

CHATSWOOD TO SYDENHAM
**ENVIRONMENTAL
IMPACT
STATEMENT**

MAY 2016

TECHNICAL PAPER 8:
PHASE 1 CONTAMINATION INVESTIGATION



Sydney Metro Chatswood to Sydenham

Transport for NSW

Technical paper 8: Phase 1 Contamination Investigation (incorporating Preliminary Site Investigation)

May 2016



**Chatswood to Sydenham - Technical paper 8: Phase 1
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Limitations

The sole purpose of this report is to present the findings of a Phase 1 Contamination Investigation carried out by Jacobs for Transport for NSW (the Client) in connection with the Sydney Metro City & Southwest Chatswood to Sydenham Environmental Impact Statement. This report was produced in accordance with and is limited to the scope of services set out in the contract between Jacobs and the Client. The scope of services, as described in this report, was developed with the Client.

The scope of services was not intended to provide a definitive or quantitative investigation of the environmental impacts, performance and compliance of the project. Environmental conditions may exist within the project area that is beyond the scope of our investigations and this report.

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- Documentation made available by Transport for NSW.

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1. Introduction

1.1 Project background

Sydney Metro is a new standalone rail network identified in Sydney's Rail Future. The Sydney Metro network consists of Sydney Metro City & Southwest and Sydney Metro Northwest.

The proposed Sydney Metro City & Southwest comprises two core components:

- The Chatswood to Sydenham project (the project), the subject of this technical paper, would involve construction and operation of an underground rail line between Chatswood and Sydenham
- The Sydenham to Bankstown upgrade would involve the conversion of the 13.5 kilometre Bankstown line to metro standards and upgrade of existing stations between Sydenham and Bankstown.

Both components are subject to assessment by the Department of Planning and Environment and approval by the Minister for Planning under Part 5.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The Sydenham to Bankstown upgrade will be subject to a separate environmental impact assessment.

Sydney Metro Northwest (formerly the North West Rail Link) is currently under construction, services will start in the first half of 2019. This includes a new metro rail line between Rouse Hill and Epping and conversion of the existing rail line between Epping and Chatswood to metro operations.

Investigations have started on the possible extension of Sydney Metro from Bankstown to Liverpool. The potential extension would support growth in Sydney's south west by connecting communities, businesses, jobs and services as well as improving access between the south west and Sydney's CBD. It would also reduce growth pressure on road infrastructure and the rail network, including the potential to relieve crowding on the T1 Western Line, T2 South Line and T2 Airport Line.

The Sydney Metro Delivery Office has been established as part of Transport for NSW to manage the planning, procurement and delivery of the Sydney Metro network.

The Sydney Metro rail network is described further below and shown in **Figure 1**.

1.2 The Sydney Metro network

The customer experience underpins how Sydney Metro is being planned and designed. The customer experience incorporates all aspects of travel associated with the transport network, service and project including:

- The decision on how to travel
- The travel information available
- The speed and comfort of the journey
- The range and quantity of services available at stations, interchanges and within station precincts.

A high quality 'door to door' transport product is critical to attract and retain customers and also to meet broader transport and land use objectives. This includes providing a system that is inherently safe for customers on trains, at stations and at the interface with the public domain; providing direct, comfortable, legible and safe routes for customers between transport modes; and provide a clean, pleasant and comfortable environment for customers at stations and on trains.

Key features of the metro product include:

- Comfortable carriages with space for customers to sit or stand
- A 'turn-up-and-go' service, with high frequency trains
- Reduced journey times with faster trains, and new underground routes through the Sydney CBD
- Increased capacity to safely and reliably carry more customers per hour due to the increased frequency of trains
- Reduced dwell times at stations as each carriage would be single-deck with three doors, allowing customers to board and alight more quickly than they can with double-deck carriages.

The Chatswood to Sydenham project would have the capacity to run up to 30 trains per hour through the Sydney CBD in each direction, which would provide the foundation for delivering a 60 per cent increase in the number of trains operating in peak periods, and cater for an extra 100,000 customers per hour.



Figure 1 – Sydney Metro network

1.3 Overview of the project

1.3.1 Location

The Sydney Metro Chatswood to Sydenham project involves the construction and operation of a metro rail line. The project would be mainly located underground in twin tunnels extending from Chatswood on Sydney's north shore, crossing under Sydney Harbour, and continue to Sydenham.

1.3.2 Key features

The proposed alignment and key operational features of the project are shown in Figure 2 and would include:

- Realignment of T1 North Shore Line surface track within the existing rail corridor between Chatswood Station and Brand Street, Artarmon, including a new bridge for a section of the 'down' (northbound) track to pass over the proposed northern dive structure
- About 250 metres of aboveground metro tracks between Chatswood Station and the Chatswood dive structure
- A dive structure (about 400 metres long) and tunnel portal south of Chatswood Station and north of Mowbray Road, Chatswood (the Chatswood dive structure)
- About 15.5 kilometres of twin rail tunnels (that is, two tunnels located side-by-side) between Mowbray Road, Chatswood and Bedwin Road, Marrickville. The tunnel corridor would extend about 30 metres either side of each tunnel centre line and around all stations
- A substation (for traction power supply) in Artarmon, next to the Gore Hill Freeway, between the proposed Crows Nest Station and the Chatswood tunnel portal
- Metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo; and new underground platforms at Central Station
- A dive structure (about 400 metres long) and tunnel portal between Sydenham Station and Bedwin Road, Marrickville (the Marrickville dive structure)
- A services facility beside the Marrickville dive structure and tunnel portal, including a tunnel water treatment plant and a substation (for traction power supply).

The project would also include:

- Permanent closure of the road bridge at Nelson Street, Chatswood, and provision of an all vehicle right-turn movement from the Pacific Highway (southbound) into Mowbray Road (westbound)
- Changes to arrangements for maintenance access from Hopetoun Avenue and Albert Avenue, Chatswood as well as a new access point from Brand Street, Artarmon
- Underground pedestrian links at some stations and connections to other modes of transport (such as the existing suburban rail network) and surrounding land uses
- Alterations to pedestrian and traffic arrangements and public transport infrastructure (where required) around the new stations and surrounding Central Station
- Installation and modification of existing Sydney Trains rail systems including overhead wiring, signalling, rail corridor fencing and noise walls, within surface sections at the northern end of the project
- Noise barriers (where required) and other environmental protection measures.

The proposed construction activities for the project broadly include:

- Demolishing buildings and structures at the station sites and other construction sites
- Constructing tunnels, dive structures and tunnel portals
- Excavating, constructing and fitting out metro stations
- Fitting out tunnel rail systems and testing and commissioning of stations, tunnels, ancillary infrastructure, rail systems and trains
- Excavating shafts, carrying out structural work and fitting out ancillary infrastructure at Artarmon
- Excavating shafts, carrying out structural work and fitting out ancillary infrastructure at Marrickville.

A number of construction sites would be required to construct the project. These include locations for tunnel equipment and tunnel boring machine support at Chatswood, Barangaroo and Marrickville as well as at station sites; a casting yard and segment storage facility at Marrickville and a temporary tunnel boring machine retrieval site at Blues Point.

The extent of the project is shown in **Figure 2**.

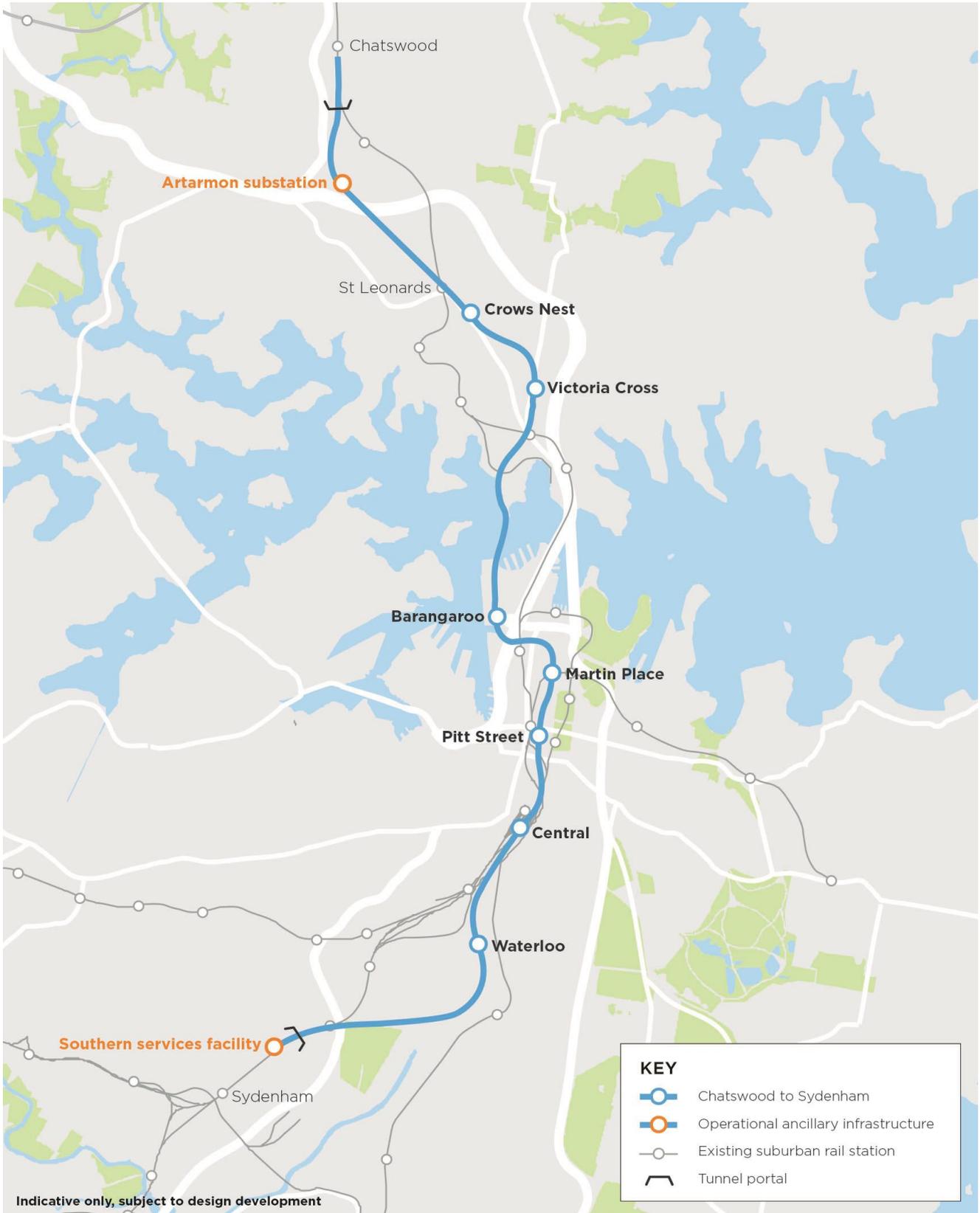


Figure 2 – Chatswood to Sydenham project

1.4 Purpose and scope

The project has been declared State significant infrastructure and critical State significant infrastructure and therefore requires assessment and approval by the Minister for Planning under Part 5.1 of the EP&A Act, including preparation of an environmental impact statement (EIS).

This technical paper, *Technical Paper 8: Phase 1 contamination assessment* is one of a number of technical documents that forms part of the EIS. The purpose of this technical paper is to identify and assess the potential impacts of the project during both construction and operation in relation to contaminated land. In doing so it responds directly to the Secretary's Environmental Assessment Requirements (SEARs) outlined in Section 1.5.

The objectives of the Phase 1 contamination investigation were to identify potential areas of environmental interest (AEI) which will assist in identifying construction limitations/constraints and management options within the project area with respect to contamination.

The AEIs were considered to be those potential risks associated with soil, groundwater and vapour contamination which may be present as a result of historic and / or current activities undertaken on and / or adjacent to the project area.

To achieve these objectives, Jacobs undertook the following scope of works:

- Review of publically available information (NSW EPA, CSIRO ASRIS database, NSW Department of Primary Industries groundwater database)
- Review of information provided by TfNSW
- Review of historical aerial photography of the general project area
- Site walkover and inspection
- Preparation of a Phase 1 contamination investigation report based on the data obtained from the desktop background review and observations from the inspection of the project area. The expected ground conditions are presented together with any contamination issues identified and recommendations for further investigations, if required.

1.5 Secretary's Environmental Assessment Requirements

The SEARs relating to contamination, and where these requirements are addressed in this technical paper, are outlined in **Table 1.1**.

Table 1.1 Secretary's environmental assessment requirements – soils and contamination

Ref	Secretary's environmental assessment requirement	Where addressed
11.1	The Proponent must verify the risk of acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Risk Map) within, and in the area likely to be impacted by, the project.	Section 2.5 Section 3.1 Section 3.3
11.2	The Proponent must assess the impact of the project on acid sulfate soils (including impacts of acidic runoff offsite) in accordance with the current guidelines.	Section 3.1 Section 3.3
11.3	The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the proponent must document how remediation would be undertaken in accordance with current guidelines.	Section 3.1 Section 3.2 Section 3.3

1.6 Relevant contamination guidelines

In preparing this report, the following guidelines were considered (where relevant):

- *Acid Sulfate Soils Assessment Guidelines* (Department of Planning, 2008)
- *Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land*, (Department of Urban Affairs and Planning & Environmental Protection Authority, 1998)
- *Guidelines for Consultants Reporting on Contaminated Sites* (Office of Environment and Heritage, 2000).

Should Transport for NSW purchase properties and take responsibility for existing contamination and contamination sources within these properties, the requirements of the Contaminated Land Management Act 1997 would be applicable for the management of contamination.

Should remediation or other construction activities be undertaken which would involve the offsite disposal of materials (both uncontaminated and contaminated), the requirements of the Protection of the Environment Operations (Waste) Regulations 2014 would need to be considered and implemented where applicable.

Should further investigations, remediation works and validation be undertaken, these activities would need to be undertaken in accordance with the following guidelines or other appropriate/endorsed guidelines available at that time.

