Integrated Management System

Planning Approval Consistency Assessment Form

SM ES-FT-414

Sydney Metro Integrated Management System (IMS)

Assessment Name:	The Bays, WBPS Grouting
Prepared by:	AFJV Environment Approval Manager
Prepared for:	Sydney Metro
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The Planning Approval Consistency Assessment Form should be completed in accordance with the Sydney Metro Planning Approval Consistency Assessment Procedure (SM ES-PW-314) and Sydney Metro Environmental Planning and Approval Manual (SM ES-ST-216)

1.0 Existing Approved Project

Planning approval reference details (Application/Document No. (including modifications)):

- CSSI 10038 Sydney Metro West Concept and Stage 1 (11 March 2021)
- Administrative Modification 1 (28 July 2021)

Date of determination:

11 March 2021

Type of planning approval:

CSSI, Critical State Significant Infrastructure.

Description of existing approved project you are assessing for consistency:

Sydney Metro West (the Concept)

Sydney Metro West (the Concept) would involve the construction and operation of a metro rail line around 24 kilometres long between Westmead and Hunter Street in the Sydney CBD. The key components are expected to include (as described in Chapter 6 of the Environmental Impact Statement (EIS)):

- Construction and operation of new passenger rail infrastructure between Westmead and the central business district of Sydney, including:
    - Tunnels, stations (including surrounding areas) and associated rail facilities
    - Stabling and maintenance facilities (including associated underground and overground connections to tunnels)
- Modification of existing rail infrastructure (including stations and surrounding areas)
- Ancillary development.

Sydney Metro West - all major civil construction works between Westmead and The Bays (the approved project)

The Sydney Metro West Project Concept; and all major civil construction works between Westmead and The Bays, including station excavation and tunnelling was determined on 11 March 2021. The scope of Stage 1 of the planning approval process for Sydney Metro West (the approved project) is described in Chapter 9 of the EIS, with the key features including:

- Tunnel excavation including tunnel support activities between Westmead and The Bays
- Station excavation for new metro stations at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock and The Bays
- Shaft excavation for services facilities
- Civil work for the stabling and maintenance facility at Clyde.

To construct the above, the Sydney Metro West Stage 1 is divided into multiple packages, each with their own design and construction scope The package relevant to this Consistency Assessment is the Central Tunnel Package (CTP) which has an overall design and construction timeframe of approximately three years, from July 2021 to Q4 2024.

This consistency assessment relates to grouting areas of rock in order to minimise groundwater inflow and settlement at The Bays. The Bays construction site would be used to:

- Carry out the excavation of the Bays Station
- Launch and support two tunnel boring machines for the drive west to the Sydney Olympic Park metro station construction site.

The construction site would include tunnel boring machine support services including high voltage power supply, spoil storage and removal, fresh air ventilation, work train, grout batching plant, water supply, water treatment and disposal, material storage as well as office facilities, worker amenities and parking, and storage and installation of precast concrete lining elements.

The Project EIS foreshadowed the need to grout areas of rock in order to minimise groundwater inflow and settlement.

In Chapter 18 Groundwater and ground movement (18.6.3) states the following:

Rock in the vicinity of water-bearing geological features such as faults, dykes and joint swarms has the potential to have relatively high hydraulic conductivity (i.e. ability of groundwater to pass through the pores and fractures in the rock). Identification of such features would be carried out, and significant water-bearing features would be grouted prior to excavation, to reduce the potential for relatively high groundwater inflows to the excavations.

Relevant background information (including EA, REF, Submissions Report, Director General's Report, MCoA):

- Sydney Metro West Concept and Stage 1, Environment Impact Statement, April 2020
- Sydney Metro West Concept and Stage 1, Amendment Report, November 2020
- Sydney Metro West Concept and Stage 1, Submissions Report, November 2020
- Sydney Metro West Concept and Stage 1, Assessment Report (SSI 10038), March 2021
- Sydney Metro West Concept and Stage 1, Conditions of Approval (CoA), released on 11 March 2021 and updated on 28 July 2021.

2.0 Description of proposed development/activity/works

Describe ancillary activities, duration of work, working hours, machinery, staffing levels, impacts on utilities/authorities, wastes generated or hazardous substances/dangerous goods used.

The proposed activity involves the establishment of work areas within both the buildings and curtilage of White Bay Power Station (WBPS) in order to surface grout some of the underlying geology in the vicinity of the main line tunnels. The grouting program for the Bays tunnel drive aims to:

- Seal the fractures in the weathered zone to consolidate the rock mass and reduce the potential for inflows into the tunnels.
- Consolidate the alluvial sands just above the top of rock to reduce the potential for sands flowing into the tunnel excavation.
- Seal the dilated bedding-plane joints below the weathered zone to reduce the potential for large inflows.

This work will consist of three separate phases:
(1) Phase 1 (Soil grouting) – grouting the lower alluvial sand layers using sodium silicate grout from accessible surface grouting locations where the tunnel has less than one-half diameter of rock cover (rock cover equivalent to greater than 3.5m);
(2) Phase 2 (Rock-mass grouting) - from the surface in areas that are accessible for grouting equipment;
(3) Phase 3 (Underground grouting) - from the TBM in those areas that were not accessible from the surface or observed to have excessive groundwater inflows.

Similar grouting work has already been completed in order to control groundwater inflows into the future excavation for the Bays Station.

This consistency assessment addresses the first two phases, namely the surface grouting program outside of the project footprint; it considered that grouting within the project footprint has already been assessed by the EIS within Chapter 18. Consequently, this CA does not address the area of Phase 2 and Phase 3 that takes place within the project alignment. Figure 1 below shows the assessment area in reference to the boundary of The Bays construction site.

The surface grouting works would primarily involve drilling a pattern of holes and the injection of grout into the holes to a pre-determined pressure in order to reduce the bulk rock mass permeability and limit groundwater changes from construction in accordance with the Projects CoA notably CoA D121 and D122.

It is anticipated that the works associated with the proposed change would begin in February 2022 and would take about four to six months to complete. The works must be complete by the time the excavation of the tunnel reaches this area. Works would be conducted during the Project's approved working hours and the works would be delivered in accordance with the Project's Environmental Protection Licence (EPL), REMMs and CoA.

Figure 1 shows the location of WBPS in the context of the Bays Construction Site:

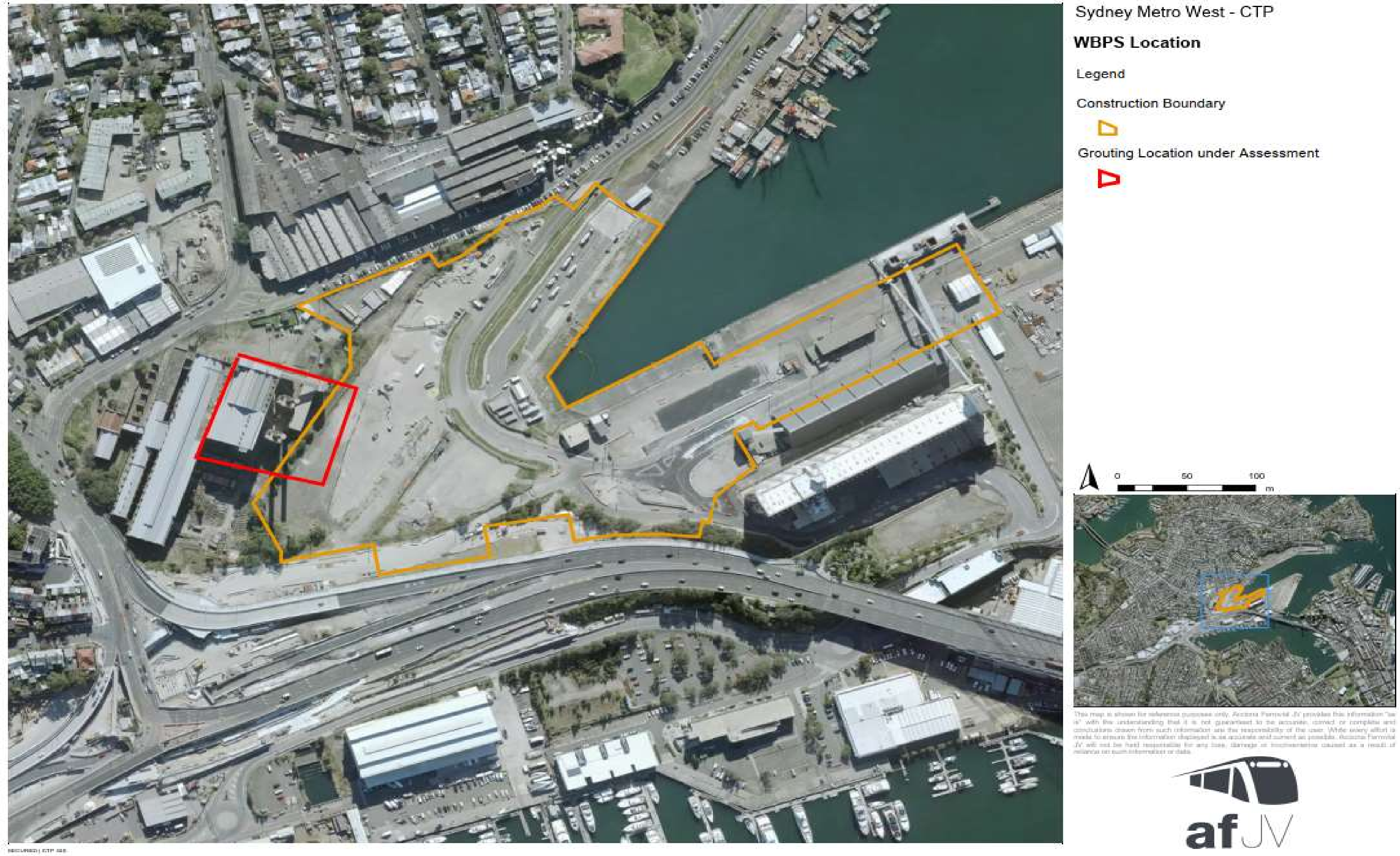

Figure 1 - Location of area under assessment

Construction would primarily involve the following activities:

- Site establishment
  - Deliveries of materials and equipment
  - Installation of site fencing
  - Installation of environmental controls and traffic control
  - Installation of grout supply lines
  - Services searching and connections
  - Installation of grout mixing equipment and associated machinery.
  - Removal of brush vegetation for access.
- Drilling
  - Set up the drilling rig on the grout hole.
  - Drill approximately 75mm to 100mm diameter primary holes with casing in the alluvial materials
  - (i.e. above rock)
  - Flush the hole with compressed air and water under controlled pressure
  - Repeat the process until all the primary holes are drilled
  - Delivery of materials to the work area
  - Removal of wastes.
- Grouting
  - Establish grouting lines from the grout pump to the top of the hole
  - Establish top of hole connection
  - Where required undertake abbreviated water testing
  - Install packers within the borehole to facilitate grouting of the target zones
  - Inject grout within the target zone at a target pressure, whilst recording duration and level of grout uptake.
  - Repeat the process until all the primary holes are grouted
  - Upon completion of the grouting work, the bore will be grouted to the ground surface, and reinstated to its pre-works condition as far as practicable
  - Delivery of grout and materials
  - Removal of wastes.
- Tertiary Grouting

– If any primary or secondary grout holes don't achieve the termination criteria, then tertiary and possibly quaternary drilling and grouting would be required. The termination criteria are reached when the grouting hole takes less than 20kg of cement per meter.

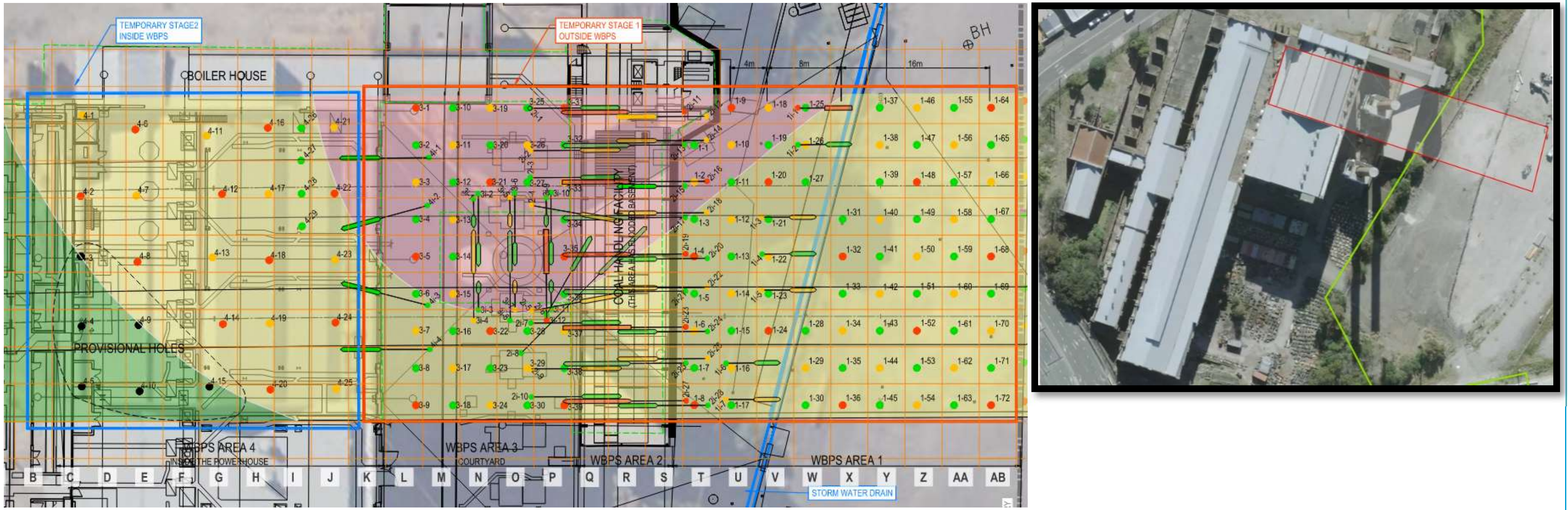

Figure 2 - Proposed Surface Grouting Holes Layout

The grouting holes are designated as primary (P), secondary (S), and tertiary (T); quaternary (Q) and quinary (X) may be added into the pattern as needed based on observations during the grouting. The primary holes would be drilled and grouted first, followed by the secondary holes, and so on.

The following plant and equipment are required:

1. Concrete core drilling/cutting equipment
2. 1x Rotary Track Mounted Drilling rig
3. Grout batching and pumping plant
4. Telehandler for materials handling
5. 50kva Generator
6. Submersible pump for spoil control
7. Vacuum Truck
8. Site vehicles (LV's)

3.0 Timeframe

When will the proposed change take place? For how long?

The grouting program within the WBPS area has been divided into four areas (Figure 1) all located within the WBPS curtilage.

- Area 1 is to the east of the buildings and extends to the Bays Station Box.
- Area 2 is beneath the Coal Handling Facility.
- Area 3 is the “courtyard area” between the Coal Handing Facility and the Boiler House.
- Area 4 is beneath the Boilerhouse.

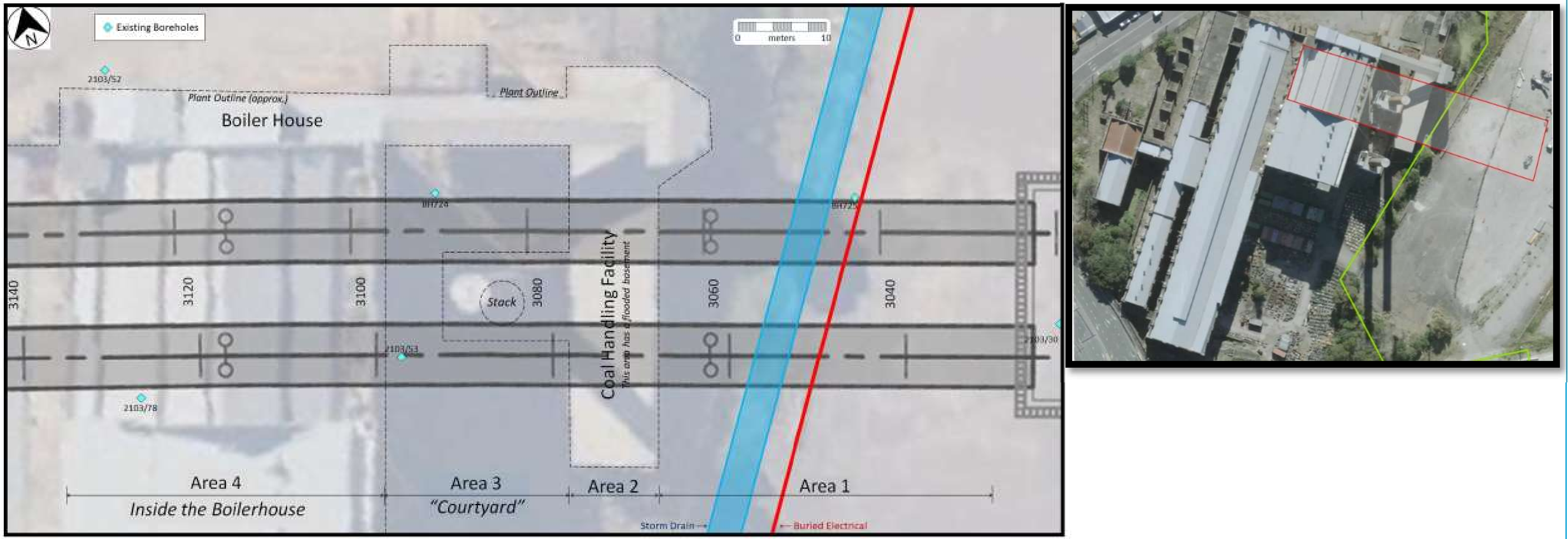

Figure 3 - Four Grouting Areas at the White Bay Power Station

Work is programmed to start in the following sequence:

- Area 1 – 8th February 2022 – 5th March 2022
- Areas 2 and 3 – 5th March 2022 – 26th March 2022

- Area 4 – 26th March 2022 – 19th April 2022

4.0 Site description

Provide a description of the site on which the proposed works are to be carried out, including, Lot and Deposited Plan details, where available. Map to be included here or as an appendix. Detail of land owner.

The White Bay Power Station is a heritage-listed former coal-fired power station on a 38,000 m2 (410,000 sq ft) site in White Bay, in the suburb of Rozelle, adjacent to the Bays Station construction site in the East, located on the junction of Victoria Road and Roberts Street. The site was added to the New South Wales State Heritage Register on 2 April 1999.

The adjacent Bays Station construction site primarily comprises industrial and wharf operations for White Bay and would be used to:

- Carry out the excavation of The Bays Station
- Launch and support two tunnel boring machines for the drive west to the Sydney Olympic Park metro station construction site.

Access to and egress from the construction site would be from James Craig Road via Port Access Road, Sommerville Road and Solomons Way. This is consistent with current access arrangements and the approved Construction Traffic Management Plan for the site.

5.0 Site Environmental Characteristics

Describe the environment (i.e., vegetation, nearby waterways, land use, surrounding land use), identify likely presence of protected flora/fauna and sensitive area.

The existing environmental characteristics of The Bays Station construction site and White Bay Power Station is included in the Stage 1 EIS and a summary is as follows:

- The site is located on the foreshore of White Bay
- White Bay has been heavily modified for port purposes and is unlikely to contain significant aquatic habitat
- Previous land uses of the site include Port and Employment and land zonings include IN2 – Light Industrial and W1 – Maritime Waters
- There is no naturally occurring native vegetation on the site. The site is almost devoid of vegetation except for opportunistic weed species. The land directly adjacent (to the south, west and north) contains a mix of planted vegetation and weeds
- Soils and groundwater have a moderate potential contamination risk associated with current and historic activities
- There is one registered Aboriginal heritage site within The Bays construction site (located within the footprint of the EIS construction site boundary (note; this site was listed in the Aboriginal Heritage Information Management System (AHIMS) after the EIS was prepared).

The non-Aboriginal heritage site characteristics are described in Table 1.

Table 1 Non-Aboriginal heritage items at The Bays

Item and listing	Significance	Proximity to The Bays Station construction site
White Bay Power Station SHR (01015), Urban Development Corporation s170 (4500460) and SREP No. 26 City West Part 3 No. 11	State	The grouting works under assessment are proposed to occur within the WBPS structure and curtilage. The construction site falls partially within the curtilage of the White Bay Power Station.
The Valley Heritage Conservation Area Leichhardt LEP 2013 (C7)	Local	Located to the north and north-west of the area under assessment.
White Bay Power Station (outlet) Canal / Circulating Water Conduit Ports Authority of NSW s170 (4560026)	Local	Located to the north of the area under assessment within the approved construction site.
White Bay Power Station (inlet) Canal Ports Authority s170 (4560062)	Local	Located to the north of the area under assessment within the approved construction site.
Beattie Street Stormwater Channel No. 15 Sydney Water s170 (4570329)	Local	Located to the north of the area under assessment within the approved construction site.

Glebe Island Silos Ports Authority of NSW s170 (4560016) and SREP No. 26 City West Part No. 1	Local	Located to the south-east of the area under assessment..

6.0 Justification for the proposed works

Address the need for the proposed works, whether there are alternatives to the proposed works (and why these are not appropriate), and the consequences with not proceeding with the proposed work.

The EIS (Chapter 18.6.3) anticipated that features with high hydraulic conductivity would need to be grouted prior to excavation to reduce the potential for relatively high groundwater inflows into the excavations.

Figure 3 shows the estimated thickness of rock cover above the tunnel crowns. The area in orange has less than one-half diameter of rock cover and is of particular concern for open face tunnelling, especially considering that the rock cover tends to be weathered and that the soil above the rock cover is unconsolidated, poorly graded sand, under a hydraulic head of approximately 18m.

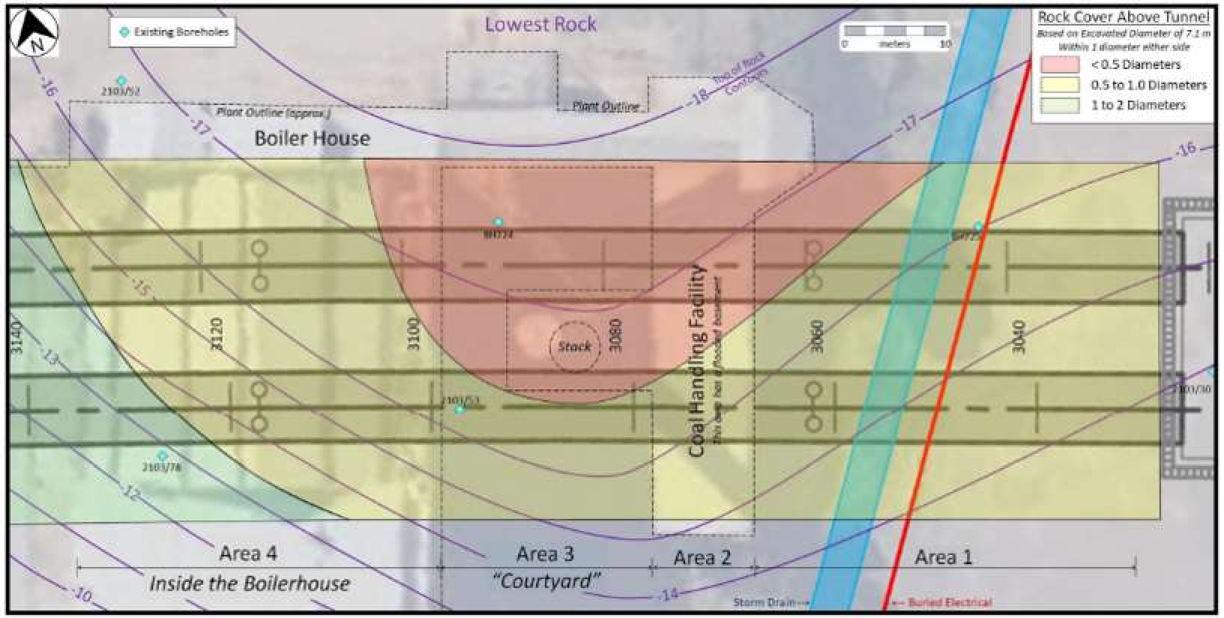

Figure 4 - Rock Cover above the Tunnel Crowns

The proposed change is required to reduce groundwater inflows to the tunnel excavations and also to reduce the risk of flowing sands from the overlying alluvium entering the tunnel excavations through potential sand-filled defects within the rock mass. Excessive groundwater inflow and potentially induced sand piping at the TBM excavation pose a substantial risk of subsidence in the overlying alluvium soil and consequently to the WBPS structures at the surface.

The grouting program for the Bays tunnel drive aims to:

- Seal the fractures in the weathered zone to consolidate the rock mass and reduce the potential for inflows.
- Consolidate the alluvial sands just above the top of rock to reduce the potential for sands flowing into the tunnel excavation.
- Seal the dilated bedding-plane joints below the weathered zone to reduce the potential for large inflows.

The surface grouting will assist in complying with the Project's Conditions of Approval (CoA) by minimising groundwater inflows into the tunnels and thus minimising the amount of ground settlement by filling in the voids within the rock which will limit the permeability of the rock.

Environmental Requirement ID	Requirement	Comment
D17	The Roxy Theatre, White Bay Power Station, the former State Abattoirs and the former RTA Depot facade fronting Unwin Street must not be destroyed, modified or otherwise adversely affected, except as identified in the documents listed in Condition A1 of this schedule.	The proposed change will assist in achieving the objectives of CoA D17 by significantly reducing the risk of settlement to the White Bay Power Station.
D121	Make good provisions for groundwater users must be provided in the event of a material decline in water supply levels, quality or quantity from registered existing bores associated with groundwater changes from construction.	The proposed change will assist in achieving the objectives of CoA D121. The proposed change represents the implementation of appropriate mitigation measures prior to excavation and tunnelling works that will assist in ensuring that groundwater drawdown is kept to manageable levels during the TBM drive.
D122	The Proponent must submit a revised Groundwater Modelling Report in association with Stage 1 of the CSSI to the Planning Secretary for information before bulk excavation at the relevant construction location. The Groundwater Modelling Report must include:	The proposed change will assist in achieving the objectives of CoA D122. The proposed change is the implementation of a practical measure to limit groundwater inflow during construction.

	(a) for each construction site where excavation will be undertaken, cumulative (additive) impacts from nearby developments, parallel transport projects and nearby excavation associated with the CSSI; (b) predicted incidental groundwater take (dewatering) including cumulative project effects; (c) potential impacts for all latter stages of the CSSI or detail and demonstrate why these later stages of the CSSI will not have lasting impacts to the groundwater system, ongoing groundwater incidental take and groundwater level drawdown effects; (d) actions required after Stage 1 to minimise the risk of inflows (including in the event latter stages of the CSSI are delayed or do not progress) and a strategy for accounting for any water taken beyond the life of the operation of the CSSI; (e) saltwater intrusion modelling analysis, from estuarine and saline groundwater in shale, into The Bays metro station site and other relevant metro station sties; and (f) a schematic of the conceptual hydrogeological model.	

7.0 Environmental Benefit

Identify whether there are environmental benefits associated with the proposed works. If so, provide details:

There are multiple improvements across the aspects of environment and community impact, these are summarised below:

- Pre-excavation grouting will significantly reduce groundwater drawdown into the tunnels, resulting in:
  - A significantly reduced risk of settlement for the State significant White Bay Power Station structures SHR (01015)
  - Significantly reduced volume of water requiring treatment and discharge at surface level.
  - Significantly reduced risk of groundwater drawdown on neighbouring structures and properties.
- Pre-excavation surface grouting will also result in a faster TBM tunnel drive from the Bays, reducing groundborne noise and vibration impacts on neighbouring properties and the WBPS.

8.0 Control Measures

Will a project and site-specific EMP be prepared? Are appropriate control measures already identified in an existing EMP?

The pre-excavation grouting at WBPS will be managed under the project CEMP (Construction Environment Management Plan) in the same way that the pre-excavation grouting of the station box has been successfully undertaken. Appropriate control measures have already been applied to this activity from work within the station box and will be enhanced with the specific heritage controls recommended by Comber in section 3.2 of their review provided in Appendix A of this document.

There are no changes to the CEMP proposed as a result of the pre-excavation grouting at WBPS.

9.0 Climate Change Impacts

Is the site likely to be adversely affected by the impacts of climate change? If yes, what adaptation/mitigation measures will be incorporated into the design?

The effects of climate change on the Sydney Metro West Stage 1 project were discussed in the EIS Chapter 26. The pre-excavation grouting at WBPS is not expected to result in any significant change to overall greenhouse gas emissions given the increase in material usage would be offset by a significant reduction in water treatment demand and a reduced risk of settlement (requiring additional construction effort to remedy). In addition to this, an element of pre-excavation grouting was already considered likely by the EIS.

10.0 Impact Assessment – Construction

Attach supporting evidence in the Appendices if required. Make reference to the relevant Appendix if used.

