underboring operations and can be managed by choosing appropriate construction methods, following good industry practice and using a reputable and experienced underboring contractor.

While underboring would require a fairly large work site (up to 800 square metres at the launch site and up to 100 square metres at the receive site), this would be temporary (up to 10 weeks), therefore no permanent impervious surfaces would be created.

As the work sites would be offset from the river's edge (either in the road reserve or in parkland), no mangrove removal would be required for the underboring method.

Cable bridge

Earthworks, such as for embankments and support piers, would be required for a cable bridge structure over the Cooks River. The construction of the bridge piers would potentially impact the stability of the river bed depending on the suitability of local geotechnical conditions and how the construction is managed.

A cable bridge would also involve the clearing and disturbance of mangroves on the southern side of the river and vegetation on the northern bank. Mangrove removal would require offsetting for the loss of key fish habitat under the FM Act. While replanting mangroves in the same location following construction would not be possible due to the introduction of permanent operational infrastructure, other offsetting mechanisms would be determined in consultation with Department of Primary Industries – Fisheries (DPI Fisheries).

The creation of impervious surfaces in the riparian zone associated with the cable bridge would also impact on in-stream flows, surface water runoff and water quality within the Cooks River. These would be permanent impervious surfaces therefore the impacts would extend beyond construction. This is discussed further in **Chapter 17 Surface water and flooding**.

13.3.2.2 Indirect impacts

The project has the potential to result in a number of indirect impacts to flora and fauna, within and adjacent to the project area, that could potentially occur at any time throughout the duration of the construction phase. These include:

- impacts to threatened fauna habitat and watercourses due to sedimentation and contaminated and/or nutrient rich runoff from work sites;
- disturbance to fauna from noise, vibration, dust or light spillage;
- unintended impacts on habitat and vegetation adjacent to the project area;
- the unintended spread of weeds and pathogens from work sites to adjacent vegetation through the transport of excavated soils or soil tracking on machinery and trucks as they travel to and from work sites;
- improper waste management of both construction and domestic waste has the potential to result in the release of wastes into the surrounding environment, resulting in smothering of vegetation and ingestion by fauna;
- injury or mortality of fauna due to direct strikes from working machinery and project vehicles during working hours (which include night works); and
- electrical works and operation of machinery have the potential to spark fires which could spread into adjacent vegetation.

Indirect impacts on key fish habitat would potentially occur should some of the mangroves on the southern bank of the Cooks River require removal or be disturbed by construction activities. This includes:

- impacts on connectivity and the condition of riparian vegetation and mangroves upstream and downstream of the project area;
- surface erosion (sheet and gully erosion) and transportation of sediment overland into the river as a result of any clearing of vegetation within the riparian zone or on the edge of the river (in the case of the mangroves) resulting in reduction of soil stability. This may cause surface erosion (sheet and gully erosion) and transportation of sediment overland into the river. Sedimentation may lead to increased water turbidity, which would disrupt light penetration through the water column and impact on primary (plant) production, with flow-on effects through the food web. Increased sediment loads may settle in downstream environments, smothering immobile invertebrates and causing a loss of deep water habitat and changes to hydrologic connectivity. Sediment could also smother naturally rocky areas, resulting in a loss of habitat where macroinvertebrates shelter in the spaces between rocks. Impacts to surface water as a result of erosion and sedimentation are discussed further in **Chapter 17 Surface water and flooding**;
- the loss habitat for native fauna species as a result of removal of mangroves. This may result in increased fragmentation of habitat areas; and
- potential for invasion of exotic plant species where construction results in bare ground or increased sunlight penetration into riparian or key fish habitat areas. The movement of construction vehicles in and around the riparian area can also act as a vector for weed propagules. The introduction of new weeds or extended penetration of weeds into native plant communities may result in a loss of biodiversity and habitat value, smothering of native juvenile plants, harbouring of feral animals and alteration of vegetation structure and riparian function.

These indirect impacts can be avoided or minimised through the implementation of standard good working practices as well as the specific environmental management and mitigation measures identified in **Section 13.4.2**.

13.3.2.3 Matters of National Environmental Significance

The significance assessment undertaken for the Grey-headed Flying-fox concluded that the project is not likely to have a significant impact on the Grey-headed Flying-fox and therefore a referral under the EPBC Act is not required (refer to Annexure D of the BDAR in **Appendix H**).

13.3.3 Operational impacts

Operational impacts on biodiversity as a result of the project are generally considered negligible due to the transmission cable circuit being predominantly underground and minimal operational maintenance activities required. However, the operation of a cable bridge at the Cooks River, should this option be selected, would potentially result in ongoing impacts to in-stream flows, surface water runoff and water quality. The bridge structure may also impact mangrove re-establishment in adjacent areas due to shading effects.

The cable bridge could result in shading impacts on mangrove vegetation immediately adjacent to the bridge on both the northern and southern banks of the river. Shading of vegetation can lead to thinning out or in worst cases loss of vegetation where permanent shade is created. However, shading impact from the cable bridge is unlikely to be significant, with shading impacting an area of mangroves of less than 200 square metres. Furthermore, areas subject to shading would vary throughout the day with limited areas of permanent shading.

13.3.4 Impacts requiring offsets

Biodiversity credits are used to offset the loss of biodiversity values on development sites. Developers buy and retire credits to offset the impact of a development on biodiversity. The number of credits required are determined using the BAM and BAM Credit Calculator, which calculates the number and class of biodiversity credits required to offset impacts of a development.

The impacts of the project requiring offset for native vegetation, including the ecosystem credits required for the project, are outlined in **Table 13-6**.

Table 13-6 Impacts to native vegetation that require offsets

PCT ID	PCT name	Vegetation class	Vegetation formation	Direct impact (ha)	Credits required
920	Mangrove Forest in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion	Mangrove Swamps	Saline Wetlands	0.76	14

The impacts of the project requiring offset for threatened species and threatened species habitat, including the number of species credits required for the project, are outlined in **Table 13-7**.

Table 13-7 Impacts on threatened species and threatened species habitat that require offsets

Species	Common Name	Direct impact number of individuals/habitat (ha)	NSW listing status	EPBC Listing status	Credits required
Myotis Macropus	Southern Myotis	0.76	Vulnerable	Not Listed	14

The *Policy and guidelines for fish habitat conservation and management* (DPI, 2013) includes a description of DPI-Fisheries' 'no net loss of key fish habitat' policy, where environmental impacts on aquatic habitat (direct and indirect) are required to be offset. DPI Fisheries calculates habitat compensation on a minimum 2:1 basis for all key fish habitat. A greater compensation ratio may be considered if opportunities for compensation are not available in the vicinity of, or of the type of, habitat that has been lost. Consultation with DPI Fisheries would be required to determine the preferred method of habitat offset for any removal of mangroves at the Cooks River crossing location.

13.4 Environmental management and mitigation measures

13.4.1 Management objectives

The management of biodiversity impacts will be undertaken with the objective of avoiding or minimising impacts on flora, fauna and habitats.

13.4.2 Environmental management and mitigation measures

A range of specific mitigation measures, in-principle management strategies and project commitments have been identified in **Table 13-8**. These measures and strategies will form part of the Construction Environmental Management Plan (CEMP) for the project. During operation, potential impacts will be managed in accordance with TransGrid's existing Environmental Management System.

Table 13-8 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measures	Timing
BD1	Relocation of resident fauna	Pre-clearance survey of trees to be removed will be undertaken by a suitably qualified ecologist to identify/locate active nests in use by native animals. The removal of nest trees will be supervised by a qualified ecologist/licensed wildlife handler. Any fauna that will not disperse independently will be captured and relocated to a suitable location nearby. Prior to any disturbance by construction works, pre-clearance surveys of stormwater culverts and pipes that may be suitable habitat for roosting bats will be undertaken to identify bats for relocation.	Construction
BD2	Critical life-cycle events (e.g. breeding or nursing)	If active bird nests are identified during the pre-clearance survey, avoidance of vegetation clearing works during late winter/early spring breeding/nesting period will be considered.	Construction
BD3	Grey-headed Flying-fox habitat	Replanting with potential Grey-headed Flying-fox habitat vegetation will be undertaken within the project area where feasible, and in consultation with local councils.	Construction
BD4	Construction footprint	No temporary facilities i.e. site offices/toilets/equipment storage will be placed outside of the designated construction laydown areas or work sites. Access tracks to work sites outside of a road reserve will be clearly demarcated.	Construction
BD5	Temporary fencing	Work sites outside of the road reserve will be delineated with temporary fencing/barriers along the perimeter to avoid encroachment into vegetated areas.	Construction
BD6	Sedimentation of waterways	Appropriate controls will be utilised to manage exposed soil surfaces and stockpiles to reduce sediment discharge into waterways, in accordance with the Blue Book (Landcom, 2004) (refer **Chapter 17 Surface water and flooding**). All works within proximity to drainage lines will have adequate sediment and erosion controls. Revegetation of disturbed areas will commence as soon as practicable to reduce the risk of erosion.	Construction
BD7	Dust generation	Dust suppression measures will be implemented during construction works to limit dust at work sites (refer to **Chapter 9 Air quality**). Revegetation of disturbed areas will commence as soon as practicable to reduce areas likely to create dust.	Construction
BD8	Spread of weeds and pathogens	Vehicles, machinery and waste associated with construction will remain within work sites and laydown areas and will not impinge on areas of retained vegetation. Weeds (listed under the NSW *Biosecurity Act 2015*) present within construction laydown areas or work sites will be managed in accordance with the regional priority objectives of the Greater Sydney Regional Strategic Management Plan 2017 – 2022.	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
BD9	Construction staff training	All construction personnel will undertake an environmental induction that will include items such as: • potential or actual presence of threatened species or habitats; • site environmental procedures (vegetation management, sediment and erosion control, exclusion fencing and the prevention of the spread of weeds); • response to environmental emergencies (chemical spills, fire, and injured fauna); and • key environmental project personnel.	Construction
BD10	Tree removal and replanting	The project will avoid the removal of trees[4] wherever feasible and reasonable. Where avoidance is not possible, a tree replanting strategy/landscape plan will be developed in consultation with the relevant councils. Similar species of trees will be replanted, where feasible. Where this is not possible, suitable trees for specific local conditions will be determined. The suitability of the replacement trees will be confirmed by a qualified arborist, in consultation with TransGrid's cable specialists. Trees will be removed at the time of construction if trenching activities impact tree roots to a point where the tree is no longer viable (as determined by the project arborist). No trees[4] will be removed within the parklands at Sydney Park in Alexandria, along Constitution Road in Dulwich Hill and at the Johnson Park Bushcare site in Dulwich Hill.	Construction and operation
BD11	Cable monitoring for tree impacts	Where cable monitoring systems identify a potential impact of tree roots on the operating transmission cable, a qualified arborist will be called on to investigate further. If there is potential for damage to the cables, the tree will need to be removed. Removal will be limited to only trees that are affecting the transmission cable.	Operation
BD12	Tree retention	The following will be considered during the detailed design phase to retain trees wherever feasible and reasonable: • review the alignment of the transmission cable circuit to avoid impacting the SRZ or more than 10% of the TPZ where possible, with priority consideration given to heritage areas and high retention value trees; and • locate construction facilities and infrastructure (e.g. site offices, plant/equipment storage) outside of tree protection zones.	Detailed design
B13	Tree protection	The following tree protection measures will be implemented: • all tree pruning must be in accordance with the AS 4373-2007 Pruning of Amenity Trees (Standards Australia 2009a) and the Code of Practice for the Amenity Tree Industry (NSW WorkCover, 1998); • all tree work on retained trees is to be carried out by an arborist with a minimum AQF Level 3 qualification in Arboriculture; • trunk, branch and/ or ground protection measures for high retention value trees that extend into or are located in the roadway, will comply with AS 4970-2009 Protection of trees on development sites (Standards Australia,	Construction

[4] This applies to any tree and not only a tree as defined in *AS 4970-2009 Protection of Trees on Development Sites (*refer to **Section 13.1.3**).

No.	Impact/issue	Environmental management and mitigation measures	Timing
		2009b); and • ground protection will be used within the TPZ and SRZ, where possible, to prevent root damage caused by compaction of the soil and the loss of water infiltration and oxygen to the trees root system. Ground protection may include a permeable membrane such as geotextile fabric beneath a layer of mulch, crushed rock or rumble boards. The location and distribution of roots of trees to be retained will be determined through low or non-destructive excavation methods such as hydro-vacuum excavation (sucker truck), air spade and manual excavation, where required, immediately prior to excavation works commencing.	
BD14	Tree monitoring	A qualified arborist will be consulted in the event there is a change to the condition of high retention value trees in the project area due to construction activity. A qualified arborist will inspect high retention value trees within the project area for any damage once construction is completed and tree protection measures have been removed.	Construction and operation
BD15	Cable installation in key fish habitat	DPI Water's *Controlled activities on waterfront land – Guidelines for laying pipes and cables in watercourses on waterfront land* (DPI, 2012) will be used to inform the cable installation at the Cooks River.	Detailed design
BD16	Protection of water quality in the Cooks River	The following water quality measures will be implemented: • water collected during construction (e.g. during dewatering or surface water inflows to the trench or pits) will be discharged or disposed of in accordance with the *Protection of the Environment Operations Act 1997 and the ANZECC Water Quality Guidelines (2000) for 95% protection level for marine ecosystems;* • The water discharge point will be at a stable point on the bank or across riparian vegetation to allow slowing of water before travelling further downstream. Where feasible, the velocity of downstream flows will not exceed natural seasonal flow velocities. Sediment and erosion mitigation measures that will be implemented are detailed in **Chapter 17 Surface water and flooding**; and • contaminated water captured during construction will be disposed of at an appropriately licensed facility.	Detailed design and construction
BD17	Habitat restoration and weed control at the Cooks River	If vegetation is removed along the Cooks River, rehabilitation and revegetation will be undertaken (where not constrained by permanent operational infrastructure) to maintain the connectivity of the riparian corridors along the river. Weed control will also be implemented within the project area at the Cooks River to maintain restored areas as weed free.	Construction
BD18	Offset for mangrove removal	Should any Grey Mangrove at the Cooks River (which constitutes key fish habitat) require removal due to the project, this will be offset in accordance with DPI Fisheries requirements under the *Policy and guidelines for fish habitat conservation and management* (DPI, 2013), to ensure no net loss of key fish habitat.	Construction

14.0 Aboriginal heritage

This chapter presents an assessment of potential impacts to Aboriginal heritage resulting from the construction and operation of the project. Further detail is provided in the Aboriginal Cultural Heritage Assessment Report in **Appendix I** of this Environmental Impact Statement (EIS).

14.1 Assessment methodology

14.1.1 Legislative and policy context

The Aboriginal heritage assessment has been undertaken in accordance with the following legislation and statutory planning instruments:

- the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*;
- the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *National Parks and Wildlife Act 1974* (NPW Act); and
- Local Environmental Plans (LEPs) for each local government area within the study area (defined in **Section 14.1.3**).

14.1.2 Methodology

The methodology adopted for the assessment was developed in accordance with the requirements of *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (Office of Environment & Heritage, 2011), *Code of Practice for the Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010b) and *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW, 2010a). Key components of the assessment methodology included:

- desktop assessment;
- consultation with Registered Aboriginal Parties (RAPs);
- archaeological survey of the study area (refer to **Section 14.1.3**);
- assessment of cultural significance; and
- preparation of an Aboriginal Cultural Heritage Assessment Report (ACHAR).

14.1.2.1 Desktop assessment

The desktop assessment comprised:

- a search of the Department of Premier and Cabinet (DPC) (formerly Office of Environment and Heritage (OEH)) Aboriginal Heritage Information Management System (AHIMS) database, review of associated site cards and reports to clarify site contents, extents and statuses;
- a review of the landscape context of the study area, with a particular emphasis on its implications for the nature and distribution of Aboriginal archaeological materials;
- a review of relevant archaeological and ethno-historic information for the study area; and
- generation of a model of past Aboriginal occupation to assist in understanding the Aboriginal archaeological values of the study area.

14.1.2.2 Consultation with RAPs

Fifteen Aboriginal organisations and/or individuals registered an interest in being consulted during the assessment. Consultation with RAPs provides an opportunity to gather relevant information on cultural values and to gain insight on potential impacts and the suitability of mitigation measures.

14.1.2.3 Archaeological survey

An archaeological survey by heritage specialists and representatives of the Metropolitan Local Aboriginal Land Council (LALC) was undertaken on 15 July 2019. Areas of archaeological potential

(including for example intact or remnant watercourses and areas of rock exposures) were targeted for pedestrian survey on the basis of preliminary desktop review including spatial mapping and review of aerial photography. Remaining trafficable portions of the transmission cable route were traversed by vehicle to confirm the findings of the desktop assessment and ground-truth the preliminary mapping.

The aims of the survey were to identify and record any existing surface evidence of past Aboriginal activity and areas with subsurface archaeological potential within and in the vicinity of the project area.

14.1.2.4 Assessment of cultural significance

The assessment of cultural significance incorporates two interrelated and interdependent components. The first involves identifying, through documentary, physical or oral evidence, the elements that make a heritage site significant, as well as the type(s) of significance it manifests. The second involves determining the degree of value that the site holds for society (i.e. its cultural significance) (Pearson and Sullivan 1995: 126).

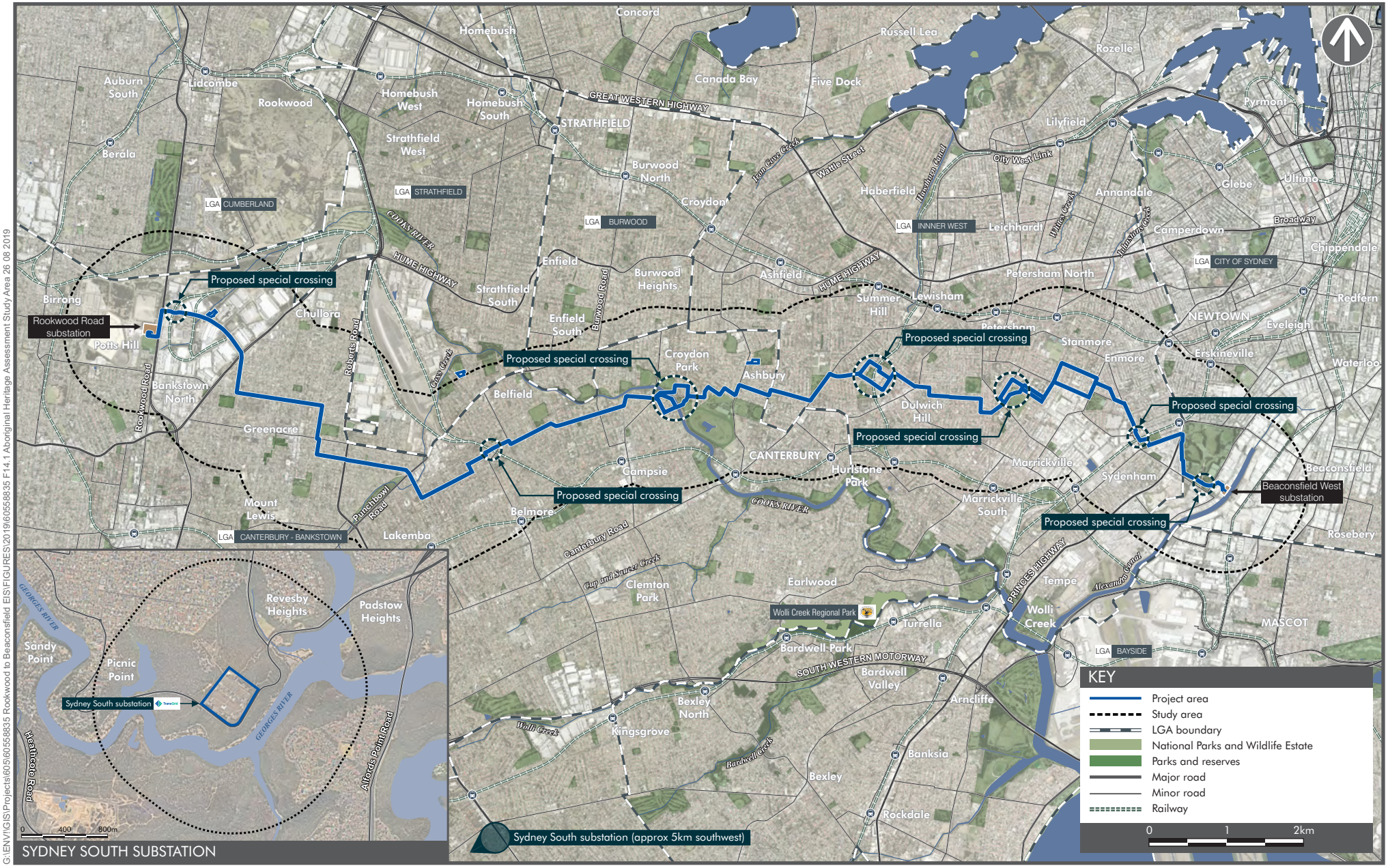
In Australia, the primary guide to the assessment of cultural significance is the *Australian ICOMOS Charter for Places of Cultural Significance* (1999), informally known as *The Burra Charter*, which defines cultural significance as the “aesthetic, historic, scientific, social or spiritual value for past, present or future generations” of a site or place.

