Integrated Management System

Barangaroo temporary northern shaft

Planning Approval Consistency Assessment Form

SM ES-FT-414

Sydney Metro Integrated Management System (IMS)

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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)):

Sydney Metro Chatswood to Sydenham SSI-7400 as modified 18 October 2017, 13 December 2017 and 21 December 2017.

Date of determination:

Infrastructure Approval date 09 January 2017

Modification 1 Approval date 18 October 2017

Modification 4 Approval date 13 December 2017

Modification 2 Approval date 21 December 2017

Consistency Assessment Barangaroo Traction Substation (TfNSW 7 Approved 9 May 2017)

Consistency Assessment Protection of High Street Cutting (TfNSW 9 approved 6 September 2017)

Consistency Assessment Barangaroo Utilities Augmentation (TfNSW 10 Approved 11 December 2017)

Consistency Assessment Barangaroo Temporary Additional Land (TfNSW 23 Approved 11 October 2017)

Type of planning approval:

Critical State Significant Infrastructure

Description of existing approved project you are assessing for consistency:

The Chatswood to Sydenham component of Sydney Metro City & Southwest project comprises a new metro rail line, approximately 16 kilometres long, between Chatswood and Sydenham. New metro stations would be provided at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo, as well as new underground metro platforms provided at Central Station. Given the modifications that have been approved, CSSI Approval No. 15_7400 is now approved to operate to Sydenham Station and also includes the upgrade of Sydenham Station.

Tunnel boring machines would be used to excavate the twin tunnels. It was anticipated that tunnelling would occur from three tunnel boring machine launch and support sites as follows:

- A site in Chatswood (south of Chatswood Station and north of Mowbray Road), referred to as the Chatswood dive site (northern)
- A site in Marrickville (north of Sydenham Station and south of Bedwin Road), referred to as the Marrickville dive site (southern)
- A site at the proposed Barangaroo Station for the crossing of Sydney Harbour (Barangaroo Station construction site)

Barangaroo Station construction site

The concept Barangaroo Station construction site was assessed on the expectation that it would cover approximately 13,800 square metres within the road reserve of Hickson Road and the adjacent Barangaroo development area. The area has since increased through construction licence from BDA and consistency assessments were prepared to assess the additional temporary construction land as referenced above. The changes addressed in the consistency assessments have been developed having regard to the interface with the development of BDA lands and the construction methodology developed by the contractor.

The site was assessed and approved to:

- Launch and support the tunnel boring machine (TBM) for the Sydney Harbour crossing drive to Blues Point
- Retrieve the cutter heads and shields of the two TBMs driven from the Marrickville dive site
- Carry out the excavation and construction of Barangaroo Station.

Access to and egress from the Barangaroo site was identified as being via Hickson Road.

The location and indicative layout of the Barangaroo Station construction site is illustrated in the Environmental Impact Statement (EIS) Figure 7-13 also shown in this document as Appendix A.

Station excavation and construction

The station would be constructed using a cut-and-cover technique, resulting in about 145,000 cubic metres of spoil. The cut-and-cover work underneath Hickson Road was identified as requiring management to generally maintain one traffic lane in each direction, with the exception of some full road closures at night. (see map in **Error! Reference source not found.**).

Station excavation and construction

The station will be constructed using a cut-and-cover technique, resulting in about 145,000 cubic metres of spoil. Cut-and-cover work underneath Hickson Road will be managed to generally maintain one traffic lane in each direction, with the exception of some full road closures at night. (see map in **Error! Reference source not found.**).

Barangaroo Station was assessed and approved to have an acoustic shed covering the excavation.

Barangaroo crossover cavern

The Barangaroo track crossover cavern would be located approximately 25m underground to the north of Barangaroo Station and would be around 230 metres long, 12 metres high and 20 metres wide. The location of the track cross-over is shown on Figure 3-1 of the Submissions and Preferred Infrastructure Report (SPIR) and included in this assessment in Appendix A.

Construction of the cross-over would be carried out from the Barangaroo Station construction site. This would involve:

- Excavation of the cavern using road headers
- Lining of the cavern to form a tanked structure

- Fit-out of the cavern with track, mechanical and electrical equipment.

Tunnel boring machine launch and support

The northern section of the station was assessed and approved to be excavated to enable assembly and launch of the (TBM) for the harbour crossing drive to Blues Point.

The harbour crossing TBM is driven from Barangaroo Station about one kilometre to the north to the Blues Point temporary site where the cutter heads and shields would be retrieved and transported back to Barangaroo Station. The remaining components (including support services) would be pulled back to Barangaroo Station through the tunnel. The TBM would be re-assembled to carry out the excavation of the second tunnel under Sydney Harbour. The cutter heads and shields would then be retrieved through the Blues Point temporary site and the remaining components (including support services) pulled back through the tunnel and retrieved from the Barangaroo Station site.

This site was identified as requiring TBM support services including high voltage power supply, water supply, fresh air ventilation, grout batching plant, drainage and water treatment, workforce facilities, spoil storage and removal, and storage and introduction of pre-cast concrete lining elements. The site would also require a separation treatment plant to remove excavated spoil from the slurry mixture and to re-circulate the slurry material to the cutting face. The separation plant would only be required when the TBM is operating in a 'slurry mode' through the non-rock section of the drive. About 90,000 cubic metres of spoil would be removed through the site from the tunnelling works.

Program

The overall program for delivery of the Sydney Metro City & Southwest Chatswood to Sydenham project was identified as seven years with the project expected to be opened to the public in 2024, Enabling works (preliminary construction activities required to facilitate substantial construction) were identified as commencing in early 2017, with substantial construction of the project planned to commence in early 2018.

The indicative construction program specific to Barangaroo is outlined in Table 7-12 of the EIS and reproduced in Appendix I. Barangaroo is a particularly important site in the delivery of the project given its role in driving TBMs under the harbour, as well as a retrieval site for the TBMs being driven from the southern sites.

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

- Chatswood to Sydenham Environmental Impact Statement and accompanying technical papers (May, 2016)
- Chatswood to Sydenham Submissions and Preferred Infrastructure Report (SPIR) (October, 2016)

All proposed works identified in this assessment would be undertaken in accordance with the mitigation measures identified in the EIS and PIR and the Infrastructure Approval as modified.

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 work involves the construction, operation and decommissioning (prior to rail operations) of the Barangaroo temporary northern shaft. The primary purpose of the shaft is to separate and relocate the construction access/egress points for the crossover cavern from the station box to the northern shaft, as well as launch and support the harbour TBMs, and removal of the hard rock TBMs. These construction related activities were identified in the EIS/SPIR as occurring in the northern section of Barangaroo station. The proposed works are intended to occur in the northern section of the Barangaroo Station site in a location that was included in the project area and identified for construction laydown activities.

Works associated with the temporary northern shaft are detailed below.

Acoustic shed installation (Stage 1)

The Stage 1 acoustic shed consists of a portal frame approximately 32m long x 16m wide x 21m high incorporating a 220T capacity gantry crane. The acoustic shed would be required to be tethered into the rock face within the State Heritage Register (SHR) curtilage of the Millers Point & Dawes Point Village Precinct to maintain the strength and support for the gantry crane. The tethering would be in the form of 2 rock bolts, for each of the five portal frames of the shed and has been designed to be within the Hickson Road cutting itself rather than within the masonry work.

The height of the acoustic shed is such that it can facilitate the safe access and egress of heavy equipment such as the TBMs and road headers but also incorporate a 5.5m high muck bin to maintain excavation production rates and maintain the construction program.

Some activities associated with the construction of the acoustic shed would be required during night-time periods due to the need for a Road Occupancy Licence (ROL). The duration of the works to construction the acoustic shed is approximately 6 to 12 weeks, dependent on the number of nights construction work can be undertaken per week under the Environment Protection Licence (EPL).

Shaft excavation

The shaft is approximately 17m long x 10m wide x 30m deep and would be excavated using traditional excavation methods including rock sawing and excavator and rock hammer within the acoustic portal frame to minimise noise impacts at nearby sensitive receivers. Spoil would be lifted out in a kibble by the gantry crane which would be fixed to the acoustic shed portal frame. Rock bolts from the shaft into the surrounding rock below ground would be installed to ensure stability. None of these below ground rock bolts would be visible.

High noise activities associated with construction of the shaft would be undertaken during the 7 am to 8 pm daytime/evening period for up to 6.5 hours per day in accordance with Approval Conditions E37 and E38 and the requirements of the EPL. The shaft spoil would be transported from site by road truck and trailers, including some out of hours works. The duration of the works to construct the shaft is approximately two months.

Tunnelling support operations and spoil removal

Following the erection of the acoustic shed and shaft excavation works, spoil associated with the excavation of the crossover cavern would be transferred

between the temporary northern shaft and the spoil loadout shed near the Barangaroo barge area.

Within the acoustic shed, spoil would be loaded into a kibble at the bottom of the shaft, lifted to the surface by gantry crane and loaded into trucks with a front-end loader.

Concrete trucks (unloaded inside the acoustic shed) would also be required to support shotcreting activities for the underground excavation and the installation of the final concrete lining of the crossover cavern, under harbour cross passage structures and the invert concrete in the running tunnels.

Loading and transporting of spoil and concrete is proposed to be undertaken out of standard hours subject to EPL requirements. The duration of the works is approximately two years (Mid 2018 to 2020).

During the 6 pm to 7 am evening/night period, tunnel ventilation fans would remain operational as part of the tunnel ventilation strategy and associated safety requirements. The gantry crane would also operate during this period to transport materials and personnel between the tunnels and ground surface.

On the outside of the shed there would be lighting at the Hickson Road level.

TBM delivery, assembly and disassembly

Harbour TBM components are proposed to be transported from the Barangaroo barge area to the temporary northern shaft via self-propelled modular trailers. For each delivery (2 of), these works are proposed to occur over a period of approximately 10 days and incorporate day, evening and night periods under Road Opening Licences (ROL). Retrieval of the hard ground TBMs (2 of) from Marrickville would also occur at the temporary northern shaft over a similar timeframe.

Assembly and dis-assembly of the harbour TBMs would occur inside the crossover cavern. The gantry crane would be utilised to raise and lower the TBM components within the acoustic shed.

Harbour TBM support operations

TBM would be launched from the crossover cavern and retrieved at Blues Point shaft. During the TBM operation, the slurry from the TBM would be transferred via pipeline to the slurry treatment plant near the Barangaroo barge area. Spoil would then be removed from site via barge. The TBM operational requirements would also be supported from the northern shaft e.g. segment delivery, grout, grease and other operational materials.

Tunnel/Station fitout shed (Stage 2)

Following completion of the tunnelling and shotcreting activities for the underground excavation and the installation of the final concrete lining of the crossover cavern, under harbour cross passage structures and the invert concrete in the running tunnels the acoustic shed and 220T gantry crane would be removed and a reduced height shed installed to facilitate the delivery of smaller plant and materials to the tunnels and crossover cavern for their fitout. The height of this shed would be designed to be no higher than the level of the adjacent bridges approx. 16m.

The temporary northern shaft would be decommissioned and reinstated to Hickson Road prior to operation of the Sydney Metro.

3.0 Timeframe

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

Approved standard working hours for the Project are as follows:

- 07:00 – 18:00 Monday to Friday
- 08:00 – 13:00 Saturdays
- No works Sundays or Public holidays

Out of hours works are required due to impacts on the road network and to support the approved 24 hour tunnelling operations and would be undertaken in accordance with the Project Planning Approval Conditions, Approved Traffic Management Plans and the applicable contractors Environmental Protection Licence.

One of the objectives of this proposal is to maintain the existing program as set in Section 7.3 of the EIS. If the temporary northern shaft was not implemented TfNSW expect the project being delayed by up to 14 months.

Subject to the endorsement of this assessment, acoustic shed stage 1 installation and shaft excavation works are expected to occur between March and June 2018. The stage 1 shed and gantry crane would be decommissioned in 2020.

A reduced height shed (Stage 2) would be built to be within the height line of the adjacent bridges. The stage 2 shed would be installed in 2020 and decommissioned along with the temporary northern shaft in 2024, before the Metro becomes operational. Hickson Road would be reinstated at this time.

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.

Barangaroo Station is located between Hickson Road and Nawi Cove / Sydney Harbour, within the suburb of Barangaroo and to the north of the Central Barangaroo development.

The temporary northern shaft is within the northern section of the approved Barangaroo Station Construction Site as shown in Figure 7-13 from the EIS also shown as Appendix A of this document and is proposed entirely within the road surface and road reserve of Hickson Road Millers Point between the Dalgety Rd and Windmill St bridges.

Hickson Road is classified as a local road which is under the control of Barangaroo Delivery Authority between Napoleon Street and Windmill Street bridge. Outside of this location the City of Sydney is the responsible road authority. The road commences at Sussex Street to the south and continues to meet George Street at The Rocks. The speed limit on Hickson Road is currently signposted as 40km/hr.

The works are within the State Heritage conservation area Dawes Point and Millers Point Conservation Area. See Map Appendix B.

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 site is located at Millers Point, however is associated with the construction of the Sydney Metro Barangaroo Station. The site comprises of Hickson Road between Dalgety Road, Argyle Place and Windmill Street. See Appendix B for a map of the works area.

The project is located in close proximity to several heritage sites of local and state significance, as well as the Millers Point Heritage Conservation Area, and the Millers Point & Dawes Point Village Precinct Heritage Conservation Area, which have state heritage significance.

The key visual features of the site are:

- The natural sandstone cutting on Hickson Road rise approximately 12 metres from Hickson Road.
- The decorative, arched Windmill Street and Argyle Place bridges are 'landmark' structures
- Glimpsed views to the harbour along Dalgety Road
- The visual prominence of the 'landmark' Palisade Hotel
- Views to the towers of the Sydney CBD and Barangaroo from the bridges and adjacent streets
- Character of the terraces at the corner of Argyle Place
- Historic character buildings on Windmill Street, facing the sandstone cutting, visually extends the vertical plane of the cutting, matching in colour and texture.

The Barangaroo Central Development is located to the south of the proposed construction site and currently comprises Barangaroo Delivery Authority (BDA) construction activities. The Cutaway cultural space is located within Barangaroo Reserve, to the west of the proposed haft.

Residential properties are located above the cliff wall on Dalgety Road and Windmill Street. Sydney Harbour and Nawi Cove are located to the west of the proposed works.

The acoustic sheds (Stage 1 and 2) and shaft works to be undertaken would be within the road or road reserve.

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.

As specified in the EIS/SPIR and the Project Planning Approval Condition E103, TfNSW are to engage in consultation with BDA to manage potential conflicts between the two adjacent construction projects (BDA development and Sydney Metro Barangaroo Station).

The SPIR states “The design development of the station at Barangaroo is subject to interface with the Barangaroo Delivery Authority.”

Consultation as specified above has led to the development of an interface agreement between TfNSW and BDA. During the development of that interface agreement the following construction constraints were identified and agreed;

- The need to maintain access and egress to support the construction of BDA Central Development site which has restricted the access and construction methodology proposed for Barangaroo station.
- TfNSW is required to maintain public access through the Hickson Road Licensed Area in a north-south direction consisting of at least:

  (i) two vehicular lanes at least 3.5 metres wide; and

  (ii) one pedestrian footpath at least 2 metres wide.

In addition to minimise the construction interface between the TfNSW and BDA Contractors, TfNSW prohibited the use of temporary anchors to support station box excavation being installed into BDA land.

These constraints would have significant impacts to the construction program but for the construction of the proposed temporary northern shaft.

In order to maintain the indicative construction program (see section 7.3 of the EIS) it is proposed to construct the temporary northern shaft within Hickson Road between the Dalgety Road and Windmill Street bridges which would enable the crossover cavern works to be undertaken concurrently with the station excavation and construction. These works are located within an area which was identified for construction related activities in the SPIR.

Alternative Options Considered

1. No temporary northern shaft
   - The access/egress point to construct the crossover cavern, launch and support the harbour TBMs would be from the station box
   - The hard rock TBMs would be removed from the station box
   - This option would result in an approximate delay of 14 months to the delivery of Sydney Metro Chatswood to Sydenham project as the cavern excavation works cannot commence until the station box has been sufficiently excavated
   - Further significant delays associated with the follow on contracts who are currently considering using this shaft to deliver a third of their scope
   - Delays of 14 months to the program also extend the duration of the environmental and community impacts associated beyond the period contemplated by the EIS and SPIR
2. Temporary shaft with reduced height shed
   - A 16m high acoustic shed would reduce the visual impact to the area.
   - The duration of the shaft and crossover cavern excavation works would be significantly extended as the contractor would become spoil bound

within the shed during the night shift (spoil bound in this context meaning the excavation would have to cease because of the amount of spoil removed exceeded the capacity of the storage on site. The proposed 21m high shed incorporates a 5.5m high spoil storage area thus allowing 24hr excavation works)

- The harbour TBM would need to be delivered via the station box and the two hard rock TBMs would need to be removed via the station box utilising mobile cranes. This would result in significant temporary works associated with the construction of mobile crane piling pads and piles which would conflict with the requirements of the BDA interface agreement and involve impacts on construction traffic and utility diversions at either end of the station at surface level. Additionally vehicle traffic movements on Hickson Road would be impacted with full road closures required of approx. 7 days on 4 separate occasions.
- This option would result in an approximate delay of 12 months to the delivery of the Sydney Metro Chatswood to Sydenham project.
- Delays of 12 months to the program also extend the duration of the environmental and community impacts associated beyond the period contemplated by the EIS and SPIR

3. Temporary shaft with no acoustic shed
   - Visual impact would be consistent with laydown area identified in the EIS, albeit with mobile cranes visible from around this location
   - The excavation of the shaft would be subject to daytime works only requiring a longer program.
   - There would be a high noise impact, exceeding the conditions of approval.
   - There would need to be water suppression dust control
   - A mobile crane would be required to lift the TBM, machinery and segments into the shaft, likely location would be Dalgety Road Bridge or Windmill Street, however due to the weight of the TBM it is unlikely these roads would be able to facilitate the weight, making this option not achievable

Based on the delivery of the project as a whole, and having regard to the options available, the concept level of design in the EIS and SPIR and the requirement for the detailed design of the Station to be developed through consultation with BDA, the temporary northern shaft with acoustic mitigation is considered to best achieve the required outcomes i.e. to deliver the project within the program, involving activities generally consistent with those described in the EIS & SPIR.

7.0 Environmental Benefit

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

Barangaroo station box and crossover cavern are key sites required to deliver the Chatswood to Sydenham Metro project to program. Barangaroo is essential for the facilitation of the harbour TBM tunnelling operations.

The acoustic sheds over the temporary shaft would provide noise and dust mitigation to ensure that works are within the limitations set by the conditions of approval.

Additionally the benefit of the temporary northern shaft is to maintain the existing program as set indicatively in Section 7.3 of the EIS. If the proposed temporary northern shaft was not implemented TfNSW anticipates the Sydney Metro Chatswood to Sydenham project delivery could be delayed by up to 14 months. With this in mind, the installation of the acoustic shed and temporary shaft significantly reduces the potential duration of construction impact to the surrounding community.

Some of the constraints imposed through the interface agreement with BDA have influenced the construction methodology and delivery of the works within the intended program. However, these constraints were imposed to manage the interface between the delivery of two projects/developments under construction within similar timeframes to ensure the overall development to this precinct is delivered within the desired timeframes.

8.0 Control Measures

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

A site-specific EMP would not be prepared for this scope, as the proposed works would be managed in accordance with the relevant contractors Construction Environmental Management Plans (CEMP).

CEMP for this project must be produced in accordance with the conditions of approval and approved by Department of Planning and Environment.

See Section 10 for more site specific mitigation measures.

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 would be incorporated into the design?

This scope is temporary and would not directly be impacted by climate change.

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	There would be no impact to vegetation Flora and Fauna as a result of this proposal as it is located entirely within the existing site area and does not require any vegetation clearing.	No additional mitigation is required.	Y	Y	
Water	The temporary shaft is located within the existing project construction area and the installation of the acoustic shed would work to assist in the separation of stormwater runoff from site water. Sandstone is generally low to very low permeability, with the majority of groundwater flow transmitted through joints and fractures. As such groundwater inflow during the construction and use of the shaft is predicted to be low. The shaft would be backfilled at the end of construction so there is no residual operational impact to groundwater.	During construction, erosion and sediment controls would be installed, inspected and maintained where required and water including stormwater runoff and groundwater would be treated as per the Contractors Construction Soil Water and Groundwater Management Plan.	Y	Y	

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				Y/N	Comments
Air quality	The main potential air quality impacts during construction would be associated with the generation of dust. Dust would be generated by the excavation of the shaft and spoil movement. Additionally as part of this proposal the sheds at both stages would be utilised to provide fresh air by way of mechanical fans to the tunnels. Exhaust from the tunnels and shaft would return to the acoustic shed where the exhaust would pass through filters and louvres. This impact is consistent with the EIS and SPIR impacts described for Barangaroo Station.	The Stage 1 acoustic shed would be constructed over the shaft prior to the excavation taking place. This would contain dust, noise and exhaust emissions. REMM AQ9 requires ventilation from acoustic sheds to be filtered Implementation of the Contractors Construction Air Quality Management Plan.	Y	Y	
Noise vibration	A Construction Noise and Vibration Impact Assessment has been prepared by Renzo Tonin for the Stage 1 acoustic shed installation, shaft excavation and tunnelling support operations. See Appendix C **Noise:** Works at the temporary northern access shaft would be undertaken in parallel with other worksite activities at Barangaroo Station. The site-specific CNVIS for the Barangaroo worksite includes the cumulative noise and vibration impacts from all activities across the site, and proposed noise and vibration management measures have been established on this basis. The predicted noise levels in the current assessment are based on the cumulative noise impacts from all works at Barangaroo. The predicted noise levels are above the noise management objectives at the nearest sensitive receivers to the northern access shaft for some, but not all activities. To assist in managing noise impacts at the northern access shaft, the construction of an acoustic shed is proposed. This would allow spoil removal activities to occur during	The shaft must be covered by the Stage 1 Acoustic Shed prior to bulk excavation occurring. Inspections of heritage structures are required prior to the commencement of the shaft excavation works to establish relevant vibration criteria. Vibration monitoring at these structures would be undertaken during work identified within the minimum working distance to verify that vibration levels achieve compliance with the relevant criteria. The potential noise and vibration impacts associated with the proposed work are to be managed in accordance with existing the Conditions of Approval and conditions of the contractors EPL. Noise mitigation and management	Y	Y	

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				Y/N	Comments
	daytime/evening periods at reduced noise levels and tunnel ventilation equipment / concrete deliveries to occur during the evening/night period at reduced noise levels. During construction of the acoustic shed, unavoidable noise impacts would occur at the nearest residential receivers when Out of Hours Works (OOHWs) are required to be carried out under ROLs. Unavoidable noise impacts would also occur during OOHW periods when ROLs are required for transporting oversize TBM equipment between the barging area and the northern access shaft. For all other longer-term construction activities during the night period, internal noise levels at the nearest receivers are predicted to be below the noise management levels at the nearest residential receivers. During day/evening periods, noise levels are predicted to be above the noise management levels for some scenarios at the nearest sensitive receivers. **Vibration:** The two heritage listed bridges over Hickson Road are located within the minimum working distances established for cosmetic damage during the excavation of the shaft with rockbreakers	measures identified in relevant CNVIS are to be implemented.			

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
Aboriginal heritage	There are no registered Aboriginal Heritage items in close proximity to the works. Additionally as identified in the Archaeological Method Statement prepared by Casey and Lowe the shaft excavation works are within an existing rock cutting so the potential for Aboriginal archaeology is nil.	In regards to archaeology – the Unexpected Finds Protocol would apply.	Y	Y	
Historic heritage	The Barangaroo Station site is within the Millers Point & Dawes Point Village Precinct which is Item 01682 on the State Heritage Register and has identified historical, associative, aesthetic, and social significance, research potential, rarity and representativeness. The shed heights have been reduced as far as possible whilst still maintaining the function of the structure. TfNSW commissioned Artefact to undertake a review of the proposal in accordance with the framework set out in the Chatswood to Sydenham EIS. See Appendix E The assessment was undertaken on a study area defined as the works area plus a 50m visual buffer. There are 16 heritage listed items of both local and state significance located within the study area. The direct and indirect impact for each of these items was assessed in comparison to the originally approved EIS impact. 11 new items have been identified as being either directly and/or indirectly impacted by this proposal. The direct impacts are all neutral – there are no direct impacts as a result of this proposal. In particular, the Hickson Road cuttings adjacent to the shaft area are within Millers Point & Dawes Point Village Precinct, but are not individually listed	See Visual section for control measures associated with the visual impact. Works must be undertaken in accordance with the Contractors CEMP and Heritage Management Plan Treatment of the shed support rock bolt holes after removal would be required. Sandstone plugs would be used for treatment for rock bolt intrusions where possible, otherwise plugging that matches the colour and texture of the sandstone. The plugging would be conducted by appropriately qualified tradespeople have experience working in heritage places. Consideration would be given to use of the acoustic shed walls for interpretive display. This display would facilitate engagement of the public with the history of the locality	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
	heritage items. Overall the proposed impacts of the shaft, acoustic shed and laydown area on heritage items are minor. Localised temporary visual impacts would affect the listed items in the direct vicinity of the acoustic shed, particularly where it would protrude over the cliff edge and be visible from Windmill Street and surrounds. Direct impacts to significant fabric are limited to the installation of 10 rock bolts on the Hickson Road cutting to tether the acoustic shed to enable safe use of the gantry crane. **Archaeological potential:** The northern temporary access shaft site is within the footprint of Hickson Road, the construction of which from 1909 – 1914 would have destroyed any earlier archaeological remains within the footprint of the road. As such, as identified in the Final Barangaroo Station Hickson Road, Barangaroo Archaeological Method Statement prepared by Casey & Lowe Pty Ltd in November 2017 and Proposed Services on Dalgety & Hickson Roads, Barangaroo Northern Headland, Historical Archaeological Assessment, Statement of Heritage Impact & Research Design, prepared by for Austral Archaeology Pty Ltd in 2013 for Baulderstone Pty Ltd this area has no archaeological potential and no archaeological significance (refer Casey & Lowe 2017: 122, Figure 4.13; page 131, Figure 5.1 and page 154, Figure 7.1). In addition a Statement of Heritage Impact has been prepared by Mott McDonald Australia to assess the physical heritage impacts specific to the Hickson Road cuttings adjacent to the shaft area and develop mitigation measures	and its design and colour scheme would be sensitive to heritage values. SOHI control measures: • Apply appropriate materials and colour to acoustic shed • Undertake dilapidation reports/ condition assessments to identify vibration sensitive heritage structures and structures that will be potentially impacted by construction works. • Refine the geotechnical assessment of the sandstone cutting at Hickson Road and the retaining wall above to restrict physical impacts of protection works as much as practical. • Assess the Hickson Road cutting to plot appropriate anchor locations for support of the shed structure under gantry loading and adjust the support structure to suit the condition of the rock face • Develop the design of anchors (for both restraint of the rock face and support of the acoustic shed) to minimise impact of anchoring			

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
	and in provided in Appendix F. The SOHI details a number of mitigation measures to minimise impacts to heritage values including a number of options to reduce the impacts of the rock bolts following decommissioning of the stage 1 acoustic shed. The SOHI concludes that impacts to heritage values would be temporary and set out recommended treatment for the rock bolts to reduce direct and physical impacts.	works (anchor heads, waler beam installation etc) on the rock face of the Hickson Road cutting. • If there is a potential for mechanical damage to heritage structures to occur; install protection barriers to prevent accidental collision impacts on the bridges, retaining walls and other items around the work site • Carry out vibration monitoring in accordance with the Monitoring and Protection Plan. • Assess vibrations recording during the works and adjust works methods and machinery used to restrict ground vibrations to the limits imposed by the Construction Noise and Vibration Impact Statement **Archaeological management:** The appropriate archaeological strategy to guide the construction of the acoustic shed is the Unexpected Heritage Finds procedure as identified in the Section 7.4 of the Casey & Lowe Archaeological Method Statement (2017:152).			

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
Community and stakeholder	The temporary shaft is proposed within the EIS assessed construction footprint however the methodology for the work site has changed. The proposal would result in noise and visual impacts to surrounding residential and non-residential receivers. This is considered on balance that without the temporary northern shaft it is expected that the construction program would be delayed by approximately 14 months. This would also have an adverse impact on the Barangaroo community.	See the Noise and Visual sections for the specific mitigations associated with these impacts. Prior to construction of the shed the surrounding community would be notified of the extent and duration of the works including information on construction methodology and the rationale for the temporary acoustic shed. All public information material would include contact details for enquiries and complaints, including the 24 hour telephone hotline.	Y	Y	
Traffic	The location of the proposed temporary northern shaft and associated acoustic shed was indicatively shown as a laydown area in the EIS/SPIR. This means there is no change to the Hickson Road traffic arrangements or parking as a result of this proposal. There are two distinct work areas required for the installation of the northern shaft, Stage 1 shed and associated works, which would be nominated as the "Upper" work area which includes the use of Windmill Street, Dalgety Road, Argyle Street and the "Lower" work area situated on Hickson Road. **Upper work area:** Works would require the temporary closures and restrictions to traffic, parking and pedestrians over a 2 month period. **Lower work area:** Works would require the following traffic management: Temporary (2-3 nights) closure of Hickson would be required for the delivery and installation of the gantry crab. (note that the "crab" is the mobile part of the gantry crane which carries	Pedestrians would be directed around the worksites. Traffic and parking impacts that are in addition to the EIS are temporary only. Traffic and parking would be managed through diversions, traffic control, signage and community notifications. The proposed works would be managed in accordance with the existing Conditions of Approval for the Project.. Where permits/licences are required, these would be obtained prior to commencement of works, in accordance with the Contractors Construction Traffic Management	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
	the crane hook and all loads. It moves back and forwards across the shaft on rails. It is a large piece of equipment as it carriers loads up to 260 tonne. It is not possible to unload this equipment under stop/ slow arrangements due to its size). The shaft spoil (approximately 6000 m3) would be transported from site by road truck and trailers, including some out of hours works. It would not be possible for the shaft spoil to be transported from the worksite via barges. This is expected to be in the order of 450 truck and trailer departures over the period of 2 months of excavation. There would also be truck movements required to remove the spoil excavated from the shaft and crossover cavern to the wharf for barging which would previously have originated from the station box. These trucks would be travelling between the shaft location and the barging area at Barangaroo Station, approx. 200m south of the shaft. Trucks would also be utilised to deliver the concrete tunnel ring panels to the shaft which are then lowered to the TBM. These movements were assessed in the EIS as being delivered 110m south of the proposed northern shaft to the Barangaroo Station box. Following the decommissioning of the Stage 1 shed, a smaller shed, Stage 2 would be established and there would be a reduced number of deliveries to and from the shed for a period of early 2020 – 2024. The Shaft and acoustic shed would then be decommissioned, and the site returned to its pre-existing condition including parking and normal road operation. Overall there is not a significant change to traffic, pedestrian	Plan			

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
	and parking impacts and management as a result of this proposal.				
Waste	Approximately 6000m^3 of additional spoil would be generated as a result of temporary northern shaft project.	All spoil would be managed in accordance with the Contractor's Spoil Management Plan. All waste generated would be classified and disposed of in accordance with the Contractors Construction Waste and Recycling Management Plan	Y	Y	
Social	Community facilities that would be closest to construction activities at temporary northern shaft include: • Barangaroo Reserve, including Munn Reserve, at the northern end of Barangaroo • KU Lance Preschool and Children's Centre, on High Street. Construction of the temporary northern shaft would not impact the access to or amenity of either of these community facilities. There are a number of Community Groups active in the Barangaroo/Millers Point area.	As per the mitigation measures specified in the EIS and Project Planning Approval specific consultation would be carried out with sensitive community facilities and Community Groups. Consultation would identify and develop reasonable measures to manage the specific construction impacts for individual sensitive community facilities.	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
Economic	The following were identified as potential business impacts during construction for the Barangaroo site: • Servicing and delivery access • Noise, vibration and dust • Supply of and access to car parking • Increased trade for food and beverage. The temporary northern shaft impacts are consistent with those impacts identified in the EIS for Barangaroo Station with the exception of new receivers on the upper levels of Dalgety Road, Windmill Street and Argyle Place. Economic impacts of the temporary northern shaft would be short term and temporary. The impacts are primarily associated with the visual impact of the Stage 1 TBM shed.	As per the EIS/SPIR mitigation measures, specific consultation would be carried out with businesses potentially impacted during construction. Consultation would aim to identify and develop reasonable measures to manage the specific construction impacts for individual businesses. Impacts on businesses are to be managed in accordance with the Contractors Business Management Plan.	Y	Y	
Visual	The visual impacts associated with this proposal are temporary only and directly associated with the requirement to mitigate noise from the shaft excavation and TBM activities as required by the Conditions of Approval. TfNSW engaged IRIS to undertake a Visual Impact Assessment of the proposed temporary northern shaft utilising the methodology used in the EIS and PIR. See Appendix D Additionally KI Studio was commissioned by the TSE contractor to prepare a Visual Impact Assessment of the Stage 1 shed. The KI Studio report contains indicative photomontages of the Stage 1 acoustic shed. See Appendix H. The EIS identified Hickson Road, including the area under the Windmill Street Bridge, as being of local landscape and	The scale of the two acoustic sheds have been reduced as far as practical whilst still maintaining their function. In views from Hickson Road, where the proposed acoustic enclosure would be seen within the tunnel and also above the bridge, against the sky, the selection of Jasper for the lower section of the enclosure would minimise the visual impact, replicating the effect of the existing tunnel, and a lighter colour for the upper section of the acoustic enclosure would be visually lighter and may reduce the	N	Y	The acoustic shed is required to mitigate noise, dust and vibration impacts associated with the shaft. In order to reduce the visual impact of the Stage 1 temporary acoustic shed TfNSW would engage the community to explore options to be retrofit to the exterior of the shed.

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
	visual sensitivity. The Millers Point and Dawes Point Village Precinct was not an area identified in the EIS. This area is considered to be of regional landscape and visual sensitivity. This is consistent with the sensitivity attributed to the landscape and views from High Street identified in the EIS, which has similar aesthetic values. The assessment divided the scope into: Stage 1 – the acoustic shed for shaft excavation and TBM scope Stage 2 – the acoustic shed for the tunnel and station fitout The visual impact assessment considered Landscape. Daytime visual and Night time visual impacts. These were compared to the assessment made during the EIS and SPIR. Landscape assessments were against the following locations: Hickson road, Hickson Road Cutting, Argyle Place, Dalgety Road and Windmill Street. The summary of impacts for the construction phase is as follows:	visual enclosure created by the introduction of built form in this area of visual separation. In views from Windmill Street, Dalgety Road and Argyle Place to the upper portions of the enclosure, techniques could be employed to further visually reduce the mass and scale of the enclosure. This might include the use of shape, line, colour and texture to disguise the form of the enclosure. Any treatment of the upper section of the enclosure should be sympathetic to the surrounding historic, urban character. This would be done by drawing upon themes, shapes, colours and textures from existing built form rather than mimicking adjacent heritage buildings. The enclosure could be shaped to minimise the impact on key view corridors, maximising the sense of space and visual separation along the alignment of the rock cutting, and minimising encroachment on the visual prominence of the Palisade Hotel. Any shaping of the enclosure should aim to protect important view corridors such as views to the Palisade Hotel (a local visual landmark), views northeast (over Hickson Road) to the Harbour			

Location	Sensitivity	Construction	
		Modification	Impact
Landscape			
Hickson Road (from the EIS)	Local	Noticeable reduction	Minor adverse
Hickson Road	Local	Noticeable reduction	Minor adverse

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

Hickson Road Cutting	Regional	Noticeable reduction	Moderate adverse
Argyle Pl, Dalgety Rd & Windmill St	Regional	Noticeable reduction	Moderate adverse

The summary of impacts for the operational phase is as follows

Location	Sensitivity	Operation	
		Modification	Impact
Landscape			
Hickson Road (from the EIS)	Local	Noticeable improvement	Minor adverse
Hickson Road	Local	Noticeable improvement	Minor adverse
Hickson Road Cutting	Regional	No perceived change	Negligible
Argyle Pl, Dalgety Rd & Windmill St	Regional	No perceived change	Negligible

The following views were assessed:

- Viewpoint 4: View south from Hickson Road at the Windmill Street Bridge (from the EIS)
- Views from western footpath on Hickson Road
- Viewpoint a: View northeast from footpath on Dalgety Road
- Viewpoint b: View southwest from Windmill Street

bridge, and northwest along Dalgety Road to the harbour. Maintaining views to the arched bridges is also important.

Condition E99 requires construction to be undertaken in a manner which minimises visual impacts, incorporating architectural treatment and finishes within key elements of temporary structures that reflect the context within which the construction site is located.

The proposed works would be carried out in accordance with the contractors Visual Amenity Management Plan

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
	Viewpoint 4: View south from Hickson Road at the Windmill Street Bridge The change from the EIS assessment in this location for the stage 1 works is a considerable reduction in local amenity which is assessed as a moderate adverse impact. This impact is reduced to minor adverse during the stage 2 shed. Once operation of the project is underway there will be no impact as a result of this proposal as the shaft and associated sheds are decommissioned. **Views from western footpath on Hickson Road** This viewpoint was not identified in the EIS. During stage 1 and stage 2 works there would be considerable noticeable reduction representing a moderate adverse impact. Once the railway is operational Hickson Road would be reinstated, however, there would be permanent alteration to the sandstone cutting in the form of approximately 10 bolt heads, or if they are removed, 10 areas of localised damage to the sandstone cutting. Overall, this change would create a noticeable reduction in the amenity of this view, which is of regional visual sensitivity, resulting in a moderate adverse visual impact. **Viewpoint a: View northeast from footpath on Dalgety Road** This viewpoint was not identified in the EIS. During construction with the stage 1 shed there would be a considerable reduction of regional views resulting high adverse impact. The stage 2 shed reduced this change to no perceived				

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
	change and negligible impact. During operation of the project there would be no impact to this viewpoint. **Viewpoint b: View southwest from Windmill Street** This viewpoint was not identified in the EIS. During construction with the stage 1 shed there would be a considerable reduction of regional views resulting high adverse impact. The stage 2 shed reduced this change to no perceived change and negligible impact. During operation of the project there would be no impact to this viewpoint. **Night time visual** There would be no perceived change during construction or operation at either stage 1 or 2 as a result of this change.				