Aspect	Nature and extent of impacts (negative and positive) during construction (if control measures implemented) of the proposed/activity, relative to the Approved Project	Proposed Control Measures in addition to project CoA and REMMs	Minimal Impact Y/N	Endorsed	
				Y/N	Comments
Flora and fauna	Minor weed and shrub clearance is required for access. To be managed under existing Flora and Fauna CEMP.	No additional measures	Y	Y	
Water	Up to 1000m3 of water is required to complete the grouting of all holes shown in Figure 2. This is more than was required for the station box, it is necessary to adopt a more sensitive drilling methodology within the power station than within the station box. Whilst the station box adopted an air flush approach, the drilling within WBPS will primarily adopt a water flush approach, which is a less aggressive method of drilling. This water is significantly less than the possible groundwater inflow to the TBM were pre-excavation grouting not to take place. The EIS assessed groundwater inflow rate at the Bays a 10.1 litres / second in table 18-7. Despite the initial water demand, the proposed change is expected to result in a positive impact on water resources on the project.	No additional measures	Y	Y	

Aspect	Nature and extent of impacts (negative and positive) during construction (if control measures implemented) of the proposed/activity, relative to the Approved Project	Proposed Control Measures in addition to project CoA and REMMs	Minimal Impact Y/N	Endorsed	
				Y/N	Comments
Air quality	The generator and site vehicles are likely to result in a negligible impact on local air quality.	No additional measures	Y	Y	
Noise and vibration	In order to confirm the degree of change, a construction noise and vibration impact assessment was undertaken for the proposed works and demonstrated no impact on the local environment. statement Works are programmed to only occur during normal working hours Monday – Friday 0700-1800 Saturday – 0800-1800	No additional measures	Y	Y	
Indigenous heritage	The heritage review has assessed that the proposed works have a very low potential to impact upon Aboriginal Objects. The heritage review is included in Appendix A.	No additional measures	Y	Y	

Aspect	Nature and extent of impacts (negative and positive) during construction (if control measures implemented) of the proposed/activity, relative to the Approved Project	Proposed Control Measures in addition to project CoA and REMMs	Minimal Impact Y/N	Endorsed	
				Y/N	Comments
Non-indigenous heritage	Comber Consultants has assessed the impact of the proposed grouting plan on the heritage significance of the White Bay Power Station in their heritage review included in Appendix A. The review has assessed that the proposed works have a very low potential to impact upon Aboriginal objects, historic relics, or structures and will have a negligible impact on the heritage significance of the White Bay Power Station. Mitigation measures have been specified that will minimise the potential for damage or harm and these will be followed during the works by ensuring that machinery is appropriately located, that archaeological monitoring is undertaken and any removed or damaged fabric is reinstated.	Mitigation measures have been specified in 3.2 of the heritage review which will be utilised in an EWMS for the works, which all personnel involved in the works will be required to sign onto.	Y	Y	
Community and stakeholder	No impacts are expected from the grouting works given most of the plant is already on site and works are well shielded by local structures (WBPS) as demonstrated in the CNVS shown in Appendix B. Overall a reduction in construction impacts due to a faster TBM drive from the Bays than would be possible should the pre-excavation grouting works not be undertaken.	No additional measures	Y	Y	

Aspect	Nature and extent of impacts (negative and positive) during construction (if control measures implemented) of the proposed/activity, relative to the Approved Project	Proposed Control Measures in addition to project CoA and REMMs	Minimal Impact Y/N	Endorsed	
				Y/N	Comments
Traffic	The plant and equipment required for the grouting operation is already onsite following the pre-excavation grouting works at the station box. The only additional traffic impact from the works under assessment is the removal of drilling spoil which would result in an additional 265 trucks over the 3-month drilling program. Given a similar volume of trucks were required for the station box grouting works without incident, it is considered that these movements represent a negligible impact to local traffic over this time frame.	No additional measures	Y	Y	
Waste	A minor impact to waste generation as additional drilling spoil/mud will require disposal via vacuum truck. The volume of drilling spoil/mud is proportionate to the amount of water required and is likely to be approximately 1,500m3 for all 265 holes shown in Figure 2.	No additional measures	Y	Y	
Social	No change from approved project	No additional measures	Y	Y	
Economic	No change from approved project	No additional measures	Y	Y	
Visual	No change from approved project	No additional measures	Y	Y	
Urban design	No change from approved project	No additional measures	Y	Y	

Aspect	Nature and extent of impacts (negative and positive) during construction (if control measures implemented) of the proposed/activity, relative to the Approved Project	Proposed Control Measures in addition to project CoA and REMMs	Minimal Impact Y/N	Endorsed	
				Y/N	Comments
Geotechnical	A risk assessment was undertaken to determine whether pre-excavation grouting was necessary under WBPS. Adopting the classification used in Chapter 18 of the EIS, and in simple terms, modelling shows a slight to moderate risk of settlement for selected structures in WBPS under an unmitigated scenario (where no grouting was undertaken). Following grouting this reduces to a negligible to slight risk of settlement for these structures. Grouting is a significant risk mitigation tool and is proposed to reduce the risk of damage to the heritage buildings of White Bay Power Station and elsewhere. Notwithstanding this, existing CoA relating to the allowable criteria for settlement (CoA D63) will be implemented and adhered.	No additional measures	Y	Y	

Aspect	Nature and extent of impacts (negative and positive) during construction (if control measures implemented) of the proposed/activity, relative to the Approved Project	Proposed Control Measures in addition to project CoA and REMMs	Minimal Impact Y/N	Endorsed	
				Y/N	Comments
Groundwater	Available data indicate that the high permeability rock (or dilated bedding planes with high permeability) are present close to the alluvial boundary / edge of the palaeochannel, The rock beneath, and in the vicinity of, White Bay Power Station (through which the TBM's will pass) could therefore be of relatively high permeability (modelled at 308 Lugeons). For this reason, and given the relatively low rock cover in the tunnels immediately west of the station box, rock in the vicinity of White Bay Power Station is proposed to be grouted. With rock grouted in the vicinity of WBPS the bedding plane feature is modelled to have a permeability of 5 Lugeons. This translates to a groundwater inflow to the single tunnel of 4.5l/s in the unmitigated (ungrouted) scenario versus a groundwater inflow of 0.2l/s under the mitigated (grouted) scenario. This approach is consistent with that identified in Chapter 18 of the EIS and is a positive benefit to the groundwater resources in this area, when measured against a do nothing scenario.	No additional measures	Y	Y	
Land use and property	The works under assessment occur on land managed by Place Management NSW (PMNSW). Land owners consent will be required for these works to take place.	Land owner consent for the works.	Y	Y	

Aspect	Nature and extent of impacts (negative and positive) during construction (if control measures implemented) of the proposed/activity, relative to the Approved Project	Proposed Control Measures in addition to project CoA and REMMs	Minimal Impact Y/N	Endorsed	
				Y/N	Comments
Climate Change	The pre-excavation grouting at WBPS is not expected to result in any significant change to overall greenhouse gas emissions given the increase in material usage would be offset by a significant reduction in water treatment demand and a reduced risk of settlement (requiring additional construction effort to remedy). In addition to this, an element of pre-excavation grouting was already considered likely by the EIS.	No additional measures	Y	Y	
Risk	No change from approved project	No additional measures	Y	Y	
Other	No change from approved project	No additional measures	Y	Y	
Management and mitigation measures	No change from approved project	No additional measures	Y	Y	

11.0 Impact Assessment – Operation

Attach supporting evidence in the Appendix if required. Make reference to the relevant Appendix if used.

Stage 1 of the planning application for Sydney Metro West (subject of this Consistency Assessment) is for major civil construction work for Sydney Metro West between Westmead and The Bays. At this stage, measures to avoid or minimise impacts have been developed only for major civil construction work for Sydney Metro West between Westmead and The Bays – which involves construction only. Impacts applicable to the operational aspects of Sydney Metro West including operation stage environmental mitigation measures would be developed when planning approval applications are made for future stages. As such, operational impacts of the proposal are not applicable, and therefore there are no changes from the approved project are anticipated.

Aspect	Nature and extent of impacts (negative and positive) during operation (if control measures implemented) of the proposed activity/works, relative to the Approved Project	Proposed Control Measures in addition to project COA and REMMs	Minimal Impact Y/N	Endorsed	
				Y/N	Comments
Flora and fauna	No change from approved project	No additional measures	Y	Y	
Water	No change from approved project	No additional measures	Y	Y	
Air quality	No change from approved project	No additional measures	Y	Y	
Noise and vibration	No change from approved project	No additional measures	Y	Y	
Indigenous heritage	No change from approved project	No additional measures	Y	Y	
Non-indigenous heritage	No change from approved project	No additional measures	Y	Y	
Community and stakeholder	No change from approved project	No additional measures	Y	Y	
Traffic	No change from approved project	No additional measures	Y	Y	
Waste	No change from approved project	No additional measures	Y	Y	

Aspect	Nature and extent of impacts (negative and positive) during operation (if control measures implemented) of the proposed activity/works, relative to the Approved Project	Proposed Control Measures in addition to project COA and REMMs	Minimal Impact Y/N	Endorsed	
				Y/N	Comments
Social	No change from approved project	No additional measures	Y	Y	
Economic	No change from approved project	No additional measures	Y	Y	
Visual	No change from approved project	No additional measures	Y	Y	
Urban design	No change from approved project	No additional measures	Y	Y	
Geotechnical	No change from approved project	No additional measures	Y	Y	
Land use	No change from approved project	No additional measures	Y	Y	
Climate Change	No change from approved project	No additional measures	Y	Y	
Risk	No change from approved project	No additional measures	Y	Y	
Other	No change from approved project	No additional measures	Y	Y	
Management and mitigation measures	No change from approved project	No additional measures	Y	Y	

12.0 Consistency with the Approved Project

Based on a review and understanding of the existing Approved Project and the proposed modifications, is there is a transformation of the Project?	No. The proposed change would not transform the project. The project would continue to provide a metro rail line between Westmead and The Bays as part of the Approved Project.
Is the project as modified consistent with the objectives and functions of the Approved Project as a whole?	Yes. The proposed change would be consistent with the objectives and functions of the approved project as a whole.
Is the project as modified consistent with the objectives and functions of elements of the Approved Project?	Yes. The revised tunnel alignment under WBPS will not change as a result of the work. Therefore, the project as modified is consistent with the objectives and functions of the tunnel alignment and the Approved project.
Are there any new environmental impacts as a result of the proposed works/modifications?	No. There are no new environmental impacts. All risks identified for the approved project and the proposed change would be adequately addressed through the application of the mitigation measures provided in the Environmental Impact Statement, Submissions Report, Amendment Report and the conditions of approval.
Is the project as modified consistent with the conditions of approval?	Yes. The proposed change is consistent with the conditions of approval.
Are the impacts of the proposed activity/works known and understood?	Yes. The impacts of the proposed change are understood.
Are the impacts of the proposed activity/works able to be managed so as not to have an adverse impact?	Yes. The impacts of the proposal are understood and will be accounted for by implementing the existing mitigation measures provided in the Environmental Impact Statement, Submissions Report, Amendment Report and the Instrument of Approval for the approved project.

13.0 Other Environmental Approvals

Identify all other approvals required for the project:	Nil. No additional environmental approvals are required.

Author certification

To be completed by person preparing checklist.

I certify that to the best of my knowledge this Consistency Checklist:

- **Examines and takes into account the fullest extent possible all matters affecting or likely to affect the environment as a result of activities associated with the Proposed Revision; and**
- **Examines the consistency of the Proposed Revision with the Approved Project; is accurate in all material respects and does not omit any material information.**

Name:	Jon May	Signature:	[signature]
Title:	Environmental Approvals Manager		
Company:	AFJV	Date:	21/01/22

This section is for Sydney Metro only.

Application supported and submitted by			
Name:	Yvette Buchli	Date:	16/02/2022
Title:	Associated Director Planning Approvals	Comments:	
Signature:	[signature]		

Based on the above assessment, are the impacts and scope of the proposed activity/modification consistent with the existing Approved Project?

Yes ☒ The proposed activity/works are consistent and no further assessment is required.

No ☐ The proposed works/activity is not consistent with the Approved Project. A modification or a new activity approval/ consent is required. Advise Project Manager of appropriate alternative planning approvals pathway to be undertaken.

Endorsed by			
Name:	S Hodgson	Date:	21/2/2022
Title:	Director Environment, Sustainability & Planning, West	Comments:	No comments. Please ensure uploaded to website
Signature:	[signature]		

Appendix A Comber Consultants Heritage Review

COMBER CONSULTANTS

ARCHAEOLOGY - HERITAGE - MEDIATION - ARBITRATION

Metro West Central Tunnelling Package – The Bays

White Bay Power Station

Heritage Review of Grouting Plan

February **2022**

Report to: Acciona Ferrovial Joint Venture

Version: D.2022

ABN 96 109 670 573 | 76 EDWIN STREET NORTH | CROYDON, NSW, 2132 | T 02 9799 6000 | F 02 9799 6011 www.comber.net.au

ACKNOWLEDGEMENT OF COUNTRY

We acknowledge the Traditional Custodians of the land that we live and work on.

We pay our respects to the Elders, past, present and emerging, for they hold the memories, the traditions, the culture and hopes of Aboriginal people.

We honour and acknowledge the stories, traditions and living cultures of Aboriginal and Torres Strait Islander peoples on this land and commit to building a brighter future together.

A better understanding and respect for Aboriginal and Torres Strait Islander cultures develops an enriched appreciation of Australia's cultural heritage and can lead to reconciliation. This is essential to the maturity of Australia as a nation and fundamental to the development of an Australian identity.

DOCUMENT CONTROL

PROJECT NO: AC425 **STATUS:** FINAL

REV	DATE	PREPARED BY	EDITED BY	APPROVED BY
A	20/01/2022	Dr Jillian Comber, Archaeologist & Patrick O'Carrigan, Architect	David Nutley	Dr Jillian Comber
B	21/01/2022	Dr Jillian Comber, Archaeologist & Patrick O'Carrigan, Architect	David Nutley	Dr Jillian Comber
C	06/02/2021	Dr Jillian Comber, Archaeologist & Patrick O'Carrigan, Architect	David Nutley	Dr Jillian Comber
D	07/02/2021	Dr Jillian Comber, Archaeologist & Patrick O'Carrigan, Architect	David Nutley	Dr Jillian Comber

INTEGRATED MANAGEMENT SYSTEM

Comber Consultants has a certified integrated management system to the requirements of ISO 9001 (quality), ISO 14001 (environmental) and ISO 45001 (health and safety). This is your assurance that Comber Consultants is committed to excellence, quality, and best practice and that we are regularly subjected to rigorous, independent assessments to ensure that we comply with stringent Management System Standards.

CONTENTS

EXECUTIVE SUMMARY

It is proposed to undertake grouting within the White Bay Power Station in respect of the Bays Tunnelling Package. The proposed grouting plan is attached at Appendix A. The White Bay Power Station is of State heritage significance and listed on the State Heritage Register.

This report has assessed the impact of the proposed grouting plan on the heritage significance of the White Bay Power Station and assessed that the proposed works have a very low potential to impact upon Aboriginal objects, historic relics or structures and will have a negligible impact on the heritage significance of the White Bay Power Station. Mitigation measures and recommendations have been provided which will minimise the potential for damage or harm by ensuring that machinery is appropriately located, that archaeological monitoring is undertaken and any removed or damaged fabric is reinstated. Therefore, the proposed grouting program can be undertaken under the project Construction Environmental Management Plan (CEMP).

The recommendations to minimise the impact are contained in section 3 of this report.

1 INTRODUCTION

1.1. Background

Sydney Metro West is a critical step in the delivery of the Future Transport Strategy 2056. Services on the North West Metro Line between Rouse Hill and Chatswood commenced in May 2019. The Sydney Metro network also includes Sydney Metro City & Southwest, Sydney Metro West and Sydney Metro Western Sydney Airport. Sydney Metro West is a new 24 kilometre metro line between Westmead and the Sydney CBD.

The planning approvals and environmental impact assessment for Sydney Metro West has been split into a number of stages recognising the size of the project. This includes:

- Stage 1 – Concept and all major civil construction works including station excavation and tunnelling between Westmead and The Bays. Planning approval for this stage was granted in March 2021.
- Stage 2 – All major civil construction works including station excavation and tunnelling from The Bays to Sydney CBD
- Stage 3 – Tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line. An Environmental Impact Statement (EIS) (Jacobs/Arcadis, 2020) for the Concept and Stage 1 (herein referred to as the Project) assessed the heritage impacts in response to the Secretary's Environmental Assessment Requirements issued by the Department of Planning, Industry and Environment (DPIE). The non-Aboriginal heritage impacts were assessed in Chapter 12 and Technical Paper 3 and Aboriginal Cultural heritage impacts were assessed in Chapter 13 and Technical Paper 4 of the Project EIS. The Project was approved by the NSW Minister for Planning and Public Spaces on 11 March 2021 (SSI 10038).

Jacobs Typsa Joint Venture (JTJV) developed a technical memorandum for the White Bay Power Station Surface Grouting Design, which is attached at Appendix A, which is being undertaken as part of the Stage 1 works. This report assesses the impact of the grouting project on the heritage significance of the White Bay Power Station.

1.2. White Bay Power Station

The White Bay Power Station is bound by Victoria Road and Robert Street on the Balmain Peninsula and is of State Heritage significance. It was developed between 1912 and 1948. It comprises two steel stacks, a coal handling unit serviced by a spur rail line, a turbine hall, a building incorporating administration offices, the old laboratory and workshop, a boiler house, a switch house and substation and an ancillary structure including coal loading wharf and coal handling system (Artefact 2021:4). It listed on the following registers:

- State Heritage Register Listing No. 01015.
- Sydney Harbour Foreshore s170 Register
- Sydney Regional Environmental Plan No 26 – City West Part 3, Item No. 11.
- The Register of the National Estate Item No. 19512.
- Register of the National Trust Classified Item.

The history and heritage of the White Bay Power Station is described in the following reports and is not repeated in this report. The reader is directed to the following which were reviewed in the preparation of this report:

- Sydney Metro West Environmental Impact Station, Westmead to The Bays and Sydney CBD.
- Heritage Management Plan, Sydney Metro West – Central Tunnelling Package.
- Sydney Metro West, Stage 1 Aboriginal Cultural Heritage Assessment Report by Artefact, 2020.
- Sydney Metro West, Technical Paper 3, Non-Aboriginal Heritage Report by Artefact, 2020.
- The White Bay Conservation Management Plan
- The ARDEM for the Bays Construction site by Artefact 2020

1.3. Location and description of proposed grouting

The White Bay Power Station is located above the Metro West tunnel alignment. The grouting plan is shown in Figure 1 below. Full details are contained at Appendix B. The grouting includes the drilling of cores approximately 70-90mm within the hard surfaces surrounding buildings and within the concrete floor of the boiler house and coal loading facility. Access for grouting will be required within the boiler house and coal handling facilities.

Figure 1: Grouting plan (overlay prepared by Patrick O'Carrigan + Partners)

1.4. Authors

This report was prepared by:

- Dr Jillian Comber, B.A., Litt.B., PhD., archaeologist with over 30 years' experience in Aboriginal and non-Aboriginal archaeology and cultural heritage management. Her CV is attached at Appendix B.
- Patrick O'Carrigan, B.Sc (Architecture) B.Arch (Hons 1), M.Arch,(Penn), P.C Arb [Adel] Architect and is qualified as both a Registered architect #5025 in NSW and Victoria and specialist Urban Designer, and is a Fellow of the Royal Australian Institute of Architects. He has over 30 years experience in heritage conservation, as a heritage advisor, author of numerous SoHI, HA, CMP for public and private items of significance. His CV is attached at Appendix B.

2 HERITAGE POTENTIAL AND IMPACTS

2.1. Aboriginal Archaeology and Impacts

There are no registered Aboriginal sites within the area proposed for the grouting and the works are not within an area of Aboriginal archaeological potential.

The Aboriginal archaeology of the White Bay Power Station study area was assessed as low-moderate in the south-western portion of The Bays Station construction site and the remainder of the site was assessed as containing low archaeological potential (Artefact 2020a:93).

The proposed works are not within the area assessed as low-moderate potential. Figure 2 shows the area of Aboriginal low-moderate archaeological potential and Figure 3 shows the grouting plan and the area of Aboriginal low-moderate archaeological potential. The proposed drilling works will have a negligible impact on Aboriginal archaeology.

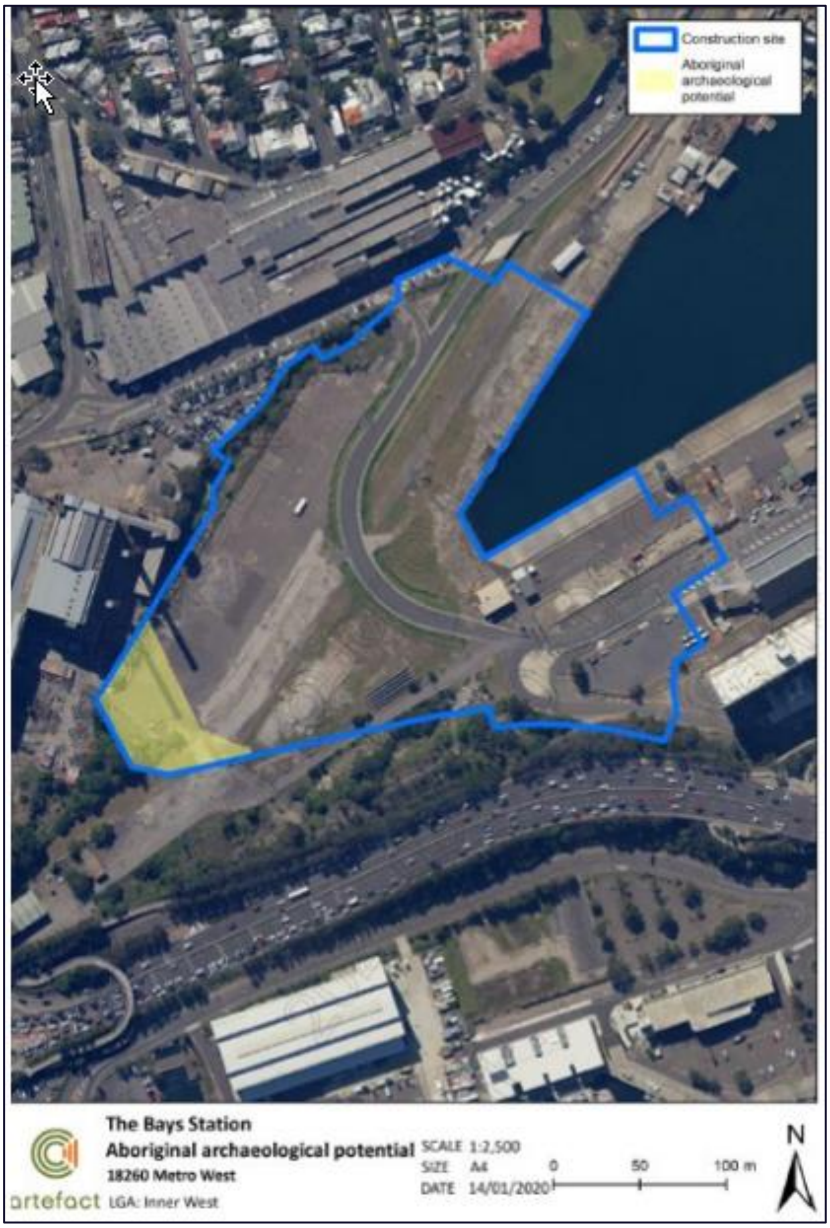

Figure 2: The area of Aboriginal archaeological potential shown in yellow (Heritage Management Plan, Sydney Metro West – Central Tunnelling Package 2021:10).

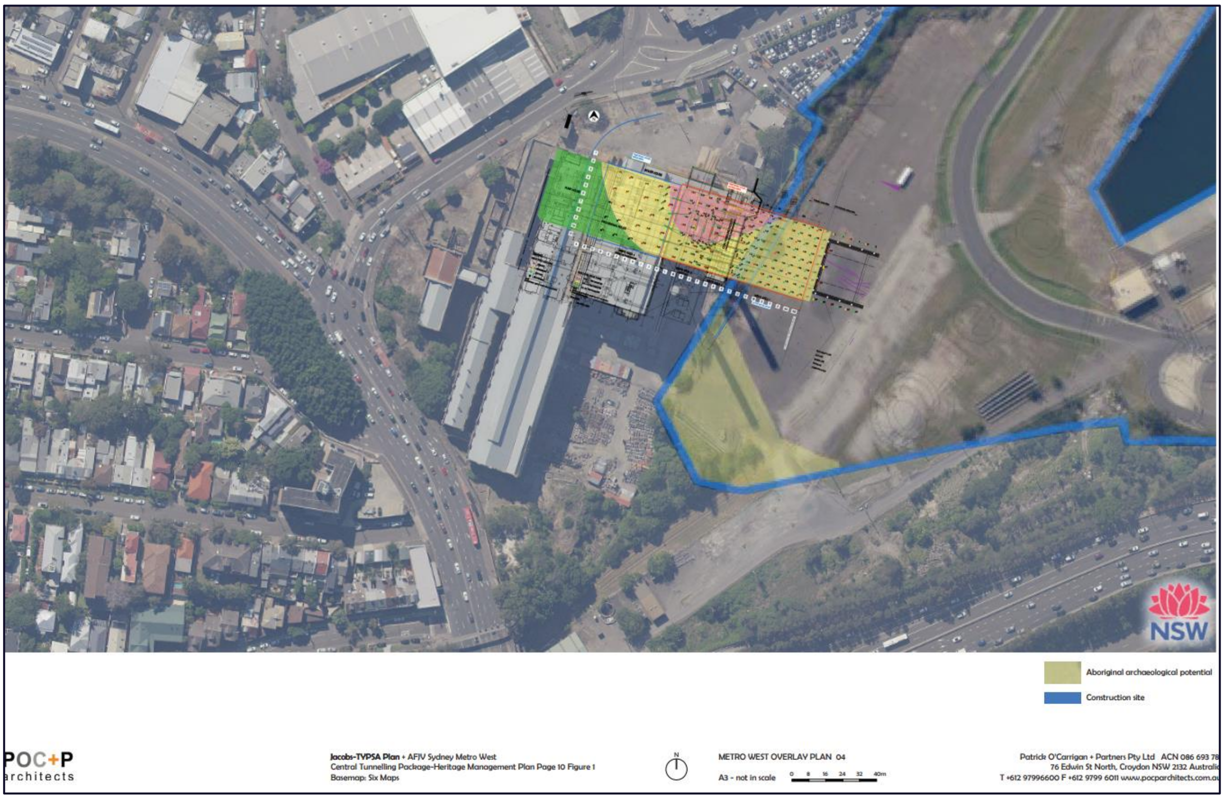

Figure 3: Showing location of proposed grouting and area of Aboriginal archaeological potential to the south of the grouting area (overlay by Patrick O'Carrigan + Partners)

2.2. Non-Aboriginal Archaeology

The White Bay Power Station construction site was assessed to contain moderate potential for relics and building materials and infill, piers, posts, beams or walls of timber structures as shown below in Table 1 and Figures 4-6. (Artefact 2020b:307; Artefact 2020c:147-8). Please note that the historical archaeology of the White Bay Power Station is not detailed in the Conservation Management Plan (CMP). On page 197 of Volume 2 it states:

> *5.13.1 Archaeology*
> *The opportunity should be taken for archaeological research to be undertaken around the site including the former White Bay Hotel site before development work is done. Information on the location of earlier structures and on work practices and conditions may be found by such investigation. The site was occupied by housing before the development of the Power Station and there is potential for information to be gathered about this period in its evolution. While much of the site was cut and filled for the Power Station, some evidence may still survive but most likely badly disturbed. Refer also to Section 5.6* (NB. s5.6 refers to statutory controls).
>
> *Such investigation should only be undertaken where the area is to be disturbed for development or further works.*

The archaeological potential and significance is detailed in the non-Aboriginal Archaeological Report (Artefact 2020b and in the Archaeological Research Design and Excavation Methodology (ARDEM) (Artefact 2020c).

The proposed grouting plan is located within the reclamation fills which has low to high archaeological potential of local or state significance. The grouting plan is located in the northern portion of the State Heritage registered boundary within the reclamation fills (as defined in the *Heritage Act 1977*). Figure 3 shows the State Heritage Register boundary and the location of the grouting program.

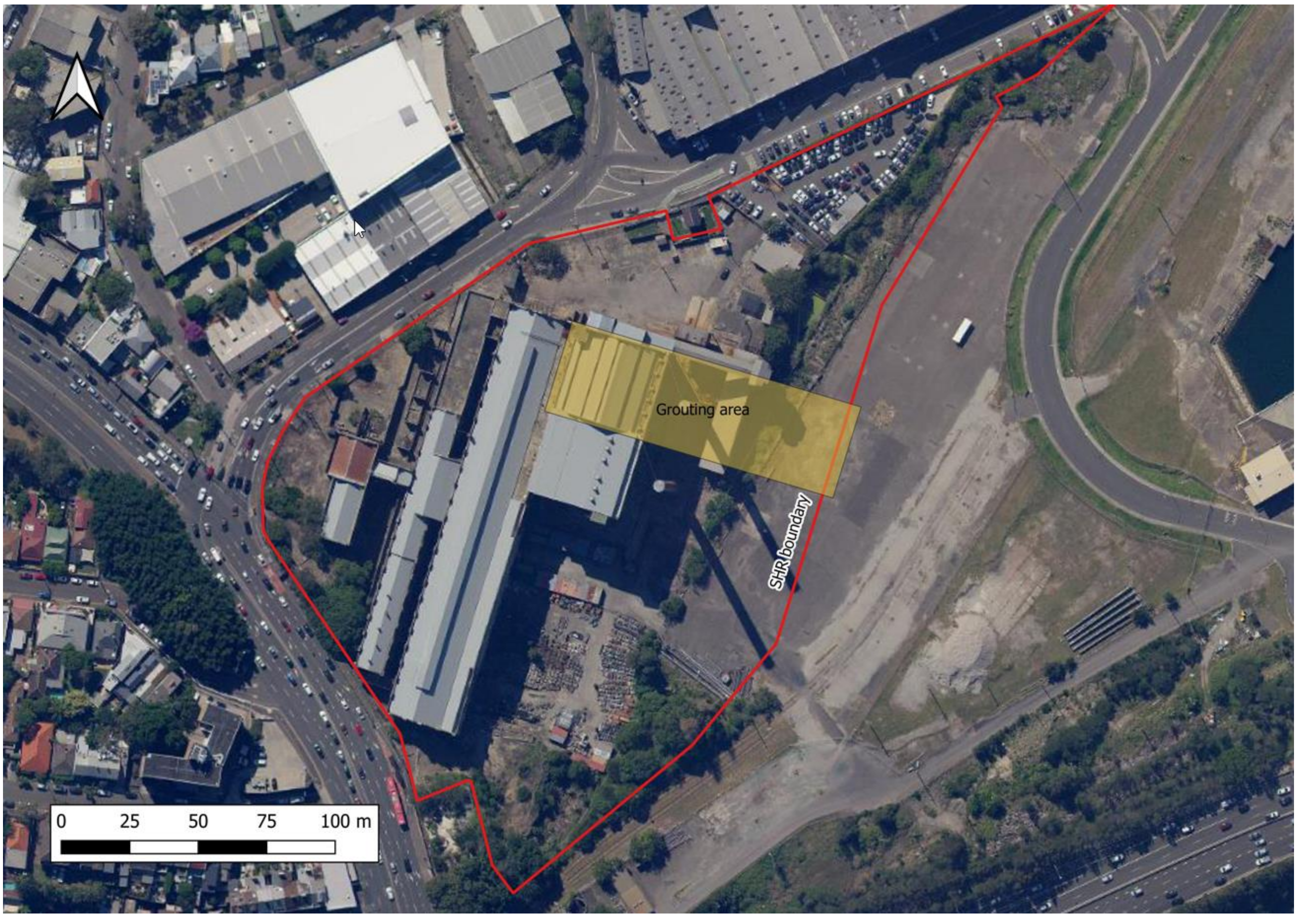

Figure 3: State Heritage Register boundary shown in red. Area proposed for grouting shown in yellow (plan prepared by Comber consultants.