- Australian Standard (AS 4482.1-2005) *Guide to the sampling and investigation of potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds*
- Australian Standard (AS 4482.2-1999) *Guide to the sampling and investigation of potentially contaminated soils – Volatile substances.*
- *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as revised 2013)*
- ANZECC & ARMCANZ, (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*
- NSW EPA (2014) *Waste Classification Guidelines*
- DECCW (2009) *Guidelines for the Implementing the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008*
- NSW EPA (1995) *Contaminated Sites: Sampling Design Guidelines*
- DEC (2006) *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme (2nd Edition)*
- DEC (2007) *Contaminated Sites: Guidelines for the Assessment and Management of Groundwater Contamination*
- NSW EPA (2015) *Contaminated Sites: Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*
- NSW EPA (2015) *Technical Note: Light Non-Aqueous Phase Liquid Assessment and Remediation*
- NSW EPA (2014) *Technical Note: Investigation of Service Station Sites*
- NSW EPA (2014) *Best Practice Note: Landfarming*
- DEC (2005) *Information for the assessment of former gasworks sites*
- DECCW (2010) *Vapour Intrusion: Technical Practice Note*

- NSW EPA (2012) *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases*
- Workcover NSW (2014) *Managing asbestos in or on soil*
- ASSMAC (1998) *Acid Sulfate Soil Assessment Guidelines*.

2. Existing environment

The information presented below is based on a review of publically available information, and observations made during a project area inspection undertaken from publically accessible areas by Jacobs on 26 May and 30 September 2015.

2.1 Location and zoning

The project area spans approximately 16 kilometres from Chatswood Station in Sydney's northern suburbs, to Sydenham Station in Sydney's inner west.

The majority of the project would comprise a tunnel extending from the Chatswood portal (located to the south of Chatswood Station) through the lower North Shore, beneath Sydney Harbour, through the CBD to the Marrickville portal (located to the north of Sydenham Station). Surface track would extend from the Chatswood portal to just south of Chatswood Station.

At the time of preparing this report the project area was within / underneath a range of land zonings as classed by the *Willoughby Local Environmental Plan 2012*, *North Sydney Local Environmental Plan 2013*, *Sydney Local Environmental Plan 2012*, and the *Marrickville Local Environmental Plan 2011*.

2.2 Topography and drainage

Based on information from the NSW Department of Primary Industries (NSW DPI) website, the project area lies within the 'Sydney Metro catchment of the Sydney basin region'. The Sydney Metro catchment is bounded by the Hawkesbury-Nepean catchment to the west and the Tasman Sea to the east. The Sydney Metro catchment consists of eight sub-catchments and includes local rivers and channels as detailed below:

- Hacking River
- Georges/Woronora River
- Cooks River
- Eastern Beaches
- Parramatta River/Port Jackson
- Lane Cove River
- Middle Harbour
- Northern Beaches (up to Narrabeen).

The topography within the project area varies and includes rolling hills throughout the central business district (CBD), low lying, flat topography towards the southern end of the project area and within the northern areas of the CBD. The highest point of the topography within the project area is located in North Sydney. At the time of undertaking the site inspection, there were no obvious areas of inconsistent topography at above ground features of the project which could indicate significant areas of filling. Based on historical information, it is understood that localised areas of quarrying and filling activities may have been undertaken in the near vicinity of the proposed alignment around between the Chatswood portal and Crows Nest Station (specifically around Artamon). At the time of the site inspection, there was no visual evidence of these quarrying and filling activities.

The majority of rain falling onto the project area would fall onto impermeable areas (i.e. roads, roofs of buildings) and available open space (i.e. parks, yards and grassed verges) and is expected to infiltrate into sub-soils and/or run off into formalised stormwater drains.

2.3 Geology

The Sydney 1:100,000 Geological Series Sheet 9130 (NSW Department of Mineral Resources, 1983) indicated that the project area is predominately underlain by Quaternary Geology (Qha), Wianamatta Ashfield Shale (Rwa), and Wianamatta Hawkesbury Sandstone (Rh) south of the harbour crossing, and Wianamatta Hawkesbury Sandstone (Rh) and Wianamatta Ashfield Shale (Rwa) to the north of the harbour crossing. A description of the geological formations underlying the project area is provided in **Table 2.1** below.

Table 2.1 Geological units underlying the project area.

Unit	Description
Quaternary Geology (Qha)	Silty to peaty quartz sand, silt and clay. Ferruginous and humic cementation in places. Common shell layers.
Wianamatta Ashfield Shale (Rwa)	Black to dark grey shale and laminate.
Wianamatta Hawkesbury Sandstone (Rh)	Medium to coarse grained quartz sandstone, very minor shale and laminate lenses.

2.4 Soils

The Sydney 1:100,000 Soil Landscape Series Sheet 9130 (Soil Conservation of NSW, 1966) indicated that the residual soils within the project area south of the harbour crossing consists of Birrong (bg), Blacktown (bt), Deep Creek (dc), Lucas Heights (lh), Gymea (gy), and Disturbed (xx) Landscape Groups. While the soils within the project area to the north of the harbour crossing consists of Hawkesbury (ha), Glenorie (gn), Gymea (gy), and Blacktown (bt) Landscape Groups. **Table 2.2** describes the soil landscape groups within the project area.

Table 2.2 Soil units underlying the project area.

Unit	Description
Birrong (bg)	<ul style="list-style-type: none"> Landscape – level to gently undulating alluvial floodplain draining Wianamatta Group shales. Local relief to 5 metres, slopes < 3%. Extensively cleared tall open forest and woodland. Soils – deep (>250 cm) yellow podzolic soils and yellow solodic soils on older alluvial terraces. Limitations – localised flooding, high soil erosion hazard, saline subsoils, seasonal waterlogging, and very low soil fertility.
Blacktown (bt)	<ul style="list-style-type: none"> Landscape - found on gently undulating rises on Wianamatta Group shales with local reliefs of up to 30 metres and slopes of less than 5 per cent. Soils - shallow to moderately deep hardsetting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines. Limitations - moderately reactive, highly plastic subsoil, with low fertility and poor drainage.
Deep Creek (dc)	<ul style="list-style-type: none"> Landscape – level to gently undulating alluvial floodplain draining the Hawkesbury Sandstone. Local reliefs of < 5 metres and slopes of < 3%. Soils – deep (>200 cm) podzols on well drained terraces, siliceous sands on current floodplain, and humus podzols in low lying areas. Limitations – flooding, extreme soil erosion hazard, sedimentation hazard, localised very low fertility and permanently high water tables.
Lucas Heights (lh)	<ul style="list-style-type: none"> Landscape – gently undulating crests and ridges on plateau surfaces of the Mlttagong formation. Local relief to 30 metres, slopes of <10%. Rock outcrop is absent. Extensively or completely cleared, low open forest and woodland. Soils – moderately deep (50 – 150 cm), hardsetting yellow podzolic soils on outer edges of crests. Limitations – stony soil, low soil fertility, low available water capacity.

Unit	Description
Glenorie (gn)	<ul style="list-style-type: none"> • Landscape – found on undulating to rolling low hills on Wianamatta Group shales with local reliefs of 50 to 80 metres and slopes of 20 %. Extensively cleared tall open forest. • Soils – shallow to moderately deep red podzolic soils on crests, moderately deep red/brown podzolic soils on upper slopes, deep yellow podzolic soils on lower slopes and humic gleys, yellow podzolic soils and gleyed podzolic soils along drainage lines. • Limitations – high soil erosion hazard, localised impermeable highly plastic subsoil, and moderately reactive
GyMEA (gy)	<ul style="list-style-type: none"> • Landscape – found on undulating to rolling low hills on Hawkesbury Sandstone with local reliefs of 20 to 80 metres and slopes of 10 to 25 % and rock outcrops of less than 25 %. • Soils – shallow to moderately deep yellow earths and earthy sands on crests and inside of benches. • Limitations – high soil erosion, rock outcrop, shallow highly permeable soil, and very low soil fertility.
Disturbed (xx)	<ul style="list-style-type: none"> • Landscape – it occurs within other landscapes and is mapped as xx. The topography varies from level plans to undulating terrain and has been disturbed by human activity to a depth of at least 100 cm. • Soils – the original soil has been removed, greatly disturbed or buried. Most of these areas have been levelled to slopes of < 5%. Landfill includes soil, rock, building and waste material. The original vegetation has been completely cleared. • Limitations – are dependent on nature of fill material and include subsidence resulting in a mass movement hazard, soil impermeability leading to poor drainage and low fertility. Care must be taken when these sites are developed.
Hawkesbury (ha)	<ul style="list-style-type: none"> • Landscape – found on rugged, rolling to very steep hills on Hawkesbury Sandstone with local reliefs of 40 to 200 metres and slopes of more than 25 % and rock outcrops of more than 50 %. • Soils – shallow (<50cm), discontinuous lithosols/siliceous sands associated with rock outcrops, earthy sands, yellow earths and some yellow podzolic soils on the inside of benches and along joints and fractures. • Limitations – extreme soils erosion hazard, mass movement (rockfall) steep slopes, rock outcrop, shallow, stony, highly permeable soils with low fertility.

2.5 Acid sulfate soils risk

Acid sulfate soils (ASS) are the common name given to naturally occurring sediments and soils containing iron sulfides (principally iron sulfide or iron disulfide or their precursors). The exposure of the sulfide in these soils to oxygen by drainage or excavation leads to the generation of sulfuric acid. Areas of ASS can typically be found in low lying and flat locations which are often swampy or prone to flooding.

ASS Risk Maps from the CSIRO Australian Soil Resource Information System (ASRIS) database were reviewed to ascertain the probability of ASS being present across the project area. Based on this information, the generalised ASS probability across the project area has been assessed as follows:

- Chatswood to Crows Nest – Low probability
- Crows Nest to North Sydney – Extremely low probability
- Sydney Harbour and Barangaroo – High probability

- Barangaroo to Pitt Street – Extremely low probability
- Pitt Street to Central – Low probability
- Central to Marrickville – Extremely low probability

A review of the ASS risk map from the Marrickville Local Environment Plan (2011) indicated that the Marrickville dive site is located within an area of Class 2 ASS.

It should be noted that there is an area of high ASS probability to the north of Alexandra Canal. It is understood that the tunnel from the proposed Waterloo Station site to Marrickville would be constructed wholly within the underlying bedrock. As such the risk of ASS being encountered during tunnelling is low. However, the construction of the Waterloo Station may require excavation of the overlying alluvial soils which may contain ASS.

2.6 Hydrogeology

The direction of groundwater flow could not be definitively assessed based on current information, although the surrounding topography of the project area and location of water bodies suggests that groundwater would flow in the following directions in the vicinity of the above ground features of the project:

- West to northwest towards Swaines Creek and the Lane Cover River from the Chatswood dive site (northern) at Chatswood
- East towards Middle Harbour from the Artarmon substation site
- South towards Lavender Bay from Victoria Cross Station
- South towards Sydney Harbour from the Blues Point temporary site
- North and west towards Sydney Harbour from the Pitt Street, Martin Place and Barangaroo Station sites
- North towards Cockle Bay from Central Station
- Southwest towards Alexandra Canal (Sheas Creek) from Waterloo Station
- Southeast towards Alexandra Canal (Sheas Creek) from the Marrickville dive site (southern).

2.6.1 Groundwater bore search

A search of the Department of Primary Industries groundwater database identified 106 registered groundwater wells within a 500 metre radius of aboveground features of the project. Details of the 84 wells are summarised in **Appendix A**.

The assessment indicates that there is a potential impact to a beneficial groundwater bore user near to the Marrickville dive site (GW105938) given that the domestic use bore is located down gradient of the Marrickville dive site. Considering the distance of the well from the site and that the tunnel is likely to create a negative groundwater gradient, the risk of contamination from the site (if present) impacting on the well is likely to be low.

2.7 Sensitive receiving environments

Based on the available information, sensitive receiving environments located near project elements which could be potentially impacted by contamination within the project area (if present) are detailed below:

- Sydney Harbour – Potential impacts from the Barangaroo Station, the Blues Point temporary site and ground improvement works
- Cockle Bay – Potential impacts from the Pitt Street and Martin Place Station sites
- Beneficial users of groundwater down gradient from the respective sites (where present).

2.8 Site inspection

A site inspection was conducted on 26 May and 30 September 2015 by an environmental scientist. The site inspection focussed on the tunnel alignment and all aboveground features of the project, as well as adjacent land uses and potential AEs. The site inspection was only undertaken from areas within the project area which were publically accessible.

At the time of the inspection the project alignment consisted primarily of urbanised areas, well established business districts, and commercial/industrial land uses. The surrounding land use was generally low to high density residential and/or commercial land use along the project alignment.

The Chatswood dive site consisted of a range of land uses; the Chatswood Ausgrid Depot, and a commercial precinct consisting of furniture/interiors shops, an art school, Guardian Funerals funeral parlour (appeared to be shop front only), and vacant shop fronts. The Ausgrid Depot appeared to be primarily office space, with a large car yard fronting onto Pacific Highway. It was unable to be ascertained from publically accessible areas whether the Ausgrid depot contained workshop and maintenance areas. The Chatswood dive site was also surrounded by commercial/industrial land use with a Caltex service station across Pacific Highway opposite the site, and another funeral parlour a short distance to the north. Additionally, the railway line travels through the proposed site.

The proposed location for the Artarmon substation is currently a being temporarily used by the Artarmon Public School. The site lay adjacent to the Gore Hill Freeway.

The Crows Nest and Victoria Cross Station sites are located within well-established commercial areas surrounded by low to high density residential land use.

The Blues Point temporary site is currently a park adjacent to Sydney Harbour. The park is vacant, grassed land adjacent to a disused ferry wharf to the east. A sea wall separates the Blues Point Park from Sydney Harbour. The park is surrounded by low to high density residential land use.

The proposed Barangaroo Station located along Hickson Road is located within a commercial centre and adjacent to the building developments of Barangaroo. In the northern section of the project, continuing south, the tunnel would pass through Martin Place, Pitt Street and Central which are all within Sydney's CBD, an area which has remained a commercial district since the 1930s. The proposed Regent Street Bridge at the Central Station site is located adjacent to a former service station.

The proposed Waterloo Station site is a commercial / industrial / retail precinct including services such as a dry cleaner, automotive sales and repairs, and shopping outlets. The areas surrounding the commercial / industrial / retail precinct appeared to be high density residential, with a potential substation located on Cope Street.

As the alignment travels south it passes under urbanised areas of Redfern, Waterloo, Alexandria and Erskineville.

In the southern areas of the alignment the predominant land uses include a combination of low to medium density residential and commercial/industrial, with the Marrickville dive site located within and adjacent to the railway corridor.

The generalised land use within and surrounding the project area as observed during the site inspection is detailed in **Table 2.3**.