14.1.2.5 Aboriginal Cultural Heritage Assessment Report

The ACHAR identified registered Aboriginal cultural heritage sites under relevant local, state and commonwealth legislation, as well as areas of archaeological potential within one kilometre of the project area. It also identified the likely direct and indirect impacts to any identified Aboriginal cultural heritage sites and recommended appropriate management measures to ensure that potential impacts from the project are managed. The ACHAR is provided in **Appendix I**. No comments were received from RAPs on the draft ACHAR.

14.1.3 Study area

The study area for the Aboriginal heritage assessment is shown in **Figure 14-1** and includes a one kilometre buffer around the project area. This buffer was applied to provide regional environmental and archaeological context. The transmission cable route has been divided into five construction precincts for assessment purposes.



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ABORIGINAL HERITAGE ASSESSMENT STUDY AREA

Powering Sydney's Future

Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations

Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 14-1

14.2 Existing environment

14.2.1 Physical description

14.2.1.1 Topography, geology and soils and geomorphology

The geology and soil landscapes within the study area were investigated for their archaeological potential. The results are summarised in **Table 14-1**.

Table 14-1 Soil landscapes in the study area (Chapman & Murphy, 1989)

Soil landscape	Stratigraphic description	Surface geology	Erosion potential	Landscape integrity and Archaeological potential
Blacktown (bt)	Shallow moderately deep (<100 centimetres) podzolic soils on crests, upper slopes and well drained areas. Deep (150-300 centimetres) podzolic soils and soloths on lower slopes and in areas of poor drainage.	Wianamatta Group Ashfield shale consisting of dark grey siltstone, and Bringelly shale consisting of shale, claystone, laminite and coal.	High	Moderate potential for intact archaeological deposit across all landforms.
Birrong (bg)	Deep (>250 centimetres) podzolic and solodic soils on older alluvial terraces. Deep (>250 centimetres) solodic soils and solonetzic soils on current floodplain.	Wianamatta Group silt and clay alluvial materials.	High	Moderate potential for intact archaeological deposit across all landforms but may be limited due to erosion.
Disturbed Terrain (xx)	Landfill including dredged estuarine sand and mud, demolition rubble and household waste.	Artificial fill.	Dependent on fill materials	Low archaeological potential within fill. Underlying soils potentially disturbed during fill activities.
Hawkesbury (ha)	Shallow (>50 centimetres), discontinuous siliceous sands associated with rock outcrop; localised podzolic soils associated with shale lenses; siliceous sands and yellow earths along drainage lines.	Hawkesbury Sandstone comprising medium to coarse-grained quartz sandstone with minor shale and laminite lenses.	High	Moderate potential for intact archaeological deposit but may be disturbed or displaced in areas impacted by erosion.
Lucas Heights (lh)	Moderately deep (50–150 centimetres), hardsetting podzolic soils and soloths.	Interbedded shale, laminite and fine to medium-grained quartz sandstone of the Mittagong Formation.	Low	Moderate potential for intact archaeological deposit in undisturbed landforms. Low potential in urbanised or developed areas.

14.2.1.2 Hydrology

The study area falls primarily within the Cooks River catchment which is a 23 kilometre long, partially tidal estuary, beginning at Yagoona in western Sydney and flowing eastward before entering Botany Bay. The river is freshwater as far as the suburb of Canterbury, becoming tidal towards its drainage to Botany Bay. Only a small portion of the river is located within the study area. The Beaconsfield West substation is located adjacent to the Alexandra Canal (formerly Shea's Creek), a highly modified waterway which also drains to the Cooks River. The existing Sydney South substation at Picnic Point is surrounded by the Georges River National Park north of Georges River. As such, it falls within the Georges River catchment.

Generally, all watercourses within the study area in proximity to the transmission cable route are highly modified urban systems with a history of anthropogenic disturbance (Roberts, 2003). The Cooks River and its tributaries mainly take the form of concrete lined channels within the western portion of the study area with areas of peripheral former mangrove swamp reclaimed with fill material. These channels serve as part of the local urban stormwater network. Within the eastern portion of the study area, the Cooks River widens and exhibits more natural stream characteristics including rehabilitated portions of riparian vegetation. The occurrence of recorded Aboriginal archaeological sites along these watercourses indicates their use by Aboriginal people in the past. Refer to **Chapter 17 Surface water and flooding** for further information.

14.2.1.3 Flora and fauna

Native vegetation within the study area has been extensively modified as a result of widespread urbanisation. According to Benson (1981), there remains very little of the original native vegetation which once covered the Cumberland Lowlands, including the study area. The Cumberland Basin, or Cumberland Plain as it is more commonly known, is an approximately 2,750 square kilometre physiographic region located to the west of Sydney's Central Business District. Historical clearance notwithstanding, native vegetation mapping for the Cumberland Plain suggests that the study area was likely vegetated with various open woodland communities, with two distinct vegetation communities likely occurring: Alluvial Woodland and Shale Plains Woodland.

Although available historical records provide only limited insight into Aboriginal peoples' use of plants across the Cumberland Plain, it is highly likely that the original vegetation communities of the study area and its environs would have supplied Aboriginal people camping within or travelling through the area with an extensive array of edible and otherwise useful plant species. Native vegetation communities and locally occurring watercourses will likewise have supported a large and diverse range of economic terrestrial, aquatic and avian fauna. Available ethnographic literature suggests that a wide range of marine and freshwater fauna were exploited by Darug-speaking peoples within the Cumberland Plain. In coastal areas, marine resources were the dominant food source, including fish and shellfish. Historical records suggest an emphasis on the procurement of land mammals including macropods, possums, gliders, fruit bats (i.e., flying foxes), dingos, koalas and wombats within inland areas of the Cumberland Plain. Freshwater fish, shellfish and eels, as well as platypus and birdlife, are also known to have been exploited by inland groups. Refer to **Chapter 13 Biodiversity** for further information.

14.2.1.4 Land use and disturbance

Land use across the study area is generally dominated by residential development with dispersed green spaces. Areas of light to heavy industrial and commercial land uses are located within the eastern portions of the study area and around the Sydney South substation. Areas of reclaimed land are located around the central and lower reaches of the Cooks River and Shea's Creek (now Alexandra Canal). No major earthworks or gross ground disturbance are evident on the southern bank of the Cooks River. The examination of historic aerial imagery for the study area indicates a range of historic land use activities and associated ground surface impacts. Key archaeological implications of these impacts include:

- destruction of Aboriginal sites in areas of grossly modified terrain;
- the disturbance of pre-existing sites and deposit(s) through both direct (e.g. residential and urban and construction, roads and infrastructure, excavations and brick pits) and indirect (erosion) means, resulting in a loss of archaeological integrity;

- increased archaeological site visibility in eroded areas; and
- the removal of any culturally scarred trees that may once have existed within the study area.

Further detail on the historical land use of each construction precinct is provided in **Appendix I**.

14.2.2 Historical context

Available sources indicate that the study area falls wholly within the traditional country of the Darug people, who spoke the Darug language. Darug is believed to have been spoken from the Hawkesbury River in the north, to Appin in the south, and from the coast west across the Cumberland Plain into the Blue Mountains.

14.2.2.1 Regional archaeological context

Key regional archaeological observations include:

- available radiometric dates indicate that Aboriginal people have occupied the Cumberland Plain for at least 36,000 years;
- compared with that available for the late Pleistocene/early Holocene, evidence for mid-to-late Holocene Aboriginal occupation of the Cumberland Plain abounds, with the majority of previously recorded sites likely dating to these periods;
- Aboriginal site distribution on the Cumberland Plain has been linked to a variety of environmental factors, with proximity to water, stream order, landform and geology variously highlighted as key determinants; and
- most surface sites will occur on landform elements within 200 metres of watercourses, with larger, more complex artefact assemblages associated with higher order streams.

14.2.2.2 Local archaeological context

Searches of the AHIMS database were undertaken on 2 May 2019 (AHIMS search #418101). A one kilometre buffer was applied to the project area. The AHIMS search reported a total of 35 Aboriginal sites. Of these, a single Aboriginal resource and gathering site (45-6-0751, Shea's Creek Dugong) was listed as ‘Destroyed’. A duplicate of the above site as an open artefact site containing shell material, ‘Shea's Creek’ (45-6-1496), is listed as ‘Not a Site’. Discounting these two sites from the AHIMS search, a total of 33 ‘Valid’ entries remain. Details for valid site entries within the AHIMS search area are provided in **Table 14-2** and shown in **Figure 14-2** and **Figure 14-3**.

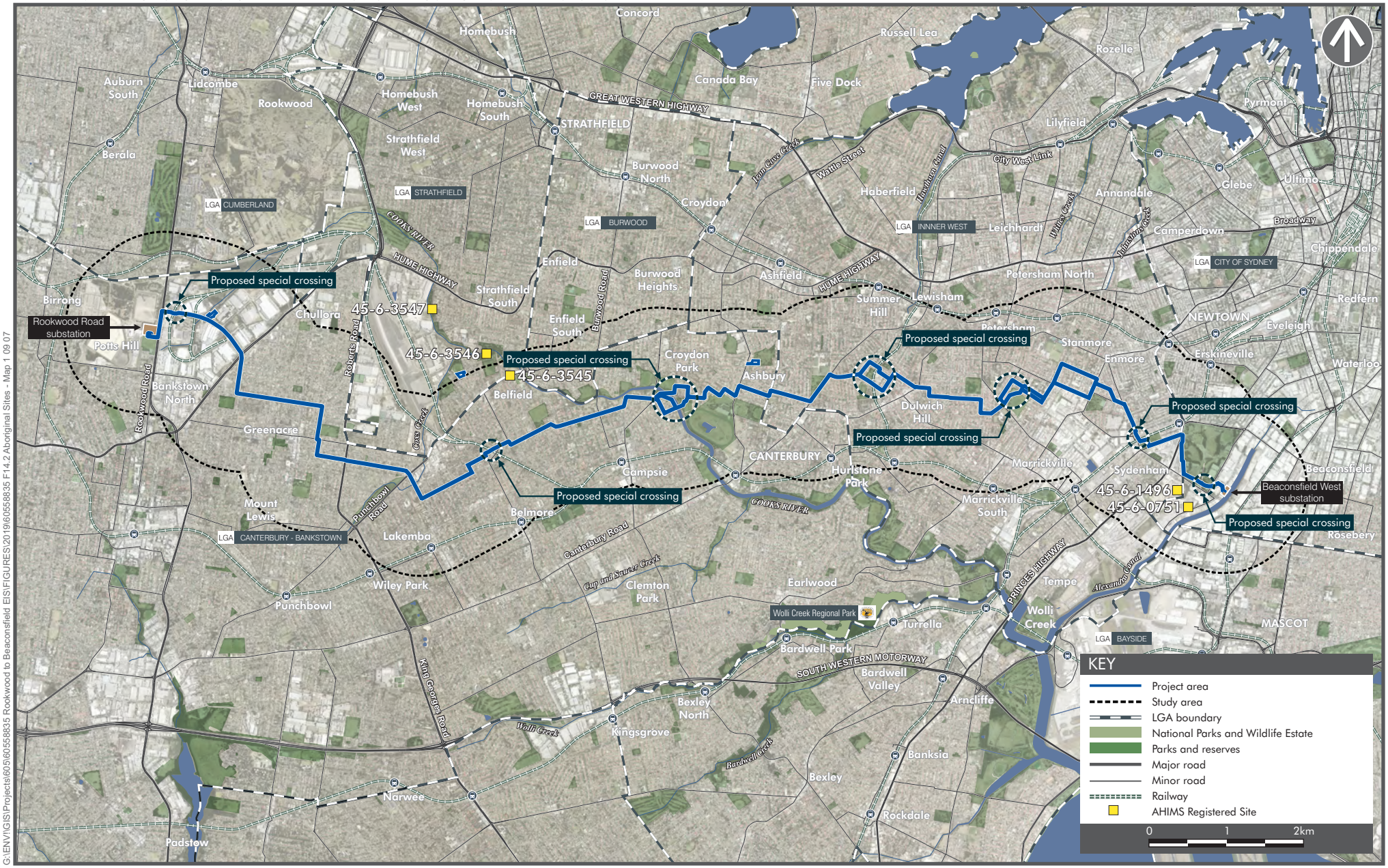
Table 14-2 AHIMS search summary for valid sites

Heritage List	Number of sites	% of total number of sites
Modified tree (carved or scarred)	1	3
Burial	1	3
Midden	1	3
Aboriginal resource and gathering	1	3
Open artefact site	5	15
Potential archaeological deposit (PAD)	6	18
Rockshelter	18	55
Total	**33**	**100**

The closest recorded valid sites within 500 metres of the project area are outlined in **Table 14-3**. Further detail on these and the remaining sites identified from the AHIMS search are provided in **Appendix I**.

Table 14-3 Valid recorded sites within 500 metres of the project area

Heritage list type	Site ID number	Site name	Site feature	Approximate distance from project area
Rockshelter	45-6-1797	ST George S.R.A	Art (Pigment or Engraved)	397 metres
Open artefact site	45-6-3546	Maria Reserve 1 (STRA-002)	Artefact(s)	381 metres
Rockshelter	46-6-2016	Georges R.S.R.A	Art (Pigment or Engraved)	420 metres
Rockshelter	46-6-1009	Georges River, plundered cave	Art (Pigment or Engraved), Shell, Artefact(s)	421 metres
Open artefact site	45-6-2902	Gkw39 (Moonah Road Talus) Botany Bay	Shell, Artefact(s)	430 metres
Rockshelter	45-6-1798	ST George S.R.A	Art (Pigment or Engraved)	436 metres
Rockshelter	45-6-0962	Georges River, falling rock cave	Art (Pigment or Engraved), Shell, Artefact(s)	448 metres
PAD	45-6-2876	MP08	PAD	491 metres



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REGISTERED ABORIGINAL SITES - MAP 1

Powering Sydney's Future

Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations

Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018), Office of Environment and Heritage (OEH), 2019

FIGURE 14-2

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REGISTERED ABORIGINAL SITES - MAP 2

Powering Sydneys Future
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018), Office of Environment and Heritage (OEH), 2018

FIGURE 14-3

14.2.3 Archaeological survey

14.2.3.1 Surface artefacts

Generally poor ground surface visibility across the study area significantly reduced the ability to identify surface evidence of past-Aboriginal occupation. Notwithstanding, the study area was generally assessed as having low to nil archaeological potential due to significant ground disturbance from urban and commercial land uses (current and historical), particularly where the study area passed within road and rail corridors and buildings (former and existing). Construction laydown areas inspected during the survey were likewise found to be located in areas of low or nil archaeological sensitivity, either due to existing ground disturbance or absence of archaeologically sensitive landforms.

The southern alluvial corridor of the Cooks River in the vicinity of Mildura Reserve (between Brighton Avenue and Lindsay Street) was assessed as having a moderate archaeological potential. This area is shown in **Figure 14-4**. The survey confirmed the desktop assessment which suggested that, despite being channelised, the alignment of the Cooks River in this portion of the study area appears to generally follow its natural course. While no surface Aboriginal objects were identified during the survey, the area was noted for its proximity to the Cooks River (within 200 metres), the presence of elevated landforms (rises and terraces) and being moderately intact. These field observations were reiterated by RAP field representative Mr. Kevin Telford who noted elevated landforms similar to those retaining Aboriginal sites elsewhere along the Cooks River which have the potential to contain flaked stone objects and shell material (middens) in subsurface context.

Localised areas of ground disturbance were identified along the northern banks of the Cooks River resulting from the previous installation of utility services including an oil and gas pipeline. Surface evidence of a sewer alignment running along the southern bank of the Cooks River suggests a narrow corridor of disturbance in that portion of the study area. Where such underground services are present, the likely result has been the disturbance of potential archaeological deposits in those areas.

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AREA OF ABORIGINAL ARCHAEOLOGICAL SENSITIVITY

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

FIGURE 14-4

Note: The project area is confined to the roadway reserve with the exception of parks and special crossings
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

14.2.4 Cultural significance

As discussed in **Section 14.1.2.4**, a cultural assessment through aesthetic, historic, scientific and social values has been undertaken to define the cultural significance of the study area as outlined in **Table 14-4**.

With respect to Aboriginal sites and places, it is possible to identify two major streams in the overall significance assessment process: the assessment of *scientific value(s)* by archaeologists and the assessment of *social (or cultural) value(s)* by Aboriginal people.

Table 14-4 Cultural significance findings

Values	Findings
Aesthetic	The study area is assessed as having low aesthetic significance on the basis of its highly urbanised character.
Historic	The study area is assessed overall as having a low historical significance due to the heavily modified nature of the landscape. Notwithstanding, it is noted that Aboriginal peoples have continuously occupied the Sydney regions which, conceptually, would retain historical significance to Aboriginal peoples living in the Sydney region today.
Scientific	No existing Aboriginal sites were identified within the project area during the archaeological survey and as such an analysis of scientific significance is not possible. The review of existing Aboriginal sites within the study area however indicates a range of site types that would contribute to the scientific study of Aboriginal occupation of the study area. In addition, the identification of an area of Aboriginal archaeological sensitivity within the project area has the potential to yield information about the past Aboriginal occupation of the project area.
Social	Verbal information from RAPs have identified the following social or cultural values for the study area: *Prior to European occupation, creeks and rivers would have been an important resource feature for Aboriginal people occupying the study area. As such, they are considered to be highly valuable cultural elements (pers.comm. Kevin Telford - Metropolitan LALC, 2019).*

14.2.5 Statement of significance

The assessment in **Table 14-4** demonstrated that the Aboriginal heritage values of the project area rest principally with its association with the Cooks River and associated landforms, which had a demonstrated cultural significance in terms of past-Aboriginal occupation of the Sydney area. Alongside local and regional Aboriginal archaeological datasets, verbal advice from the RAPs involved in this assessment indicate that the Cooks River and its tributaries functioned as a major resource gathering zones for Aboriginal peoples occupying the area.

Culturally, the study area has significance for the association with both past Aboriginal peoples and those Aboriginal peoples occupying the area today.

14.3 Assessment of potential impacts

The majority of the ground disturbance works for the transmission cable circuit would be located within road reserves, with some sections located outside the road reserve in public open space or on private property. As most of the project area has been subject to previous development, it was assessed as having low to nil archaeological potential and are therefore unlikely to impact Aboriginal sites.

However, as outlined in **Section 14.2.3**, land within Mildura Reserve (on the southern bank of the Cooks River in Campsie) was assessed as having a moderate potential for subsurface Aboriginal archaeological deposits (refer to **Figure 14-4**). **Chapter 4 Project description** identifies three options for progressing the transmission cable route and special crossings in the vicinity of the Cooks River at Campsie/Croydon Park. Where proposed ground disturbing activities for excavations associated with trenching and underboring, including launch and receive pits (i.e. Options 2 and 3) are within this mapped area of Aboriginal archaeological sensitivity, there is a risk that subsurface archaeological deposits may be impacted.

As part of the construction of the project, construction laydown areas would be required to store materials and equipment and provide space for other ancillary facilities such as temporary site offices. It is anticipated that minimal subsurface ground disturbing activities would occur at construction laydown areas, including disturbance associated with the erection of noise mitigation such as hoardings or associated with the construction of driveways or placement of soil stockpiles. The survey of the project area concluded that the proposed construction laydown areas are not located in areas of Aboriginal archaeological sensitivity, and therefore the potential ground disturbing activities are unlikely to impact Aboriginal sites.

It is not anticipated that operational activities would result in ongoing or additional impacts to Aboriginal heritage.

14.4 Environmental management and mitigation measures

The management and mitigation measures outlined in **Table 14-5** will form part of the Construction Environmental Management Plan (CEMP) for the project.

Table 14-5 Environmental management and mitigation measures

No.	Impact/issue	Environmental management and mitigation measure	Timing
AH1	Impacts to areas of Aboriginal archaeological sensitivity and/or impacts to Aboriginal sites	If impacts to the area of Aboriginal archaeological sensitivity at Mildura Reserve, Campsie cannot be avoided (refer to **Figure 14-4**), a program of archaeological test excavation will be required to determine the presence or absence of subsurface Aboriginal objects. The methodology for investigating and managing areas of Aboriginal archaeological sensitivity and known Aboriginal sites/objects will be detailed in an Aboriginal sites/objects will be detailed in an Aboriginal Cultural Heritage Management Plan (ACHMP) for the project. The ACHMP will be prepared in consultation with Registered Aboriginal Parties (RAPs) and Department of Planning, Industry and Environment (DPIE). Subject to ACHMP approval by DPIE, this document will guide the management of Aboriginal cultural heritage within the project area throughout the life of the project.	Detailed design, construction, operation
AH2	Site inductions	Prior to the commencement of works, all construction personnel will undergo an Aboriginal heritage induction which identifies the general nature of Aboriginal sites and objects, the location of areas of archaeological sensitivity, requirements of the ACHMP (if relevant), procedure for unexpected finds, personnel responsibilities, and safeguards to be implemented to protect and avoid impacts to Aboriginal sites, if discovered.	Construction
AH3	Unexpected Aboriginal objects or human remains	If unexpected Aboriginal objects or human remains are uncovered in the project area during construction, TransGrid's Unexpected Finds Protocol will be initiated. This includes[1]: 1. All ground surface disturbance in the area of the finds should cease immediately when the finds are uncovered and relevant personnel will be notified,	Construction

[1] As per Appendix E - Unexpected Finds Protocol, TransGrid Aboriginal Heritage Due Diligence Assessment (Document ref: D2018/05672)

No.	Impact/issue	Environmental management and mitigation measure	Timing
		2. If the find is suspected to be human skeletal material, the NSW Police will be contacted immediately, 3. If there is substantial doubt regarding an Aboriginal origin for the finds, then a qualified opinion from an archaeologist will be sought as soon as possible, 4. If a qualified opinion cannot be gained or the identification is positive, immediately notify the following authorities or personnel of the discovery: a) DPC (Environment Line:131 555); and b) Relevant Aboriginal Community Representatives. 5. Facilitate, in co-operation with the appropriate authorities and relevant Aboriginal community representatives: a) the recording and assessment of the finds; b) fulfilling any legal constraints arising from the find(s). This will include complying with DPC directions; and c) the development and conduct of appropriate management strategies. Strategies will depend on consultation with stakeholders and the assessment of the significance of the find(s). d) Where the find(s) are determined to be Aboriginal Objects, any re-commencement of construction related ground surface disturbance will only resume in the area of the find(s) following the preparation of an ACHMP for the project, of one does not already exist.	