Table 1: Areas of archaeological potential (Artefact 2020b:307; Artefact 2020c:147-8; Design 5).

Feature	Archaeological Potential	Significance
Reclamation Fills	Bulk fill materials – high Undocumented industrial and maritime rubbish or equipment - low	Local Local to State depending on the nature of the individual items.
First White Bay Hotel and associated structures	Low	Local
Timber Yard	Low	Nil
Rubble Ballast Dyke	Moderate	Local
Roundhouse, turntable and locomotive siding	Moderate	Local
Railway Infrastructure	High	Nil
Loading and Ash Handling Facilities of the White Bay Power Station	Low	Local

No. 9 Shed	Low	Nil
US Army Warehouses and RAAF Mess Hall	Low	Local
Circulating Water Conduit	High	State
Beattie Street Stormwater Canal	High	Local
Balmain Coal Loader	Moderate	Nil

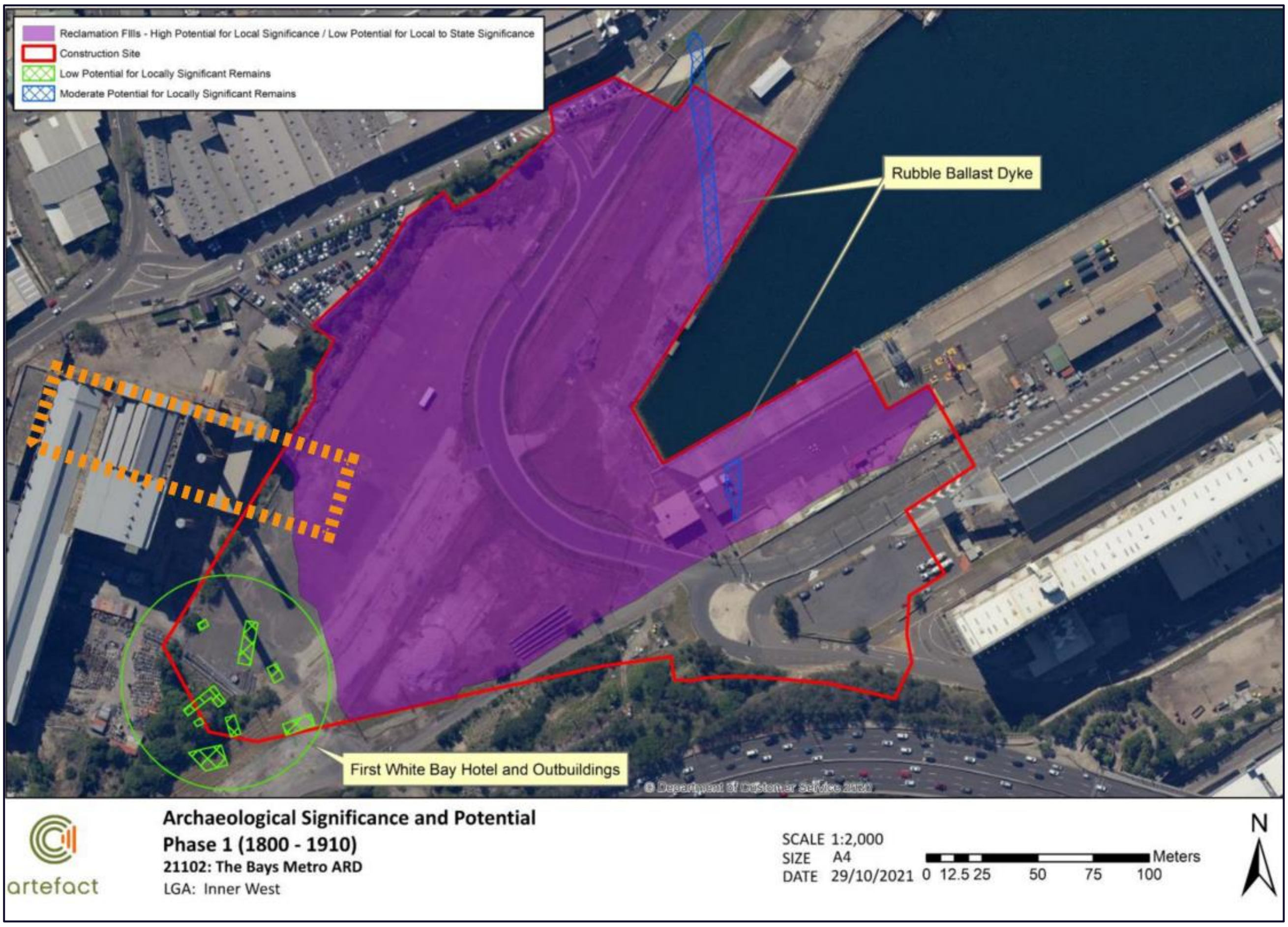

Figure 4: Showing area of reclaimed land (purple) with the boundary of the proposed grouting plan shown by orange dashed line. The reclaimed land contains low-high archaeological potential of local to State significance.

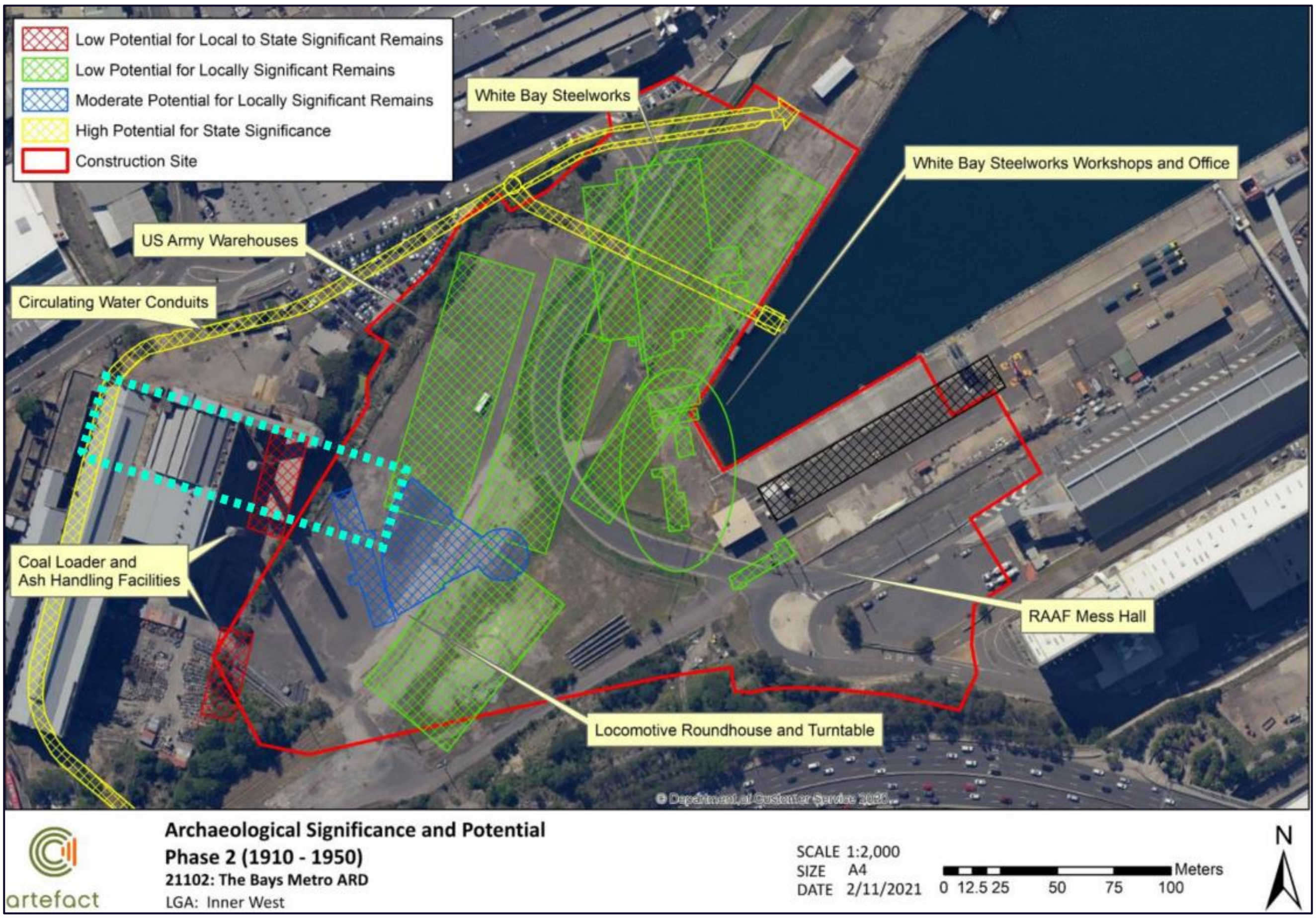

Figure 5: Showing areas of archaeological potential with an overlay of the grouting plan shown by light blue dashed line. Dark blue hatching indicates area of moderate archaeological potential of local significance. Red hatched area indicates low archaeological potential for local to State significant relics.

2.3. Built Environment

As detailed in section 1.2 of this report the White Bay Power Station is of State significance and is listed on the State Heritage Register, the Sydney Regional Environmental Plan, the Register of the National Estate and the Register of the National Trust. It contains internal and external structures and features, as described in section 1.2 of this report, related to the operation of the Power Station which are of State significance. A full description of the Power Station, fabric analyses and significance assessment is contained in the Conservation Management Plan (Design 5:2011, revised 2013).

The grouting plan includes the drilling of cores approximately 70-90mm within the hard surfaces surrounding buildings and within the concrete floor of the boiler house and coal loading facility The majority of the works will be undertaken in the open space surrounding the buildings. However, drilling in respect of the grouting will occur within the southern section of the boiler house and the coal handling facilities (Photographs 1 and 2). Figure 3 shows the State Heritage Register boundary and the location of the grouting program.

Appendix B contains full details of the proposed works. The impact to the fabric of the White Bay Power Station will be to the hard surfaces in and around the boiler house and coal handling facilities (Figures 1 and 2). The concrete surfaces are not given a specific level of significance within the CMP. They are described as part of the boiler house and coal handling facilities which have been given an overall level of significance.

The floor within the boiler house is concrete with some patches and divots. The level of significance of the boiler house has been graded as 1-2, depending on the room or section of the boiler house.

The floor within the coal handling facility is concrete with a rail line in the middle of the northern end on the ground floor. The coal handling facility has been graded as Level 2.

The grading of significance for each space according to historic, technical, aesthetic and social values is detailed below. The following is taken directly from the CMP (Design 5, Volume 2:84-86).

1. *Exceptional*
These spaces, structures or elements are of exceptional cultural significance for at least three of the four categories of historical, technical, aesthetic or social values or they contain significant machinery/plant. They play a crucial role in supporting the significance of the place.

2: *High*
These spaces, structures or elements are of high cultural significance but slightly less than those in grade 1. They retain exceptional level rankings (1) for no more than two of the four categories of historical, technical, aesthetic or social values or have high level rankings (2) for at least two of these categories. They may also retain significant machinery elements. They play an important role in strengthening and supporting the significance of the place, but less than that for grade 1.

3. *Moderate*
These spaces, structures or elements retain a moderate level of cultural significance. They retain moderate level rankings (3) for at least three of the four categories of historical, technical, aesthetic or social values. They play a moderate role in supporting the significance of the place.

4. *Little/Neutral*
These spaces, structures or elements are of minor cultural significance. They retain minor level rankings (4) for at least three of the four categories of historical, technical, aesthetic or social values. They play a minor role in supporting the significance of the place.

5. *None*
These spaces, structures or elements retain level 5 rankings for at least three of the four categories of historical, technical, aesthetic or social values and may in fact be intrusive or damaging to the cultural significance of the place. They are of no significant value and may obscure rather than support the significance of the place.

Photograph 1: Boiler House from the south east (Design 5:2011 Vol.2:19)

Figure 2: Coal handling plant from the north (Design 5:2011 Vol.2:19)

2.4. Impacts

Archaeology
The TBM tunnel drives extend some 130m out from The Bays Station box (which is outside the curtilage) and extend beneath the former White Bay Power Station. The tunnel drives in this area have limited rock cover and underlie some 20m of saturated alluvial soils (16-18m deep) and fill (2-4m depth) material. As the works will be undertaken in an area assessed as containing archaeological potential, it is possible that these alluvial soils/sands and fill material may contain Aboriginal objects and historic relics. However, these alluvial traces may be *relatively thin or non-existent due to previous fluvial and marine erosion or removal through sandstone quarrying in the early 1920s* (Jacobs 2021).

Once the hole is drilled for the grouting, it will be cleared out with air or by pumping out the water so the influx of water pulls the fines into the hole where they can be removed. This may bring Aboriginal objects or historic relics to the surface.

Built Environment
The grouting design requires that, in Areas 1, 2 and 3, there will be drilling and pumping in the open space around buildings, as well as some internal drilling and grouting within area 4, the boiler house. The act of drilling – even small diameter holes of 70-90mm diameter, especially within area 4,the boiler house will inevitably penetrate and disturb the ground floor slab. This effect will be exacerbated where the holes are not vertical, but slanted to allow angled grouting. Mitigation will be replacement of cores and their grouting in place. However unless the replacement is carefully undertaken (see mitigation section of this report) it is possible that they will be visible on the surface of the slab.

The drawdown attributed to tunnel inflows can lead to settlement of the overlying alluvial soils. Even with grouting, it is anticipated *some amount of groundwater will flow from the rock into the open tunnel heading* (Jacobs 2021) and the station box.

The idealised grid pattern for drilling of both vertical and angled grouting has some leeway (up to 0.5m) however the layout is relatively fixed and drilling will proceed via an 'observational method' from primary to quinary locations.

Of the four Areas, area 4 within the southern portion of the boiler house is the most likely to encounter unexpected drilling resistance due to unseen footings, plumbing, conduits and structures. As described in Volume 3 of the CMP and the attached grouting plan, this is due to the boiler house substructure containing a web of infrastructure beneath it.

The grout mix comprises either OPC or UFC cement and water with super plasticiser and/or emulsion and since this is a water borne process there is the risk spillage. As a direct result of the drilling or grouting, there is an increased chance of slurry, blowouts and waste that will disfigure either the internal or external floor surface particularly in area 3.

Summary
In summary, the area of the proposed works is within a small portion of the State Heritage Register boundary and within an area of low-high archaeological potential of local or state significance (areas 1-4). The fabric to be disturbed will be the hard surfaces surrounding the buildings and the concrete floors within the boiler house and coal loading facilities. Although the cement floors and hard surfaces have not been graded individually, the boiler house and coal loading facilities have been graded as high. Apart from the hard surfaces, no other fabric or building will be directly impacted upon by the proposed grouting plan.

In accordance with the Heritage NSW Material Threshold Policy the impact to fabric will have a moderate adverse impact to the State heritage significance of the White Bay Power Station. However, once the mitigation measures detailed in this report are undertaken the impact will be reduced to a minor adverse impact to State heritage significance.

3 MITIGATION AND RECOMMENDATIONS

3.1. Mitigation

The proposed grouting works include the boring of holes and subsequent grouting in the concrete floor or paved parts of various areas. Mitigation measures , such as sandbag berming of the immediate area, soaking up spillage and slurry, ponding of cement bag opening, and avoiding contamination of pristine industrial surfaces will avoid most of the more severe effects, as detailed in recommendation 3.

The proposed works have a very low potential to impact upon Aboriginal objects, historic relics or structures and once the following recommendations are undertaken will have a minor adverse impact on the State significance of the White Bay Power Station. Mitigation measures, as recommended below, will minimise the potential for damage or harm by ensuring that machinery is appropriately located, that archaeological monitoring is undertaken and any removed or damaged fabric is reinstated. Therefore, the proposed grouting program can be undertaken under the project Construction Environmental Management Plan.

3.2. Recommendations

1. No building fabric should be modified by the grouting program except where boring is proposed to the ground floor slab within the boiler house or any other building. This is to ensure impact to significant fabric is avoided. The concrete for the bore hole can be removed but the area must be recorded prior to removal of the concrete. Any floor markings, fabric etc., likely to be disturbed, defaced or penetrated must be recorded and described.

2. The removal of concrete surfaces should not be undertaken with a jackhammer or similar high-vibration tool should the concrete prove difficult to remove by core drilling. If the core drilling is not be successful, rotational saw-cutters should be used to cut the concrete.

3. Prior to drilling, the ground around the bore hole should be bunded to prevent surface water run-off into the surrounding area and the area protected from splash, and to prevent uncontrolled damage to the floor of the boiler house.

4. All grout holes within the White Bay Power Station are to be surveyed and then pre-cored. If a timber pile or other subsurface feature is identified during the course of either the survey or the coring activity then the drilling must be stopped and the hole relocated. The cored hole should then be reinstated as detailed below. The fabric or features identified should be recorded.

5. As the area of the proposed works have low-high potential to impact archaeological relics of local or State significance archaeological monitoring should be undertaken during the boring for the grouting program. If any relics are uncovered or brought to the surface during the drilling, all work must cease in the vicinity of that relic and sufficient time provided to the archaeologist to record the location and context (where possible) of that relic.

6. Prior to the commencement of works and after the completion of the concrete bore hole reinstatement, the area where works are proposed should be archivally recorded in accordance with Heritage NSW guidelines 'How to Prepare Archival Records of Heritage Items' and 'Photographic Recording of Heritage Items Using Film or Digital Capture'.

7. Concrete that is removed should be reinstated and made good following the works. Cement used to reinstate the removed concrete should be applied in a concealed manner and should be colour matched and all attempts made to minimise any visual impacts from the reinstatement.

8. Should removed concrete not be fit for reinstatement, the replaced cement must be colour matched and blend as closely as possible to the original flooring to minimise visual impact. The use of replacement concrete/cement must be recorded in the archival record prepared for the works.

9. Permanent markers such as spray paint or similar should not be used to mark any building fabric including the concrete to be removed and reinstated. Should marking be required for survey and control purposes, these must be applied with removable materials and be completely reversible. The removal of such markings must be completed immediately at the completion of the drilling in each location.

10. The smallest possible drill rig should be used inside the Power Station to minimise impact to the heritage fabric. No fabric or moveable heritage should be moved or relocated to allow the machine to enter the boiler house or any other building or structure.

11. Non-destructive digging machinery such as vacuum suction trucks should not enter any structure. They should be parked outside the building and hoses etc., fed into the building from outside without moving or impacting upon any significant heritage fabric.

REFERENCES

Acciona Ferrovial Joint Venture. 2021. Heritage Management Plan, Sydney Metro West – Central Tunnelling Package

Artefact. 2020a. Sydney Metro West, Stage 1 Aboriginal Cultural Heritage Assessment Report.

Artefact. 2020b. Sydney Metro West, Technical Paper 3, Non-Aboriginal Heritage Report

Artefact. 2020c. Sydney West Metro, ARDEM for the Bays Construction Site.

Design 5 Architects Pty Ltd. 2011. White Bay Power Station, Conservation management Plan, Volumes 1-5.

Jacobs/Arcadis. 2020. Sydney Metro West Environmental Impact Station, Westmead to The Bays and Sydney CBD.

Jacobs TYPSA. 2021. White Bay Power Station Grouting Design Cover Memo.

APPENDIX A: CVS

COMBER
CONSULTANTS

ARCHAEOLOGY - HERITAGE - MEDIATION - ARBITRATION
ABORIGINAL - HISTORIC - MARITIME

Dr Jillian Comber

- Archaeologist/Heritage Consultant
- Adjunct Research Fellow, Flinders University
- Guest Lecturer, Sydney and Flinders Universities
- Justice of the Peace
- Educator

Qualifications

- BA, (Archaeology/ Anthropology
- Litt.B (Aboriginal & Historical Archaeology)
- PhD: *Heritage In The Context Of Dispossession. An analysis of applied Aboriginal cultural heritage, legislation and policy in rural New South Wales*
- Conservation of Traditional Buildings
- Practitioners Certificate in Mediation and Conciliation
- Professional Certificate in Arbitration
- Cert IV TAE

Memberships

- Australian Association of Consulting Archaeologists, Full Member
- Australian Archaeological Association
- Australasian Society of Historical Archaeology
- International Council on Monuments and Sites, Full Member
- Australasian Institute of Maritime Archaeology
- NSW Justices Association
- Australian Institute of Training & Development

Summary

Jillian Comber, the Director of Comber Consultants has over 30 years' experience in Aboriginal and non-Aboriginal archaeology and cultural heritage management. She is experienced at survey, assessment, monitoring, testing and excavation. She has extensive skills in significance assessment and report writing and can provide the cultural heritage component for conservation management plans, REF's and other planning documents. She has a sound understanding of NSW's planning legislation, policies and procedures.

Jillian has extensive experience in the management of Aboriginal archaeological sites and places. She can provide advice on appropriate management strategies all formulated within best practice management and in accordance with Heritage NSW's guidelines/requirements and in association with the relevant Aboriginal community. She has extensive experience in Aboriginal consultation and has formed sound working relationships with Aboriginal organisations throughout NSW. She is a qualified mediator with experience in Native Title and cultural heritage mediation. In addition, Jillian has extensive experience in the management of non-Aboriginal heritage and archaeological sites and places, including the built environment. She can provide advice on appropriate management strategies all formulated within best practice management and in accordance with Heritage Council requirements. Jillian undertakes assessments, monitoring and excavation of a broad range of historical archaeological site types and can obtain s140 and s60 permits.

Jillian can provide advice in respect of the built environment, including conservation, adaptive reuse and management. The office of Comber Consultants is located in the historic Waratah House at Croydon. Jillian won a National Trust Heritage Award for the conservation and adaptive reuse of this 1889 building.

Previous Positions

- 2002-2010 Heritage Advisor to Bourke, Cobar, Parkes, Lachlan and Cowra Shire Councils and Wollongong City Council
- 1997-2001 Director, Parramatta Park Trust, NSW and Board member
- Parramatta Park is listed on the State Heritage Register and inscribed on the World Heritage List
- 1994-1997 Regional Manager, Cultural Heritage, Depart Environment & Heritage, FNQ
- 1992-1994 Cultural Heritage Coordinator, NSW NPWS
- 1988-1993 Consultant Archaeologist, NSW & Qld

Appointments:

Jillian has held or continues to hold the following appointments:

- Member, NSW State Design Review Panel.
- Member, Parramatta Light Rail Design Review Panel.
- Member of the Australian Research Council's Engagement and Impact Assessment Panel.
- Australian Research Council's Engagement and Impact Pilot Program
- Member, Waverley City Council's Heritage Review Panel.
- Past member of Marrickville City Council's Heritage Promotions Committee.
- Heritage Council's Archaeological Advisory Panel.
- Member of the Heritage Office's Experts Workshop in respect of the review of the *Heritage Act 1977.*
- Previous Lecturer in Aboriginal Cultural Heritage Management at Canberra University

Awards

- Jillian was presented with an Australia Day Award 2014 by Ashfield Council for "outstanding community service".
- Sydney University Archaeological Society's "Golden Trowel" Award.
- National Trust Heritage Award for the conservation and adaptive reuse of "Waratah House".

Permits:

Jillian has held the following permits:

Delegated Powers

Delegated powers from the Heritage Council to Jillian Comber in her role as Director of the State heritage listed and World Heritage inscribed Parramatta Park. In this role Jillian supervised conservation works and archaeological monitoring and excavation at the Dairy Precinct, the second oldest extant building in Australia; at the Macquarie Street Gatehouse and other ongoing projects related to landscaping and park maintenance.

s60 permits (Sites listed on the State Heritage Register)

- Permit to undertake archaeological monitoring at Kenmore Hospital site on behalf of Goulburn-Mulwaree Council.
- Permit to undertake archaeological monitoring and excavation at Googong on behalf of CIC Australia
- Monitoring, excavation and conservation of *Puckeys Saltworks* for Wollongong City Council.
- Permit to undertake archaeological excavations at Newtown Railway Station, on behalf of RailCorp.
- Permit to undertake archaeological monitoring at the Marsden Street Weir and Parramatta Park Weir on behalf of Parramatta City Council.
- Permit to undertake archaeological monitoring and excavation at Mulawa Women's Correctional Facility on behalf of the Department of Commerce.
- Permit to undertake archaeological excavation at Belmore Basin, Wollongong.
- Permit to undertake monitoring and recording at Marrickville Railway Station
- Permit to undertake monitoring and recording at Oatley Railway Station
- Permit to undertake archaeological monitoring and test excavations at Mays Hill, Parramatta Park.

s140 permits

- Permit to undertake archaeological monitoring and testing at Belmore Basin for Wollongong City Council.
- Permit to undertake archaeological monitoring at the Captain Cook Hotel, Botany Bay on behalf of Gale Street Pty Limited.
- Permit to undertake archaeological monitoring at 152-160 Leura Mall for Mr D. Morrison
- Permit to undertake archaeological monitoring and excavation at Brighton Lawn for Wollongong City Council.
- Permit to undertake archaeological monitoring at Wollongong Cemetery for Wollongong City Council.
- Permit to undertake archaeological excavation at 5-7 Charles Street & 116 Macquarie Streets, Parramatta
- Permit to undertake testing and salvage at the Back Creek Mining Settlement, Minmi, NSW.
- Permit to undertake testing at 83 Kent Street, Millers Point.

Exception with monitoring

- Monitoring in association with Endeavour Energy's replacement of Feeder 808 pole on Great Western Highway
- Monitoring of minor works in Parramatta Park.

Major Projects SSI-5100 and SSI-5414 for the North-West Rail Link

Archaeological monitoring and excavations at:

- Castle Hill Station
- Cherrybrook Station
- Kellyville Station
- Showground Station
- Swan Inn (State Significant)

Integrated Management System

Comber Consultants has a certified integrated management system to the requirements of ISO 9001 (quality), ISO 14001 (environmental), OHSAS 18001 (health and safety) and AS/NZS 4801 (health and safety). This is your assurance that Comber Consultants is committed to excellence, quality and best practice and that we are regularly subjected to rigorous, independent assessments to ensure that we comply with stringent Management System Standards.

POC+P
architects

Patrick O'Carrigan FRAIA AIAMA

B.Sc (Arch) B.Arch (Hons 1) [Syd] M.Arch (Penn) PC [Arb] Adel
Registered Architect NSW ARB #5025 Vic #19655

Patrick O'Carrigan is the Managing Director of Patrick O'Carrigan + Partners Pty Ltd [ABN 99 086 693 781], established in 1998 to provide architectural and urban design, heritage conservation advice, local government advice and related project management services. He is qualified as both a Registered architect in NSW and specialist Urban Designer, and is a Fellow of the Royal Australian Institute of Architects. He is recognized as a heritage consultant by the Heritage Office of NSW. In 2010 he gained a Professional Certificate in Arbitration through the University of Adelaide, and in 2011 was made an Associate of the Institute of Arbitrators and Mediators Australia.

Patrick's firm has undertaken over the past 20 years diverse projects for the public and private sectors including numerous heritage assessments, refurbishments, single and multi-unit residential projects, sustainability projects, aged care and pre-school projects, medical suites, commercial/retail outlets, office fitouts, sports facilities, public infrastructure, and urban design master-planning.

Patrick was until 2005 the President of the 26th Board of Architects of NSW, a leadership role he held since 2000. As President, he had recently overseen the introduction of the new Architects Act 2003. He was first elected to the Board of Architects in 1996. He was also the Vice-President of the Architects Accreditation Council of Australia, and has previously served the Council as National Treasurer. In addition to these non-executive directorships, Patrick holds a number of honorary positions. He is a member of: the University of Sydney Alumni Council; a Non-judicial member of the NCAT in NSW; and the ESD Committee of the Royal Australian Institute of Architects.

As a registered architect and project manager, Patrick has over 35 years professional experience in both the private and public sectors in the management of design and construction projects ranging from conservation and adaptive re-use, architectural design and project administration to, more recently, major urban capital works including master-planning and urban design.

