

Cross River Rail Environmental Impact Statement

Request for Project Change 9

Changes to the Project and changes to the
imposed conditions - Southern Portal Area

Volume 3 Technical Reports

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Author: Cross River Rail Delivery Authority

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1. Introduction

These technical reports have been prepared for the Cross River Rail (CRR) Project to assess the environmental effects arising from the Proposed Changes in comparison to the Evaluated Project.

Volume 1 describes the Proposed Changes to the design and delivery of the Evaluated Project and Volume 2 provides a set of drawings for approval. In some cases, the Proposed Changes are generally in accordance with the approved plans and drawings set out in the Evaluated Project and within the level of authorised impacts and in compliance with the CRR Project-wide Imposed Conditions. These aspects have been identified and compared and, where it is assumed to be generally in accordance with the approved plans, no further detailed assessment has been undertaken.

Where there has been a material or significant change in the design, delivery, existing environmental values, assessment criteria, or the change conflicts with the Coordinator-General's Imposed Conditions, further detailed technical assessments, modelling and surveys have been undertaken, and detailed in this report and supported by **Attachments A-E**.

2. Proposed Change

This RfPC requests that the Coordinator-General evaluate the following Proposed Changes:

- Change of construction methodology for the Southern Portal Area to a full cut and cover methodology; and
- Changes to Condition 1 (General Conditions) to include references to the latest evaluated versions of project documentation and to remove redundant references to previous drawings.

3. Technical Assessments

A requirement for technical assessments has been identified for the Proposed Change listed in Table 1.

Table 1: Requirement for technical assessments

Proposed change	Potential impacts	Technical assessments required
Change of construction methodology for the Southern Portal Area to a full cut and cover methodology	• Noise impact from construction and associated traffic • Vibration impact from construction • Traffic impact from additional haulage • Air quality impact from construction	• Construction noise impact assessment • Traffic noise impact assessment • Vibration impact assessment • Traffic impact assessment • Air quality impact assessment

Five (5) technical reports have been prepared to assess the potential changes to noise and vibration impacts, air quality impacts, and traffic and transport impacts, arising from the Proposed Change in comparison to the Evaluated Project (**Attachments A-E**). How these reports relate to potential changed impacts and associated cross-references are detailed in Table 2.

Table 2: Potential changed impacts and associated technical report cross-references

Potential changes to impacts / Technical report	Change aspects	Technical report cross-references
Construction noise impact Attachment A Technical Report: Noise This report covers detailed assessment of noise impacts from construction works at the Southern Portal worksite. Note - Potential noise impacts associated with spoil haulage from construction vehicles on public roads is covered in the Traffic Noise Report (Attachment B).	Evaluated project	Sections 1 and 4.2
	Effect of the proposed change	Section 4.3
	Mitigations proposed	Section 5
Traffic noise impact Attachment B Technical Report: Traffic Noise This report covers detailed noise assessment of additional construction related road traffic along Joe Baker Street, Peter Doherty Street and Annerley Road for the Southern Portal worksite.	Evaluated project	Sections 1 and 2
	Effect of the proposed change	Section 5.1
	Mitigations proposed	Section 5.1
Vibration impact Attachment C Technical Report: Vibration This report covers detailed assessment of vibration impacts from construction works at the Southern Portal worksite.	Evaluated project	Sections 1.2 and 3
	Effect of the proposed change	Sections 6.1 and 6.2
	Mitigations proposed	Section 7
Traffic impact Attachment D Technical Report: Traffic and Transport This report covers detailed traffic assessment of additional construction related road traffic along Joe Baker Street, Peter Doherty Street and Annerley Road for the Southern Portal worksite.	Evaluated project	Section 1.1
	Effect of the proposed change	Sections 7.1 (increase in vehicles), 7.7.2 (impact on Annerley Road / Peter Doherty) and 7.8
	Mitigations proposed	Section 7.7 (outlines the intersection upgrades required)
Air quality impact Attachment E Technical Report: Air Quality This report covers detailed assessment of air quality impacts from construction works at the Southern Portal worksite.	Evaluated project	Sections 2.1 and 3.3; Table 3.1
	Effect of the proposed change	Sections 7.2, 7.3 and 7.4
	Mitigations proposed	Section 6.3

Attachment A: Technical Report - Noise

CROSS RIVER RAIL (CRR)

Construction Noise Mitigation Design Report - Southern Portal

16 November 2020

CBGU JV

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1 Introduction

Renzo Tonin & Associates (RTA) was engaged by CBGU to undertake an assessment of the impacts of construction noise and vibration for Cross River Rail (CRR) and to compare these to the assessed project alignment as part of Request for Project Change #4 (RfPC).

The CRR project involves constructing a new 10km rail line from Dutton Park to Bowen Hills, of which 5.9km will be located underground beneath the Brisbane River and the CBD. It includes the construction of four new underground stations at Boggo Road, Woolloongabba, Albert Street and Roma Street. An overview of the rail route and major work sites are shown in Figure 1.

This document provides acoustic design and mitigation advice to inform the design of items of the Southern Portal worksite, such as boundary fences, enclosures, screens and attenuators. It also identifies time restrictions and the extent of likely residual impacts after implementation of the set noise control measures.

Since RfPC-4 submission, further detailed planning has been undertaken on the Southern Area worksite. The planning considered the level of congestion within the rail corridor, including multiple commuter rail lines servicing the Gold Coast and Cleveland regions along with freight rail lines to the Port of Brisbane, the Boggo Road Busway that passes underneath the rail corridor and a grade separated rail freight flyover crossing above the rail corridor. These key features were then overlaid with the multiple intersections with utilities (power, stormwater and sewer) which need to be upgraded and / or relocated throughout the various stages of the work. Given the complexity of this area, the Project faced a number of technical challenges, particularly with rail alignment, rail geometry and utility constraints. The design has now been further developed to resolve these various technical issues.

Once the design details of the items described in this document are developed, the final design should be reviewed and checked by Renzo Tonin & Associates (RTA).

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.



Figure 1.1 Cross River Rail (CRR) route and major work sites overview

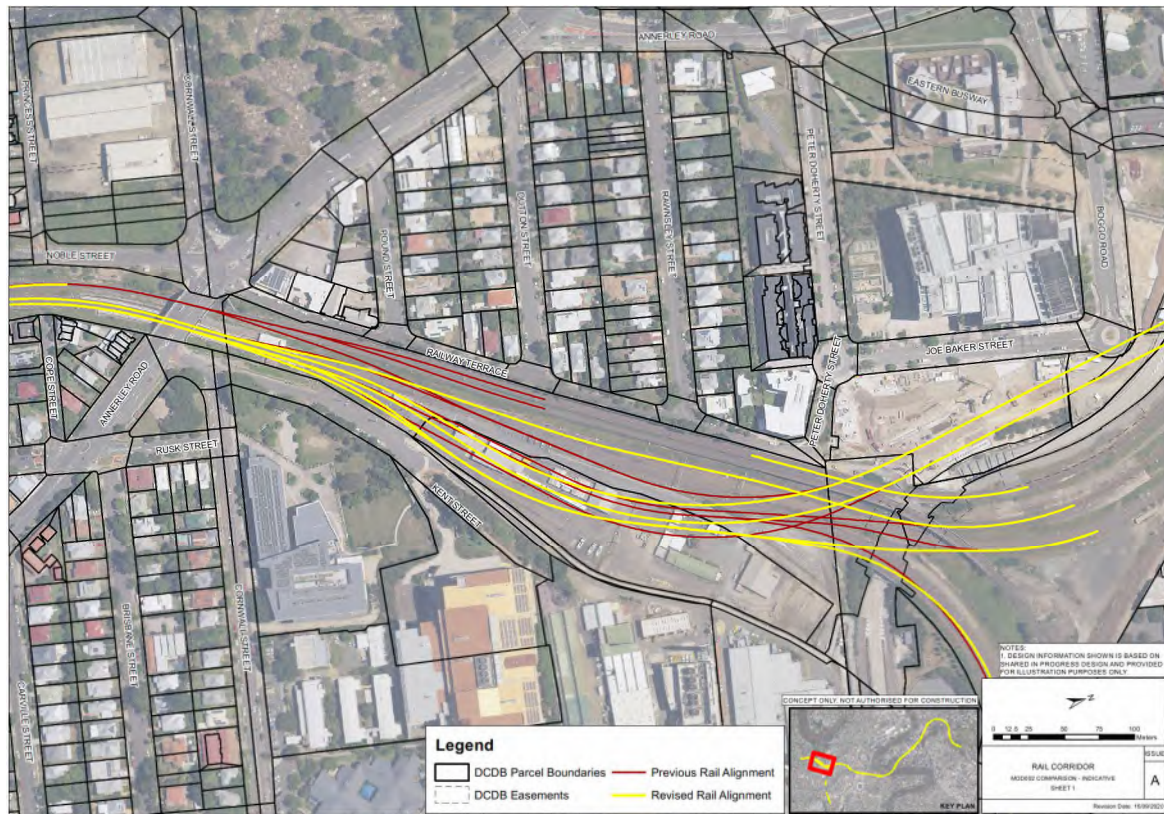


Figure 1.2 Southern Portal alignment comparison (previous vs revised)

2 Site Location and Surrounding Sensitive Locations

The location of the site and surroundings are provided in Figure B1 in Appendix B. As shown in the figure, the Project site is surrounded by various sensitive uses. Evaluation of the noise impacts of construction activities are focused on areas within 100m of the site. Due to the myriad building occupancy and land uses surrounding the site, Renzo Tonin and Associates have simplified the surrounding buildings into the following receiver categories:

- Residential
- Commercial
- Educational
- Medical (i.e. hospitals)
- Public Building (e.g. judicial buildings, municipal buildings, etc)
- Place of Worship
- Heritage Building

Residential receivers are generally considered to be the most sensitive and most likely to be impacted by construction activities. Noise and vibration impacts are assessed at residential receivers for all hours of work (e.g. standard and extended work hours). Other receivers may be less sensitive to construction activities, with impacts generally limited to hours of occupancy (e.g. commercial buildings are generally only impacted during standard work hours).

Noise sensitive receivers surrounding the Project site have been divided into Noise Catchment Areas (NCAs) based on each area's similar acoustic environment prior to commencement of construction works, as shown in **Figure B1 in Appendix B**.

3 Reference Documents and Design Criteria

The construction noise and vibration mitigation design criteria for the Cross River Rail (CRR) works are based on the following documents:

- Coordinator-General's project-wide Imposed Conditions. Cross River Rail Coordinator General's *Change Report – design refinements and condition changes 2020* dated July 2020.
- Coordinator-General's project-wide Imposed Conditions. Cross River Rail Coordinator General's *Change Report - #4*
- Coordinator-General's *Change Report – design refinements and condition changes 2020*,
- Australian Standard AS/NZS 2107.

This construction noise and vibration mitigation design report addresses potential noise impact associated with station excavation and support works at Southern Portal site.

Parts of the construction will be required to be conducted on a 24 hour day, 7 day a week basis due to rail network closures to facilitate these works. The works will be completed on this basis to minimise the impact duration to the Commuter and Freight Rail Networks, consultation is discussed in Section 5.2 in relation these and other requirements.

Potential noise impacts associated with spoil haulage from construction vehicles on public roads during the 5 day rail possession is not assessed in this report and has been addressed as part of the Traffic Noise Assessment dated 30/06/2020.

Construction Noise Goals (CNGs) for the works are provided in **Table B1** of **APPENDIX B** (refer to **Figure B1** in **APPENDIX B** for locations of noise sensitive receivers).

3.1 Coordinator General's Change Report (July 2020)

Appendix 1 of the *Coordinator-General's Change Report – design refinements and condition changes 2020*, the existing imposed conditions are found at the following weblink

<http://www.dsdmip.qld.gov.au/coordinator-general/assessments-and-approvals/coordinated-projects/completed-projects/cross-river-rail-project.html>.

3.2 CRR Delivery Authority Request for Project Change 8 (August 2020)

The Cross River Rail Delivery Authority prepared a document *Request for Project Change 8 - Design refinements and condition changes, Volumes , 21 and 3* dated August 2020. A summary of the Request for Project Change 8 is found on at <http://www.dsdmip.qld.gov.au/coordinator-general/assessments-and-approvals/coordinated-projects/completed-projects/cross-river-rail-project.html>.

4 Noise Prediction Methodology

Modelling and assessment of airborne noise impacts from construction activities associated with the worksite were determined by modelling the noise sources, receiver locations, topographical features, and possible noise mitigation measures using the Cadna-A computer noise model. The model uses the ISO 9613 algorithms to calculate the contribution of each noise source at identified sensitive receiver locations and allows for the prediction of the total noise from a site for the various stages of the construction works.

The noise prediction models take into account:

- Location of noise sources and sensitive receiver locations;
- Ground RLs and height of noise sources within the site referenced to information provided by CBGU, and 1m digital ground contours outside the construction site area;
- Noise source levels of individual construction plant;
- Separation distances between sources and receivers;
- Ground type between sources and receivers (mostly hard); and
- Attenuation from barriers (natural and purpose built).

4.1 Noise Model Inputs and Assumptions

Key details regarding the construction site layout, the likely plant and equipment (including truck movements), hours of operation and construction stages were informed by the CBGU Design Team. This information is presented in **Figures C1.2 to C1.7** and **Table C1** in **APPENDIX C** and formed the basis for all modelling assumptions used in this assessment.

The points below detail Construction stages (see figure 4.1) and include indicative timeframes for each Stage and Activity chronologically:

<u>STAGE 1</u>	11 Months (construction works within Zone F)
•Excavation & Piling	7 Months (Surface works; predominantly daytime)
•Formwork, Reinforcement, Pour (FRP), concrete works	3 Months (Surface works; predominantly daytime)
•Excavation	1 Month (Surface works; predominantly daytime)
<u>STAGE 2</u>	3 Months (construction works within Zones B, C, D & F)
•Excavation & Piling	3 Months (Surface works; predominantly daytime)
	3 Weeks (Surface works; Evening and Night [Middle road rail possession])
•Formwork, Reinforcement, Pour (FRP), concrete works	3 Months (Surface works; predominantly daytime)

3 Weeks (Surface works; Evening and Night [Middle road rail possession])

STAGE 3

12 Months (construction works within Zones A, B & C)

- Excavation & Piling 4 Months (Surface works; predominantly daytime)
- Formwork, Reinforcement, Pour (FRP), concrete works
4 Months (Surface works; predominantly daytime)
- Excavation 8 Months (Underground; predominantly daytime)

STAGE 4 Roof

3 Months (construction works within Zones A, B, C, D & E)

- Formwork, Reinforcement, Pour (FRP), concrete works
3 Months (Surface works; predominantly daytime)
- Excavation 3 Months (Underground; predominantly daytime)

STAGE 4 Excavation

3 Months (construction works within Zones A, B, C, D & E)

- Excavation & Piling 3 Months (Surface works; Day and Evening)
- Formwork, Reinforcement, Pour (FRP), concrete works
3 Months (Surface works; predominantly daytime)
- Excavation 2 Months (Underground; predominantly daytime)

STAGE 5

5 Months (construction works within Zones A, B, C, D & E)

- Formwork, Reinforcement, Pour (FRP), concrete works
5 Months (Surface works; predominantly daytime)
- Backfill 5 Months (Surface works; predominantly daytime)

Underground activities are authorised under imposed condition 10. (b).



Figure 4.1 Construction Work Zones (A, B, C, D, E & F)

All construction stages are shown in **Figures C1.2 to C1.7** and described in more detail in **Table C1** in **Appendix C** of this report.