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
Urban design	The shaft itself would not have any urban design impacts, however the temporary Stage 1 shed above it would be prominent within the Millers Point area for a period of up to 3 years, and the lower fitout (Stage 2) shed for an additional 2 years. The shed has been designed to be as compact as possible whilst still maintaining the functions of the shed, i.e. the height is determined by the gantry crane within the structure and the height of the TBM cutter heads it needs to lift into the shaft.	All temporary works proposed on the Sydney Metro project require TfNSW approval for urban design and visual amenity according to CEMF section 4.4 (b). Additionally Condition E99 requires construction to be undertaken in a manner which minimises visual impacts, incorporating architectural treatment and finishes within key elements of temporary structures that reflect the context within which the construction site is located. See Management and Mitigation at the end of this table for urban design/visual impact mitigation proposed.	Y	Y	
Geotechnical	The temporary northern shaft would be excavated into Hawkesbury Sandstone. The shaft would require rock anchors similar to the Station box, these are all underground extending from the shaft 5m into the ground. The acoustic shed is required to be tethered to the High St cutting on the eastern side in order to strengthen the gantry crane held within it. This would comprise 10 pretensioned rock bolts at 65mm diameter extending into the wall.	Treatment of the rock bolts bolt holes after removal would be required. Sandstone plugs would be used for treatment for rock bolt intrusions where possible plugging that matches the colour and texture of the sandstone may be installed. The plugging should be conducted by appropriately qualified tradespeople have experience working in heritage places.	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
Land use	The area of the temporary northern shaft was shown in the indicative construction layout as a laydown in the EIS for the duration of the project. The use of this land for the construction of the project does not change as a result of this assessment. The area will still be utilised for construction and returned to its original use of a roadway prior to operation.	No additional control measures are required.	Y	Y	
Climate Change	No change from the EIS and Modification Assessment impact . As per COA and REMMs	No additional control measures are required.	Y	Y	
Risk	The EIS and SPIR assessed the construction of the crossover cavern and TBM launching and removal being completed within the northern section of Barangaroo Station. This coupled with the constraints associated with the adjacent BDA construction site, created considerable constraints on the construction program, as the station excavation had to be well advanced prior to commencement of the crossover cavern excavation. The construction of the temporary access shaft would enable excavation of station box and the crossover cavern to occur independently and simultaneously and work to reduce program risk.	No additional control measures are required.	Y	Y	
Other	NA	No additional control measures are required.	Y	N/A	
Management and mitigation measures	N/A	N/A	Y		

11.0 Impact Assessment – Operation

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

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	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	COT
Water	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	COT
Air quality	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	COT
Noise vibration	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	COT

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
Aboriginal heritage	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	
Historic heritage	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	
Community and stakeholder	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	
Traffic	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	
Waste	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	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	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	COE
Economic	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	COE
Visual	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	COE
Urban design	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	COE
Geotechnical	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	COE

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
Land use	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	
Climate Change	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	
Risk	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	
Other	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	Y	Y	
Management and mitigation measures	There are no operational impacts as a result of the temporary northern shaft, it would be decommissioned prior to rail operations. No change to the operational impacts described in the EIS and SPIR.	No additional control measures required	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 works would not transform the project. The project would continue to provide a new metro rail line between Chatswood and Sydenham. The works are within the boundary of the existing project. The EIS and PIR assessed a concept design that was to be developed in consultation with BDA. The shaft is required to deliver the project and maintain the program identified in the approved project. The activities proposed to be undertaken within the northern shaft are consistent with the activities identified in the EIS/SPIR to deliver the project at this location.
Is the project as modified consistent with the objectives and functions of the Approved Project as a whole?	Yes. The proposed works would be consistent with the objectives and functions of the approved project.
Is the project as modified consistent with the objectives and functions of elements of the Approved Project?	Yes. The changes identified in this assessment are temporary works required to support construction of that part of the Approved Project located at Barangaroo. The activities proposed to be undertaken as part of the northern shaft with associated acoustic shed are generally consistent with the activities identified in the EIS/SPIR to deliver this element of the Approved Project within the program required. There are no changes to the Barangaroo Station design elements.
Are there any new environmental impacts as a result of the proposed works/modifications?	There are no new environmental impacts from those identified in the EIS/SPIR. However, the location at which impacts identified may be experienced has been changed. Notwithstanding that the construction methodology, in its refinement, has involved shifting identified construction activities around within the Approved Project Area, the REMMS and CoA that have been established are considered to appropriately manage the impacts for receivers. In this regard no new environmental risks are outstanding. All risks would be adequately addressed through the application of the REMMs, Conditions of Approval and the mitigation measures included in the above tables.
Is the project as modified consistent with the conditions of approval?	Yes. The proposed works would be consistent with the conditions of approval.

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:	Nicole Williams	Signature:	
Title:	Environmental Planning Manager		
Company:	TfNSW	Date:	08/3/2018

Environmental Representative Review

As an approved ER for the Sydney Metro City & Southwest project, I have reviewed the information provided in this assessment. I am satisfied that mitigation measures are adequate to minimise the impact of the proposed work.			
Name:	Jo Robertson	Signature:	
Title:	Environmental Representative	Date:	13/03/18

This section is for Sydney Metro only.

Assessment submitter

Application supported and submitted by			
Name:	Craig Tucker	Date:	13/3/18
Title: Signature:	TSE IG Environmental Manager	Comments:	

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.

Assessment Endorsement

Endorsed by			
Name:	Fil Cerone	Date:	14/3/18
Title:	Principal City & Southwest, Sustainability, Environment & Planning	Comments:	—
Signature:			

Appendix A – Map showing indicative construction layout from EIS and PIR

EIS Figure 7.13

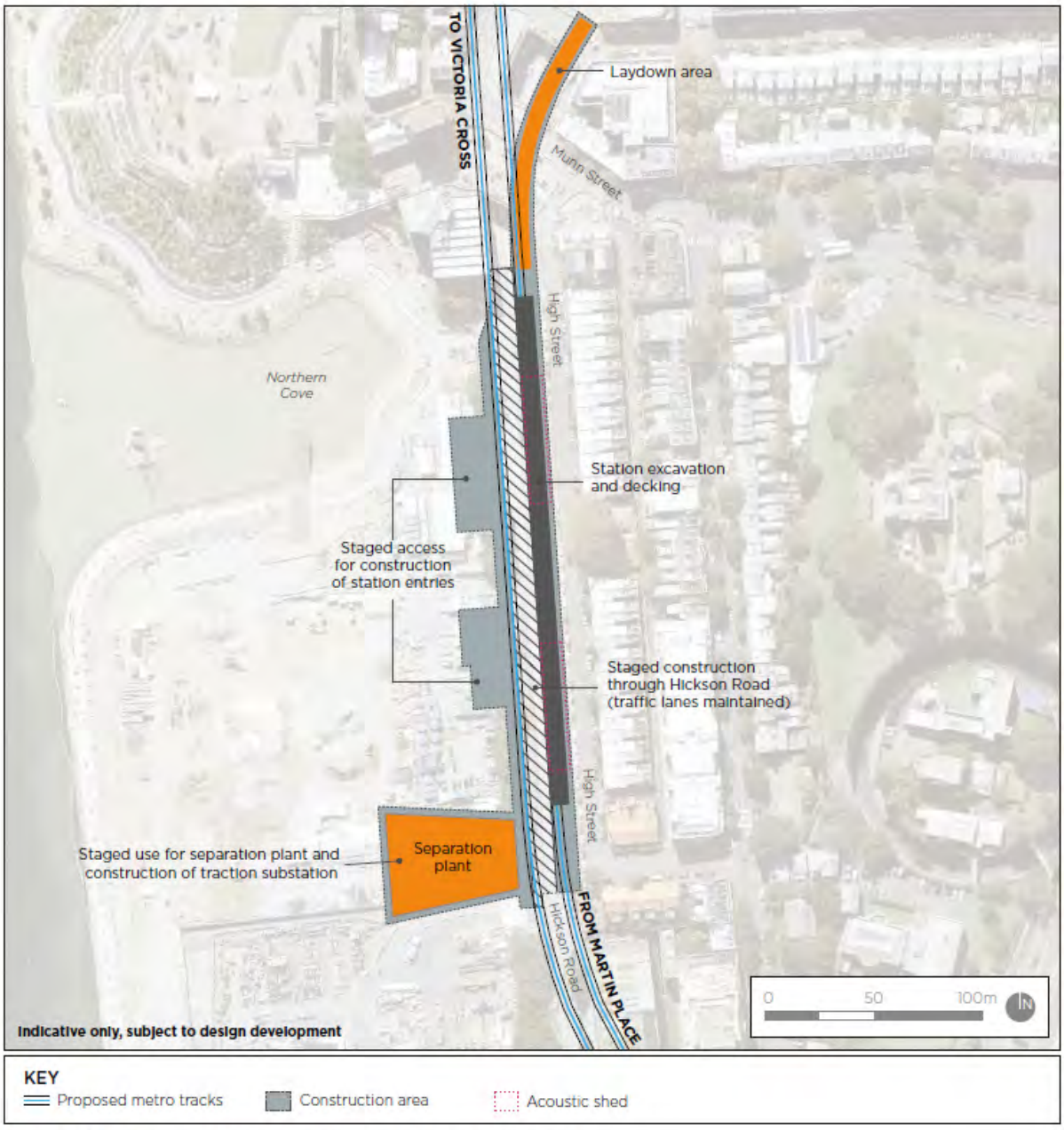


Figure 7-13 Barangaroo Station construction site indicative layout

Figure 3.8 Amended Barangaroo station layout

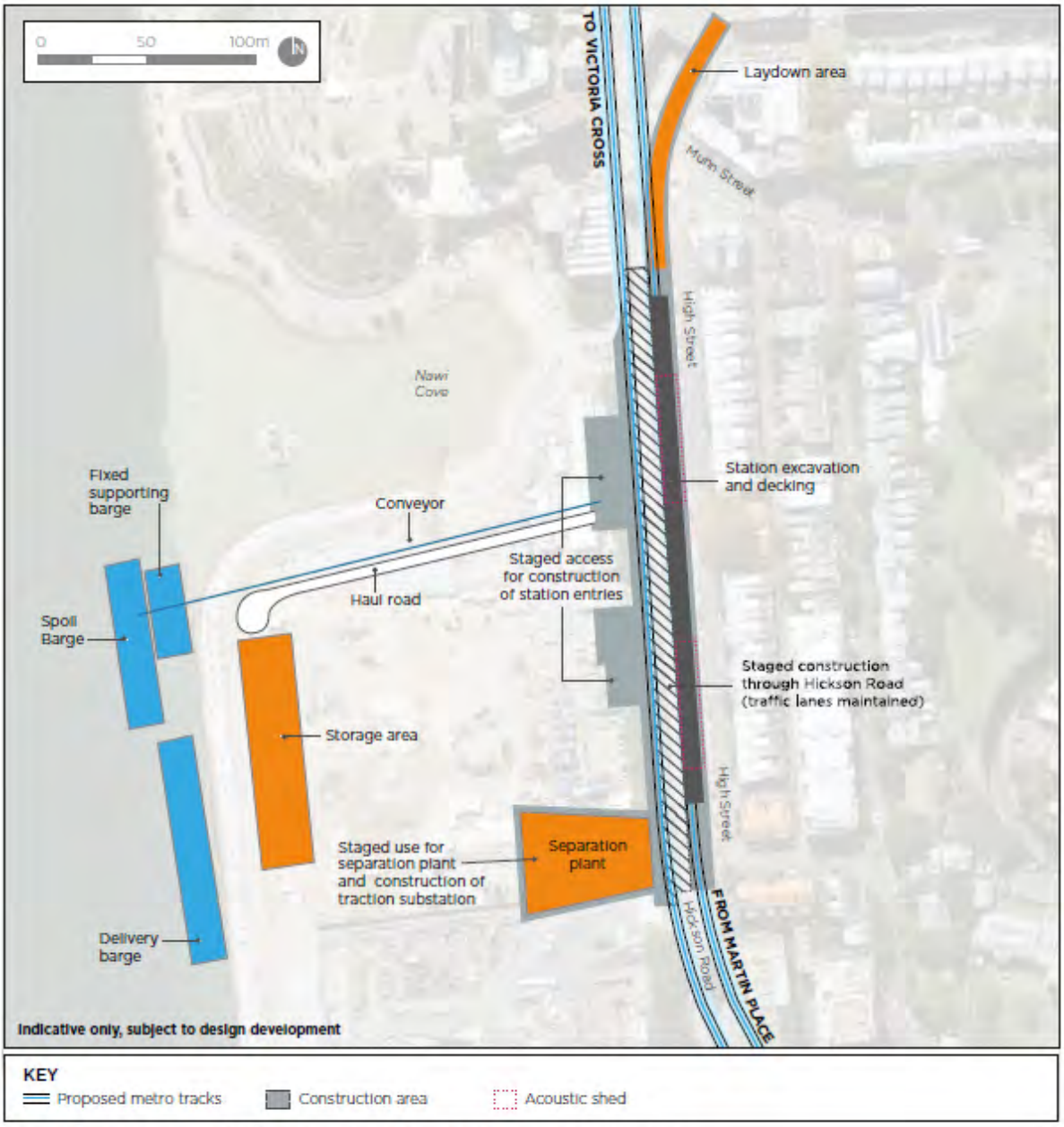


Figure 3-8 Barangaroo Station – location and layout of barging infrastructure

SPIR Figure 3-1 Crossover cavern location plan view

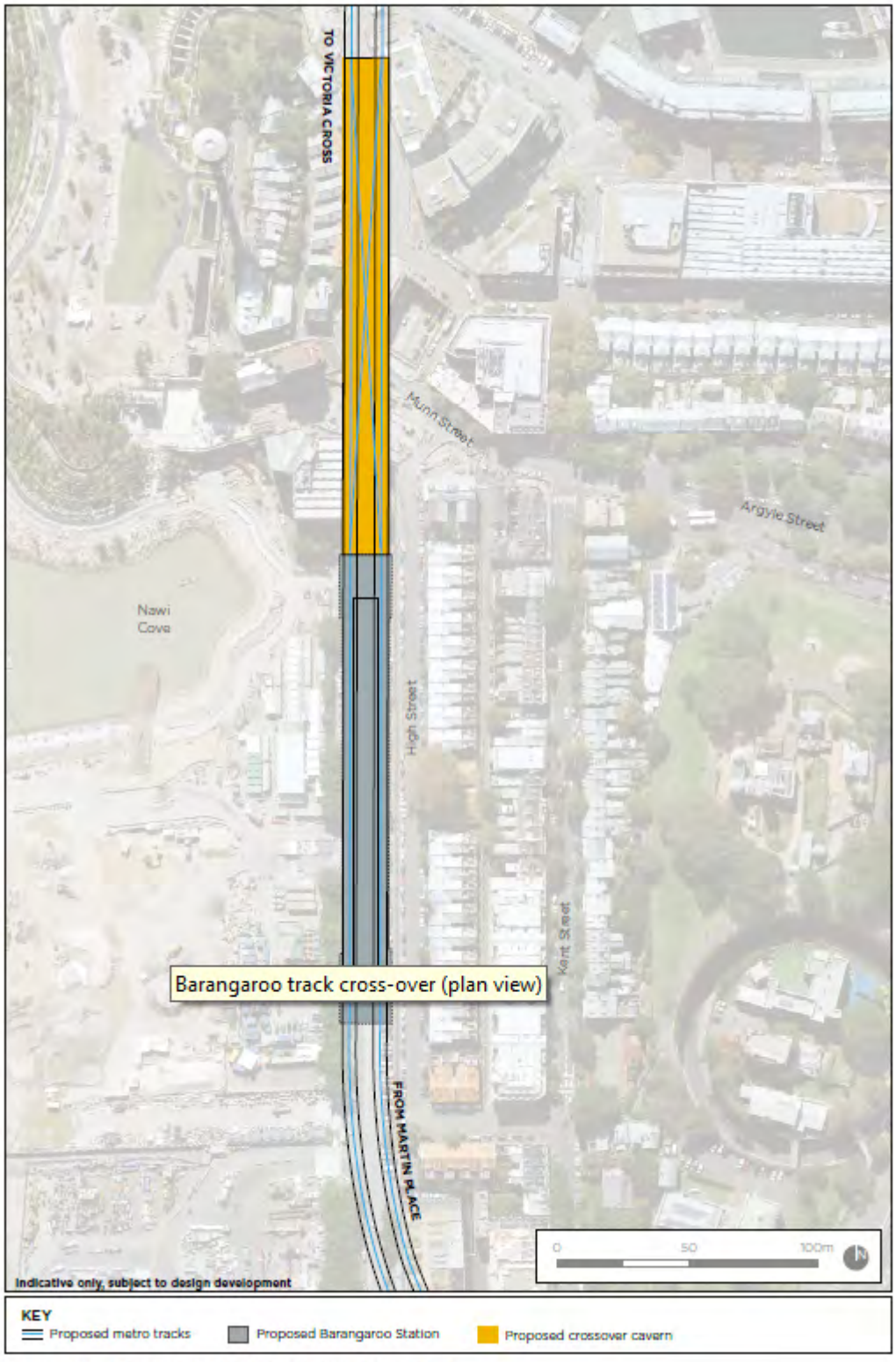
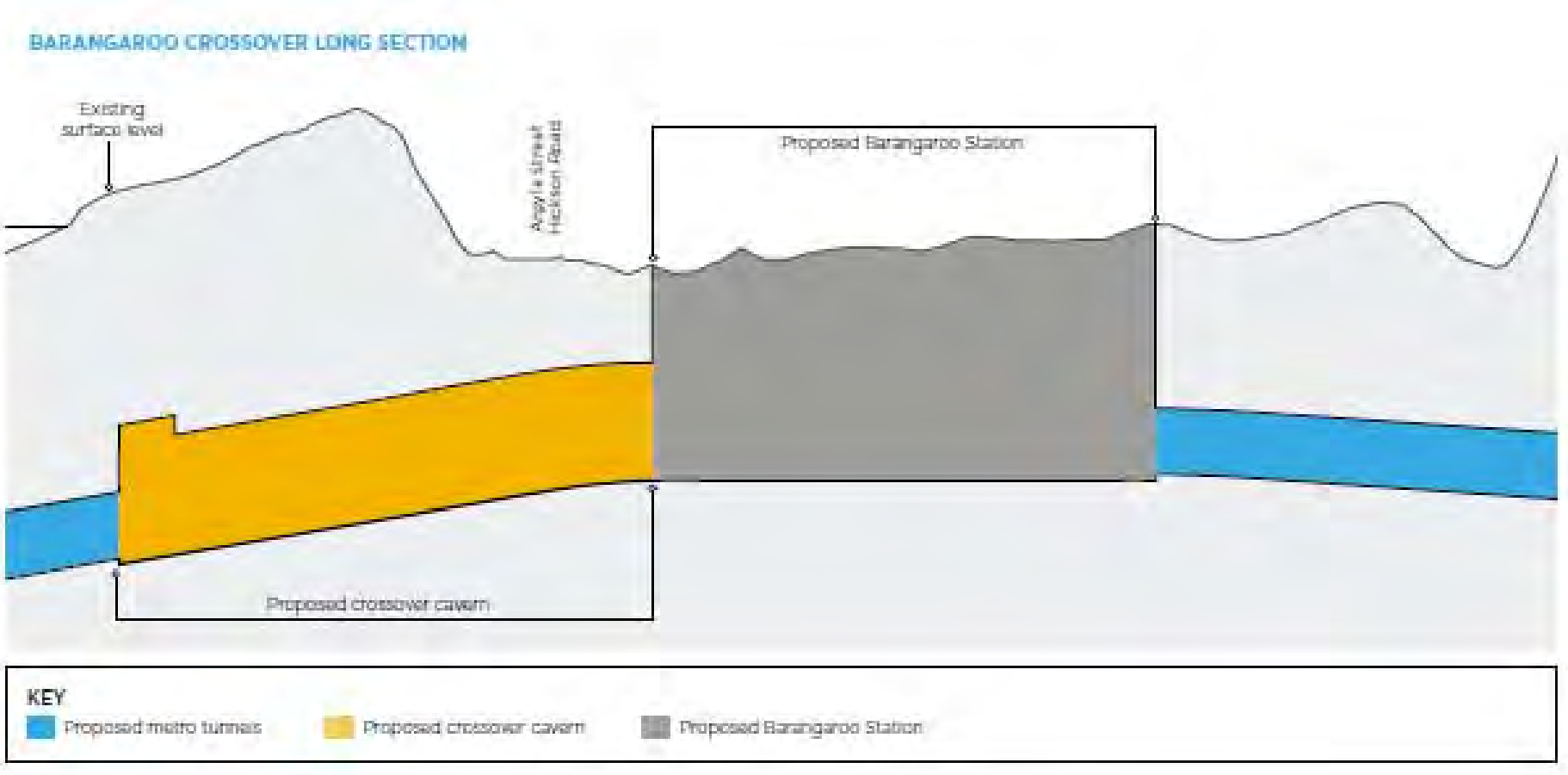
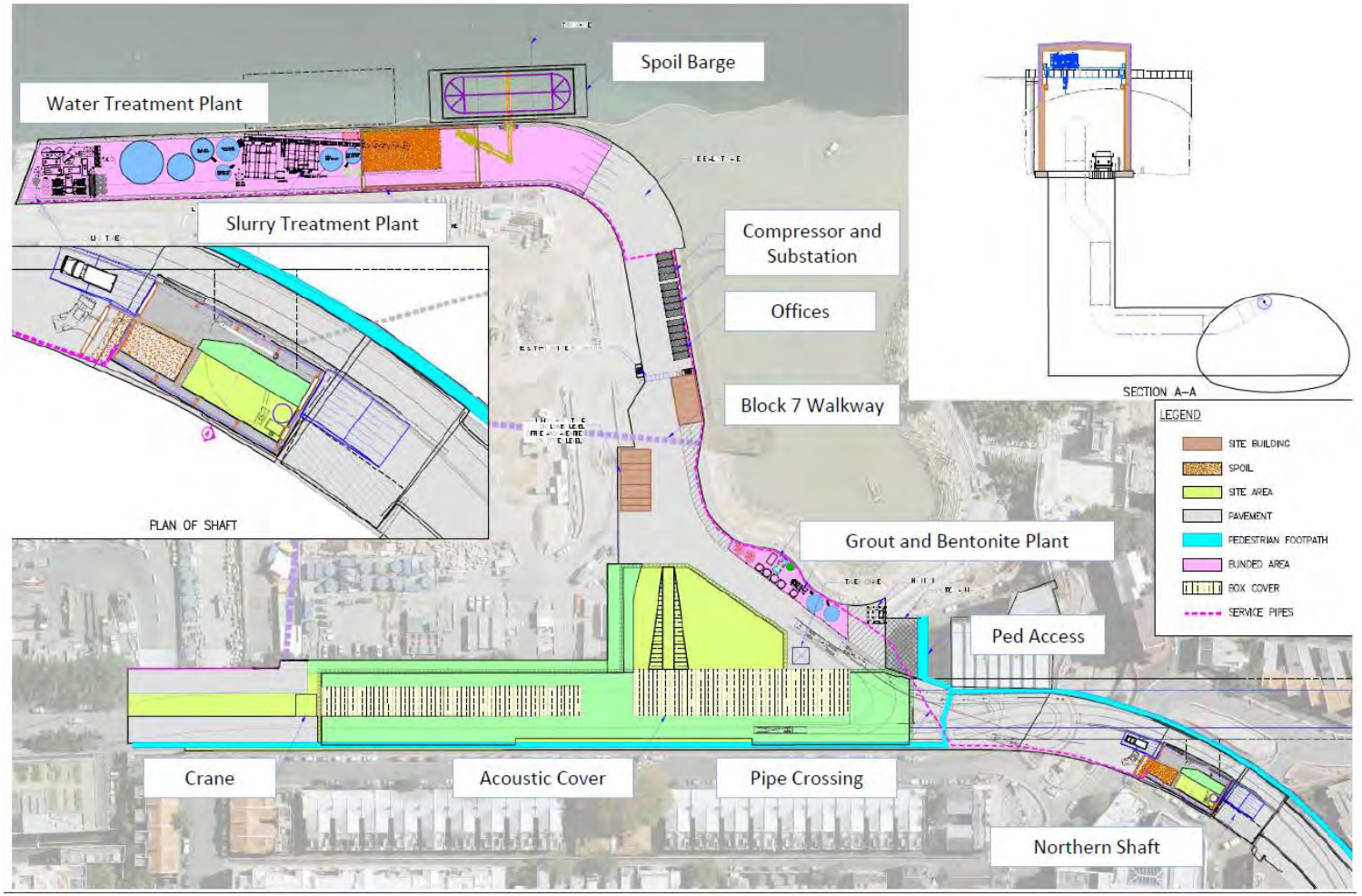


Figure 3-1 Barangaroo track cross-over (plan view)

SPIR Figure 3-2 Crossover cavern long section



Appendix B Map showing proposed temporary shaft construction layout



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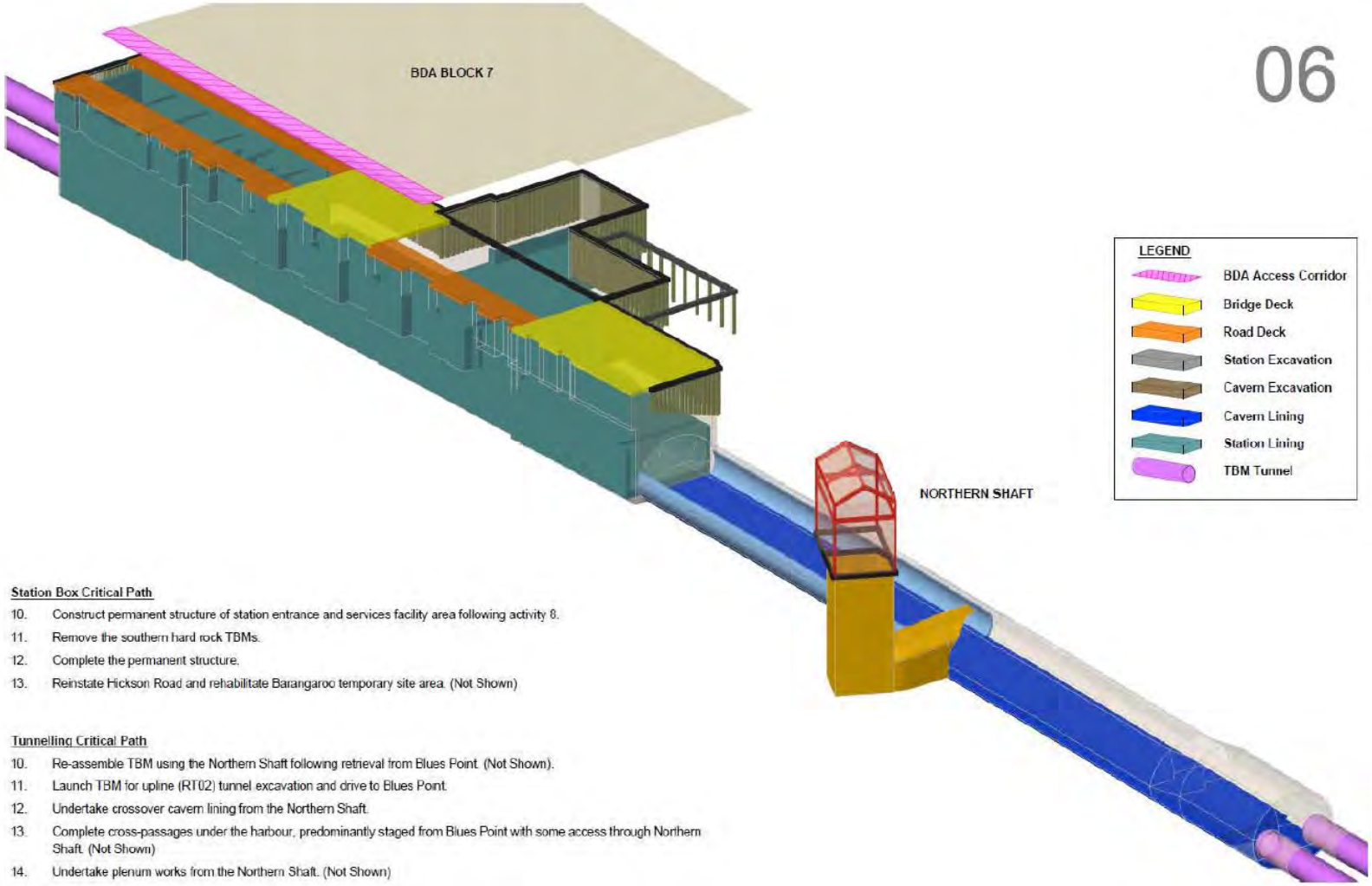

Station Box Critical Path

10. Construct permanent structure of station entrance and services facility area following activity 8.
11. Remove the southern hard rock TBMs.
12. Complete the permanent structure.
13. Reinstate Hickson Road and rehabilitate Barangaroo temporary site area. (Not Shown)

Tunnelling Critical Path

10. Re-assemble TBM using the Northern Shaft following retrieval from Blues Point. (Not Shown).
11. Launch TBM for upline (RT02) tunnel excavation and drive to Blues Point.
12. Undertake crossover cavern lining from the Northern Shaft.
13. Complete cross-passages under the harbour, predominantly staged from Blues Point with some access through Northern Shaft. (Not Shown)
14. Undertake plenum works from the Northern Shaft. (Not Shown)

Appendix C – Noise and Vibration Impact Assessment

RENZO TONIN & ASSOCIATES
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SYDNEY METRO CHATSWOOD TO SYDENHAM – TSE WORKS

Construction Noise and Vibration Assessment for Barangaroo Northern Shaft

29 January 2018

John Holland CPB Ghella JV

TH511-02 6F05 Noise Assessment (r2)

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Contents

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1 Introduction

Renzo Tonin & Associates was engaged by John Holland CPB Ghella (JHCPBG) to prepare a noise and vibration assessment for construction activities associated with the temporary tunnel access shaft, approximately 150 m north of the proposed Barangaroo station box. Within this report, this is referred to as the northern access shaft.

At Barangaroo, construction works which form part of the Tunnel and Station Excavation (TSE) works include excavation of the station box, excavation of the crossover cavern (north of the station box), barging operations and TBM launching and retrieval.

The EIS and Submissions, and Preferred Project Report assessed the construction of the crossover cavern and TBM launching and removal being completed through the western entry to the Barangaroo station box excavation. This created considerable constraints on the construction program, as the station excavation had to be well advanced prior to commencement of the crossover cavern excavation.

The design was developed prior to the TSE Contract award to include a temporary access shaft (northern access shaft) approximately 150 metres north of the station box. The construction of the northern access shaft will enable excavation of station box and the crossover cavern to occur independently and simultaneously.

The proposed northern access shaft is approximately 15 m by 10 m wide and 30 m deep and located within the existing Hickson roadway (between Dalgety Road and Windmill St). To minimise airborne noise levels, an acoustic shed will be located above the access shaft, approximately 32 m long, 14 m wide and 21 m high.

TfNSW are currently preparing a consistency assessment for the northern access shaft. The purpose of this report is to support the approval process by providing an assessment of the potential noise and vibration impacts and proposing measures to reduce potential impacts at nearby sensitive receivers.

Detailed Construction Noise and Vibration Impact Statements (CNVISs) are being finalised for the proposed activities at the Barangaroo worksite, including works associated with the northern access shaft.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. APPENDIX A contains a glossary of acoustic terms used in this report.

2 Project Description

2.1 Site layout and location of northern access shaft

A high-level overview of the Barangaroo worksite is provided in Figure 1 and identifies the location of the barging area, station box, shark fin (western entry of station box), crossover cavern (underground) and northern access shaft.

A detailed layout of the northern access shaft and adjacent land uses is provided in Figure 2.

Figure 1: Aerial photo showing location of Barangaroo worksite areas

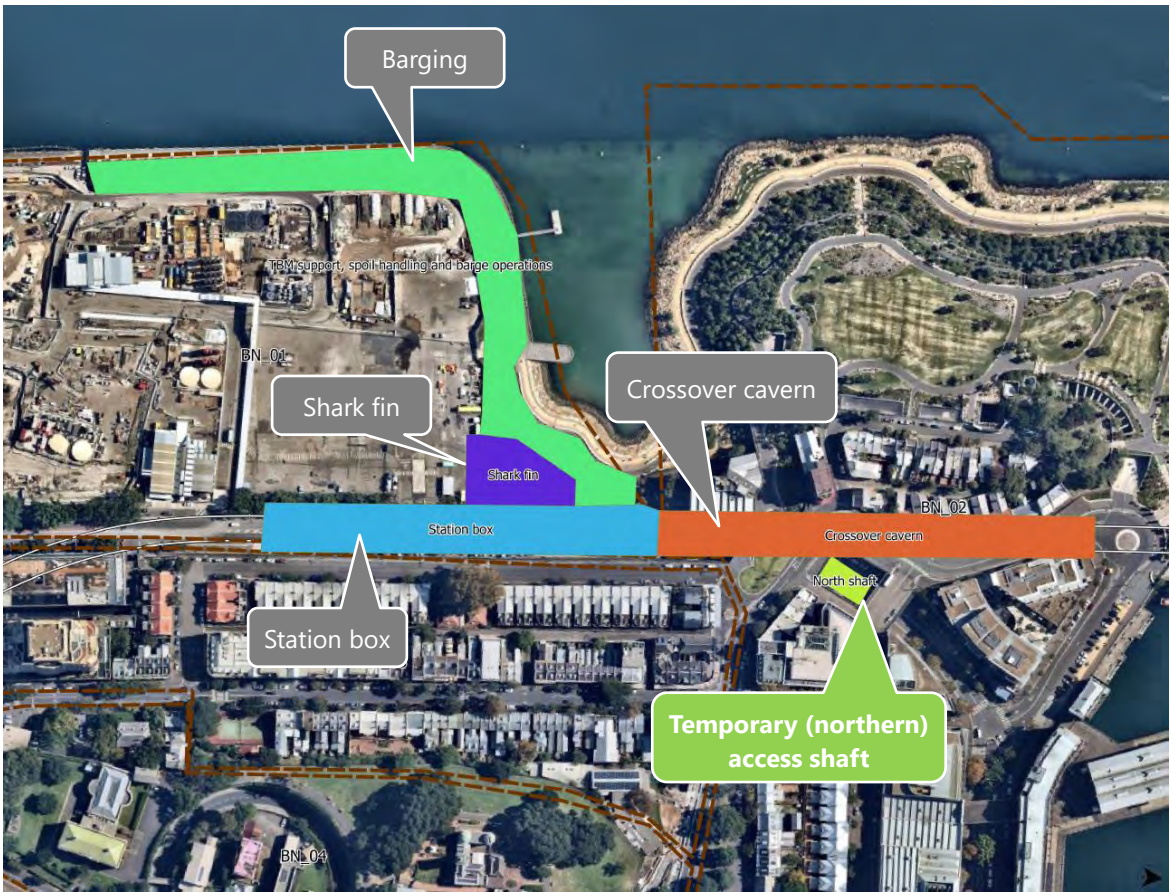
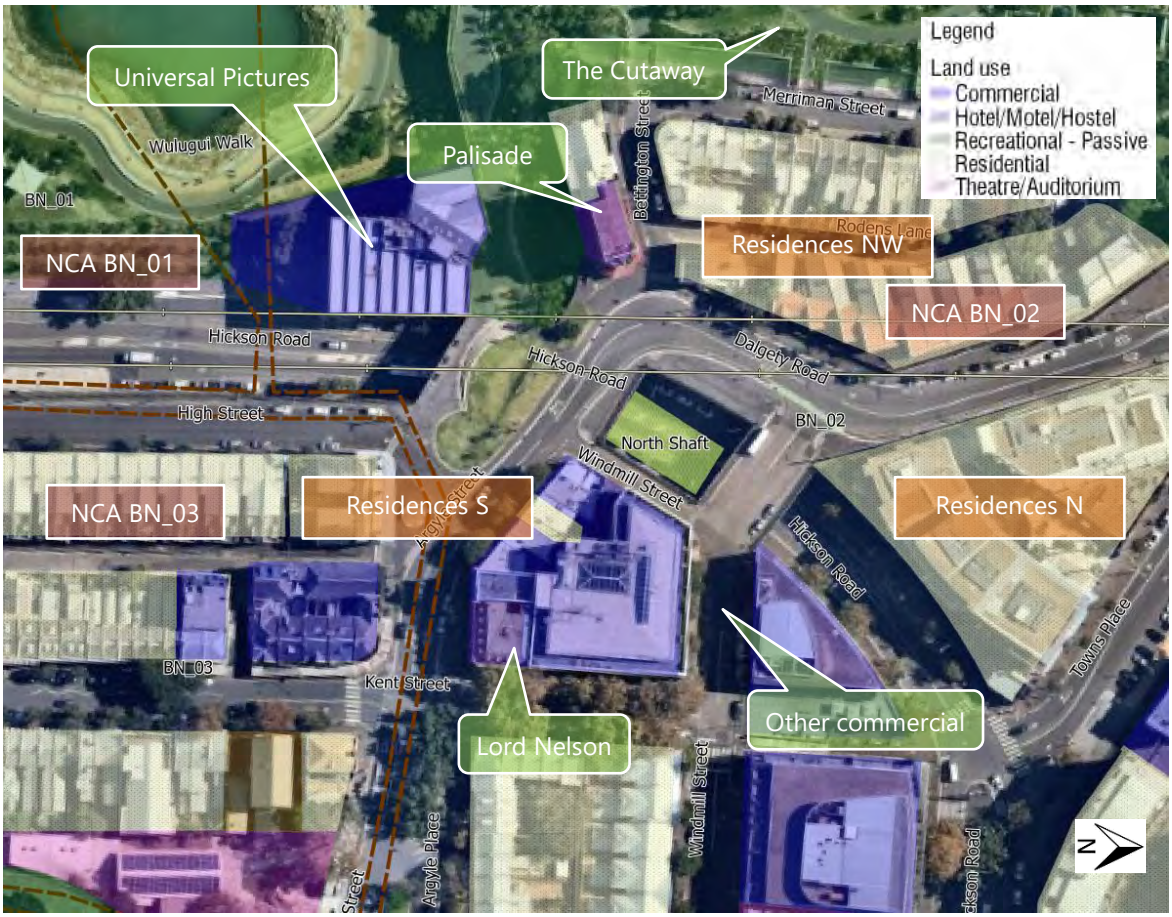


Figure 2: Aerial photo showing location of northern access shaft and adjacent land uses



2.2 Receiver locations

The location of receiver areas potentially impacted by the works is shown in Figure 2.

The nearest residential receivers are located on Dalgety Road / Bettington Street to the north-west, Hickson Road / Towns Place to the north and Argyle Place / High Street to the south.

Other sensitive receivers close to the northern access shaft include Hotel Palisade, Universal Pictures, Barangaroo Cutaway, The Lord Nelson Brewery and several commercial buildings.

Additional information relating to the location of sensitive receivers and existing noise levels is provided in Section 3.

2.3 Proposed construction works (northern access shaft)

2.3.1 Preparation works

Site preparation works are required prior to the construction of the acoustic shed. These are likely to include the following activities which may generate noise and vibration:

- Utility location, including saw cutting of road (Hickson Road) – some activities associated with these works will be required during night-time periods due to the need for a road occupancy licence (ROL). The duration of the works is approximately one week.

- Capping beam and reinforcement works, including excavation, placement of form work and concrete pouring - some activities associated with these works will be required during night-time periods due to the need for a ROL. The duration of the works is approximately two weeks.

2.3.2 Acoustic shed construction

Construction of the acoustic shed is proposed to be undertaken in three stages as follows:

- Stage 1 - Shed Installation – part 1
- Stage 2 - Bridge Crane Installation (Windmill Street)
- Stage 3 - Shed Installation – part 2

Some activities associated with these works will be required during night-time periods due to the need for a ROL. The duration of the works is approximately 6 to 12 weeks, dependent on the number of nights construction work can be undertaken per week under the Environment Protection Licence (EPL).

2.3.3 Shaft excavation works

Excavation of the northern access shaft is proposed to be undertaken inside the acoustic shed to minimise potential noise impacts at nearby sensitive receivers. High noise activities will be undertaken during the 7 am to 8 pm daytime/evening period for up to 6.5 hours per day in accordance with Approval Conditions E37 and E38 and the requirements of the EPL. The shaft spoil will be transported from site by road truck and trailers, including some out of hours works. The duration of the works is approximately two months.

2.3.4 Operations and spoil removal

Following the shaft excavation works, spoil associated with the excavation of the crossover cavern will be transferred between the northern access shaft and the spoil loadout shed near the Barangaroo barge area.

Within the acoustic shed, spoil will be loaded into a kibble at the bottom of the shaft, lifted to the surface by gantry crane and loaded into trucks with a front-end loader.

Loading and transporting of spoil is proposed to be undertaken during the 7 am to 8 pm daytime/evening period in accordance with Approval Conditions E37 and E38 and EPL requirements. The duration of the works is approximately nine months.

During the 8 pm to 7 am evening/night period, tunnel ventilation fans will remain operational as part of the tunnel ventilation strategy and associated safety requirements. The gantry crane will also operate

during this period to transport materials and personnel between the tunnels and ground surface. Concrete trucks (unloaded inside the acoustic shed) will also be required to support shotcreting activities for the underground excavation.

2.3.5 TBM delivery, assembly and disassembly

TBM components for the soft ground machine (from Barangaroo to Blues Point) are proposed to be transported from the Barangaroo barge area to the northern access shaft via SPMTs (self-propelled modular trailers). For each delivery (2 off), these works are proposed to occur over a period of approximately 10 days during day, evening and night periods under ROL. Retrieval of the hard ground TBMs (2 off) from Marrickville will also occur at the northern access shaft over a similar timeframe.

Assembly and dis-assembly of the TBMs will occur inside the crossover cavern. The gantry crane will be utilised to raise and lower the TBM components within the acoustic shed.

2.3.6 TBM support operations

TBM will be launched from the crossover caver and retrieved at Blues Point. During TBM operation, the slurry from the TBM will be transferred via pipeline to the slurry treatment plant near the Barangaroo barge area. Spoil will then be removed from site via barge during the 7am to 8pm daytime/evening period.