Prior to establishing his own firm, Patrick spent five years with the City of Sydney as Manager Urban Architecture – City Projects. This was a critical period in the development of Sydney in the lead up to the 2000 Olympics. Patrick was responsible for the management of over 20 projects and for the development and leadership of a team of 25 professionals. The three principal projects were the Sydney Customs House Project, King George V Recreation Centre and the Ultimo Community Centre Stage II with a combined value of $35M.

Much of Patrick's professional experience has concerned the useful integration of "old with new" including all aspects of conservation under the Burra Charter. Key heritage projects he has worked on include: 150 year old Customs House 1994-9; 120 year old Story of Sydney/100 George Street 1989-91; and 80 year old Pilgrim House 1986.He has undertaken heritage projects for many Councils, John Holland Rail, Depts of Education & Health, and University of Sydney.

Patrick has developed and executed major urban design projects in South East Asia and Australia, and has been responsible for managing major capital works projects. He has undertaken many restorations of terraces in the Rocks,and Dawes Point.

A lecturer in architecture, theory and urban design, Patrick has written extensively on architecture and building design and has received awards for his competition designs in North America and Australia. As a Rotary Foundation Scholar, he has undertaken postgraduate study at the University of Pennsylvania and he was the 1989 recipient of the prestigious Byera Hadley Travelling Scholarship, which he used to research environmental issues (green architecture, ESD, loose-fit/long-life, energy efficiencies) in North America and Europe.

Patrick is married with three daughters. His interests include travel, drawing/sculpture, bush-walking, history and opal-mining.

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CURRICULUM VITAE

PATRICK O'CARRIGAN FRAIA AIAMA

CURRENT POSITION

Principal Patrick O'Carrigan and Partners Pty Ltd
www.pocparchitects.com.au @pocparchitects

A design company founded in 1998 to provide architectural and urban design, visual studies, heritage conservation advice, local government advice, Interiors and healthcare and related project management services. Completed projects include Dutton Community Centre; Blue Mile Stage 3 Heritage walk; Liverpool Day Surgery Fitout; Healthscope Chemotheraphy + Infusion Centre, Norwest Private; Sydney Bone + Joint Clinic, Campbelltown Private; Specialist Services Fitout, Norwest Vascular; SE Dermatology suite; Data Centre, Sydney Olympic Park; Lawson Heritage Impact + Archival recording; Wallerawang Dual Court Indoor sports stadium, Greenwich Community Pre-School, Hornsby Heritage Study Stage 4; UTS Student Housing at Geegal; Yaralla Cottages Aged Care, Refurbishment; New Strathfield DCP Part A 2008;Balnari Aboriginal Art Gallery fitout; restoration of "Waratah"c.1905, The Priory c. 1888, St Joseph's Presbytery c.1914 and Manooka Valley West subdivision; and numerous residences, alterations and additions.

ACADEMIC QUALIFICATIONS

2010	Professional Certificate in Arbitration [General + Professional] University of Adelaide
2005	Expert Evidence Certificate, Australian Property Council
1985	Master of Architecture, University of Pennsylvania, USA
1979	Bachelor of Architecture (Hons I) University of Sydney
1978	Bachelor of Science (Architecture) University of Sydney

PROFESSIONAL QUALIFICATIONS

1983	Associate, Royal Australian Institute of Architects
1996	Fellow of Royal Australian Institute of Architects
1986	Nominated Architect # 5025 NSW Architects Registration Board, and 2018- Victorian ARB #19655
2005	Professional Certificate in Expert Witness + Evidence, API
2010	Associate, Institute of Arbitrators Mediators Australia [now Resolution Institute]
2012	A+ Practice Member of Australian Institute of Architects # E1903
2018	Register of Architects, # 19655 Architects Registration Board of Victoria

HONORARY POSITIONS

2018-23	Panel Member Pool, Local Planning Panels, NSW Dept Planning & Environment
2014-23	Senior Member, NSW Civil & Administrative Tribunal –Consumer Division -Home Building, Conclaves
2014-23	Senior Member, NCAT - Occupation Division
2013-15	Chair of Assessment Panel & author of NPrA 21 Brief, Architect's Accreditation Board of Australia
2009-13	Expert Urban Design Member, Development Review Panel, Warringah Council
2008-12	Lay Member, St Vincents Human Ethics Review Committee
2005-13	Non-judicial Member, Administrative Decisions Tribunal of NSW
2011-14	Assessor, National program of Assessment 17 & 20 Architect's Accreditation Board of Australia
2005-	Member, Pre-migration Review Panel Architect's Accreditation Board of Australia
2005-7	Monitor, National program of Assessment, Architect's Accreditation Board of Australia
2000-4	President NSW Board of Architects
2000-4	Vice-President and member of Executive Architect's Accreditation Council of Australia
2003	Member, Professional Advisory Group Administrative Decisions Tribunal of NSW
1996-0	Elected Member, NSW Board of Architects
1995-8	Committee member, Ecologically Sustainable Design Committee, Royal Australian Institute of Architects (RAIA)
1999	Member of Faculty of Architecture, University of Sydney

SPECIFIC PREVIOUS EXPERIENCE -sample

1999-

Principal, Patrick O'Carrigan + Partners P/L Architects + Urban Designers
Sydney

- Data Centres for Data Exchange Network at DXN-SYD01 Sydney Olympic Park and DXN-MEL01 Fishermans Bend, Melbourne 2017-19
- Façade restoration, new awing, signage, colour schemes for Unilodge [Former Grace Bros, Broadway building 2017-20]
- New PV solar installation at Torin Building Penrith, a State Heritage, for Origin Energy 2018-20
- New Roof and Mechanical installations, North Bondi RSL for Tobruk House Trustees, 2019-
- Heritage Assessments , Griffith Base Hospital for NSW Department of Health 2019-20
- Heritage Assessments & Archival recording, Westmead Catholic Community 2020
- Heritage Assessment Masterplan Review, Bobbin Head for NPWS, 2020
- New Orthopaedics Surgery, South West Sydney Private Hospital for Dr Dave 2018-19
- Boarding house renovations and restoration, St Johns Rd Glebe for Horn Family , 2016-19
- Refurbishment and Additions to Outback Division of General Practice premises, Bourke 2017-
- Refurbishment and Interior design for Pears & Co, Accountants, Parramatta 2017
- Tramway and Stanwell park Café 3-D photomontages for Wollongong Council, 2016-17
- Various heritage conservation projects for John Holland Rail at Bundanoon and Woodstock, 2015
- Former NSW Savings Bank, 327 King St Newtown conversion to Medical Centre, 2015 – Research, Archival, Heritage advice;
- Several State Heritage Property Restorations, Alterations and Additions at Millers Point 2015- for private clients;
- Bald Hill, Stanwell Park- Visual Impact Studies for Wollongong City Council 2014;Belmore Basin Tourism and Maritime Centre Feasibilty, for Lake Illawarra Authority, NSW Department of Lands, DPI 2012-13;
- Grand Pacific Walk Envisioning and Urban Design Masterplanning for the Wollongong City Council, 2013;
- Urban design for Blue Mile Stage Heritage Walk Stage 3: Staithe Viewing Deck and Harbour Staircase, Belmore Basin, for Wollongong City Council, 2012;

- Dutton Community Centre, South Strathfield for Meals on Wheels, and Inner West Community Transport 2011-12;
- Assessment of re-development potential 2011 for Heathcote Hall and 16 hectare site, East Heathcote for aged care development;
- Assessment + research 2010 Villawood Detention Centre in regard re-development and Commonwealth/State heritage items including initiatives for re-location, integration with new architecture, Preparation of Heritage Assessment and Statement of Heritage Impacts 2011 for Hansen Yuncken;
- Review [later 2006] then preparation [mid 2007] of a new Part A: Single Residential Development Code for Strathfield Municipal Council – see http://www.strathfield.nsw.gov.au/page/planning-and-development/controls-and-policies/strathfield-development-control-plan---dcp--2005/ This DCP has been praised for its clarity, visualisation and quality of illustrations and guidelines;
- Masterplanning of St Joseph's Parish complex, Enfield 2010-11 leading to refurbishment projects of Presbytery construction 2012;
- Masterplanning, social impacts studies followed by Refurbishment of Yaralla Cottages, Concord for Perpetual Trustees including new construction works, 2008-11;
- Visual Impacts study 2009 of new SWRL proposed for private site in Edmondsen Park leading to expert opinion for just compensation, private owner;
- Manyana, South Coast, NSW Visual Impact Study [2007] Assessment and draft Development guidelines;
- Design of sound wall in Galong NSW – public presentation on the design and treatment 2009;
- Urban design improvements, Markettown, Wetherill Park Shopping Centre 2005
- Expert Report- Visual Impacts of SWRL on private land, Edmondsen.

- Development guidelines for sub-divisions in sensitive sites inland at Currans Hill and by the beach at Bonny Hills, North Coast 2005-7;
- Expert reports concerning visual impact of a proposed new Services apartment hotel complex and heritage view guidelines in relation to the Georgian church, St Thomas', Port Macquarie 2006;
- Lawson Town Centre Statement of Heritage Impact, Blue Mountains City Council 2007-08;
- Lawson Archaeology (with Comber Consultants) + Archival Recording + Interpretation Plan for BMCC 2007-09;
- Medical fitout, Liverpool Day Care Centre, Chipping Norton
- Medical suites at Campbelltown Private: Sydney Bone and Joint clinic, Worker Rehabilitation Services and Re-training Centre; Healthscope, Sydney Psychological Medicine
- Medical suites at Norwest Private: Norwest Vascular; Specialist services; Chemotherapy and Infusion Centre;
- The Atrium Psychotherapy Suite, Bondi Junction
- Proposed Roof-top Modular Gym and Staff facilities, MWU, Sussex St, Sydney
- Expert evidence for heritage properties, visual studies and urban design issues
- Numerous residences, adaptive re-use and alterations and additions.
- Pre-purchase and post purchase assessments, building assessments, remedial and refurbishment proposals.

PREVIOUS EXPERIENCE

1993-1998 Manager, Urban Architectural Projects, CITY PROJECTS
City of Sydney

The management of a range of architectural, urban design and landscape commissions for the City of Sydney in preparation for the Sydney 2000 Olympics. Responsible for growing and leading a team of 25 in the management and delivery of 20 separate projects including the Sydney Customs House Project ($26m in total) and Customs Square, the Ultimo Community Centre Stage II ($12m in total), and King George V Recreation centre, The Rocks; community facilities, streetscape works, Installation of Olympic Flag, Sydney Town Hall.

1986-1995 Member of the RAIA Editorial Committee for *Architectural Bulletin*
1998-2000 Member of RAIA Environmental Sustainability Committee

1988-1993 Associate, Conybeare Morrison & Partners
Architects, Landscape architects & Planners, Sydney

Responsible for managing capital works with budgets ranging from $7m to $120m. Major achievements include the master plans and architecture for the Darling Walk Urban Entertainment Centre, the Sydney Showgrounds RAS Relocation Study and Conservation Plan.

Management of projects for clients as diverse as the NSW State Government (PWD, CWDC, DOH, PSG), the SEDC (Sarawak Economic Development Corporation), the Heritage Council of NSW and National Trust; and Local Government Authorities (Liverpool, North Sydney, South Sydney, Mosman, Byron Bay, Hornsby, Shellharbour & Campbelltown), the Sydney Cove Authority and Darling Harbour Authority. Completed projects and reports included those for private sector groups (CRI, Civil & Civic, McNamaras, Merlin, Ipoh Garden, Kajima)

Darling Walk, Darling Harbour
Pyrmont-Ultimo Planning Studies
Jindamar House, Narooma

1989-1991 Post-graduate research and travel, Byera Hadley Travelling Scholarship
(awarded by Board of Architects)

Development and management of research project on environmental issues (green architecture, ESD, loose-fit/long-life, energy efficiencies) and an examination of the challenges & responses of architects in North America and Europe to these issues.

1985-1988	Design Architect + Project Administrator, McConnel Smith and Johnson, School of Military Engineering, Casula1987-88 Victorian State Library Museum Competition, Melbourne 1986 Water Board Reception & Cashiers Centre, Bathurst St HQ 1987
1985	Editorial Consultant for NSW for *Architecture Australia*
1984-5	Undertook Master of Architecture, University of Pennsylvania, in Philadelphia USA
1983-1984	Project Architect, Allen Jack + Cottier Pty Ltd Administration Block, Australian Institute of Architects, Canberra Moss Vale TAFE, Stage 3
1982-1983	Project Architect, Hassell & Partners, Sydney Texas Instruments Offices, Talavera Rd, Macquarie Park
1981-1982	Graduate Architect, Clive Lucas & Partners and Fisher Hudson Architects Harrodene, Former King's School, Parramatta Boree Cabonne, Canowindra
1978-1980	Architectural Assistant Unsen Kerr Associates, Architects and Cox Tanner, Heritage Architects AMP Offices, Albury for Civil & Civic Head office, Northmead for Coca Cola –Amatil Numerous office- factory units Residential terrace conversions + detailing

COMPETITIONS & AWARDS

2016	Finalist, Think Brick Awards for Queens Park Re-build
2014	Adaptive Re-Use Award, National Trust Conservation Awards for *Waratah House*
2012	Finalist, Think Brick Awards [Horbury Hunt Medal] for Yaralla Cottages, Concord
2012	Finalist, Daegu Gosan Public Library Competition, South Korea
2011	Mia Mia House- Resilient Housing Competition, Brisbane *Second Place, Insurance Council of Australia*
2009	Burton Street Tabernacle Adaptive re-use with GTA, Entrants City of Sydney
2008	43 Dixson Ave Dulwich Hill [c.1935] ESD Alterations + Additions Conservation Area, *Finalist , Marrickville Medal 2008, Marrickville Council Heritage Conservation Awards*
2006	Restoration of Truro [c.1915] + Best New Additions, Strathfield *First Place , Strathfield Council Heritage Conservation Awards*
2006	6 Collingwood St, Woolwich New Alterations and Additions *Finalist, Good Design Awards Hunters Hill Council in Heritage and Conservation*
2003	Refurbishment of 30 Abbotsford Road [c.1908] + Sympathetic New Additions, *First Place, Strathfield Council Heritage Conservation Awards*
2006	Restoration of Glenrock [c.1885] + Best New Additions, Burwood *First Place, Burwood Council Heritage Awards*
2003	Restoration of Waratah [c.1905] + Best New Additions, Strathfield *First Place, Strathfield Council Heritage Awards*
2001	Customs House, Circular Quay Sydney with City Projects + Tonkin Zulaika + JTCW *Commendation, BHP Steel Awards*
2000	Customs House, Circular Quay Sydney with City Projects + Tonkin Zulaika + JTCW *RAIA Merit Awards*
1998	Customs House, Circular Quay Sydney with City Projects +
1999	Tonkin Zulaika + JTCW *"Development of the Year" Property Council of NSW*
1997	Federation Square, Melbourne with Tim Williams, Entrants
1995	Macquarie Street Mall , Liverpool with CMP *Award in excellence in Local Government Engineering*
1994	Pyrmont Point Housing, CWDC with Tim Williams & Anne Peden
1993	St. Thomas Aquinas Church, Blue Mountains *Second Place* in invited competition
1992	Jindamar House, Narooma *First Place in inaugural Tillings Timber Award*
1992	Pilgrim House Restoration, Pitt Street *Commendation in Dulux Colour Awards*
1992	St Johns College Redevelopment, Sydney with Mark Broadley
1990	Urban design for Piazza Nuova, Genoa, Italy, Member CMP Team Showground ideas competition, RAIA - NSW Government, Entrant for CMP
1989	Monier Design Commission, Entrant
1989	Urban Design Competition for Civic, Canberra, ACT, RAIA & NCDC
1987	Taylor Square Urban Design Competition Awarded *commend*, NSW RAIA and Department of Planning Environment
1986	Adelaide 2000: 'A New Vision for the City of Adelaide' Urban Design Competition *Awarded First Place*, City of Adelaide Council and RAIA (SA)
1986	Australia - Japan Culture Centre, Canberra, RAIA and Australia - Japan Foundation
1986	National Army Memorial, Anzac Parade Canberra Awarded *Second Place* in association with Tanner & Knox (Landscape Architects) and Alan Leach-Jones (Artist) for NCDC
1985	'Beaux-Arts Planning Revisited' Design Competition San Francisco Awarded *First Place*, AIA (Student Chapter) & the National Endowment for the Arts
1985	John Stewardson Memorial Competition, Pennsylvania, Invited Entrant
1984	Bicentennial Monument Competition, Sydney
1983	Rotary Ambassadorial Scholar
1980	David Nichol Prize + Leslie Wilkinson Prize, University of Sydney

APPENDIX B: GROUTING PLAN

Jacobs Typsa Joint Venture

Technical Memo

To	Vicky Stavropoulou	Date	13 December 2021
Copies	Colin Parker, Pawel Kozak, Fernando Lopez, Richard Davies	Document ID	SMWSTCTP-AFJ-SWD-TU200-GE-MEM-001014
From	Jack Raymer	Revision	E
Subject	Grouting Design for the White Bay Power Station		

1. Introduction

This technical memorandum provides design information for pre-excavation grouting that is recommended for the TBM tunnel drives extending some 130m out from The Bays Station box and extending beneath the former White Bay Power Station. The tunnel drives in this area have limited rock cover and underlie some 20m of saturated alluvial soils and fill material.

The pre-excavation grouting from the surface is recommended as a means to reduce groundwater inflows to the tunnel excavations and also reduce the risk of flowing sands from the overlying alluvium from entering the tunnel excavations through potential sand filled defects within the rock mass. Most of the surface grouting work area is proposed in open space within the White Bay Power Station heritage area, while some parts of the surface grouting work are proposed for inside the power station buildings. Underground grouting is not expected to be necessary and is regarded as contingency only.

This grouting design report should be read in conjunction with the Geotechnical Interpretative Report and the Groundwater Design Report for The Bays Station. A separate grouting design memorandum has been prepared for the methodology to be employed for any underground pre-excavation grouting.

2. Proposed Tunnel Construction

Twin running tunnels will be mined and constructed beneath the White Bay Power Station. The excavated diameter of each tunnel is anticipated to be 7.01m; the distance between the tunnels is 6.9 m. The excavated invert of the tunnels ranges from RL -26.1 at the Bays Station Box (approximate Ch. 3027) to RL -28.5 at approximate Ch. 3150; the excavated crown ranges from RL -19.1 at the Bays Station Box to RL -21.5 at approximate Ch. 3150.

The tunnels will be constructed using an open-faced, double shielded, TBM with segmental lining erected behind the machine. Groundwater inflows are expected through the tunnel face and tunnel perimeter back to the point where the tail-shield grout is injected. Once the tail-shield grout has been placed, the segmental lining system should control the groundwater inflows.

3. Site Conditions

For the purposes of this design, the site is divided into four areas (Figure 1):

- Area 1 is to the east of the buildings and extends to the Bays Station Box.
- Area 2 is beneath the Coal Handling Facility.
- Area 3 is the "courtyard area" between the Coal Handing Facility and the Boiler House.
- Area 4 is beneath the Boiler house.

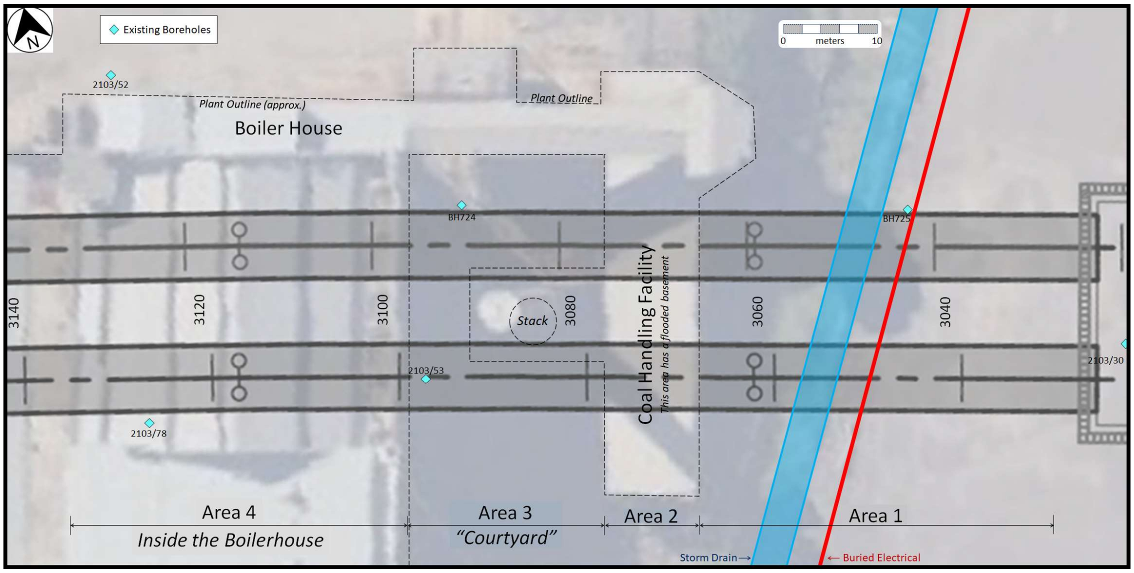


Figure 1: Four Grouting Areas at the White Bay Power Station

3.1. White Bay Power Station

The White Bay Power Station (WBPS) is an historic structure that lies above the tunnel alignment between approximately Ch. 3065 and 3180 (Figure 2). A heritage curtilage has been established around the power station and extends eastward to within several metres from the proposed western end of the Bays Station box.

Careful review of historical information made available to afJV, has indicated the potential existence of buried features (including services and tunnels) under the White Bay Power Station. In addition, it is envisaged that parts of the building are founded on timber piles, the exact locations of which are unknown. It is suggested that these features be investigated prior to the grouting works. The design proposed in subsequent sections of this Memorandum may need to be revised, should the presence of these features be confirmed.

The main concern with these buried features is that they will become obstructions when drilling the grout holes. It should be expected that a few holes will encounter otherwise unknown obstructions. In those cases, the hole should be shifted about 0.5 meters attempted again. However, it should not be acceptable if this were required of many holes or if holes had to be deleted entirely because of obstructions. Deleting holes entirely or too much shifting of holes could cause gaps in the grouting layout and lead to failure to achieve the objectives of the grouting program. Inclined holes have been proposed for certain areas where direct access from vertical holes is not possible.

Figure 2: Northern side of the White Bay Power Station

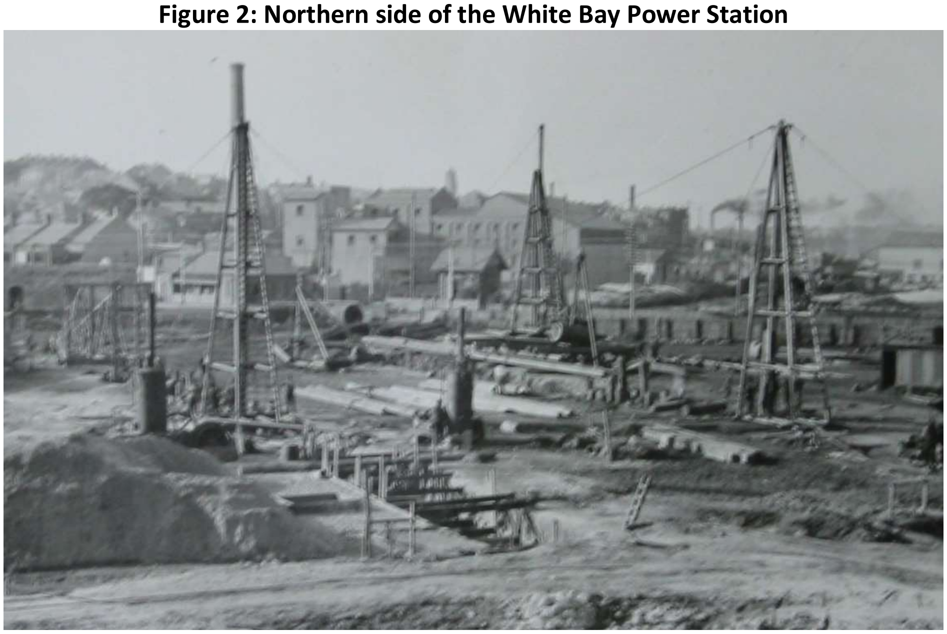


Figure 3: A 1912 photograph of piles being driven for the foundation of the White Bay Power Station

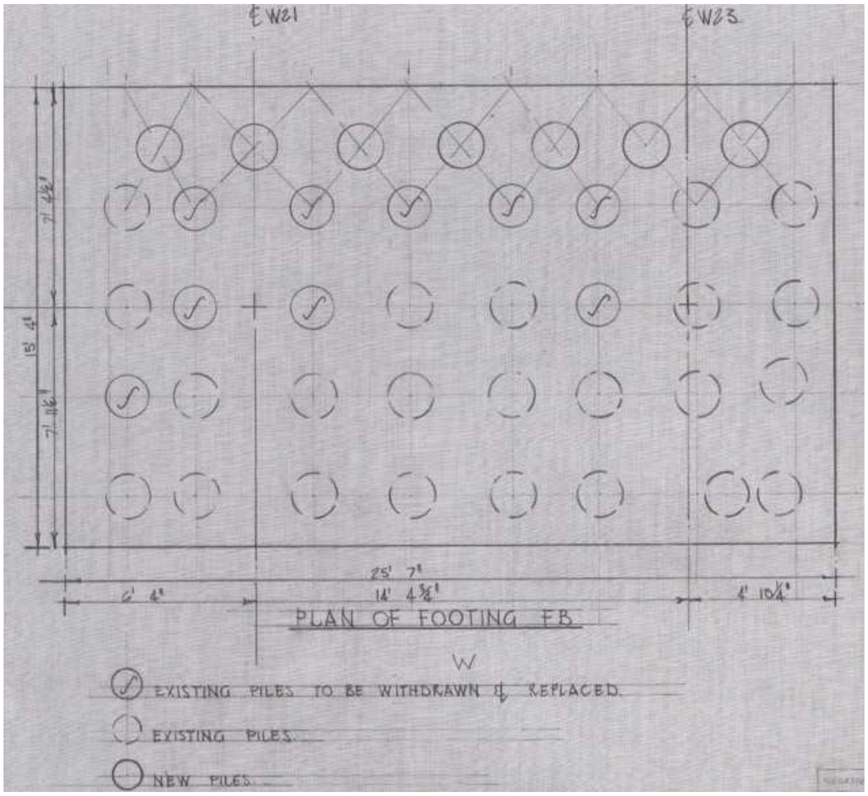


Figure 4: A 1956 Piled foundation layout plan for the Boiler House for the replacement of Boilers 3 & 4 and show replacement of some existing piles and installation of new piles.

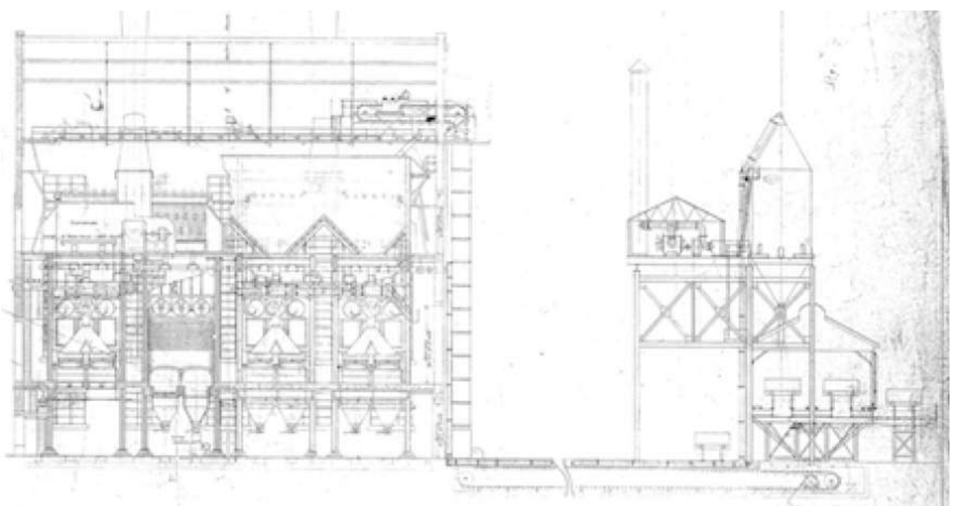


Figure 5: Old drawing showing tunnels in Area 3

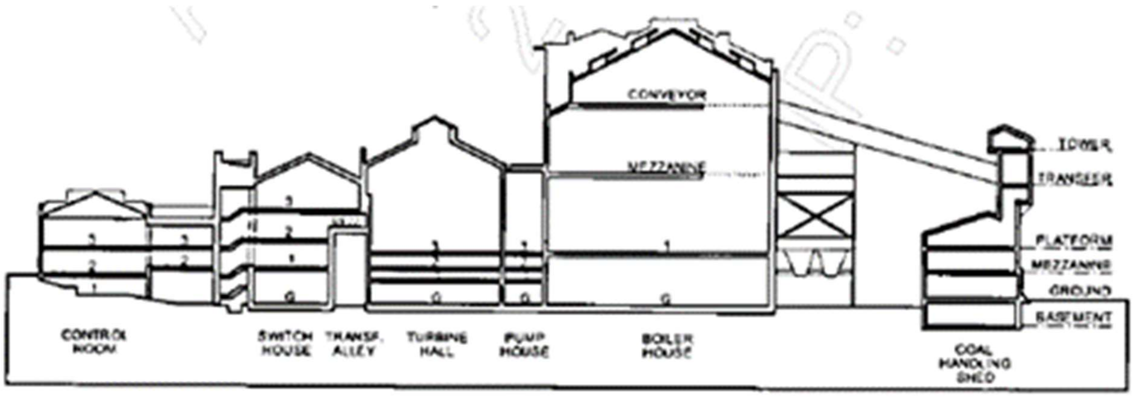


Figure 6: Historic elevation across the White Bay Power Station

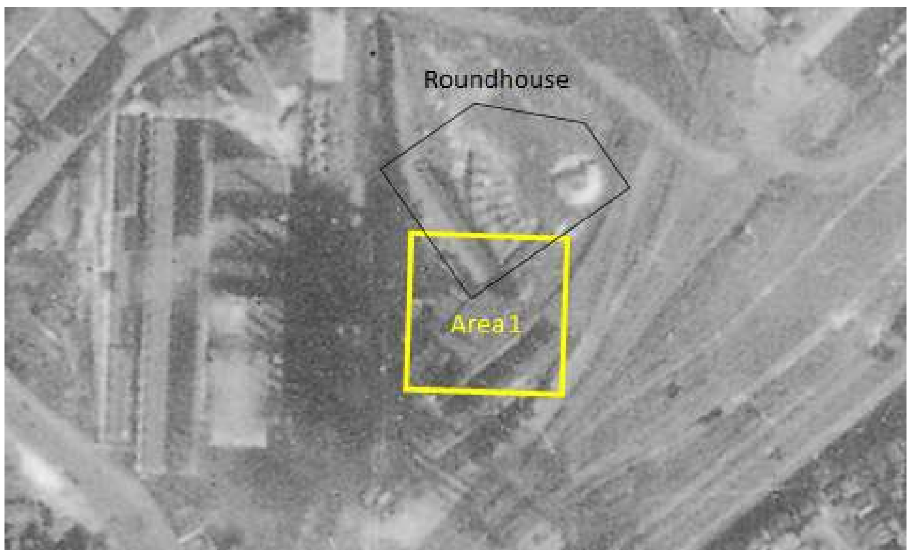


Figure 7: Area 1 in 1942, showing rail yard and roundhouse.