4.2 Construction Noise Goals (CNG's)

Noise sensitive receivers surrounding the Project site have been divided into Noise Catchment Areas (NCAs) based on each area's similar acoustic environment prior to commencement of construction works, as shown in Figure 4.1 and Figure B1 in Appendix B.



Figure 4.2 Noise Catchment Areas (NCAs)

External noise goals may be calculated and applied in accordance with the Imposed Conditions when internal building access is not available. Table 4.1 presents adjusted external Construction Noise Goals (CNG's) for noise sensitive receivers close to the works zones (Zone A, B, C, D, E and F). Refer to Figure 1.2 for construction work zones.

Table 4.1: Construction Noise Goals (CNGs) (Adjusted External noise goals)

NCA	Receiver Type	Receiver Location	Continuous Noise LAeq,adj (1hr)		Intermittent Noise LA10,adj (15min)	
			Day (Monday - Saturday 6.30am-6.30pm)	Out of Hours - evening, night (Monday – Saturday 6.30pm – 6.30am Sundays, Public Holidays)	Day (Monday - Saturday 6.30am-6.30pm)	Out of Hours - evening, night (Monday – Saturday 6.30pm – 6.30am Sundays, Public Holidays)
-	Commercial	Railway Terrace	67	-	77	-
BOG_01	Residential (Queenslander)	Railway Terrace (Pound St to Rawnsley St)	47	42	57	49

NCA	Receiver Type	Receiver Location	Continuous Noise LAeq,adj (1hr)		Intermittent Noise LA10,adj (15min)	
			Day (Monday - Saturday 6.30am- 6.30pm)	Out of Hours - evening, night (Monday – Saturday 6.30pm – 6.30am Sundays, Public Holidays)	Day (Monday - Saturday 6.30am- 6.30pm)	Out of Hours - evening, night (Monday – Saturday 6.30pm – 6.30am Sundays, Public Holidays)
BOG_02	Residential	ESA Village (Leukaemia Centre), new apartments along Peter Doherty St	62	57	67	59
	Commercial	Ecosciences Building	67	-	77	-
	Commercial	Police Station & Gaol	62	-	72	-
BOG_03	Education	Dutton Park Primary School	57	-	67	-
	Residential	Merton Road to Elliott Street	47	42	57	49
	Commercial	Burke Street	62	-	72	-
BOG_04	Commercial	Metropolitan linen service (MLS)	62	-	72	-
	Medical	PA Hospital	57	52	67	59
	Education	PA Early Education Centre	57	-	67	-
-	Residential	Rusk Street & Cornwall Street	47	42	57	49
DUT_01	Residential (Queenslander)	Cope St, Rusk St, Tamar St, Sampson St, Annerley Road, Cornwall St, Brisbane St, Ayr St, Carville St, Young St, Wilkins St E,	47	42	57	52
	Residential		57	52	67	62
DUT_02	Residential (Queenslander)	Princess St, Noble St, Fairfield Rd, Fenton St, Simpson St, Hefferan St	47	42	57	52
	Residential		57	52	67	62
	Commercial	Cornwall St, Noble St	67	-	77	-
DUT_03	Residential (Queenslander)	Railway Terrace, Dutton St, Rawnsley St	47	42	57	52
	Residential		57	52	67	62
	Commercial	Railway Terrace, Annerley Road	67	-	77	-
DUT_04	Medical	PA Hospital	57	52	67	62
DUT_05	Residential (Queenslander)	Fenton St, Cotterham St, Cameron St, Wilkins St W, Mearns St, Mildmay St, Redarc St, Victoria St	47	42	57	52
	Residential		57	52	67	62

4.3 Predicted Construction Noise Levels

Tables C6A to C6F in APPENDIX C present predicted construction noise levels for daytime (6.30am to 6.30pm) and Out of Work Hours (OOHW) at 71 of the nearest sensitive receivers. Note predicted noise levels shown in Table 4.3 are based on a '**worst case**' scenario whereby all equipment is running simultaneously. The results are compared with external Construction Noise Goals (CNG's).

The noise presented in the table is a maximum (peak) predicted level within the respective stage. The maximum (peak) level of predicted noise is not expected to be generated for the entirety of the stage. For example, Stage 1 is scheduled for 11 months during daytime only and Stage 2 is 3 months with an approximate 6 weeks of 24hr construction activities, although the maximum (peak) noise level (as modelled) may only exist for shorter defined periods. The maximum (peak) predicted noise is determined based upon a '**worst case**' scenario (e.g. all plant items operating concurrently) which may not be the case during actual construction, thus noise monitoring will be conducted to validate the modelling and confirm actual noise levels.

The majority of the noise over the noise goal occurs during the day-time. The other evening and night-time periods are for much lesser durations, are scheduled well in advance, and are well defined. This provides the Project the opportunity to plan and complete community consultation in a structured, well-planned approach, as per the requirements of imposed condition 11 (c).

There is no alternative to conducting the evening and night-time works in this location since they are regulated by QR rail possessions that are designed to minimise disruption to the rail network and allow for safe access to the rail corridor.

Figures C8 to C13 in APPENDIX C presents noise contours for the various construction stages.

Table 4.3 presents a summary of predicted construction noise levels at selected noise sensitive receivers located close to the works zones. The data has been extracted from Tables C6A to C6F in APPENDIX C and summarised below for presentation purposes.

Table 4.3: Range of predicted Construction Noise Levels at selected receivers for each Construction Stage

NCA	Representative Location	Receiver Type	Construction Noise Goals (CNG's), dB(A)				Predicted Noise Level Range, dB(A)		Potential noise levels above Imposed noise goals, dB(A)	
			Day (Leq 15min)	Day (L10 15min)	OOH (Leq 15min)	Night (Lmax)	Day (Leq 15min)	OOH (Leq 15min)	Day (Leq 15min)	OOH (Leq 15min)
STAGE 1: 11 Months (construction works within Zone F)										
BOG_01	41 Peter Doherty St (Leukaemia Foundation)	Residential	62	72	57	59	50 - 76	28 - 52	14	-
BOG_01	Rawnlsey	Residential	47	57	42	49	57 - 70	39 - 51	23	9
BOG_01	Railway Tce	Residential	47	57	42	49	58 - 72	38 - 50	25	8
DUT_03	Railway Terrace	Residential	47	57	42	49	53 - 68	34 - 48	21	6

NCA	Representative Location	Receiver Type	Construction Noise Goals (CNG's), dB(A)				Predicted Noise Level Range, dB(A)		Potential noise levels above Imposed noise goals, dB(A)	
			Day (Leq 15min)	Day (L10 15min)	OOH (Leq 15min)	Night (Lmax)	Day (Leq 15min)	OOH (Leq 15min)	Day (Leq 15min)	OOH (Leq 15min)
STAGE 2: 3 Months (construction works within Zones B, C, D & F)										
BOG_01	41 Peter Doherty St (Leukaemia Foundation)	Residential	62	72	57	59	56 - 82	52 - 70	20	13
BOG_01	Rawnlsey	Residential	47	57	42	49	54 - 71	47 - 60	24	18
BOG_01	Railway Tce	Residential	47	57	42	49	53 - 74	46 - 64	27	22
DUT_03	Railway Terrace	Residential	47	57	42	49	50 - 66	41 - 55	19	13
STAGE 3: 12 Months (construction works within Zones A, B & C)										
BOG_01	41 Peter Doherty St (Leukaemia Foundation)	Residential	62	72	57	59	55 - 80	44 - 62	18	5
BOG_01	Rawnlsey	Residential	47	57	42	49	51 - 68	40 - 53	21	11
BOG_01	Railway Tce	Residential	47	57	42	49	51 - 72	40 - 55	25	13
DUT_03	Railway Terrace	Residential	47	57	42	49	46 - 60	35 - 49	13	7
STAGE 4 Roof: 3 Months (construction works within Zones A, B, C, D & E)										
BOG_01	41 Peter Doherty St (Leukaemia Foundation)	Residential	62	72	57	59	51 - 79	49 - 75	17	18
BOG_01	Rawnlsey	Residential	47	57	42	49	50 - 65	47 - 63	18	21
BOG_01	Railway Tce	Residential	47	57	42	49	50 - 72	46 - 69	25	27
DUT_03	Railway Terrace	Residential	47	57	42	49	43 - 57	41 - 55	10	13
STAGE 4 Excavation: 3 Months (construction works within Zones A, B, C, D & E)										
BOG_01	41 Peter Doherty St (Leukaemia Foundation)	Residential	62	72	57	59	55 - 81	52 - 74	19	17
BOG_01	Rawnlsey	Residential	47	57	42	49	56 - 69	52 - 62	22	20
BOG_01	Railway Tce	Residential	47	57	42	49	57 - 72	53 - 65	25	23
DUT_03	Railway Terrace	Residential	47	57	42	49	48 - 60	44 - 55	13	13
STAGE 5: 5 Months (construction works within Zones A, B, C, D & E)										
BOG_01	41 Peter Doherty St (Leukaemia Foundation)	Residential	62	72	57	59	38 - 65	34 - 55	3	-
BOG_01	Rawnlsey	Residential	47	57	42	49	41 - 53	39 - 51	6	9
BOG_01	Railway Tce	Residential	47	57	42	49	40 - 58	39 - 50	11	8
DUT_03	Railway Terrace	Residential	47	57	42	49	36 - 49	35 - 48	2	6

Table 4.3 presents a summary of predicted construction noise levels for selected noise sensitive receivers located close to the works zones. The table shows construction noise levels may be above the CNG's by up to 20dBA (Stage 2) during daytime and up to 18dBA (Stage 4 Roof) during Out of Hours Work at the Leukaemia Foundation.

Table 4.3 shows construction noise levels may be above the CNG's by up to 24dBA (Stage 2) during daytime and up to 21dBA (Stage 4 Roof) during Out of Hours Work at Rawnlsey Street.

Table 4.3 also shows construction noise levels may be above the CNG's by up to 27dBA (Stage 2) during daytime and up to 27dBA (Stage 4 Roof) during Out of Hours Work at one of the closest receivers, 60 Railway Street.

Noise levels above the CNG's depend on the construction stage (type of construction activities), period of work, type of receiver and proximity of the nearest receiver.

Note that the potential noise levels shown in Table 4.3 are based on a '**worst case**' scenario whereby all equipment is running simultaneously. The mitigation of these noise levels and sources is further discussed in Section 5.3 which aims to reduce the predicted noise levels through various noise mitigation and management strategies.

At some receiver locations noise levels may be above the CNGs and there are no physical mitigation measures that can be applied to achieve the CNGs. The way forward may be determined in consultation with the affected receivers, as per imposed condition 11 (c).

The Noise Management Plan (NMP) identifies the management measures that can be applied to deal with residual impacts, including noise monitoring, letter box drops, phone calls, individual briefings, and agreed mitigations.

4.3.1 Variation between Assessed Project

A review of the Request for Project Change (#1) – Volume 4 Technical Reports (February 2017) was conducted to compare previous predicted construction noise levels against predicted construction noise levels in Appendix C of this report, as the same construction method was proposed as part of RfPC #1. Table E-3 on page 206 (RfPC#1) provides a range of predicted construction noise levels based on five scenarios. The RfPC#1 table contains predicted construction noise levels from both Boggo Road Station and the Southern Portal. Our review indicates there is no simple method to accurately compare the five RfPC#1 scenarios against the current construction stages for Southern Portal alone. The proposed construction works (Stages 1 to 5) is most closely related to Scenario's 3 and 4 in RfPC#1. Furthermore, the basis of the model set up and quantity of equipment modelled is not known.

Nevertheless, the table below attempts to provide an indicative comparison based on overall predicted construction noise levels. Table 4.3.1 presents a summary of the variation between the evaluated project and the proposed project changes described in Section 1 of this report.

Table 4.3.1:- Variation between Assessed Project

STAGE (RfPC#9)	Period & Construction Works Zones	RfPC#9 L10, adj (15 min)**	RfPC#1 / EIS Evaluated project L10, adj (15 min)	Potential impact RfPC#9 to Evaluated project	Significance of change
STAGE 1 (Scenario 3/4*)	11 Months (construction works within Zone F)	60 to 86dBA	72 to 84dBA	Low	No appreciable change to noise levels
STAGE 2 (Scenario 3/4*)	3 Months (construction works within Zones B, C, D & F)	66 to 92dBA	72 to 84dBA	Medium	Slight increase in noise levels
STAGE 3 (Scenario 3/4*)	12 Months (construction works within Zones A, B & C)	65 to 90dBA	72 to 84dBA	Medium	Slight increase in noise levels
STAGE 4 Roof (Scenario 3/4*)	3 Months (construction works within Zones A, B, C, D & E)	61 to 89dBA	72 to 84dBA	Medium	Slight increase in noise levels
STAGE 4 Excavation (Scenario 3/4*)	3 Months (construction works within Zones A, B, C, D & E)	65 to 91dBA	72 to 84dBA	Medium	Slight increase in noise levels
STAGE 5 (Scenario 3*)	5 Months (construction works within Zones A, B, C, D & E)	48 to 75dBA	67 to 76dBA	Low	No appreciable change to noise levels

* Note this is the Scenario from RfPC #1, the quantum of equipment used to model these scenarios is unknown. Receptor C (ESA Village) used as comparison location with same in this report, noted as BOG_1 (41 Peter Doherty Street - Leukemia Foundation).

** Note these L10, adj (15 mins) values were derived from column 8 in Table 4.3 for the receiver at BOG_1 (41 Peter Doherty Street - Leukemia Foundation). The predicted values in column 8 are presented in terms of the Leq (15 mins) noise descriptor. For assessment purposes we have adopted a conservative correction factor of +10dB to convert Leq (15 mins) values into L10, adj (15 mins) values. A similar difference of +10dB is observed between the Construction Noise Goals (CNG's) presented in terms of Day Leq (15 mins) CNG's and Day L10 (15 mins) CNG's (refer to differences in columns 4 and 5 in Table 4.3).

Note that the potential noise levels shown in Table 4.3.1 (RfPC #9) are based on a '**worst case**' scenario whereby all equipment is running simultaneously. The noise presented in the table is a maximum (peak) predicted level within the respective stage. The maximum (peak) level of predicted noise is not expected to be generated for the entirety of the stage. The mitigation of these noise levels and sources is further discussed in Section 5.3 which aims to reduce the predicted noise levels through various noise mitigation and management strategies. The equipment selection scenarios used to model the EIS and RfPC #1 are different to the '**worst case**' scenario used in this assessment.

5 Recommended Acoustic Design Measures

The construction noise management schedule for the worksite is presented in **Table C2** of **APPENDIX C**. This identifies the key noise mitigation and management strategies to manage:

- Airborne noise, including:
 - Noise barriers
 - Construction hours of work
 - Restrictions on plant and equipment

5.1 Plant and equipment

The performance requirements for specific items of plant and equipment (in particular concrete pumps, scrubbers and gensets) are specified in **Table C5** of **APPENDIX C**.

Some plant may require additional attenuation (e.g. residential grade muffler, acoustic attenuator or partial/full enclosure) to ensure specified noise level can be achieved on site. Failure to treat plant appropriately may result in noise levels above the CNGs.

5.1.1 Reversing beepers and movement warning alarms

Non-tonal reversing beepers and warning alarms (or an equivalent mechanism) must be fitted to all mobile plant that will be used on site.

5.1.2 Truck airbrake silencers

Air brake silencers are to be correctly installed and fully operational for any heavy vehicles operating in the OOHW- Evening (6:30pm to 10pm) and OOHW – Night (10pm to 6.30am).