Table 2.3 Generalised land use within and surrounding the project area (2015).

Project element	Land use within project area	Land use surrounding project area
Chatswood dive site (northern)	Commercial, industrial and retail.	Commercial, industrial, retail and railway lines
Artarmon substation	Vacant (private) land	Residential and Gore Hill Expressway
Crows Nest Station	Commercial	Low and high density residential
Victoria Cross Station	Commercial	Low and high density residential
Blues Point temporary site	Open space, disused wharf	Low and high density residential
Barangaroo Station	Commercial and construction site	Commercial, retail and high density residential
Martin Place Station	Commercial and retail	Commercial and retail
Pitt Street station	Commercial and retail	Commercial and retail
Central Station	Commercial and retail	Commercial and retail
Sydney Yard Access Bridge site (part of Central Station)	Retail and residential	Retail, residential and railway
Waterloo Station	Commercial, industrial and retail	Commercial, high density residential
Marrickville dive site (southern)	Railway	Commercial, industrial and residential

2.9 Site history

Several sources were investigated to determine the history of land use of the project area. The following list details the sources of historical information and a summary of information provided by each source.

- NSW Land and Property Management Authority, Land and Property Information Division (LPI): Historical aerial photographs (1930 to 2014)
- RTA *From the Skies: Aerial photographs of Sydney* (1943)
- NSW EPA Contaminated Sites Register and Record of Notices.

2.9.1 Historical aerial photography

Historical aerial photographs from the LPI were reviewed for the years: 1930, 1955, 1965, 1976, 1986, 1994, and 2004. Historical aerial photography from 1943 was sourced from the RTA *From the Skies: Aerial photographs of Sydney in 1943*. The aerial photography review focussed on the aboveground features of the site. The findings of the historical aerial photograph review are summarised in **Table 2.4**.

Table 2.4 Historical aerial photography review

Date of aerial photography	Site	Surrounding area
1930	<p>Chatswood: The western portion of the Chatswood dive site (northern) was located within an area occupied by residential dwellings (north eastern portion), commercial premises (southern portion) and vacant land (eastern portion). Beyond and to the east of the north shore railway line, the area was occupied by low density residential dwellings.</p> <p>Artarmon: The substation site was located within a small enclave occupied by low density residential dwellings. Quarry and brick kilns were present immediately to the southwest of the substation site.</p> <p>Crows Nest: The area appeared to be predominately residential with wide local roads. Residential density appeared to be low with small to medium sized single dwellings. The railway line was also apparent.</p> <p>Victoria Cross: Berry Street and Miller Street appeared to be a well-established residential/commercial area with small to medium sized buildings and local and arterial roads.</p> <p>Blues Point: The temporary site appeared to be located within an area used as a ship yard.</p> <p>Barangaroo: The station site appeared to be a wharf facility with multiple berthing areas and commercial/industrial land use along Hickson Road.</p> <p>Martin Place: Elizabeth Street and Castlereagh Street were already established within the CBD.</p> <p>Pitt Street: Pitt Street and Castlereagh Street were already established within the Central Business District (CBD).</p> <p>Central: Central station was a large established train station with 12 visible platforms dividing the station. Prince Alfred Park was also visible and well established. Additional public open space to the west and north (Belmore Park) of the station was also present.</p> <p>Waterloo: The station site appeared to be occupied by commercial/industrial premises (potentially small manufacturing buildings).</p> <p>Marrickville: The Marrickville dive site (southern) (near Sydenham Station) would be located within the existing railway corridor and adjoining commercial/industrial areas. Commercial/industrial and residential land use are immediately adjacent to the project area.</p>	<p>Chatswood: The land surrounding the chatswood dive site (northern) was predominantly occupied by low density residential dwellings. The properties to the south of the dive site across Mowbray Road appeared to be occupied by water tanks and a substation.</p> <p>Artarmon: The substation site was surrounded by areas of low density residential land use, quarries and brick kilns.</p> <p>Victoria Cross: McMahons Point was used as a wharf facility with several large berthing areas. The surrounding land use appeared to be primarily residential with some areas of larger, potentially office buildings towards North Sydney. Pacific Highway was under construction to the south of the Victoria Cross site.</p> <p>Blues Point: The land use surrounding the temporary site appeared to be dominated by high density residential land use (units) to the north and industrial land use to the west which included wharves and warehouse type structures.</p> <p>Barangaroo: Walsh Bay and Jones Bay were heavily in use, and Observatory Park was visible to the northeast of Barangaroo. Land use surrounding Barangaroo was primarily commercial/industrial and wharf facilities. The Sydney Harbour Bridge was under construction.</p> <p>CBD#: Commercial land use surrounded the sites of the Martin Place and Pitt street stations. Hyde Park and Domain Park were also visible and well established.</p> <p>Central: The areas surrounding Central station appeared to be well established residential or commercial land use with local and arterial roads which facilitated low traffic flow.</p> <p>Waterloo: The land use surrounding the station site appeared to be similar to that of the site (small commercial/industrial premises). The Eveleigh rail yards were located to the northwest of the site.</p> <p>Marrickville: The areas surrounding the proposed Marrickville dive site (southern) were a combination of commercial/industrial and residential. There were also some major land disturbances (brick pits and landfills) north and east of the project area in St Peters and along Alexandra Canal.</p>

Date of aerial photography	Site	Surrounding area
1943	<p>The sites appear largely unchanged from the 1930 photographs.</p>	<p>The areas surrounding the sites have remained largely the same as per the 1930 photographs with the exception of the following sites:</p> <p>North: The northern suburbs have remained largely residential, with some increase in commercial/industrial land use in St Leonards. There was increased land disturbance within Artarmon. Smoke stacks and brick kilns were more pronounced within the photograph.</p> <p>CBD: The Sydney CBD remained largely the same as the 1930 photograph. The Sydney Harbour Bridge had been completed in this photograph</p> <p>Marrickville: Some development was occurring in the areas surrounding the Sydenham portal site. There was a large land disturbance to the east of the site near Alexandra Canal. The stormwater reservoir along Railway Parade was under construction.</p>
1955	<p>With the following exceptions the sites appear largely unchanged from the 1943 photographs.</p> <p>Victoria Cross: North Sydney appeared to be increasingly commercial with the development of several large multi-storey buildings.</p> <p>Blues Point: Although wharves were still present, there were no observable signs of shipyard activities.</p>	<p>The areas surrounding the sites have remained largely the same as per the 1943 photographs with the exception of the following sites:</p> <p>Crows Nest: The land use surrounding the station site was increasingly commercial with the development of larger buildings.</p> <p>Victoria Cross: North Sydney appeared to remain primarily residential with moderate pockets of commercial land use.</p> <p>CBD: The Sydney CBD remained largely the same as per the 1943 photograph.</p> <p>Marickville: There were several additional large land disturbances in the vicinity of the Marrickville dive site (southern). The general land use was increasingly commercial/industrial.</p>

Date of aerial photography	Site	Surrounding area
1965	<p>With the following exception the sites appear largely unchanged from the 1955 photographs.</p> <p>Chatswood: The western portion of the dive site had been developed with large warehouse and/or office type buildings. Residential premises were still present within the north eastern portion of this part of the site.</p> <p>Crows Nest: The land use remained largely residential.</p> <p>Victoria Cross: The site has become increasingly commercial with the expanse of large multi storey buildings established within North Sydney business area.</p> <p>Barangaroo: The southern portion of Barangaroo had been partially filled in/reclaimed and large buildings/warehouses established on the reclaimed areas. The berthing facilities in the south had been removed.</p> <p>Waterloo: Small commercial/industrial premises formerly located on the site had been demolished and replaced by larger warehouse style buildings.</p> <p>Marrickville: The addition of some potential shipping containers stored on the site.</p>	<p>Chatswood: A television transmission tower is present to the south of the dive site.</p> <p>Artarmon: Commercial/industrial warehouse type buildings had been constructed with the brickpit to the west of the site.</p> <p>Crows Nest: The land use surrounding the Crows Nest site was now well established residential/commercial.</p> <p>Victoria Cross: The Bradfield Highway was under construction to the east of the Victoria Cross site. The greater North Sydney business area was now a well established commercial centre.</p> <p>Blues Point: The Blues Point Tower apartments had been constructed. Ships/boats were using the adjacent finger wharves.</p> <p>Barangaroo: The land surrounding Barangaroo remained largely the same as per the 1955 photograph.</p> <p>CBD: The CBD remained largely the same as per the 1955 photograph with some minor developments within public open spaces surrounding the sites such as increased vegetation growth within Hyde Park, and the creation of Prince Alfred Pool within Prince Alfred Park.</p> <p>Waterloo: Larger commercial/industrial and high density residential premises had been constructed in the areas surrounding the station.</p> <p>Marrickville: The largest land disturbance (brickpit) to the east of the dive site (Sydney Park) had commenced to be landfilled with large areas of the brickpit already completely filled. The brickpit closest to the site to the northeast had been almost completely landfilled. The stormwater reservoir adjacent to the site also appeared to be completed and had begun filling with water.</p>

Date of aerial photography	Site	Surrounding area
1976	<p>With the following exception the sites appear largely unchanged from the 1965 photographs</p> <p>Chatswood: The entire western portion of the northern dive site had been developed with large warehouse and/or office type buildings.</p> <p>Crows Nest: The station site was primarily commercial land use with an increase in larger building developments.</p> <p>Victoria Cross: The station site had become primarily commercial within the North Sydney business area.</p> <p>Blues Point: The adjoining finger wharves have been removed and the site appears to be a park.</p> <p>Barangaroo: Barangaroo was approximately 85% reclaimed. Wharf facilities have been moved to the outer edge of the reclaimed area. The northern portion of the site which originally had wharves and warehouses on the point, had been cleared.</p> <p>Central: Central station appeared to have expanded slightly to the east and was under construction.</p> <p>Waterloo: There are an increased number of larger warehouse style buildings had been constructed.</p> <p>Marrickville: The shipping containers had been removed from the dive site and appeared to be vacant land.</p>	<p>The areas surrounding the sites have remained largely the same as per the 1965 photographs with the exception of the following sites:</p> <p>Chatswood: Another water tank had been constructed to the south of the dive site.</p> <p>Artarmon: Commercial/industrial warehouse type buildings had been constructed across all of the former brickpit to the west of the site.</p> <p>Victoria Cross: Bradfield Highway in North Sydney was complete.</p> <p>Blues Point: The industrial land use to the west of the site which included wharves and warehouse type structures appeared to have been demolished/removed.</p> <p>Waterloo: Increased numbers of larger commercial/industrial and high density residential premises have been constructed in the surrounding areas.</p> <p>Marrickville: The largest brickpit to the east of the dive site (Sydney Park) was almost completely landfilled. Residential land use in the area had become increasingly commercial/industrial.</p>
1986	<p>With the following exception the sites appear largely unchanged from the 1976 photographs</p> <p>Barangaroo: The site had now been completed with all areas (with the exception of a small area towards the centre of the site) reclaimed. The site had seven warehouses and was still being used as a wharf facility in some parts.</p> <p>Marrickville: The dive site appeared to be a storage facility, potentially for cars or large storage containers.</p>	<p>The areas surrounding the sites have remained largely the same as per the 1976 photographs with the exception of the following sites:</p> <p>Barangaroo: A large development was under construction to the south of the Barangaroo site near Jones Bay with much of the existing infrastructure cleared.</p>

Date of aerial photography	Site	Surrounding area
1994	<p>With the following exception the sites appear largely unchanged from the 1986 photographs.</p> <p>Artarmon: Residential buildings on the substation site had been demolished and replaced with larger commercial/industrial warehouse style buildings.</p> <p>Barangaroo: All areas of the site were reclaimed and the site was heavily in use as a berthing and storage facility.</p> <p>Central: A large storage/stabling facility in the middle of the Central station site (first observed in 1930) had been removed.</p>	<p>The areas surrounding the sites have remained largely the same as per the 1986 photographs with the exception of the following sites:</p> <p>Artarmon: The Gore hill Expressway had been constructed.</p> <p>Crows Nest: A residential block to the west of the station site adjacent to the existing railway was demolished and transformed into public open space.</p> <p>Barangaroo: Cockle Bay (Jones Bay) had been completed and appeared to be fully functional.</p> <p>Central Station: The land surrounding Central station had increased in commercial density.</p> <p>CBD: The land use surrounding the sites within Sydney's CBD remained largely the same.</p> <p>Marrickville: Sydney Park was completely landfilled with vegetation and other park facilities (e.g. paths etc.) established within the park site.</p>
2004	<p>With the following exception the sites appear largely unchanged from the 1994 photographs.</p> <p>Barangaroo: Infrastructure on the site had increased to the south.</p> <p>Central: A carpark appeared to have been constructed at the southern end of the station site.</p> <p>Marrickville: The dive site was partially vegetated with the addition of two large above ground tanks.</p>	<p>The areas surrounding the sites remained largely the same as per the 1994 photographs with the exception of the following site:</p> <p>Crows Nest: Within the open space to the west of the station site a large residential/commercial complex had been constructed.</p>

*Martin Place and Pitt Street Stations have been included in the one CBD site when referred to in surrounding land use.

2.9.2 Site history summary

The historical aerial photography review indicated that the Marrickville, Waterloo, Victoria Cross, Crows Nest and Artarmon sites have increasingly become commercial/industrial from residential land use since the 1930s. Additionally, the Barangaroo site has seen major industrial developments since the 1950s and 1960s. Conversely, the historical industrial land use on and surrounding the Blues Point temporary site has changed to residential and open space. The land use surrounding the Marrickville, Barangaroo and Artarmon sites has seen major extractive/reclamation works within the past 50 years. The Central, Pitt Street and Martin Place station sites have remained within a commercial context since the 1930s.

2.9.3 NSW Contaminated Sites Register

At the time of preparing this report, a search of the NSW EPA Contaminated Sites Register and Record of Notices (under Section 58 of the *Contaminated Land Management Act 1997*) indicated that there were 11 sites registered with the NSW EPA within 500 metres of the project area that were either regulated or had been notified, or within the Local Government Areas throughout the alignment. The sites are shown on **Figure 3** and summarised in **Table 2.5**. NSW EPA regulated sites at Millers Point relative to the Barangaroo Station development are shown as **Figure 4**.