3.2. Subsurface Conditions

Fill and Alluvium

Fill and alluvium overlie the weathered bedrock. The fill is typically 2 to 4 meters thick and is likely to contain debris. The underlying alluvium ranges from about 10 to 18 meters thick and is stratified, with about half the thickness being poorly graded sand and half being silt, clay, or sandy silt. In the vicinity of the Power Station, the lower parts of the alluvium tend to be sandier, and the upper parts tend to be siltier. Horizontal layers of silt and clay could reduce leakage during tunnelling from White Bay down into the bedrock, depending on the continuity of those layers and the amount of clay in them.

Bedrock and Residual Soils

The bedrock is the Hawkesbury Sandstone, which consists of weakly to moderately cemented, fine to medium quartz sand. Overall, the unit is horizontally stratified, but some layers have internal cross stratification. The formation includes some thin layers of black laminite (hard siliceous mudstone) and some conglomerates. The residual soil derived from Hawkesbury Sandstone at the Bays area is relatively thin or non-existent due to previous fluvial and marine erosion or removal through sandstone quarrying in the early 1920s.

The buried bedrock underlaying the power station is assessed to form the side slopes of the White Bay palaeochannel, located some 40m to the north. As a consequence of this former topographic position (prior to alluvial deposition) the sandstone surface probably had small cliffs and ledges leading down to the north, with the rock nearer the cliff lines being more fractured with more open defects.

The boreholes in this area indicate the upper part of the bedrock is more weathered, highly fractured, and structurally weak, which is typical for the top of rock around Sydney. In most areas, the weathered zone is 1 to 2 meters thick, but beneath parts of Area 3, the weathered zone is indicated in borehole SMW_BH724 is about 6 meters thick and the bottom of the weathered zone drops below the spring line of the northern tunnel drive.

Figure 8 shows the core photographs and acoustic televiewer log from borehole SMW_BH724, which is in Area 3 at about Ch. 3094. The colours on the televiewer log indicate the relative strength of the rock: yellow is stronger, fresher, rock and reddish brown is weaker rock. The dark blue areas indicate either open voids or shattered rock. The weaker rock between 18.8m to 25.0m depth constitutes the weathered zone. The weakness of the intact rock is important because the weaker rock typically has many more fractures at different orientations than the fresh rock below, which means that the grouting behaviour of the weathered zone is likely to be different than that of the fresher rock.

Figure 9 shows the estimated thickness of rock cover above the tunnel crowns. The area in orange has less than one-half diameter of rock cover and is of particular concern for open face tunneling, especially considering that the rock cover tends to be weathered (as in Figure 8) and that the soil above the rock cover is unconsolidated, poorly graded sand, under a hydraulic head of about 18 m.

Permeability in the bedrock occurs in two principal modes. The first is in the weathered zone, where the rock tends to be more fractured, and where the fractures occur in many orientations. The second mode is dilated sub-horizontal bedding-planes, which tend to occur in the stronger rock below the weathered zone. These open bedding-planes are assessed to be associated with stress relief of the rock mass due to the proximity of the palaeochannel and can be traced for long-distances from borehole to borehole and along outcrops. Matrix permeability in the Hawkesbury Sandstone is generally negligible.

Figure 8: Core and Acoustic Televiewer Log from SWM_BH724

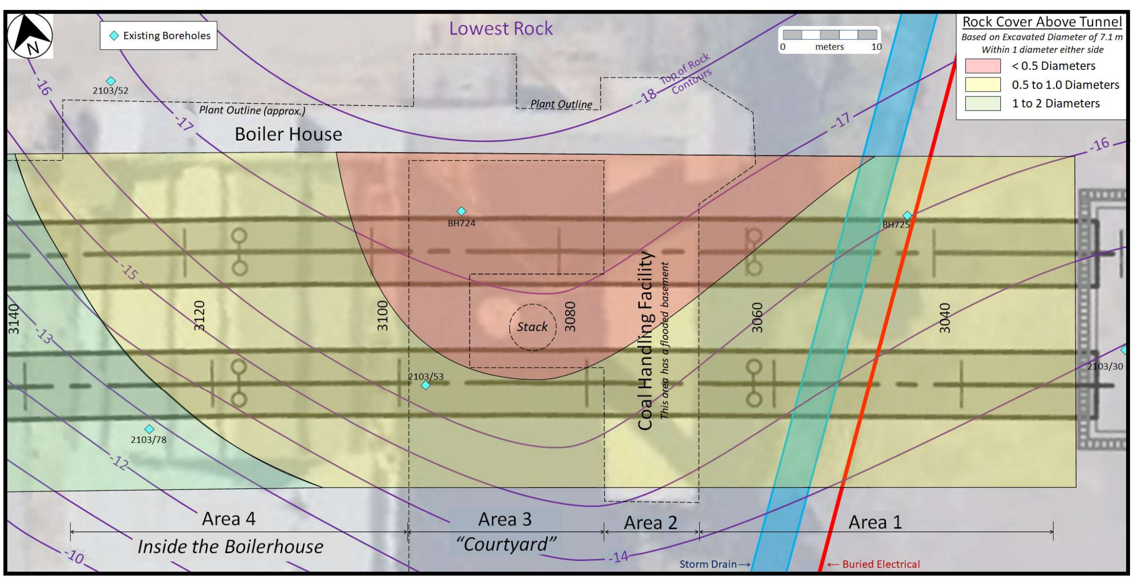


Figure 9: Rock above the tunnel crowns

3.3. Groundwater

The purpose of the grouting is to control groundwater inflows to the TBM drives; no specific inflow limits have been given for the TBM drives prior to permanent lining, but the drawdown attributed to tunnel inflows can lead to settlement of the overlying alluvial soils. Even with grouting, some amount of groundwater will flow from the rock into the open tunnel heading. Drawdown will spread through the rock and the overlying alluvium in proportion to the rate of inflow. It is not possible to create an open excavation below the water table and not create some drawdown, however small. What matters is the amount of drawdown that occurs at some critical distance and depth (to be determined) away from the tunnel. JTJV is providing a separate evaluation that will show the effects of drawdown at different horizontal and vertical distances from the tunnel.

These tunnels will not be left open to drain. The inflows should only occur in the face and shield area for a short time until the tunnel advances (the face and shield area is only a few meters in length.) Segmental lining will be installed at the back of the shield and sealed to the rock with tail-shield grout. As the TBM advances, the area open to inflows will also advance, so that no place under the White Bay Power Station should be open to inflows for more than a few days, based on afJV's prediction of TBM advance rates through the area. This short duration is expected to limit the extent of drawdown, especially through the grouted rock mass. This is an important consideration in selecting the appropriate grouting strategy.

As noted in the Hydrogeological Design Report (The Bays Retaining Wall Secant Piled Wall – Design Stage 2), the advancing TBM is predicted to induce some groundwater level drawdown, but as the TBMs continue to advance (with undrained tunnel behind them), the groundwater level is predicted to recover behind them. Predicted groundwater level drawdown is induced at the location where the TBMs lie stationary, and this drawdown is at a maximum at cessation of the second TBM's stationary period (March 2023). Groundwater levels are predicted to recover at this location from when the second TBM continues mining, and by the end of CTP works (December 2024), there is negligible residual drawdown due to drainage during the TBMs' stationary period (note that there remains some drawdown predicted at this location due to the station box excavation).

Another concern is that large inflows through the weathered zone could lead to piping, which could wash fines into the heading. If the piping is severe enough, it could progress up into the alluvium, resulting in flowing sands into the heading. This is another important consideration in selecting the appropriate grouting strategy.

4. Grouting Strategy

4.1. General

The grouting strategy is intended to limit groundwater inflows into the TBM headings. The work will be done entirely from the surface unless it is determined, at a later time, that contingency underground grouting from the TBM is also needed.

This grouting work is intended to accomplish two things:

1. To fill the dilated bedding planes in the fresh rock in order to limit the main source of flows from the fresh rock into to the tunnel headings;
2. To fill and stabilize the numerous smaller fractures and shatter zones in the weathered rock zone, in order to limit flows into the heading and to reduce the potential for alluvial sand and fines to flow into the heading.

Many drilling obstructions are anticipated in various parts of the WBPS area. The grouting strategy is intended to mitigate this difficult situation to the extent practical, given the limited information available. The first contingency plan is to shift holes around based on what is learned while doing the work. The second contingency plan is to grout from the TBM. This second contingency plan is undesirable, due to the very significant impact such work typically has on the construction schedule, and therefore every effort should be carried out to provide a comprehensive grouting program from the surface.

Rock-mass grouting in general, and this work in particular, should use the observational method to continually adjust and improve the performance as the work progresses. Grouting is as much investigation as it is construction, especially on a site as complicated as the White Bay Power Station. No amount of site investigation, short of test grouting, can show how the rock mass will respond to grout injections. And even if test grouting were performed, the conditions on a site this large would probably change considerably from one place to the next. The grouting strategy described below is based on the assumption that the observational method will be used throughout the work and that adjustments will be made to the program by the grouting team, as deemed appropriate.

4.2. Hole Order and General Pattern

The grouting holes are designated as primary (P), secondary (S), and tertiary (T); quaternary (Q) and quinary (X) may be added into the pattern as needed based on observations during the grouting. The primary holes should be drilled and grouted first, followed by the secondary holes, and so on. If one part of the site needs to be completed before starting in another part, then Q holes can be drilled and grouted within areas where all the T holes have been drilled and grouted, and T holes can be drilled and grouted within areas where all the S holes have been drilled and grouted, and S holes can be drilled and grouted within areas where all the P holes have been drilled and grouted.

Figure 10 shows the ideal hole pattern. The rows are oriented parallel to the tunnel drive. The primaries are 16m apart and the tertiary-level spacing is 4m. Diagonally, the secondaries and tertiaries are 5.6m apart and the primaries are 11.2m apart. This idealized pattern is adjusted locally to accommodate obstructions or other limitations.

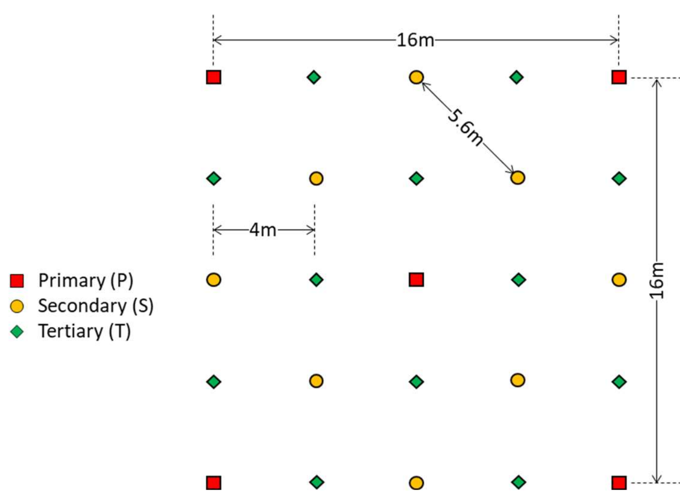


Figure 10: Idealized Hole Pattern for Rock Grouting

4.3. Hole Layout

Figure 11 shows the proposed layout for the surface grouting at the White Bay Power Station. The layout is complex in order to work within the specific constraints of each of the four areas. Inclined holes will be used as needed to reach the target areas while avoiding buried and surficial obstructions and restrictions.

- **Area 1** is located in the open area between the Coal Handling Facility and the Bays Station Box. Two underground services have been identified crossing the area: (a) a large, buried storm drain; and (b) an underground electrical service. In general, the hole pattern is expected to follow the ideal pattern shown in Figure 10, with a few slightly inclined holes and a few slightly shifted holes to avoid the services. If the roundhouse foundations (Figure 7) are encountered, then they can be drilled through using a down-hole hammer.
- **Area 2** is beneath the Coal Handling Facility. This area will be reached by inclined holes collared in Area 1 or Area 3. The efficient use of inclined holes in Area 2 is based on the assumption that the Coal Handling Facility is founded on its basement and not on a network of deep timber piles.
- **Area 3** lies between the Coal Handling Facility and the Boiler House. This "courtyard area" is open to the sky but the underground conditions are poorly understood. The large smokestack in Area 3 also limits access, which will be addressed using inclined holes. Further investigations are suggested to understand what and where the potential obstructions are, because Area 3 appears to be the area most in need of grouting and because the inclined holes targeted for Area 2 and Area 4 are to be collared in Area 3. At this point, the hole and collar locations in Area 3 can only be considered conceptual.
- **Area 4** is inside the Boiler House. There is sufficient room in the Boiler House for a small drilling rig, but there are numerous surface and subsurface obstructions that will limit where holes can be drilled (Figures 12 and 13). The most significant obstructions are the timber piles. These piles are most likely overlain by thick concrete pile caps and plinths. If a hole is located where a pile cap or plinth can be recognized in the floor, then the hole should be shifted. If extra thick concrete is encountered, then the hole is probably on a pile cap, and the hole should be shifted. The ground-penetrating radar (or similar) may be of some value for locating the pile caps and should at least be attempted, though GPR performs poorly through reinforced concrete slabs. It is anticipated that the primary holes will be drilled in Area 4, and hopefully the secondary holes. Only a few tertiary holes have been proposed to be drilled in Area 4 because of the anticipated obstructions and restrictions in Area 4, and because the rock cover becomes thicker and appears to improve moving from east to west through Area 4. If the tunnel grades are steepened, then these conditions would be expected to improve even more.

4.4. Conceptual Sections and Profiles

Figure 14 shows the lines of eight sections and profiles through the grouting area. Figures 15 and 16 are profiles parallel to the tunnel alignments and Figures 17 through 20 are sections across the grouting area at different approximate chainages. These figures are all at the same scale horizontally and vertically of approximately 1:500.

The holes shown on these profiles are conceptual and based on Figure 11. The designed hole locations will be shown on a drawing, depths, coordinates, orientations, and inclinations, as appropriate.

Each profile or section shows the tunnel and also dashed lines one diameter above and one diameter below the tunnel that represents the Grouting Box. In order to extend grout holes to the base of the Grouting Box, the grout holes need to be extended to RL-35m. This depth may be reduced for selected S, T and Q holes as the grouting progresses. In addition, should the tunnel grade be increased beneath the power station, the Grouting Box will need to be deepened accordingly.

Each profile or section shows the alluvium, the top of rock, the weathered zone, and the fresh sandstone. These layers are based on the information available to date; and are likely to change as more information comes available with the proposed site investigations at the power station. These layers are generalized and do not show individual layers or lithologies within the generalized layers.

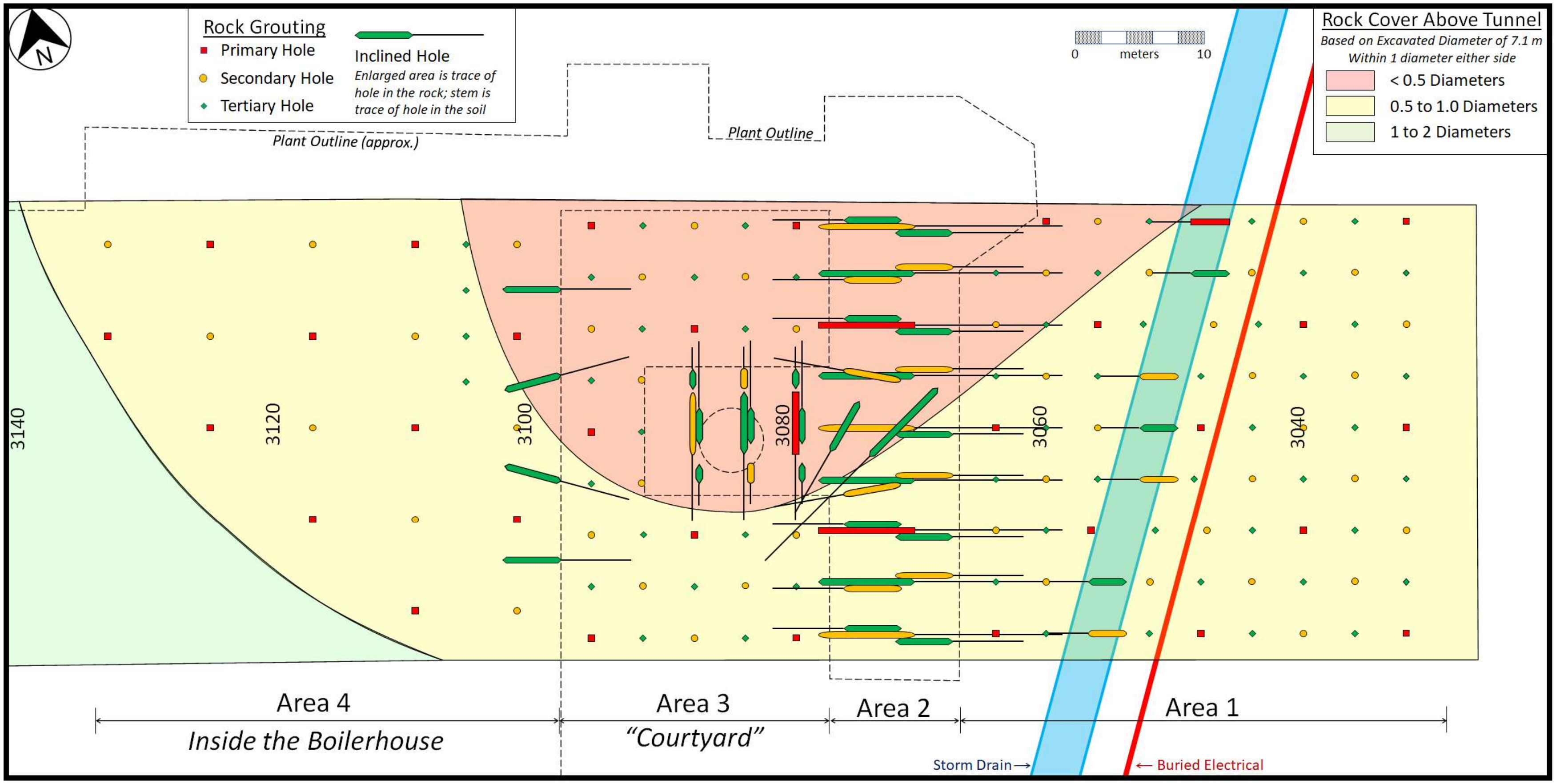


Figure 11: Conceptual Hole Layout (final design layout to be shown on a drawing)

Figure 12: View of the north east corner of the Boiler House showing accessible areas for grouting equipment

Figure 13: CME 45 Rubber-Tracked Drilling Rig

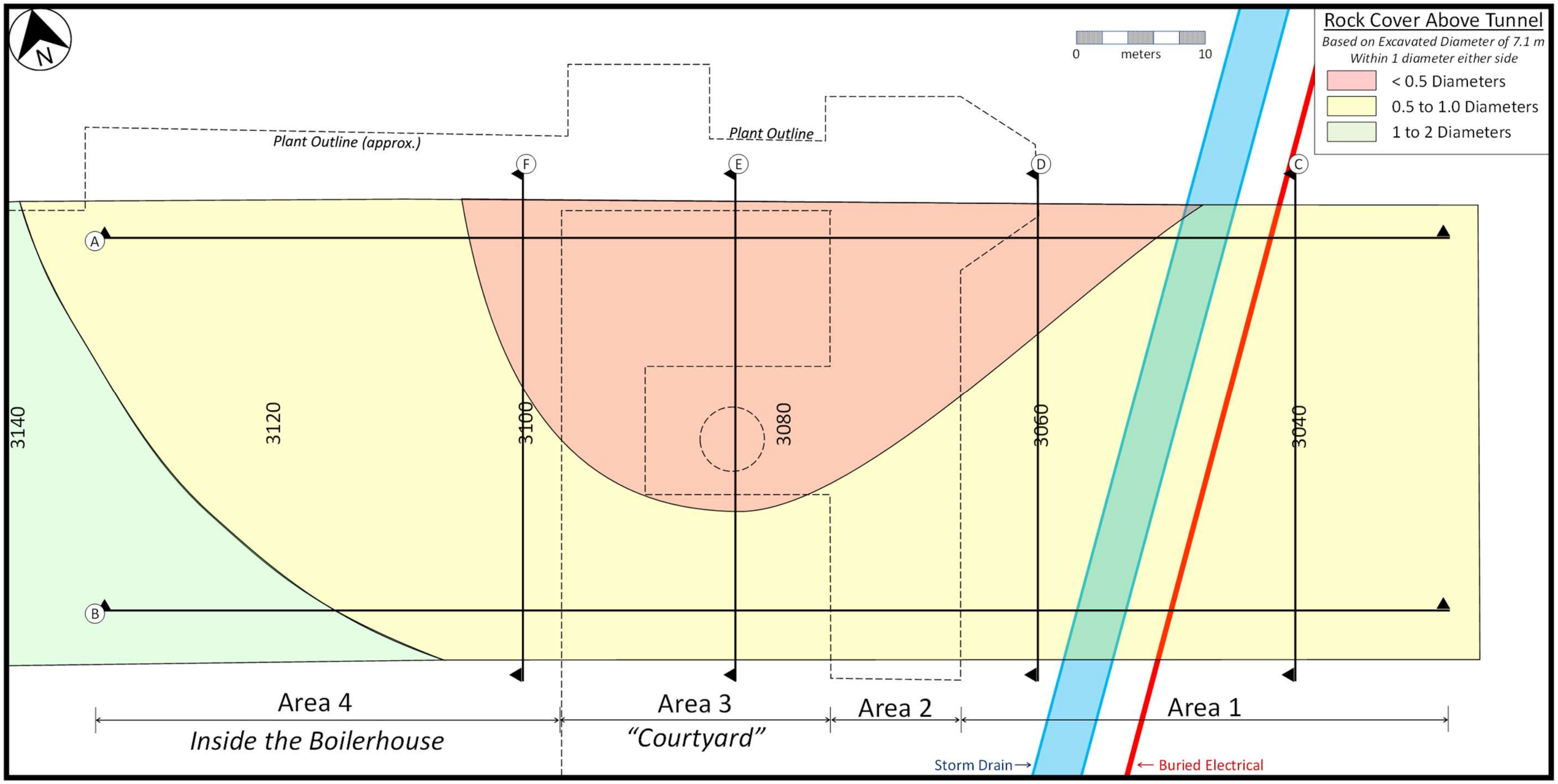


Figure 14: Plan of Section Lines through Grouting Area

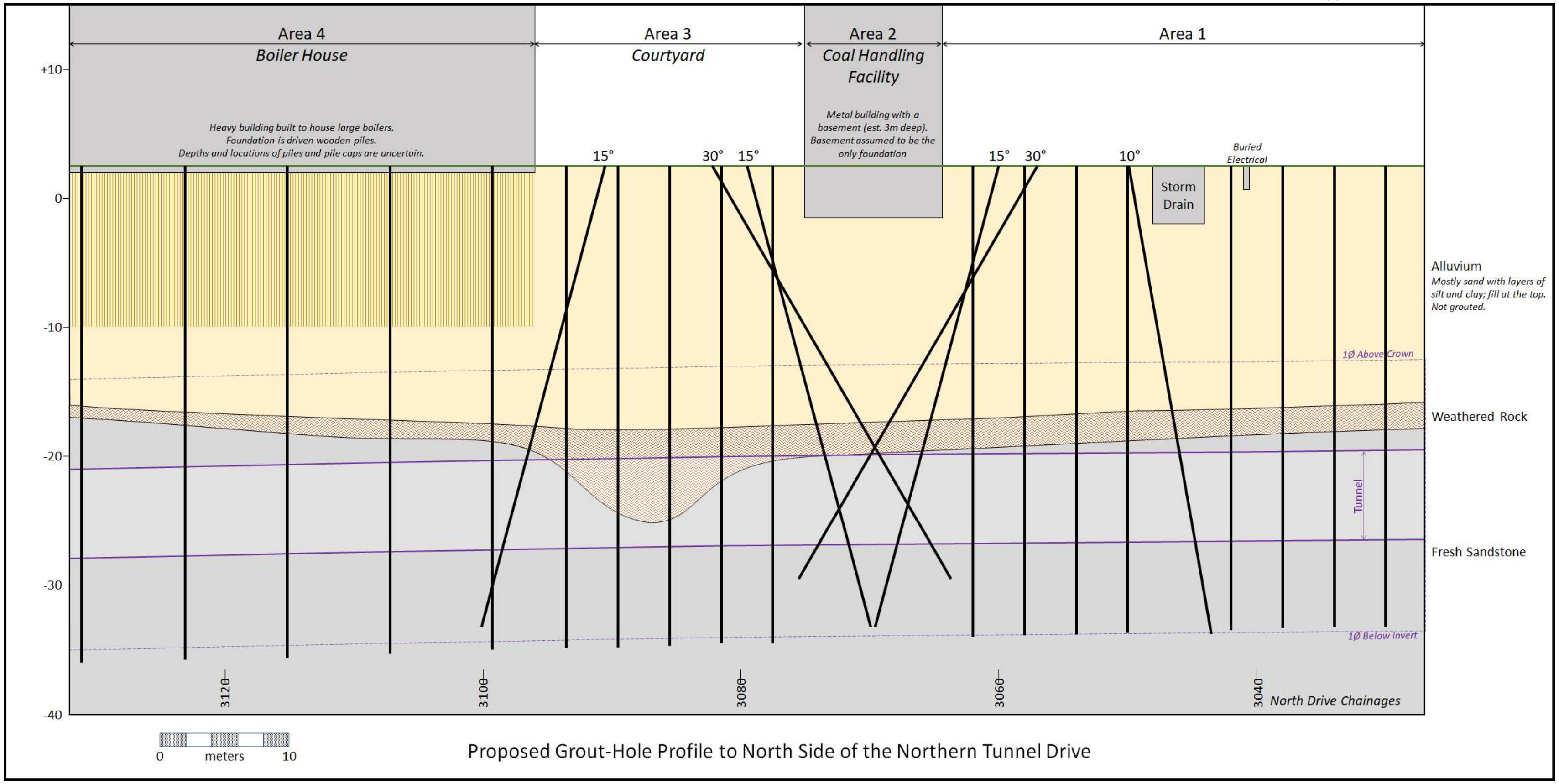


Figure 15: Longitudinal Profile A (4 meters north of north tunnel alignment)

