WestConnex M4-M5 Link

Rozelle Interchange – Modification: Iron Cove ventilation underground

Modification report

Appendix A

Secretary’s environmental assessment requirements

Appendix A

Secretary's environmental assessment requirements

The Planning Secretary's Environmental Assessment Requirements (SEARs) for the project were issued in May 2017. DPIE advised that this modification report should address the SEARs issued used in May 2017 as relevant.

Table 11-1 sets out the relevant assessment requirements (SEARs) for the proposed modification (the subject of this report) and identifies where they have been addressed in this EIS.

Table 11-1 Key assessment requirements for the proposed modification.

Environmental issue	Relevant SEAR(s)	Where addressed
Environmental Impact Assessment Process	The assessment process must discuss why it is feasible for the electrical substation, and any other structures that remain at the surface, to be undergrounded with the ventilation facility	section 2
Transport and traffic	The assessment must detail the additional construction traffic (both light and heavy vehicles) that would be generated by the proposal, including the estimated number of spoil haulage movements associated with the construction of the underground cavern and access tunnel, and the proposed access and egress arrangements. The impact of the additional traffic movements on mid-block road capacity and intersection performance must be quantitatively assessed. The traffic assessment must compare the proposed number of construction light and heavy vehicle movements associated with the modification with the original proposed and any changes to access and egress movements to the site The traffic assessment must also describe how operational maintenance vehicles would access the ventilation facility	section 7.2

Environmental issue	Relevant SEAR(s)	Where addressed
Noise and Vibration – Amenity and Structural	The construction and operational noise and vibration assessments must be quantitative assessments. The assessments must identify any sensitive receivers not previously affected by the modified activities and those where the level of impact is predicted to increase The assessment of sleep disturbance must assess the predicted number of awakening events If blasting is proposed, the assessment must demonstrate that blast impacts are capable of complying with current guidelines Assessment of construction and operational noise and vibration impacts including sleep disturbance associated with the proposed modification. This assessment must be in accordance with relevant NSW noise and vibration guidelines and potential noise and vibration mitigation measures should be identified The assessment of operational noise should focus on the relocation and use of the proposed modified ventilation facility and compare the results of this assessment to the existing baseline and approved project The assessment of construction noise and vibration impacts must address: a. the nature of construction activities (including transport, tonal or impulsive noise-generating works as relevant); b. the likely intensity and duration of potential noise and vibration impacts (both air and ground-borne); c. confirmation of works occurring within and outside standard construction hours, including estimated duration and timing, predicted levels, exceedances and number of potentially affected receivers and justification for the activity in terms of the Interim Construction Noise Guideline (DECCW, 2009); d. figures consistent with the EIS illustrating the existing, previously assessed and predicted noise levels related to the modification; and e. a cumulative noise and vibration assessment of other M4-M5 Link works proposed at Iron Cove where potential impacts are likely to differ from those that were previously assessed under the EIS for SSI 7485. Assess potential construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage)	section 7.4
Visual Amenity	The assessment must be supported by relevant perspective photographs/drawings/and/or artists impressions Qualitatively assess visual impacts associated with the modified ventilation facility when viewed from nearby sensitive receptors and public vantage points. This assessment should compare the proposed modification to the approved ventilation facility and any other associated infrastructure as described by SSI 7485	section 7.7

Environmental issue	Relevant SEAR(s)	Where addressed
Urban Design	The assessment should provide a consideration of the urban design impacts in retaining the substation at surface level Identify the urban design and landscaping aspects of the proposed modification and its components including but not limited to deletion of the surface operational buildings and ancillary facilities associated with the Motorway Operation Centre (MOC4) and realignment of pedestrian path and improvement to open space along the southern extent of Victoria Road Where relevant, consider any change from that assessed under the EIS that result in any changed residual land treatments Where relevant, consider any additional opportunities to that addressed under the EIS to utilise surplus or residual land	section 7.7
Socio-economic, Land Use and Property	The assessment must quantitatively assess all new and additional impacts on property arising from the proposed modification. The assessment must address the potential for property damage arising from settlement due to tunnelling, including groundwater drawdown during construction and operation. It must identify any areas not previously identified as potentially being impacted by settlement and where the potential for settlement is increased. The predicted degree of settlement must be provided along with the proposed mitigation measures Details must be provided on the proposed end use of the land(s) no longer required for the construction of the ventilation complex and any other above ground facilities that would be undergrounded Assess the potential impacts, by comparison to that assessed in the EIS, from the construction and operation on potentially affected property, businesses, and recreational users, including property acquisitions/adjustments, access amenity, and relevant statutory rights resulting from the proposed modification Assess potential impacts, by comparison to that assessed in the EIS, on utilities (including communications, electricity, gas, and water and sewerage) and the relocation of these utilities	section 7.5

Environmental issue	Relevant SEAR(s)	Where addressed
Water	The assessment must detail the estimated additional volumes of groundwater that would be captured and discharged as a result of the excavation of the underground facility and associated access tunnel including: groundwater drawdown levels; potential impact of the additional groundwater drawdown on groundwater resources; method of treating and discharging the groundwater; impact of the groundwater discharges on any receiving stormwater infrastructure and the receiving environment (in terms of quality and quantity) Qualitatively assess, by comparison to the EIS, the impact of the construction and operation of the proposed modification of the ventilation facility (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including impacts from permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement Assess and minimise the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems	section 7.5 section 0
Utilities	The assessment must describe any additional utility works that may be undertaken, including their location, timing and duration, and details of any proposed out-of-hours works	section 5.3.4
Heritage	Assess the potential impact of the proposed modification on State Heritage Listed and locally listed heritage items as relevant	section 7.1
Soils	Assess the potential impact of disturbance of contaminated groundwater associated with the proposed modification. Tunnels associated with the proposed modification should be carefully designed so as to not exacerbate mobilisation of contaminated groundwater and/or prevent contaminated groundwater flow	section 7.1 and section 7.5
Waste	Qualitatively assess, by comparison to the EIS, predicted waste generated from the proposed modification during construction and operation, including where relevant: a. estimates/details of the quantity of each classification of waste to be generated during the construction of the proposed modification, including spoil balance b. management of waste including estimated location and volume of stockpiles	section 7.9

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Appendix B

Traffic and transport

Roads and Maritime Services

WestConnex - M4-M5 Link

Iron Cove Ventilation Underground Modification Report

Modification report

Appendix B Traffic and Transport

November 2019

Prepared for

Roads and Maritime Services

Prepared by

The Transport Planning Partnership

Contents

1 Introduction

TTPP has been commissioned to assess the construction traffic and access impacts in relation to relocating the substation and ventilation infrastructure at the Iron Cove Motorway Operations Complex (MOC4) underground (referred as the “modification” hereafter).

All plant, equipment and materials required to construct the proposed new ventilation tunnel and caverns would be supported from the Iron Cove civil site (C8), with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site (C5) later in the construction program. As such this assessment has been completed assuming the worst-case impacts of all deliveries and spoil transportation occurring from either:

- Iron Cove civil site (C8), or
- Rozelle civil and tunnel site (C5).

The assessment considers the traffic impacts of the modification and provides a comparison with the impacts assessed as part of the approved project. The assessment has been prepared to address the relevant environmental assessment requirements for the modification as described in Secretary’s Environmental Assessment Requirements (SEARs).

2 Compliance with SEARs

Table 1 sets out the relevant SEARs related to construction traffic and access and identifies where they have been addressed in this report.

Table 1 SEARS Compliance

SEARs	Where Addressed
The assessment must detail the additional construction traffic (both light and heavy vehicles) that would be generated by the proposal, including:	-
The estimated number of spoil haulage movements associated with the construction of the underground cavern and access tunnel	Section 4.1.1 Section 4.2.1
The proposed access and egress arrangements.	Section 3.2.3
The impact of the additional traffic movements on mid-block road capacity and intersection performance must be quantitatively assessed.	Section 4.1.2
The traffic assessment must compare the proposed number of construction light and heavy vehicle movements associated with the modification with the original proposed and any changes to access and egress movements to the site.	Section 4.1.2

3 Overview of Approved Project and Modification

3.1 Approved Project

The EIS concept design includes the construction of the Iron Cove Link motorway operation complex (MOC4) ventilation facility above ground as shown in Figure 1. The EIS described this facility as being located south of Victoria Road between Springside Street and Toelle Street.

Figure 1 EIS Location of Operational Ancillary Facilities at Iron Cove Link

The EIS indicates that all plant, equipment and materials required to construct the proposed ventilation facilities would be supported from the Iron Cove civil site (C8). The associated environmental impact assessment included in the EIS was limited to key plant and equipment likely to be used for these surface construction works but does not provide detailed traffic information on the construction of this ventilation infrastructure.

3.2 Modification

3.2.1 Overview of modification

The proposed modification involves relocating the Iron Cove Motorway Operations Complex (MOC4) underground within caverns housing the electrical substation and ventilation facilities and a ventilation tunnel connecting to the ventilation outlet. Only a switch room, high voltage regulators, alternative Operational Motorway Control System (OMCS) room and a separate stair access leading down to the ventilation tunnel would be required on the surface.

The main elements of the proposed new ventilation tunnel and caverns at Iron Cove are detailed below:

- Construction of a ventilation tunnel about 340 metres in length that connects the Iron Cove Link tunnel, at an underground location between Cambridge and Waterloo Streets, with the Iron Cove cut and cover structure near Callan Street

- The ventilation tunnel would include two caverns for the housing of ventilation equipment and the electrical substation, along with access tunnels to be used for maintenance and in the event of an emergency
- A five-metre wide and 20-metre long access tunnel, to facilitate personnel access from the exhaust fan cavern into the substation cavern
- The Iron Cove cut and cover area would include a side access for the vent tunnel to connect to the cut and cover about 7 metres wide and 17 metres long. This area would also accommodate the access stairs to the surface.

3.2.2 Construction of Surface Works at the Iron Cove civil site (C8)

Typically, five light vehicles per day and less than three trucks per day, and a peak of 10 trucks per day are anticipated during peak construction activities for the surface works on the western side of Victoria Road associated with the modification.

The traffic volumes under the modification would reduce compared to the approved project due to the extent of the above ground ventilation infrastructure works required on the western side of Victoria Road being limited to the construction of the switch room, high voltage regulators and access stairs. No traffic modelling was undertaken for these surface works due to the reduction to construction traffic volumes associated with the modification.

3.2.3 Tunnelling support haulage routes

The proposed new Iron Cove ventilation tunnel and cavern can be easily accessed from within the Iron Cove cut and cover using a single roadheader. Tunnelling works using a roadheader launched from Iron Cove would commence once the southern half of the cut and cover structure has been constructed (see Figure 2).

All plant, equipment and materials required to construct the proposed new ventilation tunnel and caverns would be supported from the Iron Cove civil site (C8), with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site (C5) later in the construction program.

As such this assessment has been completed assuming the worst-case impacts of all deliveries and spoil transportation occurring from both these sites and addresses two haulage route options for spoil removal and material deliveries associated with the construction of the ventilation infrastructure via from one or both of the following sites:

- Iron Cove civil site (C8) as shown in Figure 3, or
- Rozelle civil and tunnel site (C5) as shown in Figure 4.

North of Iron Cove Bridge, the haulage route will continue north along Victoria Road, Church Street, Concord Road and Homebush Bay Drive towards the M4 Motorway.

Any tunnelling of the new ventilation tunnel and caverns supported from the Rozelle civil and tunnelling site (C5) would commence from within the Iron Cove Link Tunnel once it is excavated. This would not require the installation of any additional temporary surface support infrastructure at the Rozelle civil and tunnelling site (C5).

3.2.4 Construction Program

The proposed durations for tunnelling of the modification are different for the two haulage route options:

- Iron Cove civil site (C8) – Tunnelling works at the Iron Cove cut and cover have been scheduled to occur over about 15 months between about Q3 2020 and the end of 2021.
- Rozelle civil and tunnel site (C5) – Excavation of the ventilation tunnel and caverns would occur from about Q2 2021 if required.

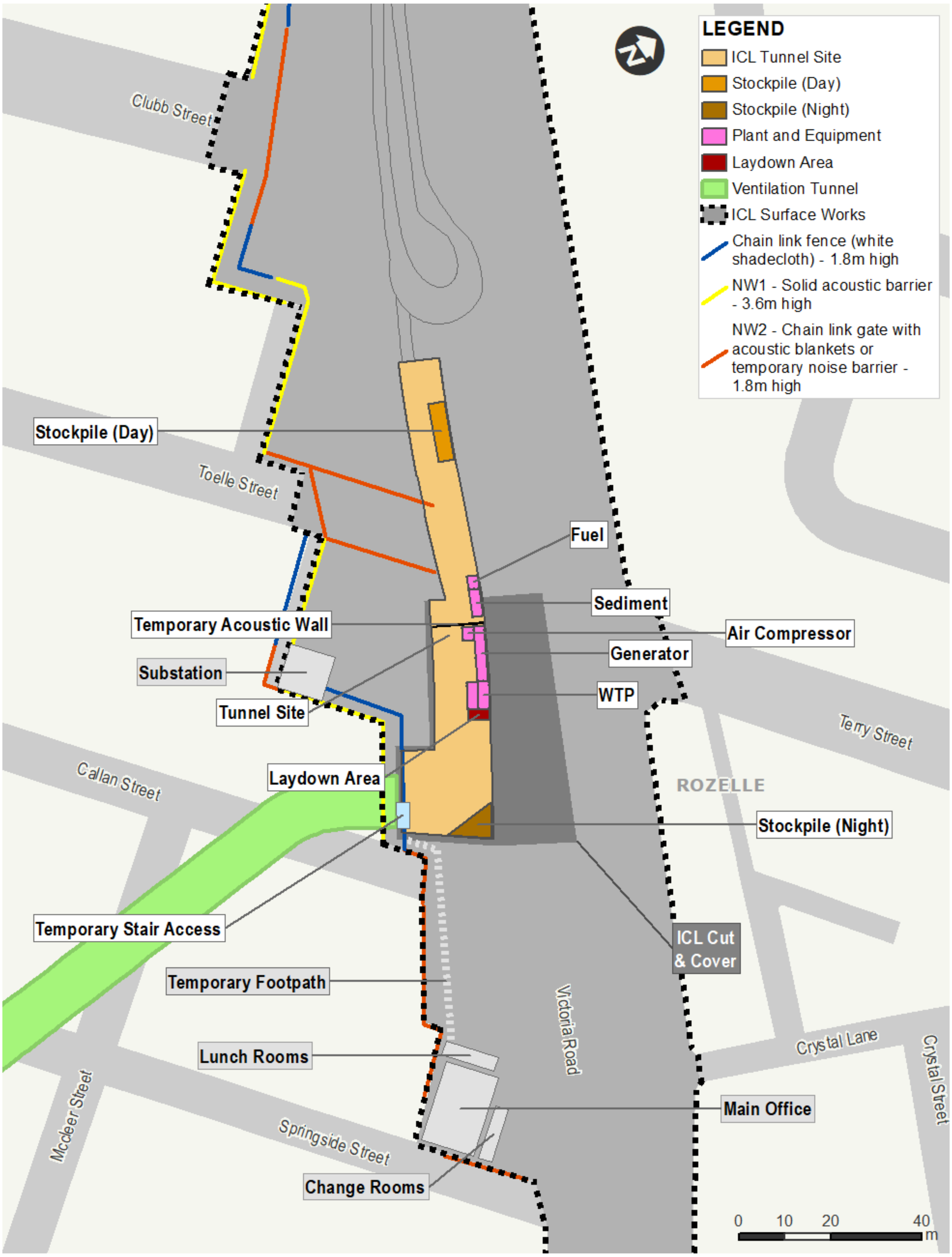

Figure 2 Indicative Layout of tunnel support site within the Iron Cove cut and cover

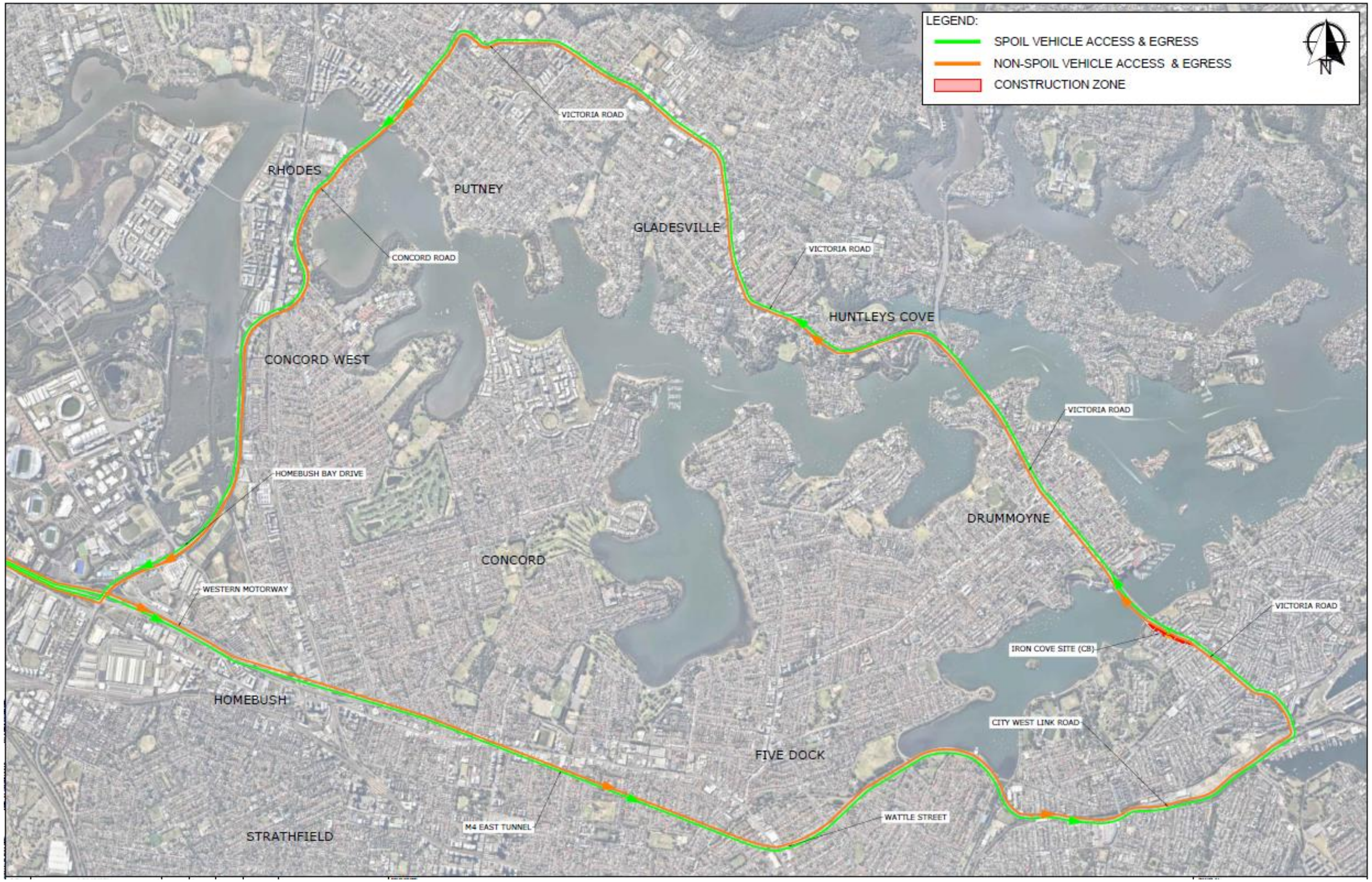

Figure 3 Haulage Routes via the Iron Cove Civil Site (C8)

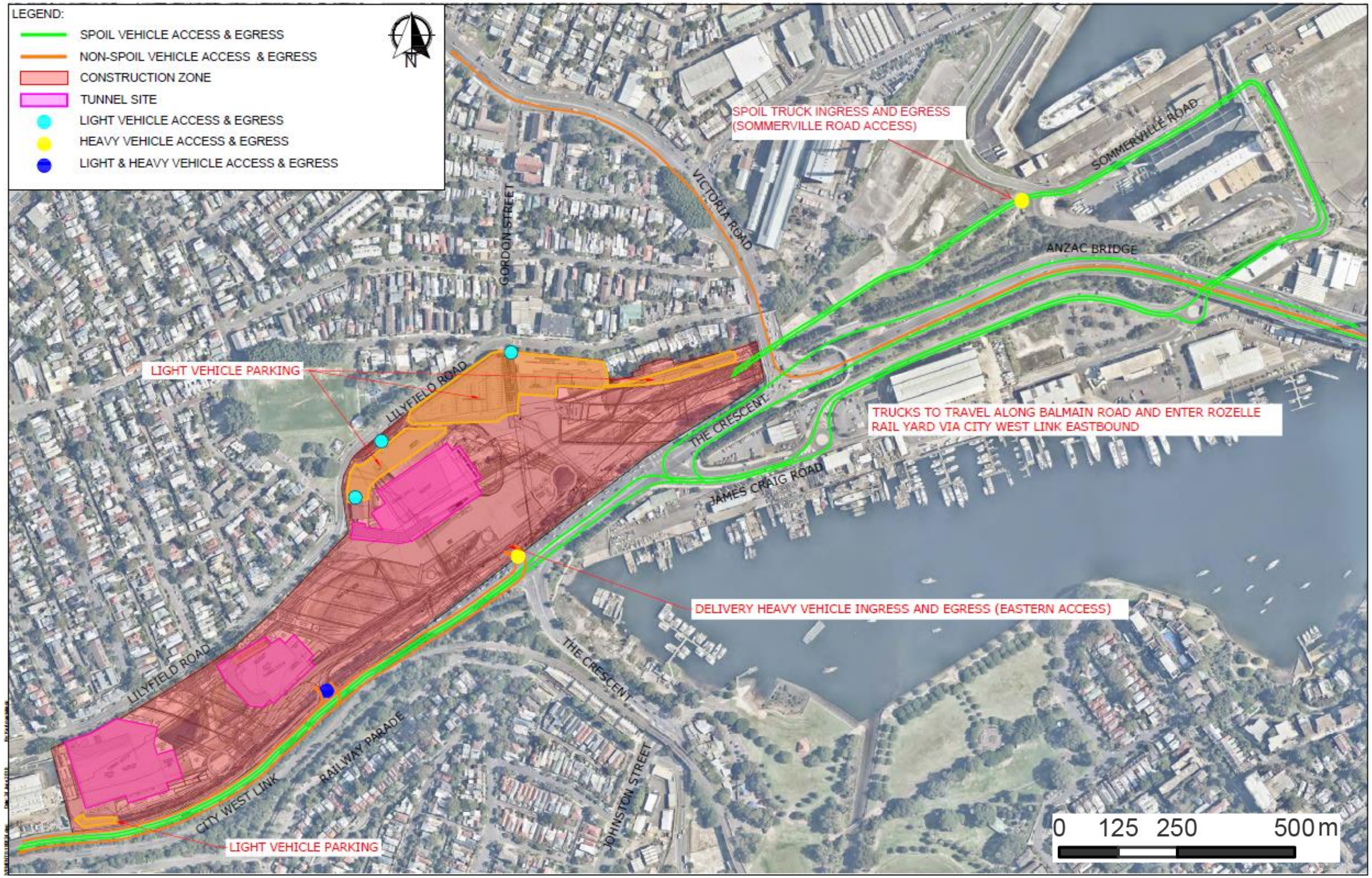

Figure 4 Haulage Routes via the Rozelle Civil and Tunnel Site (C5)

4 Impact Assessment

As the construction of the proposed new ventilation tunnel and cavern works would be supported from the Iron Cove civil site (C8) but could also use the Rozelle civil and tunnel site (C5) later in the construction program, this assessment has been completed assuming the worst-case impacts of all deliveries and spoil transportation occurring from both these sites:

- Access via the Iron Cove civil site (C8), or
- Access via the Rozelle civil and tunnel site (C5).

This assessment provides a comparison between the modification and the approved project in terms of construction traffic volumes and impacts on the road network. The two haulage route options are discussed in detail in the following sections:

- Construction traffic volumes and duration.
- Level of service assessment including intersection operating conditions in Linsig modelling and mid-block level of service.

4.1 Access via Iron Cove Civil Site (C8)

4.1.1 Construction traffic volumes and duration

The following construction vehicles would access the Iron Cove civil site (C8):

- Light vehicles
- Rigid trucks
- Concrete agitators
- Spoil trucks (truck and trailers and/or single tippers).

Work hours for construction of the ventilation tunnel and caverns from within the Iron Cove cut and cover would be in accordance with those prescribed In Planning Approval Condition E70, which allow tunnelling activities and tunnel fit out works to occur 24 hours a day, seven days a week.

Additional workforce required for tunnelling operations from the Iron Cove tunnelling site would typically range from six to ten people at any one time, made up of supervision, workforce and maintenance personnel.

Additional spoil excavated from the proposed ventilation tunnel and caverns would be transported underground to the Iron Cove cut and cover site. This would involve a total of up to 61,000 Bank Cubic Metres (BCM) to be removed, resulting in an increase of up to 4,800 truck and trailer loads exiting the project from the Iron Cove cut and cover.

The following daily traffic volumes are anticipated during peak construction activities involving spoil load out and concrete works to support tunnelling from Iron Cove, typically:

- 3 light vehicles per hour
- 3 spoil truck and trailers per hour during standard daytime hours in accordance with Planning Approval Conditions E68 and E69. The EIS identified 145 heavy vehicles per hour use Victoria Rd during the day and evening
- Six shotcrete deliveries by agitator trucks per day, with 2 concrete deliveries in the evening (6:00 pm to 10:00 pm) and typically 1 truck at night (10:00 pm to 7:00 am). A maximum of 3 in the evening and 3 at night
- Six additional heavy vehicles per day.

Tunnelling works at the Iron Cove cut and cover would commence once the southern half of the cut and cover structure has been constructed in about Q3 2020. The tunnelling works including tunnel excavation, ground support and tunnel lining as well as the concrete works in the floor of the tunnel are anticipated to be completed by the end of 2021.

The modification would overlap with peak construction activities associated with the overall Rozelle Interchange project scheduled to occur in March 2021.

Table 2 shows a comparison of the approved project and the forecasted construction traffic volumes for the modification during the AM peak hour and PM peak hour.