Table 2.5 Notified sites within 500 metres of the project area

Site	Suburb	Notified site address	Notified site activity	Contamination status	Location relative to project
Chatswood dive site (northern)					
1	Chatswood	607 Pacific Highway	Former Caltex Service Station	Contamination currently regulated under CLM Act	Within the Chatswood dive site
2	Chatswood	572 Pacific Highway	Caltex Service Station	Under assessment	50m to the west of the Chatswood dive site
Blues Point temporary site					
3	Lavender Bay	French Street	SRA Land	Regulation under CLM Act not required	Approximately 400m north of the site
Barangaroo Station					
4	Millers Point	30 – 34 Hickson Road	Former AGL Gasworks	Regulation under CLM Act not required	To the south (<50m) from the Barangaroo station footprint.
5	Millers Point	36 Hickson Road	Former AGL Gasworks	Contamination currently regulated under CLM Act	To the south (approximately 100m) from the Barangaroo station footprint.
6	Millers Point	38 Hickson Road	Former AGL Gasworks	Contamination being managed via the planning process (EP&A Act)	To the south (approximately 150m) from the Barangaroo station footprint.
7	Millers Point	Berths 5, 6 and 7 (already demolished) and part Hickson Road	Former AGL Gasworks	Contamination currently regulated under CLM Act	Adjacent to the southern edge of the Barangaroo station footprint.
8	Millers Point	Road reserve fronting 30-38 Hickson Road	Former AGL Gasworks	Contamination currently regulated under CLM Act	To the south (<50m) from the Barangaroo station footprint.
9	Millers Point	4 Towns Place	Port Services (Moores) Facility	Contamination currently regulated under POEO Act	Approximately 200 metres north of the Barangaroo site.
Pitt Street Station					
10	Sydney	447 Kent Street	Interpro House (OSP 46581)	Regulation under CLM Act not required.	Approximately 320 metres west of the Pitt Street site.
Waterloo Station					

Site	Suburb	Notified site address	Notified site activity	Contamination status	Location relative to project
11	Waterloo	2 John Street	Other industry	Regulation under CLM Act not required	Approximately 200m south of the site

Two of these notified sites pose a potential risk to construction activities across the project. These sites are listed below and are discussed further in Section 3:

- Former Caltex Service Station at 607 Pacific Highway, Chatswood
- Former gasworks at Millers Point at Barangaroo.

Soils within these areas would require further investigations or further information needs to be made available for review to determine the extent of contamination (if present) and likelihood of the contamination affecting construction and operational activities of the project.



KEY

- Proposed station location
- Proposed dive locations
- Proposed ancillary infrastructure
- Chatswood to Sydenham
- Notified contaminated sites within 500 metres of the project area

Indicative only, subject to design development



Figure 3 – NSW EPA Notified or Regulated Sites within 500m of Project Area



KEY

- Chatswood to Sydenham
- Proposed operational area at surface
- Proposed construction site area
- Existing suburban rail
- Approximate extent of regulated areas - Barangaroo

Indicative only, subject to design development



Figure 4 – NSW EPA Regulated Area at Millers Point Relative to Proposed Barangaroo Station

2.10 Previous contamination site investigations

The following provides a summary of previous investigations provided by the client for selected project elements. The summary has been prepared in consideration of the respective construction elements of the project.

2.10.1 Chatswood dive site (northern)

The Golder Associates (November 2011) *Human Health Risk Assessment – Energy Australia Chatswood Depot, 337-335 Mowbray Road* has been reviewed and is summarised below.

Golder Associates carried out a human health risk assessment (HHRA) on the soil and groundwater hydrocarbon contamination identified at the site located at 337-335 Mowbray Road, Chatswood (incorporating the original Energy Australia Depot, a former Caltex site and the former MLP property).

The HHRA focussed on the risk from hydrocarbons via the inhalation exposure route to commercial works (on and off site), intrusive workers conducting excavations (on and off site), site visitors and the general public in context of the site usage at the time of preparing the HHRA (i.e. commercial use and vacant land). No sampling was undertaken on the depot site as part of the HHRA.

The HHRA considered groundwater contamination not to be an issue because of limited direct exposure and shallow soil contamination was to be managed in accordance a site management plan (SMP) prepared by Golders in 2010. No further assessment of exposure risk for groundwater and soil contamination was undertaken as part of the HHRA.

In context of construction works associated with the project, the HHRA does not consider known asbestos contamination buried at the site and other contaminants (if present) associated with operations undertaken at the Ausgrid depot.

The site audit report Environ Australia (May 2015) *Site Audit Report – Former Caltex Station, 607 Pacific Highway, Chatswood* has been reviewed and summarised below.

The former Caltex service station is the subject of a Declaration of Investigation Site and an approved Voluntary Management Proposal (VMP). Soil and groundwater at the site was contaminated with petroleum hydrocarbons, which had migrated onto an adjacent commercial property (former MLP office building site).

Remediation of the service station (607 Pacific Highway) included removal of underground storage tanks and associated infrastructure, and excavation of contaminated soil. Excavations were validated prior to reinstatement of the site. Contaminated soil from the site was landfarmed and reinstated in the excavations following validation.

Soil containing fragments of asbestos cement material (ACM) was identified during remediation of the site. The material was excavated and consolidated into two excavations on the service station and adjoining commercial property (former MLP). The ACM was placed below a geotextile fabric marker layer and a minimum of 0.6 m of virgin excavated natural material (VENM) and asphalt paving (up to 1.5 m). The area was surveyed to record the location of the material and demonstrate the thickness of the VENM cover layer.

The service station is the subject of a Declaration of Investigation Site because of migration of petroleum hydrocarbon contaminants onto adjacent properties. Further groundwater monitoring and management of contamination remaining on the site and former MLP is to be conducted in accordance with a site management plan (SMP) that is required by the VMP. Golders Associates (April 2015) *Site Management Plan, 607 Pacific Highway Chatswood* have prepared a SMP. The Auditor considered that the SMP was appropriate.

VMP 20141703 required remediation of the site in accordance with a RAP and preparation of a Site Audit Report. An objective of the approved VMP was to remediate the site so that it is suitable for commercial/industrial use. The Auditor considered that the remediation and validation have been conducted

substantially in accordance with the remedial action plan and the objective has been achieved, subject to the SMP.

The significantly contaminated land declaration does not apply to the MLP and Ausgrid Depot. However contamination on the adjoining properties is addressed in the VMP.

The following geotechnical investigation report was provided for an area occupied by the proposed Chatswood dive site:

- Douglas Partners (May 2012) *Geotechnical Investigation – Proposed Commercial and Office Development, 5-7 Bryson Street, 591 Pacific Highway and 14 Nelson Street, Chatswood.*

No contamination assessment was undertaken as part of this investigation. However, the following information was noted in the investigation report with respect to contamination.

- The northwest portion of the site was previously occupied by a Caltex service station. It is understood that the service station site has been remediated; however, further investigation by several different environmental consultants has indicated remnant hydrocarbon contamination still present in soils and groundwater on site. Thirty groundwater wells have been installed by other consultants.
- Golder Associates prepared a Site Management Plan (SMP) for this in a report dated 7 November 2010 (Report No. 107623121-002-R-Rev0) “so that users of the Site are aware of the impacted soil and groundwater beneath the Site and that appropriate action can be implemented if and when exposure to these media occurs”.

In context of construction works associated with the project, any subsurface excavation works on the former Caltex service station site, MLP property and/or the Ausgrid Depot must be undertaken (as a minimum) in accordance with the SMP (Golders, April 2015).

2.10.2 Sydney Harbour

A review of publically available information indicated that a number of scientific publications have been produced related to the contamination of sediments within Sydney Harbour.

A review of the Sydney Institute of Marine Science (2014) *Technical Report Sydney Harbour A systematic review of the science* indicated that early investigations showed sediments in the estuary (ie. Sydney Harbour) to contain high concentrations of a suite of metals (most notably copper, zinc and lead). More recent studies have confirmed that sediments in large areas of Sydney Harbour are not only highly polluted by metals, but also by a wide range of non-metallic contaminants, e.g. organochlorine pesticides (OCs), polycyclic aromatic hydrocarbons (PAHs) and polychlorinated dibenzo-para-dioxins (dioxins) and dibenzofurans (furans). These organic contaminants have led to restrictions on the consumption of seafood from locations west of the Sydney Harbour Bridge (NSW Department of Primary Industries).

Sediment investigation components from the following reports were reviewed and summarised below:

- Golder-Douglas (August 2015) *Interim Geotechnical Data Report, Sydney Metro City and Southwest Geotechnical Investigation* (Golder-Douglas, August 2015a)
- Golder-Douglas (August 2015) *Interim Geotechnical Data Report, Western Harbour Tunnel Geotechnical Investigation* (Golder-Douglas, August 2015b).

Sediment samples were collected from two locations as part of the Golder-Douglas (August 2015a) investigation to a maximum depth of 0.7m below the surface of the sediment and analysed for a range of contaminant compounds including:

- Trace metals (Ag, Cd, Cr, Cu, Pb, Hg, Ni, Sb and Zn) and arsenic
- Polychlorinated biphenyls (PCBs)
- Organochlorine (OC) pesticide residues
- Polycyclic aromatic hydrocarbons (PAHs)

- Total petroleum hydrocarbons (TPH)
- Tri-butyltin (and mono- and di-butyltin)
- Sub-samples for polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs).

Where available, all results were assessed against the Commonwealth of Australia (2009) *National Assessment Guidelines for Dredging* (NAGD).

Concentrations of contaminants in sediment samples were below the NAGD guidelines (where available) with the exception of mercury in surficial sediment at both sampling locations.

Sediment samples were collected from seven locations as part of the Golder-Douglas (August 2015b) investigation to a maximum depth of 14.45m below the surface of the sediment and analysed for a range of contaminant compounds including:

- Trace metals (Ag, Cd, Cr, Cu, Pb, Hg, Ni, Sb and Zn) and arsenic
- PCBs
- OC pesticide residues
- PAHs
- TPH
- Tri-butyltin (and mono- and di-butyltin)
- Sub-samples for PCDD/Fs.

Where available, all results were assessed against the Commonwealth of Australia (2009) *National Assessment Guidelines for Dredging* (NAGD).

Concentrations of contaminants in sediment samples were below the NAGD guidelines (where available) with the exception of TBT, mercury and lead detected in selected samples.

Mean concentrations of PCDD/Fs exceeded a widely accepted toxic equivalency value of 20 pg (World Health Organisation).

Mean concentrations of some trace metals, notably mercury and lead, exceeded background concentrations established for Sydney Harbour

Concentrations of contaminants were typically highest in the 0-1 m interval and substantially lower in sediment at depths greater than 1 m. Several samples of subsurface sediment contained low concentrations of all contaminants and the potential for contaminated sediment below surficial (0-2 m) sediment was thought to be negligible.

The results of the sediment investigations indicated that contaminated sediments could be present in the vicinity of the proposed harbour crossing alignment.

It should be noted that the tunnelling would occur within very deep sediments (around 40 metres below the seabed) and it is not anticipated that these sediments would have any level of contaminants. Only where sediment is disturbed during the ground improvement process (eg grouting) may minor disturbances to the sea bed occur. See **Figure 5** showing profile of the harbour crossing tunnel alignment and ground improvement zone.

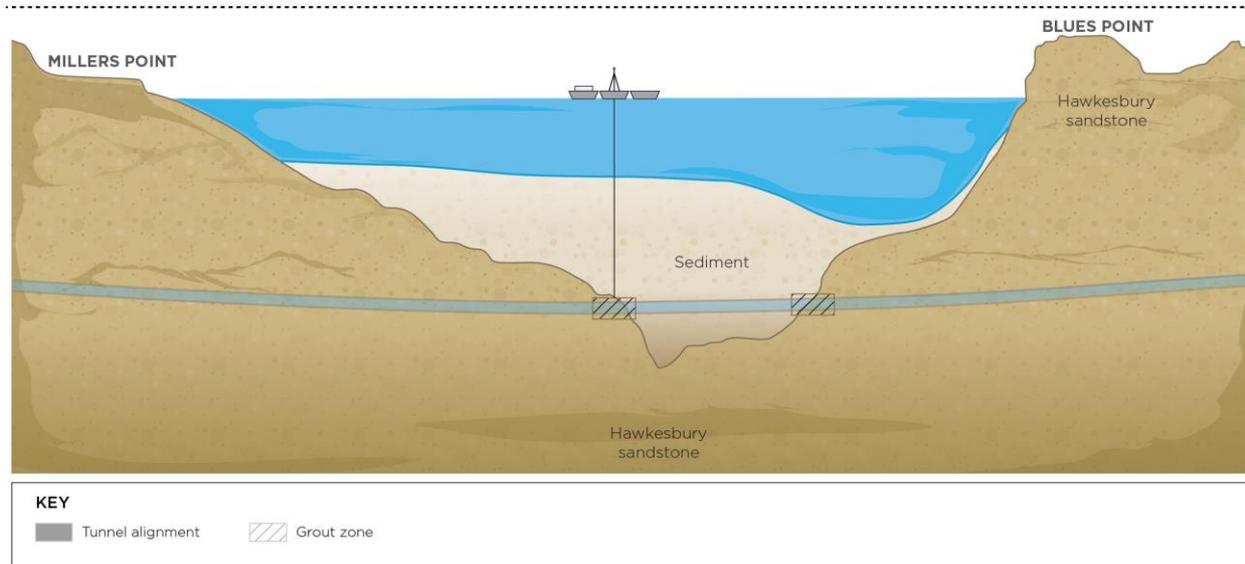


Figure 5 – Harbour tunnel depth and zone of ground improvements required

As part of the project environmental assessment process, additional sediment sampling and analysis was undertaken within sediments across the general alignment layout, and at the two grout treatment areas in order to gather data relating to sediment quality, contamination concentrations (if any) and the probable aquatic ecology aspects associated with shallow sediments (less than 1.0 metres below bed sediments - mbbs) in the treatment areas.

The objective of the sediment quality investigation was to assess potentially contaminated, near-surface sediments residing along the proposed tunnel alignment and implications of disturbing these sediments as part of grouting procedures. Sediment was collected and analysed for an appropriate suite of contaminants of potential concern, based on results of previous sediment assessment works.

The results of the sediment investigations indicate elevated concentrations of lead, mercury, TBT and normalised concentrations of PCDD/Fs and PAHs are present in shallow sediments. These results are consistent with those obtained from previous investigations and typical of large areas of sediment quality in Sydney Harbour.

The sediments within the grouting regions are likely to provide habitat for benthic infauna and epifauna.