5.2 Residual impacts

At some receiver locations noise levels may be above the Construction Noise Goals (CNGs) after all reasonable and feasible mitigation measures have been incorporated into the design. Where there are no further physical mitigation measures that can be applied to achieve the CNGs, and if internal noise levels are still above the noise goals specified in the Imposed Conditions, then alternative mitigation and construction noise management may need to be considered, such as (but not limited to):

- seeking a negotiated agreement with the affected receiver(s),
- advance notification (e.g. letter box drops and telephone calls).

Condition 11(c) in the Imposed Conditions provides guidance should Construction Works be predicted or monitored as generating noise levels that are more than 20dBA ($L_{A10\ 10min,adj}$) above the CNGs.

5.3 Noise mitigation and management

5.3.1 Other noise control measures

The following standard noise control measures are recommended to reduce potential noise impacts:

Table 5.3.1: Site noise control measures

Control type	Control measure	Typical use
At-Source Control Measures	Noise control kits	Plant that is brought to site for regular use should meet the sound power limits identified in Table C1 (refer to Appendix C). Where plant is above the CNG's then the plant may require installation of 'noise control kits' to comply with the noise limits in Table C1. Such 'noise control kits' comprise: • high performance 'residential-grade' exhaust mufflers, • additional engine cowling / enclosure lined inside with sound absorbent industrial-grade foam, and • air intake and discharge silencers / louvres. The need to fit 'noise control kits' onto the identified plant, will be confirmed once each plant item is tested prior to its regular use on site.
	Limit equipment in use	Only the equipment necessary during each stage of the works will be used.
	Limit activity duration	Any equipment not in use for extended periods shall be switched off. For example, heavy vehicles should switch engines off when not in use.
	Use and siting of plant	Avoid/ limit simultaneous operation of noisy plant and equipment within discernible range of a sensitive receiver. Direct noise-emitting plant away from sensitive receivers where practicable. Locate fixed location plant items as far from sensitive receivers as practicable.
	Equipment selection	Use quieter and less noise/ vibration emitting construction methods where feasible and reasonable.
	Non-tonal reversing alarms	Alternative reverse alarms, such as 'quackers' will be installed on all plant and equipment, where practicable.
	Site inductions & Toolbox Talks	All employees, contractors and subcontractors will receive a Project induction. The environmental component may be covered in toolboxes and should include: • location of nearest sensitive receivers • relevant project specific and standard noise and vibration mitigation measures; • permitted hours of work; • OOHV Procedure and Form construction employee parking areas.
Noise Management Measures	Community consultation	• Inform community of construction activity and potential impacts.
	Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
	Noise monitoring	Noise monitoring should be carried out as detailed in Section 5.3.3.

Prior to the commencement of works, residential receivers near the works areas, will be notified to advise that noise from the works may at times be audible. All potentially impacted receivers will be kept informed of the nature of works to be carried out, expected noise levels and duration, as well as given appropriate enquiries and complaints contact details (see Section 5.3.4).

5.3.2 Noise Control Measures

Table 5.3.2 below presents noise control methods, practical examples and expected noise reductions according to RTA opinion based on experience with past projects.

Table 5.3.2:- Relative Effectiveness of Various Form of Noise Control, dB(A)

Noise Control Method	Practical Examples	Typical Noise Reduction Possible in Practice
Reduce quantity of equipment	Use only one piece of heavy equipment at a time	3
Distance	Doubling of distance between source and receiver	6
Screening	Acoustic barriers such as earth mounds, temporary, mobile or permanent noise barriers	5 to 10
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	5 to 10
Engine Silencing	Residential class mufflers	10 to 20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	15 to 25

5.3.3 Attended noise monitoring

Attended noise monitoring should be undertaken to record noise levels resulting from construction works, subject to obtaining the property owner/occupier's consent to access the property (where required).

5.3.4 Complaints handling

All noise complaints received and responded to will be managed in accordance with procedures set out in the Construction Environmental Management Plan.

The Cross River Rail Community Team operate a 24-hour construction complaints line (1800 010 875). Enquiries/ complaints may also be received through the CRR project email (crossriversrail@cbgujv.com.au).

5.3.5 Risk Management

Risk management is an integral part of good management practice. Appendix D of this report describes various risk management aspects for this project.

6 Conclusion

This document summarises an assessment of the potential noise impacts associated with construction of the Southern Portal.

The report provides a summary of the works, the predicted noise impacts and a summary of the proposed mitigation and management measures to reduce impacts at the nearest sensitive receivers.

Potentially affected noise sensitive receivers have been identified and discussed to allow the assessment of potential construction impacts.

Expected construction noise levels have been predicted and presented in Tables C6A, C6B, C6C, C6D, C6E and C6F (refer to Appendix C). Figures C8 to C21 presents noise contours of the various construction stages during daytime, evening and night time periods.

Section 4.3.1 provides a comparison between the evaluated project and the proposed project changes described in Section 1 of this report. Scenario's from RfPC #1 / EIS Evaluated Project were loosely matched with proposed Construction Stages from the RfPC#9. Receptor C (ESA Village) used as comparison location with same in this report, noted as BOG_1 (41 Peter Doherty Street - Leukemia Foundation). The results indicate low to medium construction noise increases based on the RfPC#9 detailed noise predictions.

Noise mitigation and management measures have been presented in Section 5.3 and Table C2 (Appendix C) to aid in providing additional noise reduction benefits where noise levels are above the CG's noise goals.

References

- [1] The Department of State Development, Manufacturing, Infrastructure and Planning, Cross River Rail Coordinator General's *Change Report – design refinements and condition changes 2020* dated July 2020.
- [2] Coordinator-General's project-wide Imposed Conditions. Cross River Rail Coordinator General's *Change Report - #4*
- [3] Australian/New Zealand Standard AS/NZS 2107:2016 "*Acoustics - Recommended design sound levels and reverberation times for building interiors*"
- [4] Coordinator-General's project-wide Imposed Conditions. Cross River Rail Coordinator General's *Change Report - #1*

APPENDIX A Glossary of terminology

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

Adverse weather	Weather effects that enhance noise (particularly wind and temperature inversions) occurring at a site for a significant period of time. In the NSW INP this occurs when wind occurs for more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of nights in winter.
Air-borne 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.
Assessment period	The time period in which an assessment is made. e.g. Day 7am-10pm & Night 10pm-7am.
Assessment Point	A location at which a noise or vibration measurement is taken or estimated.
Attenuation	The reduction in the level of sound or vibration.
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.
Decibel [dB]	The units of sound measurement. The following are examples of the decibel readings of every day 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.
Free-field	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.

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.
Heavy Vehicle	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes).
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
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.
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.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the L _{Amax} .
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the L _{Amin} .
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially constant.
Reflection	Sound wave reflected from a solid object obscuring its path.
R _w	Weighted Sound Reduction Index A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory. The term supersedes the value STC which was used in older versions of the Building Code of Australia. R _w is measured and calculated using the procedure in ISO 717-1. The related field measurement is the D _{nT,w} . The higher the value the better the acoustic performance of the building element.
R' _w	Weighted Apparent Sound Reduction Index. As for R _w but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The higher the value the better the acoustic performance of the building element.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.

Sound absorption	The ability of a material to absorb sound energy by conversion to thermal energy.
Sound Insulation	Sound insulation refers to the ability of a construction or building element to limit noise transmission through the building element. The sound insulation of a material can be described by the R_w and the sound insulation between two rooms can be described by the $D_{nT,w}$.
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 micro Pascal.
Spoil	Soil or materials arising from excavation activities.
Tonal Noise	Sound containing a prominent frequency and characterised by a definite pitch.
Transmission Loss	The sound level difference between one room or area and another, usually of sound transmitted through an intervening partition or wall. Also the vibration level difference between one point and another. For example, if the sound level on one side of a wall is 100dB and 65dB on the other side, it is said that the transmission loss of the wall is 35dB. If the transmission loss is normalised or standardised, it then becomes the R_w or $R'w$ or $D_{nT,w}$.

APPENDIX B **Nearest sensitive receivers and noise management levels**

Table B1: Construction Noise Goals (CNGs) - Southern Portal

NCA	Receiver Type	Receiver Location	Continuous Noise LAeq,adj (1hr)		Intermittent Noise LA10,adj (15min)	
			Day (Monday - Saturday 6.30am-6.30pm)	Out of Hours - evening, night (Monday – Saturday 6.30pm – 6.30am Sundays, Public Holidays)	Day (Monday - Saturday 6.30am-6.30pm)	Out of Hours - evening, night (Monday – Saturday 6.30pm – 6.30am Sundays, Public Holidays)
-	Commercial	Railway Terrace	67	-	77	-
BOG01	Residential (Queenslander)	Railway Terrace (Pound St to Rawnsley St)	47	42	57	49
		ESA Village (Leukaemia Centre), new apartments along Peter Doherty St	62	57	72	59
BOG02	Residential					
	Commercial	Ecosciences Building	67	-	77	-
BOG02	Commercial	Police Station & Gaol	62	-	72	-
	Education	Dutton Park Primary School	57	-	67	-
BOG03	Residential	Merton Road to Elliott Street	47	42	57	49
	Commercial	Burke Street	62	-	72	-
BOG04	Commercial	Metropolitan linen service (MLS)	62	-	72	-
	Medical	PA Hospital	57	52	67	59
	Education	PA Early Education Centre	57	-	67	-
-	Residential	Rusk Street & Cornwall Street	47	42	57	49
DUT01	Residential (Queenslander)		47	42	57	52
	Residential		57	52	67	62
DUT02	Residential (Queenslander)		47	42	57	52
	Residential		57	52	67	62
	Commercial		67	-	77	-
DUT03	Residential (Queenslander)		47	42	57	52
	Residential		57	52	67	62
	Commercial		67	-	77	-
DUT04	Medical	PA Hospital	57	52	67	62
DUT05	Residential (Queenslander)		47	42	57	52
	Residential		57	52	67	62

Figure B1: Dutton Park Station - Site with Surrounding Land Use, Receivers and Noise Catchment Areas



APPENDIX C **Construction timetable/ activities/ management**

Figure C1.1: Southern Portal Construction Site



NORTH

Construction Work Zones
(A, B, C, D, E & F)

Figure C1.2: Southern Portal Construction Site - Noise Mitigation

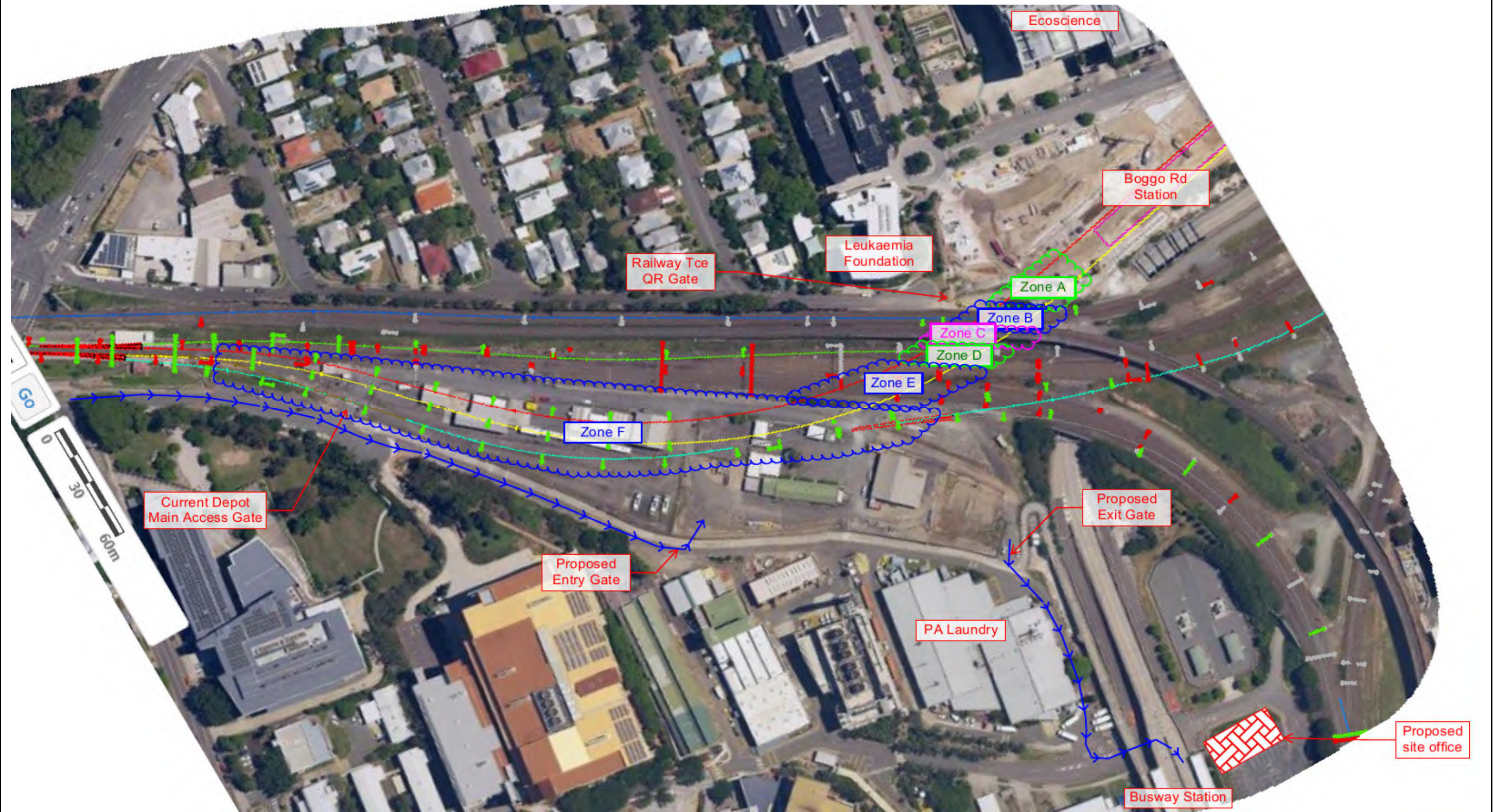


Figure C1.3: Stage 1 - 11 Months (construction works within Zone F)



Figure C1.4: Stage 2 - 3 Months (construction works within Zones B, C, D & F)