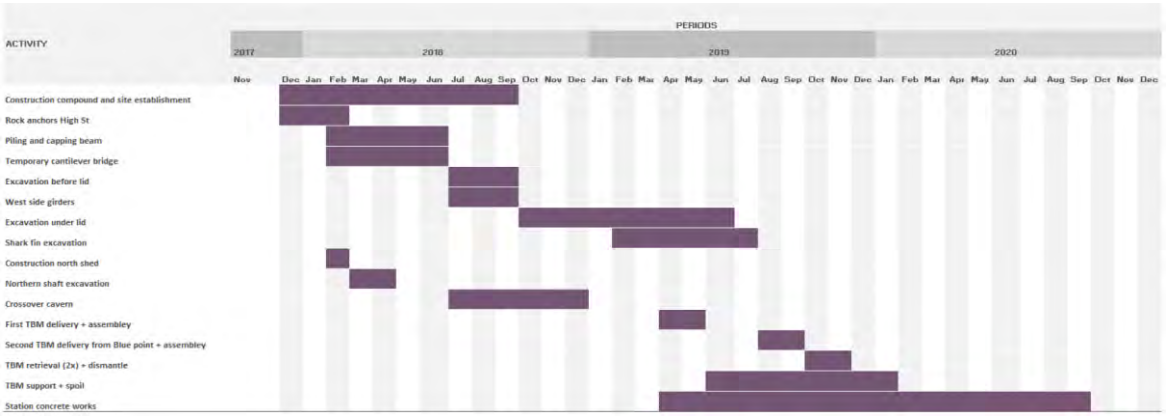
2.3.7 Indicative program

An indicative program for the works (from the Barangaroo CNVIS) is shown in Figure 3.

The figure shows that works at the northern access shaft will be undertaken in parallel with other worksite activities at Barangaroo Station, barging area, shark fin and crossover cavern. The site-specific CNVIS for the Barangaroo worksite includes the cumulative noise and vibration impacts from all activities across the site, and proposed noise and vibration management measures have been established on this basis.

The predicted noise levels in the current assessment are based on the cumulative noise impacts from all sites. In most cases, the sensitive receivers nearest to the northern shaft access shaft are dominated by these works and vice versa.

Figure 3: Indicative program



2.4 Construction Hours

The construction hours for the Project are defined by Project Planning Approval Conditions E36, E37, E38, E41, E42 and E44. The standard hours and out-of-hours work (OOHW) periods are depicted in Table 1 below. The OOHW periods are further defined as OOHW Period 1 and 2 based on the Transport for NSW Construction Noise Strategy (TfNSW CNS).

Table 1: Construction hours

Day	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Monday																								
Tuesday																								
Wednesday			OOHW Period 2								Standard Hours									OOHW Period 1				
Thursday																								
Friday																								
Saturday																								
Sunday or Public Holiday											OOHW Period 1									OOHW Period 2				

2.5 Justification for OOHW

High noise impact plant such as concrete saws, rockhammers and grinders will be mainly used during standard construction hours. However, some works associated with the acoustic shed construction, TBM assembly and TBM dis-assembly will be required during OOHW periods to minimise traffic impacts.

Project Planning Approval conditions allow construction work to be undertaken outside standard construction hours under defined circumstances, as outlined in Approval Condition E44. Section 4.3.2 of the Construction Noise and Vibration Management Plan (CNVMP) *Out of hours work under Road Occupancy Licence* identifies the need to undertake ROL works during OOHW periods. To maintain the functionality of the road network, access to busy roads for construction is often precluded or restricted before 10 pm, and so construction works need to be carried out during the 'night' period, or OOHW

Period 2. When high impact noise activities need to be extended outside standard construction hours under ROL, preference is where practicable to limit these activities:

1. Saturday from 1 pm to 10 pm;
2. Sunday from 8 am to 10 pm;
3. Weekday shoulder periods from 10 pm to 12am.
4. No high impact plant should be not carried out past midnight.

Furthermore, all major components of the soft ground TBM will be transported to the site via barge, and will be transferred with the SPMT (self-propelled modular trailer) from the Barangaroo barge area to the northern access shed.

Condition L4.3 of the Project's Environment Protection Licence (EPL) permits work to be undertaken outside standard construction hours for the delivery of oversized plant.

All OOHW works will be managed in accordance with the Out of Hours Works Protocol which has been prepared for the project in accordance with Condition E47.

3 Nearest sensitive receivers

3.1 Residential receivers

To assess and manage construction noise and vibration impact, the residential areas surrounding the Project worksite has been divided into Noise Catchment Areas (NCAs) based on each area's similar acoustic environment prior to the commencement of construction work. The NCAs are based on those established in the EIS for the Project, with some modifications to allow for site specific characteristics.

Noise assessment is undertaken at representative residential receivers in each noise catchment area (NCA) summarised in Figure 2. The NCAs relevant to this assessment are BN_01, BN_02 and BN_03.

3.2 Other sensitive receivers (Condition E34)

As well as residential receivers, 'other' noise and vibration sensitive receivers (such as educational institutions, medical facilities, places of worship and recreational areas) have been identified around the construction sites. Noise assessment is undertaken at representative 'other' sensitive receivers in each NCA.

3.3 Commercial and industrial premises

Representative commercial and industrial premises near the worksite have also been considered in this assessment.

3.4 Heritage receivers

Heritage receivers are identified in the Land Use Survey in Annexure B of the CNVMP. Table 2 identifies the heritage-listed structures close to the northern access shaft works:

Table 2: Assessment heritage receivers

Site	Item	Address	Significance
Barangaroo	Terrace duplex group including interiors	2–36 High Street	Item 883 City of Sydney LEP; SHR Item 00920
	Palisade Hotel including interior and archaeological site	35-37 Bettington Street	Item 874 City of Sydney LEP; Archaeological site A1191; SHR Item 00510
	Bridges over Hickson Road	Argyle Place (and Munn and Windmill Streets)	Item 869 City of Sydney LEP
	Retaining Wall, Palisade Fence and Steps	High Street	Item 881 City of Sydney LEP/Item 882 City of Sydney LEP
	Hickson Steps	16-28 Windmill St	Maritime NSW S170 Register Item 4920007
	Dalgety Terrace	7, 9, 11, 13 Dalgety Terrace	SHR00867

Site	Item	Address	Significance
	Terraces	27a, 29a, 31a, 33, 35a Dalgety Terrace	SHR00923
	Terraces	15, 17, 19, 21, 23, 25 Dalgety Terrace	SHR00867
	Dalgety's Bond Stores Group of Buildings	6-20 Munn Street	Maritime NSW S170 Register; SHR Item 00526
	Shops	10, 10a, 12, 12a Argyle Place	SHR00891
	Lord Nelson Hotel	19 Kent Street	SHR00509

3.5 Noise and vibration predictions

Within this report, construction noise and vibration predictions are presented at representative sensitive receivers near the northern access shaft works.

For airborne noise levels, predictions are made at ten representative receivers (refer Section 5). Ground-borne noise levels associated with the excavation of the shaft are provided in Section 6. Ground-borne vibration levels are provided in Section 7.

4 Construction noise and vibration objectives

4.1 Noise goals

4.1.1 Noise management levels

Construction noise management levels have been determined using the Conditions of Approval, in accordance with the Sydney Metro City & Southwest Construction Noise and Vibration Strategy (SMCSNVS).

For the Barangaroo worksite, internal noise management levels are applicable at residential and other sensitive receiver locations during the daytime and evening (7 am to 8 pm) period per Conditions of Approval E37 and E38. During the evening and night-time period (8 pm to 7 am), internal noise levels per Conditions E41 and E42 are applicable at residential receivers. APPENDIX B identifies the adopted external equivalent construction noise management levels (NMLs) for the nearest noise sensitive receivers to the worksite.

Works during 7am to 8pm day/evening period

If receivers are noise affected during the 7am to 8pm day/evening period [internal $L_{Aeq(15minute)}$ noise levels greater than 60 dB(A)], consultation is required to be undertaken to determine appropriate hours of respite in accordance with Conditions E37 and E38.

At all locations, internal noise levels are required to be less than 60 dB(A) for 6.5 hours of the 13-hour work period and less than 55 dB(A) for 50% of this period.

Works during 8pm to 7am evening/night period

If residential receivers are noise affected during the 8 pm to 7 am evening/night period [internal $L_{Aeq(15minute)}$ noise levels greater than 45 dB(A)], additional mitigation measures are required to be considered in accordance with the documented procedure in Addendum A of the SMCSNVS.

Additional requirements for all periods

In addition to the objectives identified above, where construction activities are tonal or impulsive in nature and are described in the ICNG as being particularly annoying, a +5 dB(A) correction must be added to the activity noise, in accordance with Conditions of Approval E37, E38, E41 and E42.

Activities defined in the ICNG as particularly annoying include, but are not limited to the use of 'beeper' style reversing or movement alarms; power saws; vibratory rolling; jack hammering, rock hammering or rock breaking; and impact piling. If construction works include ground-borne noise or a perceptible level of vibration at the affected receiver, a 5 dB(A) penalty should be added to the predicted construction noise level.

Any construction related activities that could exceed the NMLs will be identified and managed in accordance with the CNVMP.

4.1.2 Respite for high noise impact works (including Conditions E37 and E38)

Proposed daytime works need to be assessed against the requirements of Conditions E37 and E38. Consultation will be undertaken with receivers predicted to experience internal noise levels greater than $L_{Aeq(15minute)}$ 60 dB(A), between 7am and 8pm, to determine appropriate hours of respite in accordance with Conditions E37 and E38. Receivers have been identified using the following process:

- An external noise threshold equivalent to an internal noise level of $L_{Aeq(15minute)}$ 60 dB(A) was established for all identified receivers:
    - For residential receivers, the equivalent external noise threshold is based on a 10 dB(A) minimum (conservative) difference between external and internal noise levels (assuming windows open)
    - For non-residential receivers with light weight glazing, the equivalent external noise threshold is based on a 20 dB(A) minimum (conservative) difference between external and internal noise levels (assuming windows closed)
    - For non-residential receivers with heavy glazing, the equivalent external noise threshold is based on a 25 dB(A) minimum (conservative) difference between external and internal noise levels (assuming windows closed)
    - Where additional information is available (e.g. if residential or non-residential properties have been acoustically treated), alternative outdoor to indoor noise difference will be determined to establish the equivalent external noise threshold
    - Receivers predicted to exceed the equivalent external noise threshold are identified in Appendix B as requiring consultation.

The adopted difference between external and internal noise levels is identified in APPENDIX B.

4.1.3 Residential receivers in residential and non-residential zones (Conditions E41 and E42)

Condition E41 requires that residential receivers within non-residential zones do not exceed the following internal noise levels (including a 5 dB(A) penalty if considered an annoying activity).

- $L_{Aeq(15minute)}$ 60 dB(A) between 8pm and 9pm
- $L_{Aeq(15minute)}$ 45 dB(A) between 9pm and 7am.

Condition E42 requires that residential receivers within residential zones do not exceed internal noise levels of $L_{Aeq(15minute)}$ 45 dB(A) (inclusive of a 5 dB(A) penalty if considered an annoying activity) between 8pm and 7am.

Addendum A of the SMCSNVS notes that zoning will be used to identify if residential receivers are located within residential or non-residential zones. However, for this assessment, all residential receivers are conservatively assumed to be in residential zones, with a corresponding internal noise threshold level of $L_{Aeq(15minute)}$ 45 dB(A) between 8pm and 7am. Where this level is exceeded, additional mitigation will be offered in accordance with the SMCSNVS.

4.1.4 Sleep disturbance

The ICNG recommends that where construction works are planned to extend over more than two consecutive nights, maximum noise levels and the extent and frequency of maximum noise level events exceeding the RBL should be considered.

To assess the likelihood of sleep disturbance, an initial screening level of (L_{Amax} or $L_{A1(1min)}$) ≤ $L_{A90(15min)}$ + 15 dB(A) is used. In situations where this results in an external screening level of less than 55 dB(A), a minimum screening level of 55 dB(A) is set, as noted in Section 5.2.3 of the CNVMP. Note that this is equivalent to a maximum internal noise level of 45 dB(A) with windows open.

Where there are noise events found to exceed the initial screening level, further analysis is made to identify:

- the likely number of events that might occur during the night assessment period
- whether events exceed an 'awakening reaction' level of 55 dB(A) L_{Amax} (internal) that equates to NML of L_{Amax} or $L_{A1\ (1minute)}$ 65 dB(A) (assuming open windows).

The ICNG recommends that where construction works are planned to extend over more than two consecutive nights, maximum noise levels and the extent and frequency that maximum noise levels exceed the RBL should be analysed.

4.1.5 National Standard for exposure to noise

In accordance with Project Planning Approval Condition E43, TSE worksites will be managed to ensure that noise generated by construction will not exceed the National Standard for exposure to noise in the occupational environment of an eight-hour equivalent continuous A-weighted sound pressure level of $L_{Aeq,8h}$, of 85 dB(A) for any employee working at a location near a TSE worksite

4.2 Vibration goals

As reported in Section 5.6 and 5.7 of the CNVMP, construction vibration goals have been determined in accordance with Project Planning Condition E28 and the Sydney Metro Construction Noise and Vibration Strategy as follows:

- **Human annoyance** - the acceptable vibration values set out in '*Assessing Vibration: A Technical Guideline*' (Department of Environment and Conservation, 2006); and
- **Structural damage** - the vibration limits set out in the British Standard 7385 Part 2 (1993).

4.2.1 Disturbance to building occupants (human annoyance)

For disturbance to human occupants of buildings, we refer to '*Assessing Vibration; a technical guideline*'. This document provides criteria which are based on the British Standard BS 6472-1992, *'Evaluation of human exposure to vibration in buildings (1-80Hz)'*.

Intermittent vibration is assessed using vibration dose values (VDVs). For the assessment of potential vibration at the nearest vibration sensitive receivers preferred and maximum VDV goals for the day period (7:00am to 10:00pm) are presented in Table 3.

Table 3: Construction Vibration Disturbance Goals

Location	Assessment period[1]	Vibration Dose Value (VDV), m/s$^{1.75}$	
		Preferred values	Maximum values
Critical areas[2]	Day or Night	0.10	0.20
Residences	Day	0.20	0.40
	Night	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or Night	0.40	0.80
Workshops	Day or Night	0.80	1.60

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source: BS 6472-1992

4.2.2 Structural damage to buildings

A conservative vibration damage screening level per receiver type is given below:

- Reinforced or framed structures (Line 1): 25.0 mm/s
- Unreinforced or light framed structures (Line 2): 7.5 mm/s

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

4.2.3 Heritage

As noted in the CNVMP, the approach to manage potential vibration impact shall be to:

1. Identify heritage items where the 2.5 mm/s peak component particle velocity objective may be exceeded during specific construction activities
2. Structural engineering report to be undertaken on identified heritage items, to confirm structural integrity of the building and confirm if item is 'structurally sound'
3. If item confirmed as 'structurally sound', the screening criteria in Section 4.2.2 *shall be adopted, or*

4. If item confirmed as 'structurally unsound', *the more* conservative cosmetic damage objectives of 2.5 mm/s peak component particle velocity would be adopted.

4.2.4 Sensitive Scientific and Medical Equipment

No sensitive scientific or medical equipment are known near the assessed works. If they are identified, relevant vibration criteria should be established for each item in line with Section 5.8.3 of the CNVMP [1], and any corresponding management or mitigation measures determined.

4.2.5 Utilities and Other Vibration Sensitive Structures

The presence of other nearby utilities or vibration sensitive structures should be investigated prior to undertaking the works. If any utilities or other vibration sensitive structures are identified, relevant vibration criteria will be established for each item per Section 5.8.3 of the CNVMP, and any corresponding management or mitigation measures determined.

4.3 Construction related road traffic noise objectives

Construction traffic movements on public roads will aim to limit any increase in existing road traffic noise levels to no more than 2 dB(A). All feasible and reasonable noise mitigation and management measures will be implemented.

5 Noise Assessment

This section identifies the noise sources to be used on site, describes the methodology for predicting noise levels at the nearest receivers and presents the results of the assessment.

5.1 Noise Sources and construction scenarios

Noise generating equipment to be used for key construction scenarios has been identified by JHCBPG. A list of the indicative plant and equipment and corresponding sound power levels used as inputs for the noise modelling is provided in Table 4.

As noted in Section 2.3.7, the indicative program identifies that construction activities may be undertaken in parallel in several areas of the Barangaroo worksite.

The assessment includes the cumulative noise impact of the noise modelling scenarios described in Table 5. Details of the construction activities for scenarios associated with the station box, shark fin and barging area are described in the Barangaroo worksite CNVIS.

Table 4: Indicative list of plant and equipment with sound power levels used for noise modelling

Construction Scenario	Activities	Approximate duration	Plant/ Equipment	Number of plant		Sound Power Level (Lw re: 1pW) L_{Aeq}, dB(A)	Notes
				7am to 8pm	8pm to 7am		
V01	Preparation works Utility location and saw cut road	1 week	Concrete / road saw	2 *	2 *	121 + 5 dB penalty	Concrete saw not used after midnight
			General power tools (drill, etc.)	2 *	2 *	105	Only 1 power tool after midnight
			General power tools (circular saw, etc.)	1	1	110 + 5 dB penalty	Circular saw not used after midnight
			Vacuum Truck	1 *	1 *	108	
			Excavator with hammer	1	1	118 + 5 dB penalty	Hammer not used after midnight
			Excavator with bucket	1	1	103	
			Bogie Truck or Truck and Dog	1	1	108	
			Light vehicles	2 *	2 *	89	Only 1 light vehicle after midnight
			Lighting tower	0	1 *	93	
V02	Capping Beam & FRP Works Excavation, formwork, reo and pour concrete	2 weeks	Concrete / road saw	2	2	121 + 5 dB penalty	Concrete saw not used after midnight
			General power tools (drill, etc.)	2	2	105	Only 1 power tool after midnight
			General power tools (circular saw, etc.)	1	1	110 + 5 dB penalty	Circular saw not used after midnight
			Vacuum Truck	1	1	108	
			Excavator with hammer	1	1	118 + 5 dB penalty	Hammer not used after midnight
			Excavator with bucket	1	1	103	
			Bogie Truck or Truck and Dog	1	1	108	
			Jumping Jack Whacker Packer	1	1	108	
			Plate compactor	1	1	108	
			Light vehicles	2 *	2 *	89	Only 1 light vehicle after midnight
			Concrete Agitator	1 *	1 *	108	
			Generator	1 *	1 *	94	
			Concrete vibrators	2	2	106	
			Mobile crane	1	1	98	
			Mobile trench roller	1	1	109	
			Concrete pump	1 *	1 *	106	
			Lighting tower	0	1 *	93	

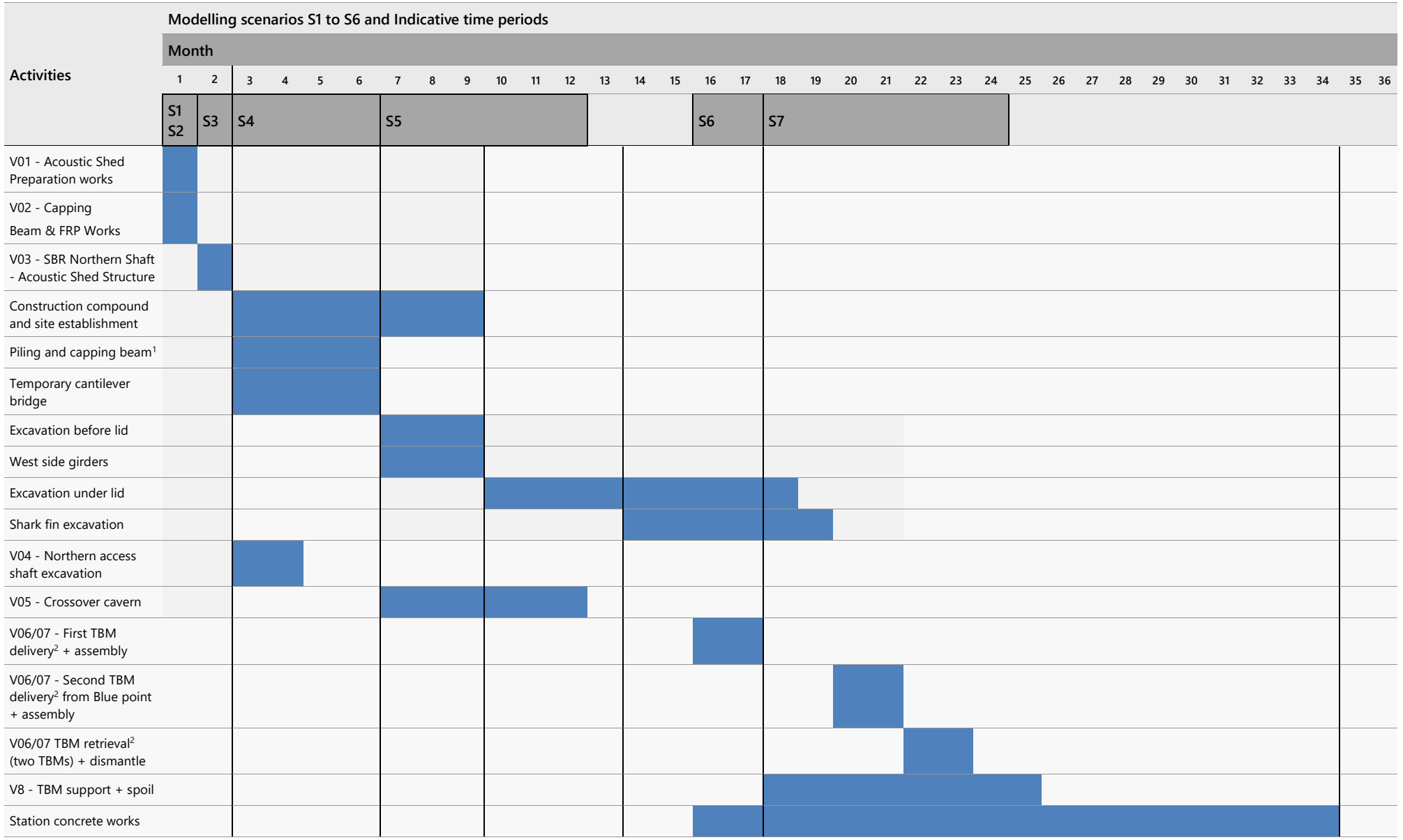
Construction Scenario	Activities	Approximate duration	Plant/ Equipment	Number of plant		Sound Power Level (Lw re: 1pW) L_{Aeq}, dB(A)	Notes
				7am to 8pm	8pm to 7am		
			Drill Rig	1 *	1 *	120 + 5 dB penalty	Drill rig not used after midnight
V03	SBR Northern Shaft - Acoustic Shed Structure	6-7 weeks	General power tools (drill, etc.)	2 *	2 *	105	Only 1 power tool after midnight
			General power tools (circular saw, etc.)	1 *	1 *	110 + 5 dB penalty	Circular saw not used after midnight
			Semi-trailer	1	1	104	
			Light vehicles	2 *	2 *	89	Only 1 light vehicle after midnight
			Generator	1	1	94	
			Mobile crane 350 t	1	1	98	
			Mobile crane 25 t Franna	1 *	1 *	103	Windmill St and Argyle Place
			86ft EWP	2 *	2 *	98	Windmill St and Argyle Place
			3/4inch impact driver	2	2	106	
			Dogmans whistles	2	2	-	Avoid use of whistles at night whenever practicable
			Lighting tower	0	1	93	Windmill St and Argyle Place
V04	Excavation of northern access shaft	2 months	Excavator with hammer 45t	1 *	0	122 + 5 dB penalty	Inside acoustic shed
			Excavator with hammer 30t	1 *	0	122 + 5 dB penalty	Inside acoustic shed
			Excavator with bucket	2 *	0	103	
			Truck & Dog (spoil haulage)	3 per hour *	0	106	
			Gantry crane	1	1	96	
V05	Mined Crossover Cavern - spoil transported from shaft to barge area Tunnel excavation & support spoil handling	9 months	Road header	2	2	n/a	Operates underground - not part of airborne noise assessment
			Dust Scrubber (SDS14) with 2x silencer	2	2	87	Attenuated to achieve stated sound power level
			Ventilation fan with attenuators	1 *	1 *	97	Attenuated to achieve stated sound power level. Not required until scrubber is moved underground.
			Drilling Jumbo	1	1	n/a	Operates underground - not part of airborne noise assessment
			Shotcrete rig	1	1	n/a	Operates underground - not part of airborne noise assessment
			Excavator with hammer 30t	4	0	n/a	Operates underground - not part of airborne noise assessment

Construction Scenario	Activities	Approximate duration	Plant/ Equipment	Number of plant		Sound Power Level (Lw re: 1pW) L_{Aeq}, dB(A)	Notes
				7am to 8pm	8pm to 7am		
			Gantry crane (electric)	1 *	1 *	96	Gantry crane at shed level. Spoil stored in the cavern after 8pm
			Crane Alarm (broadband)	1 *	1	85	Visual alarm at night
			Dump truck (Moxy CAT 725)	2	2	108	Trucks operate underground. Bring spoil from roadheader and tipping into the stockpile located inside cavern adjacent to shaft base.
			Concrete delivery truck	2 per hour *	2 per hour *	106	Access through southern gate, supplying shotcrete down drop hole, inside shed. Noise from reversing alarm should be minimised where practicable.
			FE Loader (CAT980)	1 * + 1	0	110	1 loading spoil into kibble at bottom of shaft and 1 loading spoil under Hickson Road bridge outside shed
			Dump Truck	8 per hour	0	106	Transfer spoil from shaft to Spoil Loadout shed (by the water)
V06	TBM delivery and retrieval	10 days each	Loading/unloading to/from barge with SPMT	1	1	116	
			Gantry crane in acoustic shed in Hickson Rd – with visible alarms after 10:00pm	4 lifts / hr *	4 lifts / hr *	95	
			Site Forklift	1 *	1 *	103	Forklift assists with timbers and bringing materials within the crane's reach
V07	TBM assembly and disassembly (inside cavern)	12 weeks each	Hammering Steel	2 locations *	0	110	Instantaneous noise level 115-120 dB(A). Assume hammering occurs for 1-2 min over 15 min period, so Leq(15 min) 110 dB(A)
			Gantry crane	1	1	96	Within shed
			Air/ hydraulic hand tools	2	2	112	Bottom of shaft
			Hydraulic Power Pack	1	1	76	Bottom of shaft
			Welding Machines 400 amp	4	4	95	Bottom of shaft and inside cavern
			Welding Machines 400 amp	1 *	0	95	Bottom of shaft and inside cavern
			Site Forklift	1	1	103	Bottom of shaft and inside cavern

Construction Scenario	Activities	Approximate duration	Plant/ Equipment	Number of plant		Sound Power Level (Lw re: 1pW) L_{Aeq}, dB(A)	Notes
				7am to 8pm	8pm to 7am		
			SPMT in cavern	1	1	116	Bottom of shaft and inside cavern
V08	TBM support operations	9 months	Grout plant	1*	1*	85	to be enclosed
			Ventilation fan	2*	2*	97	In the cavern with the intake going up to Hickson Rd and being directed towards the North through the shed wall (and with attenuators/louvres)
			TBM Cooling water & water treatment plant pump	1*	1*	103	partial or full enclosure may be required
			Bentonite mixing area	1*	1*	70	on surface
			DESANDER	3*	3*	104	inside acoustic shed
			55-1-G Centrifuge	3*	3*	97	inside acoustic shed
			SD 2400 Primary shaker	1*	1*	108	inside acoustic shed
			Active Tank B pump	1	1	78	outside acoustic shed
			Fresh bentonite pumps	4	4	97	outside acoustic shed. To be partly enclosed
			FE Loader in spoil loading shed	2*	-	104	highly muffled / Loading conveyor inside foreshore shed
			Excavator with bucket	1*	1*	103	inside acoustic shed
			Spoil loading conveyor / stacker	1*	-	83/m	same spoil loading operation as for Cavern
			Forklift Loading moving materials	1	1	103	outside in the foreshore area south STP shed
			Truck Movement (MSVs) Combustion Engine CATERPILLAR C7 phase 3A	2 p.h.*	2 p.h.*	106	within Cross Over Cavern
			Segment Delivery trucks (Semi trailers)	2 p.h.*	-	106	access through southern gate.
			MSV/Truck Horn		minimise	-	Broadband horn - e.g. BBS-tek. Within Cross Over Cavern

Note: * Indicates equipment that have been modelled, which are assumed to operate simultaneously during a reasonable worst-case period.

Table 5: Assessed construction works



Notes:

1.Although piling and capping beam works have been already covered by the Site establishment CNVIS, they have been included in this assessment to quantify the cumulative noise impacts due to other concurrent activities.

2. TBM retrieval and delivery has been assessed separately in scenario S8.

5.2 Modelling Methodology

Modelling and assessment of airborne noise impacts has been undertaken using a Cadna-A computer noise model developed for this project. The model calculates the contribution of each noise source at identified receiver locations and allows for the prediction of the total noise from a site for the various stages of the works.

The noise prediction model considers:

- Location of noise sources and representative receiver locations;
- Height of sources and receivers referenced to one metre digital ground contours for the site area and surrounding area;
- Sound Power Levels (L_W) of plant and equipment likely to be used during the various construction activities;
- Separation distances between sources and receivers;
- Ground type between sources and receivers; and
- Attenuation from barriers (natural and purpose built).

For this assessment the stages of construction activities as presented in Table 4 have been modelled. It is noted that a +5dB penalty has been applied to the noise levels from any stages involving "highly annoying" activities, as defined in Section 4.5 of the ICNG.

5.3 Predicted Noise Levels

Works during 7am to 8pm day/evening period

The predicted noise results consider cumulative impacts from the works described in Table 5 for scenarios S1 to S8. Table 6 summarises the predicted noise impacts for each construction stage at representative receivers in each NCA. More detailed predictions are provided in Appendix B, including the applicable NMLs and assumed outside/inside noise reductions.

Table 6: Noise level summary for 7am to 8pm day/evening period

NCA	Representative Receiver	Receiver type	Internal NML	Assumed outside – inside reduction	Equivalent external NML	Noise levels predicted to be above (◆) or below (◆) equivalent external NML							
						S1	S2	S3	S4	S5	S6	S7	S8
BN_02	25a Hickson Road Barangaroo	Residential	60	10	70	◆	◆	◆	◆	◆	◆	◆	◆
BN_02	68 Bettington Street Millers Point	Residential	60	10	70	◆	◆	◆	◆	◆	◆	◆	◆

NCA	Representative Receiver	Receiver type	Internal NML	Assumed outside – inside reduction	Equivalent external NML	Noise levels predicted to be above (◆) or below (◆) equivalent external NML							
						S1	S2	S3	S4	S5	S6	S7	S8
BN_02	8 Argyle Place Millers Point	Residential	60	10	70	◆	◆	◆	◆	◆	◆	◆	◆
BN_03	2 High Street Millers Point	Residential	60	10	70	◆	◆	◆	◆	◆	◆	◆	◆
OSR	14 Argyle Place Millers Point	Comm.	60	20	80	◆	◆	◆	◆	◆	◆	◆	◆
OSR	8 Windmill Street Millers Point	Comm.	60	20	80	◆	◆	◆	◆	◆	◆	◆	◆
OSR	35-37 Bettington Street Millers Point	Hotel	60	20	80	◆	◆	◆	◆	◆	◆	◆	◆
OSR	Cutaway	Theatre	60	5	65	◆	◆	◆	◆	◆	◆	◆	◆
OSR	25 Hickson Road Barangaroo	Comm.	60	20	80	◆	◆	◆	◆	◆	◆	◆	◆
OSR	19 Kent Street Millers Point	Hotel	60	20	80	◆	◆	◆	◆	◆	◆	◆	◆

The results in Table 6 indicate that some noise levels are predicted to be higher than the internal NML of $L_{Aeq(15minute)}$ 60 dB(A) during the 7 am to 8 pm day/evening period at the nearest receivers for some, but not all locations and scenarios.

Where internal noise levels above $L_{Aeq(15minute)}$ 60 dB(A) have been identified during the 7am to 8pm day/evening period, consultation is required to be undertaken with affected sensitive receivers to determine appropriate respite periods. At affected locations, internal noise levels are required to be less than 60 dB(A) for 6.5 hours of the 13-hour work period and less than 55 dB(A) for 50% of this period.

Further details in relation to the predicted airborne noise levels and consultation requirements will be detailed in the Barangaroo CNVIS.

Works during 8pm to 7am evening/night period

The predicted noise results consider cumulative impacts from the works described in Table 5 for scenarios S1 to S8. Table 7 summarises the predicted noise impacts for each construction stage in each NCA. More detailed predictions are provided in Appendix B, including the applicable NMLs and assumed outside/inside noise reductions.

Table 7: Noise level summary for 8pm to 7am evening/night period

NCA	Representative Receiver	Receiver type	Internal NML	Assumed outside – inside reduction	Equivalent external NML	Noise levels predicted to be above (◆) or below (◆) equivalent external NML							
						S1	S2	S3	S4	S5	S6	S7	S8
BN_02	25a Hickson Road Barangaroo	Residential	45	10	55	◆	◆	◆	◆	◆	◆	◆	◆

NCA	Representative Receiver	Receiver type	Internal NML	Assumed outside – inside reduction	Equivalent external NML	Noise levels predicted to be above (◆) or below (◆) equivalent external NML							
						S1	S2	S3	S4	S5	S6	S7	S8
BN_02	68 Bettington Street Millers Point	Residential	45	10	55	◆	◆	◆	◆	◆	◆	◆	◆
BN_02	8 Argyle Place Millers Point	Residential	45	10	55	◆	◆	◆	◆	◆	◆	◆	◆
BN_03	2 High Street Millers Point	Residential	45	10	55	◆	◆	◆	◆	◆	◆	◆	◆
OSR	35-37 Bettington Street Millers Point	Hotel/Motel /Hostel	45	20	65	◆	◆	◆	◆	◆	◆	◆	◆
OSR	19 Kent Street Millers Point	Hotel/Motel /Hostel	45	20	65	◆	◆	◆	◆	◆	◆	◆	◆

The results in Table 7 indicate that noise levels are predicted to be under the internal NML of $L_{Aeq(15minute)}$ 45 dB(A) during the 8 pm to 7 am evening/night period at the nearest receivers for most scenarios. Levels above the internal $L_{Aeq(15minute)}$ 45 dB(A) NML are predicted for the following scenarios:

- At the nearest residences in Hickson Rd, Bettington St, High St and Argyle St, internal noise levels above $L_{Aeq(15minute)}$ 45 dB(A) are predicted for activities associated with the construction of the acoustic shed during OOHW periods (S1 to S3). As discussed in Section 2.5, ROLs are required during night-time periods to undertake these works and minimise potential impacts on the road network and the safety of pedestrians and workers.

  The duration of the acoustic shed construction works during OOHW periods is approximately 6-12 weeks. However, noise impacts will not occur on all nights, but only when ROLs are required.

- At the nearest residences in High St, levels above the internal $L_{Aeq(15minute)}$ 45 dB(A) NML are predicted for activities associated with the TBM retrieval and delivery scenario during OOHW periods (S7). As discussed in Section 2.5, these works required oversize and heavy loads to be transported on public roads and may therefore occur during night-time periods to minimise potential impacts on the road network and the safety of pedestrians and workers.

  The duration of the TBM delivery and retrieval during OOHW periods is approximately 10 days per TBM (4 in total). However, noise impacts will not occur on all nights, but only when ROLs are required.

Where noise levels are predicted to be above the internal $L_{Aeq(15minute)}$ 45 dB(A) NML during the 8pm to 7am evening/night period, mitigation and management measures are required at affected receivers in accordance with Addendum A of the SMCNVS. Further details in relation to the predicted airborne noise levels, consultation and mitigation requirements will be detailed in the Barangaroo CNVIS's.

5.4 Construction traffic noise

Assessment of the potential noise impact of construction traffic was assessed. Construction traffic includes concrete truck deliveries during the day and night periods along Hickson Road, accessing the acoustic shed via the south gate.

At the nearest affected residential receivers on High Street, the predicted increase in existing road traffic noise levels due to construction traffic was less 2 dB(A) during the day and night periods. On this basis, the predicted noise levels comply with the objectives outlined in Section 4.3.

5.5 Sleep disturbance

The L_{max} (maximum) noise levels associated with concrete deliveries may potentially cause sleep disturbance at nearby residential receivers. In this case, although maximum noise levels may exceed the screening levels, they are well below the sleep disturbance NML of 65 dB(A) $L_{A1\ (1minute)}$.

Due to the proximity of the residential receivers along Hickson Road, Argyle Place, Windmill Street and Dalgety Road, maximum noise levels associated with the construction of the acoustic shed during OOHW periods may cause sleep disturbance. Potential noise sources are outlined in Table 4.

These impacts are unavoidable due to the requirement for works to be undertaken during ROLs. Where practicable, high noise works (such as concrete sawing and power drills) will be carried out prior to midnight.

Potential sleep disturbance impacts from truck movements will be managed by minimising unnecessary acceleration on site and installing air brake silencers and broadband reversing alarms on heavy vehicles as outlined in the CNVMP. For other activities, proposed measures include toolbox talks to advise all personnel of the need to follow quiet work practices during OOHW periods and of the need to respect the residential receivers surrounding the work site.

6 Ground-borne noise assessment

Review of the proposed construction equipment in Table 4 identifies that ground-borne noise impacts may occur within nearby sensitive receivers when the following equipment are utilised for excavation activities at the northern access shaft:

- Excavators with hammer attachment
- Drill rig / drilling jumbo
- Road header

For activities associated with the construction of the acoustic shed (Scenarios S1/S2, V01/V02), airborne noise levels are predicted to be higher than the associated ground-borne noise levels within the nearest sensitive receivers. The required noise mitigation and management measures to minimise potential impacts from these activities (including rockbreaking) are outlined in Section 5.3.

However, for shaft excavation activities and mined tunnel works (undertaken inside the acoustic shed), airborne noise levels will be shielded by the acoustic shed and the prominence of ground-borne noise levels may be higher than airborne noise levels within the nearest sensitive receivers.

The potential impact of ground-borne noise will be highest when excavation works with rock breakers are undertaken close to the surface and will reduced as the depth of the excavation increases. Once the northern access shaft is fully excavated, the depth of the shaft will be approximately 30 m below the ground surface of Hickson Road and a further 14 m below Dalgety Road. At these depths, the ground-borne noise levels associated with roadheaders are drill rigs / drilling jumbos are predicted to be less than 40 dB(A) within the nearest buildings and below the relevant internal noise threshold of 45 dB(A) for the 8pm to 7am evening/night period.

For excavation activities with rockbreakers (daytime/evening periods), ground-borne noise levels are predicted to be up to 65 dB(A) (including 5 dB penalty) within the nearest sensitive receivers when works are undertaken close to the ground surface. The predicted ground-borne noise levels will reduce to approximately 56 dB(A) (including 5 dB penalty) when rockbreaking is undertaken towards the bottom of the northern access shaft. These levels are above the relevant internal NML of 60 dB(A) for the 7am to 8pm day/evening period. Periods of respite will therefore be required at affected receivers in accordance with Approval Conditions E37 and E38.

Further details in relation to the predicted ground-borne noise levels and consultation requirements will be set out in the Barangaroo CNVIS's.

7 Vibration Assessment

7.1 Minimum buffer distances for vibration intensive plant

From the plant and equipment listed in Table 4, the dominant vibration generating plant and equipment include:

- Excavators with hammer attachment
- Drill rig / drilling jumbo
- Road header
- Jumping jack whacker packer / plate compactor

Potential vibration generated to receivers is dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration, and the receiver structure.

The recommended minimum working distances for vibration intensive plant are presented in Table 8 and Table 9. These distances are conservatively based on excavation of hard rock. Site specific minimum working distances for vibration significant plant items will be measured on site where plant and equipment are likely to operate close to or within the minimum working distances for cosmetic damage.

Unlike noise, vibration cannot be readily predicted. There are many variables from site to site, for example soil type and conditions, sub surface rock, building types and foundations, and actual plant on site. The data relied upon in this assessment (tabulated below) is taken from a database of vibration levels measured at various sites or obtained from other sources (e.g. BS5228-2:2009). They are not specific to this project as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

Table 8: Minimum working distances (m) for cosmetic damage (continuous vibration).

Plant item	Minimum working distance (m)		
	Reinforced or framed structures (e.g. commercial buildings)[1]	Unreinforced or light framed structures (e.g. residential buildings) [1]	Sensitive structures (e.g. heritage structures) [2]
Excavator with rock hammer (up to 90T)	5	15	30
Drilling machine	5	5	15
Roadheader	5	5	5
Plate compactor / whacker packer	5[3]	5[3]	5[3]

Note 1: Initial screening test criteria reduced by 50% due to potential dynamic magnification in accordance with BS7385.

Note 2: A site inspection should be undertaken to determine whether a heritage structure is structurally unsound.

Note 3: Minimum working distances are in 5m increments only to account for the intrinsic uncertainty of this screening method. Plate compactors are likely to have minimum working distances smaller than 5 m (e.g. 2m in accordance with TfNSW CNS).

Prior to the commencement of construction activities, a detailed site survey should be undertaken to determine if there are any sensitive structures and/or buried pipework within the minimum working distances in Table 8. If any such structures are identified, detailed assessment is required to establish safe vibration levels and a proposed monitoring plan to ensure that vibration levels comply with the appropriate criterion.