2.10.3 Barangaroo Station

A number of investigation reports were provided by the Barangaroo Delivery Authority. Specific investigations targeting the Barangaroo Central Development Area (which incorporates the construction footprint of the proposed Barangaroo station) have been reviewed and included:

- JBS Environmental (August 2012) *Data Gap Investigation - Barangaroo Central*
- JBS Environmental (July 2012) *Human Health and Ecological Risk Assessment for Proposed Imported Soils – Barangaroo Central*
- JBS Environmental (May 2013) *Human Health Risk Assessment – Barangaroo Central*
- JBS Environmental (January 2013) *Additional Human Health Risk Assessment Calculations – Basement Exposures Barangaroo Central Residential Development*
- JBS Environmental (May 2013) *Remedial Action Plan (Final Draft) Barangaroo Central*
- Environ (July 2013) *Site Audit Report Remedial Action Plan, Barangaroo Central*

- JBS&G (October 2013) *Assessment of Proposed Implications of Modifications to Barangaroo Central Concept Plan*.

A description of the proposed construction of Barangaroo Station is detailed below.

The Barangaroo station site would be approximately 2,700 square metres and located beneath Hickson Road and other station elements (ie. substation and access points) located within Central Barangaroo.

It is understood that the proposed construction method for Barangaroo Station would be “cut-and-cover”. The typical construction method for the cut-and-cover station excavation would be excavation from the ‘top down’, with temporary closure of parts of Hickson Road to do so.

A summary of the findings of the above investigations in context of the proposed construction of the Barangaroo Station is provided below:

- Surface soils (ie above the groundwater table) are contaminated with a range of compounds including heavy metals, asbestos and PAHs. Based on the information provided in reports, contaminated surface soils are present within the proposed construction footprint of the station elements within Central Barangaroo. These contaminated soils were considered not to be acting as a source of groundwater contamination.
- Areas of tar contamination are present within the south eastern portion of the Barangaroo Central Development Area (to the south of the construction footprint) which is considered to be acting as a groundwater contamination source. These tar residues will potentially occur at densities greater than water, indicating a potential for vertical migration of the tar contamination.
- Seepage water into future deep below ground structures are likely to be contaminated. The JBS Environmental (January 2013) *Additional Human Health Risk Assessment Calculations – Basement Exposures Barangaroo Central Residential Development* concluded that seepage water into below ground basements within the southern portion of the Barangaroo Central Development Area (to the south of the construction footprint) may pose a vapour risk which could impact upon future site users. It was considered that groundwater in proximity of the southern basement requires either remediation to reduce levels of a range of potentially volatile chemicals of potential concern, or basement design to prevent infiltration of adjoining groundwater into the accessible areas of the basement.
- Potential Acid Sulfate Soils (PASS) have been identified in the saturated materials (below the groundwater table) beneath the site.

The site audit report (Environ, 2013) has reported that the Barangaroo Central site can be made suitable for land uses including:

- Residential with minimal opportunity for soil access, including units
- Park, recreational open space, playing field
- Commercial / industrial.

The land occupation and proposed use would be subject to the implementation of JBS (2013) *Remedial Action Plan* and additional conditions including:

- Preparation of a Remedial Work Plan(s) (RWP) to confirm the sequence of proposed remediation and validation tasks as associated with the environmental rehabilitation of the site
- Inclusion of specific additional detail within the RWP as to the site acceptance criteria including consideration of comments made with respect to ammonia (as N), cyanide, dibenzofuran and lead soil acceptance criteria in Environ (2013)
- Identification of the extent of removal of contaminated materials with the RWP as based on the site acceptance criteria and related to the proposed development
- Reporting within the Voluntary Management Proposal (VMP) of the proposed additional depth of excavation beyond 10 metres below ground level where tar based materials are identified in excavations at a depth of 10 metres below ground level

- Provision of detail to the RWP to allow the estimation of fill material proposed to be placed in open space areas
- Inclusion of a methodology and associated decision criteria within the RWP for the insitu validation of tar containing material if identified within the alignment of basements
- Preparation and implementation of an Asbestos Management Plan
- Preparation and implementation of a Materials Compliance Management Plan
- Preparation of a Validation Sampling and Analysis Quality Plan.

It should be noted that the conditions detailed above are for the development of the Barangaroo Central and do not relate to specifically to the proposed construction of Barangaroo Station. The information contained within the respective remediation plan and associated conditions have been used to assess potential contamination constraints associated with the construction of the proposed station site only.

In summary, a number of contamination issues are present in the proposed construction footprint of Barangaroo Station including contaminated soils, groundwater and vapour. The remedial works provided in the information above have been designed to primarily address contamination to 10 metres below ground level. Based on the information above, the main contamination issues which need to be considered during design and construction of the proposed Barangaroo Station are as follows:

- Appropriate management, treatment and/or disposal of contaminated soils excavated to facilitate subsurface construction of station elements.
- Management of contaminated groundwater and vapours into subsurface excavation and structures. This would be especially relevant for excavations occurring in the southern portion of the construction footprint located closer to the declaration area. Migration of contaminated groundwater and vapour would need to be considered as part of the design phase and managed during construction.
- Risks associated with contamination extending deeper than 10 metres below ground level have not been considered as part of the remediation detailed in the above information. Tar contamination could be a concern in the deeper strata. It is understood that construction elements below Barangaroo Station could extend to 30 metres below height datum. Potential contamination risks below 10 metres would need to be addressed by design and managed during construction.

2.10.4 Central Station

A number of investigation reports provided by Transport for NSW for the Central Station site have been reviewed and included:

- CMPS&F Environmental (1996) *Detailed Investigation of Soil Contamination Phase III Central 2000 Project, Central Station*
- GHD (2010) *Report for Soil Contamination Assessment. Site A – Prince Alfred Sidings, Central Station*
- Rail Services Australia (2000) *Site History of Ex-Railway Gasworks at Sydney Yard (x3)*
- AHRB Bulletin (June 2003) *A Brief History of NSW Railway Gasworks.*

Information reviewed indicated that three gasworks were previously operated within the railway yards immediately to the south west of Central Station. The gasworks were used for the production of gas to light carriages and yards. The former location of the second Sydney station gas works appears to be within the construction footprint or in the near vicinity to the proposed services building for the Central Station Metro site. The locations of the first and third Sydney station gas works are located to the southwest of the proposed services building for the Central Station Metro site. No additional information has been made available with respect to these gasworks sites (including investigation or remediation points). It is possible that residues associated with the operation of these gasworks could still be present on site and could pose an exposure risk if not managed during construction activities and operation of the building (especially with respect to the second Sydney station gasworks site).

The CMPS&F (1996) investigation was undertaken on properties located adjacent to the railway corridor. As defined by CMPS&F and based on our understanding of the proposed Metro construction footprint, investigation areas 1, 2, 3, 4, 6 and 7 were located greater than 50m away to the south west and west from the proposed services building for the Central Station Metro site. Investigation area 5 was located approximately 50m to the east of the proposed services building for the Central Station Metro site. The results of the CMPS&F (1996) investigation indicated that elevated concentrations of selected heavy metals and hydrocarbon compounds (TPH and PAH) were present in fill and soil materials in the areas investigated.

The GHD (2010) investigation was undertaken within the Prince Aldred Sidings site located approximately 50m to the east of the proposed services building for the Central Station Metro site. The investigation identified lead and hydrocarbon compound (TPH and PAH) contamination within fill material beneath the site.

In summary, a number of contamination issues could be present in the proposed construction footprint of the service building for the Central Station Metro site including contaminated soils, groundwater and vapour associated with the former use of the area as a gasworks. Based on the information above, the main contamination issues which may need to be considered during design and construction of the proposed service building are as follows:

- Appropriate management, treatment and/or disposal of potentially contaminated soils excavated to facilitate subsurface construction of the service building and associated subsurface infrastructure.
- Management of potentially contaminated groundwater and vapours into subsurface excavation and structures. Migration of contaminated groundwater and vapour would need to be considered as part of the design phase and managed during construction.

3. Contamination investigation findings

3.1 Potential areas of environmental interest

A number of potential AEI were identified during the information review and site inspection. Based on the information contained within the preceding sections of this report, **Table 3.1** outlines the potential AEIs located in the vicinity of the project area and their associated risks to environmental receptors, construction limitations, and site users in consideration of the potential for contamination and proposed construction activities.

Based on the results of the information review and site inspection, other sites within and or adjacent to the project area (with the exception of those sites detailed below) are considered to represent a minimal / negligible contamination risk. No further consideration of contamination risk has been provided for these sites.

Table 3.1 Potential areas of environmental interest

Potential AEI	Location relative to site	Potential contamination source	Risk ranking
Current Caltex service station, Chatswood	Across Pacific Highway from the Chatswood dive site	Onsite activities associated with fuel usage and storage.	Low (possible contamination / no excavation activities)
Ausgrid Depot, Chatswood	Within Chatswood dive site	Possible fuel storage, workshops, storage and electrical transmission	Moderate (possible contamination / major excavation activities)
Former Caltex Service Station, Chatswood	Within Chatswood dive site	Former fuel storage	High (known contamination / major excavation activities)
Railway between Chatswood Station and the northern dive site	Within railway corridor and construction footprint	On site activities associated with railway use	Low – moderate (possible contamination / minimal excavation)
Sydney Harbour	Within construction site footprint	Sediments with Sydney Harbour. Potential ASS and/or PASS.	Moderate (Known contamination / minor disturbance of contaminated surface sediments in environmentally sensitive area)
Former heavy industrial land use, Blues Point	Within construction site footprint	Historical industrial activities (possible shipyard)	Moderate (possible contamination / deep shaft excavation)
Reclaimed land within Barangaroo	Adjacent to the Barangaroo station site	Historical activities/waste/fill material	Moderate – high (known isolated contamination / major excavation activities)
Former gasworks along Hickson Road, Millers Point	Adjacent to the Barangaroo station footprint	Historical activities as a gasworks	High (known contamination / major excavation activities)
Former gasworks within railyards	Within and adjacent to the service building footprint	Historical activities as a gasworks	Moderate (possible contamination / deep excavation)

Potential AEI	Location relative to site	Potential contamination source	Risk ranking
Railway at Central Station	Within Central station footprint	On site activities associated with railway use	Low (possible contamination / minimal excavation)
Regent Street service station	Adjacent to the proposed Regent street bridge at the Central Station site	Fuel storage	Moderate (possible contamination / moderate excavation activities)
Former and current commercial/industrial land use, Waterloo	Within station footprint	Historical and current commercial/industrial activities (incl. dry cleaners, automotive industry and substation)	Moderate (possible contamination / major excavation activities)
Railway between Sydenham Station and Marrickville dive structure (southern)	Within railway corridor and construction footprint	On site activities associated with railway use	Low – moderate (possible contamination / minimal excavation)

A summary of the potential AEI and their associated contaminants of concern is provided below:

- The current Caltex service station on the Pacific Highway represents a potential source of contamination associated with leaks and spills from fuel storage infrastructure (i.e. hydrocarbons and heavy metals). The service station poses a low risk to the construction of the proposed Chatswood dive site given no excavation works are proposed to be undertaken within the service station footprint associated with Chatswood dive site construction activities, however contaminants originating from the service station have the potential to migrate towards the Chatswood dive site via groundwater.
- The former service station on the Pacific Highway (now part of the Ausgrid Depot, Chatswood) represents a known source of contamination associated with leaks and spills from fuel storage infrastructure (i.e. hydrocarbons and heavy metals). The contamination associated with the former use of the site poses a high risk to site users during construction of the proposed Chatswood dive site given it would require excavation of known contaminated soils. Further investigations are required to better understand the potential risks.
- The Chatswood Ausgrid Depot represents a potential source of contamination associated with on-site activities of possible fuel storage, maintenance workshops, storage and electrical transmission. The depot poses a moderate risk to the construction/excavation of the northern dive site given that spills/leaks from fuel storages (especially underground storages) or maintenance activities that may have occurred on site, have the potential to infiltrate into subsoils and groundwater, or be flushed to on-site drainage infrastructure. Further investigations are required to better understand the potential risks.
- Blues Point Park on Henry Lawson Avenue represents a potential source of contamination associated with possible historical use of the site as a shipping yard and heavy industrial land use. The historical land use of the site poses a moderate contamination risk to construction given that soils are expected to be excavated and exposed within this area. Further investigations are required to better understand the potential risks.
- Contaminated sediments are present and ASS/PASS could be present within the harbour crossing alignment. It is acknowledged that contamination is restricted to surface sediments and disturbance of these sediments during ground improvement (i.e. grouting) is likely to be very localised.
- The location of the former gasworks along Hickson Road at Barangaroo represents a known source of contamination including hydrocarbons, heavy metals and metalloids in soil and groundwater and potential vapour issues considering the proposed station construction. Contamination poses a high risk to the construction and operation of Barangaroo Station given that soils and bedrock would be excavated and groundwater may need to be managed to facilitate construction of the station. Gasworks wastes can also be odorous. These odours (if present) may need to be managed during construction activities and vapours may need to be monitored within sub-surface spaces during operation of the station (dependant of the design of the station). Further investigations are required to better understand the potential risks.