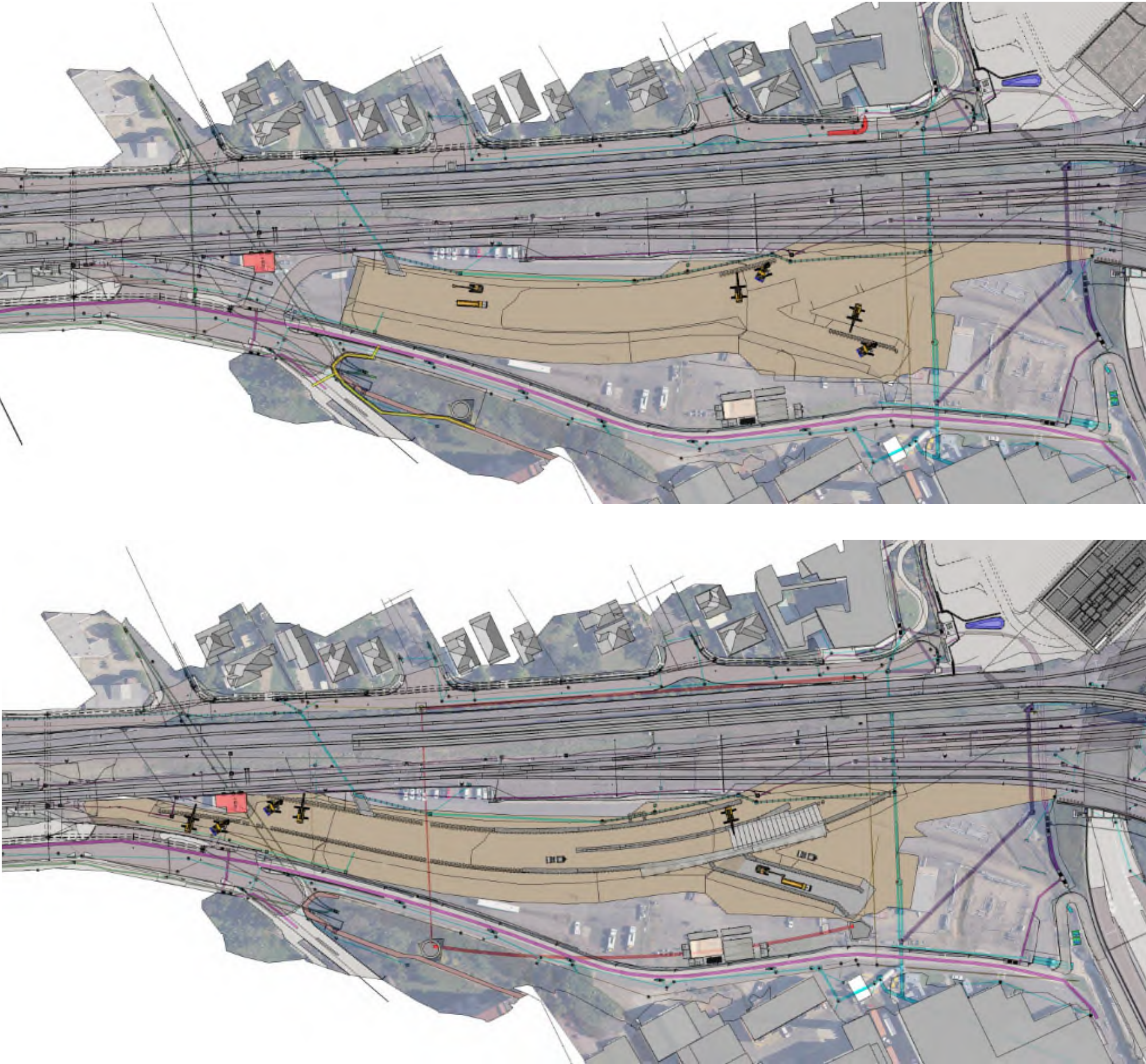


Figure C1.5: Stage 3 - 12 Months (construction works within Zones A, B & C)

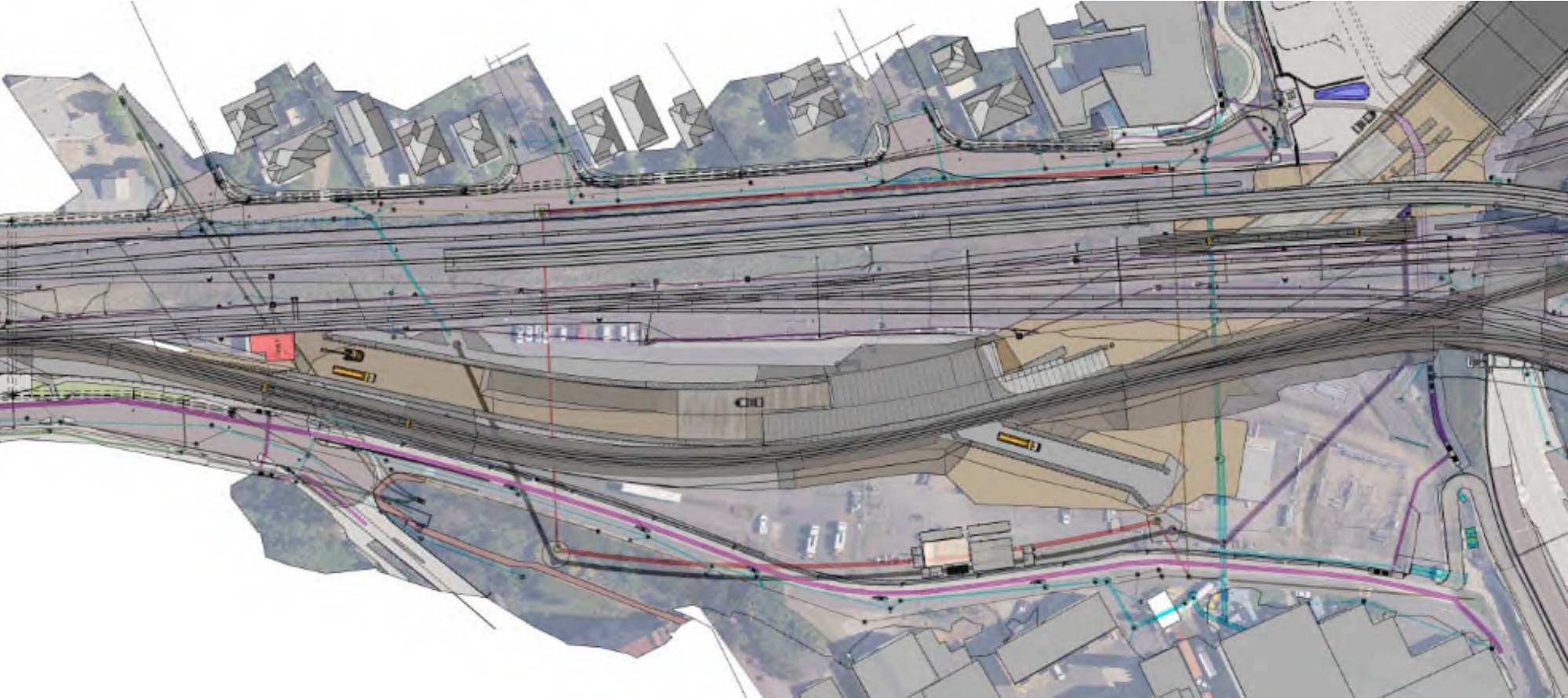
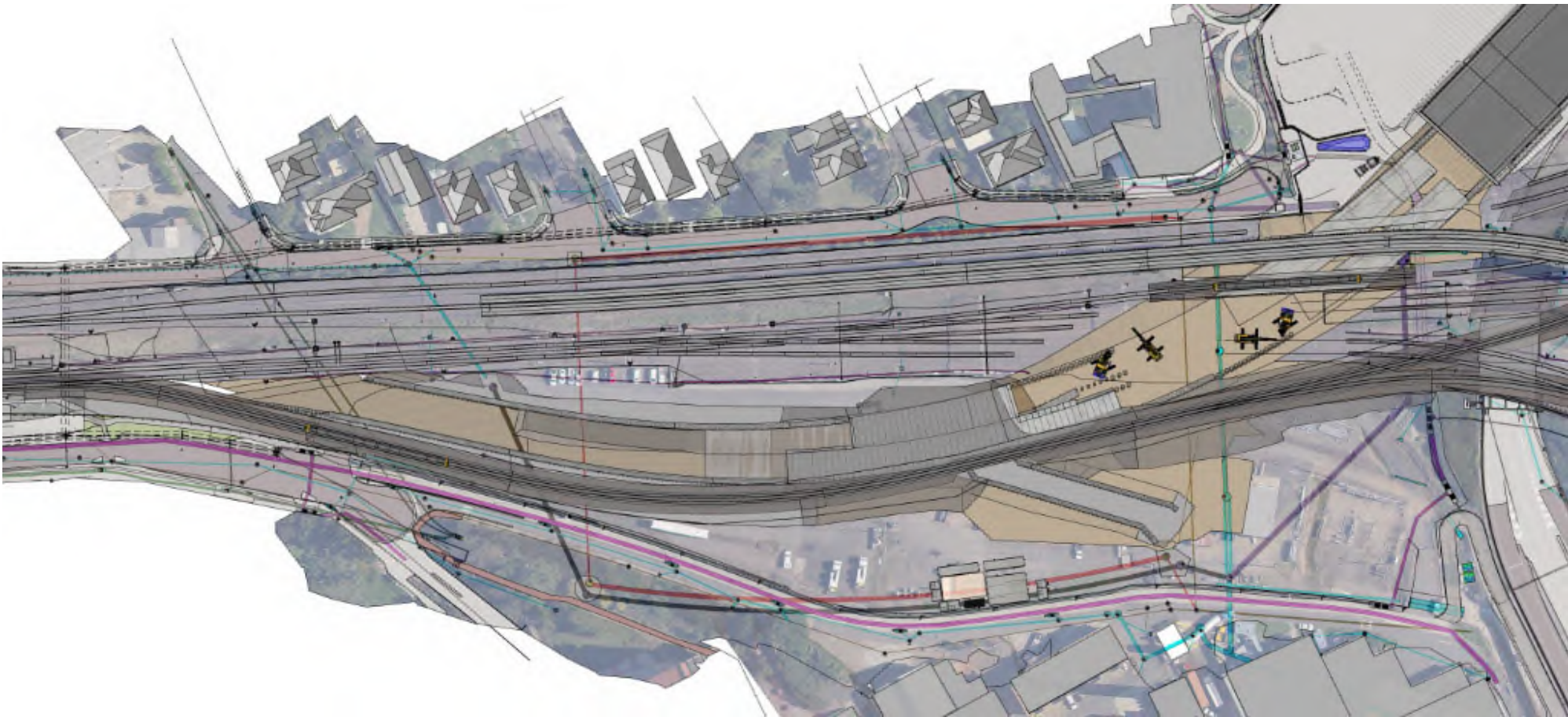
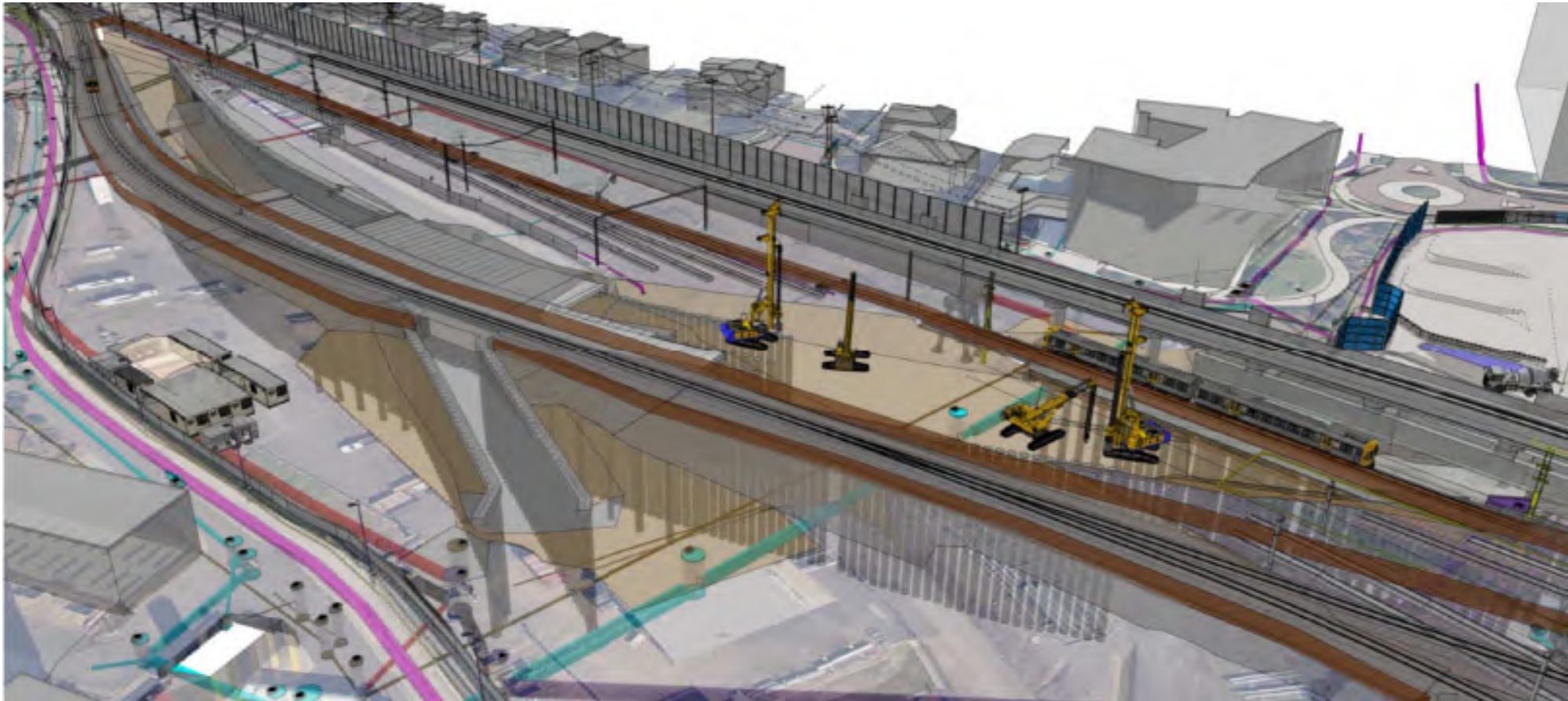


Figure C1.6: Stage 4 - Roof 3 Months (construction works within Zones A, B, C, D & E)



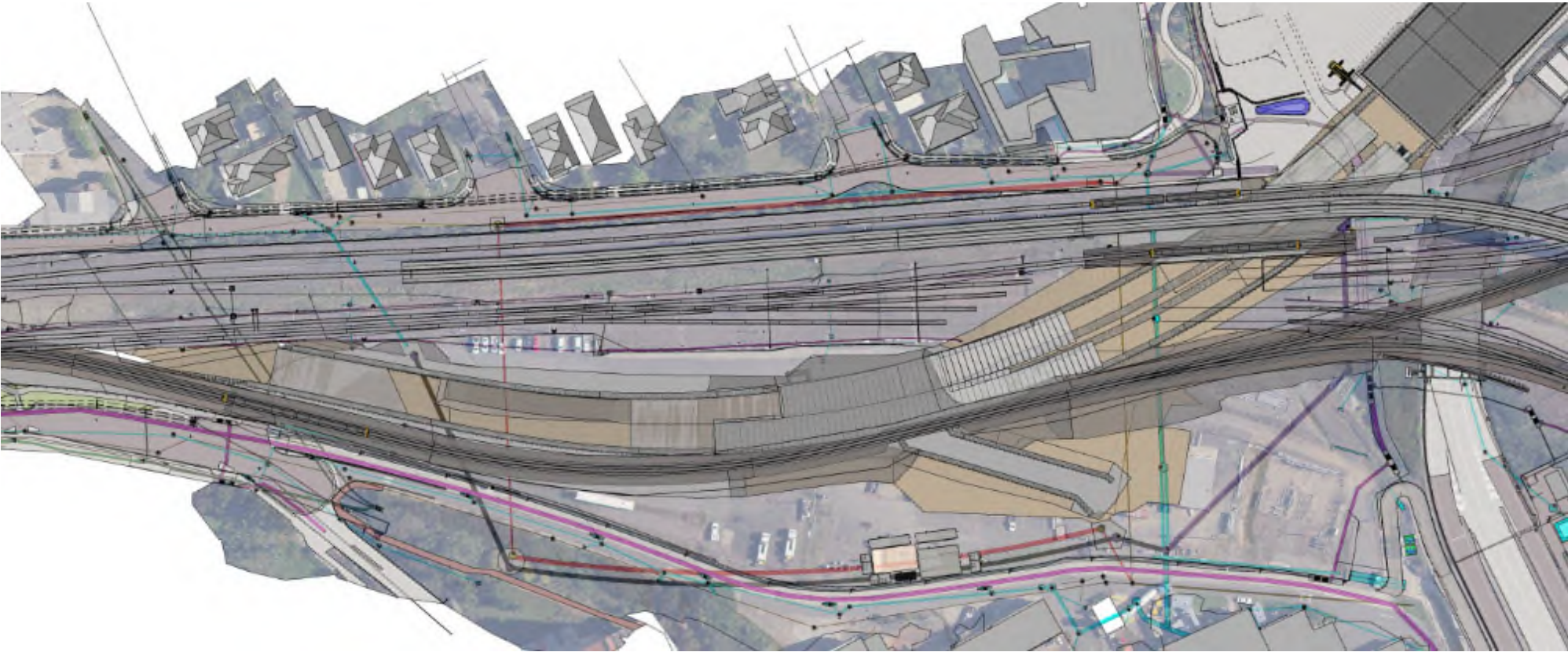


Figure C1.7: Stage 5 - 5 Months (construction works within Zones A, B, C, D & E)