Table 2 Peak Hour Construction Traffic Volumes at the Iron Cove Civil Works Site (C8) for Approved Project and Modification

Design	Daily		AM Peak Hour (7:30am-8:30am)					PM Peak Hour (4:15pm-5:15pm)				
	Heavy Vehicles	Light Vehicles	Heavy Vehicles		Light Vehicles		Total	Heavy Vehicles		Light Vehicles		Total
	One-way	One-way	In	Out	In	Out	2-Way	In	Out	In	Out	2-Way
Approved Project	102	60	13	13	18	0	44	13	13	0	18	44
Approved Project + Modification	144	90	18	18	27	0	63	18	18	0	27	63
Difference (Modification)	42	30	5	5	9	0	19	5	5	0	9	19

Table 2 indicates that the peak hourly traffic volumes associated with the modification would increase by 10 two-way heavy vehicle movements in the AM peak hour and PM peak hour, as compared with the approved project.

In order to assess the impacts of the increase in construction traffic volumes from the approved project, traffic modelling has been undertaken to assess the traffic impacts during peak construction activities (March 2021).

4.1.2 Level of Service Assessment

Roads and Maritime Services provided TTPP with the Linsig models developed as part of the EIS. LinSig is a modelling package that assesses traffic signal intersections individually and in a network of several junctions.

For the purposes of this assessment, TTPP has updated the Linsig models to accommodate the changes in road network and traffic signal phasing, and construction traffic volumes based on detailed construction traffic planning to enable a like-for-like comparison with the approved project modelling results.

Intersection Operating Conditions

TTPP updated the Linsig model to assess the impacts of the additional traffic generated by the modification and compared with the intersection performance results of the approved project for the following intersections:

- Victoria Road and Evan Street
- Victoria Road and Darling Street
- Victoria Road and Wellington Street.

The results are summarised in Table 3 Intersection Level of Service is described in Appendix A.

Table 3 Approved Project and Predicted Intersection Operating Conditions under the Modification

Scenario	Intersection	LoS	
		AM Peak Hour (7:30am-8:30am)	PM Peak Hour (4:15pm-5:15pm)
Approved Project (March 2021)	Victoria Road and Evan Street	B	E
	Victoria Road and Darling Street	E	F
	Victoria Road and Wellington Street	F	B
Approved Project + Modification (March 2021)	Victoria Road and Evan Street	B	E
	Victoria Road and Darling Street	E	F
	Victoria Road and Wellington Street	F	B

As shown in Table 3 the operational performance of the assessed intersections under the modification scenario are consistent with the modelling results of the approved project scenario.

Mid-Block Level of Service

A mid-block level of service assessment has been undertaken to determine the impact of the traffic associated with the modification compared with the approved project traffic in March 2021. The results of this assessment are summarised in Table 4.

Table 4 Road Level of Service for the Approved Project and Modification

Design	Road	Direction	Mid-Block Capacity	AM Peak Hour (veh/hr)			PM Peak Hour (veh/hr)		
				With Construction			With Construction		
				Flow	V/C	LoS	Flow	V/C	LoS
Approved Project (March 2021)	Victoria Road, east of Darling Street	Eastbound	3,250	3,576	1.10	F	2,515	0.77	D
		Westbound	3,200	1,761	0.55	C	3,078	0.95	E
Approved Project + Modification (March 2021)		Eastbound	3,250	3,576	1.10	F	2,518	0.77	D
		Westbound	3,200	1,769	0.55	C	3,082	0.96	E

The modification would result in no additional traffic during the AM peak hour and three additional light vehicles (construction workers) during the PM peak hour along Victoria Road in the eastbound direction.

The modification would result in an additional five heavy vehicles and four light vehicles in the AM peak hour, and five heavy vehicles in the PM peak hour along Victoria Road in the westbound direction.

The additional traffic volumes associated with the modification are minimal and therefore the Volume/Capacity (V/C) ratio and mid-block LoS would remain consistent with the approved project.

4.2 Access via the Rozelle civil and tunnel site (C5)

4.2.1 Construction traffic volumes and duration

Any tunnelling of the new ventilation tunnel and caverns supported from the Rozelle civil and tunnelling site (C5) would commence from within the Iron Cove Link Tunnel once it is excavated.

Work hours for construction of the ventilation tunnel would be in accordance with those prescribed by the Planning Approval Conditions, which allow tunnelling activities (excluding cut and cover tunnelling) and tunnel fit out works to occur 24 hours a day, seven days a week.

Additional spoil excavated from the proposed ventilation tunnel and caverns would be transported underground to the Rozelle civil and tunnel site (C5) and stockpiled within one of the acoustic sheds.

All plant, equipment and materials required to construct the proposed new ventilation tunnel and caverns would be supported from the Iron Cove civil site (C8), with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site (C5). As such this assessment has been completed assuming the worst-case impacts of all deliveries and spoil transportation occurring from the Rozelle civil and tunnel site (C5). The worst-case total and daily traffic volumes would therefore be as set out above in Section 4.1.1.

Excavation of the ventilation tunnel and caverns from the Rozelle civil and tunnel site (C5) would occur from about Q2 2021 if required. As such, the excavation works involving spoil haulage from the Rozelle civil and tunnel site (C5) would not overlap with peak construction activities associated with the overall Rozelle Interchange project which is scheduled to occur in March 2021.

Figure 5 shows the estimated daily number of heavy vehicles associated with the construction of the modification (green columns), in addition to the approved project construction activities (blue columns) between January 2020 and July 2022.

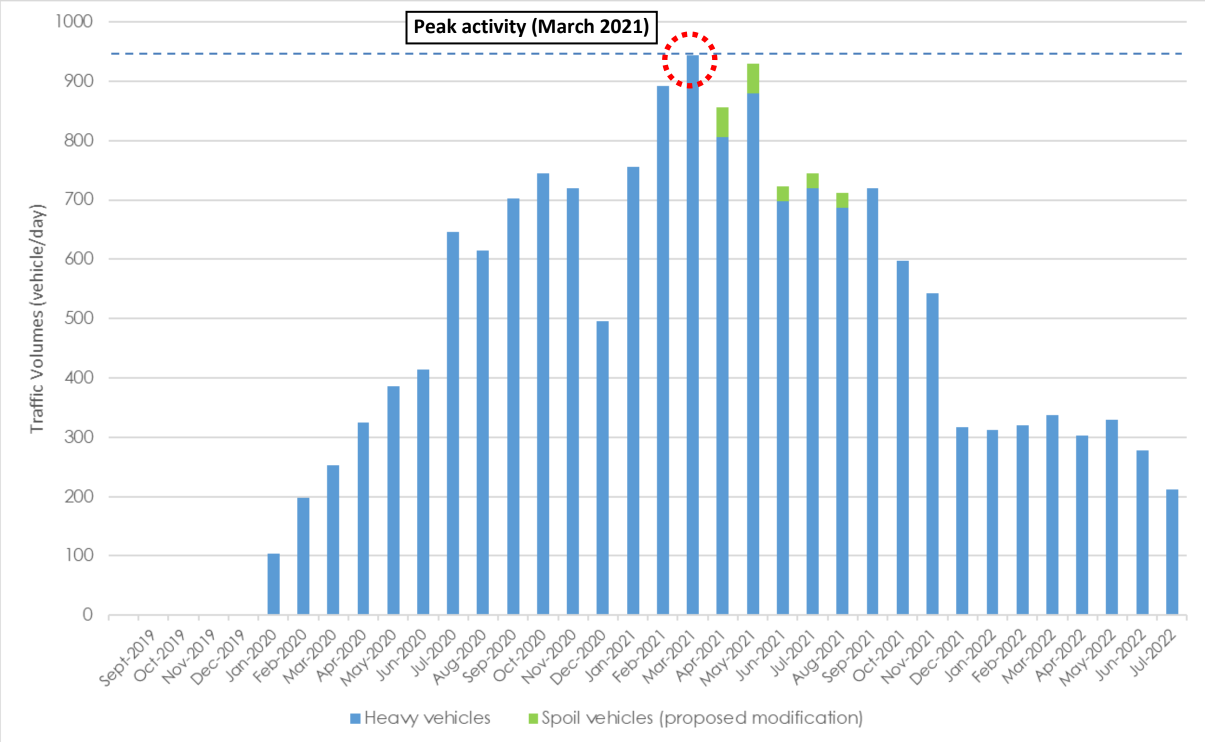

Figure 5 Construction Daily Heavy Vehicle Volumes between January 2020 and July 2022 at the Rozelle Civil and Tunnel Site (C5)

Any excavation of the proposed ventilation tunnel and caverns from the Rozelle tunnel and civil site would occur between April and August 2021 following peak production in March 2021. As such, the traffic volumes for the approved project at peak tunnel excavation are greater than during construction of the proposed ventilation tunnel and caverns, as shown in Figure 5.

5 Summary and Conclusions

This assessment was prepared to review the construction traffic and access impacts of the modification of the ventilation infrastructure at the Iron Cove Link site. The additional tunnelling required under the modification would be supported predominately from the Iron Cove civil site (C8) with some tunnelling also supported from the Rozelle civil and tunnel site (C5) later in the construction program. As such this assessment has been completed assuming the worst-case impacts of all deliveries and spoil transportation occurring from either:

- Iron Cove civil site (C8), or
- Rozelle civil and tunnel site (C5), or simultaneously.

The following conclusions are drawn based on the findings in this assessment:

- Tunnel support from within the Iron Cove cut and cover (C8): The additional construction traffic generated by the modification would not impact the operational performance of Victoria Road intersections with Evans Street, Darling Street and Wellington Street when compared the performance of the intersections generated by the approved project
- Tunnel Support from Rozelle civil and tunnel site (C5): The total volume of construction traffic generated by the modification would occur following peak construction activities in March 2021 and be less than the approved project during the peak construction activities. As such, it is concluded that the intersection and mid-block LoS during the construction of the modification would not impact the road network along City West Link.

It is important to note that surface tunnel support for the modification entirely from within the Iron Cove cut and cover or the Rozelle tunnel and civil site (C5) represent two worst case scenarios for haulage route options. However, traffic impacts associated with these worse cases are consistent with the modelling results for the approved project, indicating that either option is acceptable. Notwithstanding this, the additional tunnelling required under the modification would be supported predominately from the Iron Cove civil site (C8) with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site (C5) later in the construction program. Utilising both the Iron Cove civil site (C8) and the Rozelle civil and tunnel site (C5) to support this tunnel excavation would disperse impacts on the road network.

The proposed new ventilation tunnel and caverns would equate to a total length of about 425 metres. This calculation is based on a length of about 340 metres for the ventilation tunnel alignment and the ventilation fan cavern, 65 metres for the substation cavern and about 20 metres of access tunnel connecting the two caverns. It is important to note that Rozelle Interchange (which is Stage 2 of the M4-M5 Link Project) includes excavation of approximately 22 kilometres of tunnels and that the modification is limited to the construction of about 425 metres of additional tunnels and caverns, which represents a very small increase in the extent of tunnelling and associated construction traffic impacts.

Appendix A

Level of Service Criteria

Intersection level of Service

Average delay is commonly used to assess the operational performance of intersections, with level of service used as an index. A summary of the intersection level of service criteria is shown in Table 5.

For the purpose of analysing intersection performance in this assessment, all exit blocking constraints, applied in the microsimulation models to reflect network congestion beyond the modelled network extents, were removed. This allows for an assessment of the intersections within the modelled network, irrespective of any downstream queuing that would mask the actual operation of the intersection.

Similar to the mid-block performance measures, common practice suggests that when intersection performance falls to LoS D, investigations should be initiated to determine if suitable remediation can be provided. However, limited road capacity and high demand mean that LoS E and LoS F are regularly experienced by motorists at pinch points on the existing strategic road network in Sydney, generally during peak periods. It should also be noted that capacity constraint can be used as a demand management technique, which discourages car travel and that conversely, over-provision of capacity can encourage more car use.

Table 5 Level of Service Criteria for intersections

LoS	Average delay/vehicles (sec/veh)	Traffic signals/roundabouts	Give way and stop signs
A	≤ 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Good with acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity and accident study required
E	57 to 70	At capacity; at signals incidents would cause excessive delays	At capacity; requires other control mode
F	>70	Roundabouts require other control mode	At capacity; requires other control mode

Mid-Block Level of Service

Table 6 shows the six levels of service for mid-block carriageway locations, ranging from LoS A–F, with LoS A representing optimum operating conditions (free flow) and LoS F the poorest (forced or breakdown in flow). When a roadway performance falls below LoS D, investigations are generally initiated to determine if suitable remediation can be provided. In built up areas, limited road capacity and high demand mean that LoS E and LoS F are regularly experienced by motorists at pinch points on the existing strategic road network in Sydney. These conditions are generally experienced during peak periods. Roads and Maritime has an established program office (Easing Sydney's Congestion) aimed at delivering improvements to relieve congestion at pinch points and improving performance on strategic roads.

Table 6 Mid-Block Level of Service Definitions and Criteria

LoS	Definition	V/C Ratio
A	A condition of free flow in which individual drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high.	≤ 0.26
B	In the zone of stable flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort is a little less than with level of service A.	0.27 to 0.41
C	Also, in the zone of stable flow, but most drivers are restricted to some extent in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience declines noticeably at this level.	0.42 to 0.59
D	Close to the limit of stable flow and approaching unstable flow. All drivers are severely restricted in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is poor, and small increases in traffic flow would generally cause operational problems.	0.60 to 0.81
E	Traffic volumes are at or close to capacity, and there is virtually no freedom to select desired speeds or to manoeuvre within the traffic stream. Flow is unstable and minor disturbances within the traffic stream would cause breakdown.	0.82 to 1.00
F	In the zone of forced flow, where the amount of traffic approaching the point under consideration exceeds that which can pass it. Flow breakdown occurs, and queuing and delays result.	> 1.00

Source: Austroads, Guide to Traffic Management – Part 3 Traffic Studies and Analysis, Second Edition 2013

NSW GOVERNMENT

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Appendix C

Operational air quality

Roads and Maritime Services

WestConnex - M4-M5 Link

Iron Cove Ventilation Underground Modification Report

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Appendix C Operational Air Quality

November 2019

Prepared for

Roads and Maritime Services

Prepared by

EMM Consulting Pty Ltd

Contents

1 Introduction

A modification to the M4-M5 Link Project approval is being prepared to support proposed changes to the ancillary facilities at Iron Cove.

The environment impact statement (EIS) described an electrical substation and ventilation exhaust facility located in separate buildings that together comprise Motorway Operations Complex 4 (MOC 4) to be located on the western side of the realigned Victoria Road, on land occupied during construction by the Iron Cove Link civil site (C8). The electrical substation (that provides power for the operation of the ventilation facilities) would be located on the corner for Victoria Road and Callan Street, while the ventilation facilities would be located between Callan Street and Springside Street. A ventilation outlet would be located in the middle of the widened Victoria Road carriageway.

The proposed modification would relocate the MOC 4 underground within caverns housing the electrical substation and ventilation facilities and a ventilation tunnel connecting to the ventilation outlet (which will remain above ground in the same location illustrated in the EIS). Only a switch room, high voltage regulators, an alternative Operational Motorway Control System (OMCS) room and a stair access leading down to the ventilation tunnel would be required on the surface on the western side of Victoria Road between Toelle and Callan Streets.

The main elements of the proposed modification include:

- Construction of a ventilation tunnel about 340 metres in length that connects the Iron Cove Link tunnel, at an underground location between Cambridge and Waterloo Streets, with the Iron Cove cut and cover structure near Callan Street
- The ventilation tunnel would include two caverns for the housing of ventilation equipment and the electrical substation, along with access tunnels to be used for maintenance
- The Iron Cove cut and cover area would be extended on the southwestern side of Victoria Road to facilitate connection to the ventilation tunnel
- All plant, equipment and materials required to construct the proposed new ventilation tunnel and caverns would be supported from the Iron Cove civil site (C8), with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site (C5) later in the construction program.

2 Implications for construction phase impacts

It is understood that the construction of the modification would involve the following:

- Tunnel excavation would be completed using the methodology presented in the EIS
- An additional amount of tunnel spoil would be generated by these tunnelling works (approximately 61,000 bank cubic metres (BCM))
- All plant, equipment and materials required to construct the proposed new ventilation tunnel and caverns would be supported from the Iron Cove civil site (C8), with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site (C5) later in the construction program
- The proposed new Iron Cove ventilation tunnel and caverns can be easily accessed from within the Iron Cove cut and cover and would not require any change to the design or construction of the cut and cover. Tunnelling works using a roadheader launched from Iron Cove would commence once the southern half of the cut and cover structure has been constructed and the chamber beneath the roof of the cut and cover structure would be temporarily converted into a shed
- Any tunnelling of the proposed new ventilation tunnel and caverns supported from the Rozelle civil and tunnelling site (C5) would be commenced from within the Iron Cove Link Tunnel once it is excavated. This would not require the installation of any additional temporary surface support infrastructure at the Rozelle civil and tunnelling site (C5).

On review of the above information, it is not considered that the construction phase vehicle emission and dust impacts assessed in the EIS would alter as a result of the modification.

3 Implications for dispersion performance of MOC4 ventilation outlet

The John Holland CPB Contractors Joint Venture (the Contractor) has requested that EMM Consulting Pty Ltd (EMM) review the potential implications to the traffic emissions dispersion performance from the MOC4 ventilation outlet. EMM is currently assisting the Contractor with the final design of the Rozelle Interchange by undertaking dispersion modelling of the proposed ventilation system.

The dispersion modelling being completed by EMM of the MOC4 outlet uses the exit ventilation flow rate, traffic pollution emission rates, air temperature and ventilation outlet dimensions (release height and exit diameter) as input into the model.

To date, traffic pollutant emission rates and ventilation flow rates for the MOC4 outlet were provided to EMM by WSP Global Inc (WSP) in order to complete the dispersion modelling. Advice was sought from WSP in relation to how the proposed modification to MOC4 would alter the provided emissions data. WSP confirmed that the change from an above ground facility to a subterranean facility would have no tangible effects on the emissions to be released from the outlet. In both cases, the tunnel ventilation system is required to capture all of the vehicle emissions generated within the entire tunnel carriageway area. The factors that impact the in-tunnel pollutant concentrations (e.g. traffic volumes, tunnel grades, flow rates, vehicle pollutant generation rates, etc) will be the same for either facility configuration.

This advice from WSP therefore indicates that there would be no change to the likely traffic pollution emission rates, or the ventilation flow rates due to the modification. Further, it is understood that the modification would not alter the shape, size (release height or exit diameter) or location of the MOC4 ventilation outlet. The modification would therefore not alter any of the parameters used in the dispersion modelling for the MOC4 ventilation outlet (dimensions or emission characteristics).

On the basis of this information, it is concluded the modification would have no material effect on the dispersion performance of the MOC4 ventilation outlet.

4 Conclusions

The implications of the proposed modification for potential air quality impacts were assessed. It is concluded that the modification would not alter the potential air quality impacts, related to either construction or operational phases.

NSW GOVERNMENT

WestConnex M4-M5 Link

Rozelle Interchange – Modification: Iron Cove ventilation underground

Modification report

Appendix D

Noise and vibration

Roads and Maritime Services

WestConnex - M4-M5 Link

Iron Cove Ventilation Underground Modification Report

Modification report

Appendix D Noise and Vibration

November 2019

Prepared for

Roads and Maritime Services

Prepared by

Renzo Tonin & Associates

Contents

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Glossary of terms and abbreviations

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

Airborne noise	Noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise source and receiver.
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.
A-weighting	A filter applied to the sound recording made by a microphone to approximate the response of the human ear.
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. 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 LA90 noise level if measured as an overall level or an L90 noise level when measured in octave or third-octave bands.
Barrier (Noise)	A natural or constructed physical barrier which impedes the propagation of sound and includes fences, walls, earth mounds or berms and buildings.
Decibel [dB]	The units of sound measurement. The following are examples of the decibel readings of everyday sounds: 0dB The faintest sound we can hear, defined as 20 micro Pascal 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 110dB Operating a chainsaw or jackhammer 120dB Deafening

dB(A)	A-weighted decibel. 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 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. The dB(C) level is not widely used but has some applications.
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.
Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
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.
INP	NSW Industrial Noise Policy, EPA 1999
ICL	Iron Cove Link civil site
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.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L10(1hr)	The L10 level measured over a 1 hour period.
L10(18hr)	The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day.

L90	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).
LAeq or Leq	The “equivalent noise level” is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the LAeq.
LAeq(1hr)	The LAeq noise level for a one-hour period. In the context of the NSW EPA’s Road Noise Policy it represents the highest tenth percentile hourly A-weighted Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
LAeq(8hr)	The LAeq noise level for the period 10pm to 6am.
LAeq(9hr)	The LAeq noise level for the period 10pm to 7am.
LAeq(15hr)	The LAeq noise level for the period 7am to 10pm.
LAeq (24hr)	The LAeq noise level during a 24 hour period, usually from midnight to midnight.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmax.
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmin.
Microphone	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially constant.
Noise	Unwanted sound
RRY	Rozelle Railyards civil and Tunnel Site
Sound	A fluctuation of air pressure which is propagated as a wave through air.
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 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 of 1 pico watt.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 mico Pascal.
Spoil	Soil or materials arising from excavation activities.

1 Introduction

Renzo Tonin & Associates was engaged by John Holland CPB Contractors Joint Venture (the Contractor) to prepare a noise and vibration assessment of the proposed modification to the ventilation ancillary facilities at Iron Cove Link during the construction and operational phases.

1.1 Summary description of proposed modification

The EIS described an electrical substation and ventilation exhaust facility located in separate buildings on the surface, that together would comprise the Iron Cove Motorway Operations Complex 4 (MOC 4) (see Figure 1).

The proposed modification would relocate MOC4 underground, including the electrical substation and ventilation facilities. A switch room, high voltage regulators, an alternative Operational Motorway Control System (OMCS) room and a separate stair access leading down to the ventilation tunnel would be required on the surface (see Figure 2). The combined switch room and high voltage regulator structure would be about 6 metres wide and 30 metres long, with a height of up to 8 metres. The L-shaped OMCS room would be approximately 9 metres wide by 9 metres long and 5 metres high. A small above ground structure in the vicinity of Callan Street about 2 metres wide, 6 metres long and 3 metres high would contain an access door and a stairway. The ventilation outlet will remain above ground in the same location illustrated in the EIS.

Figure 1 Operational Iron Cove configuration shown in EIS

Figure 2 Operational Surface layout at Iron Cove under the proposed modification

The following points provide an overview of the proposed ventilation tunnel and caverns:

Construction of a ventilation tunnel about 340 metres in length that connects the Iron Cove Link tunnel, at an underground location between Cambridge and Waterloo Streets, with the Iron Cove cut and cover structure near Callan Street. This ventilation tunnel would be on average about seven metres high and about 10 metres wide. The depth of the ventilation tunnel would vary from about eight metres (from ground level to tunnel crown) at its shallowest to about 25 metres (from ground level to tunnel crown) at its deepest.

The ventilation tunnel would include two caverns for the housing of ventilation equipment and the electrical substation:

- The ventilation cavern would contain four ventilation fans laid horizontally, with associated attenuators and dampers. The dimensions of the exhaust fan cavern would be about 25 metres wide, 15 metres high and 70 metres long
- The cavern containing the electrical substation would be parallel to the cavern containing the ventilation. The dimensions of the substation cavern would be about 20 metres wide, 10 metres high and 65 metres long.

A five-metre wide and 20-metre long access tunnel, to facilitate personnel access from the exhaust fan cavern into the substation cavern.

The Iron Cove cut and cover area would include a side access for the vent tunnel to connect to the cut and cover about 7 metres wide and 17 metres long. This area would also accommodate the access stairs to the surface.

The alignment of proposed new ventilation tunnel and caverns at Iron Cove is shown in Figure 3. The approved Iron Cove Link road tunnels are shown in orange.

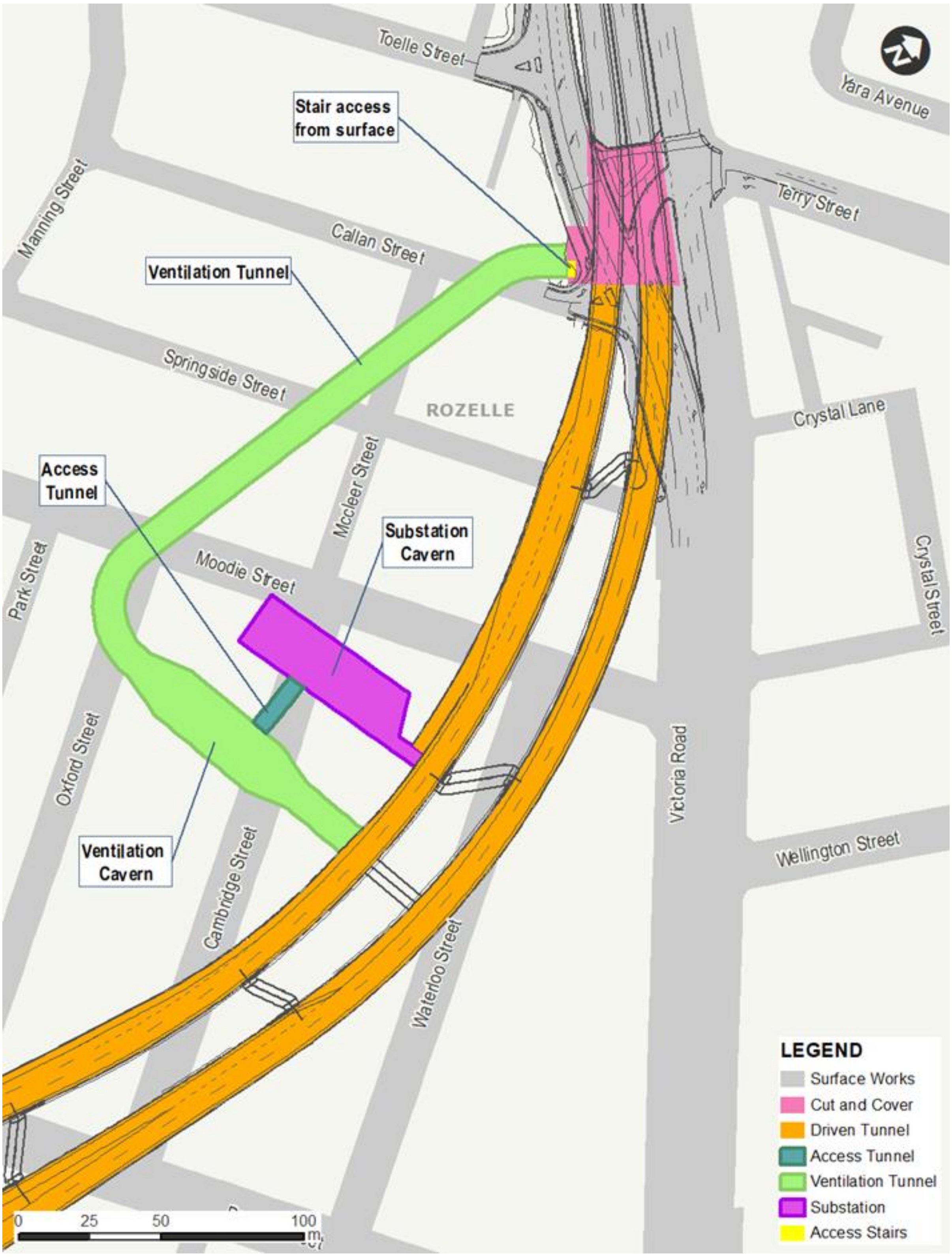


Figure 3 Proposed ICL Ventilation Ancillary Facilities – underground layout

1.2 Key aspects of the proposed modification relevant to this assessment

1.2.1 Ventilation tunnel and caverns excavation

The proposed ventilation tunnel and caverns would be constructed in hard rock (i.e. Hawksbury sandstone) and would be excavated as described in Section 6.4.2 of the EIS, in summary (Figure 4):

- Excavation of top section (top heading – see figure below) of the ventilation tunnel would be carried out using roadheaders
- The lower section (bench – see figure below) of the ventilation tunnel would be excavated using a combination of rock-breakers, and roadheaders
- Ground support, including rock bolting and shotcrete, would be installed as the tunnelling face is advanced along the ventilation tunnel.