- Reclaimed land within Barangaroo represents a known source of isolated contamination associated with unknown historical use of the reclaimed soils and potential waste materials within the soil (i.e. metals, hydrocarbons, pesticides, PCB, asbestos and gasworks wastes). The soils within Barangaroo pose a moderate to high risk to the construction of Barangaroo Station given that soils/bedrock would be excavated adjacent to this area and groundwater may need to be managed to facilitate construction of the station. Further investigations are required to better understand the potential risks.
- The railway lines south of Chatswood Station and adjacent to the Marrickville dive site represent a potential source of contamination associated with historical and current use of the sites as railways and associated activities (i.e. hydrocarbons, arsenic, phenolics, heavy metals, nitrates and ammonia and asbestos in soils). The railway lines pose a low to moderate contamination risk to construction given that excavation in these areas are likely to be limited.
- One groundwater bore registered for domestic use is located approximately 400 metres from the Marrickville dive site. The distance of the well from the site and considering that the tunnel is likely to create a negative groundwater gradient, the risk of contamination from the site (if present) impacting on the well is likely to be low. Additionally, there is a risk that ASS are present beneath or in close proximity to the Marrickville dive site. Further investigations are required to better understand the potential risks.
- The historical operation of gasworks within the railyard at Central Station represents a potential source of contamination including hydrocarbons, heavy metals and metalloids in soil and groundwater and potential vapour issues considering the proposed sub-surface excavation required to facilitate construction of the service building and associated infrastructure. Contamination poses a high risk to the construction and operation of service building given that material would be excavated and groundwater may need to be managed to facilitate construction of the building. Gasworks wastes can also be odorous. These odours (if present) may need to be managed during construction activities and vapours may need to be monitored within sub-surface spaces during operation of the service building (dependant of the design of the service building). Further investigations are required to better understand the potential risks.
- The service station on Regent Street adjacent to Central Station and adjacent to the proposed Sydney Yard Access Bridge represents a potential source of contamination associated with the possibility of leaks and spills from fuel storage infrastructure (i.e. hydrocarbons and heavy metals). The service station poses a moderate risk to the construction of the proposed Sydney Yard Access Bridge given it would require excavation of potentially contaminated soils adjacent to the service station footprint to facilitate foundation construction.
- The historical and current commercial/industrial use of the Waterloo Station site (including present day activities including dry cleaners, automotive use and a sub-station) represents a potential source of contamination associated with the chemicals used in the dry cleaning process (i.e. chlorinated hydrocarbons, and volatile organic compounds), the automotive industry (hydrocarbons), substation (hydrocarbons and PCB) and miscellaneous chemicals associated with historical commercial/industrial operations. The risk to construction activities is considered moderate given that construction would require excavation of potentially contaminated soils, contact with potentially contaminated groundwater and potential volatilisation of some organic compounds. These volatile compounds (if present) may need to be managed during construction activities and vapours may need to be monitored within sub-surface spaces during operation of the station (dependant of the design of the station). There is an area of high ASS probability to the north of Alexandra Canal. It is possible that the construction of the Waterloo Station site may require excavation of alluvial soils which could contain ASS. Further investigations are required to better understand the potential risks.

3.2 Proposed power supply routes

A review of potential contamination risks associated with power supply routes for the project has been undertaken. The proposed power supply routes include:

- Chatswood (Hampden and Mowbray Roads)
- Crows Nest (Clarke Lane)
- North Sydney (Berry Street)

- Darling Harbour to Barangaroo (Erskine Street, Lime Street, Sussex Street, Hickson Road)
- King Street Wharf to Martin Place (Napolean Street, Margaret Street, Hunter Street)
- Pyrmont to Pitt Street (Pyrmont Street, Western Distributor, Market Street)
- Surry Hills to Pitt Street (Albion Street, Mary Street, Campbell Street, Pitt Street, ,)
- Central (Hay Street, Elizabeth Street, Eddy Avenue)
- Waterloo (Cope Street, Wellington Street, George Street)
- Marrickville (May Street, Council Street, Lord Street, Edinburgh Road).

The majority of the power supply routes would be constructed by trenching within the road reserve. Where major roads are crossed by the route (such as Mowbray Road for the Chatswood dive site power supply), alternative construction methods would be used such as under boring in order to avoid impacts to the road network. Alternative construction methods such as under boring may also be used to avoid other major constraints such as services or areas of environmental sensitivity.

Based on observations made during site inspections and review of historical aerial photographs and NSW EPA contaminated sites database (regulated and notified sites within 500m of proposed route), potential contamination risks that have been identified within and/or adjacent to the power supply routes are detailed in **Table 3.2**.

Table 3.2 Potential areas of environmental interest – Power supply routes

Route	Potential AEI	Location relative to site	Potential contamination source	Risk ranking	Information source
Chatswood	Substations	Adjacent to route (corner of Hampden and Mowbray Roads)	Electrical transmission	Low (negligible to possible contamination / no excavation activities within potential AEI).	Site inspection, aerial photographs
Chatswood	Ausgrid Depot	Adjacent to route (north of Mowbray Road)	Possible fuel storage, workshops and storage.	Low (negligible to possible contamination / no excavation activities within potential AEI).	Site inspection, aerial photographs
Crows Nest	Tyre workshop	Adjacent to route (north-east of Clarke Lane)	Possible fuel storage, workshops and storage.	Low (negligible to possible contamination / no excavation activities within potential AEI).	Site inspection
North Sydney	No AEI identified			No identified risk (based on information reviewed)	Site inspection, aerial photographs
Darling Harbour to Barangaroo	Declaration area (adjacent to and within road reserve fronting 30-38 Hickson Road).	Within and adjacent to the route (Hickson Road)	Historical activities as a gasworks	Moderate (known contamination / minor excavation activities)	NSW EPA CLM database
Darling Harbour to Barangaroo	Former and current substations	Adjacent to route (corner of Erskine and Sussex Streets)	Electrical transmission	Low (negligible to possible contamination / no excavation activities within potential AEI).	Site inspection, aerial photographs

Route	Potential AEI	Location relative to site	Potential contamination source	Risk ranking	Information source
King Street Wharf to Martin Place	No AEI identified			No identified risk (based on information reviewed)	Site inspection, aerial photographs
Pymont to Pitt Street	Former Pymont Power Station	150 north west of route (20 Pymont Street)	Historical electrical generation by products	Low (negligible to possible contamination / no excavation activities within potential AEI).	NSW EPA CLM database
Pymont to Pitt Street	Historical general industrial landuse (Pymont, Darling Harbour)	Within and adjacent to the route	Manufacturing and storage of chemicals, hazardous building materials, industrial by-products	Low (possible contamination / minor excavation activities).	Aerial photographs
Surry Hills to Pitt Street	No AEI identified			No identified risk (based on information reviewed)	Site inspection, aerial photographs
Central	No AEI identified			No identified risk (based on information reviewed)	Site inspection, aerial photographs
Waterloo	Historical general industrial landuse.	Adjacent to the route	Manufacturing and storage of chemicals, hazardous building materials, industrial by-products	Low (possible contamination / minor excavation activities).	Aerial photographs
Waterloo	Substations	Adjacent to route (George Street, Waterloo)	Electrical transmission	Low (negligible to possible contamination / no excavation activities within potential AEI).	Site inspection, aerial photographs
Waterloo	Other industry (as defined by NSW EPA)	200m from proposed route (2 John Street)	Not defined by NSW EPA	Low (negligible to possible contamination / no excavation activities within potential AEI).	NSW EPA CLM database
Marrickville	Historical brickmaking and landfilling	Adjacent to route (Sydney Park and Camdenville Oval)	Industrial by-products, waste materials, leachate, landfill gas.	Moderate (possible contamination migration form adjacent sites (leachate and landfill gas) / minor excavation activities)	Site inspection, aerial photographs, NSW EPA CLM database (Camdenville Oval)
Marrickville	Service station	Adjacent to route (2 Princess Highway, St Peters)	Storage of petroleum products.	Low (negligible to possible contamination / no excavation activities within potential AEI).	Site inspection, NSW EPA CLM database
Marrickville	Historical general industrial landuse (Marrickville).	Adjacent to the route	Manufacturing and storage of chemicals, hazardous building materials, industrial by-products	Low (possible contamination / minor excavation activities).	Aerial photographs

Based on a review of the locations of the proposed power routes and available information, the majority of proposed power routes are likely to represent a low risk of contamination exposure during construction of the project elements with the exception of the following:

- Darling Harbour to Barangaroo – Route within Hickson Road which is a regulated contaminated site.
- Marrickville – Route adjacent to former landfill sites (Sydney Park and Camdenville Oval). Possible migration or landfill gas and to a lesser extent leachate into excavation areas.

It is noted that the majority of the proposed power routes are located within existing road reserves. Possible contamination constraints associated with the excavation within the road reserve could include:

- Coal tar within asphalt road pavements
- Historic use of contaminated materials as road sub grade (eg. ash and slag).

3.3 Key findings of the Phase 1 Contamination Investigation

Following a review of the available historical and government records, and a site inspection, the key findings of the Phase 1 Contamination Investigation for the Sydney Metro Chatswood to Sydenham project area include:

1. Acid Sulfate Soils risk varies across the project area. There is a high probability of encountering ASS at Barangaroo, as well as in the sediments in some areas of Sydney Harbour should excavations in these sediments be required. Additionally, there is a potential risk of encountering ASS in the alluvial soils in the vicinity of the proposed Marrickville dive site.
2. There is a potential impact to a beneficial groundwater bore user near to the Marrickville dive site given that the domestic use bore is located down gradient of the Marrickville dive site. Given the distance of the well from the site and considering that the tunnel is likely to create a negative groundwater gradient, the risk of contamination from the site (if present) impacting on the well is likely to be low.
3. There are some sensitive receiving environments located within the vicinity of the aboveground features of the project which could be potentially impacted by contamination within project area site (if present). These sensitive environments are:
 - Sydney Harbour (from the Barangaroo Station and Blues Point temporary site)
 - Cockle Bay (from the Pitt Street and Martin Place Station sites)
 - Beneficial users of groundwater down gradient from the respective sites (where present).
4. The Marrickville, Waterloo, Victoria Cross, Crows Nest and Artarmon sites have increasingly become commercial/industrial from residential land use since the 1930s. The Barangaroo site has seen major industrial developments since the 1950s and 1960s. Conversely, the historical industrial land use on and surrounding the Blues Point temporary site has changed to residential and open space. The land use surrounding the Marrickville, Barangaroo and Artarmon sites has seen major extractive/reclamation works within the past 50 years. The Central, Pitt Street and Martin Place station sites have remained within a commercial context since the 1930.
5. There are 11 contaminated sites within 500 metres of the aboveground features of the project that are either regulated or have been notified by the NSW EPA. Two of these notified sites pose a potential risk to construction activities across the project. These sites are:
 - Former Caltex Service Station at 607 Pacific Highway, Chatswood
 - Former gasworks at Millers Point at Barangaroo.

6. In total, there are thirteen areas of environmental interest located within or in close proximity to the project area that may present a low to high contamination risk to the proposed construction activities. These are:
 - Railway activities/operation south of Chatswood Station
 - Former Caltex Service Station, Chatswood
 - Ausgrid Depot, Chatswood
 - Current Caltex service station, Chatswood
 - Former heavy industrial land use at Blues Point construction site
 - Sydney Harbour sediments
 - Reclaimed land within Barangaroo
 - Former Hickson Road Gasworks
 - Railway activities/operation at Central Station
 - Former gasworks operations within the railyards at Central Station
 - Regent Street service station
 - Former and current commercial/industrial land use at Waterloo Station.
 - Railway activities/operation adjacent to southern dive site.
7. Sydney Harbour may also be impacted by disturbance of contaminants within the seabed from the ground improvement work. Disturbance of sediment by grouting activities related to the proposed harbour tunnel is likely to mobilise some shallow sediment, possibly creating increased turbidity and resuspension of contaminated sediments during the grout probe insertion and extraction works, and during the placement of anchoring blocks (if used). Considering the contamination concentrations in the sediment which would be disturbed are consistent with sediment quality throughout Sydney Harbour, the risk of spreading contamination to new areas is considered to be low. A water quality monitoring program would be implemented to monitor water quality within Sydney Harbour during ground improvement work, detect any potential impacts on the water quality of Sydney Harbour from the ground improvement work and inform management responses in the event any impacts are identified. Typical grouting environmental controls are likely to include silt curtains and booms.
8. There are two areas of environmental interest located within or in close proximity to the proposed power supply routes that may present a moderate contamination risk to the proposed construction activities. These are:
 - Darling Harbour to Barangaroo – Route within Hickson Road which is a regulated contaminated site.
 - Marrickville – Route adjacent to former landfill sites (Sydney Park and Camdenville Oval). Possible migration or landfill gas and to a lesser extent leachate into excavation areas.

Contaminated land on and/or adjacent to the project area, if not managed appropriately could potentially impact upon receivers during construction.

Additionally, if the design of the tunnel/aboveground features construction incorporates management of contamination risks and not remediation (i.e. removal of contamination risk), there is likely to be an ongoing liability and requirement to manage and/or monitor potential contamination risks to receptors during operation of the Sydney Metro. The requirement for management and/or monitoring of potential contamination risks during operation of the Sydney Metro will also be dependent on the final design of construction elements.

Exposure or disturbance of contaminated land during construction of the project may have the following impacts:

- Mobilisation of surface and subsurface contaminants during construction (impacting groundwater, surface water and soils)
- Migration of potential contaminants into surrounding areas (impacting groundwater, surface water and soils) via leaching, overland flow and/or subsurface flow (water and/or vapour)
- Mobilising potential groundwater and/or surface water contamination
- Risk of exposure to site workers, site users and site visitors
- Risk of exposure to surrounding environmental receptors (i.e. flora, fauna, surrounding ecosystems including groundwater dependent ecosystems).

If required, the broad requirements for remediation of land during the construction of the project are detailed below:

- Requirements for remediation in specific areas would be driven by the exposure scenarios that will exist pre, during and post-construction
- Where possible, remedial activities would be integrated with construction activities to achieve efficiencies in the use of plant, equipment and materials
- Where required, remediation would be performed in accordance with the (draft) National Framework for Remediation and in accordance with applicable environmental and WHS legislation
- Remediation would also be performed with due consideration to the sustainability principles adopted for the project.
- Remediation would be undertaken with due regard for the guidelines detailed in Section 1.6.

4. Mitigation measures

Based on the information reviewed, the potential AEs with respect to contamination identified could pose (without appropriate mitigation, management and safeguard measures) a risk to human and/or environmental receptors. This is due to the diverse nature of the potential contamination, the possible migration pathways, proposed construction activities and the proximity and location of these sites in relation to the project and environmental receivers.

The risk (time and financial) of contamination impacting upon construction activities could increase if excavation works take place within these areas. The risk (human health and environmental) of exposure to site users, site workers and surrounding environments, and the migration of contamination (if present), could also be increased.

Further investigations would need to be undertaken of moderate to high risk areas to better inform the risks of contamination status and to better tailor the most appropriate design and/or management procedures to be adopted.

Mitigation measures to address potential impacts associated with contamination are detailed in Table 4.1.