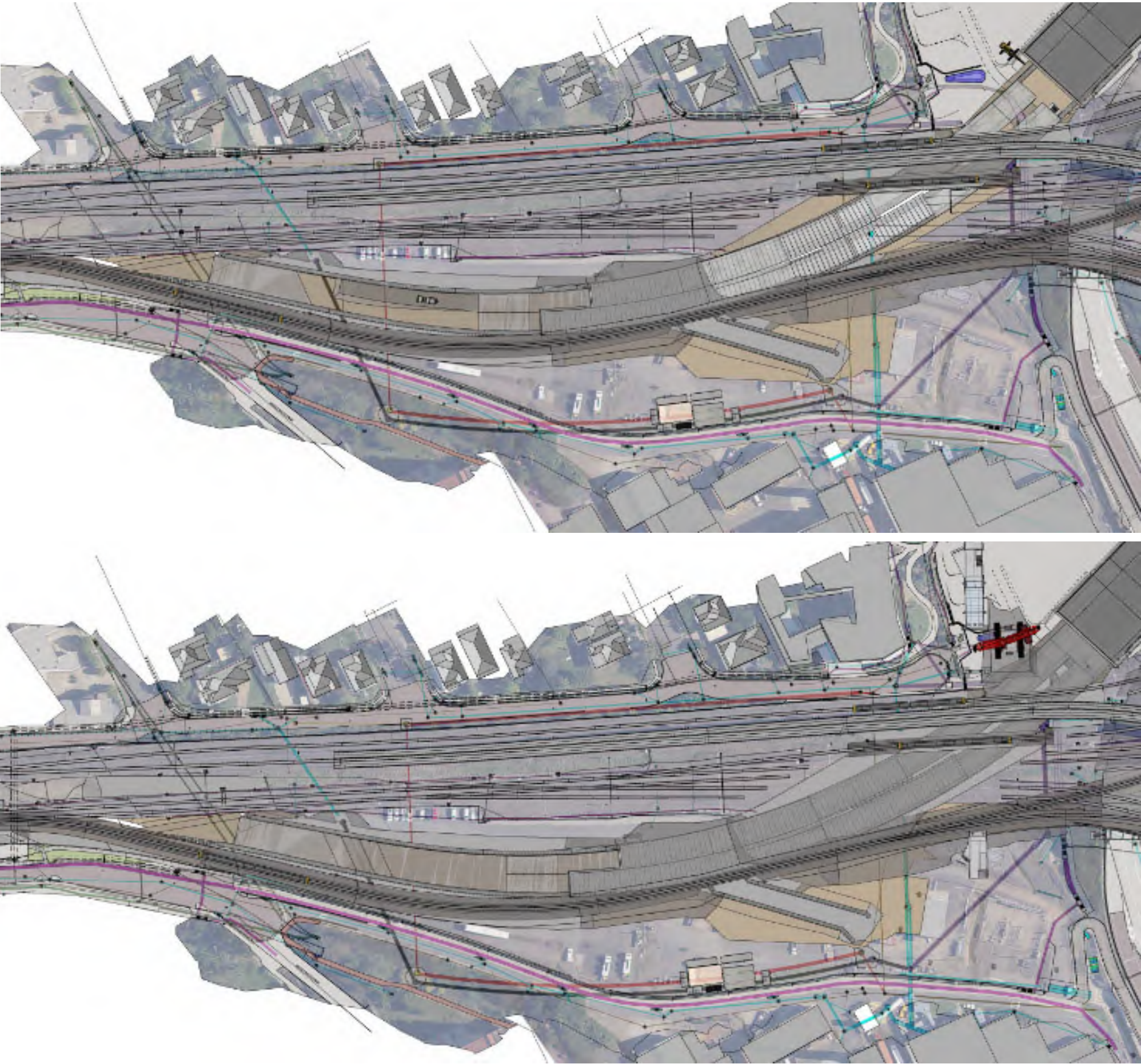


Table C1: Construction Timetable/ Activities/ Equipment - Southern Portal

Activity/ Work Area	Aspect	Plant/ Equipment	Work Zone	Operating Weight kg	Day	Evening	Night	Sound Power Level (Lw re: 1pW) in Noise Model, dB(A)	Notes
					6:30am - 6:30pm	6.30pm - 10pm	10pm - 6:30am	L _{Aeq}	
STAGE 1 - 11 Months (construction works within Zone F)									
Excavation	Excavator	Excavator	Zone F	8T-40T	3	-	-	103	
		Rock hammer attachment for excavator	Zone F	3T	10 hrs/day x 1 machine	-	-	119	
		Moxy or body truck	Zone F	10-20t	2	-	-	97	
		Truck and Quad dog to haul off site	Zone F	50T	5 / hr with peak 10 / hr	-	-	113	
		CAT 953 (Drott)	Zone F	15T	2	-	-	102	
		962 - 966 Loader	Zone F	23T	1	-	-	110	
	Piling Pad Construction	140M Grader	Zone F		1	-	-	113	
		Quarry Delivery Trucks	Zone F	50T	2 / hr	-	-	107	
		Vibrating roller (smooth & pad)	Zone F	12T	1 / hr	-	-	108	
	Piling Crew	BG28 - BG40 Piling Rig	Zone F	28T	3 / hr	-	-	112	
		120t crawler crane to service rig	Zone F	120T	3 / hr	-	-	100	
		Concrete Aqitator Truck	Zone F	25T	peak 5 / hr	-	-	108	
		Large posi track to clear spoil	Zone F	2T		-	-	108	
		Haulage Trucks	Zone F	50T	5 / hr with peak 10 / hr	-	-	108	
		Ancillary equipment - dewatering etc	Zone F			-	-	106	
	Capping Beam FRP	Franna Crane (20-25t)	Zone F	25T	1	-	-	98	
		Hand tools	Zone F		1	-	-	102	
		Concrete pump (24-36m)	Zone F	24T	1	-	-	106	
		Concrete Aqitator Truck	Zone F	25T	peak 5 / hr	-	-	108	
	Roof Installation - Lid	Precast install	220t - 350t All Terrain Hydraulic Crane	Zone F	350T	2	-	-	
Semi with Jinka delivery trucks			Zone F	50T	1/hr	1/hr	-	104	
Elevated Work Platform			Zone F		2	-	-	95	
Lighting towers if delivery restrictions require nights			Zone F		-	3	-	80	
Topping slab FRP	Franna Crane (20-25t)	Zone F	25T	1	-	-	98		
	Hand tools	Zone F		1	-	-	102		
	Concrete pump (24-36m)	Zone F	24T	1	-	-	106		
	Concrete Aqitator Truck	Zone F	25T	peak 5 / hr	-	-	108		
	Semi delivery trucks (reinforcement)	Zone F	50T	.25 / hr	-	-	104		
	120t All Terrain Hydraulic Crane	Zone F	120T	1	-	-	100		
Excavation under lid	20-30t Excavators	Zone F	30T	3	-	-	103		
	Rock hammer for excavators	Zone F	3T	1	-	-	119		
	Moxy or body truck for internal movements	Zone F	10-20T	2	-	-	97		
	Truck and Quad dog to haul off site	Zone F	40T	5 / hr with peak 10 / hr	-	-	113		
	962 - 966 Loader	Zone F	23T	1	-	-	110		
	STAGE 2 - 3 Months (construction works within Zones B, C, D & F)								
Excavation	Excavator	Excavator	Zones B, C & D	8T-40T	3	2	1	103	Evening and night works for a short 42 day window only
		Rock hammer attachment for excavator	Zones B, C & D	3T	10 hrs/day x 1 machine	-	-	119	
		Moxy or body truck	Zones B, C & D	10-20t	2	2	1 / hr	97	Evening and night works for a short 42 day window only
		Truck and Quad dog to haul off site	Zones B, C & D	50T	5 / hr with peak 10 / hr	5 / hr with peak 10 / hr	/ hr	113	Evening and night works for a short 42 day window only
		CAT 953 (Drott)	Zones B, C & D	15T	2	2		102	
		962 - 966 Loader	Zones B, C & D	23T	1	1	-	110	
	Piling Pad Construction	140M Grader	Zones B, C & D		1	-	-	113	
		Quarry Delivery Trucks	Zones B, C & D	50T	2 / hr	-	-	107	
		Vibrating roller (smooth & pad)	Zones B, C & D	12T	1 / hr			108	
	Piling Crew	BG28 - BG40 Piling Rig	Zones B, C & D	28T	3 / hr	3 / hr	2 / hr	112	Evening and night works for a short 42 day window only
		120t crawler crane to service rig	Zones B, C & D	120T	3 / hr	3 / hr	2 / hr	100	Evening and night works for a short 42 day window only
		Concrete Aqitator Truck	Zones B, C & D	25T	peak 5 / hr	peak 5 / hr	peak 5 / hr	108	Evening and night works for a short 42 day window only
		Large posi track to clear spoil	Zones B, C & D	2T				108	
		Haulage Trucks	Zones B, C & D	50T	5 / hr with peak 10 / hr	5 / hr with peak 10 / hr	5 / hr with peak 10 / hr	108	Evening and night works for a short 42 day window only
		Ancillary equipment - dewatering etc	Zones B, C & D					106	
	Capping Beam FRP	Franna Crane (20-25t)	Zones B, C & D	25T	1	-	-	98	
		Hand tools	Zones B, C & D		1	-	-	102	
		Concrete pump (24-36m)	Zones B, C & D	24T	1	-	-	106	
		Concrete Aqitator Truck	Zones B, C & D	25T	peak 5 / hr	peak 5 / hr	peak 5 / hr	108	Evening and night works for a short 42 day window only
	Topping slab FRP	Semi delivery trucks (reinforcement)	Zones B, C & D	50T	.25 / hr	-	-	104	
		Franna Crane (20-25t)	Zone F	25T	1	-	-	98	
		Hand tools	Zone F		1	-	-	102	
		Concrete pump (24-36m)	Zone F	24T	1	-	-	106	
	Excavation under lid	Concrete Aqitator Truck	Zone F	25T	peak 5 / hr	peak 5 / hr	peak 5 / hr	108	Evening and night works for a short 42 day window only
		Semi delivery trucks (reinforcement)	Zone F	50T	.25 / hr	-	-	104	
		120t All Terrain Hydraulic Crane	Zone F	120T	1	-	-	100	
STAGE 3 - 12 Months (construction works within Zones A, B & C)									
Excavation	Excavator	Excavator	Zone A	8T-40T	3	2		103	
		Rock hammer attachment for excavator	Zone A	3T	10 hrs/day x 1 machine	-		119	
		Moxy or body truck	Zone A	10-20t	2	2		97	
		Truck and Quad dog to haul off site	Zone A	50T	5 / hr with peak 10 / hr	5 / hr with peak 10 / hr		113	
		CAT 953 (Drott)	Zone A	15T	2	2		102	
		962 - 966 Loader	Zone A	23T	1	1	-	110	
	Piling Pad Construction	140M Grader	Zone A		1	-	-	113	
		Quarry Delivery Trucks	Zone A	50T	2trks / hr	-	-	107	
		Vibrating roller (smooth & pad)	Zone A	12T	1/hr	-		108	
	Piling Crew	BG28 - BG40 Piling Rig	Zone A	28T	3 / hr	-	-	112	
		120t crawler crane to service rig	Zone A	120T	3 / hr	-	-	100	
		Concrete Aqitator Truck	Zone A	25T	peak 5 / hr	-	-	108	
		Large posi track to clear spoil	Zone A	2T		-	-	108	
		Haulage Trucks	Zone A	50T	5 / hr with peak 10 / hr	-	-	108	
		Ancillary equipment - dewatering etc	Zone A			-	-	106	
	Capping Beam FRP	Franna Crane (20-25t)	Zone A	25T	1	-	-	98	
		Hand tools	Zone A		1	-	-	102	
		Concrete pump (24-36m)	Zone A	24T	1	-	-	106	
		Concrete Aqitator Truck	Zone A	25T	peak 5 / hr	peak 5 / hr	-	108	
	Excavation under lid	Semi delivery trucks (reinforcement)	Zone A	50T	.25/hr	-	-	104	
		20-30t Excavators	Zones B & C	30T	3	2	-	103	