15.0 Non-Aboriginal heritage

A Historical Heritage Impact Assessment has been prepared for the project and is provided in **Appendix J**. This chapter summarises the assessment of potential construction and operational impacts of the project on non-Aboriginal heritage and outlines environmental management and mitigation measures to avoid or reduce impacts.

15.1 Assessment methodology

The study area for the assessment comprises the project area plus a 20 metre buffer around the project area. The approach to the assessment included:

- a desktop review of available information to identify registered heritage items and conservation areas;
- development of the historical context of the study area;
- field survey at selected locations;
- identification of known or potential heritage items or areas of archaeological potential;
- assessment of the potential direct and indirect impacts to any historical values within the study area; and
- identification of measures to reduce, avoid or mitigate impacts to any known or potential heritage items.

15.2 Existing environment

15.2.1 Register searches

A search of relevant heritage lists and registers was undertaken on 29 May 2019, the complete results of which are presented in **Appendix J**.

The searches identified a number of items within the study area including:

- two items listed on the State Heritage Register (SHR) (refer to **Figure 15-1** and **Figure 15-4**);
- two Sydney Water Section 170 Register items[1] (S170 register) (refer to **Figure 15-1** to **Figure 15-4**); and
- 45 locally listed items, including 10 heritage conservation areas (HCAs) and the Local Environmental Plan (LEP) listing for Alexandra Canal (which is also listed separately on the SHR) (refer to **Figure 15-1** to **Figure 15-4**).

There were no relevant listings under the World Heritage List, National Heritage List, Commonwealth Heritage List or Australian Heritage Database.

Overall, there are nine heritage items (including HCAs) that would potentially be directly impacted by the project. There are two heritage items listed on the SHR that are partially located within the study area but are outside the project area. This includes the Potts Hill Reservoirs 1 and 2 and the Alexandra Canal. The Potts Hill Reservoir is listed on both the SHR and the S170 register. Similarly, the Alexandra Canal is also listed on two heritage registers, the SHR and the Sydney LEP. The two SHR items that are located immediately adjacent to the project area have been assessed individually due to their State significance rating. There are 37 locally listed heritage items, including the S170 register listing of the Potts Hill Reservoirs and the Sydney LEP listing of the Alexandra Canal, that are located within the study area. These 37 heritage items have been collectively assessed for indirect impacts, such as due to vibration or changes to views as a result of the project.

[1] All items that are listed on the S170 register and schedule 5 of a council's Local Environmental Plan (LEP) are given a State Heritage Inventory (SHI) number. The same item can be listed on the LEP and S170 register but have 2 SHI numbers relating to each listing.

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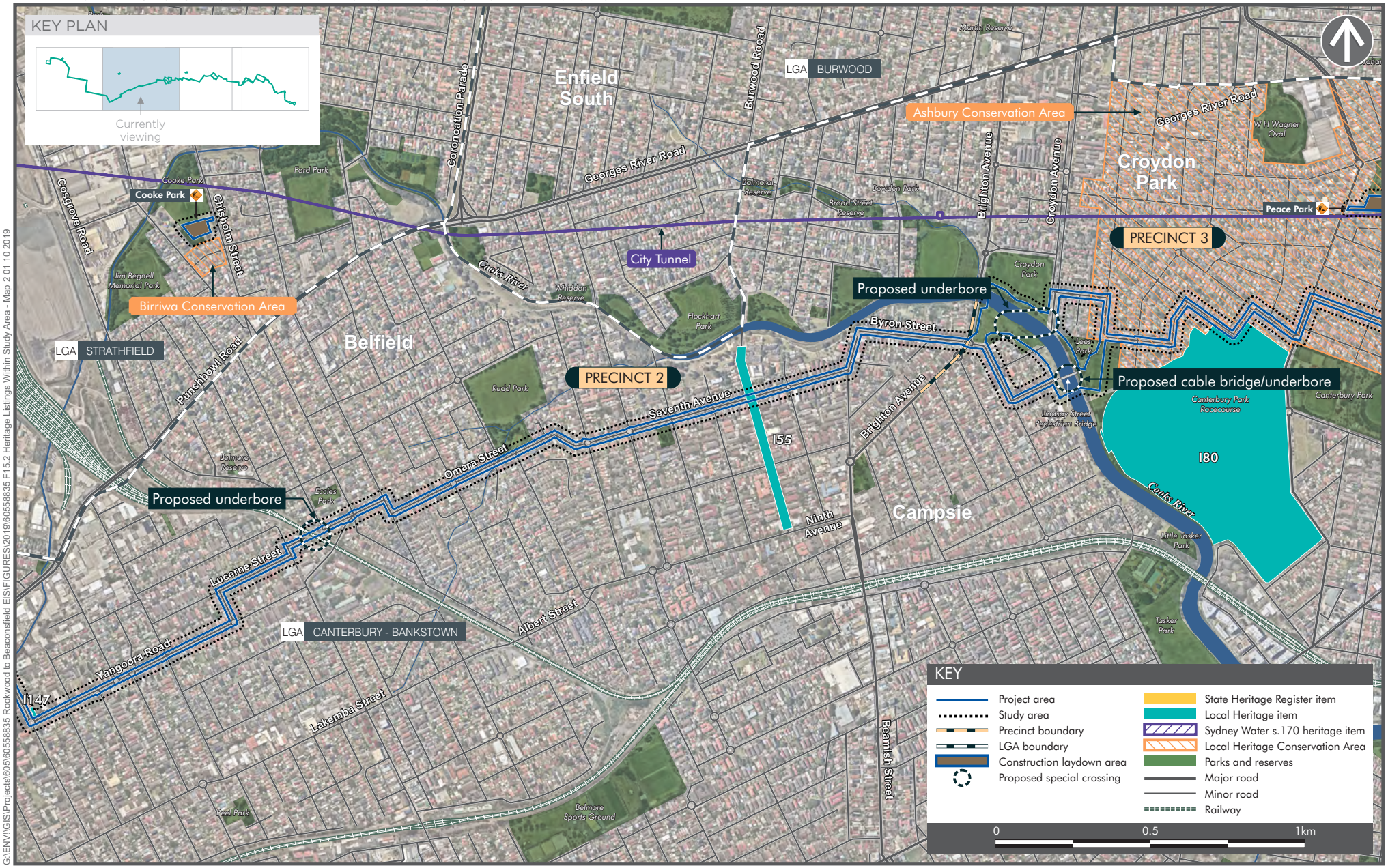
HERITAGE LISTINGS WITHIN STUDY AREA - MAP 1

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 15-1



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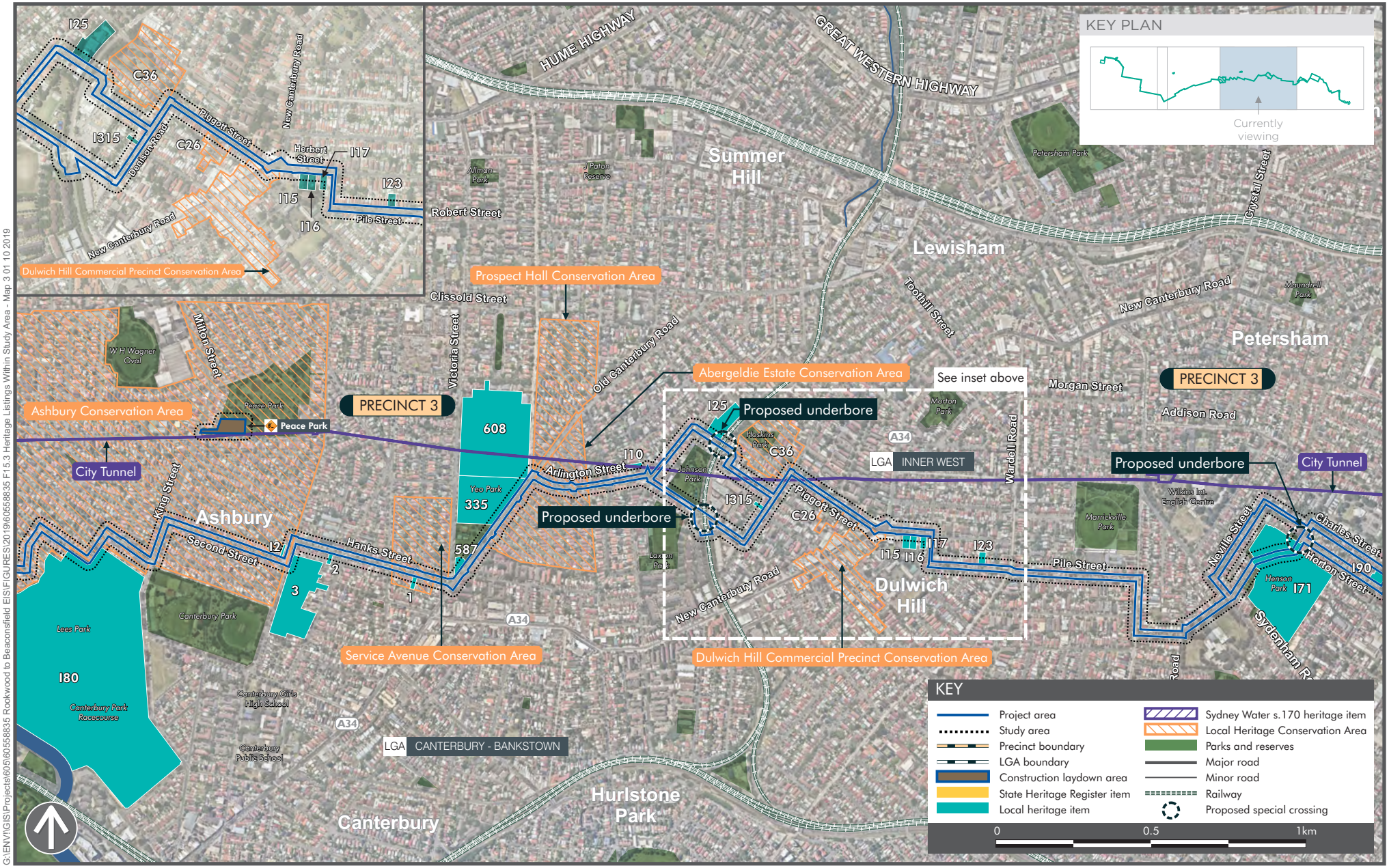
HERITAGE LISTINGS WITHIN STUDY AREA - MAP 2

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 15-2



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HERITAGE LISTINGS WITHIN STUDY AREA - MAP 3

Powering Sydney's Future

Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations

Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

FIGURE 15-3

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HERITAGE LISTINGS WITHIN STUDY AREA - MAP 4

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018),

FIGURE 15-4

Table 15-1 Heritage items within the project area, including two SHR listed items adjacent to the project area

Heritage item	Precinct					
	1	2	3	4	5	Construction laydown area
Potts Hill Reservoirs 1 and 2 and Site (SHR 01333)	x					
Alexandra Canal (SHR 01621)					x	
City Tunnel (SHI 4574202)	x			x	x	
Service Avenue Heritage Conservation Area			x			
Inter War Street Trees		x				
Ashbury Heritage Conservation Area			x			Peace Park
Henson Park			x			
Brick Paving				x		
The Abergeldie Estate Heritage Conservation Area			x			
Goodsell Estate Heritage Conservation Area				x		Camdenville Park
Llewellyn Estate Heritage Conservation Area				x		

15.2.2 Physical description

A brief description of the HCAs and heritage items located within the project area, and the two SHR listed items partially located within the study area but are outside the project area is provided in this section.

15.2.2.1 Potts Hill Reservoirs 1 and 2 and Site (SHR 01333)

The two reservoirs at Potts Hill are part of Sydney Water's supply system, having previously been part of the Upper Nepean Water Supply Scheme. They have industrial design, built features and both natural and exotic plantings. Various components that contribute to the listing include the Carrier Canal, the telescopic valve tower, a pressure tunnel inlet, a pressure tunnel access shaft building, a suction well, surge tank and reflux valve as well as various landscape elements. The curtilage of this item marginally intersects the project area at its western-most extent in Precinct 1.

15.2.2.2 Alexandra Canal (SHR 01621)

Alexandra Canal is an artificial waterway that runs from the Cooks River in the south to around Huntley Street, Alexandria in the north. It replaced the natural alignment of Sheas Creek with a channel formed by banks with sloping dry sandstone and sandstone capping. The canal is at the eastern-most extent of the project area in Precinct 5.

15.2.2.3 City Tunnel (SHI 4574202)

The City Tunnel consists of access chambers, supporting structures, a tunnel, vertical shafts and buildings attached to the shafts. It operates as water supply infrastructure and can be closed in sections for maintenance. The item is located between 15 and 67 metres below ground (i.e. the tunnel depth) so it is well below the typical trench depth for the project. There would be no direct or indirect impacts from construction activities to this item.

15.2.2.4 Service Avenue Heritage Conservation Area (Canterbury LEP 2012 Item C18)

The Service Avenue Heritage Conservation Area was once a large land grant that was subsequently subdivided near the end of the 19th century and start of the 20th Century. The HCA consists of various pre and interwar houses, on allotments fronting wide streets. Plantings are present on either side of the road that includes trees, particularly along Hanks Road where the transmission cable route would be located. These plantings form the streetscape that contribute to the aesthetics associated with the HCA.

15.2.2.5 Inter War Street Trees (Fifth Avenue, Campsie) (Canterbury LEP 2012 Item 55)

The item 'Inter War Street Trees' comprises palm trees that have been planted on both sides of Fifth Avenue. The plantings relate to the beautification of streets that was undertaken by councils in the 20th Century. The transmission cable route would cross Fifth Avenue as it proceeds along Seventh Avenue, Campsie (refer to **Plate 1**). The project would be located within the existing road reserve in this area.

Plate 1 Inter War Street Trees near the intersection of Fifth Avenue and Seventh Avenue, Campsie (view to south)

15.2.2.6 Ashbury Conservation Area (Canterbury LEP 2012 Item HCA1)

Ashbury Heritage Conservation Area is a large area that includes several major suburban streets. This HCA relates to the early 20th Century suburban expansion of Sydney. This area was developed between 1912 and 1940 and designed to have wide streets and street plantings. The trees form part of the HCA. The transmission cable route would be located within the road reserve in this area (refer to **Plate 2**). A construction laydown area is also proposed within Peace Park which is within the HCA.

Plate 2 View of Harmony Street that is included within the Ashbury Heritage Conservation Area (view to east)

15.2.2.7 Henson Park (Marrickville LEP 2011 Item 71)

Henson Park is a locally listed heritage item for its long association as a suburban oval within the Marrickville council area. The oval was formally a brick works that was converted into Henson Park in 1933 and is surrounded by houses backing onto the park along all four of its boundaries. The main entry to the oval is along Centennial Street that leads from the residential area into the oval behind the two main grandstands and the original brick decorative entrance gates. The two grandstands are located on the north-western side of the park, with the viewing areas around the oval consisting of raised grassed hills. One option for the transmission cable route in this area is to follow Centennial Street and cross behind the grandstands and oval across to Amy Street (refer to **Plate 3**). The project area through Henson Park is currently a level grassed covered area that is used by vehicles to access the areas around the main oval.

Plate 3 View across the grassed area that may be underbored through Henson Park (view to southwest)

15.2.2.8 Brick Paving (along Enmore and Juliett Streets – Marrickville LEP 2011 Item 98)

The brick paving that forms part of this heritage listing is located on various streets within Enmore. The transmission cable route would pass immediately adjacent to this heritage item along Enmore Road, where the paving is located on the eastern side, and along Juliett Street (refer to **Plate 4**). The paving is located within the footpath immediately adjacent to the road reserves and is laid in a 90-degree herringbone pattern. The paving is largely intact, with only small sections having been removed for modern driveways.

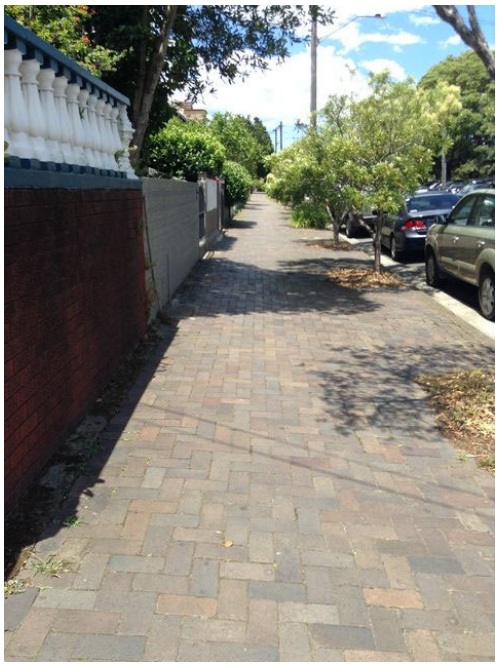


Plate 4 Brick paving that forms part of the heritage listed paving along Enmore Road and Juliett Street (view to southeast)

15.2.2.9 Abergeldie Estate Heritage Conservation Area (Marrickville LEP 2011 Item C1)

The transmission cable route within the Abergeldie Estate Heritage Conservation Area would be along Arlington Street. This street includes interwar period brick Californian Bungalows. Arlington Street itself is a wide street that includes street plantings on either side of the road within the footpaths (see **Plate 5**). The trees form part of the HCA. The transmission cable route would be within the road corridor in this area.

Plate 5 View along Arlington Street, within the Abergeldie Estate Heritage Conservation Area (view to east)

15.2.2.10 Goodsell Estate Heritage Conservation Area (Marrickville LEP 2011 Item C16)

The Goodsell Estate Heritage Conservation Area has some historic association with the former brickworks that were present to the east of this area in Sydney Park and the associated brick pit that was on the western side of the Goodsell Estate curtilage, within the current Camdenville Park (see **Plate 6**). The heritage significance of this listing focuses on the development that occurred as a result of successive land releases that occurred in Marrickville. The trees form part of the HCA.

The Camdenville Park playing field was the area where the brick pit was located for the Goodsell brick maker. The western end of Camdenville Park is cut down to be lower than the surrounding streets. This section of the oval is covered in tall grass and trees and is closed off to the public. The visible evidence indicates that this area has been highly disturbed, likely from the landscaping works that occurred after the closure of the former brickworks and this associated brick pit.

The transmission cable route traverses the western side of this HCA, crossing through the existing Camdenville Park playing fields that is within the HCA, before continuing outside of the HCA along May Street. A construction laydown area is also proposed to be located within Camdenville Park.

Plate 6 Camdenville Park playing fields (view to northeast)

15.2.2.11 Llewellyn Estate Heritage Conservation Area (Marrickville LEP 2011 Item C14)

The Llewellyn Estate listing is specific to the allotment layout and the design and styles of houses that have survived from 1894 onwards. The section of Enmore Road that is included in the Llewellyn Estate conservation area is mostly residential, with the exception of a set of shops located at the intersection of Addison Road. The shops include awnings that extend out over the footpath to the kerb of the road. Along Enmore Road and Llewellyn Street, the roads are both dual lane with parking on either side. Both roads are tree lined along the footpath, but are even more so along the boundary of Enmore Park. The trees form part of the HCA. There is sandstone kerbing along the western side of Enmore Park along Enmore Road only. The transmission cable route would be located within the road reserve in this area. The proposed activities in Llewellyn Estate (see **Plate 7**) include trenching along Enmore Road, Scouller Street, then south on Juliett Street and along part of Llewellyn Street (east of Juliett Street).

Plate 7 View to the northeast of the intersection of Addison Road and Enmore Road

15.2.2.12 Summary of archaeological potential

The project area would be largely contained to existing road reserves. These areas are expected to have been disturbed from the installation of other similar services. In addition, as the HCAs reflect the allotment and road layout of the original subdivisions, there is not expected to be historical archaeological potential present within the current road reserve areas. However, portions of the project area extend outside road reserves, including sections of the transmission cable route crossing through Goodsell Estate (which contains Camdenville Park), Cooks River, Henson Park and Sydney Park.