Table 4.1 Mitigation measures - contamination

Mitigation measures	Applicable location(s) ¹
<p>Updated desktop contamination assessments would be carried out for Chatswood dive site, Blues Point temporary site, Barangaroo Station, Central Station and Waterloo Station. If sufficient information is not available to determine the remediation requirements and the impact on potential receivers, then detailed contamination assessments, including collection and analysis of soil and groundwater samples would be carried out.</p> <p>Detailed contamination assessment would also be carried out for the Barangaroo power supply route within Hickson Road and the Marrickville power supply route adjacent to Sydney Park and Camdenville Oval.</p> <p>In the event a Remediation Action Plan is required, these would be developed in accordance with Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land (Department of Urban Affairs and Planning and Environment Protection Authority, 1998) and a site auditor would be engaged.</p>	CDS, BP, BN, CS WS, PSR
<p>Prior to ground disturbance in high probability acid sulfate areas at Barangaroo Station, Waterloo Station and Marrickville dive site, testing would be carried out to determine the presence of acid sulfate soils.</p> <p>If acid sulfate soils are encountered, they would be managed in accordance with the Acid Sulfate Soil Manual (Acid Sulfate Soil Management Advisory Committee, 1998).</p>	BN, WS, MDS

¹ STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Tunnel: Tunnel not related to other sites (eg TBM works); PSR: Power supply routes

5. References

Department of Primary Industries, *Office of Water Groundwater Database*, Office of Water website, <http://realtimedata.water.nsw.gov.au/water.stm>, (accessed May 2015).

NSW Department of Mineral Resources (1983) *Sydney 1: 100,000 Geological Series Sheet 9130*, NSW Department of Mineral Resources, Australia.

NSW Department of Primary Industries website, NSW Government (accessed June 2015).

Appendix A. Groundwater Bores

Table A.1 Registered groundwater wells within 500 metres of aboveground project features

Borehole ID	License Number	Latitude	Longitude	Bore Usage	Impact potential
Chatswood dive site (northern)					
GW112743	10BL603114	33 48'12.9"S	151 10'47.9"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112745	10BL603114	33 48'13.9"S	151 10'47.9"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112747	10BL603114	33 48'14.6"S	151 10'48.0"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112749	10BL603114	33 48'15.3"S	151 10'48.6"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112744	10BL603114	33 48'13.9"S	151 10'47.3"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112742	10BL603114	33 48'13.1"S	151 10'47.3"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112751	10BL603114	33 48'16.3"S	151 10'48.7"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112746	10BL603114	33 48'14.7"S	151 10'47.1"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112753	10BL603114	33 48'15.0"S	151 10'46.9"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112754	10BL603114	33 48'15.6"S	151 10'47.0"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112750	10BL603114	33 48'16.5"S	151 10'48.0"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112748	10BL603114	33 48'15.8"S	151 10'47.2"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112756	10BL603114	33 48'15.2"S	151 10'46.6"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112755	10BL603114	33 48'15.8"S	151 10'46.2"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW112752	10BL603114	33 48'17.7"S	151 10'47.4"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW111773	10BL603110	33 48'16.7"S	151 10'46.9"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW029731	10BL019677	33 47'59.3"S	151 10'55.5"E	Recreation	Well located hydraulically upgradient of feature at Chatswood Oval.
Artarmon substation					
GW103591	10BL159969	33 48'52.9"S	151 11'20.5"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW103841	10BL159969	33 48'52.9"S	151 11'20.5"E	Monitoring bore	Low impact potential as not beneficial

Borehole ID	License Number	Latitude	Longitude	Bore Usage	Impact potential
					groundwater user.
Barangaroo Station					
GW113561	10BL604425	33 51'39.9"S	151 12'02.4"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113560	10BL604425	33 51'38.0"S	151 12'02.2"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113559	10BL604425	33 51'36.0"S	151 12'02.1"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113558	10BL604425	33 51'33.7"S	151 12'02.0"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113562	10BL604425	33 51'41.8"S	151 12'02.6"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113597	10BL604366	33 51'46.2"S	151 12'09.4"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113557	10BL604425	33 51'31.1"S	151 12'01.8"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113563	10BL604425	33 51'44.6"S	151 12'03.2"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113566	10BL604425	33 51'46.1"S	151 12'06.6"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113596	10BL604366	33 51'46.5"S	151 12'09.5"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113612	10BL604366	33 51'46.6"S	151 12'08.3"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.

Borehole ID	License Number	Latitude	Longitude	Bore Usage	Impact potential
GW113598	10BL604366	33 51'46.8"S	151 12'09.6"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113610	10BL604366	33 51'46.8"S	151 12'08.8"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113565	10BL604425	33 51'46.0"S	151 12'04.8"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113608	10BL604366	33 51'47.2"S	151 12'10.0"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113609	10BL604366	33 51'47.2"S	151 12'10.0"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113564	10BL604425	33 51'45.8"S	151 12'03.3"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113607	10BL604366	33 51'47.5"S	151 12'08.9"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113605	10BL604366	33 51'47.9"S	151 12'09.6"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113606	10BL604366	33 51'47.8"S	151 12'07.3"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113604	10BL604366	33 51'48.2"S	151 12'09.2"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113611	10BL604366	33 51'48.1"S	151 12'07.4"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113602	10BL604366	33 51'48.4"S	151 12'08.9"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.

Borehole ID	License Number	Latitude	Longitude	Bore Usage	Impact potential
GW113603	10BL604366	33 51'48.6"S	151 12'08.5"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113601	10BL604366	33 51'49.2"S	151 12'07.3"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113600	10BL604366	33 51'49.2"S	151 12'07.3"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113599	10BL604366	33 51'49.2"S	151 12'07.3"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113555	10BL604425	33 51'26.4"S	151 12'01.8"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW113556	10BL604425	33 51'26.4"S	151 12'01.5"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
Martin Place Station					
GW109085	10BL602334	33 51'57.1"S	151 12'11.0"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW109086	10BL602334	33 51'57.2"S	151 12'10.8"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW109087	10BL602334	33 51'57.5"S	151 12'10.9"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
Central Station					
GW113879	10BL165951	33 53'10.5"S	151 12'06.6"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113860	10BL165951	33 53'11.3"S	151 12'06.6"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113855	10BL165951	33 53'11.5"S	151 12'06.5"E	Monitoring bore	Low as well located hydraulically up gradient of feature.

Borehole ID	License Number	Latitude	Longitude	Bore Usage	Impact potential
GW113856	10BL165951	33 53'11.5"S	151 12'06.4"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113874	10BL165951	33 53'11.3"S	151 12'06.1"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113873	10BL165951	33 53'11.2"S	151 12'06.0"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113883	10BL165951	33 53'11.9"S	151 12'06.6"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113893	10BL165951	33 53'11.8"S	151 12'06.5"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113892	10BL165951	33 53'11.8"S	151 12'06.4"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW109500	10BL601554	33 53'11.4"S	151 12'06.0"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113875	10BL165951	33 53'11.4"S	151 12'06.0"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113884	10BL165951	33 53'11.4"S	151 12'06.0"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113885	10BL165951	33 53'12.0"S	151 12'06.5"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113891	10BL165951	33 53'11.8"S	151 12'06.3"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113890	10BL165951	33 53'11.8"S	151 12'06.1"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113857	10BL165951	33 53'11.1"S	151 12'05.5"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113882	10BL165951	33 53'11.8"S	151 12'06.0"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113889	10BL165951	33 53'11.2"S	151 12'05.5"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113858	10BL165951	33 53'11.0"S	151 12'05.4"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113881	10BL165951	33 53'11.7"S	151 12'05.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113886	10BL165951	33 53'11.5"S	151 12'05.3"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113859	10BL165951	33 53'11.4"S	151 12'05.2"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113888	10BL165951	33 53'10.8"S	151 12'04.9"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113887	10BL165951	33 53'10.9"S	151 12'04.7"E	Monitoring bore	Low as well located hydraulically up gradient of feature.

Borehole ID	License Number	Latitude	Longitude	Bore Usage	Impact potential
GW113878	10BL165951	33 53'09.9"S	151 12'02.1"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113877	10BL165951	33 53'09.8"S	151 12'01.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113876	10BL165951	33 53'09.8"S	151 12'01.4"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113872	10BL165951	33 53'09.8"S	151 12'01.2"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113862	10BL165951	33 53'10.9"S	151 12'00.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113866	10BL165951	33 53'10.4"S	151 12'00.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113865	10BL165951	33 53'10.5"S	151 12'00.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113867	10BL165951	33 53'10.3"S	151 12'00.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113864	10BL165951	33 53'10.6"S	151 12'00.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113868	10BL165951	33 53'10.2"S	151 12'00.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113863	10BL165951	33 53'10.7"S	151 12'00.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113869	10BL165951	33 53'10.1"S	151 12'00.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113871	10BL165951	33 53'09.8"S	151 12'00.7"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113870	10BL165951	33 53'09.9"S	151 12'00.7"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113880	10BL165951	33 53'10.0"S	151 12'00.1"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW113861	10BL165951	33 53'09.0"S	151 11'59.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW109503	10BL601554	33 53'08.9"S	151 11'56.8"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW109502	10BL601554	33 53'07.5"S	151 11'56.2"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.
GW109501	10BL601554	33 53'05.3"S	151 11'56.2"E	Monitoring bore	Well located hydraulically down gradient of feature. Low impact potential as not beneficial groundwater user.

Borehole ID	License Number	Latitude	Longitude	Bore Usage	Impact potential
Waterloo Station					
GW106192	No license information available				
GW111958	10BL605133	33 54'04.1"S	151 11'57.5"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW113037	10BL602801	33 54'07.4"S	151 12'00.3"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW113039	10BL602801	33 54'07.4"S	151 11'59.5"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
GW113038	10BL602801	33 54'07.6"S	151 12'00.1"E	Monitoring bore	Low impact potential as not beneficial groundwater user.
Marrickville dive site (southern)					
GW109730	10BL162346	33 53'53.9"S	151 11'02.5"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW109733	10BL162346	33 53'54.0"S	151 11'02.2"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW109729	10BL162346	33 53'53.7"S	151 11'01.9"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW109732	10BL162346	33 53'54.1"S	151 11'01.8"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW109731	10BL162346	33 53'53.9"S	151 11'01.6"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW105317	10BL161846	33 53'47.0"S	151 10'57.9"E	Monitoring bore	Low as well located hydraulically up gradient of feature.
GW105938	10BL162977	33 53'54.2"S	151 11'27.6"E	Domestic bore	Well located down gradient (approximately 400m) from feature. Potential impact as beneficial groundwater user.

Appendix B. Preliminary Scope of Works

1. Recommended contamination investigations

1.1 Background

A review of information from publically available and previous investigations (where available) has been carried out as part of preparation of a Phase 1 contamination assessment to support the Sydney Metro City & Southwest Chatswood to Sydenham project Environmental Impact Statement. The results of this desktop review identified a number of potential higher risk contamination issues (ie. contaminated soils, contaminated groundwater and potential vapour risks) that could impact on the final design, construction and operation of the Sydney Metro if not appropriately managed or if appropriate design and /or mitigation measures are not implemented.

Specifically, the draft Phase 1 contamination assessment report recommends:

Updated desktop contamination assessments would be carried out for Chatswood dive site, Blues Point temporary site, Barangaroo Station, Central Station and Waterloo Station. If sufficient information is not available to determine the remediation requirements and the impact on potential receivers, then detailed contamination assessments, including collection and analysis of soil and groundwater samples would be carried out.

Detailed contamination assessment would also be carried out for the Barangaroo power supply route within Hickson Road and the Marrickville power supply route adjacent to Sydney Park and Camdenville Oval.

In the event a Remediation Action Plan is required, these would be developed in accordance with Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land (Department of Urban Affairs and Planning and Environment Protection Authority, 1998) and a site auditor would be engaged.

Prior to ground disturbance in high probability acid sulfate areas at Barangaroo Station, Waterloo Station and Marrickville dive site, testing would be carried out to determine the presence of acid sulfate soils. If acid sulfate soils are encountered, they would be managed in accordance with the Acid Sulfate Soil Manual (Acid Sulfate Soil Management Advisory Committee, 1998).

The locations where contamination risks would be higher are locations where the project would require construction of sub-surface infrastructure at sites where known and/or potentially contaminating activities have occurred on and/or adjacent to these locations in the past. Based on the current Phase 1 investigations, this would include the Chatswood dive site (northern), Blues Point temporary site, Barangaroo, Central Station Service Building, Regent Street (at Central Station), Waterloo Station and installation of power supply in areas within or adjacent to known contaminated sites.

Additional investigation in these areas would provide more certainty to the detailed reference design in terms of assessment of potentially high risk locations (with respect to contamination).

This recommended scope of works is structured as follows:

- Section 1.2 below discusses current gaps in contamination knowledge at key locations based on literature reviewed to date
- Section 1.3 outlines the possible scope of additional contamination investigations to inform design and / or construction at higher risk locations within the project corridor
- Section 1.4 summarises the recommended additional contamination investigations.

1.2 Key contamination knowledge gaps

1.2.1 Chatswood dive site (northern)

Based on a review of the available information, it understood that some remediation has occurred on the former Caltex Service Station site (607 Pacific Highway). Asbestos contamination has been consolidated in two excavations on the former service station site and adjoining commercial property. Further groundwater monitoring and management of contamination remaining on the site (ie. the former service station site) and the

adjoining commercial property is to be conducted in accordance with a site management plan (Golder Associates, April 2015). Potential hydrocarbon contamination impacts from the former service station on the Ausgrid Depot are addressed in the voluntary management proposal (20141703).

An Ausgrid Depot operated within the portion of the site immediately to the west of the T1 North Shore rail line. It is possible (although not verified at the time of preparing this document) that the activities / operations undertaken at the depot may have included fuel storage (underground storage tanks), workshops, chemical storage and electrical transmission.

The main contamination risks are considered to be those associated with potentially contaminated soils, water and vapour from historical and / or current activities (namely fuel storage within the depot and service station) undertaken on the site which could impact upon sub-surface construction activities. Additionally, asbestos consolidated into two excavations on the former service station site and the adjoining commercial premises would need to be considered in context of possible construction elements and responsibilities associated with ongoing contamination management.

1.2.2 Blues Point temporary site

No investigation reports have been provided with respect to contamination at the proposed temporary construction site at Blues Point. The site has a history of commercial / industrial use including potential ship yard activities undertaken on and / or adjacent to the site. The main contamination risks are considered to be associated with potentially contaminated soils, water and vapour from these historical ship yard activities undertaken on and / or adjacent to the site which could impact upon sub-surface construction activities if not managed appropriately.

Specific contamination types associated with ship yard activities could include tributyl tin (TBT) which is a highly toxic biocide.