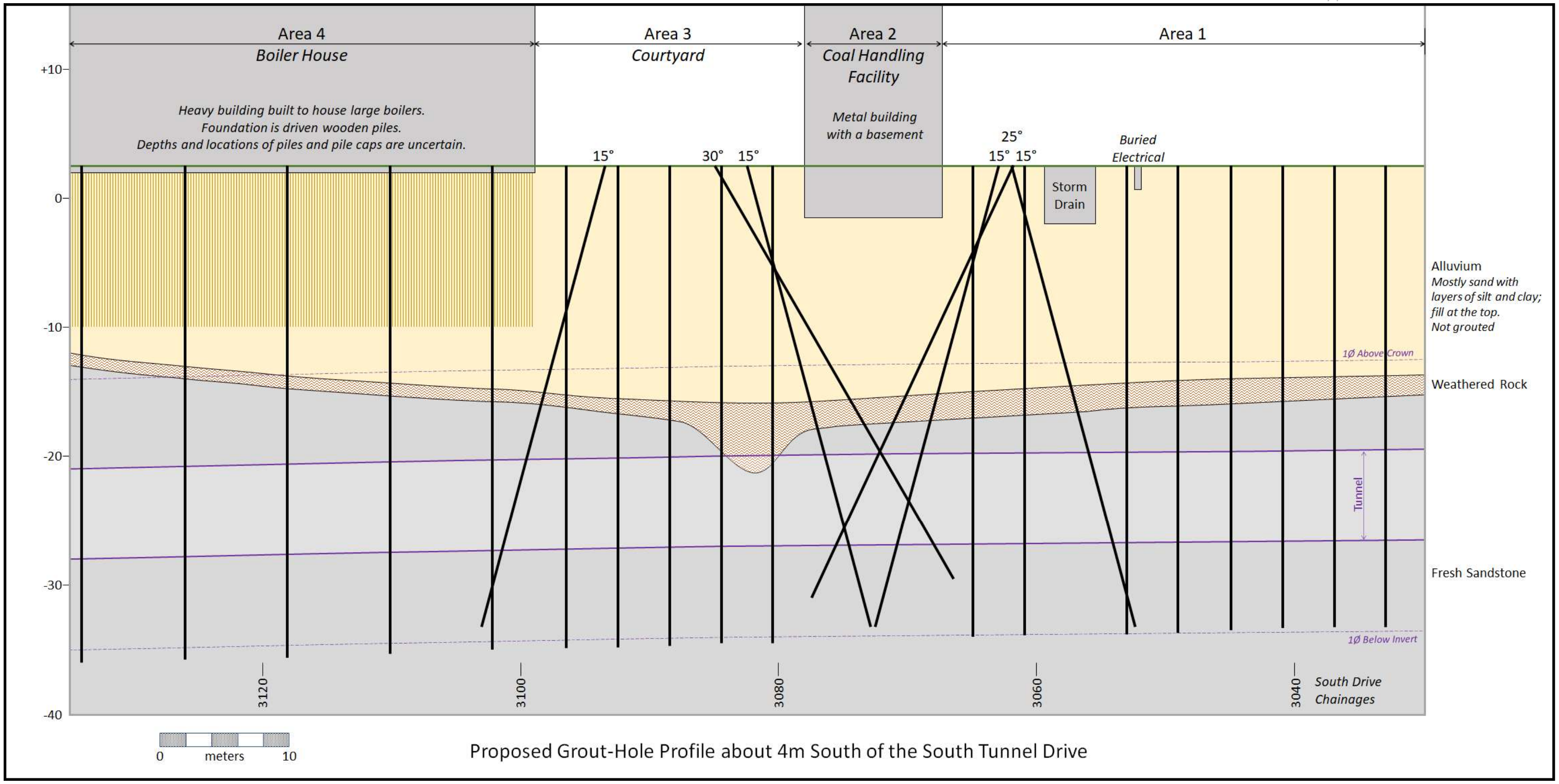


Figure 16: Longitudinal Profile B (4 meters south of south tunnel alignment)

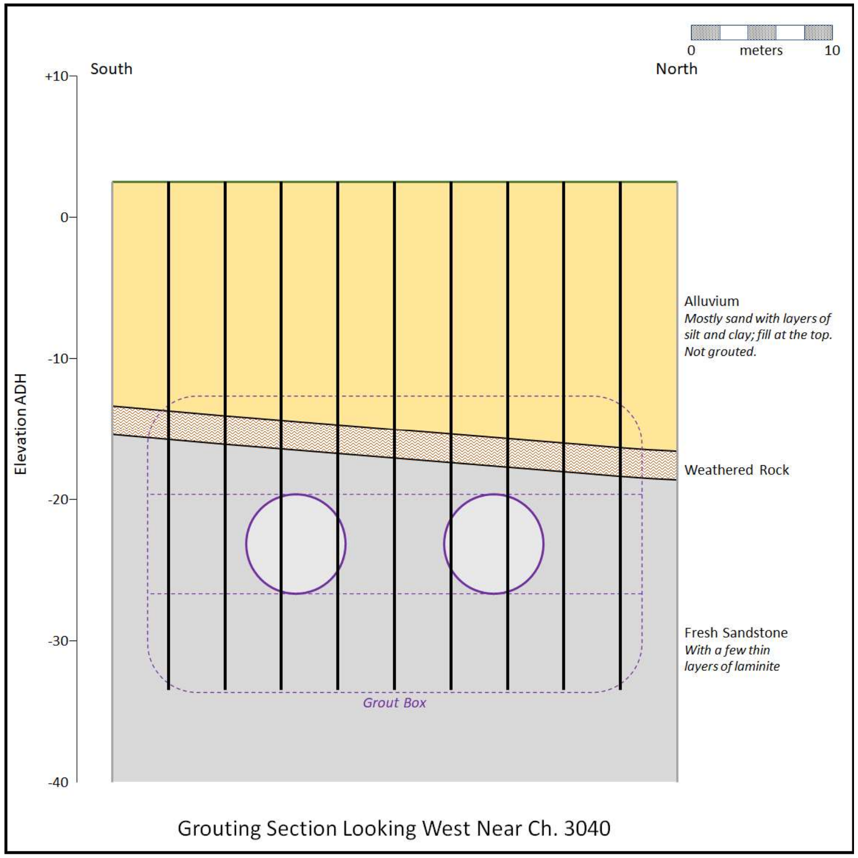


Figure 17: Cross Section C (Area 1 Near Ch. 3040)

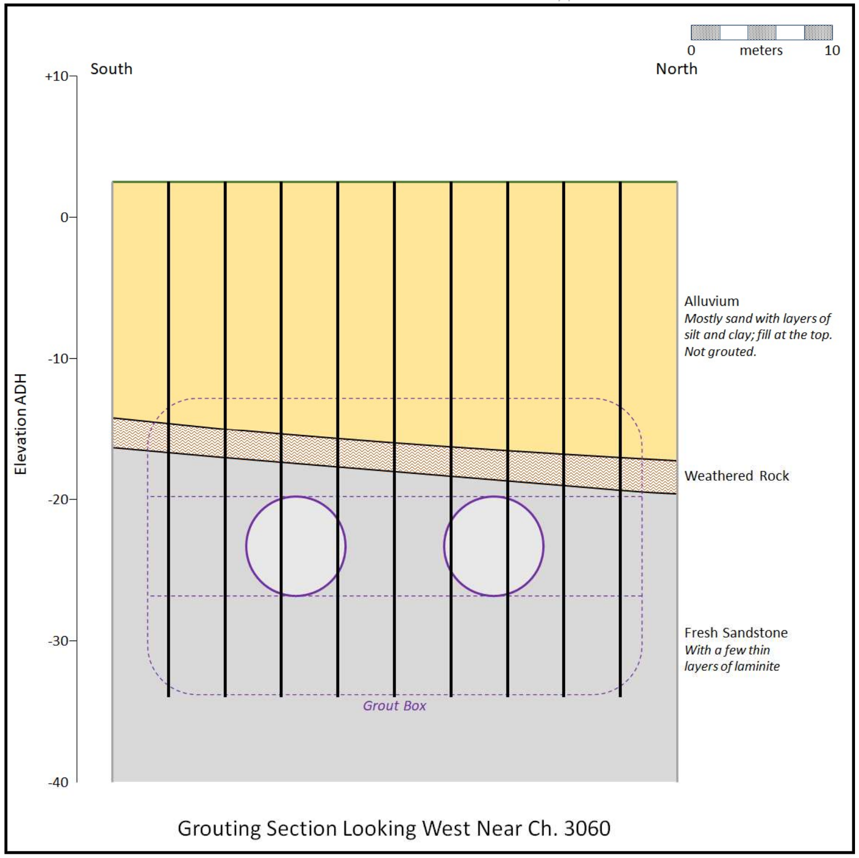


Figure 18: Cross Section D (Area 1 Near Ch. 3060)

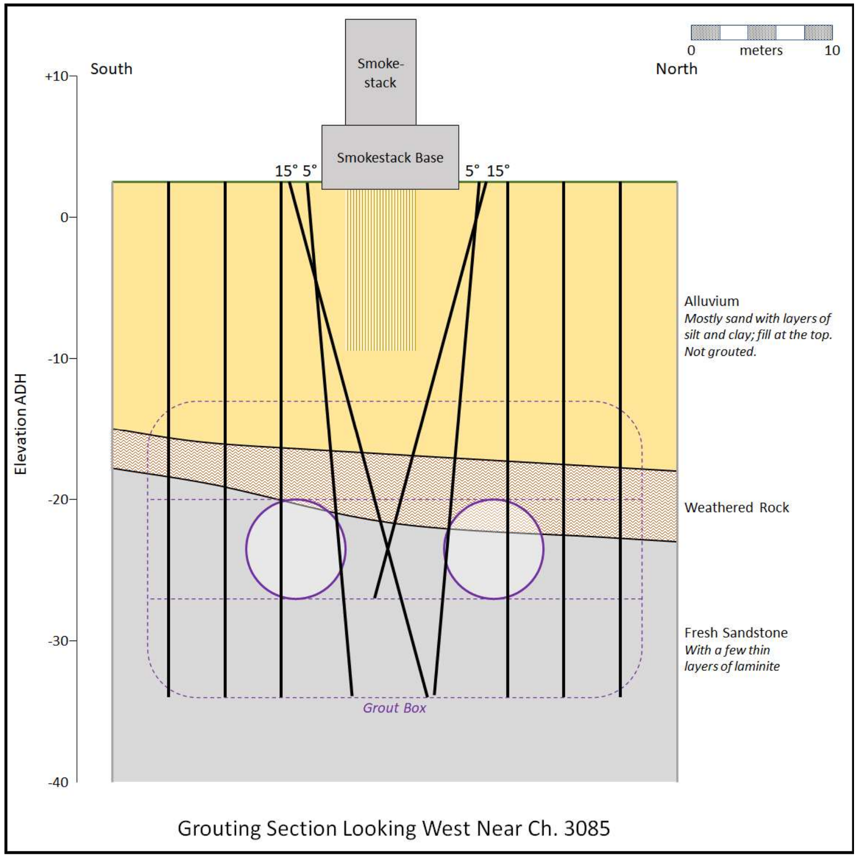


Figure 19: Cross Section E (Area 3 Near Ch. 3085)

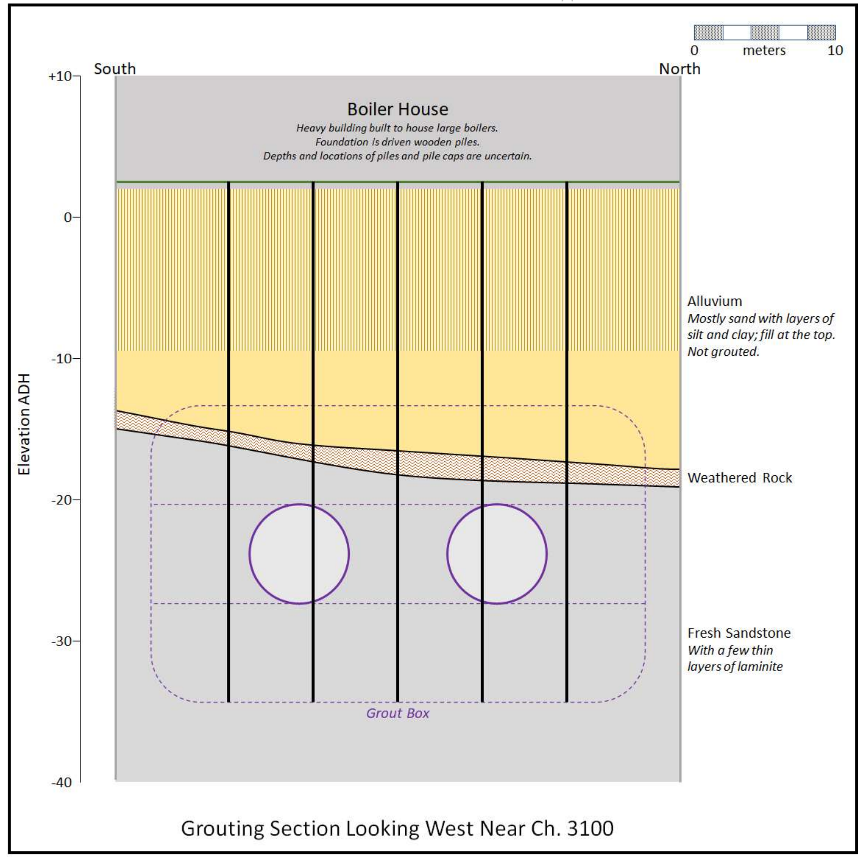


Figure 20: Cross Section F (Area 1 Near Ch. 3100)

4.5. Dilated Bedding Planes – Grouting Target

Experience around Sydney has shown that the dilated, sub-horizontal bedding planes can be grouted effectively from the surface with ordinary Portland cement (OPC) and with a relatively wide spacing of vertical or near-vertical holes. For this method to work, a moderately thick grout mix should be pushed as far a practical along the defects, to the point of refusal if possible. Because the apertures of these dilations vary considerably and can be quite large, it is not practical to estimate the volume that would be required to fill a given dilation. For example, an 80 mm wide dilation was found in borehole SMW-BH066 in the Bays Station box, (this may or may not be the largest dilation in the area, and these dilations do change with distance). In order to push the grout 10 m from the point of injection, it would be necessary to inject 25 m^3 of grout, or probably about 22 to 25 tonne of cement. At an injection rate of 50 litres per minute, it would take more than 8 hours to perform this injection. If the goal were to push the grout 16 m, then 64 m^3 and 21 hours would be required. This obviously places constraints on the maximum hole spacing.

A primary hole spacing of 16 m, with secondaries and tertiaries as needed should be adequate to grout the dilated bedding planes for the purpose of controlling groundwater inflows. In Area 1, where access is easy, secondaries and tertiaries should be used liberally to make sure that the dilations are well sealed. In Area 3, secondaries and tertiaries should be used to the maximum extent practical within the limitations of access. In Area 4, it may be that only the primaries can be drilled, or maybe the primaries and secondaries. In Area 4, it will be important to push the grout as far as possible from the primary holes, even if it requires a very high volume and more than one work shift. Alternatively, it is sometimes possible to wash out or redrill the same hole and put additional grout into high-taking stages the next day, that way, any secondary holes can be used to tighten the grouting rather than filling in gaps that were missed.

Experience around Sydney has also shown that dilated bedding planes are more difficult to grout from underground, for two reasons. First, they are roughly horizontal, and the grout holes drilled from the TBM are also close to horizontal, which greatly increases the chances that the grout holes will miss the bedding planes by running above or below them, rather than across them. Secondly, injecting large amount of grout from underground is very time consuming, and time underground is at a premium. Therefore, every effort should be made to grout the dilated bedding planes from the surface.

4.6. Weathered Zone – Grouting Target

The weathered zone is quite different from the dilated bedding planes and a different grouting strategy will be required. The weathered zone tends to contain numerous interconnected fractures at many different angles, both along bedding planes and across them in the form of high and low-angled joints. The fractures are also more typically collapsed (sometimes clay filled), rather than open, because the rock matrix is not strong enough to arch across them. This pattern tends to make the weathered zone quite permeable but with considerably less potential for pushing ordinary Portland cement (OPC) grout long distances.

The best way to grout the weathered zone is to use a closer hole spacing and ultrafine cement (UFC). All the tertiary holes on Figure 11 should be used in the weathered zone and probably a good number of quaternary holes based on field observations.

Primary holes should be grouted from bottom to top with OPC. Secondary, tertiary and subsequent holes should be grouted with UFC.

5. Grouting Definitions

A. *Grouting Contractor.* The specialty contractor hired by afJV to perform the grouting work.

B. *Grout*. Grout is the mixture of water, cement and admixtures that is pumped into the formation.

C. *Water/cement ratio* or w/c ratio or w/c. The water/cement ratio of a grout is the ratio by mass of water to cement in the mixed grout. For simplicity, w/c ratio can be expressed as a single number. For example, a 1.0 w/c ratio consists of 1 kg of water for every kg of cement.

D. *Stage*. An interval of open borehole that is isolated between the bottom of the grout packer and either the bottom of the hole or the top of the grout placed in a previous stage.

E. *Packer*. The assembly consisting of an inflatable rubber bladder surrounding an open pipe. The bladder is inflated to create a seal in the annulus between the borehole wall and the pipe.

F. *Drop Pipe*. The drop pipe is the pipe used to deliver grout down the hole to the packer. The drop pipe may consist of hard pipe or flexible tubing.

G. *Pressures*. There are several different types of pressure:

1. Hydrostatic Pressure (u): the pressure at stage-depth caused by the column of water in the open borehole. In most cases, the water level in the open borehole corresponds to the water table.
2. Top-Hole Pressure (THP): the gauge pressure measured at the approximate top of the grout hole, just above the ground surface, in the approximate vicinity of the hole. Top-hole pressure is measured from the top-hole gauge.
3. Column Pressure (CP): the pressure exerted by the weight of grout column between the top-hole gauge and the stage. Column pressure is calculated as $CP = h_g \times \gamma_g$, where h_g is the height of the top-hole gauge above the stage and γ_g is the unit weight of the particular grout mix.
4. Bottom-Hole Pressure (BHP): the total pressure exerted by the grout in the stage. BHP = THP + CP
5. Inflation Pressure (IP): the pressure to which the packer must be inflated.

H. *Refusal.* Refusal is a combination of a specified minimum flow rate and a specified maximum pressure at which marks the beginning of the process to stop pumping on a stage. For this project, pumping will continue at the specified maximum pressure for 15 minutes after refusal is reached.

6. Grouting Process

6.1. Drilling

The holes will be cased through the alluvium and drilled through rock to one diameter below the tunnel invert. Rotary, top hammer, or down-hole hammer may be used for the drilling. Once the hole is drilled, it shall be developed with air or by pumping out the water so the influx of water pulls the fines into the hole where they can be removed, rather than pushed out into the formation where they can clog the fractures. After the hole is grouted, the casings shall be pulled or cut off below grade and the hole backfilled with cement to the surface.

6.2. Stages

The holes will be grouted from the bottom upward in approximate 6m stages. An inflatable packer will be used to seal the top of stage; the bottom of the stage will either be the bottom of the hole or the top of the grout placed in the previous stage. For the uppermost stage of each hole, the packer will be seated inside the casing.

If the hole collapses due to poor ground conditions, then it may be necessary to use modified downstage grouting. In this situation, the packer is set about 1 to 2 m above the blockage and the hole below the packer is grouted. Then the rest of the hole above the packer is grouted as normal. Once the grout has set, the hole is re-entered with the drill and drilled out to the bottom. The hole is then grouted from bottom to top as normal, including the intervals that were grouted before the hole was redrilled.

Primary holes should be grouted from bottom to top with ordinary Portland cement (OPC). OPC is substantially less costly than ultrafine cement (UFC) and is adequate for the dilated bedding planes and any larger fractures in the weathered zone.

In general, secondary and tertiary holes will be grouted with UFC, based on the assumption that the large, dilated bedding planes would have been filled or mostly filled from the primary holes. However, if there is reason to suspect that a large, dilated bedding plane would still take a lot of grout, the OPC may be used to reduce the cost. The weathered zone would still have to be grouted with UFC and additional Q or X holes might be necessary to adequately complete the weathered zone. The best approach is to make sure that the large, dilated bedding planes are mostly grouted from the primary holes, such that they take little in secondary and tertiary holes.

6.3. Grout Mixes and Pressures

The primary (P) holes will be grouted with ordinary Portland cement (OPC). Table 1 shows the mixes to be used. Each stage will begin using the 1.0 mix. The superplasticizer dosing will be 1 L per 100 kg of cement.

Table 1: OPC Mix Properties

Mix Ratio w/c mass	Mix Dens. kg/L	Unit Wt. kPa/m	L mix per kg cement	kg cement per L mix
1.0	1.51	14.8	1.33	0.751
0.8	1.60	15.7	1.13	0.884
0.7	1.66	16.3	1.03	0.969

Includes 1 L superplasticizer per 100 kg cement

Secondary and subsequent holes will be grouted with ultrafine cement (UFC). Table 2 shows the mixes to be used. Each stage will begin with the 2.0 mix. The superplasticizer dosing will be 1 L per 100 kg of cement. UFC cement may not be used in stages where OPC has been used. If UFC is used in a shallower stage after OPC in a deeper stage, the grout hoses down through the packer shall be completely purged of the OPC before using the UFC. The reason is that UFC typically lacks the density and viscosity to displace OPC. Table 2 may have to be recalculated once the specific brand of UFC is selected. It is not anticipated that highly specialized UFC's would be necessary.

Table 2 : Ultrafine Grout Mix Table

Mix Ratio	*Mix Dens.*	*Unit Wt.*	*L mix per*	*kg cement*
w/c mass	*kg/L*	*kPa/m*	*kg cement*	*per L mix*
1.00	1.45	14.2	1.38	0.724
0.80	1.52	14.9	1.18	0.847
0.70	1.57	15.4	1.08	0.926
0.60	1.62	15.9	0.98	1.020

Superplasticizer dosage is 1 L per 100 kg cement

GroutAid dosage is 10 L per 100 kg cement

UFC specific gravity is 2.7

Table 3 lists the Top-Hole Pressures (THP's) to be used for surface grouting. Top-hole pressures account for the weight of the grout in the drop pipe. Table 3 includes two pressure schedules. Schedule A is the normal schedule and should be used unless there is specific problem or specific concern. Schedule B should be used adjacent to pipes, with shallow cover adjacent to streams, or in other places where grout could breakout and cause problems. Schedule B should also be used in very weak rock masses if Schedule A causes the rock to shift. Schedule A is intended to push the grout well away from the point of injection, so as to build a good, thick grout zone. In areas where Schedule B is used, is may be necessary drill more holes in order to achieve proper completion.

Table 3: Target Top-Hole Pressures

Depth (m)	Schedule A (kPa)	Schedule B (kPa)
15	105	84
18	125	100
21	164	131
24	211	169
27	258	206
30	305	244
33	352	282
36	399	319
39	446	357

6.4. Thickening the Mix

The purpose of thickening the mix (i.e., decreasing the w/c ratio) is to deliver more cement into the formation in less time with less excess water, especially when grouting large, open fractures. The mix should not be thickened to induce refusal, because that defeats the purpose of the grouting effort.

Each stage should begin with the top-listed mix on either Table 1 or 2. If, after 30 minutes, the flow rate is not declining or the target top hole pressure has not been reached, the mix may be thickened to the next mix down on the table. Likewise, after another 30 minutes, the mix may be thickened again, and so forth, according to Table 1 or Table 2. if the flow rate is not declining or the target top hole pressure has not been reached. Thickening beyond the bottom mix on each table is not recommended because it tends to create technical complexities that can end up causing premature refusal in the stage.

Thickening the mix is desirable when appropriate, but is not required and should not be done if doing so would create problems or chaos. It is much better to thicken slowly than too quickly.

The mix must never be thinned while grouting a stage. The thinner mix will not be able to push the thicker mix out into the formation because it lacks the viscosity and density. The typical result is that the stage will refuse prematurely.

6.5. Completion Criteria

Completion is evaluated based on the take per stage and the decline in take from P to S to T to Q to X holes. The grouting will be evaluated using a color-coded system.

- Red indicates that much more grouting is needed in the area. A stage is rated as Red if it takes more than 70 kg of cement per meter (approx. 650 litres of 1.0 mix per 6 m stage).
- Yellow indicates that some more grouting is needed in the area.
- Green indicates that more grouting is not needed in the area. A stage is rated as Green if it takes less than 20 kg of cement per meter (approx. 180 litres of 1.0 mix per 6 m stage).

Each stage will be rated, and the composite picture of the stages evaluated, both in terms of depth and location. For example, if all the primary holes are green below a certain depth, then the secondary and tertiary holes may not need to be drilled to that depth. However, if the tertiary (T) holes in an area are still red or yellow, then quaternary (Q) and quinary (X) holes would be indicated for that area.

The decline in take provides a broader, more statistical view of the grouting as whole. Decline in take is calculated for the entire area or for larger parts of the area. In general, there should be at least four primary holes along with the subsequent holes. The takes for each stage are added and normalized to kg of cement per meter. Then the rate of decline is calculated from P to S, then S to T, etc. The rate of decline can then be projected to determine whether additional orders of holes are needed on a systematic basis.

7. Estimated Quantities

Table 4 lists the estimated drilling quantities based on Figure 11 and the assumption that all the holes shown on Figure 11 are drilled to a depth of one diameter below the tunnels, and that an additional amount of quaternary and quinary holes are drilled equal to the amount of tertiary holes. (If all quaternary holes were drilled, there would be four times as many quaternaries as tertiaries.) Based on observations during the work, it may be possible to optimize and reduce the amount of drilling.

Table 5 lists the estimated quantities of grout materials. The estimated OPC grout take for the primaries in the fresh bedrock is based on experience with grouting dilated bedding planes in Sydney and elsewhere. The rest of the calculations proceed from there based on a number of assumptions:

- All the primaries will be grouted with OPC; all secondaries and subsequent holes will be grouted with UFC.
- Grout takes will decline at a rate of 60 percent per hole order, on average.
- Master Rheobuild superplasticizer will be added to all grout at the rate of 1 liter per 100 kg of cement.
- GroutAid silica fume emulsion may be added to UFC grout at the rate of 10 liters per 100 kg of cement. Due to the cost of GroutAid, it will be tested in the field to see if it provides sufficient benefit to be worth the cost. The testing program has yet to be developed.

Table 4: Estimated Drilling Quantities

Primary Holes

-	*Area 1*	*Area 2*	*Area 3*	*Area 4*	*Totals*
Holes	13	2	8	10	33
Drilled (m)	471.1	82.0	295.5	370.4	1,218.9
Casing (m)	231.5	44.2	153.7	184.4	613.8
Rock (m)	239.6	37.8	141.8	186.0	605.1
Stages	46	8	26	38	118

Secondary Holes

-	*Area 1*	*Area 2*	*Area 3*	*Area 4*	*Totals*
Holes	28	11	16	9	64
Drilled (m)	1,014.5	417.0	590.1	332.9	2,354.4
Casing (m)	498.4	224.3	309.3	166.6	1,198.6
Rock (m)	516.1	192.7	280.8	166.3	1,155.8
Stages	103	35	53	32	223

Tertiary Holes

_	*Area 1*	*Area 2*	*Area 3*	*Area 4*	*Totals*
Holes	37	15	24	8	84
Drilled (m)	1,340.0	572.5	885.5	299.2	3,097.1
Casing (m)	657.3	308.0	463.6	156.0	1,585.0
Rock (m)	682.7	264.4	421.9	143.2	1,512.2
Stages	134	52	78	27	291

Quaternary and Quinary Holes

_	*Area 1*	*Area 2*	*Area 3*	*Area 4*	*Totals*
Holes	37	15	24	8	84
Drilled (m)	1,340.0	572.5	885.5	299.2	3,097.1
Casing (m)	657.3	308.0	463.6	156.0	1,585.0
Rock (m)	682.7	264.4	421.9	143.2	1,512.2
Stages	134	52	78	27	291

All Holes

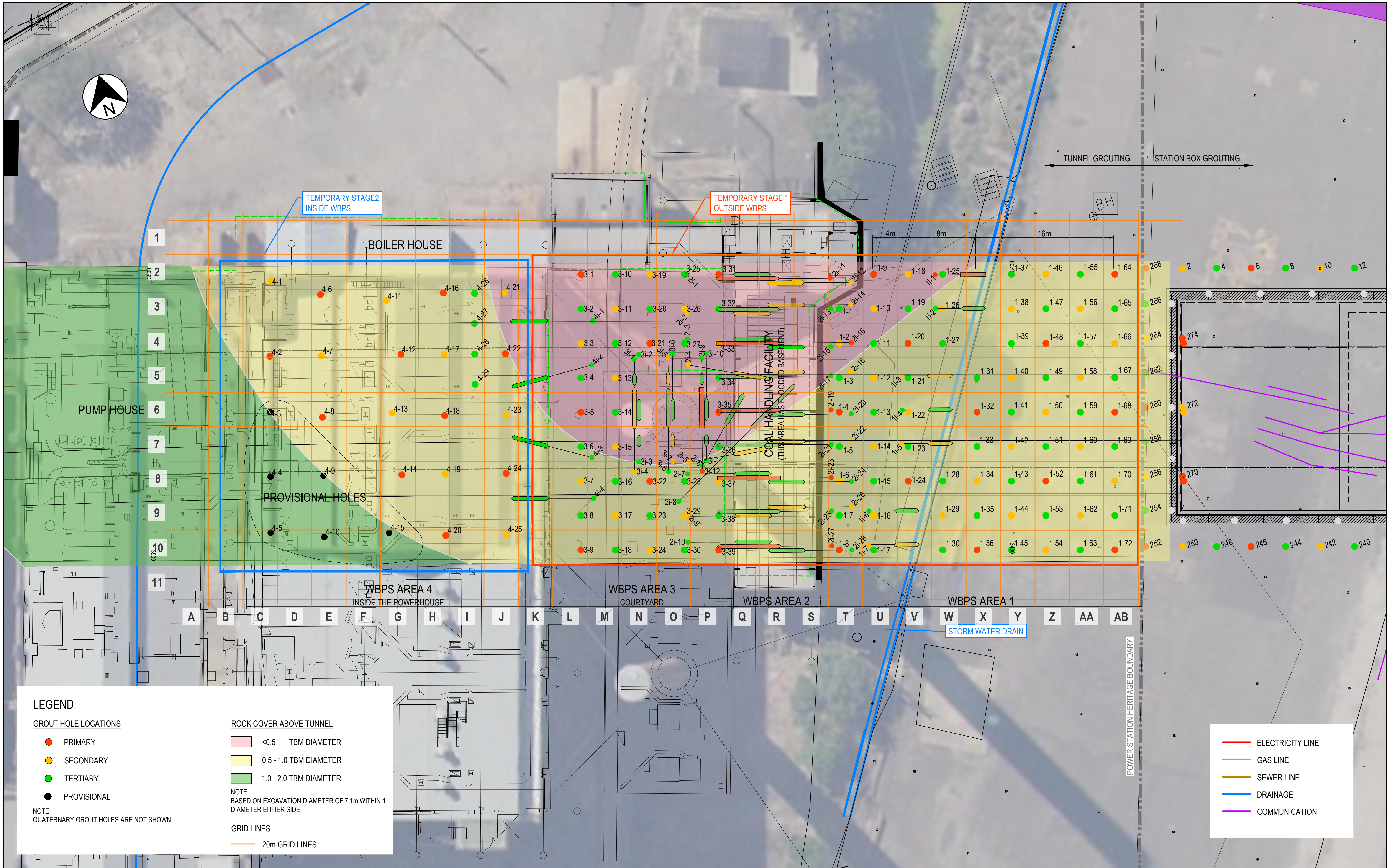
_	*Area 1*	*Area 2*	*Area 3*	*Area 4*	*Totals*
Holes	115	43	72	35	265
Drilled (m)	4,165.5	1,643.9	2,656.5	1,301.7	9,767.6
Casing (m)	2,044.6	884.6	1,390.3	662.9	4,982.4
Rock (m)	2,120.9	759.3	1,266.2	638.7	4,785.2
Stages	417	147	235	124	923