Table 9: Minimum working distances (m) for human annoyance (continuous vibration).

Plant item	Minimum working distances, m				
	Critical areas[1,4]	Residences		Offices[3,4]	Workshops[4]
		Day[2]	Night[2]		
Excavator with rock hammer (up to 90T)	120	70	95	45	30
Drilling machine	25	15	15	10	10
Roadheader	15	10	10	5	5
Plate compactor / whacker packer	Avoid contact				

Notes 1: Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring.
2: Daytime is 7 am to 10 pm; Night-time is 10 pm to 7am.
3: Examples include offices, schools, educational institutions and place of worship.
4: Applicable when in use.

7.2 Vibration assessment

7.2.1 Structural damage

The numbers of buildings which are close to or within the minimum working distances for cosmetic damage are shown in Table 10.

Table 10: Number of building within buffer distances for cosmetic damage

Plant item	Number of buildings	
	Screening test (Non-heritage) Unreinforced or light framed structures	Screening test (Heritage) Sensitive structures (e.g. heritage)
Excavator with rock hammer (up to 90T)	0	2
Drilling machine	0	2
Roadheader	0	0
Plate compactor / whacker packer	0	0

There are 2 heritage listed structures (i.e. Bridges over Hickson Road) potentially within the minimum working distances established for cosmetic damage during the excavation of the shaft. These structures should be inspected prior to the commencement of works to establish relevant vibration criteria.

Vibration monitoring is recommended to verify that vibration levels achieve compliance with the structural damage objectives where plant is required to operate within the minimum working distance identified in Table 8. If the monitoring above identifies that vibration is likely to exceed the structural

damage objectives, a different construction method with lower source vibration levels will be considered.

7.2.2 Human annoyance

The numbers of buildings where there is a probability of adverse comment or disturbance from vibration are shown in Table 11.

Table 11: Number of buildings within buffer distances for human annoyance.

Plant item	Critical areas[1,4]	Residences		Offices[3,4]	Workshops[4]
		Day[2]	Night[2]		
Excavator with rock hammer (up to 90T)	0	23	-	2	0
Drilling machine	0	0	-	0	0
Roadheader	0	0	0	0	0
Plate compactor	0	0	-	0	0

Notes: 1: Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring.
2: Daytime is 7 am to 10 pm; Night-time is 10 pm to 7am.
3: Examples include offices, schools, educational institutions and place of worship.
4: Applicable when in use.

As can be noted from the table above, there are several properties that may be exposed to vibration that may cause adverse comment during the north shaft excavation. Properties are identified in Appendix H of the Barangaroo CNVIS.

Nonetheless, due to the limited time the above plant will be operating close to these properties, the risk of annoyance is considered moderate to low. It is therefore recommended that attended vibration measurements are carried out in the event of complaint from the nearest receivers to confirm that vibration levels are within the acceptable range for human annoyance.

If measurement results indicate exceedances of the vibration objectives for human annoyance, vibration control and management measures will be provided to reduce vibration impact (see Section 7.3.1).

After applying all feasible and reasonable vibration mitigation measures, if vibration monitoring still identifies that measured vibration levels exceed the relevant vibration criteria for human annoyance, appropriate additional mitigation measures should be considered (see Section 7.3.2).

7.3 Vibration mitigation measures

7.3.1 Vibration control and management measures

In addition to the vibration control measures presented in the CNVMP, the following vibration management measures are provided to minimise vibration impact from construction activities to the

nearest affected receivers and to meet the relevant human comfort vibration and structural damage limits.

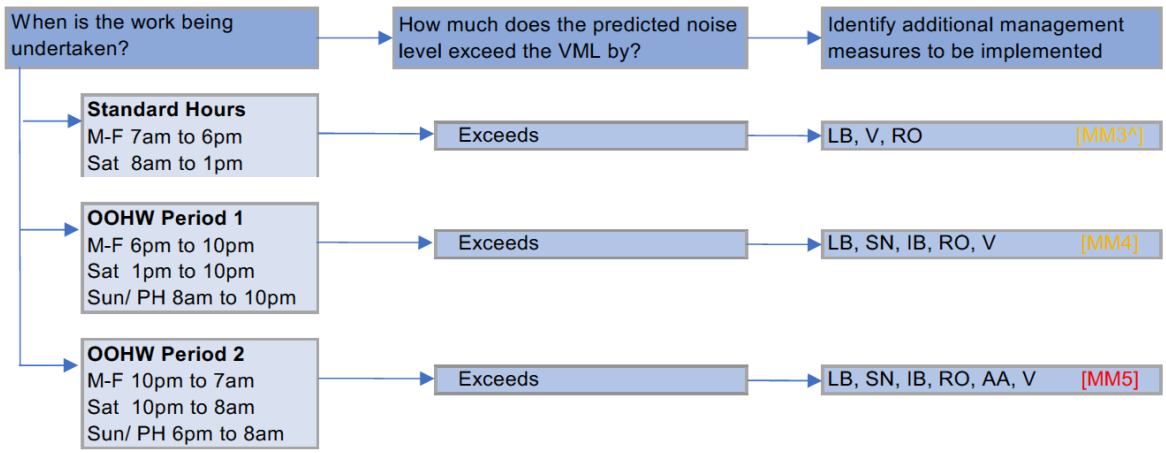
Table 12: Site vibration control measures

Control type	Control measure	Typical use
Construction Planning	Building condition surveys	Undertake building dilapidation surveys on all buildings located within the minimum working distances established for cosmetic damage prior to commencement of activities with the potential to cause property damage.
	Community consultation	Implement community consultation measures – inform community of construction activity and potential impacts
	Equipment selection/ construction method	Use less vibration emitting construction methods where feasible and reasonable.
	Plan work activities to minimise vibration.	Plan traffic flow, parking and loading/unloading areas to maximise distances between truck routes and sensitive receivers.
Complaints Management	Construction Complaints Management System	Complaints will be managed in accordance with the Construction Complaints Management System. Each complaint shall be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures shall be put in place to mitigate future occurrences. Management measures may include modification of construction methods such as using smaller equipment and establishment of minimum working distances as mentioned above.

7.3.2 Additional vibration mitigation measures

After applying all feasible and reasonable mitigation measures identified in Table 12, if vibration monitoring at representative locations still exceeds relevant vibration objectives for human annoyance, the appropriate additional vibration mitigations measures, as outlined in Section 8.2 of the CNVMP.

Table 13: Additional vibration mitigation measures



Notes: Use the abbreviation codes in the table above to confirm management measures required
Code in square brackets [] refers to noise management code for affected receivers identified in each CNVIS

7.3.3 Vibration monitoring

Attended vibration monitoring is to be undertaken to determine and verify site specific minimum working distances for cosmetic damage and human annoyance. Attended vibration monitoring will be undertaken during works whenever vibration significant plant items are operating close to or within the determined minimum working distances.

Real-time noise monitoring in accordance with Approval Condition C11 is proposed for this site and will commence prior to the start of the bulk excavation works.

Table 14: Attended vibration monitoring - nominated representative locations

Plant	Address	Vibration objectives to check	
		Structural damage - Non-heritage	Structural damage – Heritage (to inspect)
Excavator with rock hammer (90T) / Drilling machine	Hickson Rd Bridges		√

8 Recommendations

As noted in Section 5.3, the predicted noise levels are above the noise management objectives at the nearest sensitive receivers to the northern access shaft for some, but not all activities.

To assist in managing noise impacts at the northern access shaft, the construction of an acoustic shed is proposed. This will allow spoil removal activities to occur during daytime/evening periods at reduced noise levels and tunnel ventilation equipment / concrete deliveries to occur during the evening/night period at reduced noise levels.

During construction of the acoustic shed, unavoidable noise impacts will occur at the nearest residential receivers when OOHWs are required to be carried out under ROLs. Unavoidable noise impacts will also occur during OOHW periods when ROLs are required for transporting oversize TBM equipment between the barging area and the northern access shaft.

For all other longer-term construction activities during the evening/night period, internal noise levels at the nearest receivers are predicted to be below the noise management levels at the nearest residential receivers.

During day/evening periods, noise levels are predicted to be above the noise management levels for some scenarios at the nearest sensitive receivers. Consultation is required with affected receivers in accordance with Approval Conditions E37 and E38 to identify appropriate respite periods.

The following sections provide a summary of the indicative noise control measures that are proposed to be implemented to reduce noise impacts to surrounding receivers. These measures have been derived from the CNVMP. Detailed mitigation measures specific to the acoustic shed construction and other northern access shaft activities will be provided in the relevant CNVIS.

8.1 Reasonable and feasible noise and vibration mitigation

8.1.1 Standard noise and vibration management measures

An indicative list of standard noise and vibration mitigation measures to be implemented for the construction of the TSE Works to reduce construction noise and vibration is provided in the tables that follow.

- Table 15, which identifies standard noise and vibration management measures
- Table 16, which lists standard noise and vibration source mitigation measures
- Table 17, which sets out standard noise and vibration receptor mitigation measures.

Table 15: Standard noise and vibration management measures

Action required	Details	Estimated noise benefit	Comments on feasibility/ reasonableness	Preferred action?
Implement community consultation or notification measures	Notification detailing work activities, dates and hours, impacts and mitigation measures, indication of work schedule over the night period, any operational noise benefits from the works (where applicable) and contact telephone number. Notification should be a minimum of seven calendar days prior to the start of works. For this project, more advanced consultation or notification should be adopted, including: Website (if required) Contact telephone number for community Email distribution list (if required)	Ensures stakeholders know what to expect and keeps stakeholders informed of the likely impact. Community may identify solution to assist in managing impacts.	N/A	Yes
Register of Noise Sensitive Receivers	A register of all noise and vibration sensitive receivers (NSRs) would be kept. The register would include the following details for each NSR: Address of receiver Category of receiver (e.g. Residential/Commercial etc.) Contact name and phone number	N/A Ensures worksites can contact NSRs.	N/A	Yes
Site inductions	All employees, contractors and subcontractors are to receive an environment and community induction. The induction must at least include: • all site specific and relevant standard noise and vibration mitigation measures • relevant licence and approval conditions • community consultation and notification requirements • 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) • community contact protocols • complaints management requirements.	Keeps construction workforce informed of actions required to minimise noise and vibration impact.	N/A	Yes
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height where practicable, throwing of metal items and slamming of doors. No excessive revving of plant and vehicle engines Controlled release of compressed air.	0-20dB reduction Reduce annoyance + sleep disturbance.	Reasonable cost, limited noise reduction, reduced overall impact.	Yes
Verification	A noise verification program is to be carried out for the duration of the works in accordance with the Environment Protection Licence conditions. Ongoing noise monitoring during construction at sensitive receivers during critical periods (i.e. times when noise emissions are expected to be at their highest - e.g. piling and hammering) to identify and assist in managing high risk noise events.	0dB reduction Minimises noise and vibration impact.	Reasonable cost, limited noise/vibration reduction, reduced overall impact.	Yes

Action required	Details	Estimated noise benefit	Comments on feasibility/ reasonableness	Preferred action?
Attended vibration measurements	Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels satisfy the criteria for that vibration generating activity. Where there is potential for exceedances of the criteria further vibration investigations would be undertaken to determine the site-specific safe working distances for that vibration generating activity. Continuous vibration monitoring with audible and visible alarms would be conducted at the nearest sensitive receivers whenever vibration generating activities need to take place inside the applicable safe-working distances.	Reduces vibration impact + risk of structure damage.	Reasonable cost, and consideration of refinement of operations to reduce overall impact.	Yes

Table 16: Standard noise and vibration source mitigation measures

Action required	Details	Estimated noise benefit	Comments on feasibility/ reasonableness	Preferred action?
Construction hours and scheduling	Construction is proposed to be carried out during the standard daytime working hours where permitted. Due to traffic impacts and to facilitate 24-hour tunnelling operations night works will be required. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods where practicable.	Minimise high noise impact and reduce risk of annoyance.	N/A	Where reasonable and Feasible
Construction respite period - standard hours	High noise generating activities near receivers should be carried out in blocks that do not exceed three hours each, with a minimum respite period of one hour between each block unless an alternative respite strategy is adopted following community consultation in accordance with Project Planning Approval Conditions E37 and E38 and the EPL Conditions.	Minimise noise and vibration impact and reduce risk of annoyance.	Reasonable cost, limited noise/vibration reduction, reduced overall impact.	Yes
Consider vibration in selecting plant and equipment	Use quieter and less vibration emitting construction methods where feasible and reasonable.	0-20dB reduction depending on selected equipment	Reasonable cost, limited noise reduction, reduced overall impact.	Where reasonable and feasible
Construction methodology/ Equipment selection	Use quieter and less noise emitting construction methods where feasible and reasonable, especially where they can replace high noise or vibration impact works.	0-20dB reduction/ less vibration impact + risk of annoyance.	Variable noise/vibration reduction, reduced overall impact, cost varies. Reasonableness and feasibility needs to be determined on a case by case basis.	Where reasonable and feasible
Maximum noise levels	The noise levels of plant and equipment must have operating Sound Power Levels compliant with the maximum noise levels in Table 11 of the Sydney Metro City and Southwest Construction Noise and Vibration Strategy	Varies depending on plant sound power level	Reasonable cost, variable noise reduction, minimum requirement.	Yes

	Regular compliance checks on the noise emissions of all plant and machinery used for the project would indicate whether noise emissions from plant items were higher than predicted. This also identifies defective silencing equipment on the items of plant.			
Rental plant and equipment	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the maximum noise levels in Table 11 of the Sydney Metro City and Southwest Construction Noise and Vibration Strategy.	Varies depending on plant sound power level	Reasonable cost, variable noise reduction, minimum requirement.	Yes
Plan worksites and activities to minimise noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.	Reduce noise/ vibration impact + risk of annoyance.	Reasonable cost, variable noise/vibration reduction, reduced overall impact.	Where reasonable and feasible
Switch off plant not in use	Avoid the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers to reduce noise to NSRs.	3-6dB reduction	Reasonable cost, medium reduction, where practicable	Where reasonable and feasible
Non-tonal reversing 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. Whilst the use of non-tonal reversing alarms is suggested to ensure noise impacts are minimised, it is noted that OH&S requirements must also be fully satisfied.	5-10dB reduction + reduce vibration	Reasonable cost, medium noise reduction	Yes
Engine silencing	The minimising of noise emissions from mobile plant by fitting residential grade mufflers on all mobile plant regularly used at worksites. Ensure plant including the silencer is well maintained. Heavy vehicle vehicles using the sites should have RMS compliant mufflers to control engine braking noise.	0-20dB reduction Reduce annoyance + sleep disturbance.	Medium cost of install, moderate to high noise reduction.	Where reasonable and feasible
Air brake silencing	Air brake silencers should be installed and fully operational for any heavy regularly used at worksite.	5-10dB LAmax reduction	Reasonable cost, medium noise reduction	Where reasonable and feasible
Engine compression braking	Ensure vehicles are fitted with a maintained Original Equipment Manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.	5-20dB reduction	Reasonable cost, medium noise reduction	Yes

Table 17: Standard noise and vibration receptor mitigation measures

Action required	Details	Estimated noise benefit	Comments on feasibility/ reasonableness	Preferred action?
Building condition surveys	Undertake infrastructure surveys on all buildings assessed as being at risk of property damage prior to commencement of activities with the potential to cause property damage.	Limits infrastructure damage.	Reasonable cost, limited vibration reduction, reduced overall impact.	Yes

Action required	Details	Estimated noise benefit	Comments on feasibility/ reasonableness	Preferred action?
vibration monitoring	At locations where there are high-risk receptors, vibration monitoring should be conducted during the activities causing vibration.	Limits damage to infrastructure.	Reasonable cost, limited vibration reduction, reduced overall impact.	Where reasonable and feasible

8.1.2 Additional noise and vibration management measures

During the proposed construction works there will be circumstances where after application of the all reasonable and feasible mitigation measures identified in Table 15 to Table 17, the construction noise and vibration objectives (refer Section 4) will be exceeded. In these instances, and consistent with the Sydney Metro Construction Noise and Vibration Strategy (CNVS), additional noise and vibration management may be applicable, taking into consideration when works are being undertaken and the level of exceedance.

Additional management measures to be applied when mitigating and managing construction impacts are described in Table 18.

Table 18: Additional management measures

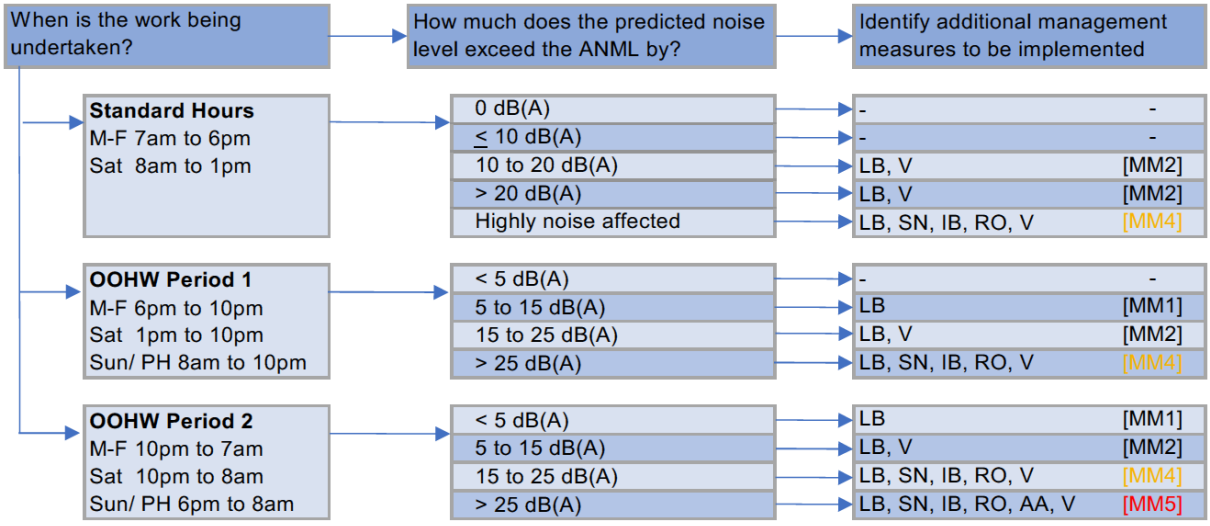
Measure	Description	Abbreviation
Letter box drops	The Sydney Metro TSE will prepare newsletters to be distributed to the local community via letterbox drop and the project email list. The newsletters will provide an overview of current and upcoming works across the TSE Worksites and other topics of interest and/or provide advanced warning of high noise impact activities during the day or potentially audible OOHW. The objective is to engage and inform and provide project-specific messages. The newsletter will disseminate TSE Works information to interested stakeholders. The newsletter will be distributed monthly.	LB
Verification monitoring	Where it has been identified that specific construction activities are likely to exceed the relevant noise or vibration goals, noise or vibration monitoring may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver have been identified). Monitoring can be in the form of either unattended logging or operator attended surveys. The purpose of monitoring is to inform the relevant personnel when the noise or vibration goal has been exceeded so that additional management measures may be considered implemented.	V
Specific notification	Specific notifications are given to identified stakeholders no later than 7 days ahead of construction activities that are likely to exceed the noise objectives. This form of communication is used to support periodic notifications, or to advise of unscheduled works. Specific notification may be in the form of personalised letter delivered or hand distributed; phone call; and/or email.	SN
Individual briefing	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the TSE Works.	IB
Project specific respite offer	The purpose of a TSE Works specific respite offer is to provide respite to residents subjected to lengthy periods of noise or vibration from an ongoing impact. This may be in the form of rescheduling works to better suit sensitive receivers (where reasonable/ feasible). Alternatively, TSE Works specific respite offer may include pre-purchased movie tickets, coffee or meal vouchers. Respite offers will be determined on a case-by-case basis.	RO
Alternative accommodation	Alternative accommodation options may be offered to residents living near construction works that are likely to incur unreasonably high impacts over an extended period. Alternative accommodation will be determined on a case-by-case basis.	AA

8.1.3 Applying additional management measures - airborne construction noise

In circumstances where, after application of all reasonable and feasible mitigation measures, the $L_{Aeq(15minute)}$ airborne construction noise levels are still predicted to exceed the NMLs, additional airborne noise management measures can be applied to further limit the risk of annoyance from construction noise. This requirement is supplemental to the basic requirements in the ICNG.

The steps to be carried out to determine the additional management measures to be implemented are identified in Figure 4.

Figure 4: Additional airborne noise management measures



Notes: Use the abbreviation codes in the table above to confirm management measures required
Code in square brackets [] refers to noise management code for affected receivers identified in each CNVIS

9 Conclusion

Renzo Tonin & Associates has completed an assessment of the environmental noise and vibration impact from the proposed construction activities at the northern access shaft.

Noise and vibration impacts from each construction activity upon the potentially most affected noise sensitive receivers has been quantified and compared to the noise management levels (NML) in the Approval Conditions and other relevant guidelines.

Exceedances of the relevant noise management levels are predicted at the nearest receivers for some, but not all stages of the works.

During the day/evening periods, potential noise impacts will be managed in accordance with the Approval Conditions and SMCNVS via implementation of respite periods in consultation with affected receivers.

During the evening/night periods, unavoidable noise impacts will occur during the construction of the acoustic shed and oversize deliveries of TBM equipment when ROLs are required. Potential noise impacts will be managed in accordance with the Project Planning Approval Conditions and SMCNVS.

Potential ground-borne noise impacts may occur at the nearest sensitive receivers during the day/evening period when rockbreakers are used to excavate the northern access shaft. Potential noise impacts will be managed in accordance with the Project Planning Approval Conditions and SMCNVS via implementation of respite periods in consultation with affected receivers.

The two heritage listed bridges over Hickson Road are located within the minimum working distances established for cosmetic damage during the excavation of the shaft with rockbreakers. Inspection of these structures is required prior to the commencement of the shaft excavation works to establish relevant vibration criteria. Vibration monitoring at these structures is recommended to verify that vibration levels achieve compliance with the relevant criteria.

Vibration associated with rockbreakers, and plate compactors / whacker packers may be perceptible within nearby buildings. Due to the limited time the above plant will be operating close to these properties, the risk of annoyance is considered moderate to low. It is therefore recommended that attended vibration measurements are carried out in the event of complaint from the nearest receivers to confirm that vibration levels are within the acceptable range for human annoyance

Construction Noise and Vibration Impact Statements (CNVIS's) are being finalised for the proposed activities at the Barangaroo worksite, including works associated with the northern access shaft. These CNVIS's will provide a detailed assessment of the potential noise impacts and confirm mitigation and management measures to be implemented.

APPENDIX A Glossary of Terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0 dB The faintest sound we can hear 30 dB A quiet library or in a quiet location in the country 45 dB Typical office space. Ambience in the city at night 60 dB CBD mall at lunch time 70 dB The sound of a car passing on the street 80 dB Loud music played at home 90 dB The sound of a truck passing on the street 100 dB The sound of a rock band 115 dB Limit of sound permitted in industry 120 dB Deafening
dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.

L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Summary of predicted noise levels

Predicted day/evening noise levels

NCA	Representative Receiver	Receiver type	Internal NML	Assumed outside – inside reduction	Equivalent external NML	Predicted LAeq(15min) Noise Levels, Day/Evening 7am to 8pm							
						S1	S2	S3	S4	S5	S6	S7	S8
BN_02	25a Hickson Road Barangaroo	Res.	60	10	70	76	76	73	84	73	71	56	54
BN_02	68 Bettington Street Millers Point	Res.	60	10	70	77	77	68	68	72	67	54	55
BN_02	8 Argyle Place Millers Point	Res.	60	10	70	69	69	63	69	68	72	55	54
BN_03	2 High Street Millers Point	Res.	60	10	70	70	70	61	75	77	77	60	59
OSR	14 Argyle Place Millers Point	Comm.	60	20	80	87	87	78	80	76	75	58	57
OSR	8 Windmill Street Millers Point	Comm.	60	20	80	80	80	78	84	71	68	54	52
OSR	35-37 Bettington Street Millers Point	Hotel	60	20	80	82	82	70	72	78	76	61	57
OSR	Cutaway	Theatre	60	5	65	53	53	57	55	51	52	45	42
OSR	25 Hickson Road Barangaroo	Comm.	60	20	80	83	83	73	85	90	83	71	74
OSR	19 Kent Street Millers Point	Hotel	60	20	80	55	55	48	62	62	65	50	50

Note: Numbers in green represent compliance with equivalent external NMLs. *Numbers in red represent exceedances of the equivalent external NMLs.*

Northern access shaft works:

S1: Acoustic Shed Preparation works

S2: Capping Beam & FRP Works for acoustic shed

S3: Northern Shaft - Acoustic Shed Structure

S4: Northern access shaft excavation (noise levels include concurrent activities at other Barangaroo worksites per Table 5*)*

S5: Crossover cavern excavation and spoil transport to barging area (noise levels include concurrent activities at other Barangaroo worksites per Table 5*)*

S6: TBM assembly and disassembly within crossover cavern (noise levels include concurrent activities at other Barangaroo worksites per Table 5*)*

S7: TBM support and spoil handling (noise levels include concurrent activities at other Barangaroo worksites per Table 5*)*

S8: TBM delivery and retrieval (noise levels include concurrent activities at other Barangaroo worksites per Table 5*)*

Predicted evening/night noise levels

NCA	Representative Receiver	Receiver type	Internal NML	Assumed outside – inside reduction	Equivalent external NML	Predicted LAeq(15min) Noise Levels, Evening/Night 8pm to 7am							
						S1	S2	S3	S4	S5	S6	S7	S8
BN_02	25a Hickson Road Barangaroo	Res.	45	10	55	70	72	69	32	55	52	49	54
BN_02	68 Bettington Street Millers Point	Res.	45	10	55	58	60	65	29	51	47	45	55
BN_02	8 Argyle Place Millers Point	Res.	45	10	55	47	49	62	33	49	42	42	54
BN_03	2 High Street Millers Point	Res.	45	10	55	52	54	57	36	50	45	45	59
OSR	35-37 Bettington Street Millers Point	Hotel	45	20	65	63	65	65	37	51	47	46	57
OSR	19 Kent Street Millers Point	Hotel	45	20	65	36	38	45	36	43	40	41	50

Note: Numbers in green represent compliance with equivalent external NMLs. *Numbers in red represent exceedances of the equivalent external NMLs.*

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S8: TBM delivery and retrieval (noise levels include concurrent activities at other Barangaroo worksites per Table 5*)*

Appendix D – Visual Impact Assessment

IRIS Visual Planning + Design

Landscape Planning | Visual Assessment | Landscape Architecture

78 Macgregor Terrace, Bardon 4064

PO Box 189 Red Hill 4059

0404558501

ABN 72166862157

MEMO

Date: 28th February 2018

RE: Proposed Barangaroo temporary northern shaft, at Hickson Road, Barangaroo

Site Location

Barangaroo, on Hickson Road, between Windmill Street, Argyle Place and Dalgety Road.

Existing project

The EIS assessed a construction site area that would extend along Hickson Road, under the Argyle Place and Windmill Street bridges. Works within this area were assessed as laydown and set up areas only, no acoustic enclosure was envisaged at this location.

Planning context

Sydney Local Environmental Plan, City of Sydney, 2012

The project is located in close proximity to several heritage sites of local and state significance, as well as the Millers Point Heritage Conservation Area, and the Millers Point & Dawes Point Village Precinct Heritage Conservation Area, which have state heritage significance. This assessment will therefore need to consider the "*settings and views*" of these heritage items under the Heritage conservation clause (5.10).

Millers Point Heritage Conservation Area

The proposal site is located at Millers Point, one of the most significant urban places in NSW and the City of Sydney. The statement of significance on the NSW Government's State Heritage Register describes Millers Point as *'an intact residential and maritime precinct of outstanding State and national significance*'. Millers Point includes a variety of roadway types and forms such as adjacent roadways separated vertically, bridges, cuttings, ramps, which forms a three-dimensional or vertical layer of street patterns, including the bridges over Hickson road.

One of the objectives for the management of this conservation area is to retain major viewscapes from the precinct to the harbour, the Sydney Harbour Bridge and headlands beyond.

The site is located on Hickson Road, at the base sheer sandstone cuttings, between the Windmill Street and Argyle Place bridges, whose Victorian sandstone blockwork pillars and palisade fencing are described as characteristic of the area. The bridges at Argyle Place and Windmill Street are described as '*landmark bridge structures*' and are state listed heritage items. They … '*form a "tunnel", and gateway between the Darling Harbour and the Walsh Bay wharf and shipping terminus*'.

The vertical sandstone cuttings of Hickson Road rise approximately 12 metres from Hickson Road.

The rock cuttings are … *'of historical and aesthetic interest'.*

At bridge level, the built form of Palisade Hotel, and rows of Victorian and Federation style terrace houses on Dalgety Road and Argyle Place provide a historic character.

The Palisade Hotel '*makes a considerable townscape contribution through its prominent siting providing terminal views along several streets and has a distinctive tall and narrow form contrasting with the lower scale buildings adjacent resulting in landmark qualities'*.

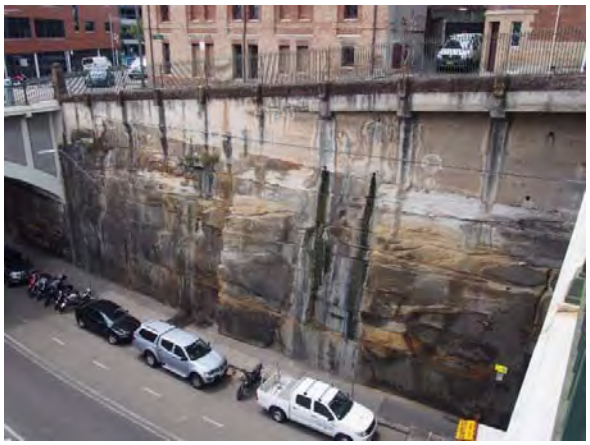
The row of terraces at the corner of Argyle Place are considered to be … *'very important to the streetscape of Millers Point'*. The *'curved rock faced stone retaining walls flanking the western edge of the street'* on Dalgety Road is also described as an important character feature.

Millers Point & Dawes Point Village Precinct Heritage Conservation Area

The proposal site is located along western edge of Millers Point & Dawes Point Village Precinct. The precinct is on the State Heritage Register, recognised for its ability to demonstrate the development of colonial and post-colonial settlement in Sydney and New South Wales through its physical forms, historical layering, documentary and archaeological records and social composition. It is regarded as a *'complete and cohesive area due to contributory materials, form and scale'.*

'All streets within the area are regarded as having a "Street Rating A: meaning Highly intact streetscapes of the key period (or periods) of significance for the heritage conservation area.'

This area is regarded as a … *'complete and cohesive area due to contributory materials, form and scale'*. The … *'natural rocky terrain, despite much alteration, remains the dominant physical element in this significant urban cultural landscape'.* The … *'vistas and glimpses of the harbour along its streets and over rooftops'* are also important to the character of this precinct.



Eastern cut – rough, weathered sandstone cutting with masonry above, with low sandstone walls and palisade fencing at street level

Existing site conditions

The key visual features of the site are:

- The natural sandstone cutting on Hickson Road
- The decorative, arched Windmill Street and Argyle Place bridges are 'landmark' structures
- Glimpsed views to the harbour along Dalgety Road
- The visual prominence of the 'landmark' Palisade Hotel
- Views to the towers of the Sydney CBD and Barangaroo from the bridges and adjacent streets
- Character of the terraces at the corner of Argyle Place
- Historic character buildings on Windmill Street, facing the sandstone cutting, visually extends the vertical plane of the cutting, matching in colour and texture.

The visual separation between Millers Point and the former waterfront precinct of the Barangaroo Headland allow glimpses to Sydney Harbour from Argyle Place

Visual separation created by sandstone cuttings along Hickson Road, and view to historic arched Bridge at Argyle Place

Sensitivity levels

The EIS identified Hickson Road, including the area under the Windmill Street Bridge, as being of **local landscape and visual sensitivity.**

The Millers Point and Dawes Point Village Precinct was not an area identified in the EIS. This area is considered to be of **regional landscape and visual sensitivity**. This is due to the aesthetic values of this historic precinct, including several heritage character buildings, views to Sydney Harbour, Sydney Harbour Bridge, over heritage roofscapes, Observatory hill, and the Sydney CBD and Barangaroo high-rise towers.

This is consistent with the sensitivity attributed to the landscape and views from High Street identified in the EIS, which has similar aesthetic values.

Character and components of the proposed design change

This summary describes the construction and operation phases of the project.

Construction phase

Stage 1:

During construction there would be an acoustic enclosure established on Hickson Road, between the Argyle Place and Windmill Street Bridges.

This acoustic enclosure would:

- be 32m long, 14m wide and 21m high
- protrude above the Windmill and Argyle Place bridges for approximately:
    - 7-7.5 metres above the road surface at the Argyle Place bridge
    - 10-10.5 metres above the road surface at Windmill Street bridge
- be a standard acoustic enclosure with steel cladding
- Have a 5-degree pitch on the roof

The acoustic enclosure would be required to be tethered to the cutting, this would include:

- Approximately 10 rock bolts extending into the eastern side of the Hickson Road cutting

Stage 1 would be required for a duration of construction would be 2-3 years.

Stage 2:

This acoustic enclosure would:

- be 32m long, 14m wide and 10.5 metres high
- would not protrude above the Windmill and Argyle Place bridges
- be a standard acoustic enclosure with steel cladding
- Have a 5-degree pitch on the roof

The acoustic enclosure would no longer be tethered to the cutting.

Stage 2 would be required for a duration of construction would be 3-4 years.

During construction the following road closures would be required:

- Hickson Road, one lane closure for approximately 18 days and 12 nights
- Hickson Road, total closure for approximately 1 night and 5 days
- Windmill Street north, parking lane and footpath closure for up to 50 days
- Windmill Street north, one lane closure intermittently under traffic control for up to 35 days
- Windmill Street (Argyle Place access Lane) closure intermittently under traffic control for approximately 50 days
- Argyle Place Footpath closure, northern side along the bridge, approximately 50 days.

Operation phase

The enclosure would be removed and Hickson Road reinstated.

There would be evidence of the rock bolts in the rock face of the eastern side of the Hickson Road cutting (10 in total).

The rock bolts may be removed and the holes in the natural sandstone patched with a mortar of similar colour to the adjacent rock.

Assessment of landscape impact

The following landscapes will be considered.

- Hickson Road (assessed in the EIS)
- Hickson Road Cutting
- Argyle Place, Dalgety Road and Windmill Street

Hickson Road

Construction impact – EIS: The project was assessed as creating a noticeable reduction in the landscape quality of this streetscape, which is of local sensitivity, resulting in a **minor adverse landscape impact** during construction.

Note: The EIS design assumed the proposed acoustic enclosures to be of a maximum height of 15 metres so they did not rise above the height of the sandstone cutting. There were also no direct impacts on the cutting proposed.

As the sandstone cutting was not specifically addressed in this assessment, the direct impacts on the wall will be addressed separately for the Hickson Road Cutting, see below.

Construction impact – proposed design change: The proposed design change proposes a full road closure of Hickson Road between the bridges. This would be required intermittently for a total of approximately 1-2 months. This would further reduce the pedestrian and vehicular accessibility of the precinct during construction. Overall, there would continue to be a **minor adverse landscape impact** during construction.

This impact is unchanged from the EIS.

Operation impact - EIS: Due to the reinstatement of Hickson Road and expanded public realm that would be created around the station, the EIS identified a noticeable improvement in the landscape quality of this streetscape, and a **minor beneficial landscape impact**.

Operation impact – proposed design change: The proposed design change does not alter accessibility and public realm outcomes of the precinct. This impact would remain as a **minor beneficial landscape impact**.

Note: As the sandstone cutting was not specifically addressed in this EIS assessment, the direct impacts on the wall will be addressed separately for the Hickson Road Cutting, see below.

Hickson Road Cutting

The parallel cuttings between the Windmill Street and Argyle Place bridges are a local landmark and important visual feature within the landscape of this precinct. These cuttings create a tunnel and a sense of visual enclosure, which forms a gateway and strong visual edge between the Millers Point and Barangaroo headland precincts.

Construction impact – proposed design change:

The proposed acoustic enclosure design proposes direct impacts on the sandstone cutting between Windmill Street and the Argyle Place bridges. This would include the insertion of approximately 10 bolts into the sandstone section of the eastern cliff, resulting in a direct removal of part of this landscape feature, changing its form and character. These changes would not be experienced during construction as access and visibility would be limited during this time. Overall, there would be a noticeable reduction in this landscape feature, which is of regional landscape sensitivity, and a **moderate adverse landscape** impact during construction.

Operations impact – proposed design change:

The cutting would be altered by the 10 rock bolts which would either be retained in place or be removed, and the resulting holes patched with a mortar similar to the colour of the adjacent rock. This would be a permanent change to the natural character and shape of the sandstone cutting. The patching is likely to be recognizable as a contemporary change to the wall. Overall, there would continue to be a noticeable change to this landscape element, which is of regional landscape sensitivity, resulting in a **moderate adverse landscape impact**.

Argyle Place, Dalgety Road and Windmill Street

Construction impact – proposed design change:

During Stage 1 construction the acoustic enclosure would create overshadowing of the Windmill Street access lane and adjacent buildings. There would also be a reduction in the accessibility of the streets surrounding the site as intermittent road, parking lane and footpath closures are required. In particular, the footpaths to the north of the Argyle Place bridge, and to the south of the Windmill Street bridge would be closed to pedestrian access for approximately 50 days. This would create a noticeable reduction in the landscape quality of these streetscapes, which are of regional landscape sensitivity, resulting in a **moderate adverse landscape impact** during operation.

Operations impact – proposed design change:

The impacted streetscapes would be reinstated, and access fully restored after construction. Therefore, there would be no perceived change in the landscape quality of these streetscapes, which are of regional landscape sensitivity, resulting in a **negligible landscape impact** during operation.

Assessment of daytime visual impact

The following views will be assessed:

- Viewpoint 4: View south from Hickson Road at the Windmill Street Bridge (from the EIS)
- Views from western footpath on Hickson Road
- Viewpoint a: View northeast from footpath on Dalgety Road
- Viewpoint b: View southwest from Windmill Street

Viewpoint 4: View south from Hickson Road at the Windmill Street Bridge

Mid-rise contemporary brick and masonry residential and office buildings line this area of Hickson Road. Street trees filter views to the buildings and frame a view to the twin arches of the Dalgety Road and Windmill Street Bridges. These elements are a focal point in the centre, middle ground of this view. Exposed sandstone cliffs and constructed sandstone walls contribute to the character of this streetscape.

Construction impact - EIS: From this location there would be views to a construction site which would include a laydown area located on the eastern side of Hickson Road (left), under the Argyle Place and Windmill Street bridges. This would include construction site perimeter fencing, hoarding, construction equipment within the construction site, as well as construction vehicles using Hickson Road. These elements would obstruct views to the sandstone cliff walls and change the character of the roadway in this area.

It is expected that the project would create a noticeable reduction in the amenity of this view, which is of local visual sensitivity, resulting in a **minor adverse visual impact** during construction.

Construction impact – proposed design change:

Stage 1 – Acoustic enclosure at maximum height

From this location there would be views to the construction and operation of an acoustic enclosure. This enclosure would be located beyond the arched Windmill Street Bridge, so that this arched feature would continue to be visible unobstructed from this location. The proposed acoustic enclosure would extend across the eastern (left) two thirds of the tunnel, blocking the existing view of the Argyle Place bridge, curved sandstone cutting and visually enclosing the tunnel.

The acoustic enclosure would also be seen rising above the Windmill Street Bridge by approximately 10 to 10.5 metres. This structure would obscure the sky and introducing built form which would replace the existing visual separation between the Barangaroo headland and the historic areas of Millers Point.

Overall, it is expected that the project would create a considerable reduction in the amenity of this view, which is of local visual sensitivity, resulting in a moderate adverse visual impact during construction.

This is an increased adverse visual impact from that identified in the EIS.

Stage 2 – Acoustic enclosure lowered

The proposed acoustic enclosure would be reduced in height so that it would not protrude above the Windmill Street Bridge. The acoustic enclosure would, however, continue to be visible, beyond the bridge, extending across the eastern (left) two thirds of the tunnel, obstructing the glimpsed view to the Argyle Place Bridge in the background, curved sandstone wall and visually enclosing the road tunnel. Above the Windmill Street Bridge views to the sky and visual separation of the Barangaroo headland from the historic areas of Millers Point would be restored.

Overall, it is expected that the project would create a noticeable reduction in the amenity of this view, which is of local visual sensitivity, resulting in a minor adverse visual impact during Stage 1 construction.