The project area at the location of the proposed Cooks River crossing was first granted to William Pascoe Crook, a missionary who was granted land on his second coming to Sydney after 14 years away in the Cook Islands. Crook was a priest and teacher in Parramatta in the 1830s, however, there is no evidence he lived on the land by the Cooks River. After his death in 1846, his block of land remained vacant until its eventual subdivision in c.1890. Streets were added in parallel but set back from the Cooks River. The area along the bank of the river remains vacant and unused. The nearby perpendicular roads that lead to the Cooks River in the area where the crossing is proposed were added in 1903, but the river bank area was retained for a transmission line easement at the same time. This resulted in no development along the foreshore area of the Cooks River where the transmission cable would be constructed.

The project area through Goodsell Estate has been highly disturbed. This area was formerly part of the Goodsell brickworks, with the brick pit located at the western end of the property. The transmission cable route would pass through the former pit location that was later filled in and landscaped, forming Camdenville Park. As such, there is a low likelihood that any intact subsurface historical archaeological deposits would be present within this area.

The project area through Henson Park will pass through the location of the former Standsure Brick Company brickworks that commenced operating in 1886. The brickworks site ceased operation 1917 and the brick pit was later filled in 1932. These works also included the levelling of the entire site that allowed for the creation of Henson Park. The likelihood for intact historical archaeological remains to be present within the project area within Henson Park t related to the former brickworks is considered to be low.

The location of the project area within Sydney Park was the site of former brick and pottery working yards. These works began in 1892 and expanded rapidly to include steam powered brick making facilities in 1912. The operations were sold to the Austral Brick Company in 1936, with works continuing on the site until the 1970s. The operation of the brick pit site included the use of former brick pits as waste depots from the 1940s until 1976. In 1982, plans were made to convert the area into a park and extensive landscaping and modifications were made to create Sydney Park.

The former brick manufacturing facilities were located around the periphery of Sydney Park, with the pits located back behind the workshops. The project area bypasses the location of the former facilities associated with the brickworks and continues mostly through the former brick pit areas which have since been converted into parkland and are highly disturbed. As such, the project area is unlikely to impact on any relics or other archaeological deposits associated with the former brickworks that may be present within Sydney Park.

15.3 Assessment of potential impacts

Statements of heritage significance for local and State heritage items that would potentially be directly impacted by the project, and for SHR listed items that are located immediately adjacent to the project area, are provided in **Appendix J**. This section provides an overview of direct and indirect impacts on heritage items and HCAs during construction and operation of the project. Impacts on archaeological potential are described separately in **Section 15.3.4**.

Direct impacts are associated with physical disturbance to a heritage item, removal of street trees/plantings and changes to the visual settings within a HCA or of a heritage item. Indirect impacts are associated with potential vibration impacts on heritage items.

15.3.1 Construction impacts - direct

The project area is primarily located within road reserves, with the exception of private property and public open space areas (such as at the Cooks River in Croydon Park/Campsie, Henson Park, Peace

Park, Camdenville Park and Sydney Park), where the transmission cable route extends outside of the road reserve.

Within the road reserves, direct impacts from trenching works on known HCAs and heritage items would be primarily limited to temporary visual impacts caused by construction activity, plant and equipment, and potential long-term visual impacts and potential reduction in heritage significance from tree removal. No direct disturbance of buildings or structures within the conservation areas is anticipated.

Three construction laydown areas are located within existing HCAs or immediately adjacent to a heritage item. These are listed in **Table 15-2**.

Table 15-2 Proposed construction laydown areas inside HCAs

Construction laydown area	HCA/heritage item
Peace Park, Ashbury	Within the curtilage of the Ashbury Conservation Area (HCA1)
Camdenville Park, St Peters	Within the curtilage of the Goodsell Estate Heritage Conservation Area (C16)
Beaconsfield West substation, Alexandria	Adjacent to the Alexandra Canal (SHR 01621)

The use of construction laydown areas is not expected to have direct heritage impacts. Only minimal ground disturbance may be required at the construction laydown areas for temporary infrastructure (including for noise mitigation controls (such as hoardings) and driveways). Once construction is complete, the construction laydown areas would be reinstated to their pre-construction condition, resulting in the reversal of any temporary visual impacts.

Potential ground disturbance is expected to have a minimal impact only. As such, impacts to subsurface archaeological deposits associated with the conservation areas at Peace Park and Camdenville Park are considered unlikely.

With respect to visual impacts, once works are completed, the road surface would be restored, and temporary visual impacts would be reversed. Tree removal would be avoided, where feasible and reasonable. Tree removal, where required, would have an impact on the heritage significance of areas where trees have been identified as contributory heritage elements. Where tree removal cannot be avoided, consideration will be given to tree replanting in another location, in consultation with the relevant local council.

There may be some tree removal or pruning of trees to create access to the Peace Park construction laydown area. Peace Park is located within the Ashbury HCA, listed for its interwar period houses. Removal of trees within this HCA would result in a direct impact to this HCA however, it would not degrade the heritage significance associated with the HCA.

The three substation sites have been highly disturbed by previous construction for the establishment of the substation sites. These substations are not located within any heritage listings or heritage conservation areas. Beaconsfield West substation is located adjacent to the Alexandra Canal and the canal wall forms the boundary of the heritage curtilage. The canal wall would not be directly impacted by the project. As such, there would be no impacts to heritage items or archaeological potential at these sites.

An overview of the direct impacts on heritage items, including any potential long-term changes to visual amenity within HCAs from possible tree removal, is provided in **Table 15-3**.

Table 15-3 Summary of potential direct construction impacts of the project on heritage items and conservation areas

Heritage item/HCA	Direct impacts
Potts Hill Reservoirs 1 and 2 and Site (SHR 01333)	There would be no impact to this State significant heritage item. The curtilage marginally intersects with the project area at its western-most extent, but no impacts to the item are expected.
Alexandra Canal (SHR 01621)	The project would not have a direct impact on the State Heritage listed canal. The canal wall, which forms the boundary of the heritage curtilage, would not be directly impacted by the project.
City Tunnel (SHI 4574202)	There would be no direct impact from construction activities to this item. The item is located between 15 and 67 metres below ground level (i.e. the tunnel depth) which provides adequate separation from the transmission cable circuit.
Service Avenue Heritage Conservation Area (Ashfield LEP 2013 Item C18)	Construction activities, including trenching, would occur along Hanks Street within this HCA. While construction would not have a direct impact on any houses, there is the potential for street trees that are included in the heritage listing to be removed, which would be a direct impact to this HCA. This impact, however, would not degrade the heritage significance associated with the HCA.
Inter War Street Trees (Fifth Avenue) (Canterbury LEP 2012 Item I55)	Construction activities, including trenching, would occur within the road reserve at the intersection of Seventh Avenue and Fifth Avenue. There is the potential that trees located at the intersection would be removed depending on the final alignment of the transmission cable route. The removal of street trees would result in a direct impact to this heritage listing.
Ashbury Heritage Conservation Area (Canterbury LEP 2012 Item HCA1)	Construction activities, including trenching, would occur within the road reserve along Dunstan Street, Hay Street, Harmony Street, Malleny Street and Cheviot Street within this HCA. While construction would not have a direct impact on any houses, there is the potential for street trees that are included in the heritage listing to be removed, which would be a direct impact on the HCA. Construction activities within this HCA also include the Peace Park construction laydown area. No excavation or trenching is proposed within the park. The construction laydown area would not have a direct impact to any houses listed as part of the HCA. There is the potential for trees to be removed as part of the establishment of the construction laydown area and this would result in a direct impact to this HCA. This impact, however, would not degrade the heritage significance associated with the HCA.
Henson Park (Marrickville LEP 2011 – Item 71)	The possible construction of the transmission cable circuit through this park would be located behind the two grandstands and away from the oval itself. The transmission cable route would be through a current grassed area and is not expected to impact on any structures or other trees that are present within the Henson Park heritage listed area.
Brick Paving (Marrickville LEP 2011 Item 98)	Construction activities within the road reserve, including trenching, would occur in proximity to this item. The brick paving also extends to the kerb and includes the kerbing in some areas. Potential impacts to this item would be

Heritage item/HCA	Direct impacts
	determined during the detailed design stage. However, as this item is located outside (but adjacent to) the road reserve, it is expected that impacts would be avoided.
The Abergeldie Estate Heritage Conservation Area (Marrickville LEP 2011 – Item C1)	Construction activities, including trenching, would occur along Arlington Street within this HCA. While construction would not have a direct impact on any listed houses, there is the potential for street trees that are included in the heritage listing to be removed, which would be a direct impact to this HCA.
Goodsell Estate Heritage Conservation Area (Marrickville LEP 2011 Item C16)	Construction activities, including trenching and establishment of a construction laydown area, would occur within this HCA. The project area within this HCA has been assessed as having no archaeological potential relating to the historical steam driven brick pit operations. While construction would not have a direct impact on any houses listed as part of the HCA, there is the potential for street trees to be removed. The removal of street trees would result in a direct impact to this HCA.
Llewellyn Estate Heritage Conservation Area (Marrickville LEP 2011 Item C14)	Construction activities, including trenching, would occur within the road reserve. While construction would not have a direct impact on any houses listed as part of the HCA, there is the potential for street trees to be removed. The removal of street trees would result in a direct impact to this HCA.

15.3.2 Construction impacts - indirect

A construction noise and vibration impact assessment has been undertaken for the project as part of the EIS. The vibration assessment undertook additional assessment of minimum working distances to all heritage items located within the study area, so as not to cause cosmetic damage. The equipment assessed included specific hydraulic and manual hammer equipment of varying classes. If these minimum working distances are complied with, then no adverse impacts from vibration intensive works are likely in terms of cosmetic damage. The minimum working distances are shown in **Table 15-4**.

Table 15-4 Minimum working distances of vibration intensive equipment to be used during the project

Plant	Rating/description	Minimum working distances to not cause cosmetic damage[1] to heritage items (metres)
Jack hammer	Hand-held	1 (nominal)
Hydraulic hammer (rock breaker)	300 kilograms - 5 to 12 tonne excavator	4
	900 kilograms – 12 to 18 tonne excavator	12
	1,600 kilograms – 18 to 34 tonne excavator	34
Piling rig	Hammer – 12 tonne down force	24

Note:

1 Cosmetic damage refers to minor damage which is not structural.

Based on the recommended minimum work distances and distances of built heritage items within the study area (including within HCAs), vibration impacts on heritage items are considered unlikely where jack hammers or hydraulic hammers up to 300 kilograms are used. The use of hydraulic hammers of a 900 kilogram size or greater is considered likely to have the potential for cosmetic or structural impacts on heritage items if used within road reserves. This is because built structures are not likely to be greater than 12 metres from rock breaking works.

The minimum working distances are therefore proposed as the mitigation measures to avoid or minimise vibration impacts on heritage items (refer to **Section 15.4.2**).

15.3.3 Operational impacts

There are not expected to be any impacts, including direct or indirect, to the known HCAs or other heritage items during the operation of the project. Construction laydown areas would be returned to their original state and have no ongoing operational impact. Operational impacts are not considered likely to affect any of the known heritage-listed sites.

There are potentially three permanent cable bridges that would be the only visible infrastructure after the project has been completed. These three bridges are not located within any HCAs or adjacent to any SHR listed items. As such, there are not expected to be any visual impacts of above ground infrastructure associated with the project on any HCAs.

15.3.4 Archaeological impacts

The transmission cable route is primarily located within road reserves, with the exception of several locations where it would cross private property and public open space (such as at the Cooks River at Croydon Park/Campsie, Henson Park, Camdenville Park and Sydney Park). The potential for the project to impact on potential archaeology within road reserves is considered negligible given the levels of previous disturbance and has not been considered further. Where the project crosses areas of open space, further consideration of archaeological potential has been undertaken.

The project area at the location of the proposed Cooks River crossing was first granted to William Pascoe Crook and does not appear to have been used. After the land was subdivided in the 1890s the area for the proposed crossing route was taken as a transmission line easement in 1903. As such, there was no development along the foreshore of Cooks River where the transmission cable route would be constructed, and therefore there is no potential for archaeological material.

Camdenville Park was formerly a brick pit and the remodelling of this area into the current open space would have disturbed most of the surrounding area. It is unlikely that any historical archaeological relics would be present within this HCA associated with the former brickworks.

Sydney Park also contains an area where former brick pits were located, being associated with the former Sydney Park brickworks. The landscaping works that have been undertaken in the creation of Sydney Park are likely to have removed any potential historical archaeological remains that may have been present at this location. The infrastructure associated with the former brick pits along the southern boundary of Sydney Park included a former pit only, and the Terrace Houses that are still present today (but are outside the project area). It is unlikely that the project would disturb any intact in situ subsurface historical archaeological deposits or relics that may be associated with the former brickworks area as they are likely to have been disturbed or removed during previous landscaping works.

As such, excavation works within public open space at the Cooks River, Henson Park, Camdenville Park and Sydney Park are assessed as unlikely to impact on any potential archaeological relics due to their historical land uses and significant levels of past disturbance.

There would not be impacts to any known or potential historical archaeological deposits located at any of the construction laydown areas. There would be minimal ground disturbance required for each construction laydown area.

15.4 Environmental management and mitigation measures

The Historical Heritage Impact Assessment identified a number of potential impacts to heritage items. Potential impacts would be limited to direct incursion into the curtilage of historic items (but not direct impacts to the physical items), trenching and excavation, underboring, tree removal, temporary visual impacts during works and potential impacts caused by vibration during construction.

The identified impacts can, however, be avoided, reduced or minimised through the implementation of the environmental management and mitigation measures described in **Section 15.4.2**.

15.4.1 Management objectives

Objectives for the management of project impacts would continue to be investigated throughout the development of the project to identity further opportunities to minimise any adverse impacts generated by the project.

Management objectives for heritage impacts include:

- avoiding or minimising direct impacts on heritage listed items or HCAs;
- avoiding removal of street trees and plantings, wherever feasible and reasonable;
- maintaining the heritage values of HCAs;
- avoiding cosmetic damage to heritage buildings or structures; and
- managing unexpected historic finds.

15.4.2 Environmental management and mitigation measures

Table 15-5 presents the proposed management and mitigation measures for heritage impacts including the timing of their implementation.

Table 15-5 Environmental management measures and mitigation

No.	Impact/issue	Environmental management and mitigation measures	Timing
NAH1	Impact on Alexandra Canal and Potts Hill Reservoirs 1 and 2	Works in the vicinity of Alexandra Canal at Beaconsfield West substation and the Potts Hill Reservoirs 1 and 2 will be managed by the Cultural Heritage Management Plan (CHMP) (refer to NAH6) to ensure that there are no direct impacts on the canal walls or the reservoirs.	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
NAH2	Removal of street trees/plantings at the intersection of Seventh Avenue and Fifth Avenue (Canterbury LEP 2012 Item 55)	The project will avoid impacts to heritage listed street plantings on Fifth Avenue wherever feasible and reasonable. During construction, manual excavation and monitoring by an arborist, with exclusion fencing used to protect trees from indirect impacts if there are works in their immediate vicinity, will be considered. If tree removal cannot be avoided, a tree replanting strategy will be discussed and agreed with the relevant local council, with consideration of the Canterbury Bankstown Tree Management Manual (Canterbury Bankstown Council, 2015).	Detailed design and construction
NAH3	Impacts on the Brick Paving (Marrickville LEP 2011 Item 98)	The design of the final transmission cable route will avoid the footpath that includes the brick paving that is immediately adjacent to the transmission cable route.	Detailed design and construction
NAH4	Impact on heritage values of the HCAs from tree removal	Removal of street trees identified as providing contributory heritage values within HCAs will be avoided where possible. If tree removal cannot be avoided, a tree replanting strategy will be developed in consultation with the relevant local council.	Construction
NAH5	Damage to heritage structures from vibration	Minimum working distances will be enforced when working in proximity to heritage structures. This includes: • hand-held jack hammers will be used, if needed, at least one metre away from the location of a heritage item; • hydraulic hammers up to 300 kilograms will only be used if greater than four metres away from the location of a heritage item; • hydraulic hammers up to 900 kilograms will only be used if greater than 12 metres away from the location of a heritage item; and • hydraulic hammers up to 1,600 kilograms will only be used if greater than 34 metres away from the location of a heritage item. If minimum working distances cannot be maintained during construction, a CHMP will be developed that includes building condition surveys and/or vibration monitoring as per environmental management measure NV14 (refer to **Chapter 8 Noise and vibration**).	Construction
NAH6	General construction impacts	A CHMP will be produced for the project as part of the Construction Environmental Management Plan (CEMP) to manage impacts on identified heritage items. The CHMP will: • guide appropriate responses to identified heritage constraints during construction; • define limits to machinery use and construction activity in proximity to heritage structures to avoid vibration impacts; • detail where and when monitoring will be undertaken to ensure no vibration or other indirect impacts on identified heritage items;	Detailed design and construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
		• define any protectionary fencing required to delineate safe working areas and/or no-go areas in relation to heritage protection; and • include maps showing the location and curtilage of heritage items. A toolbox presentation or project induction will be held with all staff and contractors prior to the commencement of works to make them aware of their responsibilities with regard to avoiding heritage impacts. Once the final design is known, the relevant local councils within the project area will be informed of any anticipated impacts to heritage items.	
NAH7	Unexpected finds	In the event that unexpected historic finds are identified during construction, all works will immediately cease at that area. Unexpected finds may include artefact scatters (including glass, animal bone, ceramic, brick and metal), building foundations and earthworks of unknown origin. The following procedure guides the management of unexpected and previously unidentified finds during the course of project works: • all work in the area will cease immediately; • alert the Environmental Specialist to the find; • if necessary, protect the area with fencing; • engage a suitably qualified archaeologist to undertake an assessment of the find/s; • if it is determined the relic is likely to be significant, a Section 146 notification form will be sent with a short letter report to the Heritage Council notifying them of the discovery; • an assessment will be undertaken using the guidelines *Assessing Significance for Historical Archaeological Sites and 'Relics'* (NSW Heritage Branch, 2009); • on the advice of the archaeologist, if necessary, prepare an Impact Assessment with Research Design and Methodology to submit to the Heritage Division along with a Section 140 excavation permit to undertake archaeological works; • undertake the archaeological mitigation in accordance with the prepared documents and any permit/exception issued by the Heritage Division; and • once the site has been mitigated to the satisfaction of the archaeologist and the Heritage Division, works may resume in the area.	Construction

16.0 Soils and contamination

This chapter provides an overview of the potential impacts to soil as a result of the construction and operation of the project, including identifying potential risks from contamination. It also outlines the proposed management and mitigation measures to mitigate impacts, as detailed in the Preliminary Site Investigation report in **Appendix K**.

16.1 Assessment methodology

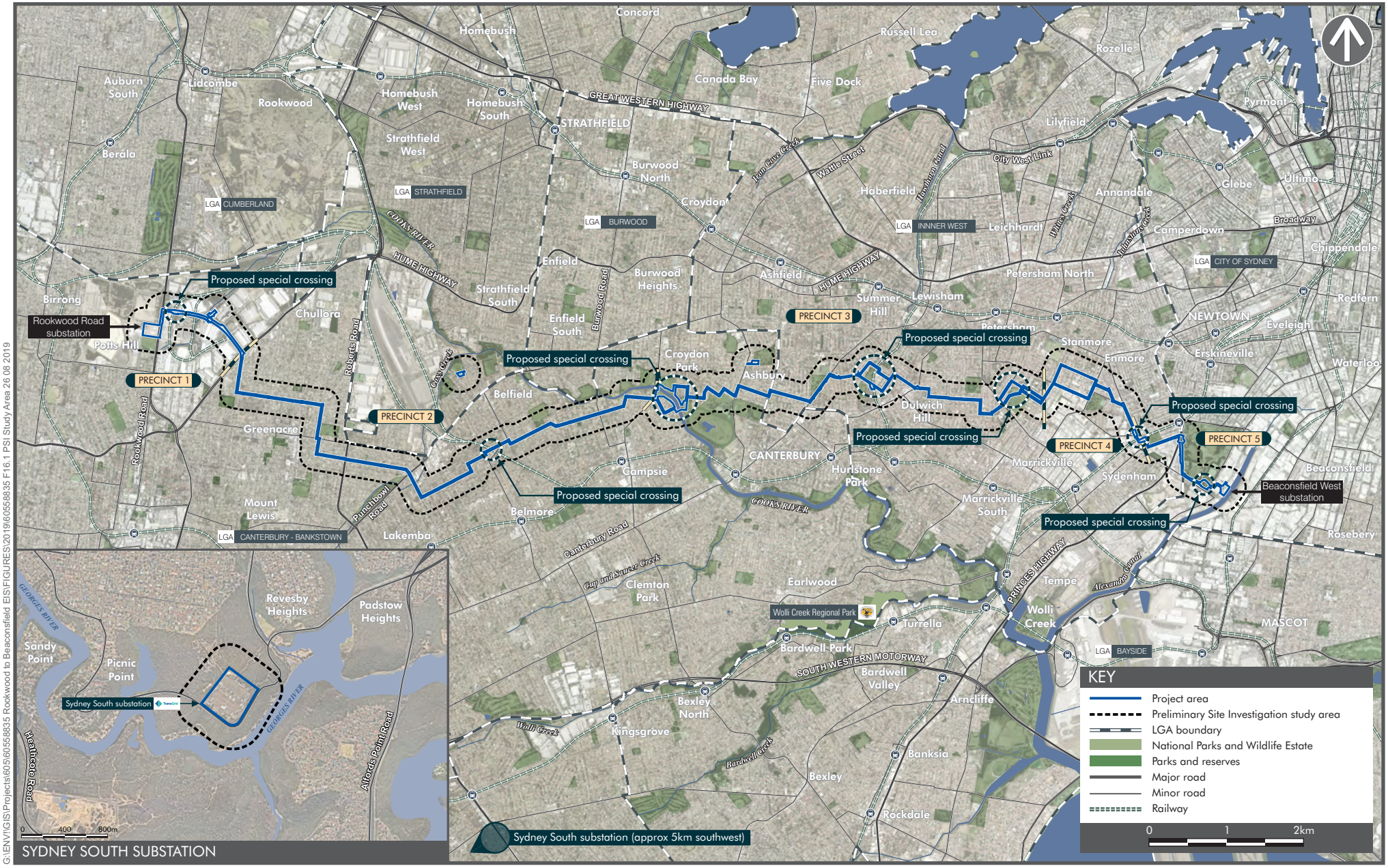
16.1.1 Soils and contamination

The methodology to assess potential soils and contamination impacts included:

- a review of published geology, soils and acid sulfate soil risk maps;
- a review of the current land use (using current aerial imagery and zoning maps) and historical land use (using 1943 aerial imagery and City of Sydney Historical Atlas of Sydney) to identify areas of commercial/industrial land use and other potentially contaminating land sources;
- review of Lotsearch Pty Ltd (Lotsearch) Environmental Risk and Planning (ERP) reports where current or historical commercial/industrial land use was identified as well as information such as known contaminated sites, historical business activities, historical aerial photographs, registered groundwater wells, Local Environmental Plans (LEP), and heritage items within 1 kilometre of the project area;
- review of relevant publicly available geotechnical and contamination reports;
- developing a preliminary conceptual site model by identifying potential areas and contaminants of potential concern, potential human and ecological receptors, exposure pathways during construction, and exposure pathways during operation or completion of the project; and
- identifying the need for further investigations and developing management and mitigation measures for the project.