		Rock hammer for excavators	Zones B & C	3T	1	2	-	119	
		Moxy or body truck for internal movements	Zones B & C	10-20T	2	2	-	97	
		Truck and Quad dog to haul off site	Zones B & C	40T	5 / hr with peak 10 / hr	5 / hr with peak 10 / hr	-	113	
		962 - 966 Loader	Zones B & C	23T	1	-	-	110	
STAGE 4 Roof - 3 Months (construction works within Zones A, B, C, D & E)									
Roof Installation - Lid	Precast install	220t - 350t All Terrain Hydraulic Crane	Zone E	350T	2	-	-	106	
		Semi with Jinka delivery trucks	Zone E	50T	1 / hr	1 / hr	-	104	
		Elevated Work Platform	Zone E		2	-	-	95	
		Lighting towers if delivery restrictions require nights	Zone E		NA	3	-	80	
	Topping slab FRP	Franna Crane (20-25t)	Zone E	25T	1	-	-	98	
		Hand tools	Zone E		1	-	-	102	
		Concrete pump (24-36m)	Zone E	24T	1	-	-	106	
		Concrete Agitator Truck	Zone E	25T	peak 5 / hr	peak 5 / hr	-	108	
		Semi delivery trucks (reinforcement)	Zone E	50T	.25/hr	-	-	104	
		120t All Terrain Hydraulic Crane	Zone E	120T	1	-	-	100	
Excavation under lid	Excavator	20-30t Excavators	Zones C & D	30T	3	2	-	103	
		Rock hammer for excavators	Zones C & D	3T	1	2	-	119	
		Moxy or body truck for internal movements	Zones C & D	10-20T	2	2	-	97	
		Truck and Quad doq to haul off site	Zones C & D	40T	5 / hr with peak 10 / hr	5 / hr with peak 10 / hr	-	113	
		962 - 966 Loader	Zones C & D	23T	1	-	-	110	
		STAGE 4 Excavation - 3 Months (construction works within Zones A, B, C, D & E)							
Excavation	Excavator	Excavator	Zone E	8T-40T	3	2	-	103	
		Rock hammer attachment for excavator	Zone E	3T	10 hrs/day x 1 machine	-	-	119	
		Moxy or body truck	Zone E	10-20t	2	2	-	97	
		Truck and Quad dog to haul off site	Zone E	50T	5 / hr with peak 10 / hr	5 / hr with peak 10 / hr	-	113	
		CAT 953 (Drott)	Zone E	15T	2	2	-	102	
		962 - 966 Loader	Zone E	23T	1	1	-	110	
		Piling Pad Construction	140M Grader	Zone E		1	-	-	113
	Quarry Delivery Trucks		Zone E	50T	2 / hr	-	-	107	
	Vibrating roller (smooth & pad)		Zone E	12T	1 / hr	-	-	108	
	Piling Crew		BG28 - BG40 Piling Riq	Zone E	28T	3 / hr	3 / hr	-	112
		120t crawler crane to service riq	Zone E	120T	3 / hr	3 / hr	-	100	
		Concrete Aqitator Truck	Zone E	25T	peak 5 / hr	peak 5 / hr	-	108	
		Large posi track to clear spoil	Zone E	2T			-	108	
		Haulage Trucks	Zone E	50T	5 / hr with peak 10 / hr	5 / hr with peak 10 / hr	-	108	
		Ancillary equipment - dewatering etc	Zone E			-	-	106	
	Capping Beam FRP	Franna Crane (20-25t)	Zone E	25T	1	-	-	98	
		Hand tools	Zone E		1	-	-	102	
		Concrete pump (24-36m)	Zone E	24T	1	-	-	106	
		Concrete Aqitator Truck	Zone E	25T	peak 5 / hr	peak 5 / hr	-	108	
		Semi delivery trucks (reinforcement)	Zone E	50T	.25/hr	-	-	104	
		Excavation under lid	Excavator	20-30t Excavators	Zones C & D	30T	3	2	-
	Rock hammer for excavators			Zones C & D	3T	1	2	-	119
	Moxy or body truck for internal movements			Zones C & D	10-20T	2	2	-	97
Truck and Quad dog to haul off site	Zones C & D			40T	5 / hr with peak 10 / hr	5 / hr with peak 10 / hr	/hr	113	
962 - 966 Loader	Zones C & D			23T	1	-	-	110	
STAGE 5 - 5 Months (construction works within Zones A, B, C, D & E)									
FRP slab	Topping slab FRP	Franna Crane (20-25t)	Zones A, B, C, D & E	25T	1	-	-	98	
		Hand tools	Zones A, B, C, D & E		1	-	-	102	
		Concrete pump (24-36m)	Zones A, B, C, D & E	24T	1	-	-	106	
		Concrete Aqitator Truck	Zones A, B, C, D & E	25T	peak 5 / hr	peak 5 / hr	-	108	
		Semi delivery trucks (reinforcement)	Zones A, B, C, D & E	50T	.25 / hr	-	-	104	
		120t All Terrain Hydraulic Crane	Zones A, B, C, D & E	120T	1	-	-	100	
		Backfill to roof structure	140M Grader			1	-	-	113
	6 wheeler body truck			10-20T	2	2	-		
	12t vibrating roller (smooth & pad)			12T	1	-	-		
	Fixed Plant Items - for underground works								
	Scrubbers	GAL14-1100/1100 with 4 x SDSI14 podded silencers	Zones A, B, C, D, E & F		4	4	4	99	
	Genset	500kVA	Zones A, B, C, D, E & F		2	2	2	100	

Zone A - Boggo Sth
Zone B - Dual Gauge
Zone C - Freight Flyover
Zone D - Middle Road
Zone E - Subs
Zone F - Greenfield

Table C2: Construction noise management schedule

SOUTHERN PORTAL

Area to be Managed		Mitigation/ Management Measure	Typical Details and Comments
Airborne Noise			
STAGE 1 - 11 Months (construction works within Zone F)			
1.1	Excavator	Zone F	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
1.2	Rock hammer attachment for excavator	Zone F	
1.3	Moxy or body truck	Zone F	
1.4	Truck and Quad dog to haul off site	Zone F	
1.5	CAT 953 (Drott)	Zone F	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
1.6	962 - 966 Loader	Zone F	
1.7	140M Grader	Zone F	
1.8	Quarry Delivery Trucks	Zone F	
1.9	Vibrating roller (smooth & pad)	Zone F	
1.10	BG28 - BG40 Piling Rig	Zone F	
1.11	120t crawler crane to service rig	Zone F	
1.12	Concrete Aqitator Truck	Zone F	
1.13	Large posi track to clear spoil	Zone F	
1.14	Haulage Trucks	Zone F	
			- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
1.15	Ancillary equipment - dewatering etc	Zone F	
1.16	Franna Crane (20-25t)	Zone F	
1.17	Hand tools	Zone F	
1.18	Concrete pump (24-36m)	Zone F	
1.19	Concrete Aqitator Truck	Zone F	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
1.20	Semi delivery trucks (reinforcement)	Zone F	
1.21	220t - 350t All Terrain Hydraulic Crane	Zone F	
1.22	Semi with Jinka delivery trucks	Zone F	
			- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
1.23	Elevated Work Platform	Zone F	
1.24	Lighting towers if delivery restrictions require nights	Zone F	
1.25	Franna Crane (20-25t)	Zone F	
1.26	Hand tools	Zone F	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
1.27	Concrete pump (24-36m)	Zone F	
1.28	Concrete Aqitator Truck	Zone F	
1.29	Semi delivery trucks (reinforcement)	Zone F	
1.30	120t All Terrain Hydraulic Crane	Zone F	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
1.31	20-30t Excavators	Zone F	
1.32	Rock hammer for excavators	Zone F	
1.33	Moxy or body truck for internal movements	Zone F	
1.34	Truck and Quad dog to haul off site	Zone F	
			- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
1.35	962 - 966 Loader	Zone F	
1.36	Monitoring	- Potential exceedance of daytime and OOHW CNGs. Allow for monitoring and implement a complaints handling procedure.	
1.37	Residual Impacts	- Provide advance notification of works and allow for noise monitoring at nearest sensitive receivers and set up complaints handling procedure. - Undertake consultation with Directly Affected Persons about predicted impacts and approach to mitigation of the impacts.	
STAGE 2 - 3 Months (construction works within Zones B, C, D & F)			
2.1	Excavator	Zones B, C & D	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
2.2	Rock hammer attachment for excavator	Zones B, C & D	
2.3	Moxy or body truck	Zones B, C & D	
2.4	Truck and Quad dog to haul off site	Zones B, C & D	
2.5	CAT 953 (Drott)	Zones B, C & D	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
2.6	962 - 966 Loader	Zones B, C & D	
2.7	140M Grader	Zones B, C & D	
2.8	Quarry Delivery Trucks	Zones B, C & D	
2.9	Vibrating roller (smooth & pad)	Zones B, C & D	
2.10	BG28 - BG40 Piling Rig	Zones B, C & D	
2.11	120t crawler crane to service rig	Zones B, C & D	
2.12	Concrete Aqitator Truck	Zones B, C & D	
2.13	Large posi track to clear spoil	Zones B, C & D	
2.14	Haulage Trucks	Zones B, C & D	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).

2.15	Ancillary equipment - dewatering etc	Zones B, C & D	
2.16	Franna Crane (20-25t)	Zones B, C & D	
2.17	Hand tools	Zones B, C & D	
2.18	Concrete pump (24-36m)	Zones B, C & D	
2.19	Concrete Agitator Truck	Zones B, C & D	
2.20	Semi delivery trucks (reinforcement)	Zones B, C & D	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
2.21	Franna Crane (20-25t)	Zone F	
2.22	Hand tools	Zone F	
2.23	Concrete pump (24-36m)	Zone F	
2.24	Concrete Agitator Truck	Zone F	
2.25	Semi delivery trucks (reinforcement)	Zone F	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
2.26	120t All Terrain Hydraulic Crane	Zone F	
2.27	Monitoring		- Potential exceedance of daytime and OOHW CNGs. Allow for monitoring and implement a complaints handling procedure. - Exceedance of Standard Hours CNGs and OOHW CNGs. See Tables C6B in 'C6 Residual' for details
2.28	Residual Impacts		- Provide advance notification of works and allow for noise monitoring at nearest sensitive receivers and set up complaints handling procedure. - Undertake consultation with Directly Affected Persons about predicted impacts and approach to mitigation of the impacts.
STAGE 3 - 12 Months (construction works within Zones A, B & C)			
3.1	Excavator	Zone A	
3.2	Rock hammer attachment for excavator	Zone A	
3.3	Moxy or body truck	Zone A	
3.4	Truck and Quad dog to haul off site	Zone A	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
3.5	CAT 953 (Drott)	Zone A	
3.6	962 - 966 Loader	Zone A	
3.7	140M Grader	Zone A	
3.8	Quarry Delivery Trucks	Zone A	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
3.9	Vibrating roller (smooth & pad)	Zone A	
3.10	BG28 - BG40 Piling Riq	Zone A	
3.11	120t crawler crane to service rig	Zone A	
3.12	Concrete Agitator Truck	Zone A	
3.13	Large posi track to clear spoil	Zone A	
3.14	Haulage Trucks	Zone A	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
3.15	Ancillary equipment - dewatering etc	Zone A	
3.16	Franna Crane (20-25t)	Zone A	
3.17	Hand tools	Zone A	
3.18	Concrete pump (24-36m)	Zone A	
3.19	Concrete Agitator Truck	Zone A	
3.20	Semi delivery trucks (reinforcement)	Zone A	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
3.21	20-30t Excavators	Zones B & C	
3.22	Rock hammer for excavators	Zones B & C	
3.23	Moxy or body truck for internal movements	Zones B & C	
3.24	Truck and Quad dog to haul off site	Zones B & C	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
3.25	962 - 966 Loader	Zones B & C	
3.26	Monitoring		- Potential exceedance of daytime and OOHW CNGs. Allow for monitoring and implement a complaints handling procedure. - Exceedance of Standard Hours CNGs and OOHW CNGs. See Tables C6C in 'C6 Residual' for details
3.27	Residual Impacts		- Provide advance notification of works and allow for noise monitoring at nearest sensitive receivers and set up complaints handling procedure. - Undertake consultation with Directly Affected Persons about predicted impacts and approach to mitigation of the impacts.
STAGE 4 Roof - 3 Months (construction works within Zones A, B, C, D & E)			
4.1	220t - 350t All Terrain Hydraulic Crane	Zone E	
4.2	Semi with Jinka delivery trucks	Zone E	
4.3	Elevated Work Platform	Zone E	
4.4	Lighting towers if delivery restrictions require nights	Zone E	
4.5	Franna Crane (20-25t)	Zone E	
4.6	Hand tools	Zone E	
4.7	Concrete pump (24-36m)	Zone E	
4.8	Concrete Agitator Truck	Zone E	
4.9	Semi delivery trucks (reinforcement)	Zone E	- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
4.10	120t All Terrain Hydraulic Crane	Zone E	

4.11	20-30t Excavators	Zones C & D		
4.12	Rock hammer for excavators	Zones C & D		
4.13	Moxy or body truck for internal movements	Zones C & D		
4.14	Truck and Quad dog to haul off site	Zones C & D		- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
4.15	962 - 966 Loader	Zones C & D		
4.16	Monitoring		- Potential exceedance of daytime and OOHW CNGs. Allow for monitoring and implement a complaints handling procedure.	- Exceedance of Standard Hours CNGs and OOHW CNGs. See Tables C6D in 'C6 Residual' for details
4.17	Residual Impacts		- Provide advance notification of works and allow for noise monitoring at nearest sensitive receivers and set up complaints handling procedure. - Undertake consultation with Directly Affected Persons about predicted impacts and approach to mitigation of the impacts.	

STAGE 4 Excavation - 3 Months (construction works within Zones A, B, C, D & E)

4.18	Excavator	Zone E		
4.19	Rock hammer attachment for excavator	Zone E		
4.20	Moxy or body truck	Zone E		
4.21	Truck and Quad dog to haul off site	Zone E		- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
4.22	CAT 953 (Drott)	Zone E		
4.23	962 - 966 Loader	Zone E		
4.24	140M Grader	Zone E		
4.25	Quarry Delivery Trucks	Zone E		- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
4.26	Vibrating roller (smooth & pad)	Zone E		
4.27	BG28 - BG40 Piling Rig	Zone E		
4.28	120t crawler crane to service rig	Zone E		
4.29	Concrete Agitator Truck	Zone E		
4.30	Large posi track to clear spoil	Zone E		
4.31	Haulage Trucks	Zone E		- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
4.32	Ancillary equipment - dewatering etc	Zone E		
4.33	Franna Crane (20-25t)	Zone E		
4.34	Hand tools	Zone E		
4.35	Concrete pump (24-36m)	Zone E		
4.36	Concrete Agitator Truck	Zone E		
4.37	Semi delivery trucks (reinforcement)	Zone E		- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
4.38	20-30t Excavators	Zones C & D		
4.39	Rock hammer for excavators	Zones C & D		
4.40	Moxy or body truck for internal movements	Zones C & D		
4.41	Truck and Quad dog to haul off site	Zones C & D		- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
4.42	962 - 966 Loader	Zones C & D		
4.43	Monitoring		- Potential exceedance of daytime and OOHW CNGs. Allow for monitoring and implement a complaints handling procedure.	- Exceedance of Standard Hours CNGs and OOHW CNGs. See Tables C6E in 'C6 Residual' for details
4.44	Residual Impacts		- Provide advance notification of works and allow for noise monitoring at nearest sensitive receivers and set up complaints handling procedure. - Undertake consultation with Directly Affected Persons about predicted impacts and approach to mitigation of the impacts.	

STAGE 5 - 5 Months (construction works within Zones A, B, C, D & E)

5.1	Franna Crane (20-25t)	Zones A, B, C, D & E		
5.2	Hand tools	Zones A, B, C, D & E		
5.3	Concrete pump (24-36m)	Zones A, B, C, D & E		
5.4	Concrete Agitator Truck	Zones A, B, C, D & E		
	Semi delivery trucks (reinforcement)	Zones A, B, C, D & E		- Truck drivers need to be instructed to avoid excessive accerelation from stopped, vigorous slamming of truck doors and to limit use of airbrakes (where safe).
5.5				
5.6	120t All Terrain Hydraulic Crane	Zones A, B, C, D & E		
5.7	140M Grader			
5.8	6 wheeler body truck			
5.9	12t vibrating roller (smooth & pad)			

Fixed Plant Items - for underground works

6.1	Scrubbers	Zones A, B, C, D, E & F	4 off fans (Type) GAL14-1100/1100) and each fan fitted with 4 x SDSI14 podded silencers	Assumed sound power level including podded silencers of 99dBA Lw
6.2	Genset	Zones A, B, C, D, E & F	500kVA packaged unit	Assumed sound power level of 100dBA Lw with packaged attenuated unit

Notes: DAY - standard construction hours (6.30am to 6.30pm)
OOHW - Out Of Hours Work. Work outside standard construction hours (between 6:30pm to 6:30am).

Table C5: Plant and equipment specifications

Priority	Item	Acoustic Requirement	Assumed Sound Power Levels (Lw re: 1pW) in Noise Model									
			Octave spectrum dB									Lw dB(A)
			31.5	63	125	250	500	1000	2000	4000	8000	
1	Typical concrete pump	Plant selection / Acoustic enclosure subject to compliance testing										106
2	Scrubber (including 4 off silencers)	Plant selection / Acoustic enclosure subject to compliance testing										99
3	Genset (500kVA packaged unit)	Plant selection / Acoustic enclosure subject to compliance testing										100
4												
5												
6												

Notes:

LEGEND * estimated by calculations and/or reference to other similar plant type data. The client is advised not to commit to fans which have not been tested in an approved laboratory. Testing plant is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions. The advice provided here is in respect of acoustics only.