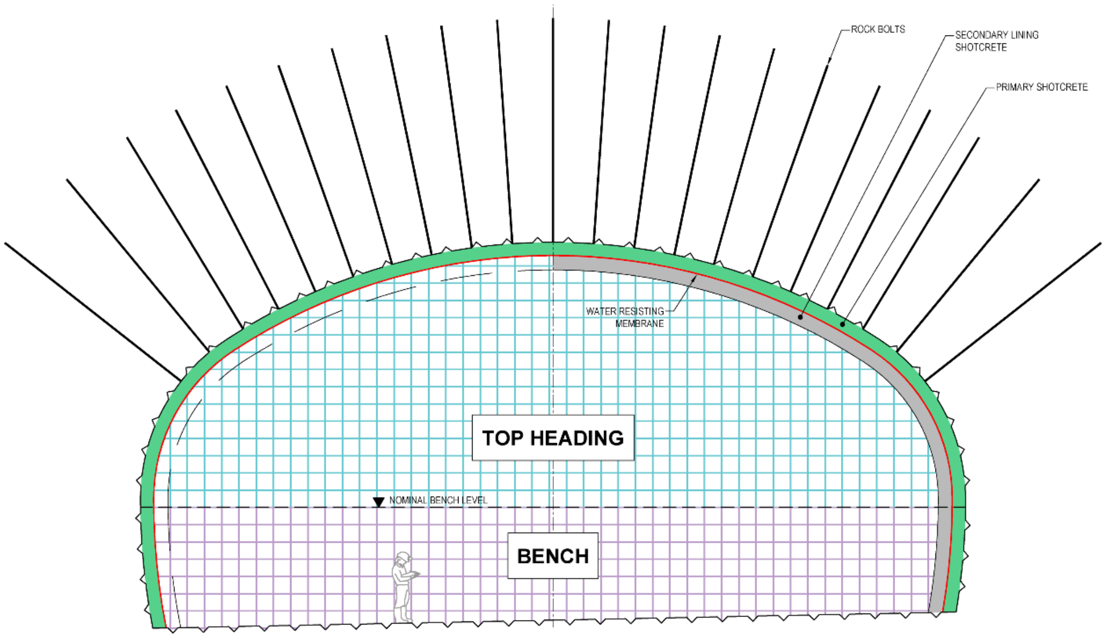


Figure 4 Ventilation tunnel section

As per the EIS, tunnelling will occur 24 hours a day, up to seven days a week. Reasonable and feasible methods to reduce potential impacts, such as using surface miners and/or blasting, would be further considered during detailed construction planning. Blasting would only be considered where the blast could be designed to comply with current guidelines, as set out in a Blast Management Strategy that would be prepared in accordance with Planning Approval Conditions E96 to E100.

All plant, equipment and materials required to construct the proposed new ventilation tunnel and caverns would be supported from the Iron Cove civil site (C8), with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site (C5) later in the program. The programs for the tunnel support site options to be used to construct the proposed ventilation tunnel and caverns are different:

- Iron Cove civil site (C8) – tunnelling works at the Iron Cove cut and cover have been scheduled to occur over about 15 months between about Q3 2020 and the end of 2021
- Rozelle civil and tunnel site (C5) – excavation of the ventilation tunnel and caverns would occur from about Q2 2021 if required.

The proposed new Iron Cove ventilation tunnel and caverns can be easily accessed from within the Iron Cove cut and cover using a single roadheader.

Any tunnelling of the proposed new ventilation tunnel and caverns supported from the Rozelle civil and tunnelling site (C5) would be commenced from within the Iron Cove Link Tunnel once it is excavated. This would not require the installation of any additional temporary surface support infrastructure at the Rozelle civil and tunnelling site (C5).

This assessment has been completed assuming the worst-case impacts of all deliveries and spoil transportation occurring from both these sites

As the proposed new ventilation tunnel and cavern works would be supported from the Iron Cove civil site (C8) but could also use the Rozelle civil and tunnel site (C5), this assessment has been completed assuming the worst case impacts of all deliveries and spoil transportation occurring from either sites. It is noted that the new ventilation tunnel and cavern excavation works would not commence from the Rozelle civil and tunnel site (C5) until the mainline tunnels are completed, so operations at the Rozelle civil and tunnel site (C5) would not change from the peak impact scenario assessed in the EIS.

1.2.2 Permanent surface works

The proposed modification substantially reduces the extent of permanent surface works required at Iron Cove. The EIS described an electrical substation and ventilation exhaust facility located in separate buildings on the surface, that together would comprise Motorway Operations Complex 4 (MOC 4). The proposed modification would relocate Motorway Operations Complex (MOC4) underground, including the electrical substation and ventilation facilities. The ventilation outlet will remain above ground in the same location. Under the proposed modification only a switch room, high voltage regulators, an alternative Operational Motorway Control System (OMCS) room and a stair access requires construction above surface level to the west of Victoria Road between Callen and Toelle Streets.

Construction of switch room, high voltage regulators, the alternative OMCS room and stair access would entail minor excavation, foundation preparation, drainage works, concrete works and structural works as well as mechanical and electrical fit out. Commissioning of the entire project will begin at Iron Cove Link and the alternative OMCS room would also be used to support commissioning and testing of motorway systems to ensure they are safe and meet required specifications.

The M4-M5 Link EIS, Appendix J, Table 5-89 identifies the total duration of surface work construction of MOC4 to be 144 weeks. This modification reduces the surface work construction time to about 40 weeks for the construction of the surface buildings to be located to the west of Victoria Road.

1.2.3 Tunnelling support from Iron Cove civil site (C8)

Tunnelling would commence once the southern half of the cut and cover structure has been constructed. It is anticipated that one roadheader would be used to excavate the rock beneath the cut and cover structure in order to gain access to the tunnel portal located under the cut and cover structure. This rock would ordinarily be excavated using large excavators with rock breakers as part of surface construction works. Using a roadheader for this work would reduce noise and vibration impacts on the surrounding community.

Once the rock beneath the cut and cover structure has been removed, the chamber beneath the roof of the cut and cover structure would be temporarily converted into a spoil shed. A temporary shed wall and roller door would be installed at the western end of the cut and cover structure, and this wall combined with the concrete roof of the cut and cover structure would assist with reducing noise emission from the spoil shed during tunnelling. A generator, dust collector, water treatment plant and ventilation fans would be installed within the dive structure and/or inside the spoil shed as appropriate to support the tunnelling works. An indicative site layout is provided in Figure 5.

Spoil from tunnelling would be loaded into off-road trucks at the tunnel face. Tunnel spoil would be transported and stockpiled in the dive structure area and loaded into trucks for off-site disposal during standard construction hours. Spoil generated outside standard construction hours would be transported from the tunnel face and stockpiled in the enclosed cut and cover structure, to be loaded into truck and dogs and/or single tippers during standard hours for disposal off-site.

Concrete deliveries would be required 24 hours a day during tunnelling for tunnel ground support and concrete lining works. Typically, there would be 6 shotcrete deliveries by agitator trucks per day, with 2 concrete deliveries in the evening (6:00 pm to 10:00 pm) and typically 1 concrete delivery truck at night (10:00 pm to 7:00 am).

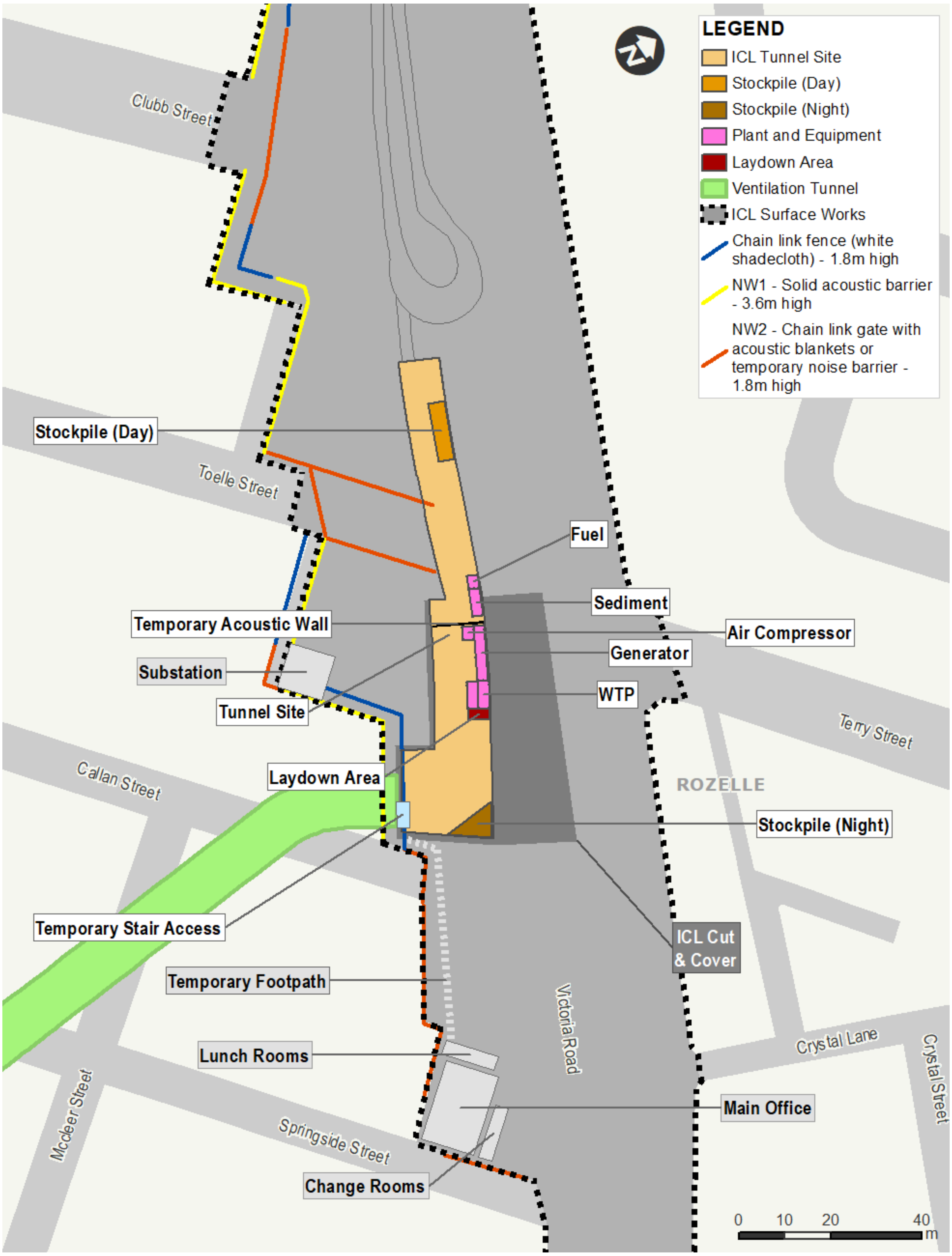


Figure 5 Proposed ICL tunnel support site indicative layout

The surface civil compound facilities at the Iron Cove civil works site (C8) including crib rooms and amenities would be co-used by the tunnelling workforce and supervision. Light vehicles and delivery vehicles would access the Iron Cove civil works site (C8) and the enclosed cut and cover structure regularly to support tunnelling operations.

1.2.4 Tunnelling support from Rozelle civil and tunnel site (C5)

Any tunnelling of the proposed modification that is supported from the Rozelle civil and tunnel site (C5) would not change the site layout or construction operations. All spoil would be transferred to one of the acoustic sheds at this worksite. At this worksite, spoil handling and haulage would occur 24 hours a day, seven days a week.

1.2.5 Changes to locations of operational noise sources

As described in Section 1.1, the EIS described an electrical substation and ventilation exhaust facility located in separate buildings to be located on the southern side of the realigned Victoria Road. The electrical substation would be located on the corner of Victoria Road and Callan Street, while the ventilation facilities would be located between Callan Street and Springside Street. A ventilation outlet would be located in the middle of the widened Victoria Road carriageway connected via tunnel to the above-ground ventilation facility.

As part of the proposed modification, both the ventilation equipment and electrical substation would be relocated to underground caverns. Above-ground structures located on the southern side of Victoria Road would be limited to a switch room, high voltage regulators, an OMCS room and a stair access leading down to the ventilation tunnel. These facilities would be located between Toelle Street and Callan Street. The ventilation outlet would remain in the middle of the widened Victoria Road carriageway.

The switch room would house equipment, such as electrical meters, which would be used to monitor the operation of the substation and ventilation facilities. The combined switch room and high voltage regulator structure would be about 6 metres wide and 30 metres long, with a height of up to 8 metres. This structure would be adjacent to the Victoria Road Shared User Path on the eastern side of the intersection of Victoria Road and Toelle Street. Within the same area would be the smaller ‘L’- shaped OMCS room with a footprint of approximately 9 metres wide by 9 metres long and 5 metres high.

A small above ground structure in the vicinity of Callan Street, about two metres wide, six metres long and three metres high would contain an access door and a stairway. The staircase would provide an alternative safe maintenance and emergency access to and from the ventilation tunnels from the surface, with the main access from within the road tunnels.

Dedicated parking would be provided for operations and maintenance personnel with access off Clubb Street and within the switch room site with access off Toelle Street.

1.3 Quality assurance

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 Compliance with SEARs

SEARS (Noise & Vibration)	Construction	Operation
The construction and operational noise and vibration assessments must be quantitative assessments. The assessments must identify any sensitive receivers not previously affected by the modified activities and those where the level of impact is predicted to increase.	Yes, quantitative assessment in Section 4	Yes, quantitative assessment in Section 5
The assessment of sleep disturbance must assess the predicted number of awakening events.	Yes, compliance with NMLs so no predicted awakening events (Section 4.2.1)	Yes, compliance with sleep disturbance screening criteria shown so no predicted awakening events (Section 0)
If blasting is proposed, the assessment must demonstrate that blast impacts are capable of complying with current guidelines.	Section 1.2.1	N/A
Assessment of construction and operational noise and vibration impacts including sleep disturbance associated with the proposed modification. This assessment must be in accordance with relevant NSW noise and vibration guidelines and potential noise and vibration mitigation measures should be identified.	Yes, all sections	Yes, all sections
The assessment of operational noise should focus on the relocation and use of the proposed modified ventilation facility and compare the results of this assessment to the existing baseline and approved project.	N/A	Yes, Section 5.1 and 5.4 assesses relocation of vent facility
The assessment of construction noise and vibration impacts must address:		N/A
1. the nature of construction activities (including transport, tonal or impulsive noise-generating works as relevant);	Section 3.1	
2. the likely intensity and duration of potential noise and vibration impacts (both air and ground-borne);	Section 3.1	
3. confirmation of works occurring within and outside standard construction hours, including estimated duration and timing, predicted levels, exceedances and number of potentially affected receivers and justification for the activity in terms of the Interim Construction Noise Guideline (DECCW, 2009);	Section 3.1 and Section 4	
4. figures consistent with the EIS illustrating the existing, previously assessed and predicted noise levels related to the modification; and	Figures and tables presented consistent with EIS	

SEARS (Noise & Vibration)	Construction	Operation
5. a cumulative noise and vibration assessment of other M4-M5 Link works proposed at Iron Cove where potential impacts are likely to differ from those that were previously assessed under the EIS for SSI 7485.	Section 4.2.1	
Assess potential construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	Yes, construction noise and vibration assessed to relevant NSW noise and vibration guidelines. Assessment methodology outlined in Section 3.1.	Yes, operational noise assessed to INP which is consistent with Approval Condition E92(d). Assessment methodology outlined in Section 3.2.

3 Methodology

3.1 Construction noise and vibration assessment methodology

3.1.1 Excavation of the ventilation tunnel and caverns

Ground-borne noise (GBN) levels that may be experienced in buildings during tunnel excavation depends on the minimum slant distance from the tunnel ground geology (e.g. Hawksbury sandstone, Ashfield shale), building foundation-to-footing interaction, receiving room dimensions and reverberation times - see Figure 6).

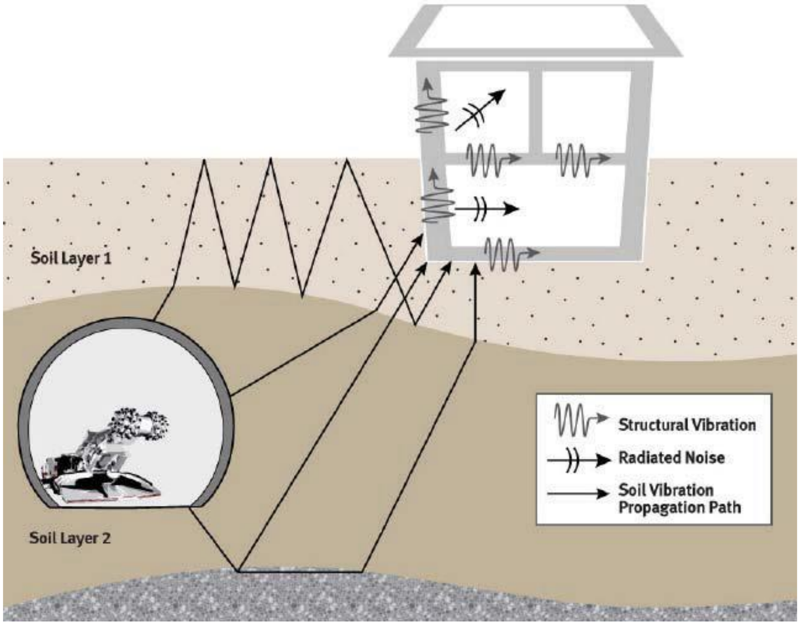


Figure 6 Ground-borne noise generation in buildings on surface during tunnelling excavation (source: Cross River Rail, EIS Chapter 16)

An empirical algorithm for roadheader excavation was used in the EIS based on previous measurements in the region of Sydney, where the geology primarily consists of sandstone rock. Figure 7 presents indicative ground-borne noise levels for road-headers as a function of the distance between plant and the receiver.

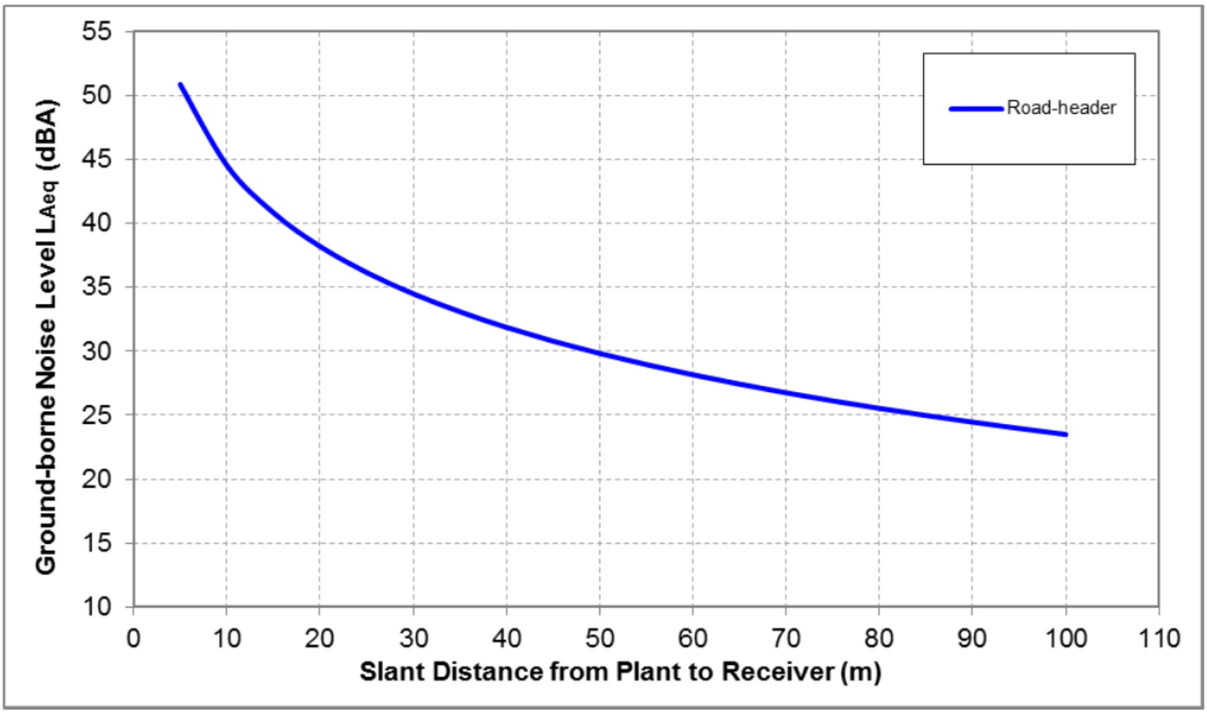


Figure 7 EIS indicative ground-borne noise levels from road-headers (Source: M4-M5 Link EIS, Appendix J, Figure 4-2)

The algorithm was used to predict ground-borne noise levels inside sensitive receiver buildings near the ventilation tunnels. The predicted noise levels were compared with the evening Ground-borne Noise Management Level (GBNML) of 40dB(A) and night-time GBNML of 35 dB(A). GBNMLs are only applicable when ground-borne noise levels are higher than airborne noise levels. The ground-borne noise levels are therefore for evening and night-time periods only, as the objectives aim to protect the amenity and sleep of people when they are at home.

The assessment of potential construction vibration impacts during roadheader tunnelling excavation was based on the minimum working distances established for cosmetic damage presented in M4-M5 Link EIS, Appendix J, Table 4-12.

The methodology used to assess ground-borne noise and vibration impacts of the proposed modification was the same as the assessment process used in the EIS. GBN predictions were based on the empirical algorithm presented in the M4-M5 Link EIS, APPENDIX J, Figure 4-2. Construction vibration impacts were based on the minimum working distances established for cosmetic damage presented in M4-M5 Link EIS, Appendix J, Table 4-12.

For the construction ground-borne noise and vibration assessment, it is noted that Appendix J of the EIS does not consider ventilation tunnels at Iron Cove, therefore a direct comparison could not be undertaken to compare impacts with the EIS design.

3.1.2 Tunnel support works from Iron Cove cut and cover

As described in Section 1.2.3, all plant and equipment required to support tunnelling from the Iron Cove cut and cover site (EIS C8) would access the tunnel from the cut and cover structure, which would be temporarily converted into a spoil shed. Table 1 lists additional plant and equipment that would be utilised at the Iron Cove Link cut and cover site to support tunnelling activities.

Table 1 Tunnel support plant and equipment - Iron Cove Link (ICL)

Activity	Plant/equipment	Worst case item in same location		Sound power level (dB(A))	Location of plant
		Day	**OOH**		
Cut and cover tunnel support (ventilation tunnels and caverns)	Roadheader	1	1	111	In tunnel
	Wheeled loader	1	-	104 (muffled)	Outside shed to load spoil trucks
	Dump trucks	4 per hour	4 per hour	106	In dive structure1/'shed'/ tunnel
	Generator and air compressor	1	1	105	In 'shed'/ dive structure2
	Shotcrete rig	1	1	104	In tunnel
	Drilling/bolting rig	1	1	125	In tunnel
	Excavator with bucket/ Muffled Wheeled Loader	1	1	104	In dive structure1/'shed'
	Dust collector	1	1	104	In shed/ tunnel
	Ventilation fans	1	1	105	In 'shed'
	Water treatment plant	1	1	100	In 'shed'/ dive structure2
	Light vehicles and delivery vehicles	4 per hour	4 per hour	89	On and off site
	Spoil trucks and deliveries	30 per day	-	108	On and off site Loaded in dive
	Concrete agitator	6 per day	Up to 3 (total)	106	On and off site. Concrete pours inside shed

Notes: 1. Daytime (standard hours) only

2. Inside acoustic enclosure, details to be confirmed at detailed design

Work hours for construction of the ventilation tunnel and caverns from within the Iron Cove cut and cover would be in accordance with those prescribed by the Planning Approval Condition E70, which allow tunnelling activities and tunnel fit out works to occur 24 hours a day, seven days a week.

The following daily traffic volumes are anticipated during peak construction activities involving spoil load out and concrete works to support tunnelling from Iron Cove. Typically:

- 30 light vehicles per day
- 30 spoil truck and trailers per day during standard daytime hours in accordance with Conditions E68 and E69
- Six shotcrete deliveries by agitator trucks per day, with 2 concrete deliveries in the evening (6 pm to 10 pm) and typically 1 truck at night (10 pm to 7 am)
- Six additional rigid heavy vehicles per day (including other deliveries and garbage removal)
- Total around 42 heavy vehicle movements per day.