16.1.2 Study area

For the soils and contamination assessment, the study area comprises the project area and a 200 metre buffer around the project area, as shown on **Figure 16-1**.



SYDNEY SOUTH SUBSTATION

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Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018)

SOILS AND CONTAMINATION STUDY AREA

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

FIGURE 16-1

16.2 Existing environment

This section provides an overview of the existing soil environment and potential and known contamination within the study area and includes the following:

- a description of the overall soil landscape (including historical cut-and-fill activities which have altered the soil landscape) and the acid sulfate soil risk classification across the study area;
- the underlying geology of the study area; and
- potential contamination that may affect the project including contamination that may have historically occurred as a result of current businesses or land uses involving potentially contaminating activities.

Further investigation was undertaken including:

- a search of the NSW EPA record of notices and notified, licensed or delicensed sites;
- a review of previous environmental assessments and the contamination that was recorded during these assessments;
- the determination of potential contaminated areas and associated contaminants of concern; and
- the identification of sensitive human and environmental receptors.

Existing waterways, drainage and topography of the study area is described in **Chapter 17 Surface water and flooding**. The existing groundwater environment within the study area is described in **Chapter 18 Groundwater**.

16.2.1 Soil landscapes

The Soil Landscapes of the Sydney 1:100 000 Sheet (Chapman and Murphy, 1989) characterises the landscape across the study area. The project would traverse three soil landscapes being Blacktown (bt), Birrong (bg) and Disturbed terrain (xx).

As the project area is located within an urban environment, landscape alteration is common and ranges from minor landscaping to extensive cut and fill activities associated with the construction of major buildings and infrastructure. The fill typically consists of locally excavated and imported materials. More substantial filling has occurred along low lying areas such as the Cooks River and Alexandra Canal where some areas have been reclaimed from locally dredged river sediments.

The study area crosses a number of areas that were former brick pits and quarries that were subsequently infilled with waste material, including putrescible waste, in the following locations:

- Precinct 3: Henson Park, formerly Daley's brick pit quarry, was filled in between 1914 and 1933, likely with municipal waste;
- Precinct 5: Camdenville Park was filled in with municipal waste and incinerator waste between the early 1920s and 1950s; and
- Precinct 5: Sydney Park, formerly the Bedford Brick Works quarries, were filled with municipal waste between 1948 and 1976.

The study area also passes close to former infilled brick pits at:

- Precinct 3: Arlington Oval, former brick pit quarry filled prior to 1932, located about 40 metres south of the project area; and
- Precinct 3: Marrickville Park, former brick pit quarry filled prior to 1910 with municipal waste, located about 50 metres north of the project area.

Other areas of mapped disturbed terrain include:

- Precinct 1: western side of Rookwood Road, along most of Muir Road (east side of the railway corridor intersecting Muir Road) and surrounding land to the north and south; and
- Precinct 5: between the Princes Highway, St Peters and the Alexandra Canal.

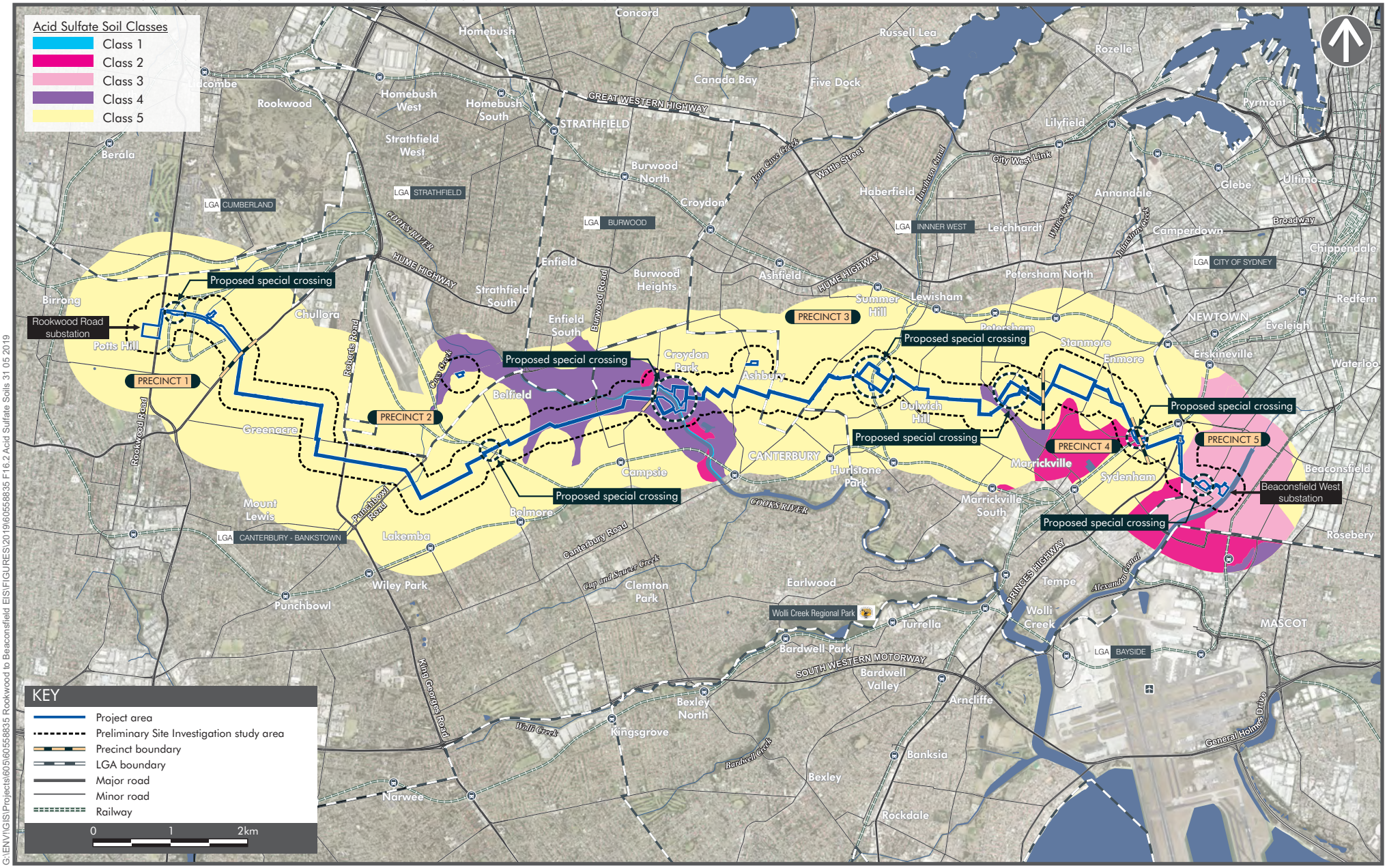
16.2.1.1 Acid sulfate soils

Acid sulfate soils (ASS) is the common name given to a range of soil types containing iron sulfides. ASS may be present as actual ASS (AASS) or potential ASS (PASS). When exposed to air, the iron sulfides (commonly pyrite) within ASS can oxidise, producing sulfuric acid. These soils may become exposed to air by either excavation or dewatering and may cause the generation of acidic runoff and/or the increased acidity of groundwater, which can impact on water quality and aquatic ecosystems.

The ASS risk class within the study area is largely Class 5 indicating no risk of intercepting acid sulfate soils for activities not resulting in the lowering of the water table by more than 1 metre, with the exception of the areas listed in **Table 16-1** and shown on **Figure 16-2**.

Table 16-1 Acid sulfate soil risk and class

Precinct	Section of project area	Probability	Acid sulfate soil risk classification
2 and 3	Along Omaha Street east of Baltimore Street and Seventh Avenue, Campsie to Hay/Harmony Street intersection in Canterbury (2.2 kilometre length)	Low	Class 4
3	Cooks River (35 metre length)	High	Class 1
3	Centennial Street, Sydenham Road and Neville Street, Marrickville (130 metre length)	Low	Class 4
4	Edgeware Road between Darley Street in Marrickville and May Street in St Peters (360 metre length)	Low	Class 2
5	Princes Highway to Alexandra Canal (1.3 km length) including the Beaconsfield West substation	Low	Class 3



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ACID SULFATE SOILS

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Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018), Office of Environment and Heritage (OEH), 2008

FIGURE 16-2

16.2.2 Geology

The geology within the study area is dominated by the Triassic aged Wianamatta Group that is overlain in part by Quaternary aged Alluvium and Marine deposits outcropping adjacent to major waterways. The Wianamatta Group includes Bringelly Shale (Rwb) and Ashfield Shale (Rwa) (Precincts 1-5). The Bringelly Shale is expected to underlie the Rookwood Road substation (Precinct 1). The residual soils derived from Bringelly Shale generally being between 3 metres and 6 metres thick and comprise medium to high plasticity clays. The Ashfield Shale comprises black to dark grey shale and laminite. The shale is underlain by the Hawkesbury Sandstone, a medium to coarse grained quartzose sandstone. The sandstone outcrops at the edge of the study area at Marrickville.

Quaternary Alluvium (Qha) is mapped within the floodplains of the Cooks River (Precinct 3) and comprise silty to peaty quartz sand, silt and clay. Quaternary Swamp Deposits (Qhs) composed of peat, sandy peat and mud are mapped within the floodplains of the Alexandra Canal (Precinct 5), including around 0.5 kilometres of the project area between the southern end of Sydney Park to Alexandra Canal. There is also a small area of Quaternary marine deposits (Qhd) mapped within Sydney Park, comprised of medium to fine-grained marine sand with podsols. The majority of the Qhd unit in Sydney Park was formerly excavated during the former brick works and filled with municipal, demolition waste and imported soil. The Beaconsfield West substation, along with about 500 metres of the transmission cable route, is expected to be underlain by the Qhs unit. The Sydney South substation, located north of the Georges River, is expected to be underlain by weathered Hawkesbury Sandstone.

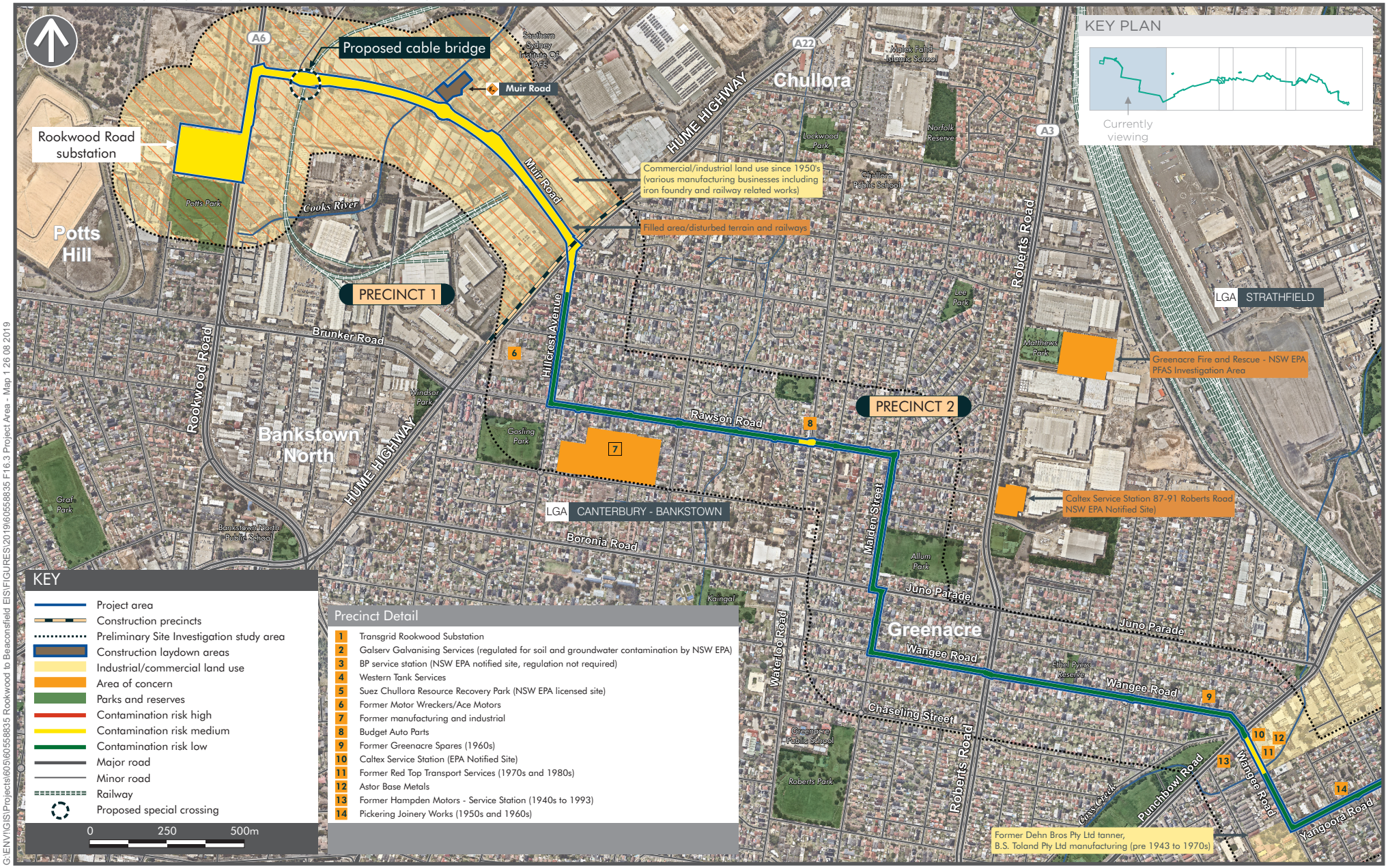
Igneous intrusions of Jurassic age including dykes are mapped within the study area. The cross cutting dykes are composed of basalt, dolerite and volcanic breccia. The project area passes through these dykes in Dulwich Hill at Arlington Street, Constitution Road, Terry Road, Hill Street, Denison Road and Pigott Street.

16.2.3 Potential contamination

Current potentially contaminating land uses identified within 50 metres of the project area are largely petrol stations, dry cleaners, workshops and industrial manufacturing sites listed in **Table 16-2**. The exact locations of each parcel are provided in **Appendix K**. The locations of potential contamination (i.e. specific areas with potentially contaminating land uses/activities) are also provided on **Figure 16-3**, **Figure 16-4**, **Figure 16-5** and **Figure 16-6**.

Table 16-2 Current potentially contaminating land uses

Precinct	Land use/activity
1	Substation, metal plating, petrol station, industrial tank washing and waste processing
2	Mechanical workshop, petrol station, electroplating
3	Fuel infrastructure, mechanics, petrol station and dry cleaning
4	Oil/fuel waste, petrol station (including vent pipes for underground storage tanks (USTs) on exterior wall, potential for USTs close to or beneath road), mechanics, dry cleaning and mechanical repair workshop
5	Engineering workshop, petrol station, depot and maintenance workshop, metal manufacturing and substation



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AREAS OF CONCERN - CONSTRUCTION PRECINCTS 1 TO 2

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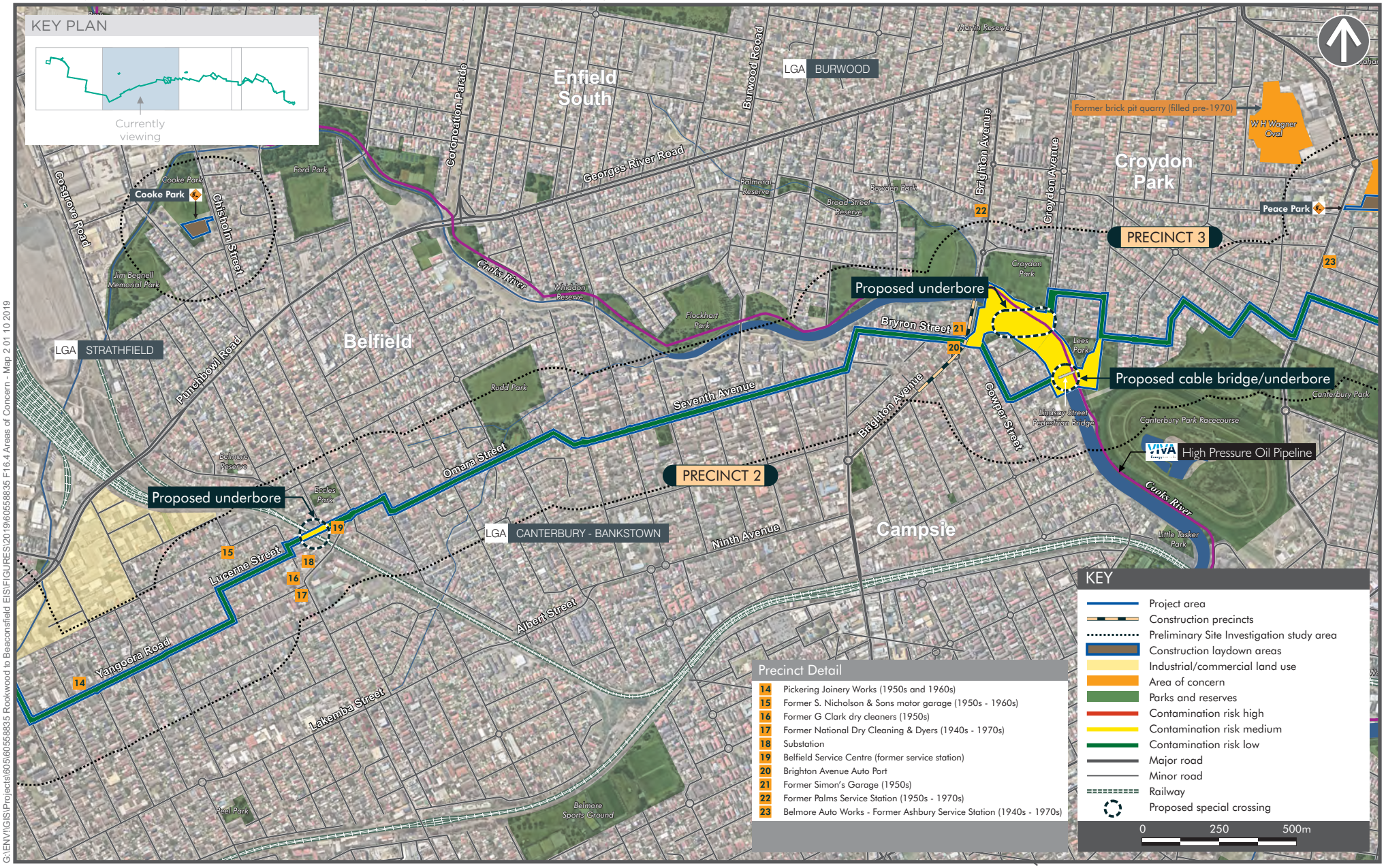
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018),

FIGURE 16-3



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AREA OF CONCERN - CONSTRUCTION PRECINCT 2 to 3