- GENERAL
- Sound power level of plant assumed based on sound power level of similar plant type, incorporating attenuation (acoustic attenuator/ muffler/ duct lining as required)
 - The specified performances must be achieved by the product selected.
 - Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
 - The information provided in this table is subject to modification and review without notice.
 - The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table C6: Managing residual impacts SOUTHERN PORTAL

ID	Noise Mitigation/ Management Measure
1	At some receiver locations noise levels may exceed the CNGs and there are no physical mitigation measures that can be applied to achieve the CNGs Therefore, after all reasonable and feasible noise mitigation measures have been applied, the way forward is to seek a negotiated agreement with the affected receiver
2	The Construction Noise Management Plan (CNMP) identifies the management measures that can be applied to deal with residual impacts, including noise monitoring, letter box drops, phone calls, individual briefings, respite offers and consideration of short-term alternative accommodation where necessary. Further mitigation measures may include changing operational procedures at evening / night in order to reduce noise impacts, e.g. reduce the number of trucks on site during the evening / night period (6.30 pm to 6.30am). The appropriate management measure would be determined by the degree of exceedance of the CNG.
3	The noise presented in the table is a maximum (peak) predicted level within the respective stage. The maximum (peak) level of predicted noise is not expected to be generated for the entirety of the stage. For example, Stage 1 is scheduled for 11 months & Stage 2 is 3 months, although the maximum (peak) noise level may only exist for shorter defined periods. The maximum (peak) predicted noise is determined based upon a worst-case scenario (eg all plant items operating concurrently) which may not be the case during actual construction, thus noise monitoring will be conducted to validate the modelling and confirm actual noise levels.

Table C6A: Residual Receivers - STAGE 1 - 11 Months (construction works within Zone F)

NCA	Address	Receiver Type	CNG, dB(A)				Predicted Noise Level, dB(A)			Exceedance, dB(A)		
			Day (LAeq 15min)	Day (LA10 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)
BOG_1	31 Peter Doherty St	Residential	62	72	57	59	43 - 64	22 - 40	-	2	-	-
BOG_1	40 Dutton St, Dutton Park	Residential	47	57	42	49	51 - 61	33 - 43	-	14	1	-
BOG_1	41 Peter Doherty St (Leukaemia Fo	Residential	62	72	57	59	50 - 76	28 - 52	-	14	0	-
BOG_1	44 Dutton St, Dutton Park	Residential	47	57	42	49	56 - 65	37 - 46	-	18	4	-
BOG_1	45 Rawnsley St, Dutton Park	Residential	47	57	42	49	56 - 68	38 - 50	-	21	8	-
BOG_1	46 Railway Terrace, Dutton Park	Residential	47	57	42	49	58 - 68	42 - 49	-	21	7	-
BOG_1	47 Rawnsley St, Dutton Park	Residential	47	57	42	49	59 - 69	40 - 50	-	22	8	-
BOG_1	48 Railway Terrace, Dutton Park	Residential	47	57	42	49	57 - 67	41 - 49	-	20	7	-
BOG_1	49 Rawnsley St, Dutton Park	Residential	47	57	42	49	57 - 70	39 - 51	-	23	9	-
BOG_1	50 Railway Terrace, Dutton Park	Residential	47	57	42	49	59 - 69	41 - 51	-	22	9	-
BOG_1	52 Rawnsley St, Dutton Park	Residential	47	57	42	49	60 - 69	35 - 49	-	22	7	-
BOG_1	56 Rawnsley St, Dutton Park	Residential	47	57	42	49	58 - 71	36 - 50	-	24	8	-
BOG_1	60 Railway Terrace, Dutton Park	Residential	47	57	42	49	58 - 72	38 - 50	-	25	8	-
BOG_1	68 Railway Terrace, Dutton Park	Residential	57	72	52	59	55 - 76	35 - 53	-	19	11	-
BOG_2	30 Joe Baker St (Ecosciencse Prec	Commercial	67	77	-	-	42 - 65	21 - 40	-	-	-	-
BOG_3	11 Quarry St	Residential	47	57	42	49	39 - 50	17 - 21	-	3	-	-
BOG_3	14 Quarry St	Residential	47	57	42	49	38 - 53	18 - 33	-	6	-	-
BOG_3	15 Elliott St	Residential	47	57	42	49	41 - 56	22 - 39	-	9	-	-
BOG_3	16 Quarry St	Residential	47	57	42	49	40 - 55	20 - 35	-	8	-	-
BOG_3	17-19 Elliott St	Residential	47	57	42	49	44 - 60	26 - 40	-	13	-	-
BOG_3	24 Elliott St	Residential	47	57	42	49	46 - 59	28 - 37	-	12	-	-
BOG_3	26 Burke St, Dutton Park	Commercial	62	72	-	-	44 - 59	25 - 38	-	-	-	-
BOG_3	2A Burke St, Dutton Park	Residential	47	57	42	49	44 - 59	25 - 38	-	12	-	-
BOG_3	30 Albert St	Residential	47	57	42	49	43 - 54	24 - 35	-	7	-	-
BOG_3	34 Albert St	Residential	47	57	42	49	44 - 54	25 - 35	-	7	-	-
BOG_3	36 Albert St	Residential	47	57	42	49	41 - 54	22 - 34	-	7	-	-
BOG_3	38 Albert St	Residential	47	57	42	49	43 - 55	24 - 36	-	8	-	-
BOG_3	40 Albert St	Residential	47	57	42	49	45 - 58	27 - 36	-	11	-	-
BOG_3	42 Albert St	Residential	47	57	42	49	57 - 58	36 - 37	-	11	-	-
BOG_3	44 Albert St	Residential	47	57	42	49	44 - 58	25 - 39	-	11	-	-
BOG_3	56 Merton Rd	Residential	47	57	42	49	37 - 38	17 - 18	-	-	-	-
BOG_4	PA	Hospital	57	67	52	59	53 - 80	34 - 64	-	23	12	-
BOG_4	PA_Laundry	Commercial	62	72	-	-	52 - 80	31 - 48	-	18	-	-
DUT_1	1 Tamar St, Annerley	Residential	47	57	42	49	42 - 58	23 - 37	-	11	-	-
DUT_1	10 Cope St, Annerley	Residential	47	57	42	49	41 - 51	23 - 33	-	4	-	-
DUT_1	10 Rusk St, Annerley	Residential	47	57	42	49	43 - 52	25 - 30	-	5	-	-
DUT_1	15 Sampson St, Annerley	Residential	47	57	42	49	40 - 49	25 - 30	-	2	-	-
DUT_1	211 Annerley Rd, Annerley	Residential	47	57	42	49	45 - 66	27 - 48	-	19	6	-
DUT_1	3 Cope St, Annerley	Residential	47	57	42	49	49 - 65	32 - 44	-	18	2	-
DUT_1	39 Cornwall St, Annerley	Residential	47	57	42	49	43 - 52	24 - 30	-	5	-	-
DUT_1	41 Tamar St, Annerley	Residential	57	67	52	59	35 - 41	17 - 22	-	-	-	-
DUT_1	53 Tamar St, Annerley	Residential	57	67	52	59	34 - 44	15 - 24	-	-	-	-
DUT_1	6 Cope St, Annerley	Residential	47	57	42	49	44 - 55	27 - 35	-	8	-	-
DUT_1	6 Rusk St, Annerley	Residential	47	57	42	49	43 - 52	24 - 29	-	5	-	-
DUT_1	64 Annerley Rd, Annerley	Residential	47	57	42	49	40 - 51	22 - 31	-	4	-	-
DUT_1	9 Cope St, Annerley	Residential	47	57	42	49	44 - 66	27 - 48	-	19	6	-
DUT_2	13A Fenton St, Fairfield	Residential	57	67	52	59	37 - 54	20 - 35	-	-	-	-
DUT_2	14 Princess St, Fairfield	Residential	57	67	52	59	43 - 54	26 - 35	-	-	-	-
DUT_2	15 Cornwall St, Fairfield	Commercial	67	77	-	-	42 - 57	24 - 38	-	-	-	-
DUT_2	18 Princess St, Fairfield	Residential	57	67	52	59	40 - 54	23 - 35	-	-	-	-
DUT_2	6 Princess St, Fairfield	Residential	57	67	52	59	47 - 55	30 - 36	-	-	-	-
DUT_2	8 Princess St, Fairfield	Residential	57	67	52	59	43 - 55	26 - 36	-	-	-	-
DUT_3	6 Railway Terrace, Dutton Park	Commercial	67	77	-	-	57 - 68	38 - 47	-	1	-	-
DUT_3	18 Pound St, Dutton Park	Residential	47	57	42	49	51 - 61	34 - 42	-	14	-	-
DUT_3	22 Pound St, Dutton Park	Residential	47	57	42	49	50 - 62	32 - 43	-	15	1	-
DUT_3	24 Railway Terrace, Dutton Park	Residential	47	57	42	49	53 - 68	35 - 48	-	21	6	-
DUT_3	30 Pound St, Dutton Park	Residential	47	57	42	49	52 - 61	35 - 43	-	14	1	-
DUT_3	31 Dutton St, Dutton Park	Residential	47	57	42	49	50 - 56	32 - 38	-	9	-	-

DUT_3	34 Railway Terrace, Dutton Park	Residential	47	57	42	49	53 - 67	35 - 47	-	20	5	-
DUT_3	35 Dutton St, Dutton Park	Residential	47	57	42	49	48 - 60	30 - 46	-	13	4	-
DUT_3	36 Railwav Terrace, Dutton Park	Residential	47	57	42	49	53 - 64	35 - 43	-	17	1	-
DUT_3	38 Railway Terrace, Dutton Park	Residential	47	57	42	49	53 - 68	34 - 48	-	21	6	-
DUT_3	39 Dutton St, Dutton Park	Residential	47	57	42	49	55 - 70	37 - 49	-	23	7	-
DUT_4	PA, TRICFNTRF	Medical	57	67	52	59	47 - 77	27 - 59	-	20	7	-
DUT_4	PA2	Medical	57	67	52	59	42 - 71	23 - 51	-	14	-	-
DUT_5	1 Fenton St, Fairfield	Residential	47	57	42	49	38 - 49	20 - 30	-	2	-	-
DUT_5	10 Cameron St, Fairfield	Residential	57	67	52	59	31 - 41	12 - 23	-	-	-	-
DUT_5	2 Cottenham St, Fairfield	Residential	47	57	42	49	32 - 42	13 - 22	-	-	-	-
DUT_5	2 Fenton St, Fairfield	Residential	47	57	42	49	36 - 49	19 - 31	-	2	-	-
DUT_5	47 Wilkins St W, Fairfield	Residential	47	57	42	49	32 - 44	15 - 25	-	-	-	-
DUT_5	46 Wilkins St W, Fairfield	Residential	47	57	42	49	30 - 43	11 - 24	-	-	-	-

Table C6B: Residual Receivers - STAGE 2 - 3 Months (construction works within Zones B, C, D & F)

NCA	Address	Receiver Type	CNG, dB(A)				Predicted Noise Level, dB(A)			Exceedance, dB(A)		
			Day (LAeq 15min)	Day (LA10 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)
BOG_1	31 Peter Doherty St	Residential	62	72	57	59	44 - 69	38 - 62	61	7	5	2
BOG_1	40 Dutton St, Dutton Park	Residential	47	57	42	49	47 - 56	40 - 47	47	9	5	-
BOG_1	41 Peter Doherty St (Leukaemia Fo	Residential	62	72	57	59	56 - 82	52 - 70	68	20	13	9
BOG_1	44 Dutton St, Dutton Park	Residential	47	57	42	49	51 - 60	41 - 51	49	13	9	0
BOG_1	45 Rawnsley St, Dutton Park	Residential	47	57	42	49	52 - 62	46 - 51	51	15	9	2
BOG_1	46 Railway Terrace, Dutton Park	Residential	47	57	42	49	57 - 68	46 - 57	54	21	15	5
BOG_1	47 Rawnsley St, Dutton Park	Residential	47	57	42	49	54 - 63	48 - 55	53	16	13	4
BOG_1	48 Railway Terrace, Dutton Park	Residential	47	57	42	49	56 - 66	45 - 55	53	19	13	4
BOG_1	49 Rawnsley St, Dutton Park	Residential	47	57	42	49	54 - 71	47 - 60	56	24	18	7
BOG_1	50 Railway Terrace, Dutton Park	Residential	47	57	42	49	56 - 69	48 - 59	55	22	17	6
BOG_1	52 Rawnsley St, Dutton Park	Residential	47	57	42	49	53 - 60	46 - 50	50	13	8	1
BOG_1	56 Rawnsley St, Dutton Park	Residential	47	57	42	49	52 - 61	46 - 52	51	14	10	2
BOG_1	60 Railway Terrace, Dutton Park	Residential	47	57	42	49	53 - 74	46 - 64	61	27	22	12
BOG_1	68 Railway Terrace, Dutton Park	Residential	57	72	52	59	52 - 65	46 - 57	56	8	15	7
BOG_2	30 Joe Baker St (Ecosciencse Prec	Commercial	67	77	-	-	46 - 70	40 - 62	59	3	-	-
BOG_3	11 Quarry St	Residential	47	57	42	49	41 - 50	36 - 45	37	3	3	-
BOG_3	14 Quarry St	Residential	47	57	42	49	39 - 53	34 - 47	44	6	5	-
BOG_3	15 Elliott St	Residential	47	57	42	49	42 - 61	37 - 54	51	14	12	2
BOG_3	16 Quarry St	Residential	47	57	42	49	41 - 56	36 - 50	47	9	8	-
BOG_3	17-19 Elliott St	Residential	47	57	42	49	46 - 63	41 - 54	51	16	12	2
BOG_3	24 Elliott St	Residential	47	57	42	49	47 - 63	43 - 54	50	16	12	1
BOG_3	26 Burke St, Dutton Park	Commercial	62	72	-	-	45 - 62	41 - 58	57	0	-	-
BOG_3	2A Burke St, Dutton Park	Residential	47	57	42	49	44 - 59	39 - 52	49	12	10	-
BOG_3	30 Albert St	Residential	47	57	42	49	44 - 55	39 - 48	46	8	6	-
BOG_3	34 Albert St	Residential	47	57	42	49	45 - 55	40 - 48	46	8	6	-
BOG_3	36 Albert St	Residential	47	57	42	49	43 - 55	38 - 48	46	8	6	-
BOG_3	38 Albert St	Residential	47	57	42	49	44 - 57	40 - 52	51	10	10	2
BOG_3	40 Albert St	Residential	47	57	42	49	47 - 62	42 - 53	51	15	11	2
BOG_3	42 Albert St	Residential	47	57	42	49	57 - 61	52 - 53	51	14	11	2
BOG_3	44 Albert St	Residential	47	57	42	49	45 - 63	41 - 54	51	16	12	2
BOG_3	56 Merton Rd	Residential	47	57	42	49	38 - 39	33 - 34	31	-	-	-
BOG_4	PA	Hospital	57	67	52	59	51 - 75	46 - 66	65	18	14	6
BOG_4	PA, Laundry	Commercial	62	72	-	-	53 - 73	48 - 62	59	11	-	-
DUT_1	1 Tamar St, Annerley	Residential	47	57	42	49	40 - 60	34 - 48	45	13	6	-
DUT_1	10 Cope St, Annerley	Residential	47	57	42	49	39 - 49	33 - 41	38	2	-	-
DUT_1	10 Rusk St, Annerley	Residential	47	57	42	49	41 - 51	34 - 42	38	4	-	-
DUT_1	15 Sampson St, Annerley	Residential	47	57	42	49	38 - 48	32 - 41	38	1	-	-
DUT_1	211 Annerley Rd, Annerley	Residential	47	57	42	49	46 - 64	39 - 55	52	17	13	3
DUT_1	3 Cope St, Annerley	Residential	47	57	42	49	47 - 64	41 - 54	51	17	12	2
DUT_1	39 Cornwall St, Annerley	Residential	47	57	42	49	40 - 50	33 - 41	38	3	-	-
DUT_1	41 Tamar St, Annerley	Residential	57	67	52	59	32 - 44	26 - 37	34	-	-	-
DUT_1	53 Tamar St, Annerley	Residential	57	67	52	59	31 - 45	26 - 38	34	-	-	-
DUT_1	6 Cope St, Annerley	Residential	47	57	42	49	41 - 53	36 - 44	41	6	2	-
DUT_1	6 Rusk St, Annerley	Residential	47	57	42	49	40 - 50	34 - 41	38	3	-	-
DUT_1	64 Annerley Rd, Annerley	Residential	47	57	42	49	38 - 51	32 - 44	40	4	2	-
DUT_1	9 Cope St, Annerley	Residential	47	57	42	49	42 - 64	37 - 55	52	17	13	3
DUT_2	13A Fenton St, Fairfield	Residential	57	67	52	59	34 - 50	27 - 42	39	-	-	-
DUT_2	14 Princess St, Fairfield	Residential	57	67	52	59	39 - 51	32 - 42	39	-	-	-
DUT_2	15 Cornwall St, Fairfield	Commercial	67	77	-	-	39 - 55	32 - 46	43	-	-	-
DUT_2	18 Princess St, Fairfield	Residential	57	67	52	59	37 - 51	30 - 42	39	-	-	-
DUT_2	6 Princess St, Fairfield	Residential	57	67	52	59	44 - 53	36 - 44	41	-	-	-
DUT_2	8 Princess St, Fairfield	Residential	57	67	52	59	39 - 52	33 - 43	41	-	-	-
DUT_3	6 Railway Terrace, Dutton Park	Commercial	67	77	-	-	55 - 63	46 - 52	50	-	-	-
DUT_3	18 Pound St, Dutton Park	Residential	47	57	42	49	48 - 55	39 - 46	45	8	4	-
DUT_3	22 Pound St, Dutton Park	Residential	47	57	42	49	46 - 58	39 - 47	46	11	5	-
DUT_3	24 Railway Terrace, Dutton Park	Residential	47	57	42	49	49 - 65	40 - 54	52	18	12	3
DUT_3	30 Pound St, Dutton Park	Residential	47	57	42	49	49 - 57	41 - 47	45	10	5	-
DUT_3	31 Dutton St, Dutton Park	Residential	47	57	42	49	46 - 52	38 - 42	41	5	-	-
DUT_3	34 Railway Terrace, Dutton Park	Residential	47	57	42	49	50 - 63	41 - 52	50	16	10	1
DUT_3	35 Dutton St, Dutton Park	Residential	47	57	42	49	45 - 59	37 - 48	47	12	6	-
DUT_3	36 Railway Terrace, Dutton Park	Residential	47	57	42	49	53 - 62	41 - 46	45	15	4	-
DUT_3	38 Railway Terrace, Dutton Park	Residential	47	57	42	49	50 - 66	41 - 55	52	19	13	3