There are a number of opportunities to incorporate noise mitigation into the Iron Cove tunnel support site design including the following standard construction features, in accordance with the M4-M5 Link EIS and Planning Approval:

- Site hoarding/ noise barriers – temporary acoustic hoarding/barriers (1.8 metres to 3.6 metre high) would be installed around the site perimeter (see Figure 5) to mitigate noise from civil works associated with the cut and cover. This temporary barrier, which will be construction regardless of the proposed modification, is included in this noise assessment
- Acoustic shed – the chamber beneath the roof of the cut and cover structure would be temporarily converted into a spoil shed by installing a temporary wall with roller door at the western end of the cut and cover structure. The roller door would be open during standard construction hours and closed outside standard construction hours. Initial investigation considered different wall constructions with the performance ratings set out in Table 2. Given the acoustic benefits of the Wavebar this has been incorporated into the wall design to minimise noise impacts on surrounding receivers
- At-receiver mitigation in the form of at-property treatment in accordance with PPA Condition E87. Properties that must be offered at-receiver mitigation are identified in Appendix D of the PPA and include receivers along the EIS Iron Cove civil works site (EIS C8). This at-property treatment, which will be implemented regardless of the proposed modification, is included in this noise assessment. At-property mitigation is only included as a final mitigation measure, as all other reasonable and feasible mitigation measures have been reviewed and adopted in the design of the Iron Cove Link tunnel support site.

Table 2 Acoustic shed performance – ICL tunnel support

Indicative shed construction	Octave band transmission loss dB						
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**
Single skin steel 1 x 0.48 mm BMT corrugated steel	7	9	13	18	22	19	20
Single skin steel + Wavebar 0.48mm thick sheet metal, 1 x 10kg Wavebar, 50mm thick insulation (perforated foil face)	14	18	20	28	38	43	50

3.1.3 Tunnel support works from Rozelle civil and tunnel site

As described in Section 1.2.4, should tunnelling be supported from the Rozelle site all plant and equipment required to construct the ventilation tunnel would access the tunnel from the Rozelle civil and tunnel site (C5) and progress towards to the Iron Cove civil worksite. There would be therefore a minor increase in spoil trucks and deliveries at RRY worksite associated with the proposed modification. However, support of excavation works associated with the proposed modification are not predicted to overlap with peak construction activities associated with the overall Rozelle Interchange Project scheduled to occur in about March 2021. Impacts of the peak construction support have been already included in the assessment of the operation of the Rozelle civil and tunnel site (C5) and suitable mitigation measures have been identified.

3.1.4 Permanent surface works

As described in Section 1.2.2, the proposed modification substantially reduces the extent of permanent surface works required at Iron Cove (C8). The construction of the switch room, high voltage regulator (HV regulator) bays, Operational Motorway Control System (OMCS) room and stair access would entail minor excavation, drainage works, foundation preparation, concrete works, and structural works as well as mechanical and electrical fit out.

The associated construction activities are presented in M4-M5 Link EIS, Appendix J, Table 5-89 under the work activity ICL-14 (i.e. ventilation station and substation). The airborne noise assessment for the construction of the facility (scenario ICL-14) was based on three typical items of plant (mobile crane, concrete trucks/agitator and concrete pump) that would likely be used for construction. Table 5-92 identifies that the plant/equipment for the work activity ICL-14, reproduced in Table 3.

Table 3 EIS construction plant/equipment schedule (Source: M4-M5 Link EIS, Appendix J)

Worksite	Works ID	Activity	Plant/equipment	Sound power level (dB(A))
Iron Cove Link (ICL)	ICL-14	Ventilation station and substation	Mobile crane	101
			Concrete truck/agitator	106
			Concrete pump	106

The technical assessment was undertaken in accordance with the assessment process documented in the EIS.

3.1.5 Construction hours

Construction of the project would be carried out during 'Standard Construction Hours' where practicable. Standard Construction Hours are defined in the ICNG and shown in Figure 8..

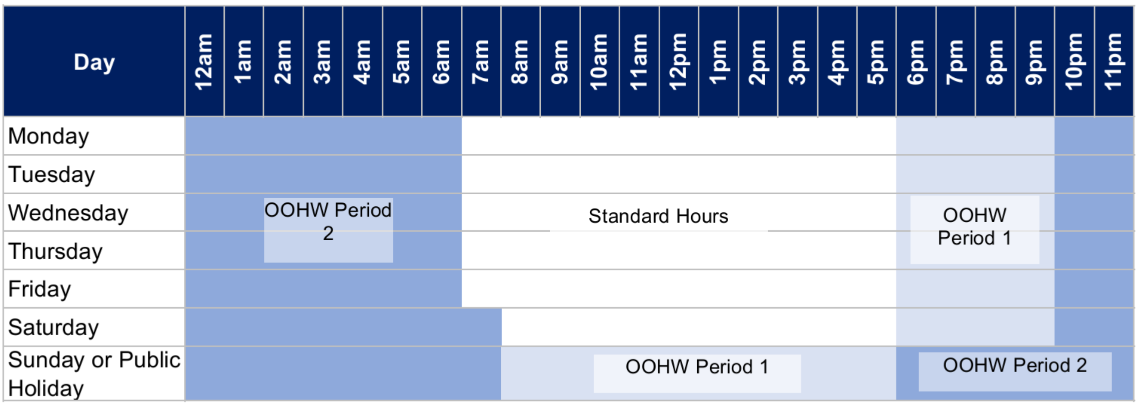


Figure 8 Construction hours

Works hours for the M4-M5 Link project are outlined in Planning Approval Conditions E68 and E69. Planning Approval Condition E68 allows works to be undertaken during standard construction hours as outlined in the ICNG, while Condition E69 allows works to be undertaken between 1:00 pm and 6:00 pm on Saturdays. Daytime works for this proposed modification would be undertaken during these hours.

Planning Approval Condition E70 permits the following works to be undertaken 24 hours a day, seven days a week:

- tunnelling activities excluding cut and cover tunnelling
- haulage of spoil and delivery of material
- works within an acoustic shed and
- tunnel fit out works.

3.1.6 Additional construction mitigation

Section 4.6.1 of the M4-M5 Link EIS, Appendix J identifies standard mitigation measures for construction activities likely to result in adverse noise or vibration impact based on the Roads and Maritime Construction Noise and Vibration Guideline (CNVG). Standard mitigation measures have been considered in this modification assessment, consistent with the EIS. Also consistent with the M4-M5 Link EIS, Appendix J, Section 4.6.2 and in accordance with Infrastructure Approval Condition E81, the following key mitigation measures have been developed based on the Roads and Maritime Construction Noise and Vibration Guideline (CNVG) and detailed in the Construction Noise and Vibration Management Plan (CNVMP):

- Validation of predicted noise/vibration levels at the nearest receiver buildings to the construction works

- Notification letterbox drops to receivers in the area around the works locations, detailing work activities, time periods over which these would occur, impacts and mitigation measures
- Specific notifications, which provide additional information when relevant and informative to more highly affected receivers than covered in general letterbox drops
- Phone calls, which detail relevant information to identified/affected stakeholders and provide personalised contact, tailored advice and the opportunity to comment on the proposed work.
- Individual briefings, which inform stakeholders about the impacts of high noise activities and mitigation measures and provide personalised contact, tailored advice and the opportunity to comment on the proposed work
- Duration respite, which refers to the increase of the duration of specific works (i.e. number of evenings or nights) so that the entire Project can be completed more quickly; this additional mitigation measure would be considered in consultation with the receivers
- Respite periods may be offered to the affected residents during works where the predicted noise/ vibration is above the management levels as noted in Figure 9, Figure 10 and Figure 11
- Alternative accommodation (or other negotiated respite offers when alternative accommodation is not suitable for the resident) would also be considered where predicted noise/ vibration is above the management levels for more than two consecutive nights.

Figure 9, Figure 10 and Figure 11 detail the above-mentioned additional mitigation measures for the all assessment periods (i.e. day, evening and night) for airborne noise, ground-borne noise and vibration respectively. Where feasible and reasonable, this approach would be implemented.

When is the work being undertaken?	How much does the predicted noise level exceed the ANML by?	Identify additional management measures to be implemented
All Hours	75 dB(A) or greater	V, N, PC, RO
Standard Hours M-F 7am to 6pm Sat 8am to 6pm	0 dB(A)	-
	≤ 10 dB(A)	-
	10 to 20 dB(A)	V, N
	> 20 dB(A)	V, N
OOHW Period 1 M-F 6pm to 10pm Sat 6pm to 10pm Sun/ PH 8am to 10pm	< 5 dB(A)	-
	5 to 15 dB(A)	N, R1, DR
	15 to 25 dB(A)	V, N, R1, DR
	> 25 dB(A)	V, N, SN, IB, PC, R1, DR
OOHW Period 2* M-F 10pm to 7am Sat 10pm to 8am Sun/ PH 6pm to 8am	< 5 dB(A)	N
	5 to 15 dB(A)	V, N, R2, DR
	15 to 25 dB(A)	V, N, SN, IB, PC, R2, DR
	> 25 dB(A)	AA, V, N, SN, IB, PC, R2, DR

Notes: Use the abbreviation codes in the table above to confirm management measures required

* Where OOHW occur in the evening/night shoulder period (10pm to 12am) or the night/morning shoulder period (5am to 7am) apply additional airborne mitigation measures from the OOHW Period 2, excluding AA.

N = Notification (should be issued a minimum of five working days prior to the start of works)

SN = Specific notifications (issued no later than seven calendar days ahead of construction activities)

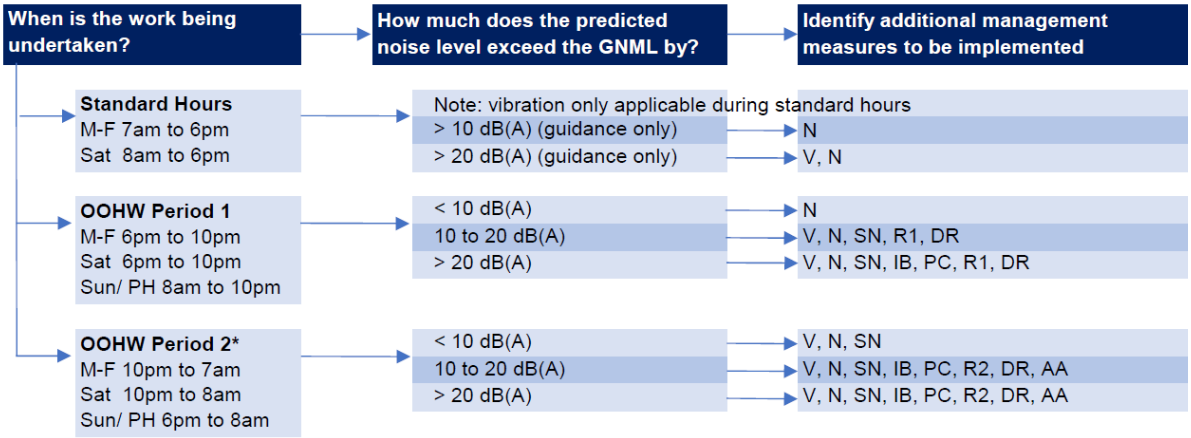
IB = Individual briefing | PC = Phone Call

AA = Alternative accommodation** | RO = Project specific respite offer | R1 = Respite period 1

V = Verification of predicted noise | DR = Duration respite | R2 = Respite period 2

** Where construction activity impacts receiver for more than two consecutive nights. AA is not applicable to shoulder periods.

Figure 9 Triggers for additional mitigation measures – airborne noise



Notes: Use the abbreviation codes in the table above to confirm management measures required

* Where OOHW occur in the evening/night shoulder period (10pm to 12am) or the night/morning shoulder period (5am to 7am) apply additional airborne mitigation measures from the OOHW Period 2, excluding AA.

N = Notification (should be issued a minimum of five working days prior to the start of works)

SN = Specific notifications (issued no later than seven calendar days ahead of construction activities)

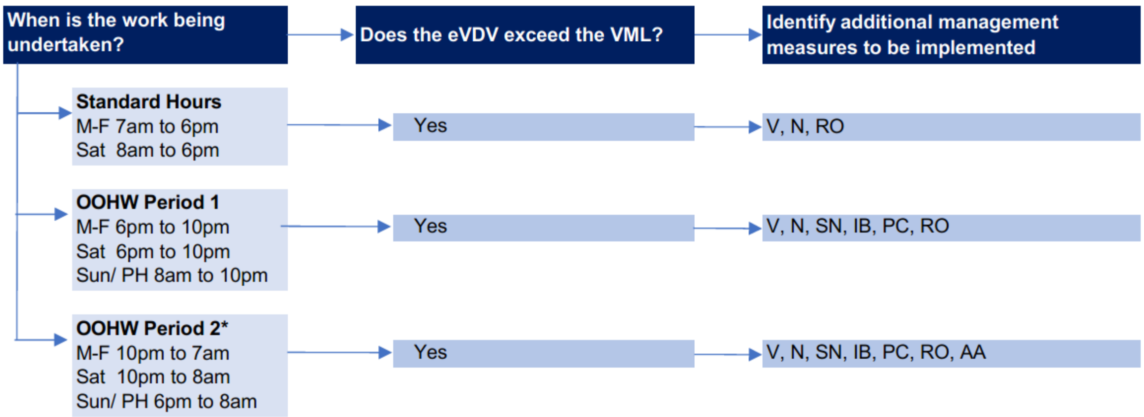
IB = Individual briefing | PC = Phone Call

AA = Alternative accommodation** | RO = Project specific respite offer | R1 = Respite period 1

V = Verification of predicted noise | DR = Duration respite | R2 = Respite period 2

** Where construction activity impacts receiver for more than two consecutive nights. AA is not applicable to shoulder periods.

Figure 10 Triggers for additional mitigation measures – ground-borne noise



Notes: Use the abbreviation codes in the table above to confirm management measures required

* Where OOHW occur in the evening/night shoulder period (10pm to 12am) or the night/morning shoulder period (5am to 7am) apply additional airborne mitigation measures from the OOHW Period 2, excluding AA.

N = Notification (should be issued a minimum of five working days prior to the start of works)

SN = Specific notifications (issued no later than seven calendar days ahead of construction activities)

IB = Individual briefing | PC = Phone Call

AA = Alternative accommodation** | RO = Project specific respite offer | R1 = Respite period 1

V = Verification of predicted noise | DR = Duration respite | R2 = Respite period 2

** Where construction activity impacts receiver for more than two consecutive nights. AA is not applicable to shoulder periods.

Figure 11 Triggers for additional mitigation measures – vibration

3.2 Operational noise and vibration assessment

Operational noise and vibration impact from the ventilation facilities, including MOC4 were assessed as part of the M4-M5 Link EIS, Appendix J. The M4-M5 Link EIS, Appendix J (Section 4.9.1) assumes an indicative sound power level of 105dB(A) at the top of the ventilation outlet, which assumes appropriate attenuators have been installed on the outlet side of the fans. Based on this noise source level the EIS predicted non-compliances at receivers in NCA 33 by up to 12dB(A).

The proposed modification assessment is based on further development of the detailed design and has determined appropriate attenuator requirements to meet the noise criteria at all relevant Noise Catchment Areas (NCAs). The following methodology was used to predict operational noise levels from the ventilation outlet, the location of which remains unchanged under the proposed modification:

- Assume ventilation fan source noise level of 123dB(A) per fan, based on further development of the detailed design
- Install four fans -three duty fans in operation as a worst case, with one fan on standby;
- Conduct noise modelling to determine acoustic losses through the proposed new ventilation tunnel between fan cavern and outlet (approx. 245m of tunnel)
- Apply attenuator insertion loss for a 5-metre acoustic attenuator based on test data available from similar previous projects
- Apply a 5-dB penalty to account for the possibility of low-frequency noise generated by the fan
- Apply +3 dB noise modelling engineering margin
- Apply the final calculated sound power level at ventilation outlet and use 3D noise modelling software to predict noise levels to nearest and most affected receivers
- Compare predicted noise levels against the noise criteria from EIS.

Operational noise from the HV regulators has been considered by modelling regulator noise and considering noise reduction from the blockwork walls around the regulators. The residences adjacent to the HV regulators in Callan Street would be essentially first row receivers once the new alignment of Victoria Road is completed. Existing noise levels of typical first row receivers were established by recent additional noise monitoring at the rear of 1B Byrnes Street in March 2019. The measured night-time RBL was 43dB(A), and the existing night-time LAeq ambient level was 60dB(A). Therefore, the controlling intrusive noise criteria for these receivers is 43 + 5 = 48dB(A). The total noise from the ventilation outlet plus the HV regulators therefore should not exceed 48dB(A).

The detailed assessment of operational noise is in Section 5. Operational noise mitigation measures would be confirmed in the Operational Noise and Vibration Review to be prepared in accordance with Planning Approval Condition E92.

4 Construction noise and vibration assessment

4.1 Tunnelling excavation of the ventilation tunnel and caverns

4.1.1 Predicted ground-borne noise levels

Table 4 presents a summary of the number of residential receivers where predicted ground-borne noise (GBN) levels are above the evening GBNML of 40 dB(A) and night-time GBNML of 35 dB(A) in each NCA ground-borne noise affected as a result of the ventilation tunnel excavation works. Note that GBN from excavation of the ventilation tunnel and cavern will be the same whether the tunnels are excavated from the Iron Cove civil site (C8) or the Rozelle civil and tunnel site (C5).

Table 4 Worst predicted ground-borne noise levels during excavation of the ventilation tunnel and caverns

NCA	Worst-case ground-borne noise level at a residential receiver (dB(A) LAeq,15min)	Number of residential receivers predicted to be within		
		35-40 dB(A)	**40-45dB(A)**	**>45 dB(A)**
NCA31	<35	0	0	0
NCA32	39	21	0	0
NCA33	47	40	14	3
NCA34	<35	0	0	0
NCA35	<35	0	0	0
NCA36	<35	0	0	0
Total number per GBN intervals		61	14	3
Total number		78		
Percentage (%) of total		78%	18%	4%

As shown in Table 4 and Figure 12 residential properties along the ventilation tunnel alignment are expected to be above the night-time GBNML in NCA33 and NCA32. Residential receivers are not expected to be GBN affected at night (from 10 pm to 7 am) in NCA31, NCA34, NCA35 and NCA36. There are 78 residential receivers along the ventilation tunnel alignment who are expected to experience maximum GBN levels above the night-time GBNML of 35dB(A) during roadheader excavation works. However, more than two thirds of these receivers (i.e. 78%) are predicted to be exposed to maximum GBN levels between 35 and 40 dB(A). Only a small portion of these receivers (i.e. 18%) is expected to be between 40 and 45 dB(A). Finally, only three receivers in NCA33 are predicted to be more than 45 dB(A). The maximum GBN level is predicted to be 47 dB(A).

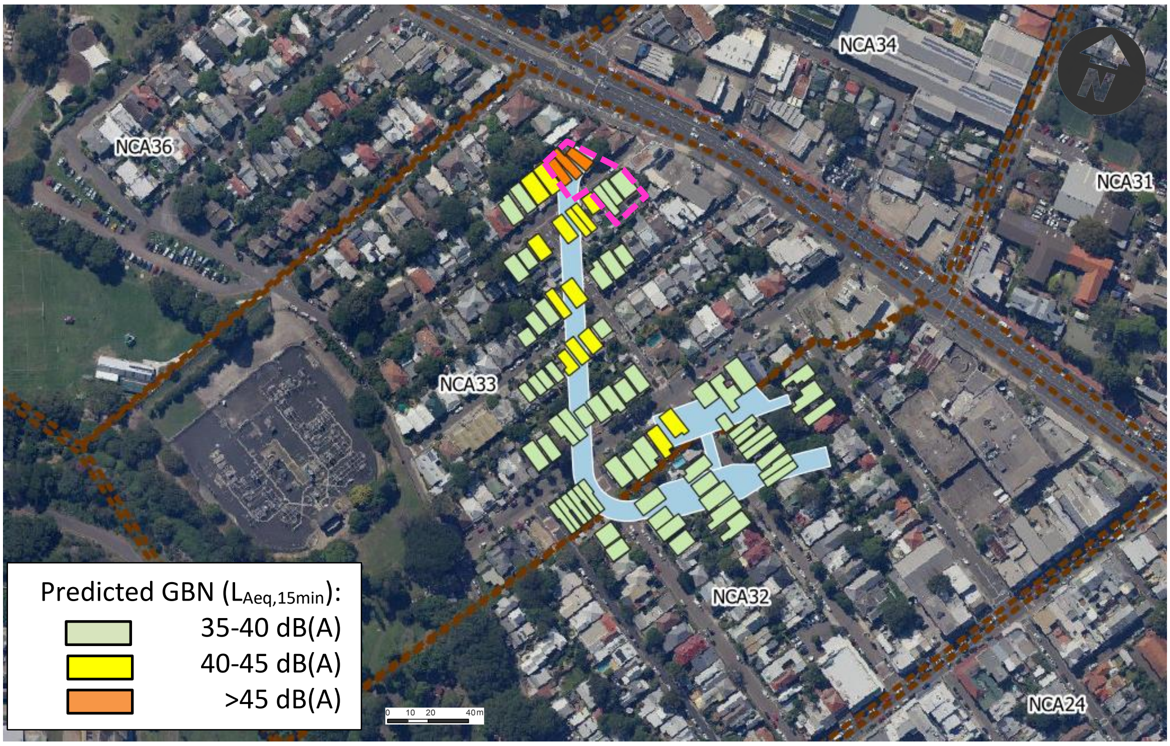


Figure 12 Maximum predicted GBN levels (ventilation tunnels in light blue). Properties within dashed pink area will also receive GBN from Iron Cove link tunnel excavation.

Figure 12 identifies residential properties where GBN levels from the ventilation tunnel excavation are expected to be above the night-time GBNML of 35 dB(A) as properties coloured green, yellow and orange. Residential properties where GBN levels are expected to be above the evening GBNML of 40 dB(A) are also shown as properties coloured yellow and orange. Properties not highlighted are not predicted to be ground-borne noise affected by the proposed modification.

These GBN affected receivers are in addition to the receivers already identified in the M4-M5 Link EIS, APPENDIX J, Table 5-148 during mainline tunnel excavation works. It is noted that Appendix J of the EIS does not consider ventilation tunnels at Iron Cove, therefore a direct comparison could not be undertaken to compare impacts with the EIS design. There are six properties identified within the pink dotted line in Figure 12 where ground-borne noise from the mainline tunnel excavation is predicted to be above the night GBNML of 35 dB(A) but below the evening GBNML of 40 dB(A), based on information provided in the M4-M5 Link EIS Annexure I.

The EIS noted that at residential locations greater than 30 metres from the nearest tunnel (taking into account the tunnel depth and the horizontal distance), exceedances of the ground-borne NML of 35 dB(A) during night-time periods are unlikely.

Figure 13 shows approximate tunnel depths (from ground elevation to the tunnel ground) for the ventilation tunnels at the Iron Cove Link site.

Figure 13 Approximate tunnel depths below existing ground elevation

As indicated in the EIS, the GBN predictions presented in Figure 12 represent the worst-case scenario when roadheader excavation works are directly underneath the receivers. At each receiver, noise levels will vary during the construction period based on the position of the roadheaders along the tunnel and caverns. This concept is described in M4-M5 Link EIS, Appendix J, Figure 5-34 and reproduced in Figure 14 below.

As can be noted from Figure 13 and Figure 14 considering an advance rate for the roadheader works of approximately 20m per week, the worst-case GBN impacted receivers along the ventilation tunnel alignment are expected to be above night-time GBN management levels for a relatively short period of time (i.e. approximately 2-3 weeks for each roadheader pass). However, it should also be noted that due to the roadheader excavation constraints, the top heading of a tunnel is generally divided in two sections (or "tunnel faces"), whilst the top heading of a cavern is usually excavated in three sections. These sections are not excavated at the same time and as such the road header would pass under properties above the tunnel more than once. Residential receivers above the tunnels would likely be exposed to two roadheader passes, whilst receivers above the caverns would likely be exposed to three roadheader passes.

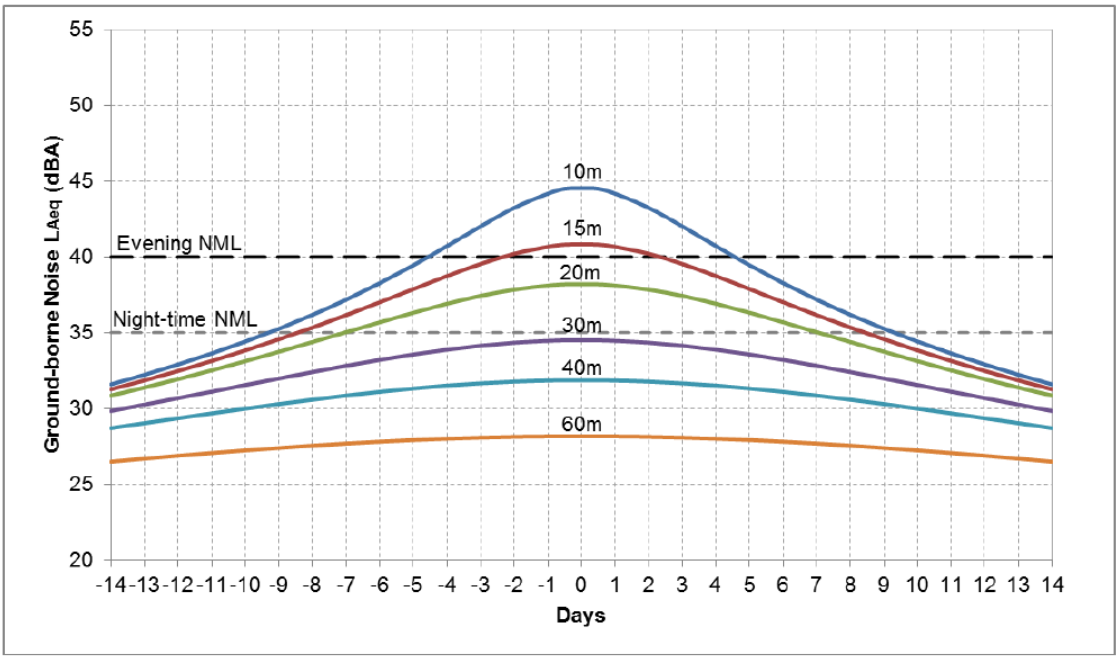


Figure 14 Ground-borne noise levels at slant distances from road-heading (progress = 20m/week) (Source: M4-M5 Link EIS, Appendix J, Figure 5-34)

The staging of the top heading excavation depends on the depth below existing ground. It is likely that the top heading of tunnels with low cover may be excavated in one stage (or 'full face"), requiring the roadheader to pass only once under the properties. As tunnel depth increases the staging of the top heading could be introduced to a maximum of two sections for the ventilation tunnel and up to three for the ventilation cavern as stated in paragraph above.