Table 5: Material Quantities

	Primary	*Secondary*	*Tertiary*	*Q & X*	*Totals*
Total OPC (tonne)	278.3				278.3
Total UFC (tonne)		106.3	111.3	44.5	262.1
SuperP. (cube)	2.8	1.1	1.1	0.4	5.4
GroutAid (cube)	0.0	10.6	11.1	4.5	26.2

Attachment 1 – Proposed Surface Grouting Layout Plan for White Bay Power Station

Drawing No. SMWSTCTP-AFJ-SWD-TU200-GE-DRG-002500



Plot Date: 14/12/21 - 17:56

100mm AT FULL SIZE

Security:

FOR REVIEW AND COMMENT

A.1	DRAFT	JR	CP	
		Design by	Verified by	Approved Initial/Date

SCALES

0 4 8 12m

SCALE 1:200 (A1)1:400 (A3)

CLIENT

Transport for NSW

sydney METRO west

af JV

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SERVICE PROVIDERS

Jacobs TYPSA

DRAWN	S.NOWAL	20.10.2021
DESIGNED	J.RAYMER	20.10.2021
DRG CHECK	V.NGUYEN	
DESIGN CHECK	C.PARKER	
APPROVED		

SYDNEY METRO WEST

WHITE BAY POWER STATION
GEOTECHNICAL
GROUTING FOR WHITE BAY POWER STATION
HOLE LAYOUT

DOCUMENT No: 1 | SHEET: 1 OF 1 | ©

STATUS: DRAFT | EDMS NO:

DRG No. SMWSTCTP-AFJ-SWD-TU200-GE-DRG-002550 | REV A.1 | VER

A1 Original | Co-ordinate System: GDA20/MGA Zone 56 | Height Datum: A.H.D | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

WHITE BAY POWER STATION - GROUT HOLE SCHEDULE - AREA 1

Grout Hole within GRID	Grout Hole Number	Easting (m) 2020	Northing (m) 2020	Primary Secondary Tertiary	Surface RL (m)	Base of Hole RL (m)	Top of Rock RL (m)	Notes	Angle from Vertical	Hole Direction	Overall Length (m)	Casing Length (m)	Rock Grouted Length (m)	Number of Grout Stages
AB2	1-64	331457.0	6251140.3	P	2.5	-33.5	-16.0		0		36.0	18.5	17.5	3
AB3	1-65	331455.8	6251136.4	T	2.5	-33.5	-15.7		0		36.0	18.2	17.8	3
AB4	1-66	331454.6	6251132.5	S	2.5	-33.5	-15.4		0		36.0	17.9	18.1	4
AB5	1-67	331453.4	6251128.7	T	2.5	-33.5	-15.1		0		36.0	17.6	18.4	4
AB6	1-68	331452.3	6251125.0	P	2.5	-33.5	-14.8		0		36.0	17.3	18.7	4
AB7	1-69	331451.1	6251121.1	Y	2.5	-33.5	-14.5		0		36.0	17.0	19.0	4
AB8	1-70	331449.9	6251117.3	S	2.5	-33.5	-14.2		0		36.0	16.7	19.3	4
AB9	1-71	331448.8	6251113.4	T	2.5	-33.5	-13.9		0		36.0	16.4	19.6	4
AB10	1-72	331447.6	6251109.6	P	2.5	-33.5	-13.6		0		36.0	16.1	19.9	4
AA2	1-55	331453.1	6251141.4	T	2.5	-33.5	-16.1		0		36.0	18.6	17.4	3
AA3	1-56	331451.9	6251137.6	S	2.5	-33.5	-15.8		0		36.0	18.3	17.7	3
AA4	1-57	331450.8	6251133.7	T	2.5	-33.5	-15.5		0		36.0	18.0	18.0	3
AA5	1-58	331449.6	6251129.9	S	2.5	-33.5	-15.2		0		36.0	17.7	18.3	4
AA6	1-59	331448.5	6251126.1	T	2.5	-33.5	-14.9		0		36.0	17.4	18.6	4
AA7	1-60	331447.3	6251122.3	S	2.5	-33.5	-14.6		0		36.0	17.1	18.9	4
AA8	1-61	331446.1	6251118.4	T	2.5	-33.5	-14.3		0		36.0	16.8	19.2	4
AA9	1-62	331444.9	6251114.6	S	2.5	-33.5	-14.0		0		36.0	16.5	19.5	4
AA10	1-63	331443.8	6251110.8	T	2.5	-33.5	-13.7		0		36.0	16.2	19.8	4
Z2	1-46	331449.3	6251142.6	S	2.5	-33.6	-16.2		0		36.1	18.7	17.4	3
Z3	1-47	331448.1	6251138.7	T	2.5	-33.6	-15.9		0		36.1	18.4	17.7	3
Z4	1-48	331447.0	6251134.9	P	2.5	-33.6	-15.6		0		36.1	18.1	18.0	3
Z5	1-49	331445.8	6251131.1	T	2.5	-33.6	-15.3		0		36.1	17.8	18.3	4
Z6	1-50	331444.6	6251127.3	S	2.5	-33.6	-15.0		0		36.1	17.5	18.6	4
Z7	1-51	331443.4	6251123.5	T	2.5	-33.6	-14.7		0		36.1	17.2	18.9	4
Z8	1-52	331442.3	6251119.6	P	2.5	-33.6	-14.4		0		36.1	16.9	19.2	4
Z9	1-53	331441.1	6251115.8	T	2.5	-33.6	-14.1		0		36.1	16.6	19.5	4
Z10	1-54	331439.9	6251112.0	S	2.5	-33.6	-13.8		0		36.1	16.3	19.8	4
Y2	1-37	331445.5	6251143.8	T	2.5	-33.6	-16.3		0		36.1	18.8	17.3	3
Y3	1-38	331444.3	6251139.9	S	2.5	-33.6	-16.0		0		36.1	18.5	17.6	3
Y4	1-39	331443.1	6251136.1	T	2.5	-33.6	-15.7		0		36.1	18.2	17.9	3
Y5	1-40	331442.0	6251132.3	S	2.5	-33.6	-15.4		0		36.1	17.9	18.2	4
Y6	1-41	331440.8	6251128.4	T	2.5	-33.6	-15.1		0		36.1	17.6	18.5	4
Y7	1-42	331439.6	6251124.6	S	2.5	-33.6	-14.8		0		36.1	17.3	18.8	4
Y8	1-43	331438.5	6251120.8	T	2.5	-33.6	-14.5		0		36.1	17.0	19.1	4
Y9	1-44	331437.3	6251117.0	S	2.5	-33.6	-14.2		0		36.1	16.7	19.4	4
Y10	1-45	331436.1	6251113.1	T	2.5	-33.6	-13.9		0		36.1	16.4	19.7	4
X5	1-31	331438.1	6251133.5	T	2.5	-33.7	-15.5		0		36.2	18.0	18.2	4
X6	1-32	331437.0	6251129.6	P	2.5	-33.7	-15.2		0		36.2	17.7	18.5	4
X7	1-33	331435.8	6251125.8	T	2.5	-33.7	-14.9		0		36.2	17.4	18.8	4
X8	1-34	331434.6	6251121.9	S	2.5	-33.7	-14.6		0		36.2	17.1	19.1	4
X9	1-35	331433.5	6251118.1	T	2.5	-33.7	-14.3		0		36.2	16.8	19.4	4
X10	1-36	331432.3	6251114.3	P	2.5	-33.7	-14.0		0		36.2	16.5	19.7	4
W2	1-25	331437.8	6251146.1	T	2.5	-33.7	-16.6		0		36.2	19.1	17.1	3
W2	1i-1	331436.9	6251146.3	P	2.5	-33.7	-16.5	angled	10	East along tunnel	36.8	19.3	17.5	3
W3	1-26	331436.7	6251142.2	S	2.5	-33.7	-16.3		0		36.2	18.8	17.4	3
W3	1i-2	331435.9	6251142.5	T	2.5	-33.7	-16.2	angled	10	East along tunnel	36.8	19.0	17.8	3
W4	1-27	331435.5	6251138.4	T	2.5	-33.7	-15.9		0		36.2	18.4	17.8	3
W8	1-28	331430.8	6251123.1	T	2.5	-33.7	-14.7		0		36.2	17.2	19.0	4
W9	1-29	331429.6	6251119.3	S	2.5	-33.7	-14.4		0		36.2	16.9	19.3	4
W10	1-30	331428.5	6251115.5	T	2.5	-33.7	-14.1		0		36.2	16.6	19.6	4
V2	1-18	331434.0	6251147.3	S	2.5	-33.8	-16.8		0		36.3	19.3	17.0	3
V3	1-19	331432.8	6251143.4	T	2.5	-33.8	-16.5		0		36.3	19.0	17.3	3
V4	1-20	331431.7	6251139.6	P	2.5	-33.8	-16.1		0		36.3	18.6	17.7	3
V5	1-21	331430.5	6251135.8	T	2.5	-33.8	-15.8		0		36.3	18.3	18.0	3
V5	1i-3	331429.8	6251136.2	S	2.5	-33.7	-15.6	angled	10	East along tunnel	36.8	18.4	18.4	4
V6	1-22	331429.3	6251132.0	S	2.5	-33.8	-15.5		0		36.3	18.0	18.3	4
V6	1i-4	331428.7	6251132.3	T	2.5	-33.7	-15.3	angled	10	East along tunnel	36.8	18.1	18.7	4
V7	1-23	331428.2	6251128.1	T	2.5	-33.8	-15.2		0		36.3	17.7	18.6	4
V7	1i-5	331427.6	6251128.7	S	2.5	-33.7	-15.6	angled	10	East along tunnel	36.8	18.4	18.4	4
V8	1-24	331427.0	6251124.3	P	2.5	-33.8	-14.9		0		36.3	17.4	18.9	4
U2	1-9	331430.1	6251148.4	P	2.5	-33.8	-17.0		0		36.3	19.5	16.8	3
U3	1-10	331429.0	6251144.6	S	2.5	-33.8	-16.7		0		36.3	19.2	17.1	3
U4	1-11	331427.9	6251140.7	T	2.5	-33.8	-16.3		0		36.3	18.8	17.5	3
U5	1-12	331426.6	6251137.0	S	2.5	-33.8	-16.0		0		36.3	18.5	17.8	3
U6	1-13	331425.5	6251133.1	T	2.5	-33.8	-15.7		0		36.3	18.2	18.1	4
U7	1-14	331424.3	6251129.3	S	2.5	-33.8	-15.4		0		36.3	17.9	18.4	4
U8	1-15	331423.2	6251125.4	T	2.5	-33.8	-15.1		0		36.3	17.6	18.7	4
U9	1-16	331422.0	6251121.7	S	2.5	-33.8	-14.8		0		36.3	17.3	19.0	4
U9	1i-6	331421.6	6251122.3	T	2.5	-33.8	-14.6	angled	10	East along tunnel	36.9	17.4	19.5	4
U10	1-17	331420.8	6251117.8	T	2.5	-33.8	-14.5		0		36.3	17.0	19.3	4
U10	1i-7	331420.4	6251118.6	S	2.5	-33.8	-14.3	angled	10	East along tunnel	36.9	17.1	19.8	4
T3	1-1	331425.2	6251145.8	T	2.5	-33.9	-16.9		0		36.4	19.4	17.0	3
T4	1-2	331424.1	6251141.9	S	2.5	-33.9	-16.5		0		36.4	19.0	17.4	3
T5	1-3	331422.9	6251138.1	T	2.5	-33.9	-16.2		0		36.4	18.7	17.7	3
T6	1-4	331421.7	6251134.2	P	2.5	-33.9	-15.9		0		36.4	18.4	18.0	3
T7	1-5	331420.5	6251130.4	Y	2.5	-33.9	-15.6		0		36.4	18.1	18.3	4
T8	1-6	331419.4	6251126.6	S	2.5	-33.9	-15.3		0		36.4	17.8	18.6	4
T9	1-7	331418.2	6251122.8	T	2.5	-33.9	-15.0		0		36.4	17.5	18.9	4
T10	1-8	331416.9	6251119.0	P	2.5	-33.9	-14.7		0		36.4	17.2	19.2	4

Security:

FOR REVIEW AND COMMENT

Cad File: C:\users\andersr3\appdata\local\projectwise\jacobs_anz_ie\d0439070\SMWSTCTP-AFJ-TBY-SN200-GE-DRG-002560-002563.dwg

Plot Date: 14/12/21 - 18:01

100mm AT FULL SIZE

REV	DESCRIPTION	Design by	Verified by	Approved Initial/Date
A	ISSUED FOR STAGE 3 THE BAYS STATION EXCAVATION	JR	CP	FL 25.12.21

SCALES

0 4 8 12m

SCALE 1:200 (A1)1:400 (A3)

CLIENT

SERVICE PROVIDERS

DRAWN	S.NOWAL	25.12.2021
DESIGNED	J.RAYMER	25.12.2021
DRG CHECK	V.NGUYEN	25.12.2021
DESIGN CHECK	C.PARKER	25.12.2021
APPROVED	F.LOPEZ	25.12.2021

SYDNEY METRO WEST
THE BAYS STATION
GEOTECHNICAL
GROUT HOLE SCHEDULE - AREA 1
SHEET 1 OF 4

DOCUMENT No: 1 | SHEET: 1 OF 1 | ©
STATUS: DESIGN STAGE 3 | EDMS NO:
DRG No. SMWSTCTP-AFJ-TBY-SN200-GE-DRG-002560 | REV A.1 | VER

A1 Original | Co-ordinate System: GDA20/MGA Zone 56 | Height Datum: A.H.D | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

WHITE BAY POWER STATION - GROUT HOLE SCHEDULE - AREA 2

Grout Hole within GRID	Grout Hole Number	Easting (m) 2020	Northing (m) 2020	Primary Secondary Tertiary	Surface RL (m)	Base of Hole RL (m)	Top of Rock RL (m)	Notes	Angle from Vertical	Hole Direction	Overall Length (m)	Casing Length (m)	Rock Grouted Length (m)	Number of Grout Stages	Grout Stages
T2	2i-12	331427.4	6251148.3	S	2.5	-33	-17.5	angled	30	west along tunnel	0	41.0	23.1	17.9	3
T3	2i-14	331426.6	6251145.9	T	2.5	-33	-17.3	angled	30	west along tunnel	0	41.0	22.9	18.1	4
T4	2i-16	331425.0	6251140.0	P	2.5	-33	-17.1	angled	30	west along tunnel	0	41.0	22.6	18.4	4
T5	2i-18	331424.3	6251138.4	T	2.5	-33	-16.9	angled	30	west along tunnel	0	41.0	22.4	18.6	4
T6	2i-20	331423.0	6251133.7	S	2.5	-33	-16.7	angled	30	west along tunnel	0	41.0	22.2	18.8	4
T7	2i-22	331422.0	6251130.7	T	2.5	-33	-16.5	angled	30	west along tunnel	0	41.0	21.9	19.1	4
T8	2i-24	331420.7	6251126.2	P	2.5	-33	-16.2	angled	30	west along tunnel	0	41.0	21.6	19.4	4
T9	2i-26	331419.8	6251123.4	T	2.5	-33	-15.8	angled	30	west along tunnel	0	41.0	21.1	19.9	4
T10	2i-28	331418.4	6251118.6	S	2.5	-33	-15.4	angled	30	west along tunnel	0	41.0	20.7	20.3	4
T2	2i-11	331425.2	6251149.5	T	2.5	-33	-17.5	angled	15	west along tunnel	0	36.8	20.7	16.0	3
T3	2i-13	331424.2	6251146.0	S	2.5	-33	-17.3	angled	15	west along tunnel	0	36.8	20.5	16.3	3
T4	2i-15	331422.4	6251140.0	T	2.5	-33	-17.1	angled	15	west along tunnel	0	36.8	20.3	16.5	3
T5	2i-17	331422.0	6251138.6	S	2.5	-33	-16.9	angled	15	west along tunnel	0	36.8	20.1	16.7	3
T6	2i-19	331420.8	6251134.8	T	2.5	-33	-16.7	angled	15	west along tunnel	0	36.8	19.9	16.9	3
T7	2i-21	331419.7	6251131.0	S	2.5	-33	-16.5	angled	15	west along tunnel	0	36.8	19.7	17.1	3
T8	2i-23	331418.6	6251127.3	T	2.5	-33	-16.2	angled	15	west along tunnel	0	36.8	19.4	17.4	3
T9	2i-25	331417.5	6251123.6	S	2.5	-33	-15.8	angled	15	west along tunnel	0	36.8	18.9	17.8	3
T10	2i-27	331416.3	6251119.7	T	2.5	-33	-15.4	angled	15	west along tunnel	0	36.8	18.5	18.2	4
O2	2i-1	331409.4	6251154.7	T	2.5	-33	-17.5	angled	15	east along tunnel	0	36.8	20.7	16.0	3
O3	2i-2	331408.1	6251150.4	S	2.5	-33	-17.3	angled	15	east along tunnel	0	36.8	20.5	16.3	3
O4	2i-3	331407.3	6251147.6	T	2.5	-33	-17.1	angled	15	east along tunnel	0	36.8	20.3	16.5	3
O5	2i-4	331406.5	6251144.7	S	2.5	-33	-16.9	angled	15	100 deg (East)	10	36.8	20.1	16.7	3
O8	2i-5	331403.2	6251133.8	T	2.5	-33	-16.7	angled	15	30 deg (North East)	60	36.8	19.9	16.9	3
P8	2i-6	331404.6	6251133.0	S	2.5	-33	-16.5	angled	15	80 deg (North East)	10	36.8	19.7	17.1	3
O8	2i-7	331402.7	6251132.6	T	2.5	-33	-16.2	angled	15	east along tunnel	0	36.8	19.4	17.4	3
O9	2i-9	331401.4	6251127.8	S	2.5	-33	-15.8	angled	15	east along tunnel	0	36.8	18.9	17.8	3
O10	2i-10	331400.5	6251125.0	T	2.5	-33	-15.4	angled	15	east along tunnel	0	36.8	18.5	18.2	4
O9	2i-8	331400.8	6251129.8	T	2.5	-33	-16.7	angled	30	45 deg (North East)	45	41.0	22.2	18.8	4

Security:

FOR REVIEW AND COMMENT

Rev	Description	Design by	Verified by	Approved Initial/Date	
A	ISSUED FOR STAGE 3 THE BAYS STATION EXCAVATION	JR	CP	FL	25.12.21

SCALES

0 4 8 12m

SCALE 1:200 (A1)1:400 (A3)

A1 Original | Co-ordinate System: GDA20/MGA Zone 56 | Height Datum: A.H.D | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

CLIENT

SERVICE PROVIDERS

DRAWN	S.NOWAL	25.12.2021
DESIGNED	J.RAYMER	25.12.2021
DRG CHECK	V.NGUYEN	25.12.2021
DESIGN CHECK	C.PARKER	25.12.2021
APPROVED	F.LOPEZ	25.12.2021

SYDNEY METRO WEST
THE BAYS STATION
GEOTECHNICAL
GROUT HOLE SCHEDULE - AREA 2
SHEET 2 OF 4

DOCUMENT No: 1 | SHEET: 1 OF 1 | ©
STATUS: DESIGN STAGE 3 | EDMS NO:
DRG No. SMWSTCTP-AFJ-TBY-SN200-GE-DRG-002561 | REV A.1 | VER

WHITE BAY POWER STATION - GROUT HOLE SCHEDULE - AREA 3
"COURT YARD AREA"

Grout Hole within GRID	Grout Hole Number	Easting (m) 2020	Northing (m) 2020	Primary Secondary Tertiary	Surface RL (m)	Base of Hole RL (m)	Top of Rock RL (m)	Notes	Angle from Vertical	Hole Direction	Overall Length (m)	Casing Length (m)	Rock Grouted Length (m)	Number of Grout Stages
L2	3-31	331413.0	6251153.6	P	2.5	-34.0	-17.7		0		36.5	20.2	16.3	3
L3	3-32	331411.8	6251149.9	T	2.5	-34.0	-17.4		0		36.5	19.9	16.6	3
L4	3-33	331410.6	6251146.0	S	2.5	-34.0	-17.2		0		36.5	19.7	16.8	3
P4	3i-9	331408.2	6251145.0	T	2.5	-34.0	-17.0	angled under chimney	5	South across tunnel	36.6	19.6	17.1	3
P4	3i-10	331408.9	6251145.4	T	2.5	-34.0	-16.8	angled under chimney	15	South across tunnel	37.8	20.0	17.8	3
P7	3i-11	331405.3	6251133.4	T	2.5	-34.0	-16.6	angled under chimney	5	North across tunnel	36.6	19.2	17.5	3
P8	3i-12	331404.4	6251132.4	P	2.5	-34.0	-16.8	angled under chimney	15	North across tunnel	37.8	20.0	17.8	3
P8	3-37	331405.9	6251130.7	S	2.5	-34.0	-16.3		0		36.5	18.8	17.7	3
P9	3-38	331404.8	6251126.9	T	2.5	-34.0	-16.1		0		36.5	18.6	17.9	3
P10	3-39	331403.6	6251123.1	P	2.5	-34.0	-15.5		0		36.5	18.0	18.5	4
O2	3-25	331409.2	6251154.9	T	2.5	-34.1	-17.8		0		36.6	20.3	16.3	3
O3	3-26	331408.0	6251151.0	S	2.5	-34.1	-17.5		0		36.6	20.0	16.6	3
O8	3-27	331406.8	6251147.2	T	2.5	-34.1	-17.3		0		36.6	19.8	16.8	3
O5	3i-5	331404.5	6251146.2	S	2.5	-34.1	-17.1	angled under chimney	5	South across tunnel	36.7	19.7	17.1	3
O5	3i-6	331405.1	6251146.4	T	2.5	-34.1	-16.8	angled under chimney	15	South across tunnel	37.9	20.0	17.9	3
O8	3i-7	331401.5	6251134.5	S	2.5	-34.1	-16.6	angled under chimney	5	North across tunnel	36.7	19.2	17.6	3
O8	3i-8	331400.7	6251133.5	T	2.5	-34.1	-16.8	angled under chimney	15	North across tunnel	37.9	20.0	17.9	3
O8	3-28	331402.1	6251131.9	T	2.5	-34.1	-16.3		0		36.6	18.8	17.8	3
O9	3-29	331400.9	6251128.1	S	2.5	-34.1	-16.1		0		36.6	18.6	18.0	3
O10	3-30	331399.8	6251124.2	T	2.5	-34.1	-15.5		0		36.6	18.0	18.6	4
N2	3-19	331405.3	6251156.0	S	2.5	-34.2	-17.8		0		36.7	20.3	16.4	3
N3	3-20	331404.2	6251152.1	T	2.5	-34.2	-17.6		0		36.7	20.1	16.6	3
N4	3-21	331403.0	6251148.3	P	2.5	-34.2	-17.3		0		36.7	19.8	16.9	3
N4	3i-1	331400.7	6251147.2	T	2.5	-34.2	-17.1	angled under chimney	5	South across tunnel	36.8	19.7	17.2	3
N4	3i-2	331401.3	6251147.5	T	2.5	-34.2	-16.8	angled under chimney	15	South across tunnel	38.0	20.0	18.0	4
N8	3i-3	331397.7	6251135.6	T	2.5	-34.2	-16.6	angled under chimney	5	North across tunnel	36.8	19.2	17.7	3
N8	3i-4	331396.9	6251134.7	S	2.5	-34.2	-16.8	angled under chimney	15	North across tunnel	38.0	20.0	18.0	4
N8	3-22	331398.3	6251133.0	P	2.5	-34.2	-16.3		0		36.7	18.8	17.9	3
N9	3-23	331397.1	6251129.2	T	2.5	-34.2	-16.0		0		36.7	18.5	18.2	4
N10	3-24	331395.9	6251125.4	S	2.5	-34.2	-15.4		0		36.7	17.9	18.8	4
M2	3-10	331401.5	6251157.2	T	2.5	-34.3	-17.8		0		36.8	20.3	16.5	3
M3	3-11	331400.3	6251153.4	S	2.5	-34.3	-17.6		0		36.8	20.1	16.7	3
M4	3-12	331399.2	6251149.5	T	2.5	-34.3	-17.3		0		36.8	19.8	17.0	3
M5	3-13	331398.0	6251145.7	S	2.5	-34.3	-17.0		0		36.8	19.5	17.3	3
M6	3-14	331396.8	6251141.8	T	2.5	-34.3	-16.7		0		36.8	19.2	17.6	3
M7	3-15	331395.6	6251138.0	S	2.5	-34.3	-16.4		0		36.8	18.9	17.9	3
M8	3-16	331394.5	6251134.2	T	2.5	-34.3	-16.2		0		36.8	18.7	18.1	4
M9	3-17	331393.3	6251130.4	S	2.5	-34.3	-15.9		0		36.8	18.4	18.4	4
M10	3-18	331392.1	6251126.6	T	2.5	-34.3	-15.0		0		36.8	17.5	19.3	4
L2	3-1	331397.6	6251158.3	P	2.5	-34.4	-17.7		10		37.5	20.5	17.0	3
L3	3-2	331396.5	6251154.5	T	2.5	-34.4	-17.5		10		37.5	20.3	17.2	3
L4	3-3	331395.3	6251150.7	S	2.5	-34.4	-17.2		0		36.9	19.7	17.2	3
L5	3-4	331394.2	6251146.9	T	2.5	-34.4	-16.9		0		36.9	19.4	17.5	3
L6	3-5	331393.0	6251143.0	P	2.5	-34.4	-16.6		0		36.9	19.1	17.8	3
L7	3-6	331391.8	6251139.2	T	2.5	-34.4	-16.3		0		36.9	18.8	18.1	4
L8	3-7	331390.6	6251135.3	S	2.5	-34.4	-16.1		0		36.9	18.6	18.3	4
L9	3-8	331389.5	6251131.6	T	2.5	-34.4	-15.6		0		36.9	18.1	18.8	4
L10	3-9	331388.3	6251127.7	P	2.5	-34.4	-14.8		0		36.9	17.3	19.6	4

Security:

FOR REVIEW AND COMMENT

A | ISSUED FOR STAGE 3 THE BAYS STATION EXCAVATION | JR | CP | FL 25.12.21

Design by | Verified by | Approved Initial/Date

SCALES

0 4 8 12m

SCALE 1:200 (A1) 1:400 (A3)

CLIENT

Transport for NSW

Sydney Metro West

afJV

SERVICE PROVIDERS

Jacobs TYPSA

DRAWN S.NOWAL 25.12.2021

DESIGNED J.RAYMER 25.12.2021

DRG CHECK V.NGUYEN 25.12.2021

DESIGN CHECK C.PARKER 25.12.2021

APPROVED F.LOPEZ 25.12.2021

SYDNEY METRO WEST

THE BAYS STATION

GEOTECHNICAL

GROUT HOLE SCHEDULE - AREA 3

SHEET 3 OF 4

DOCUMENT No: 1 | SHEET: 1 OF 1 | ©

STATUS: DESIGN STAGE 3 | EDMS NO:

DRG No. SMWSTCTP-AFJ-TBY-SN200-GE-DRG-002562 | REV A.1 | VER

A1 Original | Co-ordinate System: GDA20/MGA Zone 56 | Height Datum: A.H.D | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