This is consistent with the impact identified in the EIS.

Operation - EIS: There would be no part of the project visible from this location during the operation of the project. This would result in a negligible visual impact.

Operation impact – proposed design change: There would be no part of the project visible from this location during the operation of the project. This would result in a negligible visual impact during stage 2 construction, which is unchanged from the EIS.

Views from western footpath on Hickson Road

Construction impact – proposed design change:

During construction there would be intermittent access along Hickson Road, through the tunnel and under the Argyle Place and Windmill Street bridges. Views from this footpath would be enclosed by site perimeter fencing, hoarding, and the acoustic shed. Construction vehicles would also be seen using Hickson Road. These elements would obstruct views to the sandstone cliff walls and change the character of the roadway in this area. This would result in a noticeable reduction in amenity to a

landscape of regional sensitivity, and a **moderate adverse visual impact** during stage 1 and 2 of construction.

Operation impact – proposed design change: Hickson Road would be reinstated, however, there would be permanent alteration to the sandstone cutting in the form of approximately 10 bolt heads, or if they are removed, 10 areas of localised damage to the sandstone cutting. These holes may be patched with a mortar to match the adjacent sandstone. However, the form and shape of the cutting would be altered. Although the wall would continue to weather over time, in the short to medium term, and changes from the naturally weathered sections would be clearly visible.

Overall, this change would create a noticeable reduction in the amenity of this view, which is of regional visual sensitivity, resulting in a **moderate adverse visual impact** during operation.

Viewpoint a: View northeast from footpath on Dalgety Road

View across a wide expanse of Dalgety Road to a five storey heritage character brick building, and smaller two-storey heritage corner building on Argyle Place (right of view). A mix of contemporary and historic buildings of a similar height are located to the north, along Windmill Street, and rising from Hickson Road. Over these buildings, the upper portion of the arch and both northern and southern pylons of the Sydney Harbour Bridge can be seen. This view was not assessed in the EIS.

Construction impact – proposed design change:

Stage 1 – Acoustic enclosure at maximum height

From this location the proposed acoustic enclosure would be seen rising approximately 7 to 7.5 metres above the Argyle Place Bridge in the middle ground of this view and extending to the Argyle Place bridge (right of view). This enclosure would be seen unobstructed and block views to the west facing heritage buildings on Windmill Street, in the middle ground, and partially obscure views to the Sydney Harbour Bridge in the background. The introduction of this enclosure would limit the depth of views from this location and reduce the sense of openness and visual separation between the Palisade Hotel and Windmill Street.

It is expected that the proposal would result in a considerable reduction in the amenity of this view, which is of regional visual sensitivity, resulting in a **high adverse visual impact** during Stage 1 construction.

Stage 2 – Acoustic enclosure lowered

This acoustic enclosure would be reduced in height so that it does not protrude above the Windmill Street Bridge. As such it would not be visible from this location. Therefore, there would be no perceived change in the amenity of this view, which is of regional visual sensitivity, resulting in a **negligible visual impact** during stage 2 construction.

Operation impact – proposed design change:

The acoustic enclosure would have been removed and there would be no project elements visible in this view. This would result in no perceived change in the amenity of this view, and a **negligible visual impact** during operation.

Viewpoint b: View southwest from Windmill Street

View across a wide expanse of Windmill Street towards Dalgety Road and the six storey Palisade Hotel, a local visual landmark. The landform rises gently to the Palisade Hotel which marks the

entrance to the historic former waterfront precinct. It is surrounded by lower terrace houses, and open space, further emphasising its visual prominence. The arched Argyle Place bridge can also be seen through the decorative iron railings which enclose the cutting. The upper section of the western cutting, which is mainly masonry in this section, can also be seen. This view was not assessed in the EIS.

Construction impact – proposed design change:

Stage 1 – Acoustic enclosure at maximum height

From this location the proposed acoustic enclosure would be seen in the foreground, rising approximately 10 – 10.5 metres above the Windmill Street Bridge and extending south and east along Windmill Street. This shed would obstruct views to the cutting, Argyle Place bridge, Palisade Hotel and surrounding terraces. The enclosure would foreshorten the view, reducing the sense of openness and visual separation between the Barangaroo headland and Windmill Street. Furthermore, the size and proximity of this enclosure to viewers, would make it a dominant element in this view, with a construction character that contrasts with the detail and texture of the surrounding heritage character built-form. The proposal would result in a considerable reduction in the amenity of this view, which is of regional visual sensitivity, resulting in a **high adverse visual impact** during construction.

Stage 2 – Acoustic enclosure lowered

This acoustic enclosure would be reduced in height so that it does not protrude above the Windmill Street Bridge. However, in this view the top of the acoustic enclosure would continue to be visible and may partly obstruct views to the arched Argyle Place Bridge. With the acoustic enclosure lowered, the openness of this view would be restored, as would views to the Palisade Hotel and surrounding open space and terrace houses. On balance, it is expected that the project would create no perceived change in the amenity of this view, which is of regional visual sensitivity, resulting in a **negligible visual impact** during construction.

Operation impact – proposed design change:

The acoustic enclosure would have been removed and there would be no project elements visible in this view. Therefore, there would be no perceived change in the amenity of this view, which is of regional visual sensitivity, resulting in a **negligible visual impact** during operation.

Assessment of night time visual impact

The night setting of the site is considered to be an area of **E4: High district brightness**. This is due to its brightly lit CBD location.

Construction: It is expected that there would be night works required at this location during construction, however, this lighting would be largely contained by the proposed acoustic shed. Therefore, it is expected that at night the project would not create a perceived change in the amenity of views in this area of high district brightness, resulting in a **negligible visual impact** during evening hours.

Operation: The surrounding streets would be reinstated and there would be no additional lighting provided by the project. Therefore there would be no perceived change in visual amenity, resulting in a **negligible visual impact** during evening hours.

Summary of Impacts

The following tables summarise the potential landscape and visual impacts of the project.

No.	Location	Sensitivity	Construction		Operation	
			Modification	Impact	Modification	Impact
	Landscape					
1	Hickson Road (from the EIS)	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor adverse
1	Hickson Road	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor adverse
2	Hickson Road Cutting	Regional	Noticeable reduction	Moderate adverse	No perceived change	Moderate adverse
3	Argyle Place, Dalgety Road and Windmill Street	Regional	Noticeable reduction	Moderate adverse	No perceived change	Negligible
	Daytime visual					
4	View south from Hickson Road at the Windmill Street Bridge (from the EIS)	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
4	View south from Hickson Road at the Windmill Street Bridge (Stage 1)	Local	Considerable reduction	Moderate adverse	-	-
4	View south from Hickson Road at the Windmill Street Bridge (Stage 2)	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
a.	Views from western footpath on Hickson Road (Stage 1 & 2)	Local	Considerable reduction	Moderate adverse	Considerable reduction	Moderate adverse
b.	View northeast from footpath on Dalgety Road (Stage 1)	Regional	Considerable reduction	High adverse	-	-
b.	View northeast from footpath on Dalgety Road (Stage 2)	Regional	No perceived change	Negligible	No perceived change	Negligible
c.	View southwest from Windmill Street (Stage 1)	Regional	Considerable reduction	High adverse	-	-
c.	View southwest from Windmill Street (Stage 2)	Regional	No perceived change	Negligible	No perceived change	Negligible

No.	Location	Sensitivity	Construction		Operation	
			Modification	Impact	Modification	Impact
	Night time visual					
	Site	E4: High district brightness	No perceived change	Negligible	No perceived change	Negligible

Opportunities for reducing the visual impact:

In views from Hickson Road, where the proposed acoustic enclosure would be seen within the tunnel and also above the bridge, against the sky, the selection of a dark colour for the lower section of the enclosure would replicate the effect of the existing tunnel, and a lighter colour for the upper section of the acoustic enclosure would be visually lighter and may reduce the visual enclosure created by the introduction of built form in this area of visual separation.

In views from Windmill Street, Dalgety Road and Argyle Place to the upper portions of the enclosure, techniques could be employed to visually reduce the mass and scale of the enclosure. This might include the use of shape, line, colour and texture to disguise the form of the enclosure.

The enclosure could be shaped to minimise the impact on key view corridors, maximising the sense of space and visual separation along the alignment of the rock cutting, and minimising encroachment on the visual prominence of the Palisade Hotel. Any shaping of the enclosure should aim to protect important view corridors such as views to the Palisade Hotel (a local visual landmark), views northeast (over Hickson Road) to the Harbour bridge, and northwest along Dalgety Road to the harbour. Maintaining views to the arched bridges is also important.

Any treatment of the upper section of the enclosure should be sympathetic to the surrounding historic, urban character. This would be done by drawing upon themes, shapes, colours and textures from existing built form rather than mimicking adjacent heritage buildings.

Appendix E – Heritage Impact Assessment

artefact

Barangaroo temporary northern shaft heritage assessment

Project: Sydney Metro – Chatswood to Sydenham	**Date:** 1 March 2018
Project site: Barangaroo temporary northern shaft	**Author:** Sandra Wallace
Contractor: JAR	

Background

This heritage assessment is required to assess potential impacts to heritage listed items and archaeological resources as a result of the proposed works at the Barangaroo temporary northern shaft which will be undertaken as part of the Sydney Metro City & Southwest project. The assessment relies on the historical background and context outlined in the Non-Aboriginal Heritage Impact Assessment for the Sydney Metro City & Southwest – Chatswood to Sydenham project (Artefact 2016).

Proposed Works

To maintain the Sydney Metro City and Southwest Tunnel and Station Excavation (TSE) tunnel boring programme and form site separation between the Barangaroo Station and the Barangaroo Crossover Cavern excavation, the contactor proposes to excavate an additional shaft called Barangaroo temporary northern shaft. The shaft is proposed within the road surface of Hickson Road Barangaroo between the Dalgety Road and Windmill Street bridges (Figure 1). This area was shown indicatively as a lay-down area in the Environmental Impact Statement (EIS).

The purpose of the shaft is to undertake all the above scope that was assessed and approved as occurring in the northern portion of the Station box including:

- The assembly of the slurry Tunnel Boring Machine (TBM)
- The access point for launching of the tunnel boring machine to Blues Point
- The tunnel boring support services
- Spoil removal for slurry TBM - there would be pipes delivering the slurry from the TBM to the slurry treatment plant located at the southern foreshore through the northern temporary shaft
- Bentonite for TBM, bentonite is used to balance the pressure of the TBM and the soil and water pressure of the harbour crossing. These pipes that would deliver the bentonite to the TBM would enter through temporary northern shaft.
- Spoil removal for crossover cavern, spoil would be placed on a truck and delivered to the barge loading bay for removal
- The retrieval of the slurry TBM
- The retrieval of hardrock TBS's.

The Shaft

The shaft itself would be approximately 17 metres by 10 metres and 30 metres deep to the tunnel level. The shaft would be excavated using traditional excavation methods including rock sawing and excavator and rock hammer road headers and excavators within the acoustic portal frame to minimise noise impacts at nearby sensitive receivers. Spoil would be lifted out in a kibble by the gantry crane which would be fixed to the acoustic shed portal frame. Rock bolts from the shaft into the surrounding rock would be installed to ensure stability. None of these rock bolts would be visible above the road surface. .

The Acoustic Enclosure and gantry crane

The shaft would be covered by an acoustic enclosure 32 metres long, 14 metres wide and 21 metres high (Figure 2 and Figure 6). The shed would be founded into capping beams in the current road footprint. The shed would extend the entire envelope from Dalgety Street Bridge to Windmill Street Bridge. The shed would be clad in Colorbond having a standard colour of Jasper.

The height of the acoustic shed is such that it can facilitate the safe access and egress of heavy equipment such as the TBMs and road headers but also incorporate a 5.5m high muck bin to maintain excavation production rates and maintain the construction program. It is understood the shed would stand at its full height for 2-3 years, with a reduced height for another 4-5 years.

The acoustic shed would contain a 220T gantry crane. The gantry would be used to lower roadheaders for the excavation of the cross over cavern. It would then lower the slurry TBM into the cross over cavern for launching for the first tunnel drive and then again for relaunching the slurry TBM for the second tunnel drive. It would also be used to retrieve the two hard rock TBMs used for the Marrickville to Barangaroo sections of the tunnel.

Other duties will be lowering all supplies necessary for the construction of the crossover cavern and the tunnels. The gantry crane requires considerable height and therefore the shed would protrude up between the Windmill and Dalgety Road bridges for approximately nine metres above that road surface. The roof of the shed has a five degree pitch.

The acoustic shed above the shaft would be required to be tethered either to Hickson Road or to the High St cutting with pre-tensioned rock bolts to maintain the strength and support for the gantry crane. Two rock bolts for each of the five portal frames of the shed, a total of 10 rock bolts would be installed into the eastern side of Hickson Road cutting, (Figure 2). They have been designed to be within the cutting itself rather than within the masonry work. Each rock bolt would extend around five metres into the cutting and would have a drilling hole size a minimum of 65mm (Figure 5). The rock bolts would be cement grouted with non-shrink cement grout between the plate and the surface of the cutting. The wall of the acoustic shed would not come into contact with the cutting.

Support activities

Following the shaft excavation works, spoil associated with the excavation of the crossover cavern would be transferred between the temporary northern shaft and the spoil loadout shed near the Barangaroo barge area.

Within the acoustic shed, spoil would be loaded into a kibble at the bottom of the shaft, lifted to the surface by gantry crane and loaded into trucks with a front-end loader.

Concrete trucks (unloaded inside the acoustic shed) would also be required to support shotcreting activities for the underground excavation and the installation of the final concrete lining of the crossover cavern and under harbour cross passage structures.

The duration of the works is approximately nine two years (May 2018 to June 2020).

TBM would be launched from the crossover cavern and retrieved at Blues Point. During the TBM operation, the slurry from the TBM would be transferred via pipeline to the slurry treatment plant near the Barangaroo barge area. Spoil would then be removed from site via barge. The TBM operational requirements will also be supported from the temporary northern shaft e.g. segment delivery, grout, grease and other operational materials.

Following completion of the tunnelling activities the acoustic shed and 220T gantry crane would be removed and a reduced height shed installed to facilitate the delivery of plant and materials to the tunnels and crossover cavern for their fitout. The height of this shed would be designed to be no higher than the level of the adjacent bridges.

The temporary northern shaft would be decommissioned and reinstated to its current condition prior to operation of the Sydney Metro.

Figure 1: Plan showing configuration of acoustic enclosure shed and laydown areas

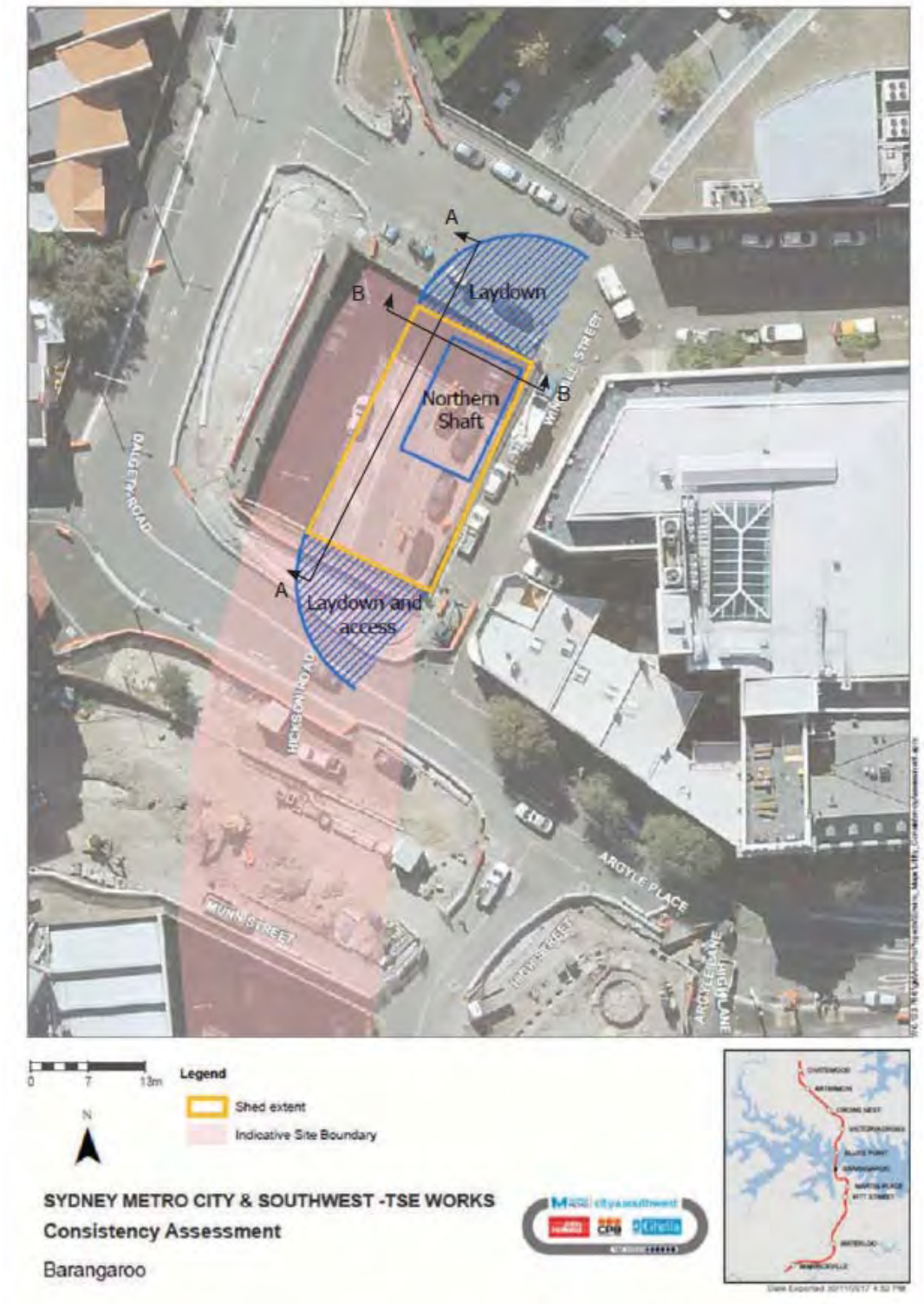


Figure 2: Plan of the proposed acoustic enclosure on Hickson Road

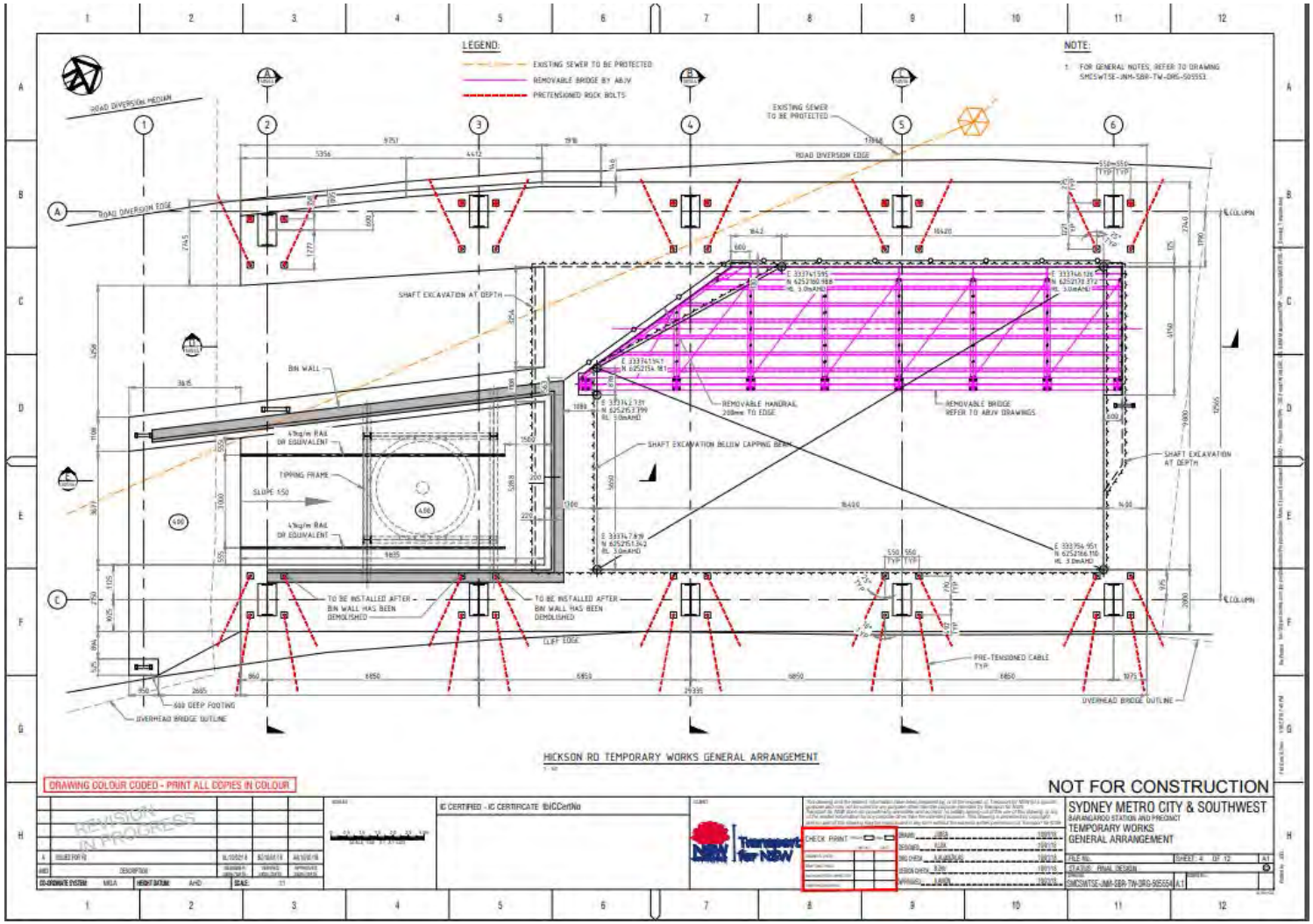


Figure 3: Sections of the proposed acoustic enclosure on Hickson Road

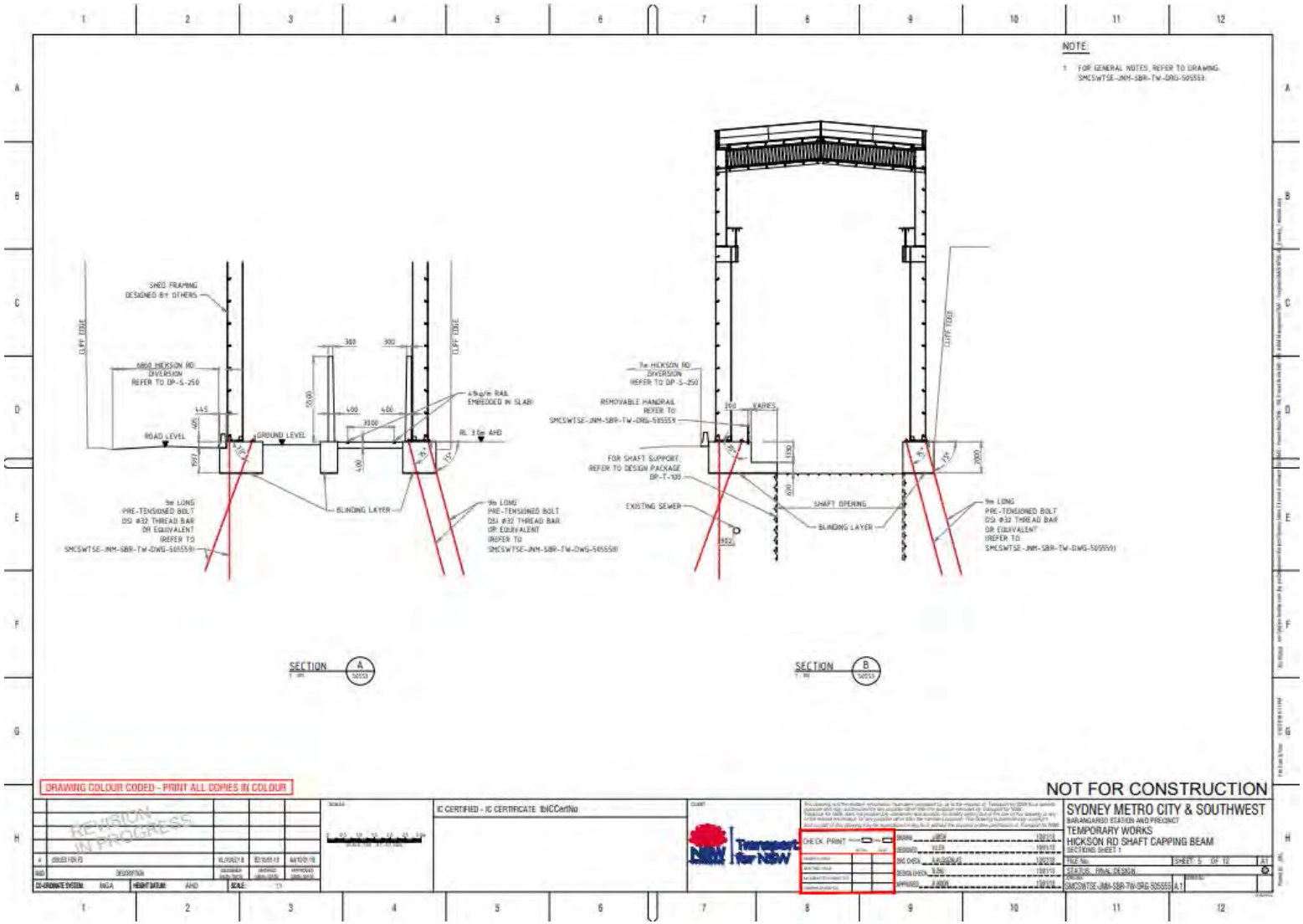


Figure 4: Sections of the proposed acoustic enclosure on Hickson Road

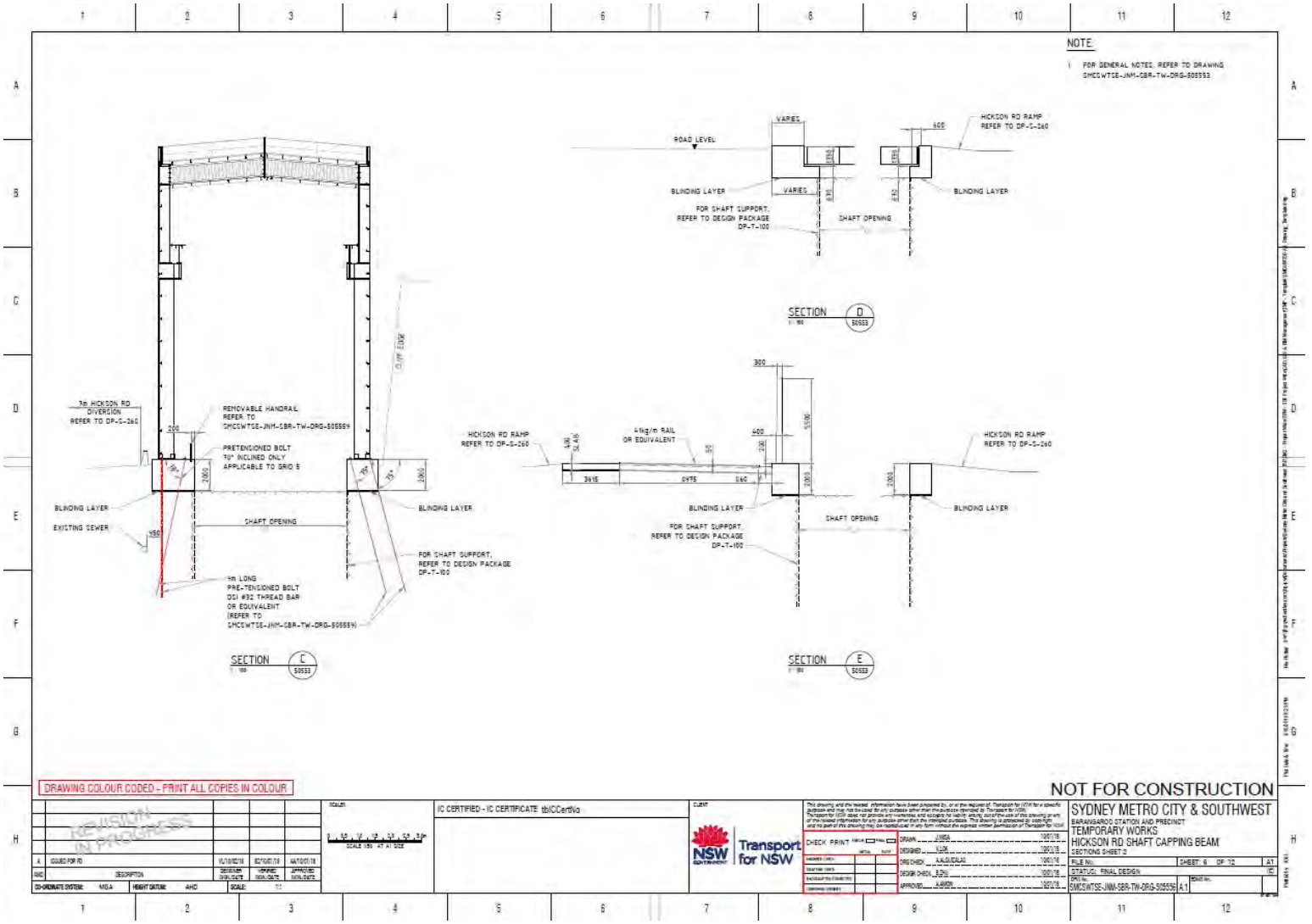


Figure 5: Sections showing details of the proposed acoustic enclosure on Hickson Road, including pretensioned rock bolts

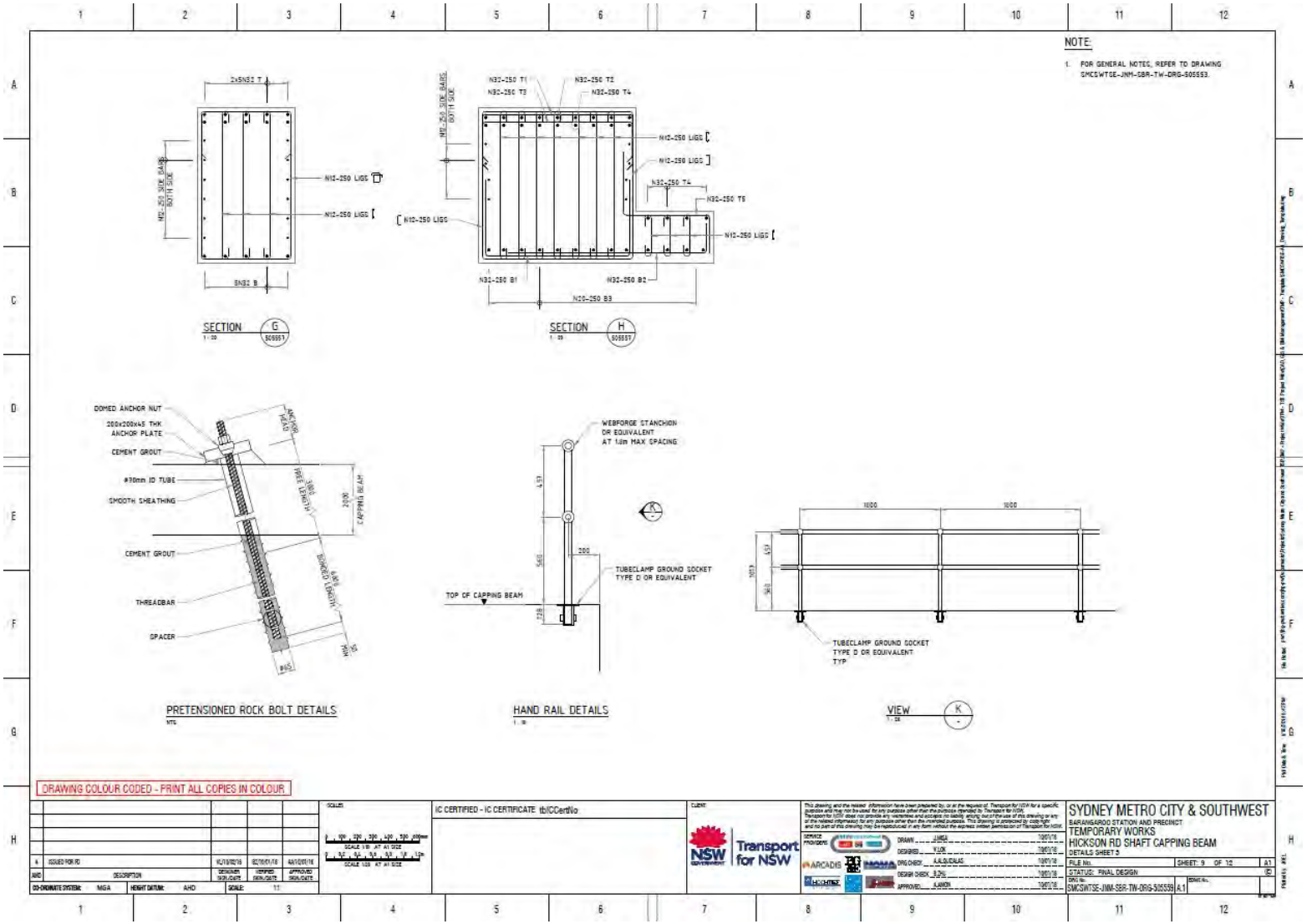
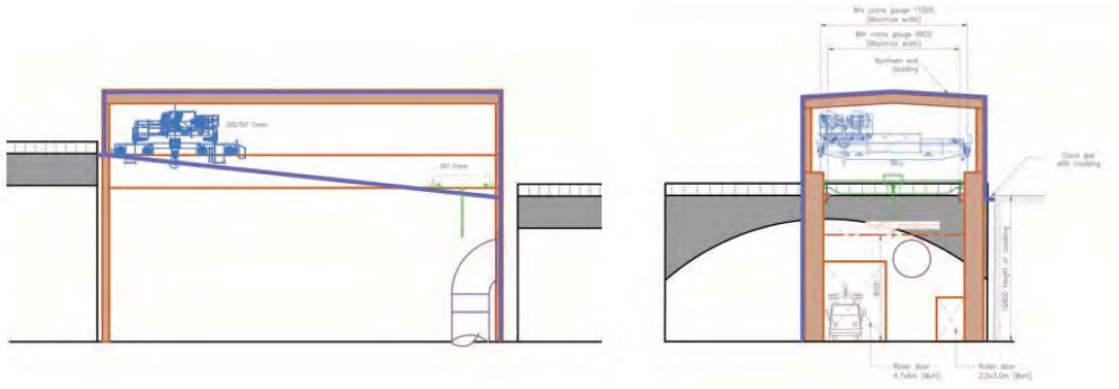


Figure 6: Sections of the proposed acoustic enclosure shed in the context of nearby bridges



Assessment Methodology

Introduction

The study area was defined as the works are and a 50 metre visual buffer to account for potential visual impacts of the acoustic shed (Figure 7).

The assessment methodology is the same as was used in the EIS heritage assessment (Artefact 2016). Descriptions and assessments of significance have been added to this report as many of the items assessed where not assessed in the EIS heritage assessment.

This report has been prepared in accordance with the NSW Heritage Office & Department of Urban Affairs and Planning *NSW Heritage Manual* (1996) and NSW Heritage Office *Statements of Heritage Impact* (NSW Heritage Office, 2002). The guidelines pose a series of questions as prompts to aid in the consideration of impacts due to the project.

Impact assessment

In order to consistently identify the potential impact of the proposed works, the terminology contained in Table 1 has been referenced throughout this document.

Table 1: Terminology for assessing the magnitude of heritage impact.

Grading	Definition
Major	Actions that would have a long-term and substantial impact on the significance of a heritage item. Actions that would remove key historic building elements, key historic landscape features, or significant archaeological materials, thereby resulting in a change of historic character, or altering of a historical resource. These actions cannot be fully mitigated.
Moderate	Actions involving the modification of a heritage item, including altering the setting of a heritage item or landscape, partially removing archaeological resources, or the alteration of significant elements of fabric from historic structures. The impacts arising from such actions may be able to be partially mitigated.

Grading	Definition
Minor	Actions that would result in the slight alteration of heritage buildings, archaeological resources, or the setting of an historical item. The impacts arising from such actions can usually be mitigated.
Negligible	Actions that would result in very minor changes to heritage items.
Neutral	Actions that would have no heritage impact.
Positive	Actions that would result in a positive outcome for heritage items.

Heritage listed items

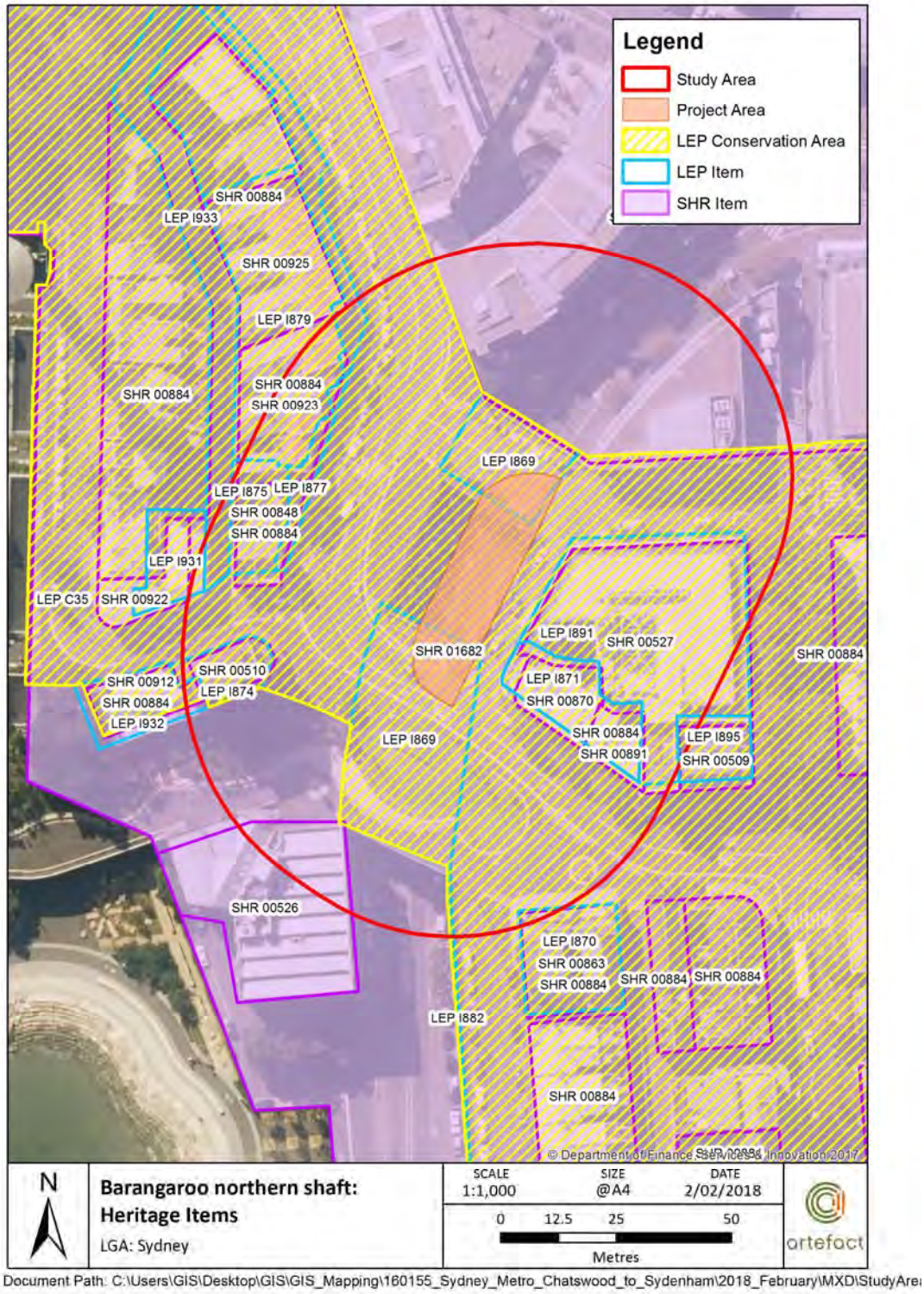
The following table outlines the heritage listed items located within the study area, which are shown on Figure 7.