Predicted ground-borne noise levels from rock-breaker tunnel excavation (i.e. bench excavation) are likely to be above the evening and night-time GBNMLs of 40dB(A) and 35dB(A) respectively, where residential receivers are located above the tunnel alignment. Rock hammer excavation works are proposed to be undertaken during the daytime period only. Alternative low vibration excavation techniques such as roadheader and surface miner excavation would be considered whenever practicable.

4.1.2 Predicted ground-borne vibration

The recommended minimum working distances during roadheader excavation works are presented in Table 5 and are based on the M4-M5 Link EIS, Appendix J, Table 4-12.

Table 5 Recommended minimum working distances (Source: M4-M5 Link EIS, Appendix J, Table 4-12)

Plant item	Work activity	Minimum working distance			
		Cosmetic damage			Human responses[1]
		Residential and light commercial[1]	Group 2 (typical)[2,3]	Group 3 (structural unsound)[2,4]	
Roadheader	Tunnelling excavation	2 m	3 m	5 m	7 m

Notes: 1. Criteria referenced from Roads and Maritime CNVG

2. Criteria referenced from DIN 4150

3. Residential buildings and buildings of similar design and/or occupancy

4. Structures with particular sensitivity to vibration and with great intrinsic value (e.g. listed buildings).

Table 6 presents the number of buildings within minimum working distances established for structural damage and for human annoyance during roadheader excavation.

Table 6 Number of buildings within minimum working distances

Work scenario	NCA	Number of buildings within minimum working distance			
		Cosmetic damage			**Human responses**
		Residential and light commercial	**Group 2 (typical)**	**Group 3 (structural unsound) ***	
Tunnelling works (roadheader)	NCA31	0	0	0	0
	NCA32	0	0	0	0
	NCA33	0	0	0	0
	NCA34	0	0	0	0
	NCA35	0	0	0	0
	NCA36	0	0	0	0

Notes: * This group identifies Heritage listed items only and represents a screening test applicable where a historic item is deemed to be sensitive to damage from vibration

As can be noted from Table 6 no sensitive receivers are located within the minimum working distances established for cosmetic damage and for human annoyance during roadheader tunnelling excavation.

It should be noted that ground-borne vibration levels from tunnelling works at or below the threshold of human perception would generally result in noise levels above the ground-borne noise management levels for residential and commercial premises. In fact, the Environmental Impact Statement for Sydney Metro City & South West Project notes that “People tend to “hear” vibration (i.e. regenerated noise) before they feel vibration”[1]. Therefore, management and mitigation measures triggered by the exceedance of ground-borne noise management levels would appropriately address and manage potential vibration impacts.

Nevertheless, potential vibration impacts and associated feasible and reasonable mitigation and management measures would be managed in accordance with the processes set out in the Construction Noise and Vibration Management Plan prepared in accordance with Planning Approval Condition C4(b).

4.1.3 Mitigation and management

In accordance with the Planning Approval Condition E82:

“*Mitigation measures must be applied when the following residential ground-borne noise levels are exceeded:*

- *Evening (6:00 pm to 10:00 pm) – internal LAeq(15min): 40dB(A*
- *Night (10:00 pm to 7:00 am) – internal LAeq(15min): 35dB(A).*

1 Sydney Metro, 2016, Environmental Impact Statement for the Sydney Metro City & South West project (Chapter 10)

The mitigation measures must be outlined in the Construction Noise and Vibration Management Sub-plan, including in any Out-Of-Hours Work Protocol, required by Condition E77."

Appropriate measures to reduce the potential for ground-borne noise impact would be identified in accordance with the processes set out Construction Noise and Vibration Management Plan prepared in accordance with Planning Approval Condition C4(b). All feasible and reasonable mitigation and management measures would be considered and implemented in order to minimise and manage potential noise impacts.

Additional mitigation and management measures, as outlined in Section 3.1.6 would also be adopted.

4.2 Tunnel support works from Iron Cove cut and cover

4.2.1 Predicted airborne noise levels

A summary of the predicted noise levels in each of the NCAs from the tunnel support activities at the Iron Cove Link cut and cover site are presented in Table 7 based on the assumptions outlined in Section 3.1.2. For comparison, predicted noise levels from the EIS Iron Cove civil works site (EIS C8) based on the EIS construction noise assessment scenario ICL-11 and ICL-12.

Table 7 EIS and contractor comparison – predicted worst case noise levels for ICL (residential)

NCA	EIS NML	Predicted $L_{Aeq(15\ minute)}$ noise levels (dB(A))		
		EIS ICL-111	**EIS ICL-121**	**Contractor – ICL Tunnel Support**
Daytime				**Single skin with Wavebar**
NCA30	71	49	50	<30
NCA31	73	55	60	<30
NCA32	73	59	80	36
NCA33	54	72	75	51
NCA34	75	69	69	53
NCA35	75	80	75	66
NCA36	54	84	79	53
NCA38	55	53	48	<30
Evening				
NCA30	65	-	50	<30
NCA31	63	-	60	<30
NCA32	63	-	80	<30
NCA33	45	-	75	42
NCA34	65	-	69	36
NCA35	65	-	75	57
NCA36	45	-	79	41
NCA38	45	-	48	<30
Night				
NCA30	49	-	50	<30
NCA31	48	-	60	<30
NCA32	48	-	80	<30
NCA33	36	-	75	42
NCA34	51	-	69	36
NCA35	51	-	75	57
NCA36	39	-	79	41
NCA38	40	-	48	<30

Notes: 1. Source: M4-M5 Link EIS, APPENDIX J, Table 5-93, Table 5-94 and Table 5-95
Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Table 7 shows that predicted noise levels from the contractor Iron Cove tunnel support site are more than 10 dB(A) below predicted noise levels from the EIS Iron Cove civil site. Therefore, cumulative noise from the addition of noise generated by the tunnel support site to the noise from civil works would be negligible.

Table 8 compares the number of receivers above night-time EIS Noise Management Levels (NMLs) for the EIS Iron Cove civil works site (EIS C8) and the contractor Iron Cove tunnel support site, with noise mitigation measures in place. Comparison of the number of receivers above the evening EIS NMLs have not been included in Table 8 as this presents the worst case impact for the construction works. Note that ICL-11 occurs during the daytime only.

Table 8 EIS and contractor comparison – number of receivers above EIS NMLs for ICL cut and cover

Activity ID (from EIS)	Activity	Time period	Number of receivers above EIS NMLs (with mitigation*)					
			EIS1			**Contractor**		
			1 to 10 dB(A)	**11 to 20 dB(A)**	**>20 dB(A)**	**1 to 10 dB(A)**	**11 to 20 dB(A)**	**>20 dB(A)**
ICL-11	Earthworks general and drainage	Day	119	38	3	-	-	-
ICL-12	Concrete works	Day	92	17	4	-	-	-
ICL-12	Concrete works	Night	158	149	87	-	-	-
N/A	Cut and cover tunnel support	Day	-	-	-	0	0	0
N/A	Cut and cover tunnel support (Single skin Wavebar wall)	Night	-	-	-	0	0	0

Notes: Source: M4-M5 Link EIS, APPENDIX J, Table 5-98
*Mitigation includes at-property treatments identified in PPA Condition E87 (see Section 4.2.3).

Table 7 reflects that predicted noise from the civil construction works under the EIS are significantly above the NML at the nearest receivers during the day and where works are required during the evening and night. Impacts will be managed through a combination of standard and additional mitigation and management measures as outlined in Section 3.1.6. In addition, Planning Approval Condition E79 requires consultation with affected receivers to assist in determining site-specific mitigation measures.

By comparison, predicted noise levels from the tunnel support works at the Iron Cove Link cut and cover site would be below NMLs at all receivers during the day. At night-time, with a single skin with Wavebar shed wall construction at the end of the cut and cover structure, no receivers are predicted to be above the NML at night.

The likelihood of sleep disturbance impact is assessed as low as the site will be mitigated and managed to comply with the NMLs at night.

4.2.2 Predicted traffic noise impacts

As noted in Section 3.1.2, the daily traffic volumes anticipated during peak tunnel support activities are:

- Day period (7:00 am to 10:00 pm), 30 light vehicles and typically 40 heavy vehicles per day
- Night period (10:00 pm to 7:00 am), typically 1 heavy vehicle (concrete delivery) at night.

The addition of the above construction traffic to the existing traffic on Victoria Road would not be discernible and is not further addressed in this report.

4.2.3 Mitigation and management

Construction noise impacts will be managed as outlined in sections 3.1.2, 3.1.5 and 3.1.6.

A detailed construction noise and vibration impact assessment will be prepared for the proposed activities at the Iron Cove site in accordance with the approved Construction Noise and Vibration Management Plan (CVNMP) to document the outputs of detailed noise and vibration modelling and confirm the optimum suite of noise and vibration mitigation measures.

4.2.4 Predicted vibration

Vibration impacts from cut and cover excavation have been addressed and are consistent with the M4-M5 Link EIS, APPENDIX J. There are no vibration significant plant associated with the tunnel support activities. Vibration impact from tunnel support activities is assessed as low, with the risk of disturbance to nearby receivers considered low to negligible.

4.3 Permanent surface works

4.3.1 Predicted airborne noise levels

Based on the assumptions made in the M4-M5 Link EIS, construction of the switch room, HV regulator bays, alternative Operational Motorway Control System (OMCS) room and stair access would be during the daytime (standard hours) only and airborne construction noise generated from within the site would be similar. Predicted worst case noise levels from the construction of MOC4 are presented in Table 9 for the EIS design and the proposed modification.

Table 9 EIS and contractor comparison – predicted worst case noise levels for ICL-14 (daytime - residential)

NCA	EIS NML	Worst-case predicted LAeq (15 minute) noise levels (dB(A)) for ICL-14	
		EIS1	**Contractor**
NCA30	71	41	39
NCA31	73	46	40
NCA32	73	52	45
NCA33	54	71	62
NCA34	75	60	57
NCA35	75	64	62
NCA36	54	54	54
NCA38	55	37	39

Notes: 1. Source: M4-M5 Link EIS, APPENDIX J, Table 5-93
Colouring indicates the range of predicted worst case NML exceedances without any additional mitigation based on nearest receiver (red >20 dBA, orange 11 - 20 dBA, yellow 1-10 dBA) based on the controlling time period

Due to the substantially reduced extent of the permanent surface works, there are fewer potentially noise affected receivers compared to the EIS. Furthermore, the proposed modification would reduce the duration of airborne noise impact from construction of the permanent surface works from 144 weeks down to about 40 weeks. The outcomes are summarised in Table 10 below.

Table 10 EIS and contractor comparison – number of receivers above EIS NMLs for ICL-14 (daytime)

Activity ID (from EIS)	Activity	Estimated duration		Number of receivers above EIS NMLs (with mitigation)					
				EIS[1]			Contractor		
		EIS1	Contract-or	1 to 10 dB(A)	11 to 20 dB(A)	>20 dB(A)	1 to 10 dB(A)	11 to 20 dB(A)	>20 dB(A)
ICL-14	Ventilation station and substation	144 weeks	40 weeks	24	4	-	11	-	-

Notes: 1. Source: M4-M5 Link EIS, APPENDIX J, Table 5-98

Construction noise impacts will be managed as outlined in sections 3.1.5 and 3.1.6.

4.3.2 Predicted vibration

There are no vibration significant plant associated with the construction of MOC4 permanent surface works. Vibration impact is assessed as low, with the risk of disturbance to nearby receivers considered low to negligible.

5 Operational noise and vibration assessment

5.1 Predicted operational noise levels

In the EIS, noise emissions from fixed facilities in the Iron Cove area are predicted to exceed the criteria by up to 12 dB(A) at the most-affected receivers either side of Callan Street. The EIS proposed that noise generating operational equipment would be reviewed at the detailed design stage of the Project when specific plant selection is finalised, and appropriate noise control measures determined to ensure compliance with relevant operational noise criteria.

Under the proposed modification the ventilation equipment would be located underground in tunnels and caverns instead of in the MOC4 ventilation building. Locating equipment underground reduces potential noise impacts as noise breakout through ventilation building walls, roof, doors etc is no longer an issue as the above ground building has been replaced with an underground cavern. Similarly, for the substation, transformer noise and building services, noise impact is reduced as the substation is also located underground.

There is potential for noise emission from the above ground ventilation outlet. This has been reviewed as part of the development of the detailed design, including review of the fan selections and attenuator selections. The review considered the location of the ventilation fans underground. From the detailed design development, a source sound power level of 123dB(A) was assumed, with three fans in operation (one fan on standby). It was determined that to achieve the night-time design criteria of 45dB(A) at residential receivers in Noise Catchment Area (NCA) 33, an acoustic attenuator capable of achieving 35dB(A) noise reduction would need to be installed on the outlet side of the fans. Acoustic losses along the long tunnel between the underground fan room and the exhaust outlet assist in reducing noise emissions at the outlet.

Table 11 compares the EIS predicted operational noise levels for Iron Cove against the proposed modification.

Table 11 Operational noise levels at the closest residential receivers – Iron Cove fixed facilities

Receiver	NCA	Criteria	EIS predicted operational noise levels, dB(A)	Proposed modification predicted operational noise levels, dB(A)
Closest residential receivers	NCA33	45	57	44
	NCA34	45	40	40
	NCA35	45	42	38
	NCA36	45	39	41

The criteria of 45dB(A) in Table 11 is consistent with the EIS and was established according to the NSW Industrial Noise Policy (INP), based on the night-time amenity criteria for residences in urban areas.

The proposed attenuator on the outlet side of the fans has been selected such that the non-compliance predicted at NCA33 in the EIS has been mitigated. Compliance is now predicted at all surrounding NCAs. Although noise levels at the closest receiver in NCA36 are expected to be 2 dB higher than in the EIS, compliance with the noise criteria of 45dB(A) is still achieved. Therefore, noise impacts at the closest receivers associated with the operation of the Iron Cove fixed facilities are consistent with or less than the EIS.

Noise emissions from either the ventilation fan cavern or the substation cavern will be treated at the source by appropriate acoustic treatment of door openings and louvres to the caverns.

5.2 Operational noise from HV regulators

While under the proposed modification a switch room, high voltage regulators, an alternative Operational Motorway Control System (OMCS) room and a separate stair access leading down to the ventilation tunnel would be required on the surface, the only element of this surface infrastructure which required noise assessment are the high voltage regulators (HV regulators).

The HV regulators are electrical transformers with operational noise levels expected to be approximately 65dB(A) at 1m, which would be confirmed during procurement. The regulators would be surrounded by core-filled blockwork on all sides.

There are also On Load Tap Changers (OLTC) attached to the regulators that operate for periods of 10-15 seconds at a time, and usually occur during peak hours of tunnel operation as more load is required. This operation generates noise levels of approximately 72dB(A) at 1m over this short duration. If OLTC operation occurred for 15 seconds within a 15-minute assessment period, this would add approximately 1dBA to the total HV regulator plus OLTC noise emission.

The nearest residential receivers are on the north side of Callan Street, and share a common boundary with the site. Most receivers are single storey dwellings, however there is one dwelling with a recent double storey addition.

Based on a HV regulator noise level of 65dB(A) at 1m, + 1dB(A) for OLTC, 8dB(A) distance loss, and 10dB(A) reduction from the blockwork walls, noise levels could be up to 48dB(A) at ground level receivers. At first floor receivers noise levels may be up to approximately 53dB(A). A low-frequency annoyance penalty has not been applied for regulator noise as this noise emission would not emerge enough above the ambient traffic noise levels (around 60dB(A)) to trigger the application of this penalty under the Industrial Noise Policy (NSW Environment Protection Authority 2000) procedures.

The aim is to mitigate HV regulator noise to 45dB(A), so that the combination of HV regulator noise and ventilation outlet noise would not exceed 48dB(A) at any nearby property.

During the night-time when electrical loads are low, the predicted noise levels may be 3dB(A) less than those shown for full load, in which case ground level receivers would be 45dB(A) and would comply. Some additional noise mitigation may be required for the first-floor receiver.

The following additional noise mitigation measures would be considered during the detailed design so that the combination of HV regulator noise and ventilation outlet noise would comply at nearby properties:

During the procurement process for the HV regulators, the aim would be to procure equipment less than 65dB(A) at full load, and less than 62dB(A) at typical night-time loads.

Blockwork walls around the transformers would be as high as practical (minimum 4m high), particularly on southern and eastern sides to maximise noise reductions.

If additional noise reduction is required, installing a partial pitched roof would be investigated. A full roof is not practical due to cooling requirements.

If further reduction is required, the underside of the pitched roof and the inner face of the walls would be lined with acoustic absorption material where practical.

Operational noise mitigation measures would be confirmed in the Operational Noise and Vibration Review to be prepared in accordance with Planning Approval Condition E92.

5.3 Predicted operational vibration levels

Operational vibration impacts are predicted to be negligible for the following reasons:

- The majority of operational sources are relocated underground as part of this proposed modification and there are relatively large distances to buildings at the surface. Figure 13 demonstrates the depth of the ventilation and substation tunnels/ caverns
- Ventilation fans would be installed with appropriate vibration isolation mounts such that vibration is not transmitted from the fan cavern to the surrounds
- The substation is also relocated underground, and substations do not generally contain plant or machinery that generates significant levels of vibration
- The HV regulators and OLTC do generate any significant levels of vibration during operation.

5.4 Change in traffic noise levels

Modelling for traffic noise levels in the EIS did not include the ventilation facility between Springside Street and Callan Street or the substation between Callan Street and Toelle Street. This conservative approach to traffic noise modelling reflects the uncertainty related to the detailed design of operational infrastructure. As these surface operational buildings did not influence the EIS traffic noise model, the proposed removal of the ventilation facility will have no impact on the traffic noise predictions. The proposed construction of operational buildings between Callan Street and Toelle Street will provide some traffic noise shielding to residents adjacent to these structures, potentially improving operational traffic noise relative to the EIS predictions.

All properties impacted by traffic noise would be mitigated in accordance with the RMS Noise Mitigation Guideline as part of the operation noise and vibration review required by the Planning Approval.

5.5 Sleep disturbance from operation

The operational noise sources are generally fairly constant noise sources and are unlikely to cause sleep disturbance as will be mitigated to meet the INP criteria. Electrical switching equipment is wholly contained within the switch room and are therefore not expected to be an issue. The item that has the most potential to cause sleep disturbance is the On Load Tap Changer (OLTC), which is attached to the HV regulator and located inside the concrete blockwork walls. The OLTC operates for periods of 10 -15 seconds at a time. This operation generates noise levels of approximately 72dB(A) at 1m.

Based on 8dB(A) distance loss and 10dB(A) reduction from the blockwork walls, maximum noise levels from this operation could be up to 54dB(A) at the nearest receivers.

The INP does not contain sleep disturbance criteria. Taking guidance from the Noise Policy for Industry (EPA, 2017), sleep disturbance screening criteria is either LAFmax 52dB(A), or the prevailing RBL plus 15dB, whichever is the greater.

Based on a night-time RBL of 43dB(A), the sleep disturbance screening criteria is 43 + 15 = 58dB(A). As the predicted maximum noise level of 54dB(A) is below the screening criteria of 58dB(A), sleep disturbance impacts are unlikely.

6 Conclusion

Renzo Tonin & Associates was engaged by the Contractor to prepare a noise and vibration assessment of the proposed modification to the ventilation ancillary facilities at Iron Cove Link during the construction and operational phases. The findings of this noise and vibration assessments are summarised below.

6.1 Construction noise and vibration

6.1.1 Tunnelling of underground ventilation tunnel and caverns

There are 78 residential properties where ground-borne noise (GBN) levels are predicted to be above the night-time GBNML in Noise Catchment Area (NCA) 33 and NCA32. However, more than two thirds of these receivers (i.e. 78%) are predicted to be exposed to maximum ground borne noise (GBN) levels between 35 and 40 dBA. Only a small portion of these receivers (i.e. 18%) is expected to be between 40 and 45 dBA. Finally, only three receivers in NCA33 are predicted to be more than 45 dBA. The maximum GBN level is predicted to be 47 dBA. These GBN affected receivers are in addition to the receivers already identified in the M4-M5 Link EIS, APPENDIX J, Table 5-148 during mainline tunnel excavation works. Due to the advance rate of roadheader works, this impact is expected to be relatively short-term in duration (i.e. approximately 2-3 weeks per roadheader pass).

In accordance with Planning Approval Condition E82, mitigation measures would be implemented when predicted GBN levels are above relevant GBN management levels in accordance with the approved Construction Noise and Vibration Management Plan (CVNMP). The proposed new ventilation tunnel and caverns would equate to a total length of about 425 metres. This calculation is based on a length of about 340 metres for the ventilation tunnel alignment and the ventilation fan cavern, 65 metres for the substation cavern and about 20 metres of access tunnel connecting the two caverns. It is important to note that Rozelle Interchange (which is Stage 2 of the M4-M5 Link Project) includes excavation of approximately 23 kilometres of tunnels and that the proposed modification is limited to the construction of about 425 metres of additional tunnels and caverns, which represents a very small increase in the extent of tunnelling and associated construction ground-borne noise impacts.

No sensitive receivers are located within minimum working distances for roadheader during tunnelling works for the proposed ventilation tunnels, therefore the risk of disturbance due to vibration from roadheader excavation works is considered low.

6.1.2 Tunnel support construction works

All plant, equipment and materials required to construct the proposed new ventilation tunnel and caverns would be supported from the Iron Cove civil site, with the potential for some tunnelling to be supported from the Rozelle civil and tunnel site later in the construction program. As the proposed new ventilation tunnel and cavern works would be supported from the Iron Cove Link civil site but could also use the Rozelle civil and tunnel site, this assessment has been completed assuming the worst-case impacts of all deliveries and spoil transportation occurring from either site.

The Iron Cove civil site within the cut and cover - there would be no properties affected by construction noise associated with the tunnel support site operation. As tunnel support would be a 24-hour operation, noise impacts at night were also predicted and found to be below the noise management level (NML) at receivers nearby the worksite. A detailed construction noise and vibration assessment will be prepared for the proposed activities at the Iron Cove Link site in accordance with the approved CNVMP to document the outputs of detailed noise and vibration modelling and confirm the optimum suite of noise and vibration mitigation measures

Rozelle civil and tunnel site - should tunnelling be supported from Rozelle civil and tunnel site there would be a minor increase in spoil trucks and deliveries due to the proposed modification. However, support of excavation works associated with the proposed modification would not overlap with peak construction activities associated with the overall Project which are scheduled to occur in March 2021. Impacts of the peak construction support has been already included in the assessment of the operation of the Rozelle civil and tunnel site and suitable mitigation measures have been identified. As such, the slight increase in spoil trucks and deliveries at Rozelle civil and tunnel site worksite would not require additional mitigation measures.

It is important to note that the above tunnel support options represent two worst case scenarios with all tunnel support either via the Iron Cove civil site or the Rozelle civil and tunnel site. Construction noise impacts associated with these worst cases are similar to the EIS results indicating either option is acceptable. It is likely that the additional tunnelling required under the proposed modification would be completed predominately from the Iron Cove civil site with some tunnelling also supported from the Rozelle civil and tunnel site later in the programme.

6.1.3 Permanent surface construction works

Construction airborne noise: the proposed modification would result in a shorter duration of surface works than the EIS concept design and greatly reduced scope of works at Iron Cove as only a switch room, high voltage regulator (HV regulator) bays, Operational Motorway Control System (OMCS) room and stair access need to be built. Potential construction noise and vibration impacts would be managed in accordance with the processes set out in the CNVMP prepared in accordance with Planning Approval Condition C4(b).

6.2 Operational noise and vibration

The proposed relocation of the ventilation fans and substation underground would have a long-term acoustic benefit by reducing the operational noise impacts compared to the EIS. The predicted noise exceedance at NCA33 identified in the EIS would be avoided through selection of appropriate noise attenuators and noise compliance would be achieved at all surrounding NCAs.

The assessment completed in this report has demonstrated that the operation of the HV regulators would comply with the required noise criteria, subject to the implementation of mitigation measures. Mitigation measures for the HV regulators at surface have been identified and would be confirmed during detailed design so that the combination of HV regulator noise and ventilation outlet noise would comply at nearby properties.

Noise impacts from the operation of the Iron Cove fixed facilities are consistent with or less than the potential impacts identified in the EIS. Operational noise mitigation measures would be confirmed in the Operational Noise and Vibration Review to be prepared in accordance with Planning Approval Condition E92.

WestConnex M4-M5 Link

Rozelle Interchange – Modification: Iron Cove ventilation underground

Modification report

Appendix E

Groundwater drawdown and potential surface settlement

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Roads and Maritime Services

WestConnex - M4-M5 Link

Iron Cove Ventilation Underground Modification Report

Modification report

Appendix E Groundwater drawdown and potential surface settlement

November 2019

Prepared for

Roads and Maritime Services

Prepared by

WSP/Arcadis Joint Venture (WAJ)

Contents

1 Introduction

1.1 Purpose

This report has been prepared by WSP/Arcadis Joint Venture (WAJ) to provide an overview of the predicted project-induced surface settlement and potential impacts to existing structures associated with the proposed modification to underground the ventilation ancillary facilities at Iron Cove Link.

The Planning Approval (SSI 7485) for the M4-M5 Link Project sets out requirements that must be met with respect to geotechnical modelling, settlement predictions and impact assessment and management. Pertinent to this report are Planning Approval Conditions E101 to E104 which detail requirements relating to geotechnical modelling, settlement criteria and monitoring. Planning Approval Conditions E105 to E109 set out requirements relating to pre- and post-building dilapidation surveys and a mechanism for addressing property damage disputes. The conditions require the Proponent to take account of ground settlement as a result of the Rozelle Interchange project (the project) works and undertake the design and construction of the project to limit the potential impacts on existing and approved buildings and other surface and sub-surface infrastructure.