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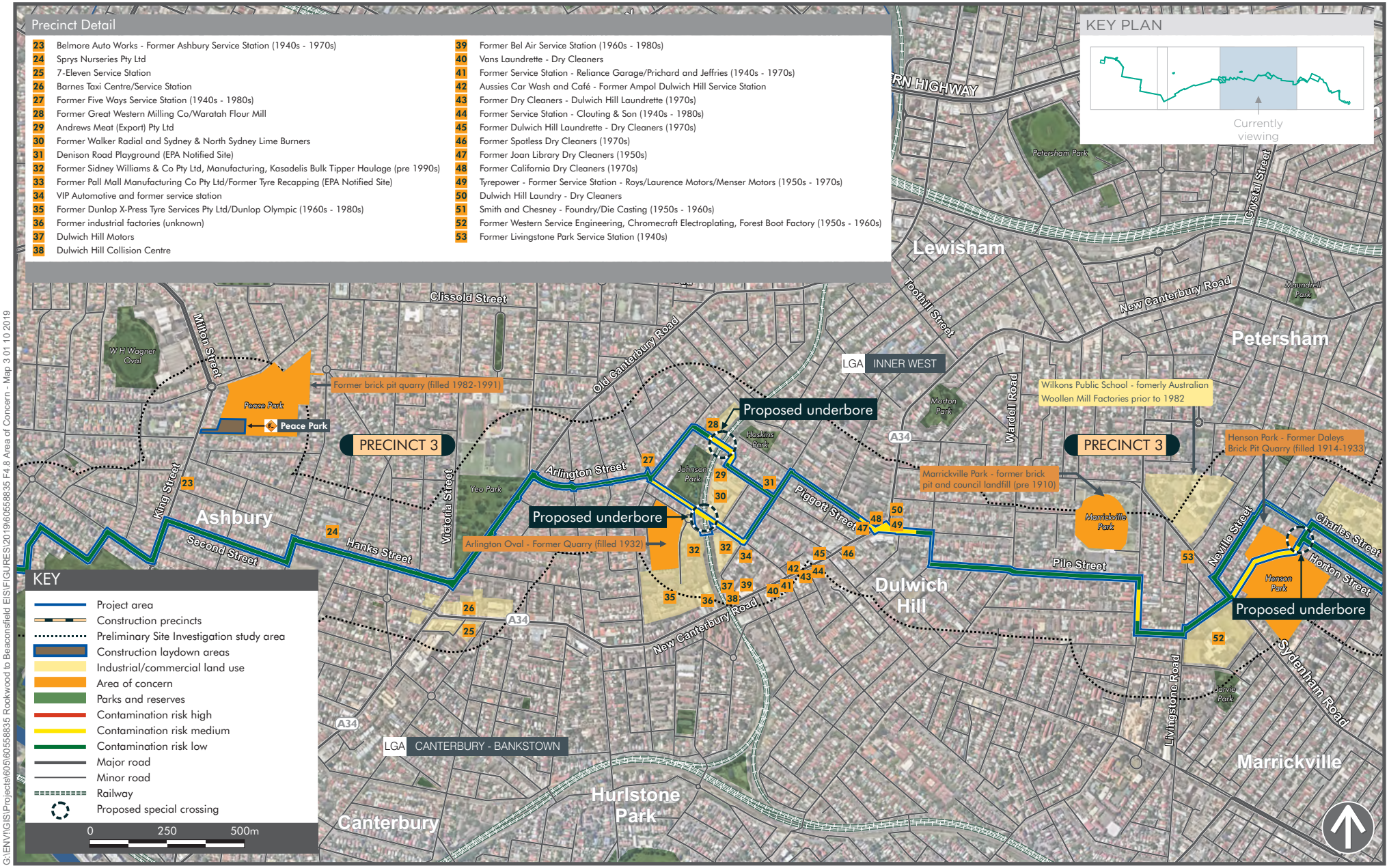
Potts Hill to Alexandria Transmission Cable Project

FIGURE 16-4

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018),

Precinct Detail

23	Belmore Auto Works - Former Ashbury Service Station (1940s - 1970s)
24	Sprys Nurseries Pty Ltd
25	7-Eleven Service Station
26	Barnes Taxi Centre/Service Station
27	Former Five Ways Service Station (1940s - 1980s)
28	Former Great Western Milling Co/Waratah Flour Mill
29	Andrews Meat (Export) Pty Ltd
30	Former Walker Radial and Sydney & North Sydney Lime Burners
31	Denison Road Playground (EPA Notified Site)
32	Former Sidney Williams & Co Pty Ltd, Manufacturing, Kasadelis Bulk Tipper Haulage (pre 1990s)
33	Former Pall Mall Manufacturing Co Pty Ltd/Former Tyre Recapping (EPA Notified Site)
34	VIP Automotive and former service station
35	Former Dunlop X-Press Tyre Services Pty Ltd/Dunlop Olympic (1960s - 1980s)
36	Former industrial factories (unknown)
37	Dulwich Hill Motors
38	Dulwich Hill Collision Centre
39	Former Bel Air Service Station (1960s - 1980s)
40	Vans Laundrette - Dry Cleaners
41	Former Service Station - Reliance Garage/Prichard and Jeffries (1940s - 1970s)
42	Aussies Car Wash and Café - Former Ampol Dulwich Hill Service Station
43	Former Dry Cleaners - Dulwich Hill Laundrette (1970s)
44	Former Service Station - Clouting & Son (1940s - 1980s)
45	Former Dulwich Hill Laundrette - Dry Cleaners (1970s)
46	Former Spotless Dry Cleaners (1970s)
47	Former Joan Library Dry Cleaners (1950s)
48	Former California Dry Cleaners (1970s)
49	Tyrepower - Former Service Station - Roys/Laurence Motors/Menser Motors (1950s - 1970s)
50	Dulwich Hill Laundry - Dry Cleaners
51	Smith and Chesney - Foundry/Die Casting (1950s - 1960s)
52	Former Western Service Engineering, Chromecraft Electroplating, Forest Boot Factory (1950s - 1960s)
53	Former Livingstone Park Service Station (1940s)



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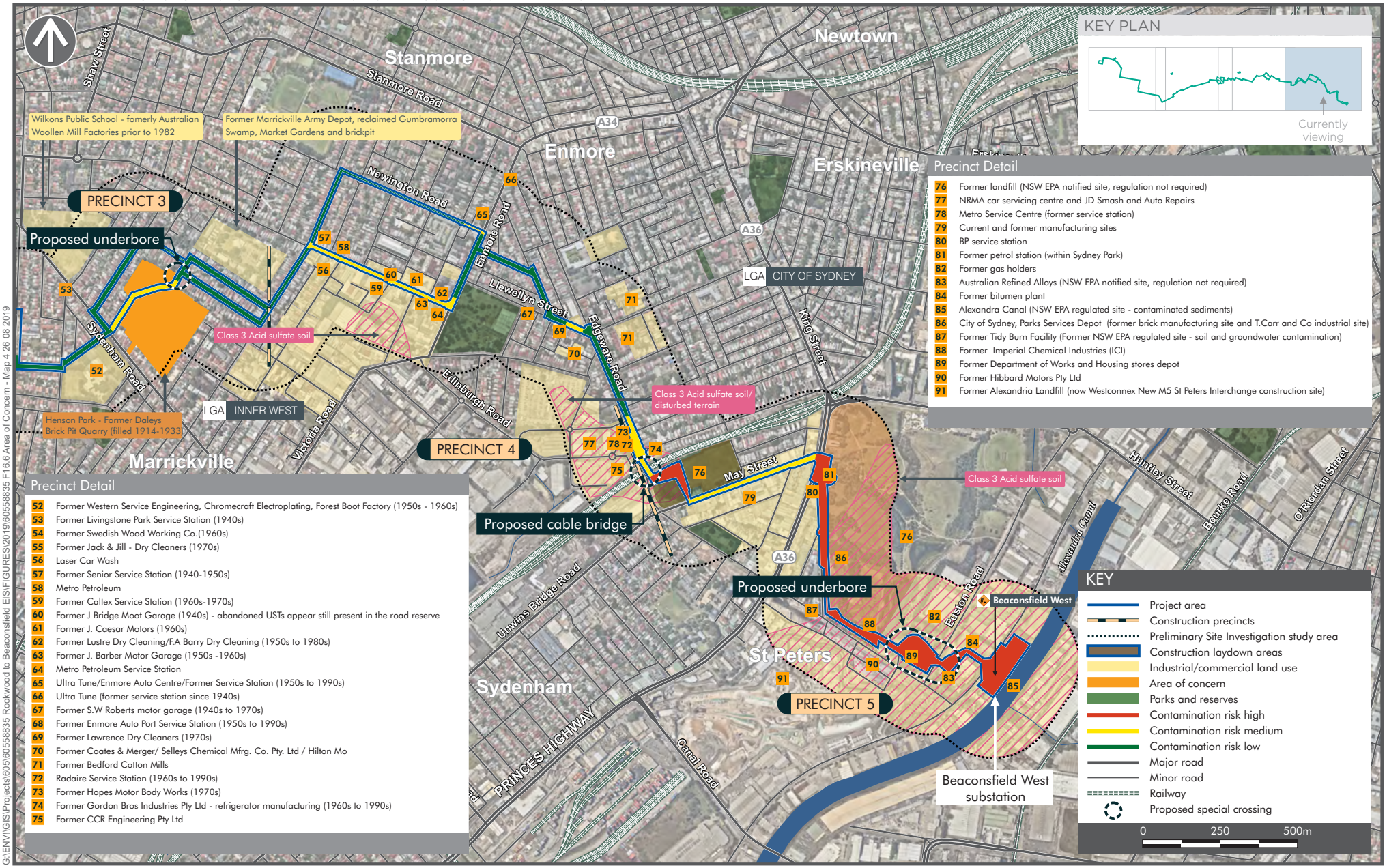
AREAS OF CONCERN - CONSTRUCTION PRECINCT 3

Powering Sydney's Future
Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018),

FIGURE 16-5



KEY PLAN

Precinct Detail

52	Former Western Service Engineering, Chromecraft Electroplating, Forest Boot Factory (1950s - 1960s)
53	Former Livingstone Park Service Station (1940s)
54	Former Swedish Wood Working Co.(1960s)
55	Former Jack & Jill - Dry Cleaners (1970s)
56	Laser Car Wash
57	Former Senior Service Station (1940-1950s)
58	Metro Petroleum
59	Former Caltex Service Station (1960s-1970s)
60	Former J Bridge Moot Garage (1940s) - abandoned USTs appear still present in the road reserve
61	Former J. Caesar Motors (1960s)
62	Former Lustre Dry Cleaning/F.A Barry Dry Cleaning (1950s to 1980s)
63	Former J. Barber Motor Garage (1950s -1960s)
64	Metro Petroleum Service Station
65	Ultra Tune/Enmore Auto Centre/Former Service Station (1950s to 1990s)
66	Ultra Tune (former service station since 1940s)
67	Former S.W Roberts motor garage (1940s to 1970s)
68	Former Enmore Auto Port Service Station (1950s to 1990s)
69	Former Lawrence Dry Cleaners (1970s)
70	Former Coates & Merger/ Selleys Chemical Mfrg. Co. Pty. Ltd / Hilton Mo
71	Former Bedford Cotton Mills
72	Radaire Service Station (1960s to 1990s)
73	Former Hopes Motor Body Works (1970s)
74	Former Gordon Bros Industries Pty Ltd - refrigerator manufacturing (1960s to 1990s)
75	Former CCR Engineering Pty Ltd

Precinct Detail

76	Former landfill (NSW EPA notified site, regulation not required)
77	NRMA car servicing centre and JD Smash and Auto Repairs
78	Metro Service Centre (former service station)
79	Current and former manufacturing sites
80	BP service station
81	Former petrol station (within Sydney Park)
82	Former gas holders
83	Australian Refined Alloys (NSW EPA notified site, regulation not required)
84	Former bitumen plant
85	Alexandra Canal (NSW EPA regulated site - contaminated sediments)
86	City of Sydney, Parks Services Depot (former brick manufacturing site and T.Carr and Co industrial site)
87	Former Tidy Burn Facility (Former NSW EPA regulated site - soil and groundwater contamination)
88	Former Imperial Chemical Industries (ICI)
89	Former Department of Works and Housing stores depot
90	Former Hibbard Motors Pty Ltd
91	Former Alexandria Landfill (now Westconnex New M5 St Peters Interchange construction site)

KEY

- Project area
- Construction precincts
- Preliminary Site Investigation study area
- Construction laydown areas
- Industrial/commercial land use
- Area of concern
- Parks and reserves
- Contamination risk high
- Contamination risk medium
- Contamination risk low
- Major road
- Minor road
- Railway
- Proposed special crossing

0 250 500m

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AREAS OF CONCERN - CONSTRUCTION PRECINCT 4 to 5

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Potts Hill to Alexandria Transmission Cable Project

Note: The project area is confined to the roadway reserve with the exception of parks and existing substations
Source: Department of Finance, Services and Innovation - Spatial Services (2018), Nearmap (2018),

FIGURE 16-6

16.2.3.1 NSW EPA Record of Notices and notified, licensed or delicensed sites

The NSW EPA Record of Notices is a database of sites that have been issued a regulatory notice in relation to the site under the CLM Act. There are four sites listed on the NSW EPA Record of Notices within the study area:

- Precinct 1:
  - Galserv Galvanising Services, 117-153 Rookwood Road, Yagoona;
- Precinct 5:
  - Sydney Park, Alexandria;
  - Former Tidyburn Facility, 53 Barwon Park Road, St Peters; and
  - Alexandra Canal.

The Galserv Galvanising Services site is directly adjacent to the transmission cable route (refer to **Figure 16-3**). Galserv Galvanising Services was declared a remediation site (number 21095) in 2006. The site was contaminated in such a way as to present a significant risk of harm to human health and the environment based on contaminated groundwater with high concentrations of metals and ammonia. Furthermore, asbestos was found in the unsealed area south of the site.

Groundwater is expected to flow to the east of Rookwood Road due to the topography and drain towards the Cooks River, therefore the potential for groundwater impacts within Rookwood Road from the Galserv site is considered to be low. Groundwater in the vicinity of Muir Road (likely to be encountered at depths greater than 3 metres below ground level) may be impacted by contaminated groundwater migrating from the Galserv site. Depending on the concentrations of ammonia and preferential pathways, there could be a potential for subsurface ammonia vapours from groundwater in the vicinity of Rookwood Road. No data or reports were available for review for the Galserv site.

The project area would pass through Sydney Park along the western and southern perimeter (refer to **Figure 16-6**). Sydney Park was declared significantly contaminated land by the NSW EPA on 25 February 2019 due to methane and carbon dioxide concentrations in ground gas from former use as a landfill. The landfill gas risk would be managed during construction. Landfill gas is discussed further in **Chapter 9 Air quality**.

The former Tidyburn Facility was located on the corner of Barwon Park Road and Campbell Road, 15 metres west and topographically up-gradient of the transmission cable route (refer to **Figure 16-6**). The property was formerly declared to contain polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPH) and Benzene, toluene, ethylbenzene, xylenes (BTEX) contamination in soil and naphthalene and TPH in groundwater that presented a significant risk of harm to human health and the environment. The property was subsequently remediated and redeveloped into high density residential apartments. A site audit statement was issued in February 2015 and the NSW EPA remediation order was repealed in June 2015. The property is therefore not considered to be a current source of contamination to soil and groundwater within the study area.

The NSW EPA declared the Alexandra Canal (refer to **Figure 16-6**) a remediation site in August 2000 and issued a remediation order to Sydney Water Corporation for the Alexandra Canal sediments in March 2012 due to the presence of chlorinated hydrocarbon, organochlorine pesticide, polychlorinated biphenyl and metal contamination in sediments along the canal. The order prevents activities that would result in the disturbance of the bed sediments.

The NSW EPA also maintains a list of notified contaminated sites that have been reported to NSW EPA. This occurs where the notifier considers that the site is contaminated and warrants reporting to the NSW EPA. However, it may not yet be determined whether the contamination on the site is significant enough to warrant regulation under the CLM Act, as explained above. Seven sites were listed on the NSW EPA record of notified sites within the study area and are detailed in **Table 16-3** and are shown in **Figure 16-3**, **Figure 16-4**, **Figure 16-5** and **Figure 16-6**.

Table 16-3 Sites notified to the NSW EPA

Precinct	Site name and address	Description of notification	Proximity to transmission cable route
1	BP Service Station Potts Hill, 155 Rookwood Road, Yagoona	'Service station' on NSW EPA Contaminated Land list. Regulation under the *Contaminated Land Management Act 1997* (CLM Act) not required.	< 5 metres
2	Caltex Service Station, 81 Wangee Road, Lakemba	'Service station' on NSW EPA Contaminated Land list. Regulation under CLM Act not required.	< 5 metres
3	Denison Road playground, 194 Denison Road, Dulwich Hill	'Landfill', on NSW EPA Contaminated Land list. Regulation under CLM Act not required.	< 5 metres
3	Former Tyre Recapping, 115-117 Constitution Road, Dulwich Hill	'Other industry' on NSW EPA Contaminated Land list. Regulation under CLM Act not required.	< 5 metres
4	Camdenville Park, May Street, St Peters	'Other industry' on NSW EPA Contaminated Land list. Regulation under CLM Act not required.	Project area transects this site
5	BP Express, Service Station, 2 Princes Highway, St Peters	'Service station' on NSW EPA Contaminated Land list. Regulation under CLM Act not required.	<10 metres
5	Australian Refined Alloys, 202-212 Euston Road, Alexandria	'Other industry' on NSW EPA Contaminated Land list. Regulation under CLM Act not required.	Project area transects this site

16.2.3.2 Recorded contamination

Various previous assessments have been undertaken within the study area as part of separate investigations. This section outlines the contamination that has been recorded during these previous assessments.

Precinct 1 – Rookwood Road substation

A Site Audit Report (SAR) was prepared by ERM and a Remediation and Validation Report was prepared by Coffey in 2009 for the Rookwood Road substation, prior to its development as a substation. The reports noted that the site was formerly used for grit blasting and application of protective coatings to metallic items. The contaminants of potential concern (CoPCs) identified based on the site history review undertaken by Coffey (2009) were heavy metals, petroleum hydrocarbons, BTEX, asbestos, polychlorinated biphenyls (PCBs), phenols and organochlorine pesticides (OCPs). Remediation was undertaken by removal of shallow contaminated soils to the extent practical by Coffey in 2008. Residual grit remained along the eastern and southern margins of the property and was not considered to present a risk to human health or the environment. The SAR stated that the site was suitable for commercial/industrial land use.

It was recommended in the SAR and the Remediation and Validation Report that during further excavation works at the site, if materials are encountered with observable odours, discolouration or staining, an assessment should be made by a qualified environmental consultant and implementation of an unexpected finds protocol should be undertaken during any future development works.

Precinct 5 – Camdenville Park

A Remedial and Construction Environmental Action Plan was prepared for Camdenville Park, St Peters (GHD, 2013) which noted the site was formerly used for clay/shale quarrying and production of bricks and considered to be contaminated by waste materials (lead and petroleum hydrocarbons). The Action Plan details remedial works to be undertaken in association with Marrickville Council's upgrade works at the park.

Precinct 5 – Sydney Park

A preliminary geotechnical investigation and contamination advice report was prepared for the proposed transmission cable route through Sydney Park in Alexandria (Douglas Partners, 2017) including historical information on previous investigations within Sydney Park.

The report found that fill material across the length of the transmission cable route is likely to be variable, but typically comprised of sand and gravel with some building waste (bricks, glass, concrete, ceramic, metal), sandstone and some clay. Domestic waste (from the former landfill) would also be encountered within the excavation areas. Landfill gas screening recorded very low to negligible detection.

Precinct 5 – Australian Refined Alloys 202-212 Euston Road

A Remedial Action Plan (RAP) was prepared for Enirgi Metals Group Pty Ltd (Enirgi) for their property operating as Australian Refined Alloys at 202-212 Euston Road, Alexandria (ERM, 2017). The project area would pass through the western and northern part of the property between Euston Road and Burrows Road. The RAP found that based on previous investigations, the CoPCs for the property were asbestos, heavy metals, PAHs, OCPs, PCBs, total recoverable hydrocarbons (TRH), BTEX, acidity and volatile organic compounds (VOCs).

Groundwater levels gauged between 2006 and 2016 ranged between 1.5 and 2.8 metres below ground level. Concentrations of copper, lead and zinc in groundwater exceeded the ANZECC (2000) 80% marine trigger values in two monitoring wells within proximity of the project area.

Precinct 5 – Beaconsfield West substation

A Phase 1 Environmental Site Assessment (ESA) with limited sampling was undertaken for the Beaconsfield West substation (PB, 2005). The Phase 1 ESA comprised a desktop review of potential contamination at the property, as well as the collection of soil samples from three locations. No exceedances of the adopted commercial/industrial criteria were reported.

A number of Phase II Environmental Site Assessments (i.e. intrusive investigations) were undertaken (Aargus, 2009a,b,c). Assessment results noted exceedances of lead, total petroleum hydrocarbons and several contaminants. Asbestos was also widely reported and concluded to present a risk to human health and the environment.