1.2.3 Barangaroo Station

The extent of proposed remedial works outlined in previous investigation reports have been designed to primarily address contamination to ten metres below ground level (to facilitate the construction of basement car park levels within the Barangaroo Development Authority site). The previous investigation reports therefore do not provide remediation information to the depth of the proposed Barangaroo Station construction (ie. approximately 20-25 metres below ground level).

1.2.4 Barangaroo Power Supply Route

The exact extent (both laterally and vertically) of the proposed power supply route is not known especially in relation to the regulated contaminated areas known to be located in Millers Point.

1.2.5 Central Station Service Building

No investigation reports have been provided with respect to contamination associated with the historical operation of gasworks with the Central Station railyards. The construction of the service building at this site would require the excavation of subsurface materials to facilitate the construction of the building and associated infrastructure within or in the near vicinity to the former gasworks operations. The potential contamination could pose a risk to the construction and operation of the service building given that material would be excavated and groundwater may need to be managed to facilitate construction of the building. Gasworks wastes can also be odorous. These odours (if present) may need to be managed during construction activities and vapours may need to be monitored within sub-surface spaces during operation of the service building (dependant of the design of the service building).

1.2.6 Regent Street (at Central Station)

No investigation reports have been provided with respect to contamination at the proposed access from Regent Street. This site would require the demolition of a number of terrace houses and has a service station on an

adjacent property. The main contamination risks are considered to be associated with potentially contaminated soils, water and vapour which may have migrated from the adjacent service station which could impact upon any sub-surface construction activities required.

1.2.7 Waterloo Station

No investigation reports were available with respect to contamination at the proposed station site located at Waterloo. The station site has a long history of commercial / industrial use including present day dry cleaning premises, automotive industry and substation use. The main contamination risks are considered to be associated with potentially contaminated soils, water and vapour from historical and / or current activities undertaken on the site. Risk of contamination exposure is associated with excavation of the station box and associated sub-surface work at the site as well as long term exposure associated with the potential for ongoing vapour and groundwater management during operation should contamination be present.

Higher risk contamination types would include solvents from dry cleaning activities which could partition into vapour or form dense non-aqueous phase liquids (DNAPLs) within the underlying groundwater. The partitioning of vapour (if present) at elevated concentrations could pose a risk to construction activities and operation of the station if not managed or appropriate considerations are not taken during the design phase.

The Waterloo Station site is also located close to an area of high acid sulphate soil (ASS) probability to the north of Alexandra Canal. There is a potential risk of encountering ASS in the alluvial soils in the vicinity of the proposed Waterloo Station site.

1.2.8 Marrickville Power Supply Route

No investigation reports have been provided with respect to the vapour risk (specifically landfill gas) from the former landfill operations known to have been undertaken adjacent to the proposed route. The main contamination risks are considered to be associated with the intrusion of landfill gas (if present) from adjoining former landfill sites into excavations (ie. trenches) during the installation of the power supply route.

1.3 Outline of proposed scope of additional investigations

The proposed scope for the additional investigations focuses on quantifying contamination risks to both the design and construction on the higher risk (high to moderate ranking) sites. Generic investigations to address waste classification and management of contaminated soils and / or ASS (if present) will also need to be undertaken on other metro sites requiring the disturbance of sub-surface materials to facilitate construction.

Based on the presence of known and potential contamination at the sites associated with current and / or historical commercial / industrial activities undertaken on and immediately adjacent to the sites, the following issues should be considered during design and construction of the project.

1.3.1 Chatswood dive site (northern)

Design (operational) considerations

Groundwater (as seepage) entering into below ground structures could represent a contamination source which could migrate into metro infrastructure or other services and could also represent a vapour risk to metro workers and users.

The design would need to address the potential for contaminated groundwater and vapours seeping into the subsurface excavation and associated structures. This would be especially relevant for any excavation occurring within or adjoining areas of existing contamination.

Subject to an updated desktop review of information for this site, it is recommended that the following investigations be undertaken within the construction footprint of the Chatswood dive site:

- To assess the presence of contaminated groundwater and potential vapour risk to the below ground structures, it is proposed to install a number nested groundwater wells within the construction footprint of the ventilation shaft to assess groundwater quality and vapour risk across a number of depth profiles / aquifers. This investigation should enable the vapour risk from groundwater at a number of different depths to be assessed in context of the depth of infrastructure construction.

Any design should also consider the presence of asbestos contamination consolidated in two excavations on the former service station site and the adjoining commercial premises.

Construction phase considerations

Appropriate management, treatment and / or disposal of contaminated fill, soils and / or bedrock materials excavated during construction of the metro infrastructure will be necessary.

To support the procurement of the construction contract, the types and extents of contaminated material would need to be considered and better understood especially on the Ausgrid Depot site. It is recommended that the following investigations be undertaken within the construction footprint of the Chatswood dive site:

- Obtain site specific contamination information (if available) to assess the preliminary waste classification based on the results of the contamination investigations previously undertaken within the proposed construction footprint.

Subject to an updated desktop review of information for this site, investigate fill / soil within the proposed construction footprint for waste classification and general management requirements during construction to reduce risk to workers, the public and the environment. The investigation would be completed by the drilling boreholes and collection of fill and soil samples for laboratory analysis. The results of the laboratory analysis would be compared against the relevant waste guidelines and NSW EPA endorsed contaminated land guidelines so that the materials can be appropriately classified and managed.

Any construction activities to be undertaken the areas occupied by the excavation used for asbestos consolidation will need to be managed in accordance with the site management plan (Golders, 2015).

1.3.2 Blues Point temporary site

Construction phase considerations

Appropriate management, treatment and / or disposal of contaminated fill, soils and / or bedrock materials excavated during construction of the project will be necessary. Currently, no information is available to understand the types and extent of contaminated material (including groundwater) present at the site.

To support the procurement of the construction contract, the types and extents of contaminated material would need to be considered and better understood.

It is recommended that the following investigations be undertaken within the construction footprint of the Blues Point temporary site:

- Obtain site specific contamination information (if available) to assess the preliminary waste classification based on the results of the contamination investigations previously undertaken within the proposed construction footprint.

Subject to an updated desktop review of information for this site, investigate fill / soil within the proposed construction footprint for waste classification and general management requirements during construction to reduce risk to workers, the public and the environment. The investigation would be completed by the drilling boreholes and collection of fill and soil samples for laboratory analysis. The results of the laboratory analysis would be compared against the relevant waste guidelines and NSW EPA endorsed contaminated land guidelines so that the materials can be appropriately classified and managed.

1.3.3 Barangaroo Station

Design (operational) considerations

Groundwater (as seepage) entering into below ground structures could represent a contamination source which could increase the risk of vapours impacting upon station works and users. Also, any lowering of the water table associated with the operation of the station should consider the possible risk of oxidation of acid sulphate soils (ASS) (if present) and potential impacts to the durability of station structures and impacts to the environment.

The design would need to address the potential for contaminated groundwater and vapours seeping into the subsurface excavation and associated structures. This would be especially relevant for any excavation occurring in the near vicinity to the declaration area being the former Millers Point Gasworks which occupies only a portion of Barangaroo and Hickson Road.

Subject to an updated desktop review of information for this site, it is recommended that the following investigations be undertaken within the construction footprint of Barangaroo Station:

- To assess the potential vapour risk to the below ground structures, it is proposed to install a number nested groundwater wells within the construction footprint to assess groundwater quality and vapour partitioning across a number of depth profiles / aquifers. This investigation should enable the vapour risk from groundwater at a number of different depths to be assessed in context of the depth of the station construction.

Construction phase considerations

Appropriate management, treatment and / or disposal of contaminated fill, soils and/or bedrock materials excavated during construction of the station elements will be necessary. Currently there is limited information available to understand the types and extent of contaminated material (including groundwater) present at the site below a depth of ten metres.

To support the procurement of the construction contract, the types and extents of contaminated material would need to be considered and better understood.

It is recommended that the following investigations be undertaken within the construction footprint of the Barangaroo Station site:

- Undertake a further detailed review of information provided by Barangaroo Development Authority to assess the preliminary waste classification based on the results of the contamination investigations (if any) previously undertaken within the proposed construction footprint.
- Subject to an updated desktop review of information for this site, investigate fill / soil within the proposed construction footprint for waste classification, presence / absence of ASS and general management requirements during construction to reduce risk to workers, the public and the environment. The investigation would be completed by the drilling boreholes to the depth of the proposed station construction (where possible) and collection of fill, soil and bedrock samples for laboratory analysis. The results of the laboratory analysis would be compared against the relevant waste and ASS guidelines and NSW EPA endorsed contaminated land guidelines so that the materials can be appropriately classified and managed.

1.3.4 Barangaroo Power Supply Route

Construction phase considerations

Appropriate management, treatment and / or disposal of contaminated fill, soils and/or bedrock materials excavated during construction for the power route supply will be necessary.

To support the procurement of the construction contract, the types and extents of contaminated material would need to be considered and better understood.

It is recommended that the following investigations be undertaken within the proposed power supply route:

- Investigate fill / soil within the proposed construction footprint for waste classification and general management requirements during construction to reduce risk to workers, the public and the environment. The investigation would be completed by the drilling boreholes to the depth of the proposed excavation (where possible) and collection of fill, soil and bedrock samples for laboratory analysis. The results of the laboratory analysis would be compared against the relevant waste guidelines and NSW EPA endorsed contaminated land guidelines so that the materials can be appropriately classified and managed.

1.3.5 Central Station Service Building

Design (operational) considerations

Groundwater (as seepage) entering into below ground structures could represent a contamination source (should contamination be present) which could increase the risk of vapours impacting upon building users.

The design would need to address the potential for contaminated groundwater and vapours seeping into the service building and associated subsurface infrastructure.

Subject to an updated desktop review of information for this site, it is recommended that the following investigations be undertaken within the construction footprint of Central Station service building:

- To assess the potential vapour risk to the below ground structures, install a number of groundwater wells within the construction footprint to assess groundwater quality and vapour partitioning across a number of depth profiles / aquifers. This investigation should enable the vapour risk from groundwater to be assessed in context of the depth of the service building and associated infrastructure.

Construction phase considerations

Appropriate management, treatment and / or disposal of contaminated fill, soils and/or bedrock materials (if present) excavated during construction of the service building and associated infrastructure will be necessary. Currently there is no quantitative information available to understand the types and extent of contaminated material (including groundwater) present, if any, at the site.

To support the procurement of the construction contract, the types and extents of contaminated material (where present) would need to be considered and better understood.

Subject to an updated desktop review of information for this site, it is recommended that the following investigations be undertaken within the construction footprint of the Central Station service building:

- Investigate fill / soil within the proposed construction footprint for waste classification and general management requirements during construction to reduce risk to workers, the public and the environment. The investigation would be completed by the drilling boreholes to the depth of the proposed building construction (where possible) and collection of fill, soil and bedrock samples for laboratory analysis. The results of the laboratory analysis would be compared against the relevant waste guidelines and NSW EPA endorsed contaminated land guidelines so that the materials can be appropriately classified and managed.

1.3.6 Regent Street (at Central Station)

It is understood that the Regent Street site would need to form part of an early works program to construct the Sydney Yard Access Bridge. It is assumed that to facilitate the design components for the access bridge, as a minimum, a geotechnical investigation would be required at the site. To assess potential contamination issues, samples could be collected during the geotechnical investigation and submitted for laboratory analysis to quantify the contamination risks associated with the construction activities.

It is recommended that during any scoping for the geotechnical investigation, consideration is given to the inclusion of an appropriate level of contamination testing.

1.3.7 Waterloo Station

Design (operational) considerations

Groundwater (as seepage) entering into below ground structures could represent a contamination source which could increase the risk of vapours impacting upon station works and users. Also, any lowering of the water table associated with the operation of the station should consider the possible risk of oxidation of ASS (if present) and potential impacts to the durability of station structures and impacts to the environment.

The design would need to address the potential for contaminated groundwater and vapours seeping into the subsurface excavation and associated structures.

Subject to an updated desktop review of information for this site, it is recommended that the following investigations be undertaken within the construction footprint of Waterloo Station:

- To assess the potential vapour risk to the below ground structures, it is proposed to install a number nested groundwater wells with the construction footprint to assess groundwater quality and vapour partitioning across a number of depth profiles / aquifers. This investigation should enable the vapour risk from groundwater at a number of different depths to be assessed in context of the depth of the station construction.

Construction phase considerations

Appropriate management, treatment and / or disposal of contaminated fill, soils and / or bedrock materials excavated during construction of the station elements will be necessary. Currently, no information has been made available to understand the types and extent of contaminated material (including groundwater) present at the site.

To support the procurement of the construction contract, the types and extents of contaminated material would need to be considered and better understood.

1.3.8 Marrickville Power Supply Route

Construction phase considerations

There is the potential for gas and to a lesser extent leachate from historical landfilling operations to enter excavations associated with the power supply route which could pose an asphyxiation or explosion risk to construction workers.

To support the procurement of the construction contract, the potential for landfill related contamination types would need to be considered and better understood.

It is recommended that the following investigations be undertaken within the proposed power supply route in the vicinity of Sydney park and Camdenville Oval:

- To assess the potential vapour risk to construction workers within power supply excavations, it is proposed to install a number of soil vapour points to the depth of the proposed excavation. This investigation should enable the vapour risk to be assessed in context of the depth of power supply excavation.

1.4 Summary of recommended contamination investigations

Recommendations	Chatswood dive site	Blues Point temporary site	Barangaroo Station	Central Station Service Building	Regent Street (at Central Station)	Barangaroo Power Supply Route	Waterloo Station	Marrickville Power Supply Route
To assess the potential vapour risk to the below ground structures, it is proposed to install a number of groundwater wells and vapour points to assess groundwater quality and vapour partitioning across a number of depth profiles / aquifers	X		X	X			X	X
Investigate fill / soil within the proposed construction footprint for the presence of ASS / PASS.			X				X	
Appropriate scoping and collection of contamination samples during proposed geotechnical investigations					X			
Further detailed review of site-specific contamination information (if available) to assess the preliminary waste classification	X	X	X			X	X	
Investigate fill / soil within the proposed construction footprint (completed by the drilling boreholes and collection of fill and soil samples for laboratory analysis) for waste classification and general management requirements during construction to reduce risk to workers, the public and the environment.	X	X	X	X		X	X	
Investigate fill / soil within the proposed construction footprint for the presence of ASS / PASS.			X				X	

X – Contamination investigations recommended. Subject to updated desktop review at Chatswood dive site, Blues Point temporary site, Barangaroo Station, Central Station and Waterloo Station.