Table 2: Overview of heritage items within the Barangaroo study area

Heritage item	Register listings	Significance	Relationship to the study area
Millers Point & Dawes Point Village Precinct	State Heritage Register 01682	State	Within project area and study area (50m visual buffer)
Millers Point Conservation Area	State Heritage Register 00884 Department of Housing S170 register Sydney LEP 2012 C35 Register of the National Estate	State	Partially within study area (50m visual buffer)
Bridges over Hickson Road	Sydney LEP 2012 I869	Local	Within project area and study area (50m visual buffer)
Warehouses	State Heritage Register 00526 State Environmental Planning Policy (Major Development) 2005 Barangaroo heritage Roads and Maritime S170	State	Partially within study area (50m visual buffer)
Shops (1,3,5,7 Argyle Place)	State Heritage Register 00863 Department of Housing S170 register Sydney LEP 2012 I870	State	Partially within study area (50m visual buffer)
Shops (6, 8 Argyle Place)	State Heritage Register 00870 Department of Housing S170 register Sydney LEP 2012 I871	State	Within study area (50m visual buffer)
Walsh Bay Wharves Precinct	SHR 00559	State	Partially within study area (50m visual buffer)
Edwardian terrace (66-68 Bettington Street)	State Heritage Register 00848 S170 State agency heritage register Sydney LEP 2012 I875	State	Within study area (50m visual buffer)
Terrace (18, 18a, 20, 20a Munn Street)	State Heritage Register 00912 Department of Housing S170 register Sydney LEP 2012 I932	State	Partially within study area (50m visual buffer)
Terraces (15-35A Dalgety Road)	State Heritage Register 00923 State Heritage Register 00925 Department of Housing S170 register Sydney LEP 2012 I879	State	Partially within study area (50m visual buffer)

Heritage item	Register listings	Significance	Relationship to the study area
Lord Nelson Hotel	State Heritage Register 00509 Sydney LEP 2012 I895	State	Partially within study area (50m visual buffer)
Palisade Hotel	State Heritage Register 00510 Sydney LEP 2012 I874	State	Within study area (50m visual buffer)
Oswald Bond Store	State Heritage Register 00527 Sydney LEP 2012 I891 National Trust Register 9186	State	Partially within study area (50m visual buffer)
Victorian Terrace (56-60 Bettington Street)	State Heritage Register 00922 Sydney LEP 2012 I931	Local	Partially within study area (50m visual buffer)
Sandstone Wall and Stairs Including Iron Palisade Fence	Sydney LEP 2012 I877	Local	Partially within study area (50m visual buffer)
Retaining wall	Sydney LEP 2012 I1933	Local	Partially within study area (50m visual buffer)

Figure 7: Listed heritage items within the study area



Heritage significance

Table 3: Millers Point & Dawes Point Village Precinct heritage impact assessment

Millers Point & Dawes Point Village Precinct[1]	
Image	
Significance	State
Description	The precinct is bounded on the north by the existing Walsh Bay State Heritage Register listed precinct, on the far-north by the waters of Sydney Harbour in the vicinity of Ives Steps on Dawes Point/Tar-ra, on the north-west by the existing Sydney Harbour Bridge State

[1] Description and Statement of significance extracted from State Heritage Register inventory sheet “Millers Point & Dawes Point Village Precinct” last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=5054725 on 31/01/2018.

Millers Point & Dawes Point Village Precinct[1]	
	Heritage Register listed item, on the north-east by the Bradfield Highway (bridge approaches) forming a distinctive physical boundary, on the south by the existing high-rise apartment buildings forming a distinctive boundary, on the west by the edge of the concrete-surfaced Darling Harbour wharf aprons forming a distinctive change in the landscape, and on the north-west by the cliff-edges of Old Millers Point, again forming a distinctive boundary.
Statement of significance	Millers Point & Dawes Point Village Precinct is of State significance for its ability to demonstrate, in its physical forms, historical layering, documentary and archaeological records and social composition, the development of colonial and post-colonial settlement in Sydney and New South Wales. The natural rocky terrain, despite much alteration, remains the dominant physical element in this significant urban cultural landscape in which land and water, nature and culture are intimately connected historically, socially, visually and functionally. The close connections between the local Cadigal people and the place remain evident in the extensive archaeological resources, the historical records and the geographical place names of the area, as well as the continuing esteem of Sydney's Aboriginal communities for the place. Much (but not all) of the colonial-era development was removed in the mass resumptions and demolitions following the bubonic plague outbreak of 1900, but remains substantially represented in the diverse archaeology of the place, its associated historical records, the local place name patterns, some of the remaining merchants villas and terraces, and the walking-scale, low-rise, village-like character of the place with its central 'green' in Argyle Place, and its vistas and glimpses of the harbour along its streets and over rooftops, the sounds of boats, ships and wharf work, and the smells of the sea and harbour waters. The post-colonial phase is well represented by the early 20th century public housing built for waterside workers and their families, the technologically innovative warehousing, the landmark Harbour Bridge approaches on the heights, the parklands marking the edges of the precinct, and the connections to working on the wharves and docklands still evident in the street patterns, the mixing of houses, shops and pubs, and social and family histories of the local residents. Millers Point & Dawes Point Village Precinct has evolved in response to both the physical characteristics of its peninsular location, and to the broader historical patterns and processes that have shaped the development of New South Wales since the 1780s, including the British invasion of the continent; cross-cultural relations; convictism; the defence of Sydney; the spread of maritime industries such as fishing and boat building; transporting and storing goods for export and import; immigration and emigration; astronomical and scientific achievements; small scale manufacturing; wind and gas generated energy production; the growth of controlled and market economies; contested waterfront work practises; the growth of trade unionism; the development of the state's oldest local government authority the City of Sydney; the development of public health, town planning and heritage conservation as roles for colonial and state government; the provision of religious and spiritual guidance; as inspiration for creative and artistic endeavour; and the evolution and regeneration of locally-distinctive and self-sustaining communities. The whole place remains a living cultural landscape greatly valued by both its local residents and the people of New South Wales.

Table 4: Millers Point Conservation Area heritage impact assessment

Millers Point Conservation Area[2]	
Image	
Significance	State
Description	An integrated port town developed between the 1810s and the 1930s and little changed since then; considered remarkable for its completeness and intactness. Its components include deep-sea wharves and associated infrastructure, bond and free stores, roadways and accessways, public housing built for port workers, former private merchant housing, hotels and shops, schools, churches, post office and community facilities. This is the Department of Housing's Conservation Area only and only applies to Department of Housing property. Because of this, the Department's Conservation Area is not contiguous.

[2] Description and Statement of significance extracted from State Heritage Register inventory sheet "Millers Point Conservation Area" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=5001049 on 31/01/2018.

Millers Point Conservation Area[2]	
Statement of significance	Millers Point Conservation Area is an intact residential and maritime precinct of outstanding State and national significance. It contains buildings and civic spaces dating from the 1830s and is an important example of nineteenth and early twentieth century adaptation of the landscape. The precinct has changed little since the 1930s.

Table 5: Walsh Bay Wharves Precinct heritage impact assessment

Walsh Bay Wharves Precinct heritage impact assessment [3]	
Image	**Figure 8: Walsh Bay Wharves Precinct** 
Significance	State
Description	Integrated port precinct comprising wharves, shore sheds, bond stores, bridges and roads. A standard modular timber design was developed for the wharves, wharf sheds and shore sheds so that they could easily be adapted to the requirements of individual sites.
Statement of significance	The Walsh Bay area is of State cultural significance due to its unique combination of steep rocky terrain, early, mid, late-Victorian and Edwardian housing, surviving relatively intact Victorian bond stores, and the results of an early twentieth century urban redevelopment scheme of unique scale: the magnificent timber wharf and shore structures and associated rock cuttings, roads and bridges. The Walsh Bay Wharves and associated buildings and works are a virtually intact port and stevedoring facility created by the Sydney Harbour Trust in response to the requirements of maritime trade at the time (1900s-1910s). The precinct documents the workings of a technologically advanced early twentieth century shipping port, developed specifically to accommodate new mechanised transportation technology. The wharves have a strong distinctive character created by the logical use of heavy timber construction and the regular grid layout of piles, columns, beams and infill cladding. The precinct is unified in materials, form and scale and contains structures demonstrating

[3] Description and Statement of significance extracted from State Heritage Register inventory sheet "Walsh Bay Wharves Precinct" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=5045067 on 31/01/2018.

Walsh Bay Wharves Precinct heritage impact assessment [3]	
	maritime uses. It demonstrates the life of inner Sydney in the early twentieth century. The precinct demonstrates technical and creative excellence of the period 1820-1930.

Table 6: Bridges over Hickson Road heritage impact assessment

Bridges over Hickson Road[4]	
Image	**Figure 9: View north onto Hickson Road from Argyle Place, showing the deep cutting and Windmill Street bridge. Artefact Heritage 2015** 
Significance	Local
Description	Constructed in 1908 this heritage group includes landmark bridge structures which form a "tunnel", and gateway between the Darling Harbour and the Walsh Bay wharf and shipping terminus. Rock excavations and concrete walling form dramatic high walls, and the generous width of Hickson Road emphasises the scale. Demonstrates an early use of reinforced concrete in Sydney. The bridges are located on Munn Street, Argyle Place and Windmill Street.
Statement of significance	Of historical significance as physical evidence of the major state government redevelopment of the district, in the years following the 1901 bubonic plague. Of historical significance as physical evidence of the growth of maritime activities to the west of Circular Quay.

[4] Description and Statement of significance extracted from State Heritage Register inventory sheet "Bridges over Hickson Road" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=2423650 on 31/01/2018.

Table 7: Oswald Bond Store heritage impact assessment.

Oswald Bond Store[5]	
Image	**Figure 10: View to Oswald Bond Store** 
Significance	State
Description	The Bond Store is an example of late Victorian (1892-3 facades)/ Federation (1904) and Free Classical style warehouse structure [Tropman 5.3]. The existing building is essentially in sound condition, there is some cracking and water damage identified on Level 3. Only part of the original 1892-3 brickwork facades survived the 1903 fire. The existing building dates from 1904 when it was rebuilt to original detail after the fire, with the omission of the two upper levels and with other fire prevention measures. The internal timber structure was rebuilt using the original storey post system.
Statement of significance	The Oswald Bond Store is of State significance as an outstanding example of a turn of the century bond store in the Free Classical style. The Store has a strong architectural presence, its scale and facade contributing to the streetscape. The timber driveway doors are part of a rare avenue of industrial openings along Windmill Street, which are a reminder of the commercial use of the area. The storey post system supporting the internal floors is typical of the construction of the Sydney Harbour Trust during this period.

[5] Description and Statement of significance extracted from State Heritage Register inventory sheet "Oswald Bond Store" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=5045357 on 31/01/2018.

Table 8: "Shops" (1,3,5,7 Argyle Place) heritage impact assessment

"Shops" (1,3,5,7 Argyle Place)[6]	
Image	**Figure 11: View across Argyle Place towards Shops heritage item** 
Significance	State
Description	Constructed c.1910 in the Federation style, the two storey shops, with residences over, form part of a group located in a conservation area and are important to the streetscape.
Statement of significance	An interesting example of early 20th Century commercial and residential development being part of the-post plague redevelopment, very important to the streetscape of Millers Point. It is part of the Millers Point Conservation Area, an intact residential and maritime precinct. It contains residential buildings and civic spaces dating from the 1830's and is an important example of 19th century adaptation of the landscape.

[6] Description and Statement of significance extracted from State Heritage Register inventory sheet "Shops" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?id=2423570 on 31/01/2018.

Table 9: "Shops" (6, 8 Argyle Place) heritage impact assessment

"Shops" (6,8 Argyle Place)[7]	
Image	**Figure 12: Shops 6, 8 Argyle Place** 
Significance	State
Description	Constructed c.1906, this item is one of a row of terraces, consisting of commercial on the ground floor and residential space above.
Statement of significance	This building is one of a group of five post-plague Edwardian commercial and residential properties, which are very important to the streetscape of Millers Point. It is part of the Millers Point Conservation Area, an intact residential and maritime precinct. It contains residential buildings and civic spaces dating from the 1830's and is an important example of C19th adaptation of the landscape.

[7] Description and Statement of significance extracted from State Heritage Register inventory sheet "Shops" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=5045110 on 31/01/2018.

Table 10: Warehouses heritage impact assessment

Warehouses[8]	
Image	**Figure 13: Warehouses viewed from High Street. Artefact Heritage 2015** 
Significance	State
Description	The group consists of two complimentary warehouse buildings fronting onto what is now the Munn Reserve. The former Dalgety's Bond Stores were originally a complex of three warehouse components, known as Dalgety's Bond A, B and C. Only blocks A and C survive.
Statement of significance	The Munn Street former warehouse complex is important as a townscape feature in this area of dramatic topography. Its different building forms and shapes display a progression of functional architectural style, reflecting the difficulties of building on this contorted terrain. It also demonstrates the redevelopment and change of the area associated with civil works that followed the bubonic plague of 1901. It perpetuates the memory of Dalgety & Co, one of Australia's largest mercantile companies, and maintains a historic link with the maritime activities of Millers Point. The internal structure and mechanical features provide additional scientific significance.

[8] Description and Statement of significance extracted from State Heritage Register inventory sheet "Warehouses" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=5051348 on 31/01/2018.

Table 11: Lord Nelson Hotel heritage impact assessment

Lord Nelson Hotel[9]	
Image	**Figure 14: View to the Lord Nelson Hotel from Argyle Place** 
Significance	State
Description	The Lord Nelson Hotel is a three-storey building constructed of smooth faced sandstone. Designed in the Old Colonial Regency style, the building features a modern hipped roof with dormer windows. Built on a splay corner, the street facades on the first and second levels of the building feature regular, multi-paned timber double hung windows. The ground level facades to both Kent and Argyle Streets contain a large, fixed timber paned window on either side of the splayed corner. The oldest working licensed hotel in Sydney, the Lord Nelson Hotel is a fine example of its architectural type and provides a strong contribution to the Millers Point streetscape.
Statement of significance	The Lord Nelson Hotel is highly significant as the oldest working licensed hotel in the city. The Hotel was only one of only two hotels in the immediate area to be retained by the Sydney Harbour Trust when Millers Point was resumed during the time of the plague in 1900. The Lord Nelson Hotel is also significant as one of three hotel buildings in the Old Colonial Regency style in the city. The other two include the hero of Waterloo and a commercial terrace at 246 George Street. The Lord Nelson is the finest example of the three. It is also significant as it provides a strong contribution to the urban character of the immediate area. The building provides a rare surviving working example of an early hotel from the nineteenth century. It also has significance as part of a network of corner hotels in the northern end of the city which provided social and recreational venues and budget accommodation. The site may have scientific significance due to the age of the building and its continual use since the early days of European settlement. (Graham Brooks and Associates 1997:64)

[9] Description and Statement of significance extracted from State Heritage Register inventory sheet "Lord Nelson Hotel" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?id=5045112 on 31/01/2018.

Table 12: Palisade Hotel heritage impact assessment

Palisade Hotel[10]	
Image	**Figure 15: View of Palisade Hotel from Dalgety Road bridge** 
Significance	State
Description	Built to the boundaries of its site, the Palisade Hotel is a seven storey masonry building, including basement, that abuts Bettington Street to the north, the junction of Argyle Place and Dalgety Road to the east, and the Munn Street Reserve to the south. The building has stone and brickwork base courses, load bearing brickwork with stone detailing above, and timber and steel floor and roof framing. The ground floor façade is tiled with original ceramic tiles. The side facades of the building feature projecting two-storey bays. The building has a prominent location and is a landmark in the surrounding streetscape.
Statement of significance	The Palisade Hotel is of historic significance for its association with the acquisition, redevelopment and long-term management of large areas around Sydney Harbour by the NSW Government following the outbreak of the bubonic plague in 1900. The hotel is significant having been built by the Sydney Harbour Trust in 1915/16 as one of four hotels provided by the Trust to replace those demolished to provide facilities for port workers and the local community. Stylistically the hotel was built in an era of prodigious hotel building between 1900 and 1914, which ended with the onset of World War I. Its ongoing use as a hotel since its construction in 1916 with relatively few modifications to layout and fabric further highlights its significance. Its prominent location and continued use demonstrates its significance as part of the social life of Millers Point. The Palisade Hotel is significant having

[10] Description and Statement of significance extracted from State Heritage Register inventory sheet "Palisade Hotel Including Interior" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=2423579 on 31/01/2018.

	been designed by H.D. Walsh, an engineer important in the history of NSW especially related to developments around Sydney Harbour in the early twentieth century. The hotel is of aesthetic significance as an exceptional example of a federation free style building with arts and crafts influences. Its dramatic form with a very tall and narrow expression is an important contributory feature to the Millers Point townscape resulting in the building being a prominent landmark feature in the area. Its prominent siting provides terminal views along several streets.

Table 13: Edwardian terrace heritage impact assessment

Edwardian terrace[11]	
Image	**Figure 16: View of Edwardian terrace from corner of Bettington Street and Dalgety Road** 
Significance	State
Description	The terraces at 66-68 Bettington Street are fine two-storey Edwardian terraces of painted rendered masonry construction. Constructed soon after the 1900 resumptions of Millers Point, the terraces contain three bedrooms and feature tiled verandahs, coloured glass windows, slat roofs and timber and cast iron verandahs. The terraces remain in good condition and are largely intact.
Statement of significance	This is one of a pair of fine Edwardian terraces, constructed c.1900 with original external detailing intact.

[11] Description and Statement of significance extracted from State Heritage Register inventory sheet "Edwardian terrace" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?id=5045418 on 31/01/2018.

Edwardian terrace[11]	
	It is part of the Millers Point Conservation Area, an intact residential and maritime precinct. It contains residential buildings and civic spaces dating from the 1830's and is an important example of C19th adaptation of the landscape.

Table 14: "Terrace" (18, 18a, 20, 20a Munn Street) heritage impact assessment

"Terrace" (18, 18a, 20, 20a Munn Street)[12]	
Image	**Figure 17: View towards Terrace from Munn Street** 
Significance	State
Description	This heritage item comprises a two-storey terrace of face brick with sandstone trim to doors and windows. Constructed circa 1911 and designed in the Federation style, the terrace features a two-storey verandah with timber balustrading, face brick and stone walls and a corrugated galvanised iron roof.
Statement of significance	This group of early twentieth century terrace houses was previously larger, some being demolished for Darling Harbour Port expansion. It is part of the Millers Point Conservation Area, an intact residential and maritime precinct. It contains residential buildings and civic spaces dating from the 1830's and is an important example of C19th adaptation of the landscape.

[12] Description and Statement of significance extracted from State Heritage Register inventory sheet "Terrace" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?id=5045226 on 31/01/2018.

Table 15: "Terraces" (15-35A Dalgety Road) heritage impact assessment

"Terraces" (15-35A Dalgety Road)[13]	
Image	**Figure 18: Views towards the Terraces heritage item from Dalgety Road**  
Significance	State
Description	Comprising two storey terrace houses of face brick construction, this terrace was constructed circa 1911 as worker's housing during the post plague redevelopment of the area by the Sydney Harbour Trust. The large terraces, which are designed in the Federation style, feature elaborate timber verandahs with ornamental brackets and tiled terracotta Marseilles roofs. The terraces remain in good condition.
Statement of significance	This terrace is one of a group of early twentieth century workmen's terraces built as part of the post plague redevelopment. It is part of the Millers Point Conservation Area, an intact residential and maritime precinct. It contains residential buildings and civic spaces dating from the 1830's and is an important example of C19th adaptation of the landscape.

[13] Description and Statement of significance extracted from State Heritage Register inventory sheet "Terraces" (15, 17, 19, 21, 23, 25 Dalgety Road) and "Terraces" (27a, 29a, 31a, 33, 35a Dalgety Terrace) last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=5045105 and http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=5000844 on 31/01/2018.

Table 16: "Victorian Terrace" (56-60 Bettington Street) heritage impact assessment

"Victorian Terrace" (56-60 Bettington Street)[14]	
Image	**Figure 19: Photograph of the Victorian Terrace at 56-60 Bettington Street** 
Significance	Local
Description	The Terrace Group heritage item comprises a terrace group that wraps the corner site at Merriman Street and Bettington Street. The two-storey Victorian workers terraces feature an unusual curved wall, which is atypical for the time in which it was built around circa 1870. The terrace group features cantilevered balconies and chimney details with interesting decorative elements.
Statement of significance	Of heritage significance for its contribution to an architecturally consistent and historically important residential streetscape. Of historical significance as physical evidence of the development of the district as a Victorian working class community. Cantilevered balconies and chimney details are interesting decorative elements. The group of eight residences are asymmetrically presented and are "stepped up" the sloping Merriman Street.

[14] Description and Statement of significance extracted from State Heritage Register inventory sheet "Terrace Group (56-60 Bettington Street) Including Interiors" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?id=2423580 on 01/02/2018.

Table 17: Sandstone Wall and Stairs Including Iron Palisade Fence heritage impact assessment

Sandstone Wall and Stairs Including Iron Palisade Fence[15]	
Image	**Figure 20: View of sandstone wall on western side of Dalgety Road** 
Significance	Local
Description	This item comprises a wall that is located 137 metres along the western edge of Dalgety Road, and stairs between Dalgety Road and Rhodens Lane. The sandstone wall is surmounted by an iron palisade fence.
Statement of significance	Historically important landscape item relating to heritage buildings of Dalgety Terrace.

[15] Description and Statement of significance extracted from State Heritage Register inventory sheet "Sandstone Wall and Stairs Including Iron Palisade Fence" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=2424623 on 31/01/2018.

Table 18: Retaining wall

Retaining wall[16]	
Image	**Figure 21: Photograph of the retaining wall along Rodens Lane** 
Significance	Local
Description	The Retaining wall heritage item comprises a square sandstone retaining wall with lime rich pointing. Constructed between 1909 and 1910, the wall varies in height along Rodens Lane. A timber picket fence sits along the top of the retaining wall, and at various points along the wall vegetation is growing from the joints. The wall remains in good condition.
Statement of significance	The sandstone retaining wall along Rodens Lane is significant because it demonstrates the earlier sandstone quarrying activities along the point and the need to terrace the sandstone outcrop to retain land for residential properties. The retaining wall forms one of the earliest land divisions between the wharf facilities along Dalgety Road and the residential properties along Merriman Street.

[16] Description and Statement of significance extracted from State Heritage Register inventory sheet "Retaining wall" last accessed via http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?id=2426265 on 01/02/2018.

Archaeological potential

Archaeological potential has been assessed in the initial consistency assessment prepared by AMBS (16314M Barangaroo 4 December 2017).

> *The northern temporary access shaft site is within the footprint of Hickson Road, the construction of which from 1909 – 1914 will have destroyed any earlier archaeological remains within the footprint of the road. As such, as identified in the Final Barangaroo Station Hickson Road, Barangaroo Archaeological Method Statement prepared by Casey & Lowe Pty Ltd in November 2017 and Proposed Services on Dalgety & Hickson Roads, Barangaroo Northern Headland, Historical Archaeological Assessment, Statement of Heritage Impact & Research Design, prepared by for Austral Archaeology Pty Ltd in 2013 for Baulderstone Pty Ltd this area has no archaeological potential and no archaeological significance (refer Casey & Lowe 2017: 122, Figure 4.13; page 131, Figure 5.1 and page 154, Figure 7.1).*
>
> *The appropriate archaeological strategy to guide the construction of the acoustic shed is the Unexpected Heritage Finds procedure as identified in the Section 7.4 of the Casey & Lowe Archaeological Method Statement (2017:152). JHCPBG is aware of the heritage constraints associated with the proposed work and will ensure compliance with Condition E10.*

Heritage Impact Assessment

Heritage impact

The tables below provide an assessment of the direct and indirect impacts of the proposal to each of the heritage items located within the study area.

Table 19: Summary of impacts to heritage items within study area

Item name	Direct impact	Indirect impact
Millers Point & Dawes Point Village Precinct	The proposal would involve works that would impact fabric that is part of the Millers Point & Dawes Point Village Precinct. In order to secure the acoustic enclosure, the proposal would require installation of ten pretensioned rock bolts to the sandstone cutting on the eastern side of Hickson Road to support five portal frames anchored to the cutting. The sandstone and concrete cutting at Hickson Road, while not identified as a significant element in itself within the SHR curtilage of the Millers Point & Dawes Point Village Precinct, is a landscape feature that strongly contributes to the overall character and visual qualities of the conservation area. The cutting is a tangible reminder of the evolution of the area at the turn of the twentieth century and is a distinctive landmark in the locality. Although the installation of rock bolts would result in a direct impact to significant fabric of the cutting, this direct impact is considered to be minor within the overall context and scale of the Millers Point & Dawes Point Village Precinct. This assessment is assuming recommended management measures for treatments to the rock bolt holes would be undertaken. The proposal would result in a minor direct impact to the Millers Point & Dawes Point Village Precinct.	The proposal would involve activities that would result in indirect impacts on the setting and visual qualities of the Millers Point & Dawes Point Village Precinct, including erection of the acoustic enclosure and establishment of temporary laydown areas. The establishment of an acoustic enclosure over the proposed shaft to the tunnel level would result in the erection of a shed between Dalgety Road bridge to Windmill Street Bridge, which would extend above the road surface at Hickson Road and protrude several metres above Dalgety Road, which is in the vicinity of numerous heritage items. The establishment of temporary laydown areas on Dalgety Road and Windmill Street would result in further changes to the visual qualities and setting of the streetscape in this locality, which is largely characterised by its scale, contributing heritage items and views to the harbour beyond. It is noted that indirect impact to the Millers Point & Dawes Point Precinct would be restricted to relatively localised areas and would be temporary in nature. Areas along Hickson Road, where the shed would be most obtrusive, are considered to have less sensitivity in terms of surrounding heritage items. It is assumed that the 'Jasper' colour of the Colorbond cladding would further reduce the visual prominence of the shed within the broader context of the Millers Point & Dawes Point Village Precinct. Detailed assessment of visual impacts to items within the conservation area are covered in more detail below.

Item name	Direct impact	Indirect impact
		The proposal would result in a minor-moderate temporary indirect visual impact to the Millers Point & Dawes Point Village Precinct.
Walsh Bay Wharves Precinct	The proposal does not involve any works that directly affect physical fabric of the Walsh Bay Wharves Precinct. The proposal would result in a neutral physical impact to the Walsh Bay Wharves Precinct.	The proposed erection of the acoustic enclosure and laydown areas would introduce new elements away from the Walsh Bay Wharves Precinct, with significant views and vistas within this heritage item being located further north from the project area. The proposal would result in a neutral visual impact to the Walsh Bay Wharves Precinct. There would be no direct impacts to this item.
Millers Point Conservation Area	The proposal does not involve any works that directly affect physical fabric of the Millers Point Conservation Area including the listed elements within its curtilage. As such, there would be no direct impacts to the significant values of the conservation area. The proposal would result in a neutral physical impact to the Millers Point Conservation Area.	The proposed establishment of an acoustic enclosure and laydown areas would result in the introduction of new, albeit temporary, visual elements within the Millers Point Conservation Area. This would result in a range of visual impacts to the significant listed elements within the curtilage of the conservation area. Impacts to individual heritage items listed within the Millers Point Conservation Area that are located in the study area are described below. The proposal would result in negligible to minor indirect visual impacts to elements within the Millers Point Conservation Area.
Bridges over Hickson Road	The proposal would result in works immediately adjacent to the heritage curtilages of the bridges over Hickson Road. It is assumed the proposal would not involve any direct impacts to the significant fabric of these bridges although use as a laydown area may result in minor impacts. The proposal would result in a minor direct impact to the Bridges over Hickson Road heritage item.	The proposal would involve activities that would result in indirect impacts on the setting and visual qualities of the Bridges over Hickson Road heritage item, including erection of the acoustic enclosure and establishment of temporary laydown areas both within and adjacent to the item's heritage curtilages. The establishment of an acoustic enclosure over the proposed shaft to the tunnel level would result in the erection of a shed occupying the space between the bridges, which would protrude above the road surface at Dalgety Road. As such, the proposal would temporarily obscure the legibility and appreciation of the bridges at

Item name	Direct impact	Indirect impact
		both the Hickson Road and Dalgety Road levels in these locations and detract from the visual prominence of these elements. This would be accentuated by the establishment of laydown areas on the bridge road decks. It is noted the shed and laydown areas would be temporary and have been developed to be recessive in appearance so as to reduce the visual impact to the Bridges over Hickson Road heritage item. Views towards the bridges from the northern side of the Windmill Street Bridge and from the southern side of the Dalgety Road bridge would be less affected. The proposal would result in a moderate indirect visual impact to the Bridges over Hickson Road heritage item.
Warehouses	The proposal does not involve any works that directly affect the physical fabric of the Warehouses heritage item. The proposal would result in a neutral physical impact to the Warehouses heritage item.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new visual elements in the vicinity of the Warehouses heritage item. It is noted this heritage item is located more than 30 metres away from the project area, and its northern elevation fronts a low-lying location on Munn Street. Any indirect impacts would therefore affect only distant views and vistas. Potential visual impacts from this locality would be primarily associated with the proposed laydown area located on the road deck of the Dalgety Road bridge. New development within this area would be temporary, and is not considered to diminish the visual quality and setting of the heritage item. The proposal would result in a negligible indirect visual impact to the Warehouses heritage item.
Shops (1,3,5,7 Argyle Place)	The proposal does not involve any works that directly affect physical fabric of the Shops heritage item. The proposal would result in a neutral physical impact to the Shops heritage item.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new visual elements in the vicinity of the Shops heritage item. It is noted this heritage item is located more than 45 metres away from the project area, and indirect impacts would therefore

Item name	Direct impact	Indirect impact
		affect only distant views and vistas. Potential visual impacts from this locality would be primarily associated with the proposed laydown area located on the road deck of the Dalgety Road bridge. New development within this area would be temporary in nature. The proposal would result in a negligible indirect visual impact to the Shops heritage item.
Shops (6, 8 Argyle Place)	The proposal does not involve any works that directly affect physical fabric of the Shops heritage item. The proposal would result in a neutral physical impact to the Shops heritage item.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new visual elements in the immediate vicinity of the Shops heritage item. This particularly relates to views to and from the side (west) elevation of the building, which overlooks the project area. The temporary nature of the shed, and its recessive appearance would mean the shed would not visually dominate the surrounding context of the Shops heritage item and Dalgety Road pavement level. It is also noted that the higher pavement level of the shops adjacent to the Dalgety Road bridge would result in the shed extending a shorter distance in this locality. While views would be somewhat diminished by the proposal, these would be temporary. The proposal would result in a moderate indirect visual impact to the Shops heritage item.
Edwardian terrace	The proposal does not involve any works that directly affect physical fabric of the Edwardian terrace heritage item. The proposal would result in a neutral physical impact to the Edwardian terrace heritage item.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new, albeit temporary, visual elements that would be discernible from views out from the Edwardian terrace heritage item. This particularly relates to views from the side (east) elevation of the building. It is noted that the principal views from the terrace are to the south from the building's principal elevation. The temporary nature of the shed, and its recessive appearance would mean the shed would not visually dominate the terrace's surrounding streetscape context.

Item name	Direct impact	Indirect impact
		Indirect impacts may also be associated with the proposed laydown area located on the road deck of the Dalgety Road bridge. New development within this area would be temporary in nature, and are not considered to diminish the visual quality and setting of the Edwardian terrace heritage item. The proposal would result in a minor indirect visual impact to the Edwardian terrace heritage item.
Terrace (18, 18a, 20, 20a Munn Street)	The proposal does not involve any works that directly affect physical fabric of the Terrace heritage item. The proposal would result in a neutral physical impact to the Terrace heritage item.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new visual elements in the vicinity of the Terrace heritage item. It is noted that the Terrace heritage item is located approximately 30 metres along Bettington Street, and views towards the project area are largely concealed by the adjoining Palisade Hotel. Moreover, principal views to and from the Terrace heritage item are associated with its front (south) elevation, which overlooks Munn Street Reserve and Barangaroo Reserve beyond. The proposal would result in a negligible indirect visual impact to the Edwardian terrace heritage item.
Terraces (15-35A Dalgety Road)	The proposal does not involve any works that directly affect physical fabric of the Terraces heritage item. The proposal would result in a neutral physical impact to the Terraces (15-35A Dalgety Road) heritage item.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new visual elements in the vicinity of the Terraces heritage item. It is noted that principal views from the Terraces heritage item are focused northeast, towards the Walsh Bay Precinct. The temporary nature of the shed, and its recessive appearance would mean the shed would not visually dominate the terrace's immediate surrounding streetscape context. While views towards the terraces from the south along Argyle Place and Dalgety Road to the south would potentially be obscured, it is considered that key views to the terraces from Windmill Street to the east and Dalgety Road to the north would not be diminished.

Item name	Direct impact	Indirect impact
		The proposal would result in a negligible indirect visual impact to the Terraces (15-35A Dalgety Road) heritage item.
Lord Nelson Hotel	The proposal does not involve any works that directly affect physical fabric of the Lord Nelson Hotel. The proposal would result in a neutral physical impact to the Lord Nelson Hotel.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new visual elements in the vicinity of the Lord Nelson Hotel. It is noted that the Lord Nelson Hotel is located approximately 30 metres along Argyle Place, and views towards the project area are concealed by adjoining development. Moreover, principal views to and from the Lord Nelson Hotel are associated with its front (south) elevation, which overlooks Argyle Place. The proposal would result in a negligible indirect visual impact to the Lord Nelson Hotel.
Palisade Hotel	The proposal does not involve any works that directly affect physical fabric of the Palisade Hotel. The proposal would result in a neutral physical impact to the Palisade Hotel.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new, albeit temporary, visual elements that would be discernible for views to and from the Palisade Hotel. This particularly relates to principal views to and from the front (east) elevation of the building, which overlooks the project area. The temporary nature of the shed, and its recessive appearance would mean the shed would not visually dominate the surrounding context of the Palisade Hotel. The Palisade Hotel, as a seven-storey building, is a prominent landmark in the locality. Views towards the Palisade Hotel would not be diminished, and the overall form and configuration of the hotel's front (east) elevation would still be able to be accessed and appreciated from vantage points in the surrounding streetscape. The proposal would result in a minor indirect visual impact to the Palisade Hotel.
Oswald Bond Store	The proposal does not involve any works that directly affect physical fabric of the Oswald Bond Store. The proposal would result in a neutral physical impact to the Oswald Bond Store.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new visual elements in the immediate vicinity of the Oswald Bond Store.

Item name	Direct impact	Indirect impact
		This particularly relates to views to and from the side (west) elevation of the building, which overlooks the project area. The temporary nature of the shed, and its recessive appearance would mean the shed would not visually dominate the surrounding context of the Oswald Bond Store. Although it is noted the lower pavement level of the Oswald Bond Store adjacent to the Dalgety Road bridge would result in the shed extending a higher distance in this locality. Views to and from the store would be somewhat diminished by the proposal, in particular the lower levels of the building as seen from vantage points along Windmill Street and Dalgety Road. The proposal would result in a moderate indirect impact to the Oswald Bond Store.
Victorian Terrace (56-60 Bettington Street)	The proposal does not involve any works that directly affect physical fabric of the Victorian Terrace heritage item. The proposal would result in a neutral physical impact to the Victorian Terrace heritage item.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new, albeit temporary, visual elements in the vicinity of the Victorian Terrace heritage item. It is noted that the Terrace heritage item is located more than 45 metres along Bettington Street, and views towards the project area are largely concealed by adjoining development. There are only limited views from this heritage item towards the project area. It is anticipated that views towards the Victorian Terrace heritage item would not be affected by the proposal. The proposal would result in a negligible indirect visual impact to the Victorian Terrace heritage item.
Sandstone Wall and Stairs Including Iron Palisade Fence	The proposal does not involve any works that directly affect physical fabric of the Sandstone Wall and Stairs Including Iron Palisade Fence heritage item. The proposal would result in a neutral physical impact to the Sandstone Wall and Stairs Including Iron Palisade Fence heritage item.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new, albeit temporary, visual elements in the vicinity of the Sandstone Wall and Stairs Including Iron Palisade Fence heritage item. The temporary nature of the shed, and its recessive appearance would mean the shed would not visually dominate the surrounding streetscape, and views towards the sandstone wall and stairs would not be affected.

Item name	Direct impact	Indirect impact
		The proposal would result in a negligible indirect visual impact to the Sandstone Wall and Stairs Including Iron Palisade Fence heritage item.
Retaining wall	The proposal does not involve any works that directly affect physical fabric of the Retaining wall heritage item. The proposal would result in a neutral physical impact to the Retaining wall heritage item.	The proposed erection of the acoustic enclosure and laydown areas at Dalgety Road level would introduce new, albeit temporary, visual elements in the vicinity of the Retaining wall heritage item. It is noted that the Retaining wall heritage item is located more than 40 metres away from the project area on Rodens Lane, which is largely concealed from the project area. As such, visual impacts to this heritage item and its setting are not anticipated. The proposal would result in a neutral indirect impact to the Retaining wall heritage item.

Summary

The following table outlines the potential heritage constraints within the study area:

Table 20: Overview of potential heritage constraints for Barangaroo study area.

Heritage item	Direct impact (current)	Direct impact (as assessed in EIS)	Indirect impact	Indirect impact (as assessed in EIS)
Millers Point & Dawes Point Village Precinct	Minor	Minor	Minor -Moderate	Minor to moderate
Millers Point Conservation Area	Neutral	Neutral	Negligible – Minor	Neutral
Bridges over Hickson Road	Neutral	Neutral	Moderate	Minor
Oswald Bond Store	Neutral	Neutral	Moderate	Neutral
Shops (6, 8 Argyle Place)	Neural	Neural	Moderate	Neutral
Edwardian terrace	Neutral	Not assessed	Minor	Not assessed
Palisade Hotel	Neutral	Not assessed	Minor	Not assessed
Lord Nelson Hotel	Neutral	Not assessed	Negligible	Not assessed
Terraces (15-35A Dalgety Road)	Neutral	Not assessed	Negligible	Not assessed
Terrace (18, 18a, 20, 20a Munn Street)	Neutral	Not assessed	Negligible	Not assessed
Warehouses	Neutral	Not assessed	Negligible	Not assessed
Shops (1,3,5,7 Argyle Place)	Neutral	Not assessed	Negligible	Not assessed

Heritage item	Direct impact (current)	Direct impact (as assessed in EIS)	Indirect impact	Indirect impact (as assessed in EIS)
Victorian Terrace (56-60 Bettington Street)	Neutral	Not assessed	Negligible	Not assessed
Sandstone Wall and Stairs Including Iron Palisade Fence	Neutral	Not assessed	Negligible	Not assessed
Walsh Bay Wharves precinct	Neutral	Not assessed	Neutral	Not assessed
Retaining wall	Neutral	Not assessed	Neutral	Not assessed

Archaeology

There would be no impacts to Aboriginal or non-Aboriginal archaeology as a result of the proposed works as they would take place within a deep sandstone cutting.

Discussion

Overall the proposed impacts of the shaft, acoustic shed and laydown area on heritage items are minor. Localised temporary visual impacts would affect the listed items in the direct vicinity of the acoustic shed, particularly where it will protrude over the cliff edge and be visible from Windmill Street and surrounds. The chosen colour (Jasper) would minimise impacts as it is visually recessive.

Direct impacts to significant fabric are limited to installation of 10 rock bolts on the Hickson Road cutting to tether the acoustic shed to enable safe use of the gantry crane. This would result in a minor impact to the SHR listed Millers Point & Dawes Point Village Precinct although installing rock bolts would result in localised direct impacts to the cutting, a significant landscape element of the listing.

It is assumed there would be no direct impacts as a result of installation and operation of the laydown areas on Windmill Street Bridge and Dalgety Street Bridge.

Management

It is assumed the following recommendations and management measures would be considered in regard to the proposed works:

- Treatment of the rock bolt holes after removal would be required. Sandstone plugs would be used for treatment for rock bolt intrusions where possible, otherwise plugging that matches the colour and texture of the sandstone may be appropriate. The plugging should be conducted by appropriately qualified tradespeople have experience working in heritage places.
- Impacts to fabric would be avoided by use of barriers and exclusion zones where appropriate. This would be necessary for the parapets and balustrades of the Hickson Road Bridges during use of the laydown areas, for the cutting during construction and operation of the acoustic shed and in any other location where construction or operation would occur in close proximity to heritage fabric.
- Consideration would be given to use of the acoustic shed walls for interpretive display. This display would facilitate engagement of the public with the history of the locality and its design and colour scheme would be sensitive to heritage values.
- A vibration assessment would be undertaken to assess the likelihood of damage to heritage fabric as a result of the works.