16.2.3.3 Potential areas and contaminants of concern

Potential areas and CoPCs within the study area are described in **Table 16-4**. Only sources or activities that are within, adjacent or topographically up-gradient have been considered as potential areas and sources of contamination. The locations are shown in **Figure 16-3**, **Figure 16-4**, **Figure 16-5** and **Figure 16-6**.

Table 16-4 Potential areas and contaminants of concern – precincts and Sydney South substation

Source or area	Site located within or outside of proposed excavation area	CoPC
Precinct 1		
Rookwood Road substation	Within	Heavy metals (aluminium, arsenic, copper, cadmium, chromium, nickel, lead, zinc and mercury), petroleum hydrocarbons, asbestos, PCBs, phenols, and OCPs

Source or area	Site located within or outside of proposed excavation area	CoPC
Galserv Galvanising Services, 117-153 Rookwood Road (EPA regulated site)	Outside	Heavy metals (zinc, lead, cadmium, copper, nickel and arsenic), pH, ammonia, cyanide, Per- and poly-fluoralkyl substances (PFAS)
Service station (BP Potts Hill, 155 Rookwood Road, Yagoona)	Outside	Petroleum hydrocarbons, lead
Disturbed terrain/filled land along Muir Road	Within and outside	Heavy metals, asbestos, hydrocarbons, pesticides
Former railways under Muir Road	Within	Heavy metals, asbestos, creosote, hydrocarbons
Suez Recycling & Recovery Pty Ltd, Muir Rd, Chullora	Outside	Heavy metals, hydrocarbons, pesticides
Various historical manufacturing industries	Outside	Heavy metals, hydrocarbons, VOCs and semi-volatile organic compounds (SVOCs), PFAS
Herbicide application along waterways	Outside	Herbicides
Precinct 2		
Budget Auto Parts (workshop) 24 Rawson Road, Greenacre	Outside	Petroleum hydrocarbons, lead
Service stations and workshops (Lakemba and Belmore)	Outside	Petroleum hydrocarbons, lead, solvents
Former Dehn Bros tannery in Lakemba	Outside	Chromium III and VI, manganese, aluminium, ammonium sulfate, ammonia, ammonium nitrate, arsenic phenolics, formaldehyde, sulfide, tannic acid
Precinct 3		
Service stations (Cooks River crossing and Dulwich Hill)	Outside	Petroleum hydrocarbons, lead
Viva Energy high pressure oil pipeline at Cooks River	Within	Petroleum hydrocarbons
Potential filling from unknown source	Within	Heavy metals, asbestos, hydrocarbons, pesticides
Dry cleaners (Dulwich Hill)	Outside	Chlorinated and petroleum hydrocarbons
Former landfill (Arlington Oval and Marrickville Park)	Outside	Landfill gases, heavy metals, nutrients, asbestos, hydrocarbons, pesticides, PFAS
Former landfill (Henson Park)	Within	
Foundries (Dulwich Hill and Marrickville)	Outside	Heavy metals, phenols, PFAS
Various historical manufacturing industries (Dulwich Hill)	Outside	Heavy metals, hydrocarbons, VOCs and SVOCs, PFAS
Precinct 4		
Former and current service stations in Addison Road and east end of Edgeware Road	Outside	Petroleum hydrocarbons, lead

Source or area	Site located within or outside of proposed excavation area	CoPC
Various current and former dry cleaners in Addison Road and Llewellyn Street	Outside	Chlorinated and petroleum hydrocarbons
Various historical manufacturing industries (Marrickville)	Outside	Heavy metals, hydrocarbons, VOCs and SVOCs, PFAS
Precinct 5		
Numerous existing and former petroleum service stations and mechanical workshops	Outside and within	Petroleum hydrocarbons, lead
Various historical manufacturing sites	Outside and within	Heavy metals, hydrocarbons, VOCs and SVOCs, PFAS
Disturbed terrain/fill	Outside and within	Heavy metals, asbestos, petroleum hydrocarbons, pesticides
Former landfills: Camdenville Park and Sydney Park	Outside and within	Landfill gases, heavy metals, nutrients, asbestos, petroleum hydrocarbons, pesticides, PFAS
Beaconsfield West substation	Within	Petroleum hydrocarbons, asbestos, PCBs, heavy metals
Precincts 1 to 5 (general road reserve area)		
Imported fill for road construction/maintenance or service trenches	Within	Heavy metals, asbestos, petroleum hydrocarbons, pesticides
Underground services	Within	Asbestos and pesticides
Road accidents	Within	Petroleum hydrocarbons
Sydney South substation		
Sydney South substation	Within	Heavy metals, petroleum hydrocarbons, asbestos and PCBs

Note:
Petroleum hydrocarbons include total recoverable hydrocarbons (TRH), polychlorinated hydrocarbons (PAH) and monocyclic aromatic hydrocarbons (benzene, toluene, ethylbenzene, and total xylenes [BTEX]).

Potential areas and CoPCs at the construction laydown areas are described in **Table 16-5**.

Table 16-5 Areas and contaminants of potential concern – construction laydown areas

Construction laydown area	Potential contaminating activities and/or sources	CoPC
12 Muir Road, Chullora	Infilling of former Cooks River tributary and Muir Road construction	Heavy Metals, asbestos, hydrocarbons, PCBs
	Chullora iron foundry	Heavy metals, hydrocarbons, asbestos
	Herbicide application along waterway of the Cooks River drainage line and associated ponds	Herbicides
	Former railway activities when formerly part of Chullora railway workshops/World War II aircraft and ammunition factories	Heavy metals, hydrocarbons, creosote asbestos

Construction laydown area	Potential contaminating activities and/or sources	CoPC
Cooke Park, Belfield	The centre of the park formerly contained a quarry pit that was filled	Heavy metals, hydrocarbons, asbestos and landfill gas
Peace Park, Ashbury	Uncontrolled filling and landfill. Anecdotal information suggests that part of Peace Park was reportedly remediated in 2018 due to asbestos containing material discovered within soil at the park	Heavy metals, hydrocarbons, asbestos and landfill gas
	Recreational parkland – potential herbicide application	Herbicides
Camdenville Park, St Peters	Uncontrolled filling/landfill	Heavy metals, hydrocarbons, asbestos and landfill gas
	Recreational parkland	Herbicides
Beaconsfield West substation	Potential uncontrolled filling, former industrial manufacturing and substation	Asbestos, heavy metals, hydrocarbons and PCBs

16.2.3.4 Receptors

Human receptors within the study area are mainly local residents, members of the public and workers in surrounding businesses. Day care centres, pre-schools, primary schools and high schools are located within the study area and in close proximity to the project area.

Human receptors during construction would also comprise project personnel, construction workers and workers at waste receiving facilities.

Ecological receptors that are down-gradient or within the study area are:

- Cooks River (Precinct 1 to 5), which drains into Botany Bay to the east;
- Coxs Creek (Precinct 2) which drains into Cooks River at Strathfield South;
- Alexandra Canal (Precinct 5) which drains into the lower reaches of the Cooks River; and
- Terrestrial ecological receptors, particularly within parks.

No high priority Groundwater Dependant Ecosystems (GDEs) have been identified within the study area. Refer to **Chapter 18 Groundwater** for further details on GDEs.

16.3 Assessment of potential construction impacts

Potential impacts on soil as a result of the construction of the project, including identifying potential risks from contamination, is discussed below. Impacts on water and groundwater quality resulting from contamination during construction of the project are discussed further in **Chapter 17 Surface water and flooding** and **Chapter 18 Groundwater**.

16.3.1 Impacts from existing soil and groundwater contamination

The construction works are likely to encounter areas of contaminated soil, groundwater, soil vapour and landfill gas, as discussed below. The potential impacts from the works are related to excavating and managing soil, stockpiling, dewatering groundwater and surface water runoff and importing fill materials for backfilling excavations. Contaminated or acid sulfate soil may be mobilised by the construction of the project and transported into surface water or stormwater networks. This has the potential to impact water quality in the Cooks River and Parramatta River unless suitable mitigation measures are implemented (refer to **Chapter 17 Surface water and flooding** for further information on potential impacts and mitigation measures).

Potentially contaminated soils and groundwater as well as associated vapours (e.g. landfill gas from former landfills) could impact on human health and ecological receptors. Contaminated soil would require disposal to landfill while contaminated groundwater would require treatment. As noted in

Chapter 9 Air quality, vapours encountered during construction (at former landfills) may result in a level of annoyance on nearby sensitive receivers as they would be subject to an unpleasant odour. These impacts are not anticipated, but if encountered, are expected to be short-term in duration and not likely to lead to ongoing stress and annoyance for nearby sensitive receivers.

Construction laydown areas would be used for the storage of plant and equipment and some of the laydown areas would be used to stockpile spoil from trenching and excavation activities. Potential contamination impacts from the use of construction laydown areas would be primarily from the disturbance of existing contamination in surface soils from plant and vehicle movements and from stockpiling spoil resulting in exposure to workers or off-site receptors from erosion and transport of sediment (including through site runoff) from surface soil.

To assess the relative risk during project construction, a conceptual site model was developed, and a qualitative risk assessment undertaken for each precinct as well as each construction laydown area. The matrix in **Table 16-6** was used to assign the risk assuming the absence of appropriate controls and mitigation measures (i.e. pre-mitigation). The conceptual site model is presented in **Table 16-7** and **Table 16-8**.

Table 16-6 Risk matrix for qualitative assessment

Exposure pathway between contamination source and receptor	Presence of contamination at concentrations of concern		
	Unlikely to be present	Potentially present	Known to be present
Incomplete	Low	Low	Low
Complete	Low	Medium	High

Sections of the project area were assessed as low risk where no current or historical contaminating activities were identified, and the surrounding land use was primarily residential.

Sections of the project area were assessed as medium contamination risk where historical and current potentially contaminating land uses were located in close proximity to the route. These land uses included service stations, dry cleaners, mechanical workshops, manufacturing sites, areas of historically filled land including Muir Road in Chullora and former infilled brick pits at Arlington Oval, Marrickville Park and Henson Park.

Sections of the project area were assessed as high contamination risk where known contamination was identified from previous site investigations. These areas include:

- where the project area would intersect the former landfill in Camdenville Park; and
- the project area starting from Sydney Park at the Princes Highway to (and including) Beaconsfield West substation.

The project area and the assessed contamination risk are shown on **Figure 16-3**, **Figure 16-4**, **Figure 16-5** and **Figure 16-6**.

Of the five locations identified as construction laydown areas, Beaconsfield West substation laydown area was assessed as low risk due to the existence of pavement covering the site. All other laydown areas were assessed as medium risk based on the potential for existing soil contamination, associated with former land uses, and the potential for complete pathways between the contamination and sensitive human and ecological receptors.

Risks would be mitigated through implementation of the appropriate environmental control measures as outlined in **Section 16.5**.

Table 16-7 Preliminary conceptual site model and risk assessment – transmission cable route and substations

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
Precinct 1 and Rookwood substation	All (special crossing location)	Sources: Filled land, various former and current industrial sites including Galserv Galvanising Services and a service station could potentially have resulted in soil and groundwater contamination within the transmission cable route. CoPC: Heavy metals, TRH, BTEX, ammonia, cyanide, pH, PCBs, SVOCs[1], VOCs[2], PFAS and asbestos	Potentially present in soil, soil vapour and groundwater	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Cooks River (including recreational users and aquatic ecology)	Yes	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	Yes	
Precinct 2	24 Rawson Road, Greenacre (15 metre length)	Source: Budget Auto Parts (workshop), 24 Rawson Road, Greenacre could potentially have resulted in soil and groundwater contamination	Potentially present in soil, groundwater and soil vapour	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium
				Transport via wind as dust	Construction workers, public	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
		within the transmission cable route. CoPC: Lead, TRH, BTEX and PAHs		Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Cooks River (including recreational users and aquatic ecology)	Yes	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	Yes	
	Wangee Road between Punchbowl Road to Yangoora Road, Lakemba	Source: Caltex Service Station, former Red Top Transport Services and Astor Base Metals and Former Hampden Motors Service Station and former tannery within Hampden Park Public School. CoPC: Heavy metals (including hexavalent chromium), TRH, BTEX, SVOCs[1] and VOCs[2]	Potentially present in soil, groundwater and soil vapour	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Coxs Creek and Cooks River (including recreational users	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
					and aquatic ecology)		
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	Yes	
	Walker Street, Belmore Street and Carter Street, Belfield (special crossing location)	Source: Dry cleaners up-gradient of Walker Street and former petrol station and current mechanical workshop in Carter Street. CoPC: Heavy metals, TRH, BTEX, PAHs and VOCs	Potentially present in soil, soil vapour and groundwater	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Construction workers	Yes	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
	Remainder of Precinct 2	Source: No specific point source identified. Mainly surrounding low to medium density residential land use. General road construction, maintenance and road use may have resulted in soil contamination[3]. CoPC: Heavy metals, petroleum hydrocarbons, OCPs and asbestos	Unlikely present	Direct contact, inhalation or ingestion	Construction workers	Yes	Low
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Construction workers	Yes	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	Yes	
Precinct 3	Cooks River Crossing	Sources: Current and former petrol stations at the intersection of Brighton Street and Byron Street, potential uncontrolled filling in reserves either side of the Cooks River and Viva Energy high-pressure oil pipeline on the north side of the Cooks River.	Potentially present in soil, soil vapour and groundwater	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
		CoPC: Heavy metals, TRH, BTEX, PCBs, SVOCs[1], VOCs[2], and asbestos		Surface water runoff	Coxs Creek and Cooks River (including recreational users and aquatic ecology)	Yes	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	Yes	
	Constitution Road between Arlington Road intersection and Denison Road, Dulwich Hill (special crossing location) West end of Terry Road,	Sources: Former manufacturing sites, service stations, dry cleaners, Arlington Oval and Marrickville Park former landfills. CoPC: Heavy metals, TRH, BTEX, ammonia, cyanide, pH, PCBs, SVOCs1, VOCs2, PFAS and asbestos	Potentially present in soil vapour or groundwater. Potentially present in soil in special crossing area outside of road reserve.	Direct contact, inhalation or ingestion	Construction workers	Yes	Low
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Cooks River (including recreational users and aquatic ecology)	Yes	
				Discharge of contaminated	Cooks River (including	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
	west end of Hill Street, Dulwich Hill Denison Road Playground, Dulwich Hill Pigott Street, New Canterbury Road and Herbert Street intersection, Dulwich Eastern end of Pile Street			groundwater from excavations (dewatering) and discharge to surface water	recreational users and aquatic ecology)		
	128 Livingstone Road, Marrickville	Source: Former foundry CoPC: Heavy metals, phenols	Potentially present in groundwater	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Cooks River (including	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
					recreational users and aquatic ecology)		
				Discharge of contaminated groundwater and leachate from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	Yes	
	Henson Park	Source: Former brick pit quarry filled with spoil of unknown sources across Sydney. CoPC: Heavy metals, TRH, BTEX, PCBs, SVOCs1, VOCs2, PFAS, asbestos, ammonia, pH, and landfill gases	Potentially present in soil, soil vapour (landfill gas) and groundwater	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Cooks River (including recreational users and aquatic ecology)	Yes	
				Discharge of contaminated groundwater from excavations	Cooks River (including recreational users	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
				(dewatering) and discharge to surface water	and aquatic ecology)		
	Remainder of Precinct 3	Source: No specific point source identified. Mainly surrounding low to medium density residential land use. General road construction, maintenance and road use may have resulted in soil contamiation[3]. CoPC: Heavy metals, petroleum hydrocarbons, OCPs and asbestos	Unlikely present	Direct contact, inhalation or ingestion	Construction workers	No	Low
				Transport via wind as dust	Construction workers, public	No	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	No	
				Surface water runoff	Cooks River, Hawthorne Canal (including recreational users and aquatic ecology)	No	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River, Hawthorne Canal (including recreational users and aquatic ecology)	No	
Precinct 4	Addison Road/Illawarra Road/Agar	Sources: Existing and former petroleum service stations, filled land, dry cleaners,	Potentially present in soil,	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
	Street intersection to Enmore Road/Addison Road intersection, Marrickville Newington Road between Philpott Street and Enmore Road, Marrickville Llewellyn Street between Juliett Street and Edgeware Road, Marrickville Edgeware Road between Smidmore Street and Illawarra Railway, Marrickville	industrial businesses and manufacturing. CoPC: Heavy metals, TRH, BTEX, PCBs, SVOCs[1], VOCs[2], PFAS and asbestos Acid sulfate soils	soil vapour and groundwater	Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Cooks River (including recreational users and aquatic ecology)	Yes	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
	Remainder of Precinct 4	Source: No specific point source identified. Mainly surrounding low to medium density residential land use. General road construction, maintenance and road use may have resulted in soil contamiation[3]. CoPC: Heavy metals, petroleum hydrocarbons, OCPs and asbestos	Unlikely present	Direct contact, inhalation or ingestion	Construction workers	No	Low
				Transport via wind as dust	Construction workers, public	No	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	No	
				Surface water runoff	Cooks River (including recreational users and aquatic ecology)	No	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	No	
Precinct 5 and Beaconsfield West substation	Within Camdenville Park	Sources: Camdenville Park former landfill CoPC: Heavy metals, TRH, BTEX, PCBs, SVOCs[1],	Known to be present in soil, groundwater and landfill gas	Direct contact, inhalation or ingestion	Construction workers	Yes	High
				Transport via wind as dust	Construction workers, public	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
		VOCs[2], PFAS, asbestos, ammonia, pH, and landfill gases		Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Cooks River (including recreational users and aquatic ecology)	Yes	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Cooks River (including recreational users and aquatic ecology)	Yes	
	Bedwin Road and May Street	Sources: Camdenville Park former landfill, existing and former petroleum service stations, historical manufacturing sites and filled land. CoPC: Heavy metals, TRH, BTEX, PCBs, SVOCs[1], VOCs[2], PFAS, asbestos,	Potentially present in groundwater, soil and soil vapour	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium
				Transport via wind as dust	Construction workers, public	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
		nutrients, ammonia, pH, and landfill gases		Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Alexandria Canal (including recreational users and aquatic ecology)	Yes	
				Discharge of contaminated groundwater and leachate from excavations (dewatering) and discharge to surface water	Alexandria Canal (including recreational users and aquatic ecology)	Yes	
	Princes Highway to Beaconsfield West substation though Sydney Park	Sources: Sydney Park former landfill, Australian Refined Alloys, widespread historical industrial land use and disturbed terrain (filled land) CoPC: Heavy metals, TRH, BTEX, PCBs, SVOCs[1], VOCs[2], PFAS, asbestos, nutrients, ammonia, pH, and landfill gases	Known to be present in soil, groundwater and landfill gas	Direct contact, inhalation or ingestion	Construction workers	Yes	High
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Alexandra Canal	Yes	

Precinct/ substation	Section of precinct	Summary of existing sources of CoPC (see Table 16-4 for further detail)	Likelihood of presence of contamination within transmission cable route	Potential pathway between existing contamination and receptor	Receptors	Potential complete pathway	Qualitative risk
				Discharge of contaminated groundwater and leachate from excavations (dewatering) and discharge to surface water	Alexandra Canal	Yes	
Sydney South substation	-	Sources: Transformers within substation could have resulted in soil and groundwater contamination within the project area. The substation was formerly the location of a radio communications site (also known as Picnic Point remote receiving station) during WWII which could have used hazardous building materials. CoPC: Heavy metals, petroleum hydrocarbons, asbestos and PCBs	Potentially present	Direct contact, inhalation or ingestion	Construction workers	Yes	Medium
				Transport via wind as dust	Construction workers, public	Yes	
				Transport of spoil by vehicles onto roads and disposal to landfill	Construction workers, public, landfill workers	Yes	
				Surface water runoff	Georges River (including recreational users and aquatic ecology)	Yes	
				Discharge of contaminated groundwater from excavations (dewatering) and discharge to surface water	Georges River (including recreational users and aquatic ecology)	Yes	

Notes:
1 SVOCs – includes a range of common semi-volatile organic compounds including OCPs, OPPs, PAHs and phenols,
2 VOCs – includes a range of common volatile organic compounds including monoaromatic substances (MAH), fumigants, halogenated aliphatic compounds and oxygenated compounds.
3 There were no specific sources of contamination identified, however there is a potential for areas of localised contaminated soil or fill to be present associated with the use of contaminated spoil during historical road construction, in backfilling of service trenches, use of asbestos containing material for services, use of pesticides in service trenches or spills of fuel, oil or chemicals from road accidents.