Potential settlement associated with the proposed modification is currently being assessed as part of the project-wide settlement modelling and impact assessment processes and will be finalised during detailed design. The settlement criteria adopted for the project and the assessment and monitoring processes to be adopted by JHCPB in designing and constructing the Rozelle Interchange (Stage 2) of the M4-M5 Link Project are in accordance with the Planning Approval and are described within this report. This process includes:

- Review of ground conditions including soil and rock types and natural fluctuations in groundwater levels
- Calculation of predicted ground movement as a result of tunnel construction
- Development of a detailed ground settlement model which addresses the short-term and long-term settlement expected
- Identification of buildings and surface and sub-surface infrastructure which may be considered as sensitive and potentially at risk based on the expected settlement
- Monitoring of baseline conditions and any actual ground movement.

As tunnel excavation progresses, the results of the surface monitoring of settlement will be reviewed against the model to verify predications and, if required, refinements made to the design and/or construction methodology.

1.2 Structure of this report

This report is structured as follows:

- A description of the proposed modification is provided in Section 2
- An overview of the assessment of the potential settlement impacts of the project included in the Environmental Impact Statement (EIS) is set out in Section 3 along with extracts from the former Department of Planning and Environment's Environmental Assessment Report (EA Report) on the M4-M5 Link Project
- The potential impacts of the proposed modification are set out in Section 4
- An overview of the tunnel design, modelling and building impact assessment development and approval process is provided in Section 5
- An overview of settlement monitoring to be undertaken prior to and during construction is set out in Section 6
- Conclusions are documented in Section 7.

2 The proposed modification

The EIS described an electrical substation and ventilation exhaust facility located in separate buildings on the surface in the vicinity of Callan and Springside Streets, Rozelle, that together would comprise the Iron Cove Motorway Operations Complex (MOC 4).

The proposed modification would relocate MOC4 underground, including the electrical substation and ventilation facilities (the ventilation outlet will remain above ground in the same location as illustrated in the EIS) A switch room, high voltage regulators, an alternative Operational Motorway Control System (OMCS) room and a separate stair access leading down to the ventilation tunnel would be required on the surface on the western side of Victoria Road between Toelle and Callan Streets.

The following points provide an overview of the proposed ventilation tunnel and caverns:

- Construction of about 340 metres of ventilation tunnel with connections to the main Iron Cove Link tunnel on the western side of the tunnel portals and south of Moodie Street, between Waterloo and Cambridge Streets. This ventilation tunnel would be on average about 10 metres wide. The depth of the ventilation tunnel would vary from about eight metres (from ground level to tunnel crown) at its shallowest to about 25 metres (from ground level to tunnel crown) at its deepest
- The ventilation tunnel would include two caverns for the housing of ventilation equipment and the electrical substation
- The ventilation cavern would contain four ventilation fans laid horizontally, with associated attenuators and dampers. The dimensions of the exhaust fan cavern would be about 25 metres wide, 15 metres high and 70 metres long
- The cavern containing the electrical substation would be parallel to the cavern containing the ventilation. The dimensions of the substation cavern would be about 20 metres wide, 10 metres high and 65 metres long
- A five-metre wide and 20-metre long access tunnel, to facilitate personnel access from the exhaust fan cavern into the substation cavern
- The Iron Cove cut and cover area would include a side access for the vent tunnel to connect to the cut and cover about 7 metres wide and 17 metres long. This area would also accommodate the access stairs to the surface.

The ventilation tunnel and caverns would be constructed in sound rock (i.e. sandstone) and would be excavated as described for the M4-M5 Link Project's other ventilation tunnels in Section 6.4.2 of the EIS. The ventilation tunnel and caverns would be drained and a sprayed shotcrete lining, consistent with the other ventilation tunnels and caverns to be constructed as part of the approved project. The tunnel lining would be installed progressively with the tunnel excavation.

The alignment of proposed new ventilation tunnel and caverns at Iron Cove is shown in Figure 1. The approved Iron Cove Link road tunnels are shown in orange, with the approved cross passages shown in brown.

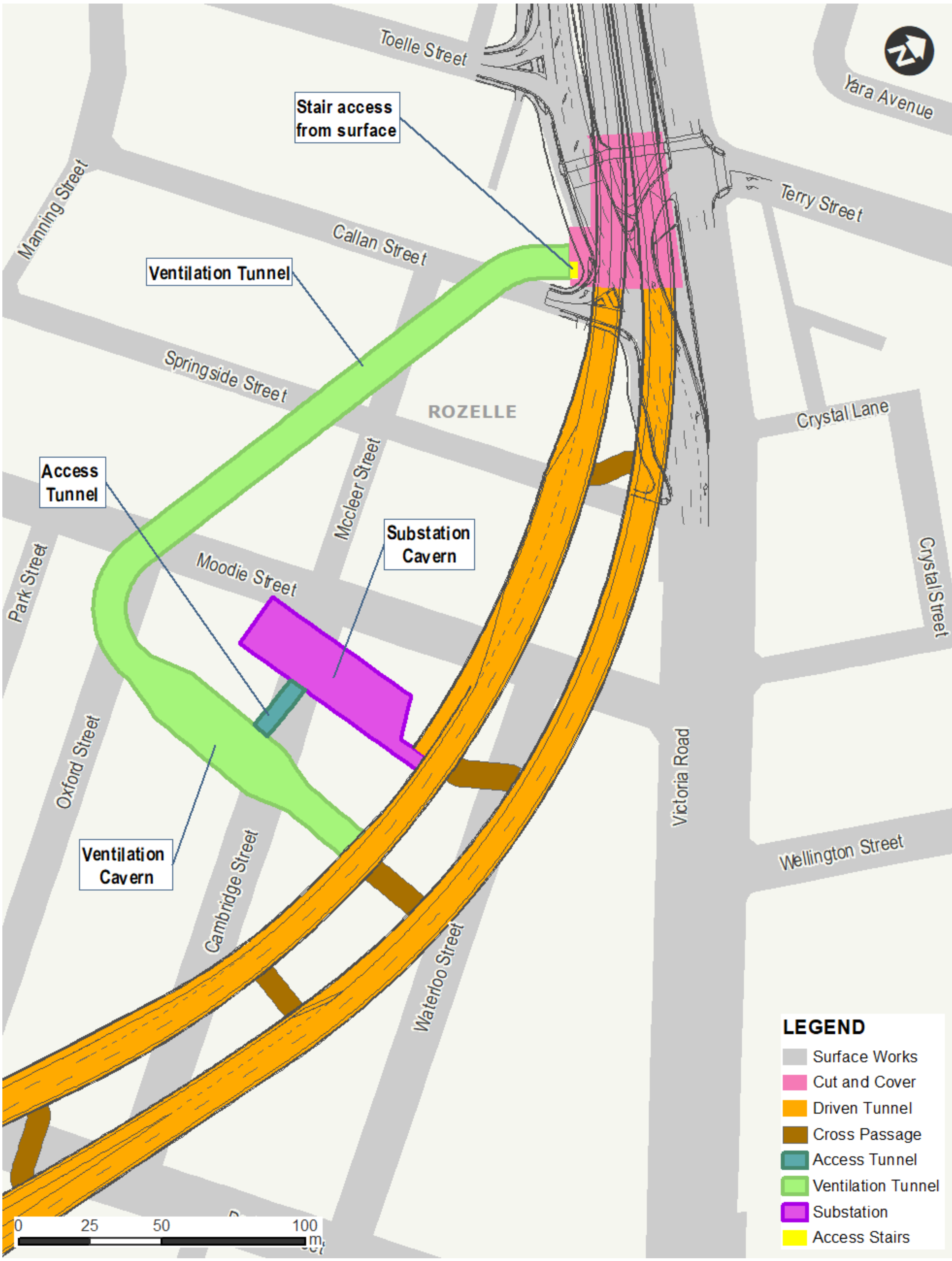

Figure 1 Alignment of proposed new ventilation tunnel and caverns at Iron Cove

3 EIS findings, independent assessment and Planning Approval Conditions

3.1 Overview of EIS findings on ground movement

The EIS identifies two causes of potential ground movement associated with the construction of the project:

- Tunnel excavation induced ground movement, which is the slight movement of the soil and rock around the tunnel as a result of the tunnel excavation removing material. This is a short-term effect, which happens as soon as the tunnel is excavated and can cause heave and/or settlement
- Soil consolidation (soil shrinkage) and rock compression due to the groundwater drawdown due to inflow into underlying tunnels. This is a longer-term effect, which may take some time to occur and causes settlement only.

These aspects are assessed separately in Chapters 12 and 19 of the EIS.

EIS Chapter 12 notes that the areas most likely to be affected by settlement are usually where tunnelling is closest to the ground surface (shallowest), around the tunnel portals and entry and exit ramps, and where soils are more likely to be compressible and thus have more voids which can compress. The EIS states that induced ground movement due to the tunnel excavation would occur primarily during the construction phase. Generally, settlement would be greatest in magnitude directly above the tunnel centreline, reducing with increased distance from both the tunnel sides and ahead of the tunnel face.

The EIS notes that the manner in which a building or structure responds to ground movement also depends on its size, design, materials, foundations and age. For instance, the EIS states that a timber or steel framed structure may be flexible, deflecting as the ground moves whereas a masonry building if subject to similar ground movement may behave differently. The EIS notes that other relevant factors may include the overall height (number of storeys) of the building and whether the building has basement levels.

The EIS adopts settlement criteria applied to other WestConnex projects and notes that preliminary geotechnical investigations and the assessment of potential settlement impacts have been carried out to inform the development of the concept design documented in the EIS. The preliminary assessment documented in the EIS shows that over the majority of the tunnel alignment predicted ground movement is less than 20 millimetres, which would be consistent with the criteria for sensitive buildings. The assessment focuses on areas where the tunnel was shallower and identified some areas where predicted ground movement would be greater than 20 millimetres.

The EIS concludes that further assessment including hydrogeological modelling would be undertaken during detailed design to determine the level of predicted settlement impacts.

Potential impacts associated with groundwater drawdown were addressed in EIS Chapter 19. The EIS notes that groundwater levels are impacted by both natural external influences such as rainfall permeation and drought and built elements including existing development and construction works including tunnel excavation.

The EIS documents rates of operational groundwater inflows monitored in recent years from several tunnels in the Sydney area designed to allow limited inflow of groundwater (referred to as drained structures) with similar geology, hydrogeology and construction to that proposed by the M4-M5 Link Project. The EIS noted that the groundwater inflow for these projects including the Eastern Distributer, M5 East Motorway, Epping to Chatswood Rail Line, Lane Cove Tunnel and Cross City Tunnel vary from 0.6 litres per second per kilometre to up to 1.7 litres per second per kilometre.

The EIS notes that the short-term inflow during construction would be dependent upon a number of factors including tunnelling progress, tunnelling construction methodology, fractured zones intersected, localised groundwater gradients and storability (the volume of water released from storage per unit decline in hydraulic head in the aquifer, per unit area of the aquifer).

The EIS states that initial inflows to tunnels can be large, because of the large hydraulic gradients that initially develop near the tunnel walls; however, these gradients would reduce in time as drawdown impacts extend to greater distances from the tunnels and inflows approach steady state conditions. The EIS identifies that higher inflow rates are likely from zones of higher permeability, where saturated geological structural features are intersected by the tunnels. During construction, high permeability zones that are likely to have higher inflows over the longer term would be grouted to reduce the inflow rate. Grouting is the process of pumping grout into the rock mass by drilling and the injection of cement to reduce the permeability of the rock.

Initial groundwater inflows to the tunnels during construction are estimated in the EIS to range between 0.45 megalitres per day and 2.87 megalitres per day. The EIS concludes that the maximum inflows are predicted to peak towards the end of construction in 2021 at 2.45 megalitres per day or 0.77 litres per second per kilometre. This prediction is below the overall WestConnex tunnel operational inflow criterion of one litre per second per kilometre for any kilometre length of the tunnel.

The EIS concludes that during construction, the regional extent of drawdown impacts due to tunnel construction would be minimal, even though initial groundwater inflows are high. This is due to the generally low hydraulic conductivity of the Ashfield Shale and the Hawkesbury Sandstone restricting the extent of drawdown during the relatively short construction timeframe.

With respect to potential impacts on existing groundwater users, the EIS groundwater model predicted that no registered bore within two kilometres of the project footprint would be drawn down more than two metres (the minimum impact criterion under the NSW Aquifer Interference Policy) during the project construction program.

The EIS notes additional groundwater modelling would be conducted during construction using measured tunnel inflow rates and monitored groundwater drawdown to better calibrate the model and predict impacts. The EIS also notes that monitoring of settlement throughout the construction program would be undertaken. The EIS concludes that a geotechnical model of representative geological and groundwater conditions would be prepared prior to excavation and tunnelling for the project. The model would be used to assess predicted settlement impacts and ground movement caused by excavation and tunnelling on adjacent property and infrastructure.

The EIS identifies a range of options that are available to minimise settlement in areas where ground movement in excess of the relevant settlement screening criteria are predicted including:

- Review of the proposed tunnel design including the proposed tunnel support system and the tunnel lining
- Review of the construction methodology such as the rate of tunnel advance and consideration of ground improvement options.

The EIS concludes that it is anticipated that a combination of the abovementioned options would be sufficient to ensure that ground movement associated with the project is less than the relevant settlement criteria.

3.2 Department of Planning and Environment’s Environmental Assessment Report and Planning Approval

The Environmental Assessment Report (EA Report) prepared by the former Department of Planning and Environment (now Department of Planning, Industry and Environment) dated March 2018 noted there is potential for settlement due to tunnel excavation and groundwater drawdown. The EA Report acknowledged the EIS findings that areas most likely to be affected are where the tunnel would be closer to surface level or intersect paleochannels.

The EA Report noted that further modelling is required during detailed design of the project to confirm settlement predictions.

The EA Report proposed a number of measures to manage settlement in areas identified as likely to be affected by settlement, including building conditions surveys, the implementation of a settlement monitoring program and rectification of any property damage caused by settlement. Additional numerical modelling will also be undertaken during detailed design to refine the spatial extent of potential settlement impacts. The EA Report considered that the design outcomes for the project should be guided by strict and contemporary settlement criteria similarly imposed on projects such as the WestConnex New M5 project (recently modified in relation to settlement).

Relevant Conditions in the Planning Approval for the M4-M5 Link and Revised Environmental Management Measures (REMMs) are set out in Appendix A and B.

4 Potential impacts of the proposed modification

As noted in Section 3, cumulative settlement impacts include the combined impacts of settlement from tunnel excavation induced ground movement and groundwater drawdown.

The new ventilation tunnel and caverns would equate to a total length of about 425 metres and would be excavated below residences not identified in the EIS as being near the tunnel alignment. This calculation is based on a length of about 340 metres for the ventilation tunnel alignment and the ventilation fan cavern, 65 metres for the substation cavern and about 20 metres of access tunnel connecting the two caverns. It is important to note that Rozelle Interchange (which is Stage 2 of the M4-M5 Link Project) includes excavation of approximately 23 kilometres of tunnels and that the proposed modification is limited to the construction of about 425 metres of additional tunnels and caverns, which represents a very small increase in the extent of tunnelling.

Areas most likely to be affected by settlement are where tunnelling is closest to the ground surface (shallowest), and where soils are more likely to be compressible because they have more voids which can compress. In Iron Cove, the depth to Hawksbury Sandstone is very shallow, with overlaying soils generally less than two metres in depth.

The depth of the proposed new ventilation tunnel and caverns would vary from about eight metres (from ground level to tunnel crown) at its shallowest to about 25 metres (from ground level to tunnel crown) at its deepest (see Figure 2).

Figure 2 Indicative depth from ground level to crown of ventilation tunnel and caverns

The proposed new ventilation tunnel and caverns would be located within Hawksbury Sandstone which is a highly competent bedrock. A cross-section of the geotechnical profile in Iron Cove which illustrates the proposed tunnel and ventilation cavern is provided in Figure 3. The crown (top) of the tunnel and ventilation cavern is marked in orange and the base is marked in blue.

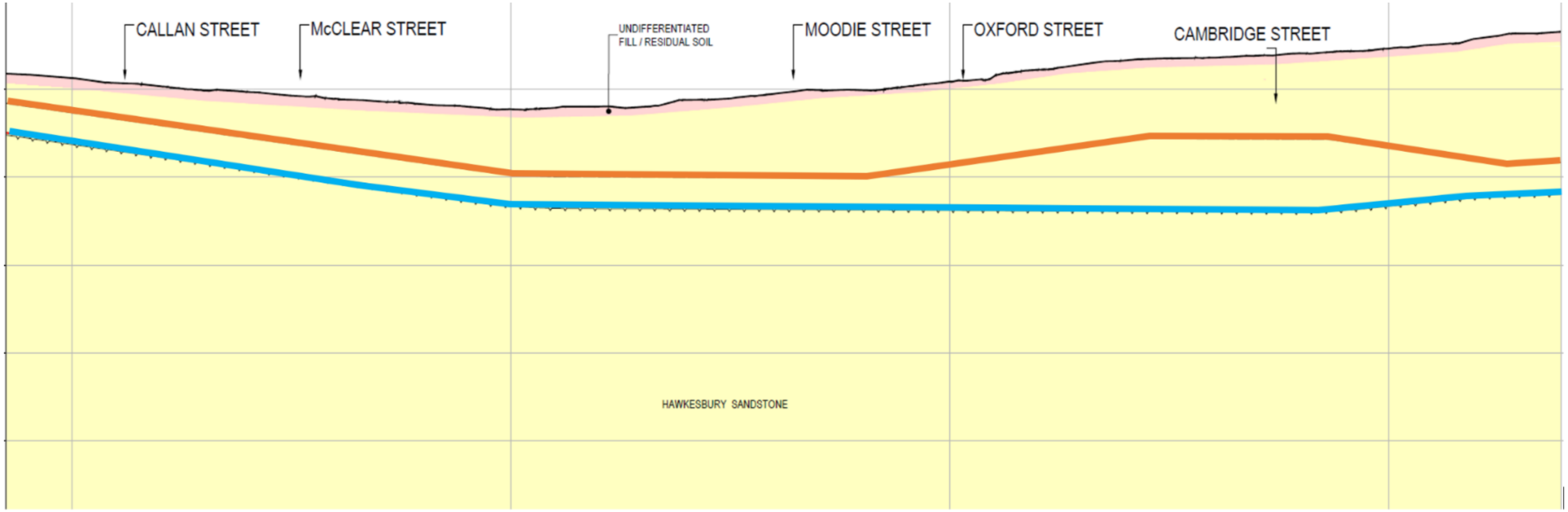

Figure 3 Iron Cove ventilation tunnel geological cross-section. Orange represent the top of the tunnel and blue represent the base of the tunnel.

Even the shallowest section of the proposed new tunnel would have substantial rock cover above the crown of the tunnel. It is also noted that the wider cavern excavations are generally located at depths greater than 15 metres. The ventilation tunnel and caverns connect to the Iron Cove Link road tunnel alignment and are therefore located at similar depths.

Consistent with the EIS findings, tunnel excavation induced ground movement is anticipated to be the prevalent mechanism causing ground movement. Risks associated with groundwater drawdown and associated induced settlement within Hawkesbury Sandstone is considered low because of the geotechnical properties of the rock. As groundwater is removed from this rock type the structural integrity and strength of the rock remains due to its competent nature. As a result, the cumulative settlement impacts are not anticipated to be an issue for tunnels excavated in the Hawkesbury Sandstone which would include the proposed new ventilation tunnel and caverns at Iron Cove.

The findings of the EIS described in Chapter 19 regarding groundwater would be consistent with the implementation of the proposed modification. Tunnel groundwater inflow criteria would not be altered. The proposed new ventilation tunnel and caverns, as noted above, are located in Hawksbury Sandstone. Hawksbury Sandstone has low permeability and predicted groundwater inflows and groundwater induced settlement associated with the proposed modification would be minimal.

With respect to potential impacts on existing groundwater users, there no registered bores within two kilometres of the footprint of the proposed modification and no impacts are therefore anticipated for existing groundwater users as a result of the proposed modification.

Planning Approval Condition E190 requires the Proponent to take all practicable measures to limit operational groundwater inflows into each tunnel to no greater than one litre per second per km length of tunnel. Based on the preliminary analysis completed to date on the concept design, the total groundwater inflow that would be expected for the proposed modification in steady state would be about 0.4 litre per second per kilometre length. During construction this may increase by about 0.1 litre per second to about 0.5 litres per second per kilometre length.

The preliminary settlement analysis completed to date, which combines both predicted excavation induced, and short and long-term groundwater drawdown settlement is illustrated in Figure 4. This assessment is based on the concept design and the predicted ground settlement ranges from 0 to 20 millimetres, which is consistent with settlement screening criteria set out in Planning Approval Condition E103 of the Infrastructure Approval (see Table 1).

Table 1 Comparison of preliminary settlement analysis against the screening criteria in Condition E103

Surface and Sub-Surface Structures	Maximum Settlement	Maximum Angular Distortion	Limiting Tensile Strain (percent)*	Compliance
Buildings – Low or non-sensitive properties (i.e. ≤ 2 levels and carparks)	30 mm	1 in 350	0.1	✓
Buildings and pools – High or sensitive properties (i.e. ≥ 3 levels and heritage items)	20 mm	1 in 500	0.1	✓
Roads and parking areas	40 mm	1 in 250	n/a	✓
Parks	50 mm	1 in 250	n/a	✓

* As defined in Burland et al. 'Building response to tunnelling – Case studies from construction of the Jubilee Link Extension', London, Thomas Telford (2001)

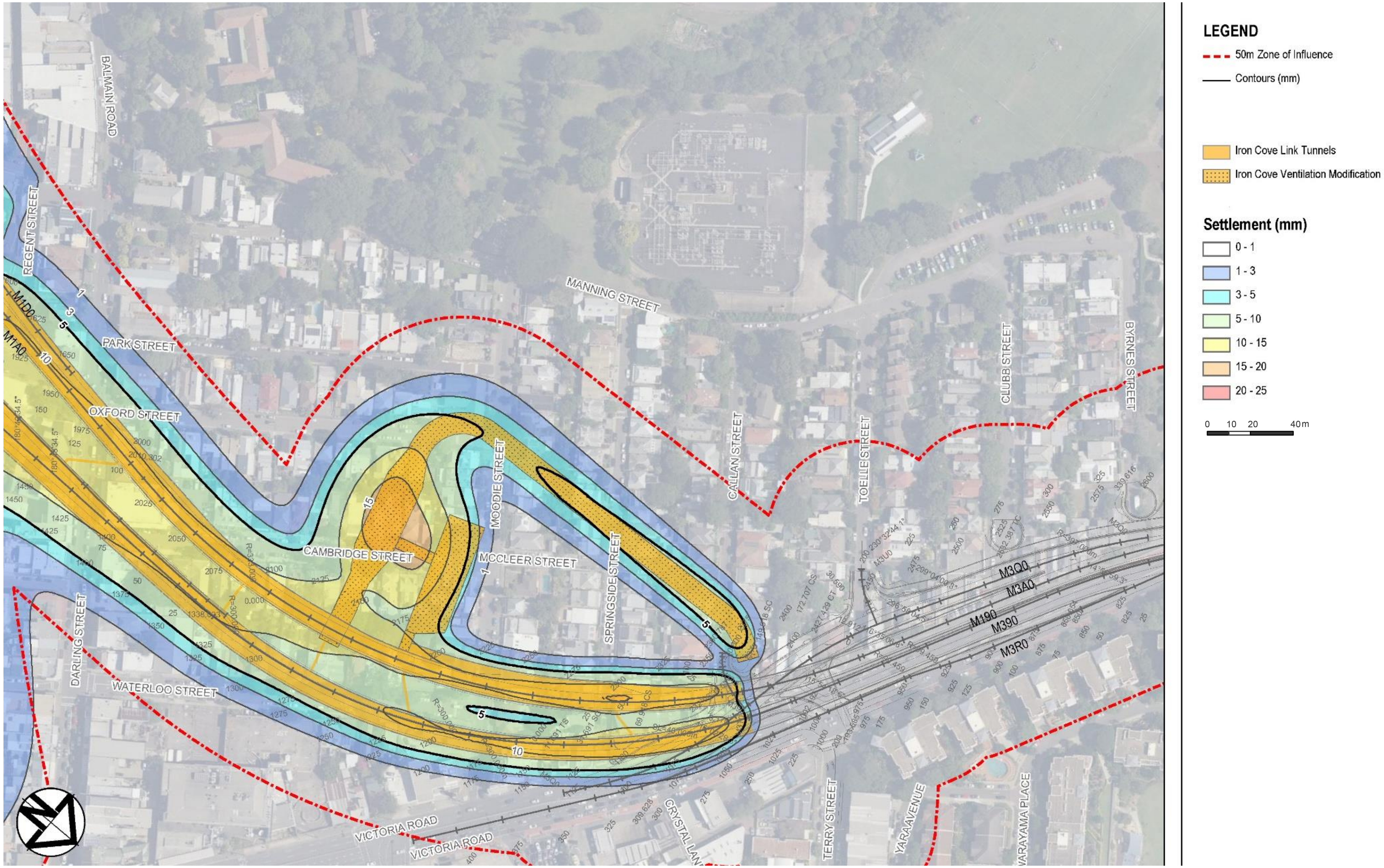

Figure 4 Preliminary settlement analysis of proposed modification (note this is subject to design development)

Based on the preliminary settlement analysis and building and structure impact assessment undertaken to date which has taken into consideration rock type, tunnel depth and building types (number of storeys and basement and foundation extents), it is not anticipated that the settlement screening criteria set out in Planning Approval Condition E103 would be triggered during excavation of the proposed new ventilation tunnel and caverns at Iron Cove.

As a result of the proposed modification, the subsurface stratum acquisition requirements and areas potentially subject to surface settlement would alter accordingly. The potential excavation-induced and groundwater drawdown impacts of the proposed ventilation tunnel and caverns would be consistent with those already identified in the EIS as:

- The proposed ventilation tunnels and caverns would be excavated in Hawkesbury sandstone
- The proposed ventilation tunnels and caverns are being constructed at a similar depth to the main road tunnel alignment for the Iron Cove Link
- The same tunnelling methodology is proposed for the construction of the proposed ventilation tunnel and caverns.