Appendix F – Statement of Heritage Impact

MOTT MACDONALD

Barangaroo Northern Shaft

Statement of Heritage Impact

Transport for NSW

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Barangaroo Northern Shaft

Statement of Heritage Impact

Transport for NSW

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	15/02/18	AB	-	AB	Draft for review
B	23/02/18	AB		AB	Final for review
C	28/02/18	AB		AB	Final

Document reference: 392734369800SS08 | 1 | A

Information class: Standard

Contents

1 Aim and Objectives of the Statement of Heritage Impact

This Statement of Heritage Impact (SOHI) has been prepared by Mott MacDonald Australia for Transport for NSW (TfNSW) to assess the heritage impact of the proposed construction of the northern shaft and acoustic shed on Hickson Road in Millers Point as part of the Barangaroo worksite within the Sydney Metro Chatswood to Sydenham project.

TfNSW are currently preparing a consistency assessment for the northern access shaft. The purpose of this report is to support the approval process by providing an assessment of the potential heritage impacts and proposing measures to eliminate, reduce or mitigate those potential impacts.

The heritage significance of the site and nearby items has been established previously in the Construction Heritage Management Plan (Document No: SMCSWTSE-JCG-TPW-EM-PLN-002015) and the previous Heritage Significance Assessment for the Hickson Road Retaining Wall (Document No: NWRLSRT-PBA-SHC-HE-REP-000002). It should be noted that the extent of the Hickson Road cutting that is likely to be impacted by the proposed works is not included in the existing Heritage Significance Assessment, however as this extent is part of the same structure and from the same period of construction, it is considered to have a similar level of heritage significance as the adjacent wall.

The condition and intactness of assets in and near the site has yet to be fully established, and this forms part of the recommendations of this report and contained within the various assessments listed below.

An outline of the proposed works to construct and operate the northern shaft is contained in this report.

1.1 Project Methodology and Key Resources

No primary historical research has been carried out in preparing this document. The historical background for this report is based on data contained within existing reports and heritage listings. Review of this data indicates that it is sufficient for the purposes of this SoHI.

The assessments of heritage significance are based on the NSW SHR listings for the various heritage assets surrounding the proposed shaft and shed.

The description of the scope of works has been taken from the various reference documents listed below.

No community consultation has been carried out in preparation of this report.

This SoHI has been prepared with reference to the guidelines provided by the NSW Office of Environment and Heritage (OEH).

1.2 Author Identification

This report has been prepared by Alex Been, Heritage Consultant and Principal Structural Engineer of Mott MacDonald.

1.3 Reference Documents

This report has been prepared with reference to the following key documents:

- Barangaroo Temporary Shaft and Acoustic Shed Heritage Memo, ambs ecology and heritage, 04.12.2017 and 25.01.2018
- Construction Noise and Vibration Impact Statement: Local Area & Utility Works - Barangaroo - Stage 2, Renzo Tonin & Associates (NSW) Pty Ltd, 29.11.2017
- Construction Noise and Vibration Assessment for Barangaroo Northern Shaft, Renzo Tonin & Associates (NSW) Pty Ltd, 29.01.2018
- Visual Impact Assessment - Barangaroo Northern Shaft - Sydney Metro Area, KI Studio, 30.01.2018
- Barangaroo Station and Precinct Temporary Works Drawings – Rev A, 10.01.18, TfNSW
- Sydney Metro and Southwest Pre-Construction Dilapidation Survey - Hickson Road Wall – 27.09.2017 – Opus International Consultants
- Barangaroo Northern Shaft – Planning Approval Consistency Assessment Form – Sydney Metro
- CPS-SBR-044 Heritage Wall North - Recommended Support

2 Outline of Proposed Works

It is understood that the primary driver for the construction of the northern shaft is to simplify the construction of the Crossover Cavern and other tunnels to the north and south of Barangaroo Station.

The works proposed to enable the construction and operation of the northern shaft are as follows:

2.1 Site Establishment and Preparation

Site establishment works including:

- Installation of laybacks and driveways on Hickson Road and High Street.
- Vegetation clearing: along Wulugul Walk, and along Hickson Road
- Utilities identification and relocation on Hickson Road and part of Sussex Street, and on High Street
- Trenching on Hickson Road and Sussex Street to support utility relocation works, close to 25 Hickson Road, close to 1 High Street, and under the Western Distributor bridge.
- Road realignments and traffic/ pedestrian alteration works along Hickson Road from Windmill Street to the High Steps.
- Installation of permanent rock bolts into the cut sandstone face of the Hickson Road cutting to restrain fractured sections of the rock face.
- Removal of rock flakes (rock scaling) from the Hickson Road cutting that cannot be restrained by rock bolts.

2.2 Acoustic Shed Construction

Construction of the acoustic shed will include the following works:

- Removal of the existing kerb and gutter, footpath and road surface
- Capping beam and reinforcement works, including excavation, placement of form work and concrete pouring and installation of ground anchors through the capping beam into bedrock below.
- Construction of a structural steel frame clad in acoustic panels. The Shed will be approximately 32m long, 16m wide and over 21m high (up to 14m above the higher-level road levels).
- Installation of a 220T gantry crane within the acoustic shed.
- Anchoring of each of five portal frames to the cutting to resist loads associated with operation of the gantry crane. This anchoring will take the form of brackets at each portal being anchored to the cutting by rock bolts. Currently it is proposed to install 10 rock bolts in total.

2.3 Shaft excavation

Excavation of the northern shaft will include the following works:

- Excavation of the northern access shaft in bedrock. The proposed shaft is approximately 17m by 10m wide and 30m deep and located within the existing Hickson roadway (between Dalgety Road and Windmill St). The shaft will connect with the

Crossover Cavern at its base. The shaft will be excavated using rock saws, rock hammers and excavators.
- Removal of shaft spoil from site by road truck-and-trailers.

2.4 Operations and soil removal

During operation the following works are expected:

- Removal of spoil from excavation of the crossover cavern by kibble using the gantry crane, and removal from site by truck-and-trailers.
- Delivery of concrete for use in shotcreting within the excavation.
- Gantry crane operation, to lower roadheaders for the excavation of the cross over cavern, lower and retrieve TBMs, and lower all supplies (segments, grout, grease and other operational materials) necessary for the construction of the crossover cavern and the tunnels.

2.5 Post Operation Works

At completion of the tunnelling activities the gantry will be removed and the acoustic shed will be reduced in height to enable ongoing delivery of materials for tunnel fitouts. It is expected that the acoustic shed will be reduced in height to the level of the adjacent bridges. At the completion of these works and prior to operation of the Sydney Metro the temporary northern shaft will be decommissioned and reinstated to its current condition.

3 Alternative Methods Considered

As described in the review of proposed works in section 4, the works have the potential to impact on heritage items in the vicinity of the works site. Accordingly, alternative works have been considered to reduce these potential impacts, as discussed in the consistency assessment and replicated as follows:

3.1 No construction of the northern shaft

In order to avoid construction of the northern shaft the access/egress point to construct the crossover cavern, launch and support the harbour TBMs would be from the station box. The hard rock TBMs would be removed from the station box. This would result in an approximate delay of 14 months to the TSE contract as the cavern excavation works cannot commence until the station box has been sufficiently excavated. Further significant delays associated with the follow-on contracts which is currently planning on using this shaft to facilitate a third of those scopes of work.

3.2 Temporary shaft with no acoustic shed

This option would have a visual impact consistent with laydown area identified in the environmental impact statement. However, the excavation of the shaft would be subject to daytime works only requiring a longer program. There would be a high noise impact, exceeding the conditions of approval. There would need to be water suppression dust control. Due to the absence of the gantry crane within the acoustic shed, a mobile crane would be required to lift the TBM, machinery and segments into the shaft. As there is insufficient clear space at the location of the shaft on Hickson Road to enable cranage, the practical location for the crane would be at high level on Dalgety Road Bridge or Windmill Street. However, due to the weight of the TBM it is unlikely these roads would be able to accommodate the crane loads, making this option unachievable.

3.3 Temporary shaft with a reduced height acoustic shed

A 16m high acoustic shed would reduce the visual impact to the area. The duration of the shaft and crossover cavern excavation works would be significantly extended as the contractor would become spoil bound within the shed during the night shift (spoil bound in this context meaning the excavation would have to cease because of the amount of spoil removed exceeds the capacity of the storage on site. The 21m high shed incorporates a 5.5m high spoil storage area, thus allowing 24hr excavation works). The harbour TBM would need to be delivered via the station box and the two hard-rock TBMs would need to be removed via the station box utilising mobile cranes. This would result in significant temporary works associated with the construction of mobile crane piling pads and piles, which would conflict with the requirements of the interface agreement and involve impacts on construction traffic and utility diversions at either end of the station at surface level. Additionally, the works would impact traffic on Hickson Road, with full road closures required for approximately 7 days on 4 separate occasions. This option would result in an approximate delay of 12 months to the delivery of the Sydney Metro Chatswood to Sydenham project.

4 Review of Proposed Works

If the construction of the Barangaroo Northern Shaft proceeds as proposed the following heritage impacts are likely and mitigation strategies are recommended as follows:

4.1 Site Preparation

ACTION	IMPACT	EXISTING MITIGATION	ADDITIONAL PROPOSED MITIGATION
Ground excavation for installation of capping beam and relocation of in-ground services. Installation of rock bolts into the Hickson Road cutting. Rock scaling (removal) of rock flakes on the Hickson Road cutting. Installation of ground anchors through capping beam.	Removal of sandstone kerb and gutter	None	Store stone for reinstatement at completion of project
	Disturbance of archaeology	Archaeological study suggests there is no potential for significant archaeology on site. Apply “Unexpected Heritage Finds” procedure as identified in the Section 7.4 of the Casey & Lowe Archaeological Method Statement.	None
	Ground vibrations associated with plant engines, excavation and installation of ground anchors	Assess heritage structures within the zone of influence of vibratory works against guidelines for “structural soundness” and adopt appropriate vibration limits and monitoring protocols as per the project wide CNVMP. Undertake building dilapidation surveys on all buildings located within the minimum working distances established for cosmetic damage prior to commencement of activities with the potential to cause property damage. Use less vibration emitting construction methods where feasible and reasonable. Plan traffic flow, parking and loading/unloading areas to maximise distances between truck routes and sensitive receivers.	None

ACTION	IMPACT	EXISTING MITIGATION	ADDITIONAL PROPOSED MITIGATION
	Physical impact of rock bolts	None	Consider removal of the bolt heads after completion of the works (subject to geotechnical advice)
	Physical impact of removal of rock flakes	None	Limit rock scaling as much as possible (subject to geotechnical advice). Consider use of catch nets to reduce hazard associated with calving rock to reduce the extent of pre-emptive rock removal.
	Physical impact of ground anchors	Design and install ground anchors to avoid directly affecting heritage structures	None

4.2 Acoustic Shed Construction

ACTION	IMPACT	EXISTING MITIGATION	ADDITIONAL PROPOSED MITIGATION
Construction of shed structure and plant (gantry crane etc)	Physical impact on heritage structures during construction (collisions etc)	None	Impose adequate clearances to heritage structures to avoid unintended collisions and damage.
	Shed dimensions block significant views to and from heritage items	Shed located on a curve in Hickson Road and thereby reduces the visual impact of the shed on views along Hickson Road.	Design the shed to minimise the dimensions as much as possible, including limiting height, plan dimensions and

ACTION	IMPACT	EXISTING MITIGATION	ADDITIONAL PROPOSED MITIGATION
	along Hickson Road and at higher-level buildings.		roof profile. Carry out study of views to and from nearby heritage items and adjust shed dimensions to enable maintenance of important views wherever possible.
Bracing of shed structure by ground anchoring into Hickson Road cutting	Physical impact on stone cutting	None	Design ground anchors to impose the minimum impact on the Hickson Road cutting. Consider spacing, location to avoid damaging or destabilising sensitive sections of the wall. Consider detailing of anchor heads to minimise damage to the surface. Ground anchors to be temporary and cut back to the wall line at completion to minimise patching.
Installation of the shed cladding	Cladding material and colour	No assessment of proposed materials and colours has been submitted to date. It is understood that these issues will be considered during the design of the acoustic shed.	Choose cladding materials and colour appropriate to the setting. Use high standard of finish and material and construction.

4.3 Shaft Excavation

ACTION	IMPACT	EXISTING MITIGATION	ADDITIONAL PROPOSED MITIGATION
Excavation of shaft. Installation of rock bolts into sandstone cutting to prevent rock collapse.	Ground vibrations associated with plant engines, excavation and installation of rock bolts.	Impose vibration limits as per project wide guidelines and monitor at sensitive receivers. Check heritage structures meet guidelines for “structural soundness”. Carry out dilapidation surveys of heritage items.	None
	Physical impact of rock bolts.	None.	Recess bolt heads to reduce visibility and match previous rock bolting along Hickson Road.
	Rock relaxation associated with shaft excavation	None.	Geotechnical assessment to consider extent of rock relaxation and impact on Hickson Road cutting.
Removal of spoil from site	Increased heavy vehicle traffic	Protect heritage structures from traffic impacts (such as sandstone kerb and gutter). Install barriers etc as necessary.	None

4.4 Operations and Soil Removal

ACTION	IMPACT	EXISTING MITIGATION	ADDITIONAL PROPOSED MITIGATION
Removal of spoil from site	Increased heavy vehicle traffic	Protect heritage structures from traffic impacts (such as sandstone kerb and gutter). Install barriers etc as necessary.	None

4.5 Post Operation Works

Impacts associated with the completion of the project, site demobilisation and covering of the shaft have not been assessed by Mott MacDonald at this stage.

5 Conclusions and Recommendations

The proposed works to excavate the northern shaft, construct the acoustic shed, and carry out the operations within, will affect adjacent and nearby heritage items. Mitigation strategies have been suggested as outlined above. In furtherance to those recommendations, works to assess the potential level of impact on heritage items, and to control the impacts are proposed as follows:

- Conduct assessment of latest shed dimensions on significant views to and from heritage items. Determine any areas where a reduction in shed dimensions could lessen the impact. Minimise acoustic shed structure dimensions in general as much as possible.
- Apply appropriate materials and colour to acoustic shed
- Undertake dilapidation reports/ condition assessments to identify vibration sensitive heritage structures and structures that will be potentially impacted by construction works.
- Refine the geotechnical assessment of the sandstone cutting at Hickson Road and the retaining wall above to restrict physical impacts of protection works as much as practical.
- Assess the Hickson Road cutting to plot appropriate anchor locations for support of the shed structure under gantry loading and adjust the support structure to suit the condition of the rock face
- Develop the design of anchors (for both restraint of the rock face and support of the acoustic shed) to minimise impact of anchoring works (anchor heads, waler beam installation etc) on the rock face of the Hickson Road cutting.
- Carry out archival recording of the rock face prior to commencing works. A general dilapidation survey has already been conducted, however it would be appropriate to record the arrangement of the rock face and the retaining wall above in detail prior to commencement of works.
- Install protection barriers or buffer zones to prevent accidental collision impacts on the bridges, retaining walls and other items around the work site
- Carry out vibration monitoring in accordance with the Monitoring and Protection Plan.
- Assess vibrations recording during the works and adjust works methods and machinery used to restrict ground vibrations to the limits imposed by the Construction Noise and Vibration Assessment

By the implementation of the existing monitoring and protection plans and by consideration of the (site and project specific) proposed mitigation strategies listed above during design and construction of the proposed works, the risk of impacts on heritage items in the vicinity of the work site shall be controlled to an acceptable degree.

Subject to appropriate detailing and subject to implementation of the mitigation strategies proposed above, works that have a direct and physical impact on heritage structures (such as installation of rock bolts and anchors) are acceptable.

Temporary works to enable the construction of the northern shaft and enable operations within the shaft and tunnels have been shown to have a significant beneficial impact on reducing the construction programme for local works at Barangaroo and in subsequent Sydney Metro construction contracts. In this context, and given the temporary nature of any heritage impacts

associated with these temporary works (such as restriction of sight lines and views to and from heritage items in Millers Point by the construction of the acoustic shed), the works are considered acceptable.

Any alteration to the scope of works during development of detailed design for the acoustic shed and shaft, and during the construction phase, will require re-assessment to capture any increased risk of heritage impact, and may require the adjustment of, or addition to, proposed mitigations.

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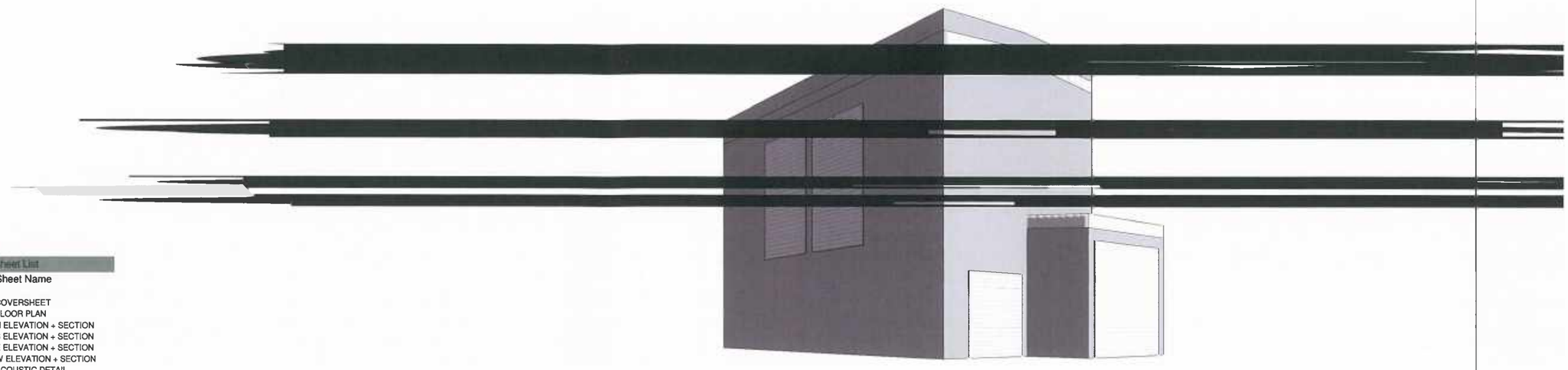
Appendix G - Acoustic Shed design

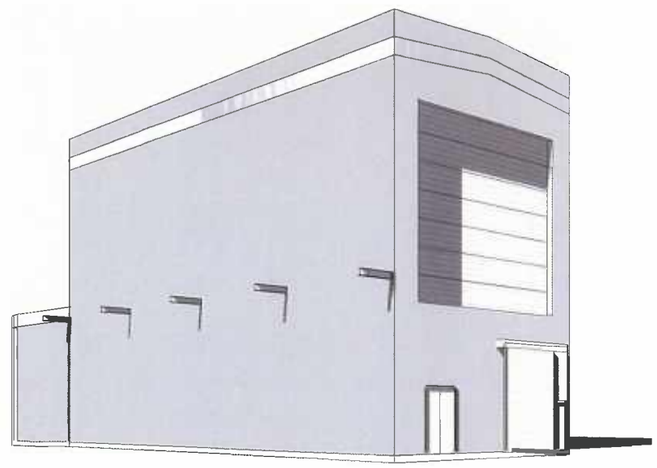


2 S/W PERSPECTIVE

Sheet List	
No.	Sheet Name
BTB-A-000	COVERSHEET
BTB-A-001	FLOOR PLAN
BTB-A-002	N ELEVATION + SECTION
BTB-A-003	S ELEVATION + SECTION
BTB-A-004	E ELEVATION + SECTION
BTB-A-005	W ELEVATION + SECTION
BTB-A-006	ACOUSTIC DETAIL
BTB-A-007	ROOF PLAN
BTB-A-008	SECTIONS
BTB-A-009	WALL SECTIONS

BUILDING COLOUR CHART	
Item	Finish
STEEL	UNPAINTED
WALLS	JASPER
ROOF	JASPER
DOORS	JASPER
LOUVRES	JASPER
FAN BOX	JASPER
GUTTERS	N/A (BOX)
DOWNPIPES	PLAIN

DESIGN INPUTS		
Item	Detail	Reference
INTERNAL PORTAL CRANE	1x 220T	EILBECK REF. DWG. NO. 27320-DMS-100 REV D
INTERNAL PORTAL CRANE	DRILLING DETAIL	EILBECK REF. DWG. NO. 27320-DMS-101 REV A



3 N/E PERSPECTIVE

FOR APPROVAL

Date: _____

Name: _____

Signature: _____

GENERAL NOTES:
ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN. WORK TO FIGURED DIMENSIONS, DO NOT SCALE FROM DRAWINGS. ALL CONSTRUCTION TO MEET ALL APPLICABLE AUSTRALIAN STANDARDS AND BUILDING CODE OF AUSTRALIA / NATIONAL CONSTRUCTION CODE REQUIREMENTS. THESE DRAWINGS TO BE READ IN CONJUNCTION WITH ENGINEER'S & SPECIALIST PLANS / REPORTS. DRAWINGS REPRESENT 'DESIGN INTENT' ONLY. IT IS THE RESPONSIBILITY OF THE BUILDER TO ENSURE COMPATABILITY WITH COMPONENTS, MATERIALS, ENGINEER'S SPECIFICATION, STRUCTURAL ADEQUACY OF EXISTING COMPONENTS & COMPLIANCE WITH ALL RELEVANT BUILDING STANDARDS & CODES. BUILDER TO CHECK ALL HEIGHTS & MEASUREMENTS ON SITE. NOT FOR CONSTRUCTION UNLESS MARKED 'CONSTRUCTION ISSUE'. PLANS ARE COPYRIGHT TO PROTECTOR BUILDING SYSTEMS.

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Project Address:	SYDNEY METRO 2	SHEET NUMBER:	BTB-A-000
Project name:	BARANGAROO TBM SHED	SHEET NAME:	COVERSHEET
Project number:	BTB-A	SCALE: 1 : 200 @A0	STATUS: CONSTRUCTION

No.	Date	Revision Description	BY	CHK
0	25/01/18	CONSTRUCTION	PH	RG

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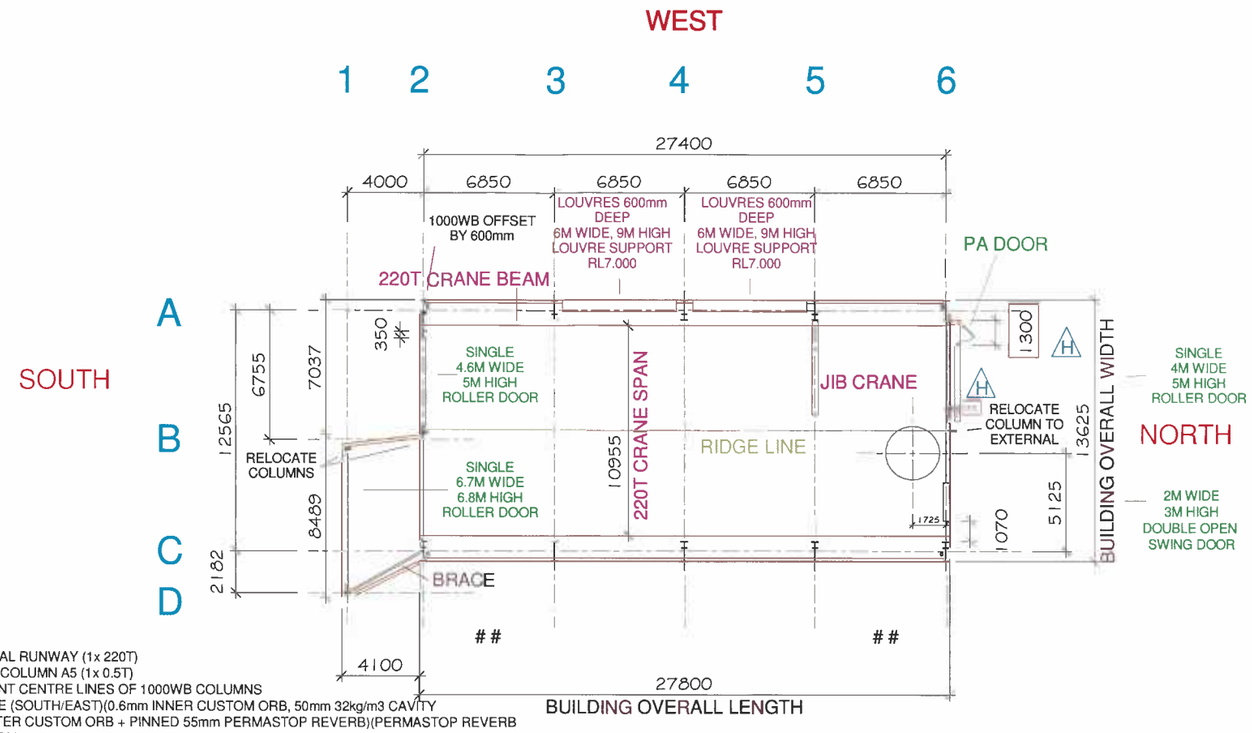

PLAN VIEW

NOTES
1. 1x CRANE ON INTERNAL RUNWAY (1x 220T)
2. 1x DEREK CRANE ON COLUMN A5 (1x 0.5T)
3. GRIDLINES REPRESENT CENTRE LINES OF 1000WB COLUMNS
4. WALL CLADDING TYPE (SOUTH/EAST)(0.6mm INNER CUSTOM ORB, 50mm 32kg/m3 CAVITY INSULATION, 0.6mm OUTER CUSTOM ORB + PINNED 55mm PERMASTOP REVERB)(PERMASTOP REVERB 4M ABOVE BASEPLATE RL)
5. WALL CLADDING TYPE (WEST/NORTH)(51mm SPEEDPANEL (45Okg/m ^{3}) + PINNED 55mm PERMASTOP REVERB)(PERMASTOP REVERB 4M ABOVE BASEPLATE RL)
6. ALL WALL CLADDING - RL 0.000 TO PARAPET
7. SOUTH WALL CLADDING UNDER SKILLION HEIGHT CLEAR OPEN.
8. PIN COLUMNS ON GRID C TO ROCK FACE AT RL = FFL + 8.000
9. ROOF CLADDING TYPE (0.6mm CEILING CUSTOM ORB, 55mm PERMASTOP CAVITY INSULATION, 0.48mm ROOF TRIMDECK + 55mm PERMASTOP REVERB UNDER CEILING)
10. INTERNAL BOX GUTTER
11. FFL - FINISHED FLOOR LEVEL RL = 0.000
12. ALL COLUMNS LAND ON FFL
13. PORTAL CRANE TOP OF BEAM RL = FFL+13.800
14. DEREK CRANE RL (UNDERSIDE OF LOWER CONNECTION PLATE) = FFL+5.000
15. CLEAR EAVE HEIGHT RL = FFL+17.450
16. SOUTH SKILLION CLEAR EAVE HEIGHT RL = FFL+7.500
17. PARAPET WALLS (ALL WALLS APPROX. 1000mm ABOVE ROOF LINE)
18. NO ROOF VENTS OR FANS
19. # - ALLOWABLE BRACED BAY
20. ## - PREFERRED BRACED BAY
21. DOWNPIPES RUN VERTICAL DOWN TO FFL (NO COLLECTOR SYSTEM)
22. ALL STEELWORK SUPPLIED UNPAINTED

1 FLOOR PLAN
1 : 100

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Date: _____
Name: _____
Signature: _____

GENERAL NOTES:
ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN. WORK TO FIGURED DIMENSIONS, DO NOT SCALE FROM DRAWINGS. ALL CONSTRUCTION TO MEET ALL APPLICABLE AUSTRALIAN STANDARDS AND BUILDING CODE OF AUSTRALIA / NATIONAL CONSTRUCTION CODE REQUIREMENTS. THESE DRAWINGS TO BE READ IN CONJUNCTION WITH ENGINEER'S & SPECIALIST PLANS / REPORTS. DRAWINGS REPRESENT 'DESIGN INTENT' ONLY. IT IS THE RESPONSIBILITY OF THE BUILDER TO ENSURE COMPATABILITY WITH COMPONENTS, MATERIALS, ENGINEER'S SPECIFICATION, STRUCTURAL ADEQUACY OF EXISTING COMPONENTS & COMPLIANCE WITH ALL RELEVANT BUILDING STANDARDS & CODES. BUILDER TO CHECK ALL HEIGHTS & MEASUREMENTS ON SITE. NOT FOR CONSTRUCTION UNLESS MARKED 'CONSTRUCTION ISSUE'. PLANS ARE COPYRIGHT TO PROTECTOR BUILDING SYSTEMS.

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NORTH

Project Address:	SYDNEY METRO 2	SHEET NUMBER: BTB-A-001	
Project name:	BARANGAROO TBM SHED	SHEET NAME: FLOOR PLAN	
Project number:	BTB-A	SCALE: 1 : 100 @A0	STATUS: CONSTRUCTION

No.	Date	Revision Description	BY	CHK
0	25/01/18	CONSTRUCTION	PH	RG

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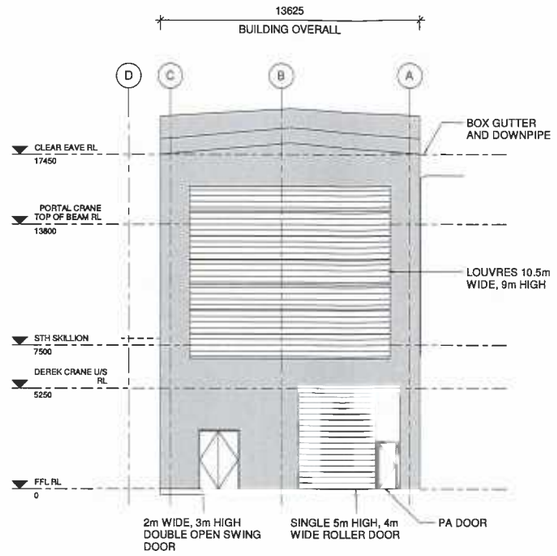

1 NORTH ELEVATION
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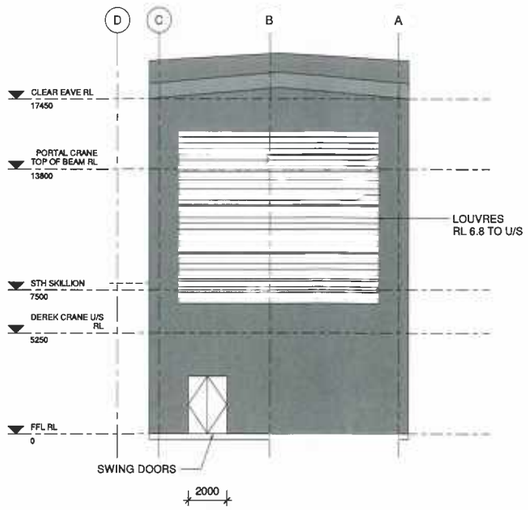

2 NORTH SECTION
1 : 100

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Date: _____
Name: _____
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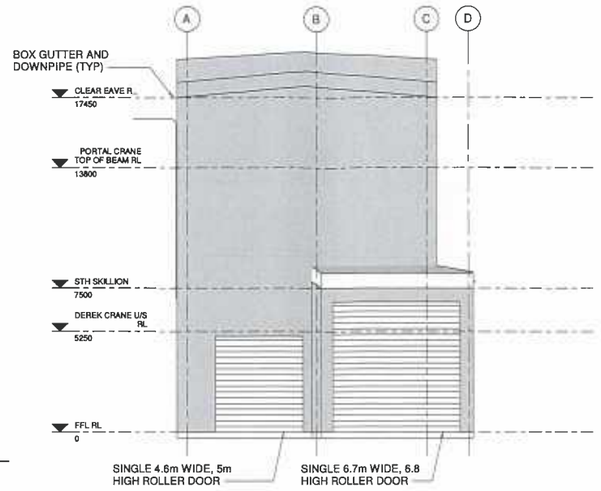

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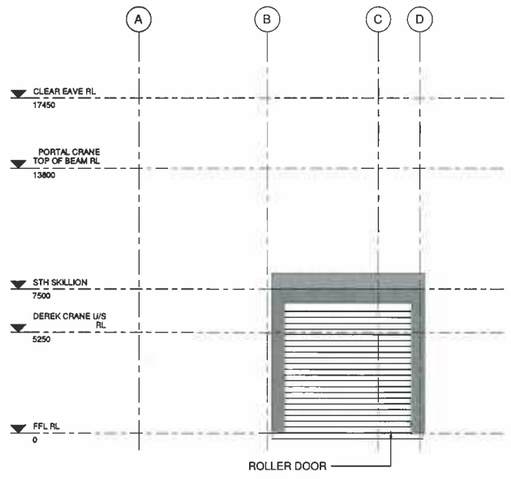

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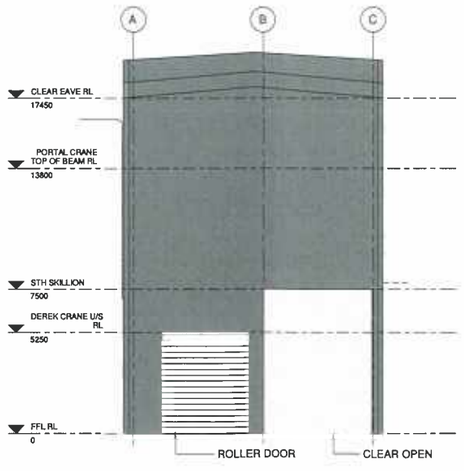

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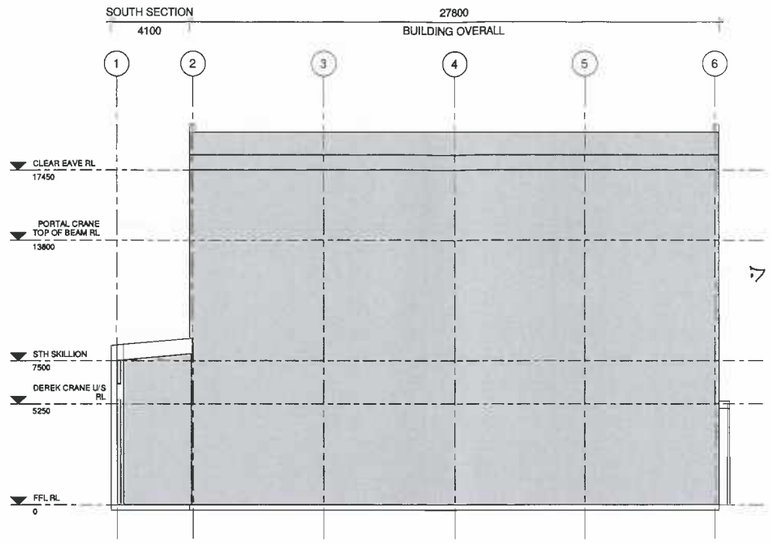

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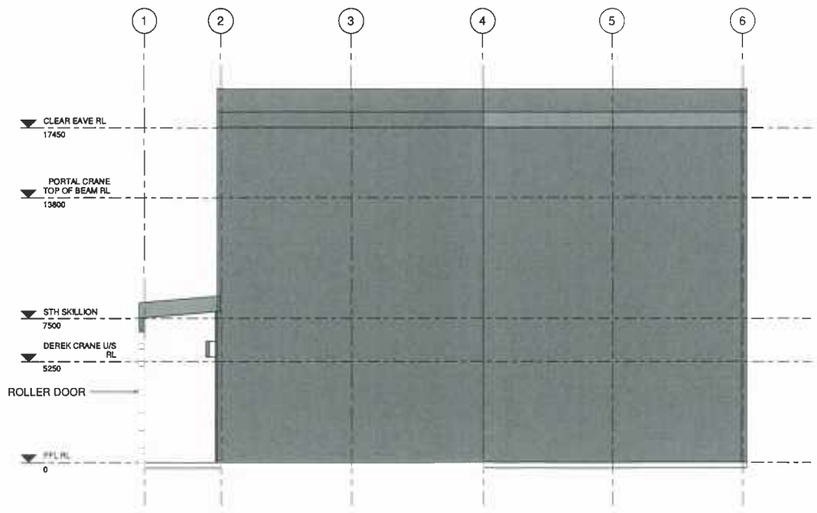
1 : 100



2 EAST SECTION (GRID C)
1 : 100

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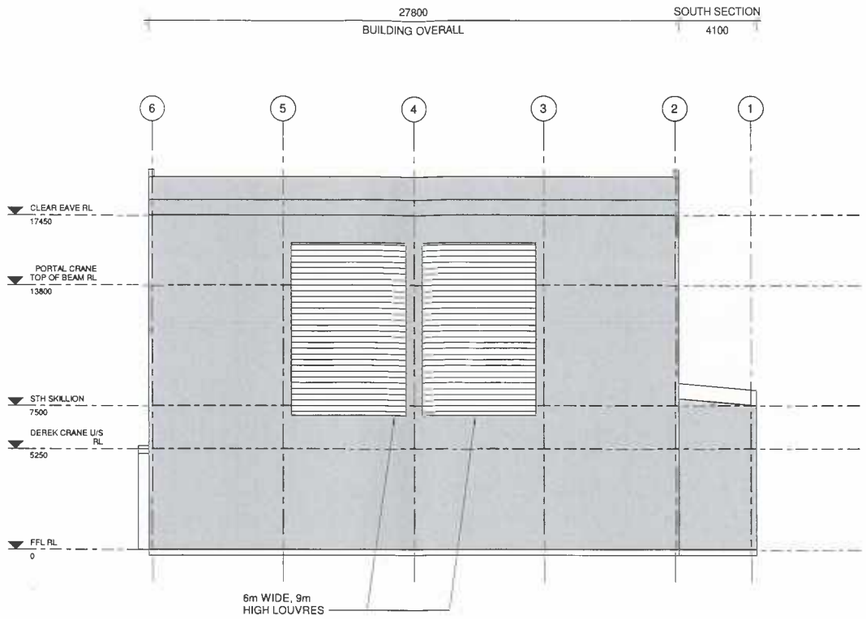

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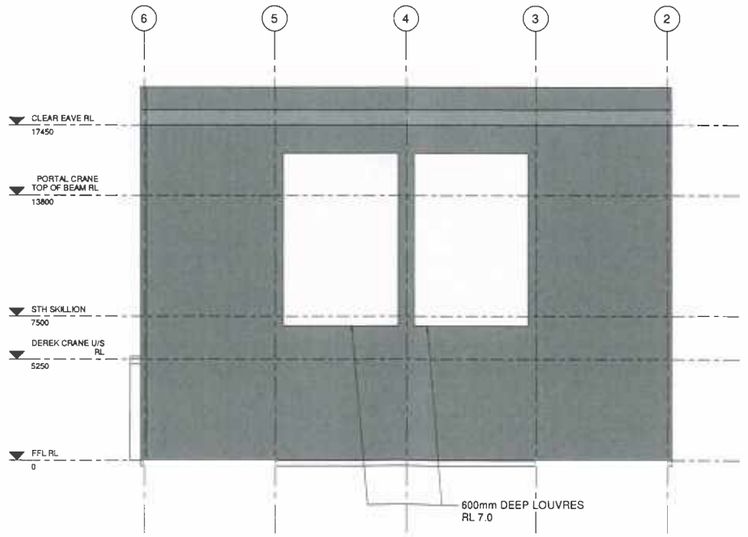

2 WEST SECTION (GRID A)
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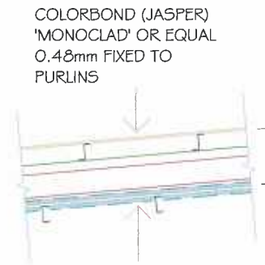
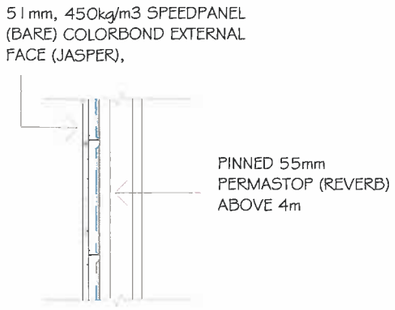
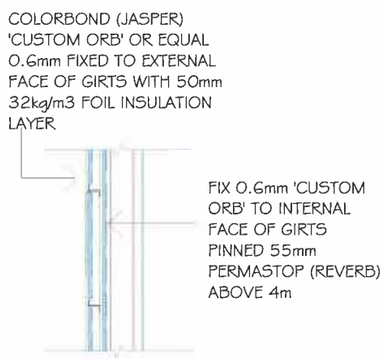
ROOF



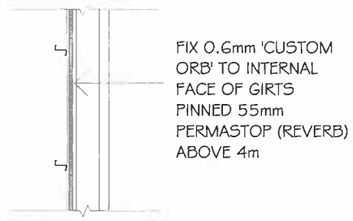
WALL
NORTH / WEST



WALL
SOUTH / EAST

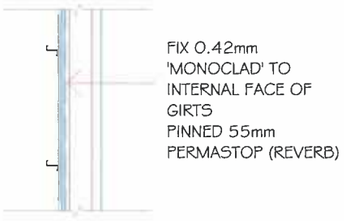


WALL
EAST (BELOW WINDMILL STREET LEVEL)