WHITE BAY POWER STATION - GROUT HOLE SCHEDULE - AREA 4

Grout Hole within GRID	Grout Hole Number	Easting (m) 2020	Northing (m) 2020	Primary Secondary Tertiary	Surface RL (m)	Base of Hole RL (m)	Top of Rock RL (m)	Notes	Angle from Vertical	Hole Direction	Overall Length (m)	Casing Length (m)	Rock Grouted Length (m)	Number of Grout Stages
M3	4i-1	331397.4	6251152.8	T	2.5	-34.2	-17.2	Angled under Boiler House	15	west along tunnel	38.0	20.4	17.6	3
M5	4i-2	331395.8	6251147.9	T	2.5	-34.2	-16.6	Angled under Boiler House	15	southwest 240 deg	38.0	19.8	18.2	4
M7	4i-3	331392.7	6251137.7	T	2.5	-34.2	-16.2	Angled under Boiler House	15	northwest 300 deg	38.0	19.4	18.6	4
M9	4i-4	331391.5	6251133.1	T	2.5	-34.2	-15.5	Angled under Boiler House	15	west along tunnel	38.0	18.6	19.4	4
J3	4-21	331388.6	6251158.9	S	2.5	-34.2	-17.5	Inside Boiler House	0		36.7	20.0	16.7	3
J4	4-22	331386.6	6251152.1	P	2.5	-34.2	-19.9	Inside Boiler House	0		36.7	22.4	14.3	3
J6	4-23	331384.5	6251145.3	S	2.5	-34.2	-16.4	Inside Boiler House	0		36.7	18.9	17.8	3
J8	4-24	331382.6	6251138.8	P	2.5	-34.2	-16.0	Inside Boiler House	0		36.7	18.5	18.2	4
J10	4-25	331380.5	6251131.5	S	2.5	-34.2	-14.6	Inside Boiler House	0		36.7	17.1	19.6	4
I3	4-26	331385.2	6251159.9	T	2.5	-34.3	-17.4	Inside Boiler House	0		36.8	19.9	16.9	3
I4	4-27	331384.2	6251156.5	T	2.5	-34.3	-17.1	Inside Boiler House	0		36.8	19.6	17.2	3
I4	4-28	331383.2	6251153.1	T	2.5	-34.3	-16.8	Inside Boiler House	0		36.8	19.3	17.5	3
I5	4-29	331382.2	6251149.8	T	2.5	-34.3	-16.5	Inside Boiler House	0		36.8	19.0	17.8	3
H3	4-16	331381.8	6251161.0	P	2.5	-34.4	-17.2	Inside Boiler House	0		36.9	19.7	17.2	3
H4	4-17	331379.7	6251154.1	S	2.5	-34.4	-16.7	Inside Boiler House	0		36.9	19.2	17.7	3
H6	4-18	331377.7	6251147.3	P	2.5	-34.4	-16.2	Inside Boiler House	0		36.9	18.7	18.2	4
H8	4-19	331375.8	6251140.8	S	2.5	-34.4	-15.2	Inside Boiler House	0		36.9	17.7	19.2	4
H10	4-20	331373.6	6251133.5	P	2.5	-34.4	-13.9	Inside Boiler House	0		36.9	16.4	20.5	4
G3	4-11	331375.2	6251162.1	S	2.5	-34.6	-17.2	Inside Boiler House	0		37.1	19.7	17.4	3
G4	4-12	331375.0	6251155.6	P	2.5	-34.6	-16.2	Inside Boiler House	0		37.1	18.7	18.4	4
G6	4-13	331372.0	6251149.4	S	2.5	-34.6	-15.5	Inside Boiler House	0		37.1	18.0	19.1	4
G8	4-14	331371.0	6251142.2	P	2.5	-34.6	-14.6	Inside Boiler House	0		37.1	17.1	20.0	4
G10	4-15	331367.6	6251136.2	Provisional	2.5	-34.4	-13.9	Inside Boiler House	0		36.9	16.4	20.5	4
E3	4-6	331368.1	6251165.0	P	2.5	-34.8	-16.2	Inside Boiler House	0		37.3	18.7	18.6	4
E4	4-7	331366.1	6251158.1	S	2.5	-34.8	-15.5	Inside Boiler House	0		37.3	18.0	19.3	4
E6	4-8	331364.1	6251151.3	P	2.5	-34.8	-14.6	Inside Boiler House	0		37.3	17.1	20.2	4
E8	4-9	331362.2	6251144.8	Provisional	2.5	-34.4	-13.9	Inside Boiler House	0		36.9	16.4	20.5	4
E10	4-10	331360.3	6251137.9	Provisional	2.5	-34.4	-13.9	Inside Boiler House	0		36.9	16.4	20.5	4
C2	4-1	331362.9	6251167.9	S	2.5	-35.0	-15.5	Inside Boiler House	0		37.5	18.0	19.5	4
C4	4-2	331360.3	6251159.8	P	2.5	-35.0	-14.6	Inside Boiler House	0		37.5	17.1	20.4	4
C6	4-3	331358.4	6251153.6	Provisional	2.5	-34.4	-13.9	Inside Boiler House	0		36.9	16.4	20.5	4
C8	4-4	331356.3	6251146.4	Provisional	2.5	-34.4	-13.9	Inside Boiler House	0		36.9	16.4	20.5	4
C10	4-5	331354.7	6251140.9	Provisional	2.5	-34.4	-13.9	Inside Boiler House	0		36.9	16.4	20.5	4

100mm AT FULL SIZE

Plot Date: 14/12/21 - 18:00

Cad File: C:\users\andersr3\appdata\local\projectwise\jacobs_anz_ie\d0439070\SMWSTCTP-AFJ-TBY-SN200-GE-DRG-002560-002563.dwg

Security:

FOR REVIEW AND COMMENT

Rev	Description	Design by	Verified by	Approved Initial/Date
A	ISSUED FOR STAGE 3 THE BAYS STATION EXCAVATION	JR	CP	FL 25.12.21

SCALES

0 4 8 12m

SCALE 1:200 (A1) 1:400 (A3)

A1 Original | Co-ordinate System: GDA20/MGA Zone 56 | Height Datum: A.H.D | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing.

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DRAWN	S.NOWAL	25.12.2021
DESIGNED	J.RAYMER	25.12.2021
DRG CHECK	V.NGUYEN	25.12.2021
DESIGN CHECK	C.PARKER	25.12.2021
APPROVED	F.LOPEZ	25.12.2021

SYDNEY METRO WEST
THE BAYS STATION
GEOTECHNICAL
GROUT HOLE SCHEDULE - AREA 4
SHEET 4 OF 4

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Appendix B Construction Noise and Vibration Assessment

Construction noise and vibration impact assessment

WBPS Pre excavation Grouting

Proposed works	WBPS Pre-excavation Grouting		
Proponent	AFJV		
Assessment Date	19/01/2022		
Prepared by	Tin Le	**Assessment Id**	20220119

Introduction

This report has been prepared using the construction noise self-assessment platform KNOWnoise: *Minor Works* and presents an assessment of the likely noise impacts related to proposed works associated with the above project. Where possible, these works would be completed during standard construction hours; however, there may be a need to work outside these hours due to technical, community or access limitations. The location of the proposed works is illustrated in Appendix A.

Planned works

A description of the proposed works is as follows.

Pre-excavation Grouting at WBPS under CA05

Proposed activities and equipment for the works are summarised in Appendix B.

Though subject to change, the works are expected to commence around 08/02/2022 and would be completed by 09/02/2022.

Assessment criteria and mitigation requirements

Noise

The Interim Construction Noise Guideline (ICNG) (DECC 2009) describes noise more than the background level as potentially having an adverse impact on sensitive receivers and increasing the likelihood of complaint. During standard construction hours, where construction noise is within 10 dB(A) of the RBL, impacts would be acceptable.

Where construction noise is more than 10 dB(A) above the RBL during standard construction hours, a residential receiver is considered noise affected and the proponent should undertake all reasonable and feasible steps necessary to manage the impact and consult with the affected community.

Above a LAeq, 15 minute noise level of 75 dB(A), a receiver is highly affected, requiring consideration of additional mitigation measures including alternative accommodation in the night period.

Outside standard construction hours, construction noise at a residential receiver more than 5 dB(A) above the RBL is taken to be noise affected.

In addition, annoying noise such as rock hammers, impact piling, or other impulsive noise sources usually result in greater annoyance than continuous construction noise. A 5 dB(A) penalty is applicable to such activities prior to comparison with the NMLs.

Other sensitive land uses, such as schools and offices, typically find noise from construction disruptive when the properties are being used (such as during work and school times). Table 2 presents NMLs from the ICNG for sensitive land uses based on the principle that the characteristic activities for each of these land uses should not be unduly disturbed.

The difference between an internal noise level and the external noise level is about 10 dB(A), which provides a conservative assumption that windows are open for ventilation. Buildings where windows are fixed or cannot otherwise be opened may achieve a greater noise level performance.

Table 1 Non-residential sensitive land uses noise management levels

Land use	Noise assessment location	NML ($L_{Aeq,15min}$)
Classrooms at schools and other educational institutions	Internal	45
Places of worship		
Active recreation areas (such as sporting activities and activities which generate their own noise or focus for participants)	External	65
Passive recreation areas (contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External	60
Industrial premises	External	75
Office, retail outlets	External	70

Standard mitigation measures, as described in the ICNG and Construction Noise and Vibration Strategy (CNVS), would be implemented where reasonable and feasible. However, after these measures have been applied, noise and vibration levels may continue to exceed the NMLs.

In this case, additional mitigation measures outlined in the CNVS, which largely focus on engagement with affected sensitive receivers, should be implemented where reasonable and feasible, unless other agreements are in place with the impacted receiver.

Triggers and additional mitigation measures for airborne noise are summarised in Table 2. Further details of specific additional mitigation measures are described in the CNVG.

Table 2 Triggers for additional mitigation measures – Airborne noise (CNVS)

Construction hours	dB above NML	Additional management measures
Approved hours Monday – Friday: 7am – 6pm Saturday: 8am to 6pm	0 to 10	-
	10 to 20	LB
	20 to 30	LB, M, SN
	>30	LB, M, SN
Evening Monday – Friday: 6pm – 10pm Saturday: 7am – 8am, 6pm – 10pm Sunday / PH: 8am – 6pm	0 to 10	LB
	10 to 20	LB, M
	20 to 30	LB, M, SN, RO
	> 30	LB, M, SN, IB, PC, RO
Night Monday – Saturday: 10am – 7am Saturday: 10pm –8am) Sunday / PH: 6pm –7am	0 to 10	LB
	10 to 20	LB, M, SN, RO
	20 to 30	LB, M, SN, IB, PC, RO, AA
	> 30	LB, M, SN, IB, PC, RO, AA

Notes: PC = Phone calls and emails; SN = Specific notification
M = monitoring; LB = Letterbox drops
IB = Individual briefings; DR = Duration reduction
AA = Alternative accommodation; RO = Project specific respite offer

Sleep disturbance

The CNVS requires maximum noise levels to be analysed in terms of the extent and number of times the maximum noise exceeds specific noise trigger levels, in general accordance with the Noise Policy for Industry (NPfI) (EPA 2017). These triggers are:

- LAeq, 15 minute 40 dBA or the prevailing RBL plus 5 dB, whichever is greater, and the
- LAmax 52 dBA or the prevailing RBL plus 15 dB, whichever is greater.

The NPfI also recommends review of the DECCW (2011) Road Noise Policy (RNP) for further risk assessment. The RNP recommends maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep and one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.

Vibration

Effects of vibration from construction may be segregated into:

- Human exposure – disturbance to building occupants: vibration in which the occupants or users of the building are inconvenienced or possibly disturbed.
- Effects on building contents – vibration where the building contents may be affected.
- Effects on building structures – vibration in which the integrity of the building or structure itself may be prejudiced.

Vibration criteria relating to human comfort applicable to this project are taken from the DEC (2006) document Assessing Vibration – A Technical Guideline for intermittent vibration – such as from drilling, compacting or activities that would result in continuous vibration if operated continuously. Intermittent vibration is assessed as a vibration dose value (VDV) and relates to the level of vibration over time (cumulative over the night or day period). VDVs that may result in adverse comment from receivers are summarised in Table 3.

Table 3 Summary of vibration dose values which might result in adverse comment

Time	Low probability of adverse comment ($m/s^{1.75}$)	Adverse comment possible ($m/s^{1.75}$)	Adverse comment probable ($m/s^{1.75}$)
Day (6am to 10pm)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Night (10pm to 6am)	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Guidance for the consideration of potential building damage from construction vibration is in line with BS 7385-1 *Evaluation and measurement for vibration in buildings - Guide for measurement of vibration and evaluation of their effects on buildings*. These guideline values are presented in Table 4.

Table 4 Building damage vibration guidelines (BS 7385-1)

Type of building	Guideline values for vibration (PPV mm/s)		
	4Hz to 15Hz	15Hz to 40Hz	40Hz and above
Reinforced or framed structures / Industrial and heavy commercial buildings	50		
Un-reinforced or light framed structures / Residential or light commercial type buildings	15 - 20	20 - 50	50

For heritage structures, criteria are in line with the German Standard *DIN 4150-3: Structural Vibration- effects of vibration on structures,* as summarised in Table 5.

Table 5 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on heritage structures (DIN 4150-3).

Type of building	Guideline values for vibration (PPV mm/s)			
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	Vibration at horizontal plane of highest floor at all frequencies
Structures that, because of their sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8

The safe working distances presented in Table 6 are indicative and will vary depending on the item of plant and local geotechnical conditions. The cosmetic damage thresholds apply to typical buildings under typical geotechnical conditions and vibration monitoring is recommended at specific sites. Where structures are more sensitive, such as heritage items, more stringent conditions are applicable and should be considered individually.

In relation to human response, the safe working distances relate to continuous vibration. For most construction activities, vibration emissions are intermittent and higher vibration levels over shorter periods are acceptable. Additional assessment should be undertaken where the human response criteria are exceeded.

Table 6 Safe working distances for vibration intensive plant

Plant item	Rating/description	Safe working distance	
		Cosmetic damage (BS 7385-1)	Human response (DECCW)
Vibratory roller	<50 kN (typically 1-2 t) <100 kN (typically 2-4 t) <200 kN (typically 4-6 t) <300 kN (typically 7-13 t) >300 kN (typically 13-18 t) >300 kN (> 18 t)	5 m 6 m 12 m 15 m 20 m 25 m	15 m to 20 m 20 m 40 m 100 m 100 m 100 m
Small hydraulic hammer	300 kg – 5 to 12 t excavator	2 m	7 m
Medium hydraulic hammer	900 kg – 12 to 18t excavator	7 m	23 m
Large hydraulic hammer	1600 kg – 18 to 34 t excavator	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤800 mm	2 m	n/a
Jackhammer	Hand held	1 m	Avoid contact with structure

Existing environment and noise management levels

The proposed works would be undertaken in a predominantly Urban/ Industrial, characterised as:

Areas with dense transportation with some commerce of industry.

Typically on or near an arterial or sub arterial road OR near rail line;

24 hour traffic movement

Background noise levels adopted for the project area and associated noise management levels (NMLs) are summarised in Table 7. NMLs have been established in line with the ICNG.

Table 7 Construction NMLs

Land use	**Urban/ Industrial**		Using custom background noise data?		**Yes**
Criterion	Day	Weekend Day	Evening	Night	Sleep
RBL	43	43	43	35	
NML	53	53	48	40	40

Assessment methodology

Based on the nominated works area (illustrated in Appendix A), proposed equipment and the minimum distance from the works to each sensitive receiver, noise levels were calculated based on CONCAWE (1981) P*ropagation of noise from petroleum and petrochemical complexes to neighboring communities.*

This method considers geometric spreading, atmospheric absorption, ground effects and is valid for meteorological conditions of a gentle breeze from source to receiver and stable atmosphere (temperature inversion).

KNOWnoise: Minor works is a 2-Dimensional assessment platform and does not consider terrain effects (e.g. hills, valleys) or the presence of solid structures such as homes or noise barriers. This will result in a conservative prediction, suitable for the project being assessed.

Considering the nature of the works and the type of surrounding land uses, sensitive receivers up to a radius of 200 metres from the works have been included in the assessment.

Sound power levels and predicted noise levels depend on the number of plant items operating at any one time and their precise location relative to a sensitive receiver. Equipment was assumed to be working at the worst-case location relative to each receiver and represents a worst-case assessment. Where the activity is further away from receivers or less equipment is used the predicted levels will decrease.

Sound power levels for plant and equipment expected to be used for each activity has been estimated based on guidance in the following standards and guidelines as well as typical measured noise levels for specific equipment.

- Australian Standard AS2436-2010: Guide to noise and vibration control on construction, demolition and maintenance sites
- Construction Noise and Vibration Strategy (CNVS) (TfNSW, 2019)
- British Standard 5228-1:2009 Code of practice for noise and vibration control on construction and open sites
- United Kingdom Department for Environment, Food and Rural Affairs (DEFRA) Noise database for prediction of noise on construction and open sites

Construction noise sources and associated sound power levels are listed in Appendix B. The maximum predicted LAeq noise level within the work area was identified for each receiver.

Predicted noise levels

Detailed predicted noise levels for each potentially affected receiver are presented Appendix C.

Predictions indicate 0 receivers are predicted to be classified as Highly Impacted during the Day period. A summary of predicted exceedances of the NML for the Day period is presented in Table 8.

Table 8 Summary of predicted noise levels with comparison against CNVS criteria

Criterion		Predicted number of receivers
Maximum cumulative predicted $L_{Aeq, 15\ minute}$ noise level		70 dB(A)
Number of highly noise affected receivers (>75 dB)		0
Impact class	Predicted noise level	Predicted number of receivers
Noticable	0 <= 10 dB above NML	0
Clearly Audible	10 <= 20 dB above NML	0
Moderately Intrusive	20 <= 30 dB above NML	0
Highly Intrusive	> 30 dB above NML	0

Predicted impact classes for the Day period are illustrated graphically in Appendix C. Each identified receiver in the study area has been coloured to highlight the predicted level of impact.

Sleep disturbance

In the event works are planned for more than two consecutive nights, sleep disturbance is considered. Table 9 summarises the number of residents predicted to exceed the sleep disturbance screening criterion. Further analysis is also provided to indicate the number of receivers expected to be woken, at LAmax noise levels greater than 65 dBA.

Where exceedances of the awakening criteria are predicted, additional care should be taken and mitigation measures implemented in the with the CNVG.

Table 9 Summary of predicted exceedances of sleep disturbance screening criterion and awakening criterion.

Criterion	Predicted number of receivers
Potentially Sleep Disturbed (exceed RBL + 15 screening criterion)	0
Sleep Disturbed (exceed 65 dBA awakening criterion)	0

Predicted vibration impacts

The level of vibration impact on sensitive receivers (buildings and human comfort) will largely depend on the type of machinery in use and the distance from source to receiver.

Based on the proposed work locations and selected equipment, the following level of vibration impact is expected. A summary of vibration impacts is provided for each sensitive receiver in Appendix C.

Impact classification	Number of potentially affected receivers
Human comfort	0
Cosmetic damage	0
Heritage structure	0

Proposed noise mitigation measures

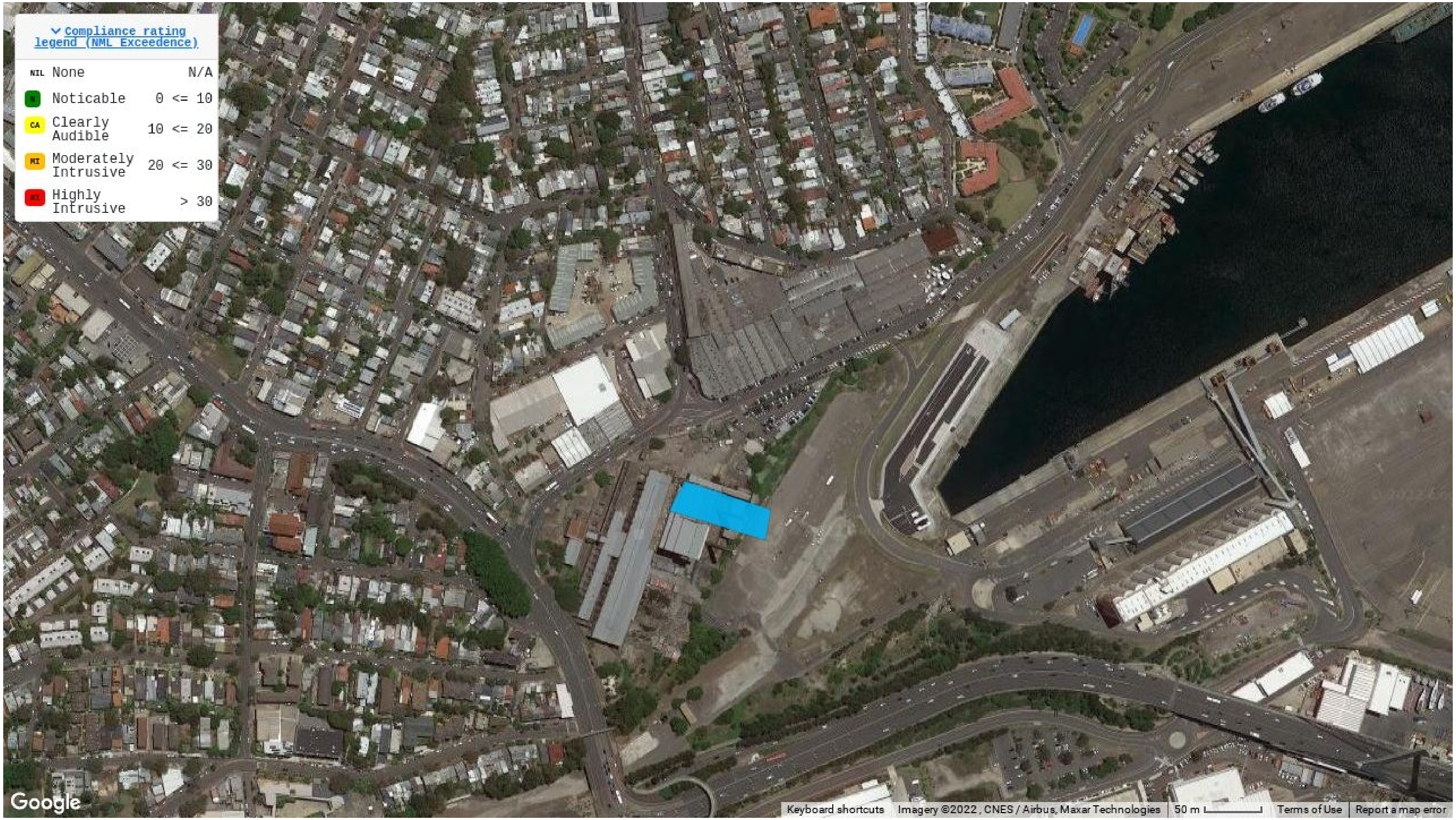
The safeguards and controls listed in Table 6 will be implemented where reasonable and feasible with the intention of achieving the project noise criteria and to maintain noise impacts at a practical minimum.

Table 10 Safeguards and controls

Action	Description
Community consultation or notification	Notify the affected community. The notification will detail work activities, dates and hours, impacts and mitigation measures, indication of work schedule over the night time period, any operational noise benefits from the works (where applicable) and contact telephone number. Notification should be a minimum of 7 calendar days prior to the start of works. For projects other than maintenance works more advanced consultation or notification may be required.
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction. The induction would at least include: • all project specific and relevant standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures site opening/closing times (including deliveries) environmental incident procedures
Behaviour	No swearing or unnecessary shouting or loud stereos/radios on site. Limit compression braking at night in residential areas. No dropping of materials from height, throwing of metal items and slamming of doors.
Verification	Where indicated in Appendix C, a noise verification program would be undertaken for the duration of the works.
Construction hours	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Respite for out-of-hours works	Respite would be scheduled as indicated in Appendix C and described in the CNVG.
Equipment selection	Use quieter construction methods where feasible and reasonable. Ensure plant including the silencer is well maintained. Plant noise levels will have an operating noise emission level compliant with Appendix F of the CNVG
Use and siting of plant	The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.

Action	Description
Plan worksites and activities to minimise noise and vibration.	Locate compounds away from sensitive receivers and discourage access from local roads. Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site. Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impact by concentrating noisy activities at one location and move to another as quickly as possible. Very noise activities should be scheduled for normal working hours. If the work can not be undertaken during the day, it should be completed before 11:00pm. Where practicable, work should be scheduled to avoid major student examination periods when students are studying for examinations such as before or during Higher School Certificate and at the end of higher education semesters.
Non-tonal reverse alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.
Shield stationary noise sources such as pumps, generators, and compressors	These should be enclosed or shielded where reasonable and feasible.
Implement any project specific mitigation measures	
1	None

Appendix A Project location and predicted level of impact



Appendix B Proposed activities and equipment

Pre-excavation Grouting at WBPS

Equipment	Quantity	Usage	Reduction	SWL
Drill rig - tracked mobile 20 tonne	1	40 %	5	109
Generator (100 kVA)	1	100 %	5	88
Grout pump	1	70 %	5	90
Light vehicle	3	10 %	0	80
Telehandler	1	40 %	0	96
Vacuum (Industrial)	1	30 %	0	95

Activity Sound Power Level: 109

Appendix C Detailed noise predicted for each receiver

Noise

Assessment: WBPS Pre-excavation Grouting				NML, LAeq, 15 minute				Sleep, LAmax		Predicted noise level, dBA		Exceedance summary										
													Exceed NML by (dB):				Exceed sleep disturbance by (dB):		Impact classification			
NCA	Rec	Address	Land use	Day	O/day	Eve	Night	Screen	Awake	Cumulative LAeq, 15 minute	LMax	Highly Affected?	Day	O/day	Eve	Night	Screen	Awake	Day	O/day	Eve	Night
NCA 1	577698	174 MULLENS STREET ROZELLE	NONE	65	65	65	65			52	66		0	0	0	0	-	0	None	None	None	None
NCA 1	577697	2-8 PARSONS STREET ROZELLE	NONE	65	65	65	65			54	68		0	0	0	0	-	0	None	None	None	None
NCA 1	577696	2-8 PARSONS STREET ROZELLE	NONE	65	65	65	65			56	69		0	0	0	0	-	0	None	None	None	None
NCA 1	577695	2-8 PARSONS STREET ROZELLE	NONE	65	65	65	65			58	72		0	0	0	0	-	0	None	None	None	None
NCA 1	577694	UNIT 2/ 4 MANSFIELD STREET ROZELLE	NONE	65	65	65	65			52	65		0	0	0	0	-	0	None	None	None	None
NCA 1	577693	UNIT 2/ 4 MANSFIELD STREET ROZELLE	NONE	65	65	65	65			55	69		0	0	0	0	-	0	None	None	None	None
NCA 1	577692		IND	75	75	75	75			66	79		0	0	0	0	-	0	None	None	None	None
NCA 1	577691	165 VICTORIA ROAD ROZELLE	NONE	65	65	65	65			55	69		0	0	0	0	-	0	None	None	None	None
NCA 1	577690		NONE	65	65	65	65			61	75		0	0	0	0	-	0	None	None	None	None
NCA 1	577689	18 CRESCENT STREET ROZELLE	RES	53	53	48	40			50	64		0	0	2	10	-	0	None	None	Noticable	Clearly Audible
NCA 1	577688	20 CRESCENT STREET ROZELLE	RES	53	53	48	40			50	63		0	0	2	10	-	0	None	None	Noticable	Noticable
NCA 1	577687	9 LILYFIELD ROAD ROZELLE	RES	53	53	48	40			50	64		0	0	2	10	-	0	None	None	Noticable	Clearly Audible
NCA 1	577686	23 PARSONS STREET ROZELLE	RES	53	53	48	40			51	64		0	0	3	11	-	0	None	None	Noticable	Clearly Audible
NCA 1	577685	4 ROBERT STREET ROZELLE	NONE	65	65	65	65			54	67		0	0	0	0	-	0	None	None	None	None
NCA 1	577684	165 VICTORIA ROAD ROZELLE	NONE	65	65	65	65			55	68		0	0	0	0	-	0	None	None	None	None
NCA 1	577683	6 HORNSEY STREET ROZELLE	RES	53	53	48	40			49	63		0	0	1	9	-	0	None	None	Noticable	Noticable
NCA 1	577682	2 HORNSEY STREET ROZELLE	RES	53	53	48	40			50	63		0	0	2	10	-	0	None	None	Noticable	Noticable
NCA 1	577681	2 ROBERT STREET ROZELLE	NONE	65	65	65	65			54	67		0	0	0	0	-	0	None	None	None	None
NCA 1	577680	13 LILYFIELD ROAD ROZELLE	RES	53	53	48	40			50	64		0	0	2	10	-	0	None	None	Noticable	Noticable
NCA 1	577679	21 PARSONS STREET ROZELLE	RES	53	53	48	40			51	65		0	0	3	11	-	0	None	None	Noticable	Clearly Audible
NCA 1	577678	13 LILYFIELD ROAD ROZELLE	RES	53	53	48	40			50	63		0	0	2	10	-	0	None	None	Noticable	Noticable
NCA 1	577677	17 PARSONS STREET ROZELLE	RES	53	53	48	40			51	65		0	0	3	11	-	0	None	None	Noticable	Clearly Audible
NCA 1	577676	32 VICTORIA ROAD ROZELLE	NONE	65	65	65	65			50	64		0	0	0	0	-	0	None	None	None	None
NCA 1	577675	6 ROBERT STREET ROZELLE	NONE	65	65	65	65			54	68		0	0	0	0	-	0	None	None	None	None
NCA 1	577674	165 VICTORIA ROAD ROZELLE	IND	75	75	75	75			67	80		0	0	0	0	-	0	None	None	None	None
NCA 1	577673	10 ROBERT STREET ROZELLE	NONE	65	65	65	65			55	68		0	0	0	0	-	0	None	None	None	None
NCA 1	577672	8 ROBERT STREET ROZELLE	NONE	65	65	65	65			54	68		0	0	0	0	-	0	None	None	None	None
NCA 1	577671	12 ROBERT STREET ROZELLE	NONE	65	65	65	65			55	69		0	0	0	0	-	0	None	None	None	None
NCA 1	577670	UNIT 16/ 3 HORNSEY STREET ROZELLE	RES	53	53	48	40			51	64		0	0	3	11	-	0	None	None	Noticable	Clearly Audible
NCA 1	577669	UNIT 15/ 1-13 PARSONS STREET ROZELLE	NONE	65	65	65	65			52	65		0	0	0	0	-	0	None	None	None	None
NCA 1	577668	24 ROBERT STREET ROZELLE	NONE	65	65	65	65			55	68		0	0	0	0	-	0	None	None	None	None
NCA 1	577667	165 VICTORIA ROAD ROZELLE	IND	75	75	75	75			70	84		0	0	0	0	-	0	None	None	None	None

Vibration

NCA	Receiver	Address	Vibration Impact