The Conditions in the Planning Approval set in place comprehensive requirements to ensure the potential impacts of the detailed design and construction methodology of the project, including the proposed modification, are assessed and potential impacts on property are minimised.

5 Tunnel design and modelling development and building assessment

5.1 Design development and approval

The design of the tunnel is subject to a staged engineering approval process that incorporates internal checking, quality assurance and external review and certification before any construction can begin. The design will be steadily developed through from concept to the final level of detail required to construct it.

An Independent Certifier has been appointed to the project to certify the design.

The tunnel design is broken down into packages to cover discreet geographical areas of the tunnel, to account for the shape of the tunnel and ground conditions at those areas and the construction program. Each tunnel design package is developed based on:

- Review of ground conditions and natural ground water parameters
- Calculation of predicted ground movement as a result of the tunnel construction
- Development of a detailed ground settlement model which addresses the short-term and long-term settlement expected (see Section 5.2)
- Identification of buildings and infrastructure which may be considered as sensitive and potentially at risk based on the expected settlement (see Section 5.3).

The Independent Certifier for the project and Roads and Maritime Services (RMS) comment on the design at each stage of its development and check its compliance with the project requirements including the Planning Approval. These comments are then reviewed by the designer and the contractor and any changes required are incorporated in the next stage of the design. The design is only issued to the contractor for construction to begin after completion of this detailed review process and when all comments have been closed out and the Independent Certifier issues a certificate to confirm that the design meets the requirements of the contract, including the requirements set out in the Planning Approval.

5.2 Settlement prediction methodology

Ground movement is predominantly associated with short-term impacts during construction and long-term ground settlement. Outcomes are predicted by the following methods:

- Short-term settlements are estimated by adding the tunnel excavation induced settlements and the groundwater drawdown induced settlements during the construction period (typically two to five years). Settlement associated with tunnelling induced ground loss (mined tunnels) and the movement of earth retaining walls (cut and cover tunnels) are derived by performing numerical modelling and by empirical methods
- Long-term settlements are derived by adding the tunnel excavation induced settlements and groundwater drawdown induced settlements for 50 years when indicated that the steady state condition is reached. This will include the time dependent consolidation of the soft layers and compression of the hard layers.

Figure 1 shows construction induced impact assessment flowchart.

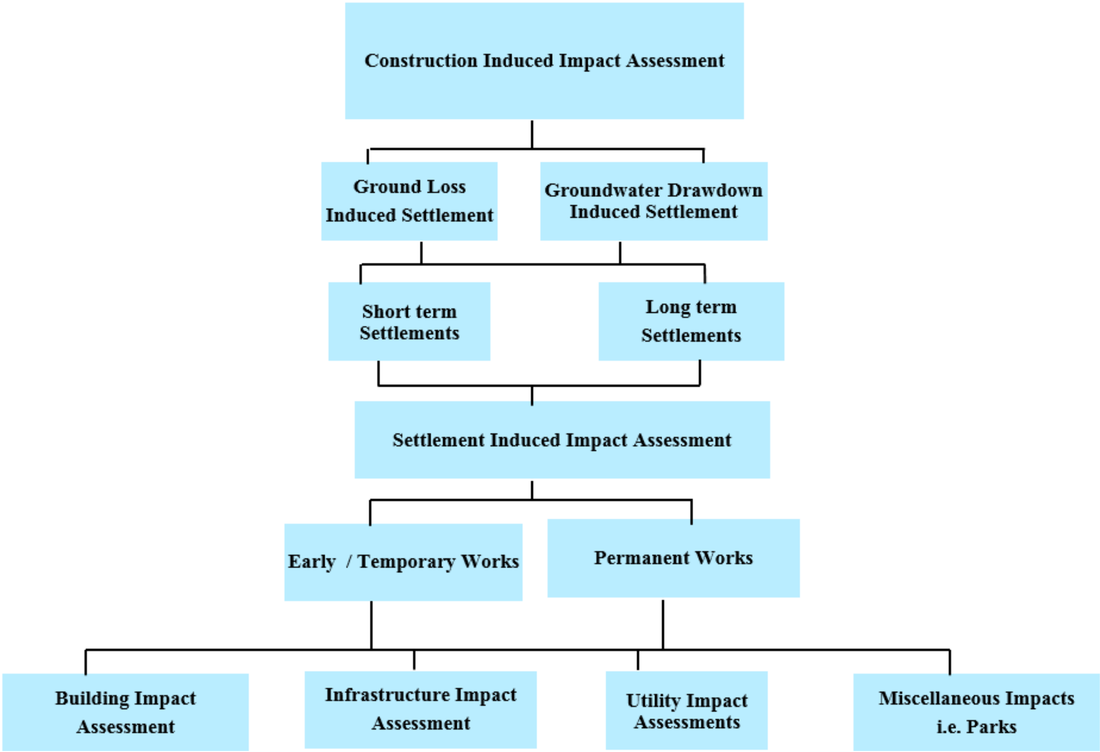

Figure 1 Construction Impact Assessment Flowchart

Settlement induced by mined tunnel excavation using road headers, rock hammers and if adopted surface miners and drill and blast is predicted using empirical methods and validated by performing detailed numerical modelling, giving consideration to the expected construction sequences.

Tunnelling induced ground loss values are assumed based on past projects in similar ground conditions and validated based on numerical analysis results. Three-dimensional models are developed to account for the complex nature of the project alignment, characterized by interacting tunnels. This is a proven approach that is being used by the tunnelling industry worldwide.

During construction and long-term operation of a drained underground structure (which allows the controlled inflow of groundwater), there is potential for groundwater to drain into the excavation, resulting in lowering of the natural/baseline groundwater table. This groundwater drawdown results in an increased effective weight of the ground, which will induce elastic compression of the ground in the short term and consolidation settlement in the long term. Tunnel excavation induced groundwater drawdown has been predicted for the both short- and long-term condition using numerical analysis tools. The zone of influence adopted for the assessment of potential groundwater drawdown impact has been developed based on previous experience and precedence from other recent tunnelling projects in Sydney. Buildings and infrastructure located beyond the zone of influence are considered to have “negligible” or no impact as a result of ground movements from the work. No further assessment is undertaken when existing infrastructure is outside the zone of influence defined above as the settlement beyond this limit is negligible and therefore the effect dissipates.

Preliminary settlement contours are presented in Figure 4 and these settlement contours will be refined and updated as the design development progresses and include the results of the excavation and groundwater induced settlement modelling and indicate any locations(s) where the settlement screening criteria in Planning Approval Condition E103 and determined under Planning Approval Condition E102 are predicted to be exceeded for further assessment.

5.3 Building and structure impact assessment

Each structure including buildings, swimming pools, utilities and roads within the potential zone of influence corridor is to be evaluated for potential impact due to settlement resulting from the project. Tunnelling (excavation) induced settlements and sub-surface movements can induce changes in the stresses and strains within existing buildings and structures which, depending on the magnitude, may lead to damage. The impact of the ground movement on a building or structure is influenced by:

- The nature of its construction
- The form of its foundations
- The magnitude of the ground movement
- The proximity of the building to the ground movement
- The dimensions
- Its geometrical relationship to the works
- The associated change in strains and stresses in the building or structure.

In addition to the settlement screening criteria set out in Planning Approval Condition E103 of the Infrastructure Approval, individual criteria will be developed for other surface and subsurface structures where required in consultation with the asset owner.

A staged approach will be adopted with an initial conservative overestimation of settlement to identify and eliminate from further consideration those structures at low risk of damage. A more refined analysis will be undertaken for buildings and structures that are identified as potentially at higher risk of damage. This works to focus the assessment on the buildings and structures potentially most susceptible to damage, with second and third stage detailed evaluation carried out on buildings and structures where a higher potential for damage is predicted in the initial assessment.

As noted in Section 4, based on the preliminary settlement analysis and building and structure impact assessment undertaken to date, it is not anticipated that the settlement screening criteria set out in Planning Approval Condition E103 would be triggered during excavation of the proposed new ventilation tunnel and caverns at Iron Cove.

Based on the findings of detailed settlement modelling pre-dilapidation and subsequent post-dilapidation surveys are offered to property and asset owners in advance of and following tunnel excavation in accordance with Planning Approval Conditions E105 to E107.

The tunnel excavation commences only following:

- Comprehensive settlement modelling
- Building and structure impact assessment
- Design development and refinement by specialist consultants and designers
- RMS review and Independent Certifier approval.

This process will work to ensure the project requirements including in the Planning Approval have been met.

An Independent Property Impact Assessment Panel (IPIAP) has been established by RMS in accordance with Planning Approval Condition E109. The Panel is composed of independent geotechnical and engineering specialists with experience in conducting property damage assessments. The purpose of the IPIAP is to independently review and resolve property damage disputes at the request of either the affected owner or RMS.

6 Settlement monitoring

Ground settlement will be monitored prior to and during excavation and impacts assessed in order to validate the modelling set out in Section 5.2. Monitoring and assessment will be carried out with the primary function of collating baseline data on natural groundwater fluctuations prior to the commencement of tunnelling and checking that actual ground movements are consistent with the predicted ground movements during excavation, and that design assumptions and predicted effects on third party assets are acceptable. Monitoring and assessment will include:

- Monitoring ground levels (surface and subsurface) and effects on adjacent and overlaying structures
- Providing an indication and warning of any impending instability, excessive deformation or failure
- Investigating ground behaviour and the response of structures and other property
- Determining pre-construction behaviour of existing structures
- Evaluating critical design assumptions and validating design models
- Developing and implementing contingency plans if the actual behaviour significantly deviates from the acceptable criteria
- Providing assurance to third party building and infrastructure owners and other stakeholders that the impacts of construction are as predicted and acceptable.

The monitoring program will identify trigger values to ensure that if the monitoring data indicates changes in what was predicted, then processes will be put in place to ensure review of the data is undertaken. For each aspect being monitored the trigger level will vary, but a common approach ensures that any changes to expected ground behaviour is captured early with an appropriate level of response implemented. This will include review by appropriately qualified specialists. Contingency actions may include additional monitoring, assessment of potential causes and if required design and/or construction methodology refinement.

Figure 2 shows how monitoring is carried out, starting from the design outcome (predicted effects), establishing trigger levels and baseline readings, monitoring review and reporting cycles, contingency measures and protection measures, if required.

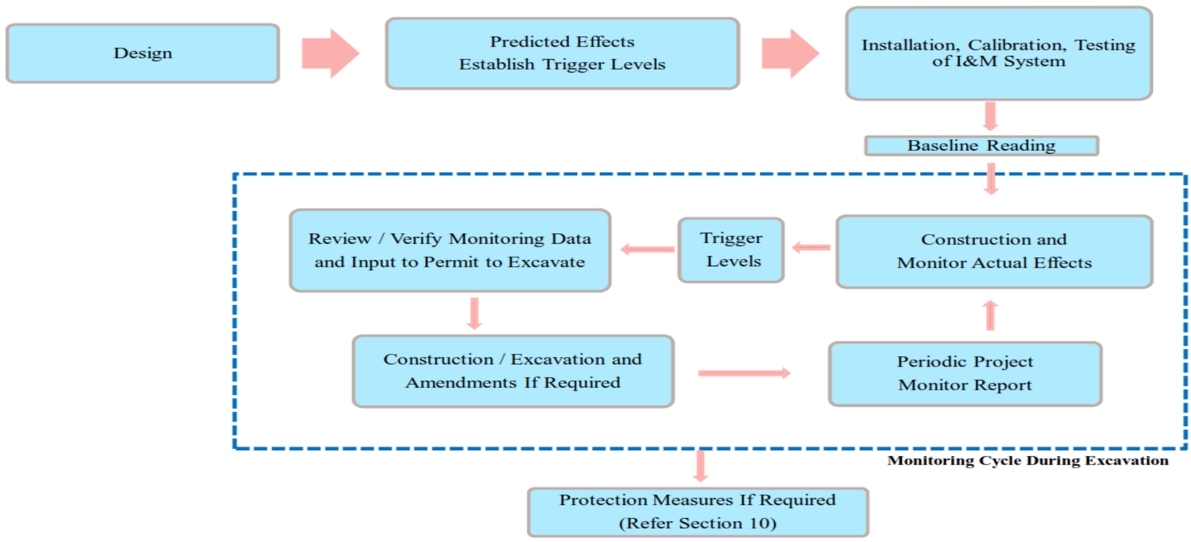

Figure 2 Monitoring Design Strategy Flowchart

7 Conclusion

The EIS included a preliminary assessment of potential settlement impacts from excavation and groundwater drawdown separately. This report summarises information and processes to provide an overall understanding of the geotechnical and settlement compliance program to be implemented during design and construction.

The preliminary settlement prediction and impact assessment indicates that the proposed modification is not anticipated to cause ground settlement above the criteria set out in the Planning Approval. The reasons for this are consistent with the EIS and include:

- The ventilation tunnels and caverns would be excavated in Hawkesbury sandstone
- The ventilation tunnels and caverns are being constructed at a similar depth to the main road tunnel alignment for the Iron Cove Link
- The same tunnelling methodology is proposed for the construction of the proposed ventilation tunnel and caverns.

The design will be reviewed as it is developed and approved by the Independent Certifier prior to construction. Comprehensive ground movement predictions that take into account the cumulative impacts of potential excavation induced ground movements and groundwater drawdown will be undertaken during design development in accordance with the Planning Approval. The findings of this modelling will be used to identify and assess buildings adopting a risk based approach as required under the Planning Approval.

The settlement monitoring program will identify trigger values to ensure that if the monitoring data indicates changes in what was predicted, then processes will be put in place to ensure review of the data is undertaken. For each aspect being monitored the trigger level will vary, but a common approach ensures that any changes to expected ground behaviour is captured early with an appropriate level of response implemented. This will include review by appropriately qualified specialists. Contingency actions may include additional monitoring, assessment of potential causes and if required design and/or construction methodology refinement.

Combined with other Planning Approval requirements including building condition surveys and the Independent Property Impact Assessment Panel, the Planning Approval sets in place comprehensive requirements to ensure the potential impacts of the detailed design and construction methodology are assessed and impacts on property are minimised. The proposed modification can be constructed in accordance with the existing Planning Approval and does not require any modifications to either the Conditions of Approval or the REMMs to successfully manage potential settlement or groundwater drawdown impacts.

Appendix A Planning Approval Compliance Matrix

There are a number of conditions in the Planning Approval for the M4-M5 Link that are applicable to groundwater and settlement. The below table references where in this report each of these conditions is discussed.

<table>
<tr><th>No.</th><th>Requirement</th><th>Reference</th></tr>
<tr><td>E101</td><td>A geotechnical model of representative geological and groundwater conditions must be prepared prior to excavation and tunnelling to identify geological structures and groundwater features. The model must include details of proposed excavations and tunnels, construction staging, and identify surface and sub-surface structures, including any specific attributes, which may be impacted by the CSSI. The Proponent must use this model to assess the cumulative predicted settlement, ground movement, stress redistribution and horizontal strain profiles caused by excavation and tunnelling, including groundwater drawdown and associated impacts, on adjacent surface and sub-surface structures.</td><td>Section 5</td></tr>
<tr><td>E102</td><td>The Proponent must undertake a review of surface and sub-surface structures at risk from damage to determine appropriate criteria to prevent damage, prior to excavation and tunnelling works that may pose a settlement risk. Criteria for surface and sub-surface structures which are not included in Condition E103 (Table 9) must be determined in consultation with the owner(s) of the surface and sub-surface structures prior to commencement of any excavation or tunnelling works potentially affecting the surface and sub-surface structures.</td><td>Section 5</td></tr>
<tr><td>E103</td><td>In the case of buildings, roads, parking areas and parks, the appropriate criteria which governs the greatest risk of damage are to be selected from Table 9 (Maximum Settlement, Maximum Angular Distortion or Limiting Tensile Strain) unless the Proponent has determined more stringent criteria as a result of Condition E102.
Table 9: Settlement criteria
<table>
<tr><th>Surface and Sub-Surface Structures</th><th>Maximum Settlement</th><th>Maximum Angular Distortion</th><th>Limiting Tensile Strain (percent)*</th></tr>
<tr><td>Buildings – Low or non-sensitive properties (i.e. ≤ 2 levels and carparks)</td><td>30 mm</td><td>1 in 350</td><td>0.1</td></tr>
<tr><td>Buildings and pools – High or sensitive properties (i.e. ≥ 3 levels and heritage items)</td><td>20 mm</td><td>1 in 500</td><td>0.1</td></tr>
<tr><td>Roads and parking areas</td><td>40 mm</td><td>1 in 250</td><td>n/a</td></tr>
<tr><td>Parks</td><td>50 mm</td><td>1 in 250</td><td>n/a</td></tr>
</table>
* As defined in Burland et al. 'Building response to tunnelling – Case studies from construction of the Jubilee Link Extension', London, Thomas Telford (2001)</td><td>Section 5</td></tr>
<tr><td>E104</td><td>Should the geotechnical model in Condition E101 identify exceedances of the relevant criteria established by Conditions E102 and E103, the Proponent must implement an instrumentation and monitoring program to measure settlement, distortion or strain as required. The Proponent must also identify and implement appropriate mitigation measures in consultation with the owner(s) of the relevant surface and sub-surface structures prior to excavation and tunnelling works to ensure where possible that the surface and sub-surface structures will not experience exceedances of the relevant criteria.
The adopted criteria does not remove any responsibility from the Proponent for the protection of existing surface and sub-surface structures or for rectifying any damage to surface and sub-surface structures resulting from the CSSI.</td><td>Section 5</td></tr>
</table>

No.	Requirement	Reference
E105	The Proponent must offer pre-dilapidation surveys and must undertake and prepare pre-dilapidation reports where the offer is accepted, on the current condition of surface and sub-surface structures identified as at risk from settlement or vibration by the geotechnical model described in Condition E101. The pre-dilapidation surveys and reports must be prepared by a suitably qualified and experienced person(s) and must be provided to the owners of the surface and sub-surface structures for review prior to the commencement of potentially impacting works.	Section 5
E106	Where pre-dilapidation surveys have been undertaken in accordance with Condition E105, subsequent post-dilapidation surveys must be undertaken to assess damage to the surface and sub-surface structures that may have resulted from the construction of the CSSI within three (3) months of the completion of construction.	Section 5
E107	The results of the surveys must be documented in a Condition Survey Report for each surface and sub-surface structure surveyed. Copies of the Condition Survey Reports must be provided to the owner(s) of the structures surveyed within three (3) weeks of completing the surveys and no later than four (4) months following the completion of construction.	Section 5
E108	Where damage has been determined to occur as a result of the project, the Proponent must carry out rectification at its expense and to the reasonable requirements of the surface and sub-surface structure owner(s) within three (3) months of completion of the post-dilapidation surveys unless another timeframe is agreed with the owner of the affected surface or sub-surface structure.	Section 5
E109	The Proponent must establish an Independent Property Impact Assessment Panel before works that have the potential to result in property impacts commence. The Panel must comprise geotechnical and engineering experts independent of the design and construction team. The Panel will be responsible for independently reviewing Condition Survey Reports undertaken under Conditions E105 and E106, the resolution of property damage disputes, and the establishment of ongoing settlement and vibration monitoring requirements. The Secretary must be informed of the Panel Members prior to property impact. Either the affected owner or the Proponent may refer unresolved disputes arising from potential and/or actual property impacts to the Panel for resolution. All costs incurred in establishing and implementing the Panel must be borne by the Proponent regardless of which party makes a referral to the Panel.	Section 5
E156	Identified impacts to heritage items and heritage conservation areas must be minimised through both detailed design and construction.	Section 5
E190	The Proponent must take all practicable measures to limit operational groundwater inflows into each tunnel to no greater than one litre per second across any given kilometre (1L/s/km). Compliance with this condition cannot be determined by averaging groundwater inflows across the length of the tunnel.	Section 5
E191	The Proponent must identify and commit to the implementation of 'make good' provisions for groundwater users in the event of a decline in water supply levels, quality and quantity from registered existing bores associated with groundwater changes from either construction and/or ongoing operational dewatering caused by the CSSI.	Section 3 and 4

No.	Requirement	Reference
E192	The Proponent must undertake further modelling of groundwater drawdown, tunnel inflows and saline water migration (using particle tracking) prior to finalising the design of the tunnels and undertaking any works that would impact on groundwater flows or levels. The modelling must be undertaken in consultation with DPI Water and include the results and hydrogeological analyses of at least 12 continuous months of current baseline groundwater monitoring data from bores identified in the EIS and SPIR. The modelling must also include data from any other existing monitoring bores identified in consultation with DPI Water, as required to supplement baseline data.	Section 5 and 6
E193	The results of the groundwater modelling must be documented in a Groundwater Modelling Report. The Groundwater Modelling Report must be finalised in accordance with the Australian Groundwater Modelling Guidelines (National Water Commission, 2012) and prepared in consultation with DPI Water. The Groundwater Modelling Report must include, but not be limited to: (a) justification for layer choice; (b) specification and justification of the grid based hydraulic conductivity and storage parameters (specific yield and specific storage) assigned to each layer and/or zone with reference to those values determined from data analyses and the literature; (c) an explanation of how groundwater flow was simulated within each model layer with reference to confined, unconfined or variably saturated flow solutions; (d) an explanation and justification of the drain-cell conductance term(s) applied to the tunnel boundaries to limit tunnel inflows; (e) an explanation and justification of the groundwater recharge values applied across the model domain, including around the modelled specific yield values and the water table fluctuations observed within the monitoring data in response to rainfall-fed groundwater recharge; (f) details (including figures) of the expected changes in groundwater flow directions in the vicinity of landfills, groundwater wells and surface water receptors; (g) cross-section diagrams of geology showing baseline groundwater levels in the monitoring piezometers, and for the predicted baseline condition groundwater levels in 2030 and 2100; (h) statistical evaluation of the model's calibration; (i) details of the groundwater monitoring data inputs (levels and quality); (j) details of the proposed groundwater model update and validation as additional data is collected; (k) assessment of impacts of groundwater drawdown, taking into consideration the NSW Aquifer Interference Policy (DPI, 2012), including potential impacts on licensed bores and groundwater dependent ecosystems; (l) a comparison of the results with the modelling results detailed in the documents referred to in Condition A1; and (m) documentation of any additional measures that would be implemented to manage and/or mitigate groundwater impacts not previously identified.	Section 5 and 6

Appendix B Revised Environmental Mitigation Measures Compliance Matrix

Revised Environmental Management Measures (REMMs) were included in the Preferred Infrastructure and Submissions Report. Relevant REMMs and where they are discussed in this report are shown in the below table.

<table>
<tr><th>Number</th><th>Requirement</th><th>Reference</th></tr>
<tr><td>PL6</td><td>Ground settlement will be managed to comply with the following criteria where possible
<table>
<tr><th>Beneath structure/facility</th><th>Maximum settlement</th><th>Maximum angular distortion</th><th>Limiting tensile strain (per cent)*</th></tr>
<tr><td>Buildings – Low or non-sensitive properties
(ie less than or equal to two levels and carparks)</td><td>30 mm</td><td>1 in 350</td><td>0.1</td></tr>
<tr><td>Buildings – High or sensitive properties
(ie greater than or equal to 3 levels and carparks)</td><td>20 mm</td><td>1 in 500</td><td>0.1</td></tr>
<tr><td>Roads and parking areas</td><td>40 mm</td><td>1 in 250</td><td>N/A</td></tr>
<tr><td>Parks</td><td>50 mm</td><td>1 in 250</td><td>N/A</td></tr>
</table>
* As defined in Burland et al. ‘Building response to tunnelling – Case Studies from construction
of the Jubilee Line Extension’, London, Thomas Telfor (2001)</td><td>Section 5.2 and 5.3</td></tr>
<tr><td>PL7</td><td>Further assessment of potential settlement impacts, including numerical modelling, will be undertaken during detailed design. In areas where ground movement in excess of settlement criteria are is predicted, an instrumentation and monitoring program to measure settlement, distortion or strain will be implemented. Feasible and reasonable measures will be investigated and implemented to ensure where possible that the predicted settlement is within the criteria. Measures that will be considered may include (but are not limited to):
Review of the proposed tunnel design including:
• the depth and alignment of tunnels
• the proximity of multiple tunnels to each other
• the proposed tunnel support system
• the tunnel lining to manage groundwater inflows
• Rationalising the layout of the proposed ventilation tunnels including the number, location an length of tunnels
• Review of the proposed construction methodology
• Consideration of ground improvement options.</td><td>Section 5.2 and 5.3</td></tr>
</table>

Number	Requirement	Reference
PL8	A Settlement Monitoring Program will be prepared that will provide details on: • Settlement criteria and predictions • Location of monitoring points • Duration of monitoring • Data collection (type and method) • Comparison of actual settlement with predictions • Triggers and corrective actions that will be implemented if, based on monitoring results, actual settlement is likely to exceed predictions or the relevant criteria, with the aim of complying with the criteria. The Settlement Monitoring Program will be endorsed the Independent Property Impact Assessment Panel (see PL11) prior to the commencement of any construction activities with the potential to result in settlement, as determined by the panel, unless otherwise agreed to by the Secretary.	Section 6
PL9	Settlement monitoring will be carried out for the period in accordance with the program starting prior to commencement of tunnel construction through to until all settlement has stabilised following completion of tunnel construction. The results of settlement monitoring will be compared to predicted settlement. The implementation and adequacy of the Settlement Monitoring Program will be monitored by the Independent Property Impact Assessment Panel	Section 6
GW1	Groundwater inflows within the tunnels will be minimised by designing the final tunnel alignment to minimise intersections with known palaeochannels and alluvium present in the project footprint.	Section 5
GW2	Appropriate waterproofing measures will be identified and included in the detailed design to permanently, where reasonable and feasible, reduce the inflow into the tunnels to below one litre per second per kilometre for any kilometre length of the tunnel.	Section 5
GW6	Potential impacts associated with subsurface components of the project intercepting and altering groundwater flows and levels will be considered during detailed design. Measures to reduce potential impacts will be identified and included in the detailed construction methodology and the detailed design as relevant.	Section 5
GW7	A detailed groundwater model will be developed by the construction contractor during detailed design. The model will be used to predict groundwater inflow rates and volumes within the tunnels and groundwater levels (including drawdown) in adjacent areas during construction and operation of the project.	Section 5
GW8	Groundwater inflow within and groundwater levels in the vicinity of the tunnels will be monitored during construction and compared to model predictions and groundwater performance criteria applied to the project. The groundwater model will be updated based on the results of the monitoring as required and proposed management measures to minimise potential groundwater impacts adjusted accordingly to ensure that groundwater inflow performance criteria are met.	Section 6
GW9	Further investigations will be carried out to identify areas where groundwater inflows to the tunnels are likely to be elevated, to guide the development of the detailed design and construction methodology. The investigations will be carried out prior to the commencement of excavations with the potential to result in groundwater inflow at each identified location.	Section 6

Number	Requirement	Reference
OGW9	A groundwater monitoring program will be prepared and implemented to monitor groundwater inflows in the tunnels and groundwater levels as well as groundwater quality in the three main aquifers and inflows during construction. The program will identify groundwater monitoring locations, performance criteria in relation to groundwater inflow and levels and potential remedial actions that will be considered to address any non-compliances with performance criteria. As a minimum, the program will include manual groundwater level and quality monitoring monthly and inflow volumes and quality weekly. The monitoring program will be developed in consultation with the NSW EPA, DPI-Fisheries, DPI Water, City of Sydney Council and Inner West Council.	Section 6

WestConnex M4-M5 Link

Rozelle Interchange – Modification: Iron Cove ventilation underground

Modification report

Appendix F

Urban design and visual amenity

Roads and Maritime Services

WestConnex - M4-M5 Link

Iron Cove ventilation underground modification report

Modification report

Appendix F Urban design and visual amenity

November 2019

Prepared for

Roads and Maritime Services

Prepared by

John Holland CPB Joint Venture

Contents

1 Proposed modification

The Iron Cove Link motorway operations complex (MOC4) described in the EIS would be constructed on the southern side of the realigned Victoria Road, on land occupied during construction by the Iron Cove Link civil site (C8). The electrical substation (that provides power for the operation of the ventilation facilities) would be about four metres high and located on the corner of Victoria Road and Callan Street, while the ventilation exhaust facilities building would be located between Callan Street and Springside Street and be around 10 metres above ground level, about 50 metres in length and adjacent to residential properties.