WALL
PARAPET WALL DETAILS

PLENUM



ACOUSTIC DETAILS

CONTRACT SPECIFICATION AND BUILDUP

CLADDING	
WALLS	0.6mm Cladding + 50mm FI32 Insulation LD Foil (32kg/m^3) + 0.6mm Cladding
ROOF	0.48mm Cladding + 55mm Permastop Foil (11kg/m^3) + 0.6mm Cladding
REVERB	
WALL	55mm Perforated Permastop Foil (11kg/m^3) (Above FFL+2.5m)
ROOF	55mm Perforated Permastop Foil (11kg/m^3)

ACOUSTIC DETAILS

CURRENT SPECIFICATION AND BUILDUP

CLADDING	
N/W WALL	51mm Speedpanel 450kg/m^3
S/E WALL	0.6mm Cladding + 50mm FI32 Insulation LD Foil (32kg/m^3) + 0.6mm Cladding
E WALL	0.6mm Cladding (BELOW WINDMILL STREET LEVEL ONLY)
PLENUM	0.42mm Cladding
ROOF	0.48mm Cladding + 55mm Permastop LD Foil (11kg/m^3) + 0.6mm Cladding
REVERB	
WALL	55mm Permastop LD Foil (11kg/m^3) (Above FFL + 4m)(Includes Plenum Lining)
ROOF	55mm Permastop LD Foil (11kg/m^3)

1 ACOUSTIC DETAIL
1 : 25

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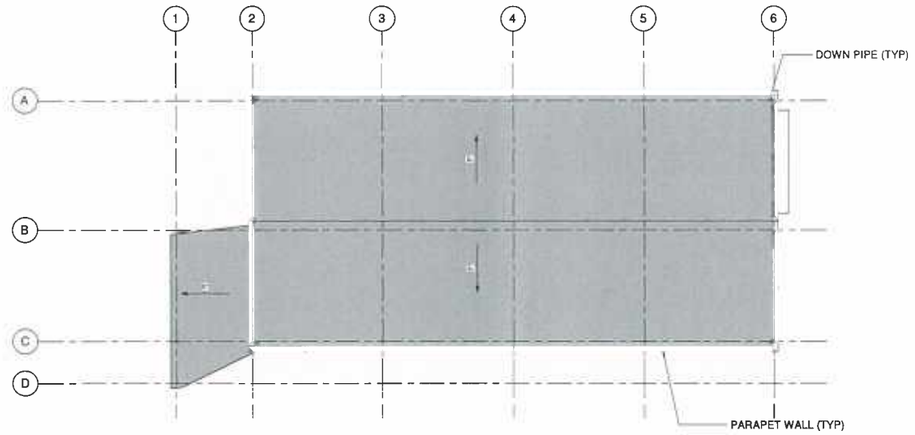

1 PROPOSED ROOF PLAN
1 : 100

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Project number:	BTB-A	SCALE: 1 : 100 @A0	STATUS: CONSTRUCTION

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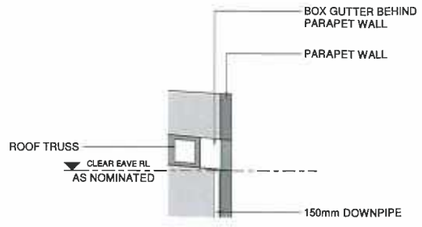

BOX GUTTER DETAIL (TYP)
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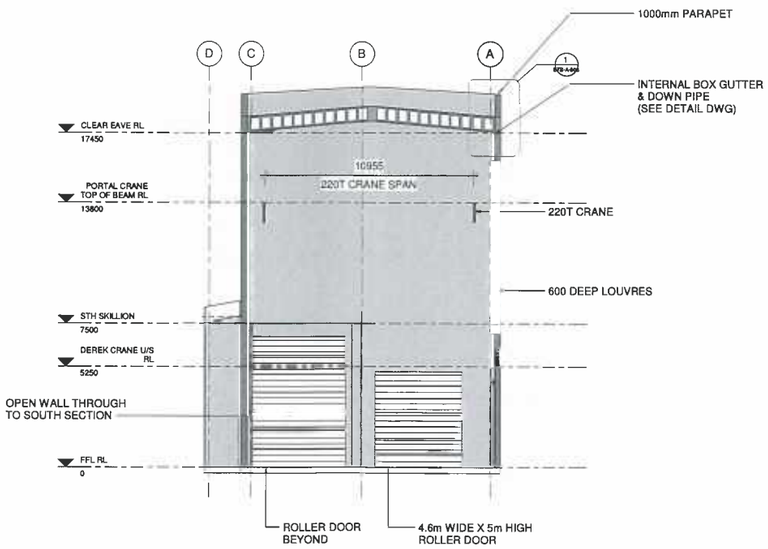

SECTION GRID 4
LOOKING SOUTH
2 1 : 100

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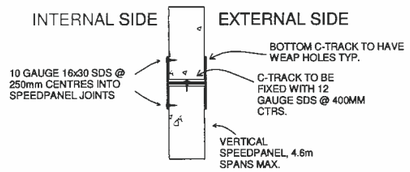
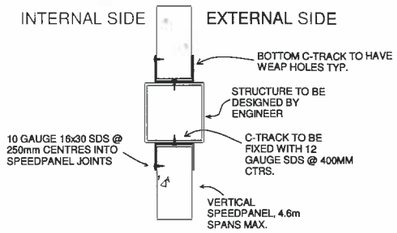
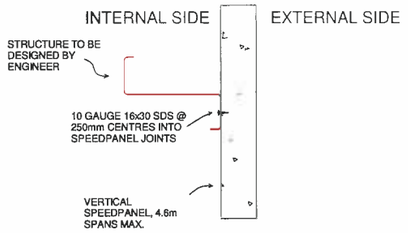


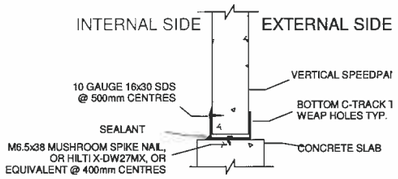
VERTICAL SPEEDPANEL
INTERMEDIATE CONNECTION



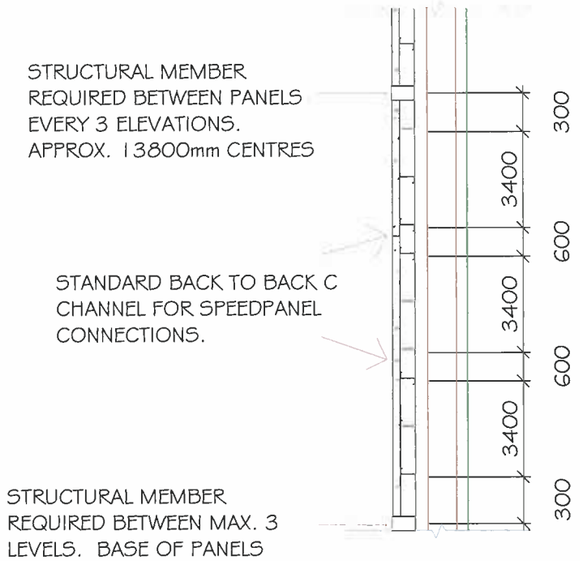
VERTICAL SPEEDPANEL
STRUCTURAL CONNECTION
REQ'D @;
- 3 RISES OF VERTICAL PANELS
- ROLLER DOOR HEADERS



VERTICAL SPEEDPANEL
GIRT CONNECTION

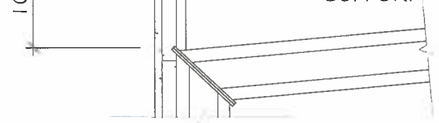


STANDARD CONNECTION
DETAIL TO CONCRETE
SECTION VIEW



WALL

CONNECTION DETAILS



WALL

PARAPET WALL DETAILS

1 WALL SECTIONS
1 : 20

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Project name:	BARANGAROO TBM SHED	SHEET NAME:	WALL SECTIONS
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Appendix H - Stage 1 shed photomontage

1.4 STRUCTURE OF THE REPORT

This report is structure as follows:

Section 1 provides information as to the background, the purpose of the study, the methodology applied and the general locality of the site.

Section 2 provides an general site analysis to provide the surrounding context to the site, including descriptions about the land use, built form, heritage and topography.

This section also discusses the visual sensitivity and magnitude of change surrounding the site to identify an overall visual impact.

1.5 METHODOLOGY

Preparation of this report has involved both a desk-top analysis and a site visit and is consistent with Roads and Maritime guidelines as outlined in:

- *Guidelines for landscape character and visual impact assessment No. EIA-N04 Version 2.0, March 2013.*

In assessing the proposed construction site, sensitivity considerations were taken into account on the various impacted properties. The sensitivity is measured depending on the nature of the viewer and the setting. For example, commercial properties are generally considered less sensitive than private residences and heritage listed properties are generally considered more sensitive then residential properties. Roads and open spaces are generally considered least sensitive depending on their scale and significance

The impact that the temporary construction site will have on the particular location has been assessed relative to the general setting. In relation to viewpoints, whilst the assessment does not assess specific viewpoint locations, the potential impact on viewpoints in the area that would most likely be impacted by the proposal are taken into consideration as accurately as possible.

Hence, the assessment evaluates the impact of the overall setting and not of a specific viewpoint

It should be noted that even though the assessment may discuss high impacts, the nature of this project is of a temporary nature. The combination of the visual sensitivity and magnitude will provide the rating of the visual impact and is based on the table shown below.

Figure 1.6 Magnitude

Figure 1.7 Sensitivity

	high	moderate	low	negligible
high	high impact	high- moderate	moderate	negligible
moderate	high- moderate	moderate	moderate-low	negligible
low	moderate	moderate-low	low	negligible
negligible	negligible	negligible	negligible	negligible

Figure 1.5 Visual Impacts Rating Table, example illustrating the resulting impact as a combination of sensitivity and magnitude.

02 VISUAL IMPACT ASSESSMENT

2.1 BARANGAROO - NORTHERN SHAFT

General Setting

The work site is situated along Hickson Road in Millers Point, between Windmill Street and Dalgety Road Bridges. This urban setting is a highly modified environment, with the surrounding land use a mixture of residential and commercial properties.

Hickson Road lays low in the landscape, just a few metres above sea level. Between Hickson Road and the harbour, is Barangaroo Reserve and a pocket of residential terraces and commercial buildings. Hickson Road is in a deep cutting, whilst the adjacent Dalgety Road and Windmill Street are more than ten metres above it.

Historic buildings, residential terraces and multi-storey offic buildings define the urban fabric, with most of these elements situated on top of the cutting.

Visual setting

The elevated position of the built form allows for panoramic vistas to the harbor from numerous vantage points. Because of the height of the cutting, the vistas look over and beyond the construction site, limiting its visual presence on the upper grounds, except for the temporary shed which would protrude up to the upper street levels, between Argyle Place and Windmill Street. Other elements visible from various vantage points would be along the foreshore which is well away from the cutting.

For visitors of Barangaroo Reserve, the areas of the construction site along the foreshore would be more exposed, depending on the particular location of the viewer.

There would be no public access to Hickson Road from Lance Lane to Windmill Street.

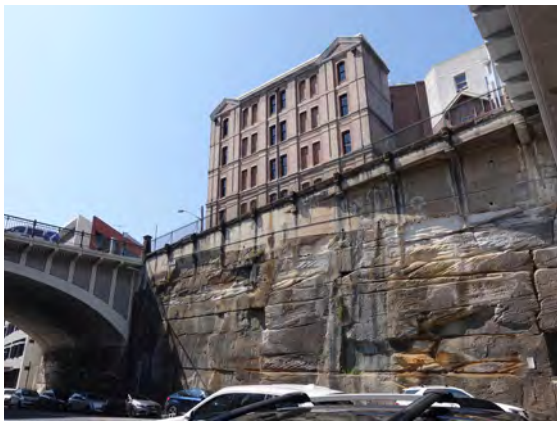

Figure 2.1 View where the proposed 21M high shed would be located. Some office buildings would directly overlook the construction site.

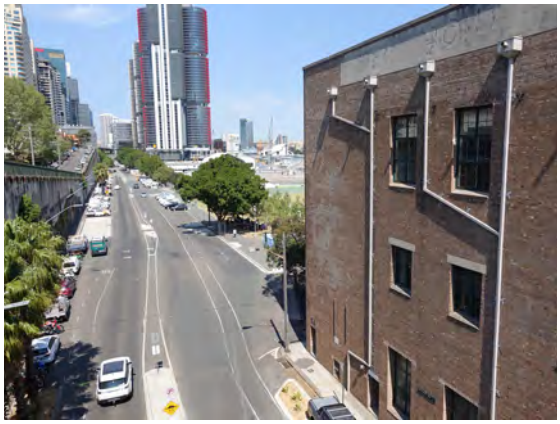

Figure 2.2 View from Munn Reserve which spans over Hickson Road, to the left the road cutting.

Figure 2.3 There is a mix of residential and commercial buildings north of the site along Hickson Road.

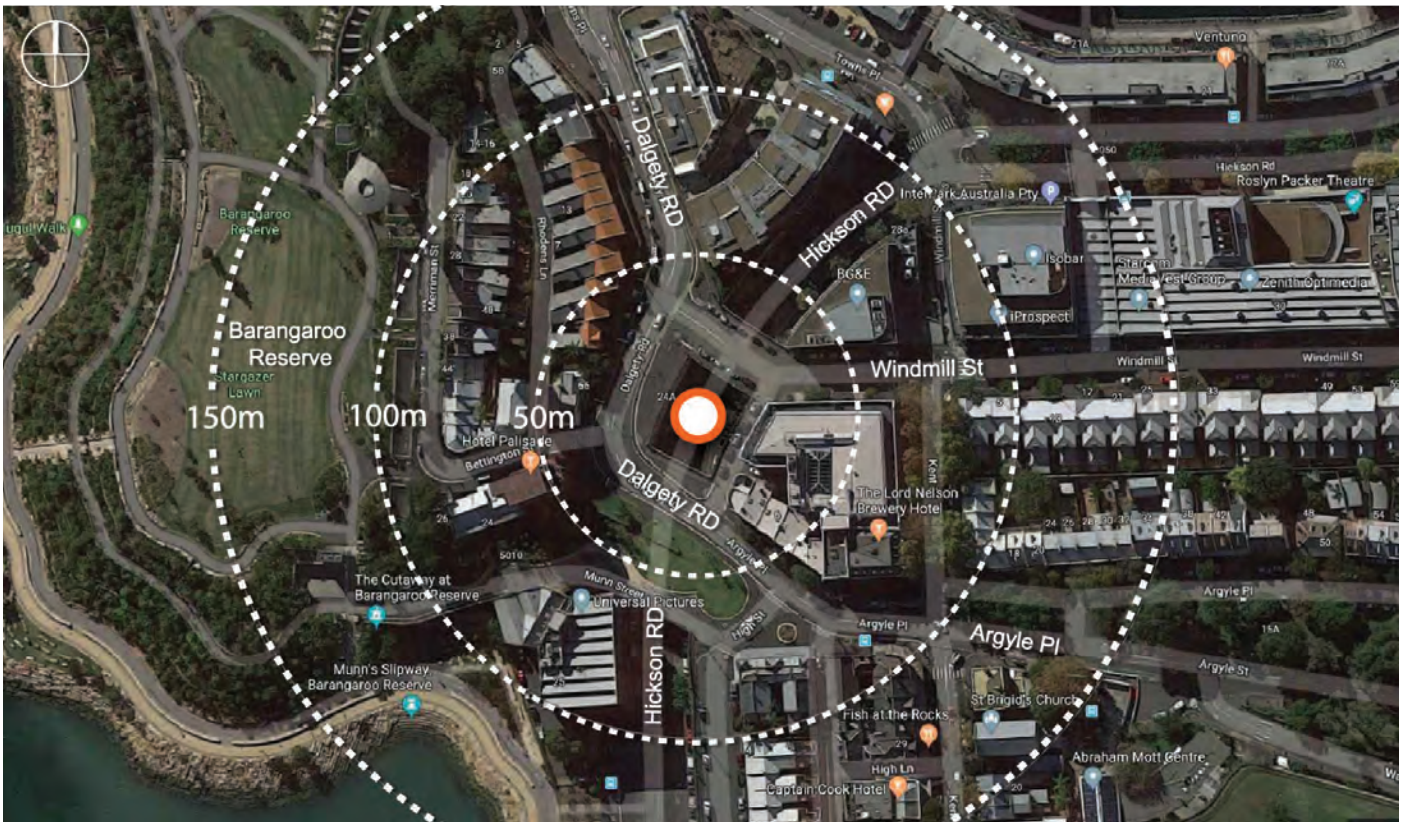

Figure 2.4 Aerial photo indicating the proposed location of the construction site (white and orange circle).

Figure 2.5 View of the temporary shed location on Hickson Road, wedged between the two bridges.

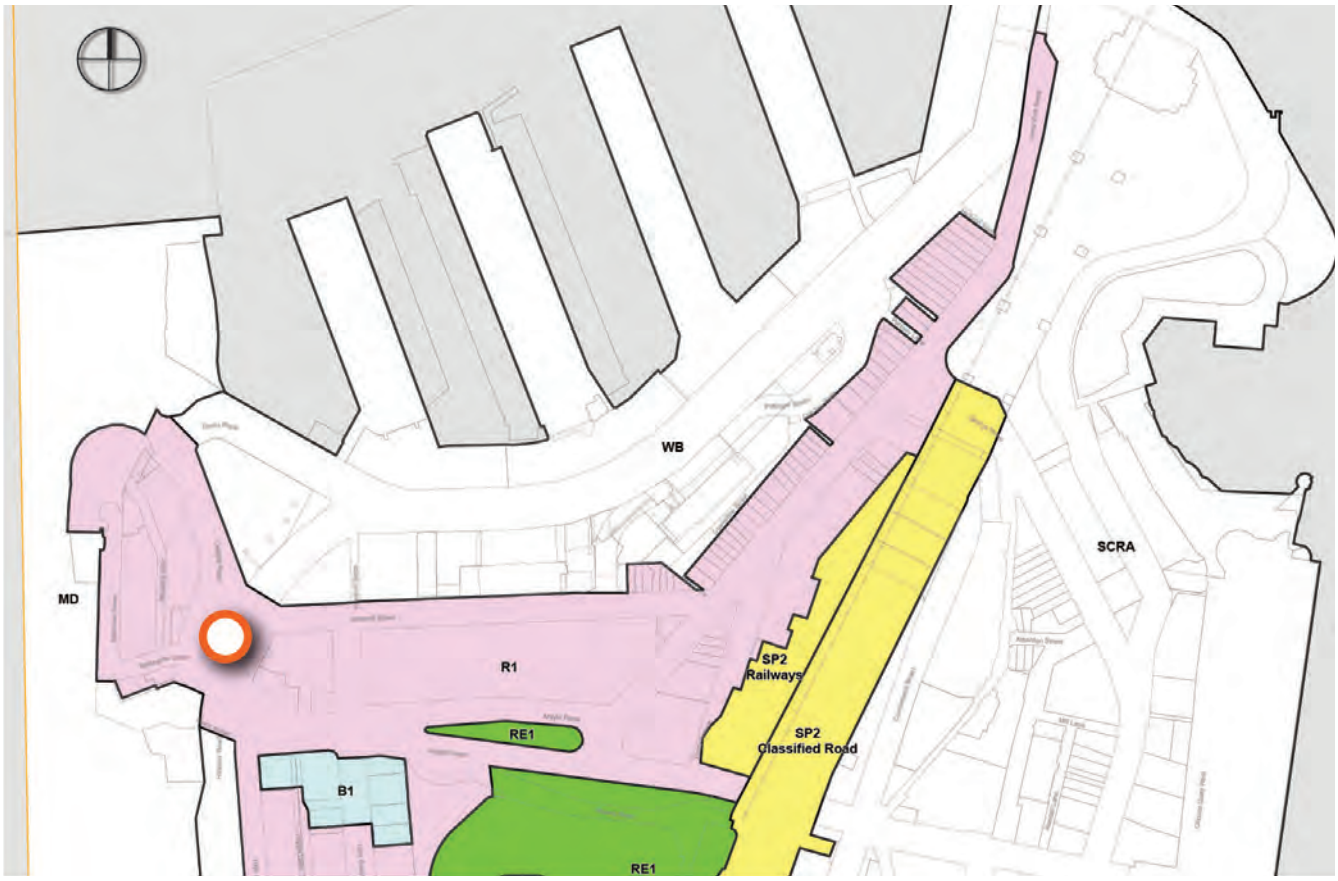

Figure 2.6 Excerpt from the Sydney Council 2012 LEP showing the land use in the vicinity of the proposal site.

Land Use

- B1 Neighbourhood Centre
- B4 Mixed Use
- R1 General Residential
- RE1 Public Recreation
- SP2 Infrastructure
- MD SEPP Major Development 2005
- WB SREP 16 Walsh Bay

The above map illustrates the various land uses surrounding the proposed site. Note that the site is also surrounded by areas identified as Major Development area in the LE (including Barangaroo Reserve) and Walsh Bay which includes residential, commercial and cultural facilities.

The area identified as General Residential occupies the upper grounds and includes a number of commercial properties.

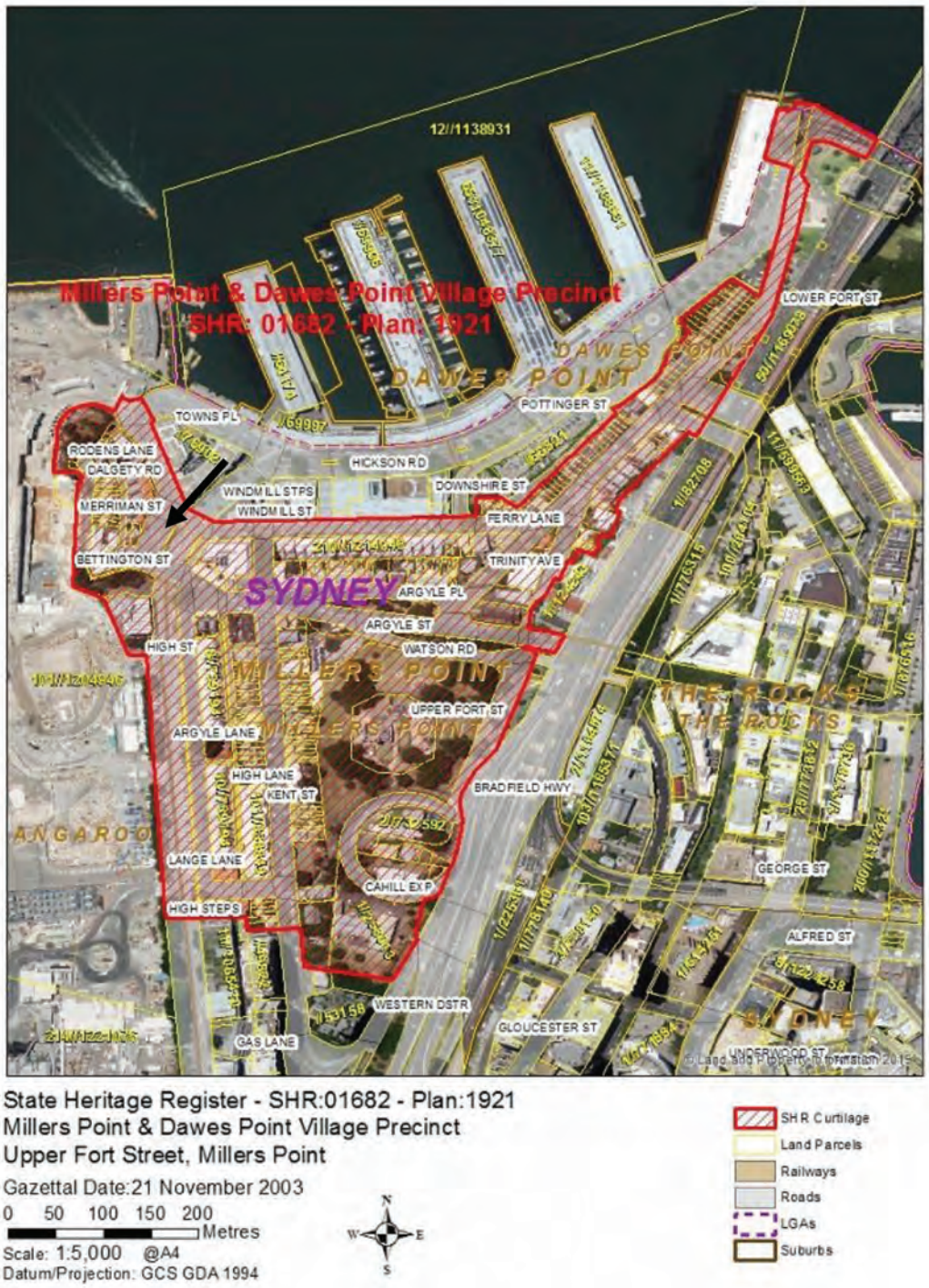

Figure 2.7 Excerpt from Heritage Council of NSW showing the heritage listed Millers Point and Dawes Point Village Precinct.

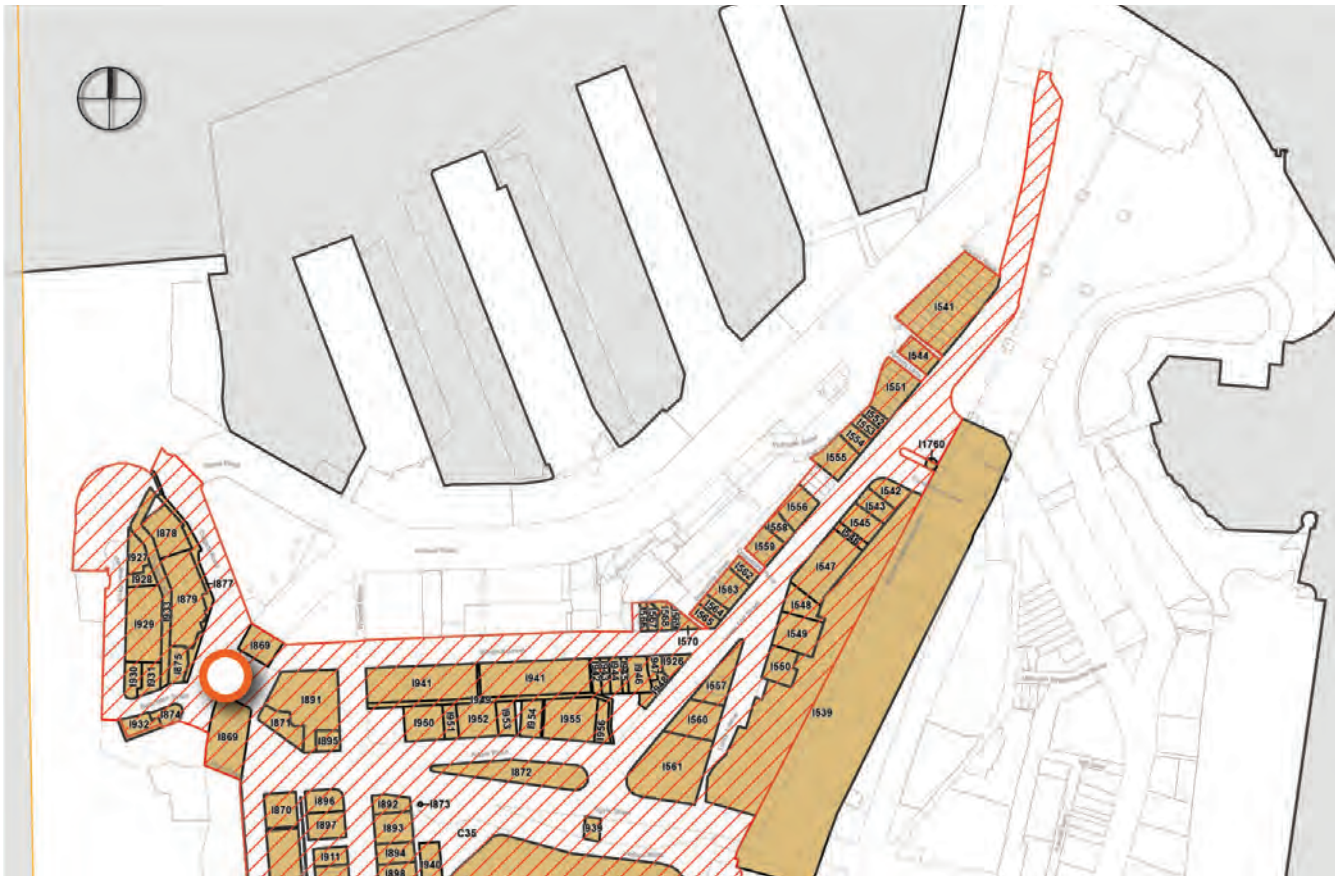

Figure 2.8 Excerpt from Barangaroo LEP showing the conservation area and heritage listed items in the vicinity of the proposal site.

Visual Sensitivity

The visual sensitivity along Hickson Road is considered low. Most viewers are either road users in transit or office workers The exception is the residential development at the corner with Towns Place which has a high sensitivity due to its land use.

Along Windmill Street and Argyle Place are predominantly commercial properties with a low sensitivity. The same applies for Munn Street.

Along Dalgety Road, a row of terraces flank the street, overlooking the site. These properties are considered to have a high visual sensitivity. The Palisade Hotel, at the corner of Dalgety Road and Bettington Street is considered moderate in sensitivity due to the slightly less transient nature of the viewers utilising this premise which functions as a hotel with restaurant on the upper level and pub on the ground floo .

It should be noted, that the overall setting is highly sensitive to change from a landscape character impact point of view. This is due to its historical context, situated in a conservation area with most properties heritage listed in the LEP.

Visual Magnitude

The magnitude of impact for the Hickson Road users is considered high. The shed would have a strong presence within the streetscape.

For the office buildings a negligible magnitude o change is identified, except for the upper stories facing Windmill Street.

For the residential development at the corner of Town Place, a moderate magnitude of change is identified. The building does not directly front the site, and the existing bridge would partially screen the shed, reducing its overall visual presence.

The commercial properties fronting Windmill Street (No. 1 Kent Street) are likely to experience a high magnitude of change. This is driven by the proximity of the shed to the viewers, although most of the shed would be screened by the cutting.

The magnitude of change for the row of terraces fronting Dalgety Road is considered to be moderate. Most of the terraces face Walsh Bay and away from the construction site, hence limiting the visual exposure of the shed.

In the case of the Palisade Hotel, a moderate magnitude of change is assessed, based on the limited exposure of the shed above road level.

Visual Impact

The visual impact for road users on Hickson Road is considered moderate, driven by the low sensitivity, whilst for the office buildings a negligible visual impact i assessed.

For the residences at the corner of Town Place, a moderate to high visual impact is assessed. The exposure to the overall structure, albeit partially screened by the bridge contributes to this outcome.

For the commercial properties facing the shed along Windmill Street, a moderate visual impact is assessed based on the limited sensitivity of the viewer.

A moderate to high visual impact has been identified for the row of terraces flanking Dalgety Road, based on the viewing aspects and outlooks these properties have.

The Palisade Hotel would likely experience a moderate visual impact based on the visual exposure of the shed.

For road users of Windmill Street and Dalgety Road, a low to moderate visual impact is assessed, as most of the shed would be screened by the cutting and the sensitivity would be low.

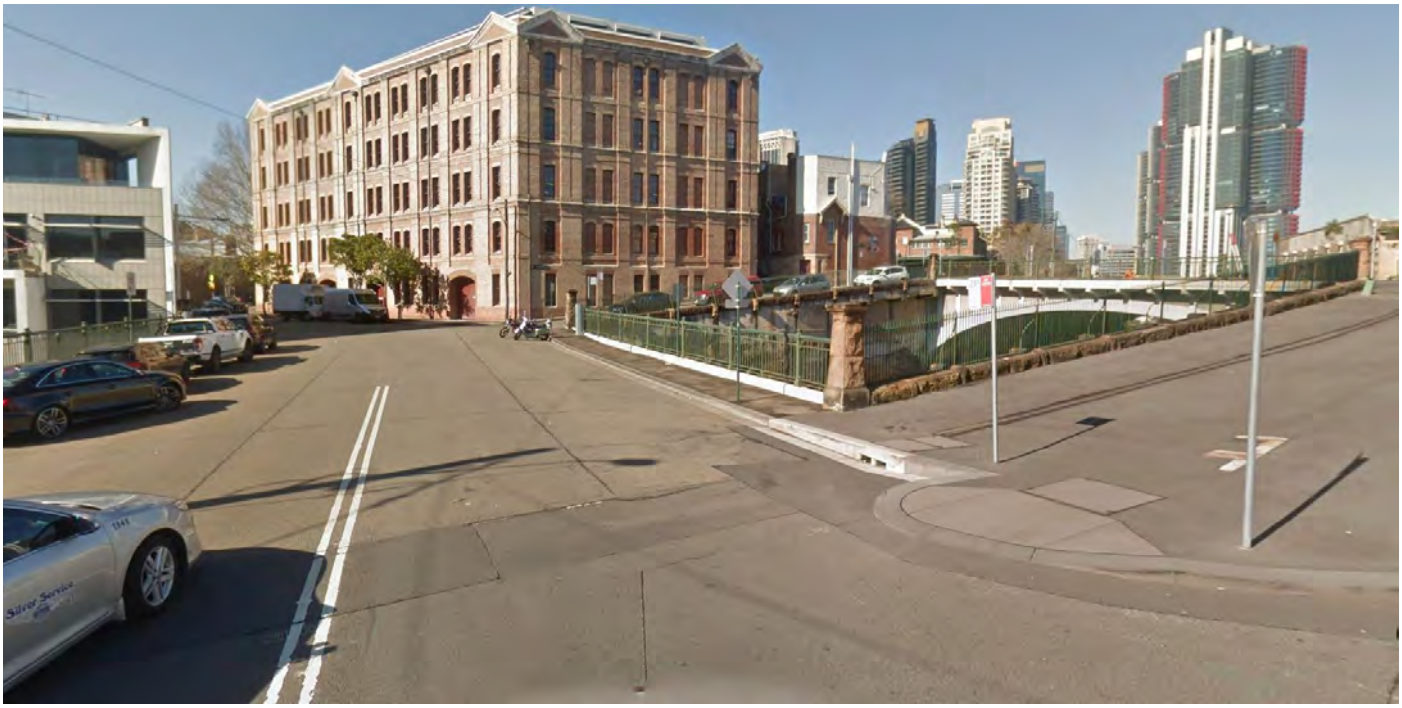

Figure 2.9 Existing situation looking east along Windmill Street.

Recommended Mitigation strategy

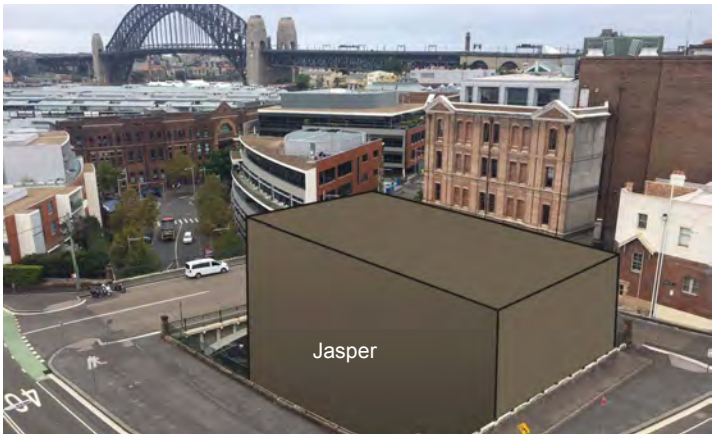

Figure 2.10 Indicative view from the Hotel Palisade illustrating the proposed shed colour - Colorbond Jasper

Figure 2.11 Indicative photomontage view from Argyle Pl. near Munn Reserve

Figure 2.12 Barangaroo Northern Shaft - COLORBOND Shed and DULUX colour selection

Figure 2.13 Indicative view from the corner of Dalgety Road and Windmill Street illustrating the proposed shed colour - Colorbond Jasper

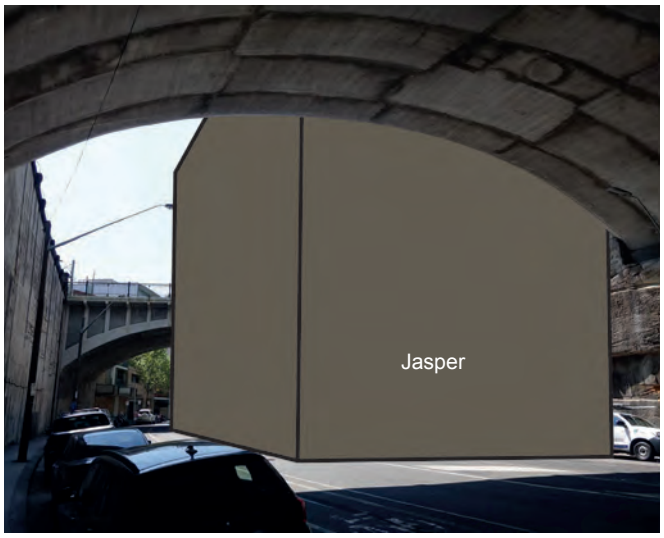

Figure 2.14 Indicative view from Hickson Road illustrating the proposed shed colour - Colorbond Jasper

Design Study

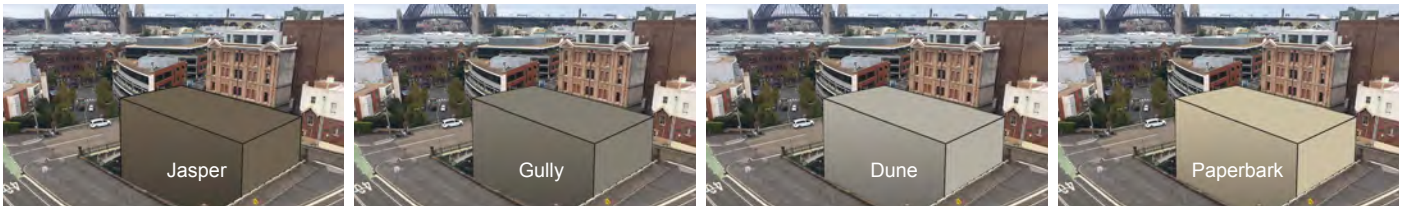

Figure 2.15 Indicative view from the Hotel Palisade illustrating the colorbond colour options considered

Figure 2.16 Indicative view from Hickson Road illustrating the colorbond colour options considered

Figure 2.17 Indicative view from the corner of Dalgety Road and Windmill Street illustrating the colorbond colour options considered

Figure 2.18 Indicative view from Argyle Pl. near Munn Reserve illustrating the colorbond colour options considered

Summary Table	
Description of the setting	Important historic urban environment with a mixture of heritage and modern buildings of various scales. Strong visual context to Sydney Harbour from the upper grounds. Arterial road setting adjacent to the Sydney Metro and Barangaroo Development Authority site compounds. Limited scenic quality within a highly urbanised area which has been subject to extensive construction work over an extended period of time. Road is flanked by well established vegetation, contributing to the streetscape quality.
Visible element of the project	The large shed would be partially visible from various vantage points from the upper grounds. The large cutting screens most of the building from these vantage points. The shed is partially screened by two existing bridges from the lower grounds along Hickson Road, visually limiting its presence.
Category of viewer	Residents, workers, pedestrians and road users.
Nature of impact	Adverse
Visual sensitivity	High for residents, for all other viewer groups it is considered low.
Magnitude of impact	Either negligible, low to moderate or moderate for road users and viewers in commercial properties. For residents a moderate to high impact has been identified.
Overall rating of visual impact	An overall moderate visual impact is assessed for the overall site. The highest impact would likely be experienced by the residences to the west and north of the site.
Comment / mitigation measures	No high visual impact has been identified. The strategic location of the shed, wedged between two bridges and greatly screened by the large sandstone cutting of Hickson Road, limits the visual exposure of the shed. It should be noted, that the proposed works are of a temporary nature and the shed will reduce noise impacts and contribute to the efficient and timely delivery of th project. No lasting visual impacts have been identified once the construction has been completed. Note that the indicative visual amenity strategy will be incorporated into the Visual Amenity Plan (SMCSWTSE-JCG-TPW-EM-PLN-002020).

Appendix I - Program

Table 7-12 Barangaroo Station indicative construction program

Construction activity	Indicative construction timeframe																											
	2017				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works and site establishment																																
Station excavation																																
Assembly and commissioning of TBM																																
TBM drive 1 to Blues Point																																
Assembly and commissioning of TBM																																
TBM drive 2 to Blues Point																																
TBM retreival (southern drives)																																
Station structural works																																
Station fit out																																
Station testing and commissioning																																