Table 16-8 Preliminary conceptual site model and risk assessment – construction laydown areas

Construction laydown area	Summary of existing sources of soil or groundwater contamination and CoPC	Potential pathway	Receptor	Potential pathway complete	Qualitative risk
12 Muir Road	Source: Chullora iron foundry and filled land within the construction laydown area could have potentially caused soil and groundwater contamination. CoPC: Heavy metals, hydrocarbons, asbestos, SVOCs, PCB	Direct contact, inhalation and ingestion from disturbance or erosion of surface soils	Workers	Yes	Medium
		Erosion of soil and transport via wind as dust	Workers, public	Yes	
		Erosion of soil –entering surface runoff	Cooks River (including recreational users and aquatic ecology)	Yes	
		Movement of vehicles transporting soil off-site	Public, Cooks River (including recreational users and aquatic ecology)	Yes	
Cooke Park	Source: Filled quarry pit within the park could have caused soil and groundwater contamination. CoPC: Heavy metals, hydrocarbons, asbestos and landfill gas	Direct contact, inhalation and ingestion from disturbance or erosion of surface soils	Workers	Yes	Medium
		Erosion of soil and transport via wind as dust	Workers, public	Yes	
		Erosion of soil –entering surface runoff	Cooks River (including recreational users and aquatic ecology)	Yes	
		Movement of vehicles transporting soil off-site	Public, Cooks River (including recreational users and aquatic ecology)	Yes	

Construction laydown area	Summary of existing sources of soil or groundwater contamination and CoPC	Potential pathway	Receptor	Potential pathway complete	Qualitative risk
Peace Park	Source: Filled land within the construction laydown area could have caused soil and groundwater contamination. CoPC: Heavy metals, hydrocarbons, asbestos, SVOCs, PCB	Direct contact, inhalation and ingestion from disturbance or erosion of surface soils	Workers	Yes	Medium
		Erosion of soil and transport via wind as dust	Workers, public	Yes	
		Erosion of soil –entering surface runoff	Cooks River	Yes	
		Movement of vehicles transporting soil off-site	Public, Cooks River (including recreational users and aquatic ecology)	Yes	
Camdenville Park	Source: Soil and groundwater contamination known to be present from historical filling of quarry with waste. Landfill gases known to be present in subsurface. CoPC: Heavy metals, hydrocarbons, asbestos, SVOCs, PCB, landfill gases	Direct contact, inhalation and ingestion from disturbance or erosion of surface soils	Workers	Yes	Medium
		Erosion of soil and transport via wind as dust	Workers, public	Yes	
		Erosion of soil –entering surface runoff	Cooks River (including recreational users and aquatic ecology)	Yes	
		Movement of vehicles transporting soil off-site	Public, Cooks River (including recreational users and aquatic ecology)	Yes	
		Diffusion of landfill gases to the surface	Workers	Yes	

Construction laydown area	Summary of existing sources of soil or groundwater contamination and CoPC	Potential pathway	Receptor	Potential pathway complete	Qualitative risk
Beaconsfield West substation	Source: Soil and groundwater contamination known to be present from historical filling of quarry with waste. Landfill gases known to be present in subsurface. CoPC: Heavy metals, hydrocarbons, asbestos, PCBs	Direct contact, inhalation and ingestion from disturbance or erosion of surface soils	Workers	No[1]	Low
		Erosion of soil and transport via wind as dust	Workers, public	No[1]	
		Erosion of soil –entering surface runoff	Alexandra Canal	No[1]	
		Movement of vehicles transporting soil off-site	Public, Alexandra Canal (including recreational users and aquatic ecology)	No[1]	

Note:
1 Assumes that the construction laydown area at Beaconsfield West substation would be covered by existing hardstand or bitumen surface and no surface soils would be exposed.

16.3.2 Impacts on soil and groundwater

Construction activities that could result in contamination include spills of fuels when refuelling plant and equipment and hydraulic oil spills. Spills could contaminate soil or enter surface water runoff, the stormwater system and ultimately a local waterway.

One option for the transmission cable route at the Cooks River crossing is to install the conduits via underboring. The transmission cable route would therefore pass under or over the Viva Energy high pressure oil pipeline running along the northern side of the Cooks River. If the construction is not managed appropriately, there is a risk of damage to the pipeline during construction which could result in pollution which would impact surrounding soil, groundwater and the Cooks River. Horizontal direction drilling (HDD) for underboring could cause a frac-out of drilling slurry, resulting in a release of drilling slurry at the ground surface through an underground pathway (e.g. tree root or underground service). Drilling slurry released to the environment, as a result of inappropriate management or frac-out, could potentially contain elevated concentrations of CoPC exceeding ecological or human health-based criteria due to contact with subsurface contamination. The drilling slurry could contaminate surface soils or enter stormwater if not contained. Specific potential contamination sources at each underbore location are:

- Enfield Intermodal, Belfield: the drilling slurry could be potentially contaminated by groundwater from nearby former dry cleaners and former petrol station/current mechanical workshop;
- Cooks River, Campsie/Croydon Park: the drilling slurry could be potentially contaminated by groundwater contaminated from nearby current and former petrol stations, uncontrolled filling and Cooks River sediments;
- Arlington Light Rail Station, Dulwich Hill: the drilling slurry could be potentially contaminated with groundwater contaminated by leachate from Arlington Park former infilled brick pit and surrounding former industry;
- Amy Street, Marrickville: the drilling slurry could be potentially contaminated with leachate from Henson Park filled brick pit/potential former landfill; and
- Sydney Park, Alexandria: the drilling slurry could be contaminated by leachate from Sydney Park former landfill and groundwater contaminated by surrounding industrial sources.

The use of the construction laydown areas could result in soil contamination from spills of oils, fuels and other chemicals, if appropriate management and mitigation measures are not implemented. If not managed by appropriate controls, stockpiling of contaminated spoil at construction laydown areas has the potential to contaminate the soil at the area or potentially lead to contaminated soil being mobilised off-site.

16.3.3 Acid sulfate soils

ASS is the common name given to a range of soil types containing iron sulfides, the most common being pyrite. ASS may be present as actual ASS (AASS) or potential ASS (PASS). ASS have the potential to produce sulfuric acid and release toxic quantities of iron, aluminium and heavy metals. The heavy metals and acid can leach into soil and groundwater or impacted runoff can enter waterways and have negative impacts on water quality and aquatic ecosystems. Based on review of the acid sulfate soil risk and classification maps and proposed construction works, there is a risk of disturbance of ASS within Precincts 2, 3, 4 and 5, as outlined in **Table 16-1**.

Impacts during construction would be caused by excavation of PASS or AASS during cable trenching and other excavations for underboring launch/receive pits or bridge footings, if not managed appropriately. It is also expected that localised lowering of the water table at underboring launch/received pit locations at the Cooks River and Sydney Park (Precinct 5) would occur, due to the temporary dewatering. The lowering of the water table has the potential to cause PASS to oxidise. Given the localised and temporary dewatering that would be required, only a small area of surrounding soil could be expected to be exposed to oxidising conditions that would require management.

Works within the construction laydown areas would not include subsurface excavation greater than 1m below ground level and none of the areas are mapped as within Class 1 or 2 land. As such disturbance of acid sulfate soils is unlikely to occur in these areas and therefore there would be no

impacts associated with ASS. The construction laydown areas would also not be used to treat and stockpile excavated ASS from the project.

16.4 Assessment of potential operational impacts

Potential impacts on soil as a result of the operation of the project, including identifying potential risks from contamination is discussed below. Impacts on water and groundwater quality resulting from contamination during operation of the project are discussed further in **Chapter 17 Surface water and flooding** and **Chapter 18 Groundwater**.

16.4.1 Potential issues from existing contamination

The potential impacts from existing contamination during operation of the project are associated with emissions and migration of landfill gas and migration of leachate in Sydney Park and Camdenville Park. Arlington Oval, Marrickville Park and Henson Park in Precinct 3 are also former infilled brick pits and the potential presence and extent of landfill gases at these locations is unknown. Assessment would need to be undertaken prior to the commencement of construction as part of site investigations. Site investigations would include assessment for the presence and risk of subsurface landfill gas by sampling ground gas following the *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases* (NSW EPA, 2012). One option for the transmission cable route option passes directly through the former filled pit within Henson Park in Precinct 3. The transmission cable route option passes within 20 to 50 meters of both Arlington Oval and Marrickville Park.

Following completion of the project, there is a potential for landfill gas migration into link and sensor pits due to there being a subsurface void where landfill gas could accumulate, particularly for pits located close to or within former landfills. The risk would be the potential exposure to workers accessing the pits for maintenance being exposed to vapours or creation of a potentially explosive atmosphere. This could result in risk of injury to workers or nearby members of the public from the inadvertent ignition of gas.

If capping is not replaced over the backfilled trenches within landfilled areas, this could create a pathway for surface water infiltration into the underlying waste. This could contribute to the generation of additional leachate. Mitigation measures that could be adopted to prevent this risk are discussed in **Section 16.5**.

16.4.2 Potential contamination sources

Following completion of the project there are not expected to be any new contaminant sources or additional activities that could result in further land contamination as a result of the operation of the project.

16.5 Environmental management and mitigation measures

16.5.1 Environmental management objectives and outcomes

The objectives of the management approach for soils and contamination are:

- demonstrate that the construction works will be undertaken in accordance with requirements of the CLM Act, Protection of the Environment Operations Act 1997 (POEO Act), Environmentally Hazardous Chemicals Act 1985 (EHC Act) and State Environmental Planning Policy No. 55 – Remediation of Land (SEPP 55);
- prevent impacts to project workers and surrounding human and ecological receptors from the disturbance of contaminated soils; and
- prevent impacts to surrounding watercourses and aquatic ecological receptors from the excavation of acid sulfate soils.

The environmental management and mitigation measures to be undertaken during the project to manage potential contamination issues and achieve the management objectives are presented in **Table 16-9**.

Table 16-9 Environmental management measures – soils and contamination

No.	Impact/issue	Environmental management and mitigation measures	Timing
CT1	Assessment of excavation areas	Soil investigations will be undertaken prior to construction along the project area to: • assess the presence of contamination and risks posed to project workers and the environment, so that appropriate controls can be implemented during construction; • chemically classify the soil in-situ, for potential reuse or off-site disposal to licensed landfill or reuse facility in accordance with the applicable land use criteria, Waste Classification Guidelines (NSW EPA, 2014a) or applicable Resource Recovery exemption and order; and • assess for the presence of acid sulfate soils and liming rates, so Acid Sulfate Soils Management Plans (ASSMPs) can be prepared and waste classified in accordance with Waste Classification Guidelines (NSW EPA, 2014a). A Sampling, Analysis and Quality Plan (SAQP) will be prepared for soil investigation in accordance with the NEPM (ASC NEPM 2013). The SAQP will detail: • data quality objectives (DQOs) and data quality indicators (DQIs); • justification of the number, density and location of sampling locations based on the potential for contamination, excavation extent and quantities requiring off-site disposal; • the sampling locations would target areas of concern and provide lineal coverage of the transmission cable route; • analytical suite and schedule, including contaminants of concern; • assessment criteria for on-site reuse or off-site disposal (waste classification); and • sampling and laboratory methodologies, field and laboratory quality assurance and control. Following the completion of the soil investigations a report will be prepared for each construction precinct providing conclusions on waste classification and recommendations for health and environmental controls during construction. The reports will provide clear commentary on the classification of the waste in accordance with the Waste Classification Guidelines (NSW EPA, 2014a).	Construction
CT2	Assessment of imported Virgin Excavated Natural Material (VENM)	Prior to the backfilling of trenches during construction with VENM, the VENM source(s) will be identified and assessed against the definition of VENM in the Waste Classification Guidelines (NSW EPA, 2014a) and POEO Act. The VENM source(s) will be assessed by an appropriately qualified contaminated land consultant, which will entail: • identifying whether the current and past activities at the source site that had potential to contaminate the land, whether AASS or PASS is present and that the site is not within an area mapped as containing naturally occurring asbestos; and	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
		• undertaking chemical assessment to ascertain that the material is not contaminated. The NSW EPA VENM certificate will be completed and signed by the consultant (or supplier) and provided to TransGrid proponent prior to importation and use of the VENM. The VENM would also be inspected at the work site to check the imported VENM is from the same source assessed.	
CT3	Construction laydown areas	Limited baseline soil investigations and site inspections will be undertaken for each construction laydown area to manage identified risks during construction. The investigations will include limited sampling to identify and assess contamination in surface soil. A baseline report will be prepared for each construction laydown area. Where contamination is identified, a site-specific management plan will be implemented prior to construction to inform the management of asbestos or chemical contamination in soil while the construction laydown area is in use. Following demobilisation of the construction laydown area a post–construction report would be prepared for each construction laydown area. The post-construction report would compare to the baseline report and confirm whether or not conditions are the same and if remedial works are required to clean up contamination from the project works within the construction laydown areas.	Construction
CT4	Contaminated soil management during construction	Protocols for the management of contaminated soil during construction will be included in the CEMP for all construction works and would: • detail requirements for safety controls including the following where required: - air monitoring; - exclusion zones and decontamination; - excavation ventilation; - dust suppression and containment; - odour suppression and monitoring; - personnel protective equipment; - training and supervision; • detail requirements for environmental controls including the following: - sediment and erosion control; - management of surface water runoff around the excavation areas and prevention of surface water entering excavations; - stockpile management and separation; and - materials tracking and records. Sediment and erosion mitigation measures that will be implemented are detailed in **Chapter 17 Surface water and flooding**.	Construction
CT5	Spoil waste management and transport	Spoil which has been assessed as not suitable for reuse or cannot be reused will be classified in accordance with the Waste Classification Guidelines (NSW EPA, 2014a). The spoil will be transported to an appropriate waste disposal facility licensed to receive such waste. Approval will be obtained from the respective landfill facility prior to transport	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
		and would require an estimate of the likely volume of waste to be disposed. The following material handling requirements will be implemented for trucks transporting materials off-site: • a licensed transporter will be used to transport material to an appropriately licensed NSW EPA waste facility; • all truck loads will be filled to the correct level and not over filled; • trucks carrying waste materials will be covered prior to exiting the work site and will remain covered until authorised to unload at the destination (NSW EPA licensed waste facility); • trucks will be fitted with seals to ensure that the movement of potentially saturated materials is undertaken appropriately. The integrity of the seals will be inspected and tested prior to commencement of each day's haulage works; • in the event that materials are tracked or spilt outside of the construction zone, soil will be immediately cleaned up in a way that prevents contamination of land, the stormwater or waterways; and • all truckloads and landfill waste tickets/dockets will be tracked and a register completed to reconcile and check spoil has been lawfully disposed. Temporary spoil stockpiles may be stored at select construction laydown areas. As all spoil will be classified in-situ prior to excavation, the stockpiled material will already be classified in accordance with NSW EPA (2014a). Stockpiles will be kept separate based on their classification. All stockpiles will be tracked in accordance with protocols within the CEMP for material tracking. Stockpiles will be managed with appropriate sediment and erosion controls at all times (refer to **Chapter 17 Surface water and flooding**).	
CT6	Asbestos management	An Asbestos Management Plan (AMP) will be developed for areas identified during pre-construction investigations as containing Asbestos Containing Materials (ACM), areas suspected of containing ACM and to address unexpected finds of ACM during construction. Specifically, protocols will be stipulated for separation, monitoring, validation and clearance of asbestos. The AMP and associated Standard Work Procedures will satisfy the requirements of: • Work Health and Safety Regulation 2011; • the Safe Work Australia Asbestos Codes of Practice and Guidance Notes: - Code of Practice: How to Manage and Control Asbestos in the Workplace; - Code of Practice: How to Safely Remove Asbestos; and - Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibre, 2nd Edition [NOHSC: 3003 (2005)]. An Occupational Hygienist (Hygienist) will be on-site for the duration of the excavation works where ACM has been identified from pre-construction or where unexpected finds of ACM are encountered. The Hygienist will:	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
		• undertake air monitoring for asbestos during excavation; • provide on-site visual inspection, identification of asbestos impacted material and clearance of non-asbestos impacted surfaces; and • supervise works to ensure compliance with the AMP and NSW regulatory requirements for asbestos containing material management and disposal. In the event that friable asbestos is detected, a suitably licensed Asbestos Removal Contractor (licensed to undertake friable asbestos (Class A) removal) will be required to undertake and oversee all the asbestos removal and disposal works outlined in the AMP. All persons performing the works will be required to undertake a suitable risk assessment and develop a Safe Work Method Statement (SWMS) for all of their work activities prior to commencing work in ACM impacted areas. Identified ACM will be segregated, managed and disposed of as Special Waste and transported and disposed in accordance with Protection of the Environment Operations (Waste) Regulation (2014). Where more than 100 kg of asbestos waste or more than 10 square metres of asbestos sheeting is transported, the NSW EPA online tool WasteLocate will be used. The handling and disposal of asbestos waste will be tracked and recorded.	
CT7	Acid sulfate soils	ASSMPs will be prepared in accordance with the ASSMAC (1998) guidelines based on the results of the pre-construction investigations for locations within Precinct 2, 3, 4 and 5. The ASSMPs will incorporate the following procedures: • soil will be treated with lime in accordance with the ASSMP where PASS is not able to be loaded and transported to a landfill licensed to receive untreated PASS within 24 hours of excavation or if AASS are identified and excavated; • exposure of PASS material within an excavated trench or excavation site will be minimised to reduce the potential for oxidation and acid leachate generation; • excavation will be done under dry conditions, where possible using a truck and shovel (tracked excavator) operation and the watertable will be lowered within excavation areas, as part of excavation dewatering; • excavated fill will be monitored for colour and leachate quality; • no PASS material will be placed and left at the surface untreated; • soil will be placed into an appropriately bunded treatment area (pads) and treated with a neutralising agent (e.g. lime). Leachate water from the PASS material will be managed and treated to ensure no acid is released to the environment; • leachate generated during the ASS treatment operations will be captured. Any water potentially affected by leachate collecting within the excavation will be treated with hydrated lime or equivalent prior to	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
		discharge. Water potentially affected by leachate accumulating within the work site will not be discharged until it meets acceptable water quality standards or collected and disposed at a licensed liquid waste treatment facility; and • PASS materials will be kept separate from non-PASS materials at all times to reduce the volume of material requiring treatment. Acid is transported by water; therefore, excavation works in PASS will be conducted during dry periods (where practical) to minimise the risk of overflow associated with sudden or heavy rain and to allow better control of treated waters for discharge.	
CT8	Unexpected finds	An unexpected finds procedure will be included in the CEMP. An unexpected find is potential contamination that was not previously identified during this PSI or pre-construction investigations. Project workers will be trained in identifying the following: • soil that appears to be contaminated based on visual and olfactory (odour) observations; • ACM (i.e. either bonded or friable asbestos); • groundwater that appears to be contaminated based on visual and olfactory (odour) observations (including potential hydrocarbon sheens on the water surface, free phase liquids such as petroleum fuel, discolouration etc.); • drums or USTs; and • fill containing wastes (e.g. slag, refuse, demolition materials). In the event of an unexpected find: • excavation works will temporarily be suspended at the location of the unexpected find, the environment manager contacted and the area of concern appropriately isolated; • the area will be inspected by a contaminated land consultant and if required, appropriate sampling and analysis will be undertaken, the sampling works will be documented in a report; • the requirement for additional controls will be assessed by the consultant and implemented by the proponent; and • workplace health and safety and environmental protection requirements will be reviewed, depending on the type of unexpected finds encountered.	Construction
CT9	Former landfill management	Site-specific management plans for former landfill sites will be required for excavation works in Sydney Park and Camdenville Park. Plans may also be required for Henson Park and works in proximity to Arlington Oval and Marrickville Park, following the outcome of investigations (see CT1). The development of the plans will include consultation with the relevant councils. Approval will be sought from the NSW EPA in all areas where exhumation of landfill waste is required in accordance with Clause 110A of the *Protection of the Environment Operations Legislation Amendment (Waste) Regulation 2018 (Amendment Regulation).*	Construction

No.	Impact/issue	Environmental management and mitigation measures	Timing
		Where there are existing environmental management plans, such as for Camdenville Park, site specific mitigation measures outlined in these plans will be reviewed and implemented as required. The plan will be prepared by a contaminated land consultant and occupational hygienist. The plan will specify: • an excavation plan specifying areas classified as per in-situ waste classification and suitability for reuse; • trench ventilation during excavation to prevent the accumulation of landfill gases within the trench (refer to AQ12); • ambient and in-trench monitoring for landfill gases (methane, carbon dioxide, hydrogen sulfide and carbon dioxide), ammonia and volatile organic compounds; • action levels for evacuation of the work zone where health and lower explosive limit (LEL) levels are exceeded and additional controls to allow work to re-commence once implemented; • exclusion zone around the work site on either side of the trench, including fully fenced security chain mesh fences with bracing, where required; • geotechnical considerations for the base of the trench to mitigate the risk of subsidence of the installed cable; • final capping layer above the concrete cable conduit casing as per the Environmental Guidelines Solid Waste Landfills (NSW EPA, 2016), unless otherwise specified or agreed by with City of Sydney Council and Inner West Council: - compacted clay layer at least 600 mm thick, with an in situ saturated hydraulic conductivity of less than 1 x 10–9 metres/s (where subsurface waste either side of the trench is less than; - a revegetating layer from the top of the capping layer to the surface comprising clean soils with 200 mm of topsoil (in landscaped areas); and • the construction of joint bays, link boxes and sensor pits within former landfill areas will be designed to prevent the accumulation of landfill gases. Inner West Council and City of Sydney Council will be consulted on the design, monitoring and location of the pits within Sydney Park, Camdenville Park and Henson Park (if required).	
CT10	Sydney Park	TransGrid will undertake additional investigations at Sydney Park on leachate and methane risks prior to or during construction and will report these findings to the City of Sydney.	Detailed design and construction
CT11	Drilling slurry	TransGrid will investigate and adopt good practice measures for the management of drilling slurry during horizontal directional drilling, where used, taking into consideration the volume of slurry that will be generated (refer to **Chapter 19 Waste management**).	Detailed design and construction