The proposed modification would relocate the Iron Cove Motorway Operations Complex (MOC4) underground within caverns housing the electrical substation and ventilation facilities and a ventilation tunnel connecting to the ventilation outlet (which will remain above ground in the same location illustrated in the EIS). Only a switch room, high voltage regulators, an alternative Operational Motorway Control System (OMCS) room and a separate stair access leading down to the ventilation tunnel would be required on the surface on the western side of Victoria Road between Toelle and Callan Streets located where the above ground substation was illustrated in the EIS and within the boundaries of the Iron Cove Link civil site (C8).

The combined switch room and high voltage regulator structure would be about six metres wide and 30 metres long, with a height of up to five metres. This structure would be adjacent to the Victoria Road Shared Use Path on the eastern side of the intersection of Victoria Road and Toelle Street. Within the same area would be the smaller 'L'- shaped OMCS room with a footprint of approximately nine metres wide by nine metres long and five metres high.

A small above-ground structure in the vicinity of Callan Street, about two metres wide, six metres long and three metres high would contain an access door and a stairway. The staircase would provide an alternative safe maintenance and emergency access to and from the ventilation tunnels from the surface, with the main access from within the road tunnels.

Dedicated parking would be provided for operations and maintenance personnel with access off Clubb Street and within the switch room site with access off Toelle Street.

This proposed modification has been developed to improve urban design outcomes when compared with the design assessed in the Environmental Impact Statement (EIS) and Submissions and Preferred Infrastructure Report (SPIR).

The proposed modification aligns with the aspirations and objectives of the WestConnex Urban Design Framework, specifically:

"*The WestConnex Motorway will be a sustainable, high quality and transformational project for the people of Sydney and NSW. Exhibiting design excellence as a whole and in all constituent parts, it shall be sensitively integrated into the built and natural environments and help build local communities. It will enhance the form, function, character and liveability and contribute to the future liveability of the city.:*

Reducing surface infrastructure would improve visual impacts compared to the EIS, particularly a reduction in overshadowing due to the much smaller scale of permanent infrastructure.

Figure 1 Location of operational ancillary facilities at Iron Cove as shown in EIS

Figure 2 Location of operational ancillary facilities at Iron Cove, based on the proposed modification

2 Review of landscape character impacts

2.1 Landscape character impacts for the proposed modification

The landscape character impact of the proposed modification would be the same as compared to the landscape character associated with the design as assessed in the EIS.

As was undertaken in the EIS, landscape character impacts were assessed including ratings for sensitivity and magnitude at each nominated Landscape Character Zone (LCZ) related to the proposed modification. These LCZ's are shown on Figure 3 from the EIS.

Although the proposed modification would provide a reduction in operational facilities located above ground, the assessment results did not change to such a degree that would alter these overall LCZ conditions as assessed in the EIS.

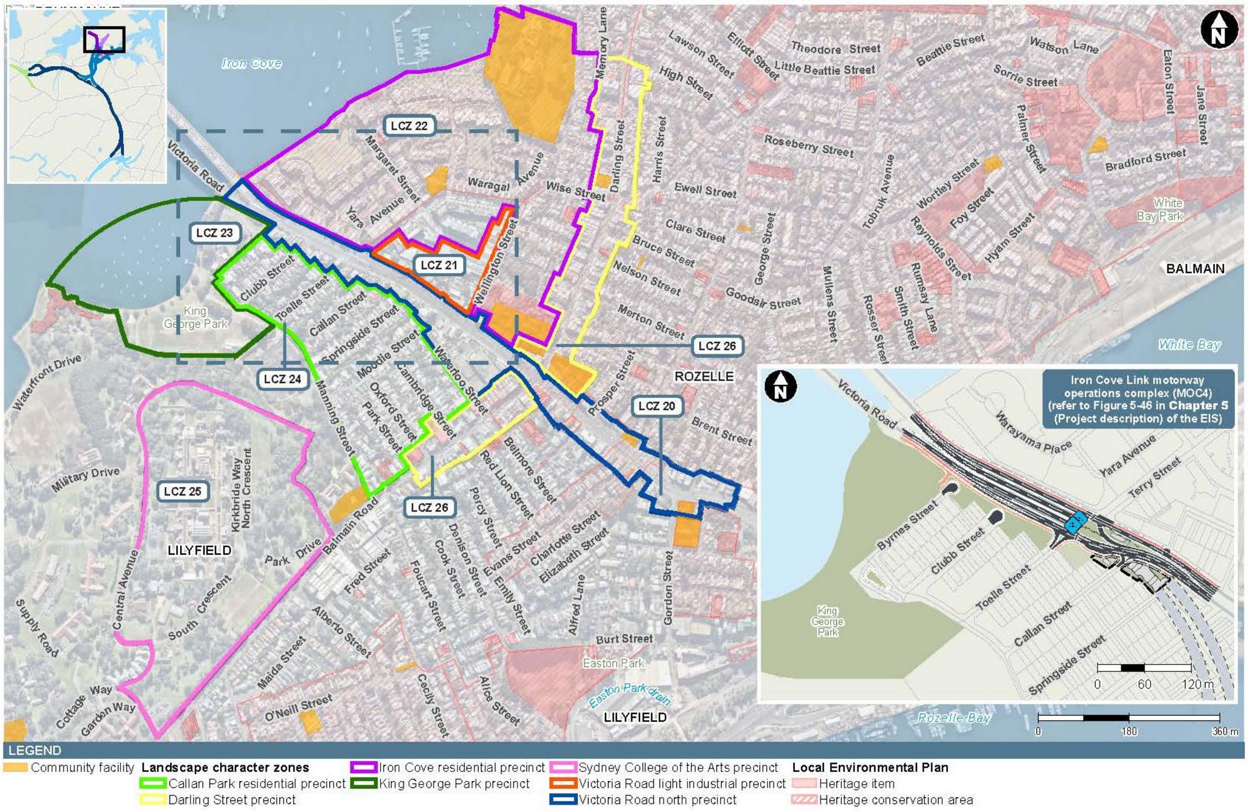

Figure 3 Northern landscape character zones as shown in EIS (Figure 13-3)

3 Review of visual impacts

3.1 EIS Visual impacts at Iron Cove Link

The EIS assessed visual impacts on receivers including ratings for sensitivity and magnitude at each nominated viewpoint.

The visual impact assessment identified the potential for 'high' visual impacts for residents on the west side of Terry Street, for the view looking south along Terry Street towards the project (IC4). The sensitivity of the three storey apartments on the west side of Terry Street was considered to be high, as the apartments currently look out onto a well-considered, almost entirely residential streetscape of substantial visual quality.

The magnitude of the change for residents on the west side of Terry Street was also considered to be high given that the view of the ventilation outlet (as part of the Iron Cove Link motorway operations complex (MOC4)) would comprise a substantial, highly contrasting element within the context of a well-articulated and substantially detailed residential development within this part of the street, and the revealed, small scale, period housing profiles on the opposite side of Victoria Road.

The EIS included the removal of residential and commercial development fronting onto Victoria Road, and replacement with well setback, lower scale existing period housing profiles and streetscape improvements, in addition to centre median planting with substantial tree cover. This is considered to comprise an improvement in the visual character of this central part of the view. 'High' visual impacts were not anticipated in the EIS for the other viewpoints identified around the Iron Cove Link.

Viewpoints used in the EIS have been reviewed and the relevant viewpoints to the Iron Cove Link (including the Iron Cove Link motorway operations complex (MOC4)) are shown in the following figures.

Impacts recorded in the EIS are also shown in the figures below.

Figure 4 Visual impact assessment summary – Iron Cove Link viewpoints (EIS Figure 13-31)

Figure 5 EIS Image: Existing view from Victoria Road near Iron Cove Bridge looking east - Viewpoint IC1 (EIS Figure 13-32)

Figure 6 EIS Image: 3D artist's impression image at 10 years of operation from Victoria Road near Iron Cove Bridge looking east - Viewpoint IC1 (EIS Appendix O Figure 7-34)

Figure 7 EIS Image: Existing view from Victoria Road near Terry Street looking east- Viewpoint IC3 (EIS Appendix O Figure 7-38)

Figure 8 EIS Image: Existing view looking east along Victoria Road at corner of Crystal Street - Viewpoint IC6 (EIS Appendix O Figure 7-47)

Figure 9 EIS Image: Photomontage at 10 years of project operation for the view looking east along Victoria Road at corner of Crystal Street - Viewpoint IC6 (EIS Appendix O Figure 13-37)

Table 1 Summary of visual impacts on sensitive receivers (EIS Table 13-17)

Receiver location	Receiver type	Sensitivity	Magnitude	Overall rating
View looking east along Victoria Road near Iron Cove Bridge (IC1)	Residents	Moderate	Moderate	Moderate
	Pedestrians	Low	Moderate	Moderate–Low
	Recreation	Moderate	Moderate	Moderate
	Motorists/public transport/cyclists	Low	Moderate	Moderate–Low
View looking west from Manning Street towards bioretention facility (IC2)	Residents	Moderate	Low	Moderate–Low
	Recreational users	Moderate	Low	Moderate–Low
	Pedestrians	Moderate	Low	Moderate–Low
View looking east along Victoria Road near Terry Street (IC3)	Pedestrians	Low	Moderate	Moderate–Low
	Motorists/public transport/cyclists	Low	Moderate	Moderate–Low
View looking south along Terry Street towards Victoria Road (IC4)	Residents – Balmain Shores corner of Terry Street	Low	Moderate	Moderate–Low
	Residents – Nagurra Place: north side	Low	Low	Low
	Residents – Nagurra Place: south side	Moderate	High	High–Moderate
	Residents – Terry Street: west side	High	High	High

Receiver location	Receiver type	Sensitivity	Magnitude	Overall rating
	Residents – Terry Street: east side	Moderate	Low	Moderate-Low
	Pedestrians	Low	Low	Low
	Motorists/cyclists	Low	Low	Low
View looking north along Springside Street towards Victoria Road (IC5)	Residents	Moderate	Moderate	Moderate
	Pedestrians	Moderate	Moderate	Moderate
View looking east along Victoria Road at corner of Crystal Street (IC6)	Pedestrians	Low	Moderate	Moderate–Low
	Motorists/public transport/cyclists	Low	Moderate	Moderate–Low

3.2 Visual impacts at Iron Cove Link proposed modification

The proposed modification would improve amenity adjacent to the new shared path located next to Victoria Road westbound, due to increased areas offered with the reduction in operation facilities located above ground.

In regard to visual impact, the overall impact of the proposed modification would be slightly improved with the reduction in visible facilities, compared to comparable visual impacts as assessed in the EIS.

The major visual change from what was assessed at the EIS is the removal of the MOC4 facility from the corner of Springside Street and Victoria Road. This results in residents that were to be impacted under the EIS concept design no longer being impacted under the proposed modification in this location.

The ventilation facility building and substation shown in the EIS is now proposed to be underground, with a new switch room, high voltage regulators, and an alternative Operational Motorway Control System (OMCS) located at the corner of Victoria Road and Toelle Street.

To consolidate above ground structures within a reduced footprint in this location, the structures would be adjacent the shared path and screening of the facility with vegetation would be reduced.

A separate small above ground structure in the vicinity of Callan Street would contain an access door and a stairway to the ventilation tunnel. The visible mass of this new building is noticeably smaller than the EIS assessed MOC4 ventilation facility.

Although the location and form of the visible structures at Iron Cove Link is reduced, there is still a number of structures adjacent to Victoria Road when compared to the existing condition, and what was assessed at EIS.

Overall, the visual impact is generally similar, whilst the overall visible scale and size of the structure has been reduced from what was assessed in the EIS.

As was undertaken in the EIS, visual impacts on receivers was assessed including ratings for sensitivity and magnitude at each nominated viewpoint related to the proposed modification.

Artists impressions, photomontages and cross section of the relevant viewpoints to the Iron Cove Link (including the Iron Cove Link motorway operations complex (MOC4)) were prepared to reflect the proposed modification and are shown following. The images were created by 3d modelling or overlaying the 3d model and existing site photograph to create a viewpoint image used for assessment, showing the proposed works.

Impacts were re-assessed for the proposed modification using the method outlined in the EIS, including the production of updated photomontages.

The assessment resulted in the same visual impacts as recorded in the EIS and shown in the EIS Table 13-17, as the slight improvement associated with the proposed modification does not alter the overall rating category.

Figure 10 Iron Cove Link viewpoints, based on the proposed modification

Figure 11 Iron Cove Link - Typical section AA

Figure 12 EIS Image: Photomontage at 10 years of operation from Victoria Road near Iron Cove Bridge looking east - Viewpoint IC1 (EIS Appendix O Figure 7-34)

Figure 13 3D artist's impression image at 10 years of project operation of view from Victoria Road near Iron Cove Bridge looking east in proximity to IC1, based on the proposed modification. This modification does not alter the ventilation outlet from the approved project. Exterior design of the ventilation outlet is subject to the Urban Design and Landscape Plan.

Figure 14 EIS Image: Photomontages at 10 years of operation from Victoria Road near Terry Street looking east - Viewpoint IC3 (EIS Appendix O Figure 7-40)

Figure 15 Photomontage at 10 years of project operation for the view looking east along Victoria Road in proximity to EIS Viewpoint IC6, based on the proposed modification. This modification does not alter the ventilation outlet from the approved project. Exterior design of the ventilation outlet is subject to the Urban Design and Landscape Plan.

Figure 16 EIS Image: Photomontage at 10 years of operation looking west along Victoria Road from corner of Crystal Street - Viewpoint IC6 (EIS Appendix O 7-48)

Figure 17 Photomontage at 10 years of operation looking west along Victoria Road from corner of Crystal Street in proximity to IC1, based on the proposed modification. This modification does not alter the ventilation outlet from the approved project. Exterior design of the ventilation outlet is subject to the Urban Design and Landscape Plan.

3.3 Additional views of the proposed ancillary facilities not included in the EIS

In this section, additional views of the proposed ancillary facilities have been prepared and assessed in supplement to the EIS visual impact and consistency assessment outlined in section 3.2.

Additional viewpoint locations were identified in consultation with the project team, to reflect the scale and form of the proposed ancillary facilities in its setting. The images were created by 3d modelling to create a viewpoint image used for assessment. Viewpoint locations were selected to represent pedestrian views of nearby receivers in close proximity to the proposed facilities and shown in Figure 18 below. To assist in making the visual assessment process easier to comprehend and more accurate, each assessment provides an existing image of each viewpoint.

Figure 18 Iron Cove Link additional viewpoints, based on the proposed ancillary facilities

Viewpoint IC7 - view east from Toelle Street

Existing situation

The viewpoint is situated along Toelle Street, approximately 15m south of Victoria Road. The existing view is shown in Figure 19. The view comprises a narrow, local street with single storey, free standing cottages which form a clear built edge to the street. A limited area of Victoria Road is visible in the periphery of the view, including street signage and overhead wiring. This viewpoint is representative of views from nearby residents and pedestrians.

Project effects

The change in view from this viewpoint is shown in Figure 20. The key project effects that would be visible from this location include:

- New road widening and alignment, including road furniture such as road signage and lighting
- The proposed switching room facility on the corner of Toelle Street and Victoria Road
- Ventilation outlet in between the eastbound and westbound carriageways
- New landscaped areas along the verge and in the median of Victoria Road

In this view, the ventilation outlet would comprise a dominant feature from this location, set within the broad expanse of the carriageway and projecting above the skyline. This modification does not alter the ventilation outlet from the approved project. The operational facilities in the centre of the view would be located along the new edge of Victoria Road, which would be of a similar scale and proportion to existing commercial buildings.

The character of the view would change as the end of Toelle Street is absorbed into the arterial road corridor.

Figure 19 3D Viewpoint IC7 - existing condition, looking east along Toelle Street toward the proposed ancillary facilities

Figure 20 3D Viewpoint IC7 - artist's impression at 10 years of operation, looking east along Toelle Street toward the proposed ancillary facilities.

Note: Operation infrastructure subject to detailed design. This modification does not alter the ventilation outlet from the approved project. Exterior design of the ventilation outlet is subject to the Urban Design and Landscape Plan. Pedestrian traffic lights on Victoria Rd will be included in detailed design.

Visual impact assessment

Table 2 - Viewpoint IC7 visual impact assessment

Viewpoint	Sensitivity	Magnitude	Rating
IC6	**Sensitivity to change: Moderate** This viewpoint looks out across the existing narrow local street toward established cottage houses, where viewers would be sensitive to a change in the setting. The existing streetscape is of moderate visual quality and provides a low capacity to absorb change with the introduction of major new project infrastructure.	**Magnitude of change: High** The project would result in a contrasting and permanent change in the view. Due to the proximity of the viewer, the scale of the intervention is relatively large, and most noticeable for residents closest to Victoria Road.	**High-Moderate**

Viewpoint IC8 - view south from Victoria Road

Existing situation

The viewpoint is located at the existing central median along Victoria Road, at the signalised crossing point near Toelle Street. The existing view is shown in Figure 21. The view comprises a busy arterial road, free standing residential properties and mixed-use buildings, forming a poor visual environment. The view is representative of a typical pedestrian view and would be similar for motorists and residential receptors facing Victoria Road.

Project effects

The change in view from this location is shown in Figure 22. The key project effects that would be visible from this location are:

- New widened road corridor which would include road lighting and signage
- New landscape treatments in the widened median (foreground)
- New landscape treatments along the verge
- Proposed operational facilities building at the corner of Victoria Road and Toelle Street.

The operational buildings would be setback from the verge and staggered to maximise landscaped screening opportunities, where possible. The scale and height of the buildings would be in keeping with the single and double-storey dwellings and commercial buildings along Victoria Road.

Visual impact assessment

Table 3 - Viewpoint IC8 visual impact assessment

Viewpoint	Sensitivity	Magnitude	Rating
IC7	**Sensitivity to change: Low** The viewpoint looks across a major arterial road where the outlook is of low visual quality. The view would be predominantly experienced by motorists who would not be sensitive to change. Pedestrians and properties fronting Victoria Road would also experience this view.	**Magnitude of change: Moderate** The project would increase the scale of the road corridor in this view. New built elements would be introduced that were of a similar scale to the existing dwellings, which would be offset by the introduction of new landscaped areas. It was considered that the project works would provide a positive contribution to the visual amenity from this location.	**Low-moderate**

Figure 21 3D Viewpoint IC8 - existing condition, looking south along Victoria Road toward the proposed ancillary facilities

Figure 22 3D Viewpoint IC8 - artist's impression at 10 years of operation looking south along Victoria Road toward the proposed ancillary facilities. Note: Pedestrian traffic lights will be included in detailed design.

Viewpoint IC9 - view west along Callan Street

Existing situation

This viewpoint location is situated along Callan Street, approximately 50 metres south of Victoria Road. The existing view comprises of a narrow, laneway-scaled, local street, with no trees and established single storey dwelling built close to the boundary. The view is primarily representative of views experienced from nearby residents and pedestrians along Callan Street where views are typically confined to the narrow streetscape that slopes down from Victoria Road.

Proposed effects

From this viewpoint, it would be unlikely that the proposed facilities would be visible in this location. From similar locations along Callan Street, it would be possible that the buildings may be partially visible, however views would be limited, and the buildings would recede into the background of the view, obscured by vegetation and residential properties. It is also noted that for similar views along Callan Street, the ventilation outlet would potentially be visible. This modification does not alter the ventilation outlet from the approved project.

Figure 23 3D Viewpoint IC9 - existing condition, looking west along Callan Street toward the proposed ancillary facilities

Visual impact assessment

Table 4 -Viewpoint IC9 visual impact assessment

Viewpoint	Sensitivity	Magnitude	Rating
IC8	**Sensitivity to change: Moderate** The viewpoint looks across residential properties along a narrow street and would be sensitive to a change in setting.	**Magnitude of change: Negligible** Due to the topography and scale of the operational buildings in the background, there would be limited, if any change to the view.	**Negligible**

Summary of visual impacts

A summary of the visual impacts for the additional representative viewpoints discussed in this section of the report are provided below in Table 5.

Table 5 - Viewpoint IC9 visual impact assessment

Viewpoint	Sensitivity to change	Magnitude of change	Overall Rating
IC6	**Moderate**	**High**	**High-Moderate**
IC7	**Low**	**Moderate**	**Low-moderate**
IC8	**Moderate**	**Negligible**	**Negligible**

It is noted that the additional viewpoints that have been assessed in this section are focussed primarily on visual impact related to the proposed facilities at the corner of Toelle Street and Victoria Road. For that reason, viewpoint locations were selected at pedestrian eye level, and in closer proximity to the buildings compared to the viewpoints in the EIS.

In consideration of this, the assessment demonstrates that for nearby residential receptors in close proximity to the proposed buildings, the visual impact would be highest, particularly on Toelle Street and represented in viewpoint IC7. It is noted that the ventilation outlet, which would be visible from this viewpoint, has contributed to the high visual impact rating at this location. This modification does not alter the ventilation outlet from the approved project.

For views along Victoria Road, and represented in viewpoint IC8, the proposed buildings would be visible within the context of the broader project works which, through wide, landscaped verges, was considered to improve the visual amenity of views in the area.

Finally, viewpoints from adjacent side streets, such as IC9, are unlikely to experience any major adverse visual impact from the proposed building envelope.

4 Review of Revised Environmental Management Measures and MCoAs

4.1 Review of relevant revised environmental management measures

The Submissions and Preferred Infrastructure Report (SPIR) for the M4-M5 Link Project identified the revised environmental management measures (REMM) that would be adopted to avoid or reduce environmental impacts of the EIS, with all measures identified incorporated into management plans.

The REMM's related to Urban Design outcomes at Iron Cove Link facilities are listed below for reference.

Given the minor change in visual impacts, and that the size and form of the facilities and locations at Iron Cove Link assessed during the EIS are generally consistent with those shown in the proposed modification, the REMM's listed below are adequate to achieve the overall project outcomes.

With reference to REMM LV8, the operational facilities are still able to be designed to satisfy the functional requirements and adopt the design principles detailed in the M4-M5 Link Urban Design Report.

REMM LV19 will be complied with through the use of vegetation to reduce the visual impact associated with the ventilation outlet, where possible.

Through detailed design, the design of Iron Cove Link facilities will consider the height, bulk, scale and landscape setting in accordance with the design principles detailed in the M4-M5 Link Urban Design Report to satisfy REMM LV22.

4.2 Review of relevant Conditions of Approval

The detailed design of the Iron Cove Link will be managed under the existing Planning Approval Conditions. The Urban Design and Landscape Plan(s) (UDLP) will be prepared under Planning Approval Conditions E133 to E137.

Overshadowing will be assessed with a Solar Access and Overshadowing Report under Planning Approval Condition E138.

The UDLP and Overshadowing will be reviewed by the Design Review Panel (DRP) and the UDLP will be approved by the Secretary of the Department of Planning, Industry and Environment.

Impact	Ref	Revised environmental management measure	Timing
General impacts on landscape and visual amenity	LV8	Visible elements of operational facilities will be designed to satisfy functional requirements and adopt the design principles detailed in the M4-M5 Link Urban Design Report. The proposed designs will be documented in the relevant UDLP for the project	Construction
Impacts on visual amenity at Iron Cove Link	LV19	Investigate vegetative and other screening measures along Victoria Road to improve the visual amenity of the streetscape and reduce impacts associated with the ventilation outlet and increased glare from the portals to residential dwellings to the north of Victoria Road. Reasonable and feasible landscaping measures will be included in the relevant UDLP.	Construction

Impact	Ref	Revised environmental management measure	Timing
Visual amenity impacts associated with design of ventilation outlets at Rozelle, Iron Cove Link and St Peters	LV22	Investigate measures during detailed design to reduce the height, bulk, scale and enhance the landscape setting of the ventilation outlets, subject to achieving desired ventilation outcomes, and in accordance with the design principles detailed in the M4- M5 Link Urban Design Report	Construction

5 Conclusion

The proposed modification would improve amenity adjacent to the new shared path located next to Victoria Road westbound, due to increased landscaped areas offered with the reduction in operational facilities located above ground.

The overall visual impact of the proposed modification would be slightly improved with the reduction in visible facilities, with the same visual impacts recorded as was assessed in the EIS.