DUT_3	39 Dutton St, Dutton Park	Residential	47	57	42	49	52 - 66	43 - 56	53	19	14	4
DUT_4	PA TRICFNTRF	Medical	57	67	52	59	46 - 74	35 - 63	62	17	11	3
DUT_4	PA2	Medical	57	67	52	59	39 - 68	31 - 58	55	11	6	-
DUT_5	1 Fenton St, Fairfield	Residential	47	57	42	49	38 - 49	32 - 41	37	2	-	-
DUT_5	10 Cameron St, Fairfield	Residential	57	67	52	59	29 - 43	23 - 36	32	-	-	-
DUT_5	2 Cottenham St, Fairfield	Residential	47	57	42	49	30 - 43	24 - 37	33	-	-	-
DUT_5	2 Fenton St, Fairfield	Residential	47	57	42	49	34 - 48	29 - 40	37	1	-	-
DUT_5	47 Wilkins St W, Fairfield	Residential	47	57	42	49	30 - 45	25 - 38	35	-	-	-
DUT_5	46 Wilkins St W, Fairfield	Residential	47	57	42	49	28 - 45	22 - 37	34	-	-	-

Table C6C: Residual Receivers - STAGE 3 - 12 Months (construction works within Zones A, B & C)

NCA	Address	Receiver Type	CNG, dB(A)				Predicted Noise Level, dB(A)			Exceedance, dB(A)		
			Day (LAeq 15min)	Day (LA10 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)
BOG_1	31 Peter Doherty St	Residential	62	72	57	59	47 - 75	30 - 57	-	13	0	-
BOG_1	40 Dutton St, Dutton Park	Residential	47	57	42	49	44 - 51	34 - 43	-	4	1	-
BOG_1	41 Peter Doherty St (Leukaemia Fo	Residential	62	72	57	59	55 - 80	44 - 62	-	18	5	-
BOG_1	44 Dutton St, Dutton Park	Residential	47	57	42	49	45 - 56	37 - 47	-	9	5	-
BOG_1	45 Rawnsley St, Dutton Park	Residential	47	57	42	49	50 - 56	39 - 50	-	9	8	-
BOG_1	46 Railway Terrace, Dutton Park	Residential	47	57	42	49	48 - 63	42 - 50	-	16	8	-
BOG_1	47 Rawnsley St, Dutton Park	Residential	47	57	42	49	52 - 62	41 - 50	-	15	8	-
BOG_1	48 Railway Terrace, Dutton Park	Residential	47	57	42	49	49 - 60	41 - 49	-	13	7	-
BOG_1	49 Rawnsley St, Dutton Park	Residential	47	57	42	49	51 - 68	40 - 53	-	21	11	-
BOG_1	50 Railway Terrace, Dutton Park	Residential	47	57	42	49	53 - 64	42 - 52	-	17	10	-
BOG_1	52 Rawnsley St, Dutton Park	Residential	47	57	42	49	51 - 53	40 - 49	-	6	7	-
BOG_1	56 Rawnsley St, Dutton Park	Residential	47	57	42	49	51 - 54	38 - 50	-	7	8	-
BOG_1	60 Railway Terrace, Dutton Park	Residential	47	57	42	49	51 - 72	40 - 55	-	25	13	-
BOG_1	68 Railway Terrace, Dutton Park	Residential	57	72	52	59	52 - 61	37 - 53	-	4	11	-
BOG_2	30 Joe Baker St (Ecosciencse Prec	Commercial	67	77	-	-	48 - 72	30 - 54	-	5	-	-
BOG_3	11 Quarry St	Residential	47	57	42	49	43 - 54	25 - 36	-	7	-	-
BOG_3	14 Quarry St	Residential	47	57	42	49	41 - 55	24 - 38	-	8	-	-
BOG_3	15 Elliott St	Residential	47	57	42	49	44 - 63	27 - 46	-	16	4	-
BOG_3	16 Quarry St	Residential	47	57	42	49	43 - 59	26 - 41	-	12	-	-
BOG_3	17-19 Elliott St	Residential	47	57	42	49	48 - 64	31 - 47	-	17	5	-
BOG_3	24 Elliott St	Residential	47	57	42	49	49 - 67	32 - 49	-	20	7	-
BOG_3	26 Burke St, Dutton Park	Commercial	62	72	-	-	48 - 70	30 - 51	-	8	-	-
BOG_3	2A Burke St, Dutton Park	Residential	47	57	42	49	46 - 61	30 - 44	-	14	2	-
BOG_3	30 Albert St	Residential	47	57	42	49	46 - 57	29 - 40	-	10	-	-
BOG_3	34 Albert St	Residential	47	57	42	49	47 - 56	31 - 40	-	9	-	-
BOG_3	36 Albert St	Residential	47	57	42	49	44 - 56	28 - 40	-	9	-	-
BOG_3	38 Albert St	Residential	47	57	42	49	46 - 60	30 - 43	-	13	1	-
BOG_3	40 Albert St	Residential	47	57	42	49	49 - 66	32 - 48	-	19	6	-
BOG_3	42 Albert St	Residential	47	57	42	49	59 - 63	43 - 45	-	16	3	-
BOG_3	44 Albert St	Residential	47	57	42	49	47 - 66	30 - 48	-	19	6	-
BOG_3	56 Merton Rd	Residential	47	57	42	49	39 - 41	23 - 24	-	-	-	-
BOG_4	PA	Hospital	57	67	52	59	52 - 71	37 - 64	-	14	12	-
BOG_4	PA Laundry	Commercial	62	72	-	-	54 - 73	37 - 55	-	11	-	-
DUT_1	1 Tamar St, Annerley	Residential	47	57	42	49	41 - 60	25 - 43	-	13	1	-
DUT_1	10 Cope St, Annerley	Residential	47	57	42	49	39 - 47	25 - 35	-	-	-	-
DUT_1	10 Rusk St, Annerley	Residential	47	57	42	49	41 - 51	27 - 34	-	4	-	-
DUT_1	15 Sampson St, Annerley	Residential	47	57	42	49	37 - 48	26 - 33	-	1	-	-
DUT_1	211 Annerley Rd, Annerley	Residential	47	57	42	49	45 - 61	30 - 49	-	14	7	-
DUT_1	3 Cope St, Annerley	Residential	47	57	42	49	46 - 62	33 - 47	-	15	5	-
DUT_1	39 Cornwall St, Annerley	Residential	47	57	42	49	39 - 47	26 - 32	-	-	-	-
DUT_1	41 Tamar St, Annerley	Residential	57	67	52	59	31 - 45	18 - 28	-	-	-	-
DUT_1	53 Tamar St, Annerley	Residential	57	67	52	59	32 - 46	17 - 29	-	-	-	-
DUT_1	6 Cope St, Annerley	Residential	47	57	42	49	40 - 52	28 - 38	-	5	-	-
DUT_1	6 Rusk St, Annerley	Residential	47	57	42	49	40 - 48	26 - 32	-	1	-	-
DUT_1	64 Annerley Rd, Annerley	Residential	47	57	42	49	38 - 53	24 - 36	-	6	-	-
DUT_1	9 Cope St, Annerley	Residential	47	57	42	49	41 - 62	28 - 49	-	15	7	-
DUT_2	13A Fenton St, Fairfield	Residential	57	67	52	59	32 - 47	21 - 36	-	-	-	-
DUT_2	14 Princess St, Fairfield	Residential	57	67	52	59	36 - 46	26 - 36	-	-	-	-
DUT_2	15 Cornwall St, Fairfield	Commercial	67	77	-	-	37 - 51	25 - 39	-	-	-	-
DUT_2	18 Princess St, Fairfield	Residential	57	67	52	59	35 - 46	24 - 36	-	-	-	-
DUT_2	6 Princess St, Fairfield	Residential	57	67	52	59	40 - 50	30 - 38	-	-	-	-
DUT_2	8 Princess St, Fairfield	Residential	57	67	52	59	38 - 49	26 - 37	-	-	-	-
DUT_3	6 Railway Terrace, Dutton Park	Commercial	67	77	-	-	51 - 57	39 - 47	-	-	-	-
DUT_3	18 Pound St, Dutton Park	Residential	47	57	42	49	44 - 51	34 - 42	-	4	0	-
DUT_3	22 Pound St, Dutton Park	Residential	47	57	42	49	43 - 50	33 - 44	-	3	2	-
DUT_3	24 Railway Terrace, Dutton Park	Residential	47	57	42	49	45 - 60	35 - 49	-	13	7	-
DUT_3	30 Pound St, Dutton Park	Residential	47	57	42	49	44 - 50	36 - 43	-	3	1	-
DUT_3	31 Dutton St, Dutton Park	Residential	47	57	42	49	42 - 46	33 - 38	-	-	-	-
DUT_3	34 Railway Terrace, Dutton Park	Residential	47	57	42	49	46 - 57	36 - 48	-	10	6	-
DUT_3	35 Dutton St, Dutton Park	Residential	47	57	42	49	42 - 52	32 - 46	-	5	4	-
DUT_3	36 Railwav Terrace, Dutton Park	Residential	47	57	42	49	45 - 49	36 - 43	-	2	1	-
DUT_3	38 Railway Terrace, Dutton Park	Residential	47	57	42	49	46 - 60	35 - 49	-	13	7	-
DUT_3	39 Dutton St, Dutton Park	Residential	47	57	42	49	47 - 60	38 - 50	-	13	8	-
DUT_4	PA TRICFNTRF	Medical	57	67	52	59	41 - 70	30 - 60	-	13	8	-
DUT_4	PA2	Medical	57	67	52	59	37 - 65	25 - 53	-	8	1	-

DUT_5	1 Fenton St, Fairfield	Residential	47	57	42	49	38 - 49	22 - 33	-	2	-	-
DUT_5	10 Cameron St, Fairfield	Residential	57	67	52	59	29 - 43	15 - 27	-	-	-	-
DUT_5	2 Cottenham St, Fairfield	Residential	47	57	42	49	30 - 43	16 - 27	-	-	-	-
DUT_5	2 Fenton St, Fairfield	Residential	47	57	42	49	35 - 47	21 - 33	-	-	-	-
DUT_5	47 Wilkins St W, Fairfield	Residential	47	57	42	49	29 - 47	16 - 30	-	-	-	-
DUT_5	46 Wilkins St W, Fairfield	Residential	47	57	42	49	28 - 46	14 - 29	-	-	-	-

Table C6D: Residual Receivers - STAGE 4 Roof - 3 Months (construction works within Zones A, B, C, D & E)

NCA	Address	Receiver Type	CNG, dB(A)		Predicted Noise Level, dB(A)						Exceedance, dB(A)		
			Day (LAeq 15min)	Day (LA10 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)	
BOG_1	31 Peter Doherty St	Residential	62	72	57	59	40 - 65	38 - 64	-	3	7	-	
BOG_1	40 Dutton St, Dutton Park	Residential	47	57	42	49	41 - 53	39 - 51	-	6	9	-	
BOG_1	41 Peter Doherty St (Leukaemia Fo	Residential	62	72	57	59	51 - 79	49 - 75	-	17	18	-	
BOG_1	44 Dutton St, Dutton Park	Residential	47	57	42	49	42 - 57	40 - 53	-	10	11	-	
BOG_1	45 Rawnsley St, Dutton Park	Residential	47	57	42	49	49 - 63	46 - 59	-	16	17	-	
BOG_1	46 Railway Terrace, Dutton Park	Residential	47	57	42	49	46 - 60	45 - 58	-	13	16	-	
BOG_1	47 Rawnsley St, Dutton Park	Residential	47	57	42	49	53 - 64	51 - 60	-	17	18	-	
BOG_1	48 Railway Terrace, Dutton Park	Residential	47	57	42	49	45 - 61	44 - 58	-	14	16	-	
BOG_1	49 Rawnsley St, Dutton Park	Residential	47	57	42	49	50 - 65	47 - 63	-	18	21	-	
BOG_1	50 Railway Terrace, Dutton Park	Residential	47	57	42	49	51 - 63	50 - 59	-	16	17	-	
BOG_1	52 Rawnsley St, Dutton Park	Residential	47	57	42	49	49 - 55	45 - 50	-	8	8	-	
BOG_1	56 Rawnsley St, Dutton Park	Residential	47	57	42	49	48 - 57	45 - 54	-	10	12	-	
BOG_1	60 Railway Terrace, Dutton Park	Residential	47	57	42	49	50 - 72	46 - 69	-	25	27	-	
BOG_1	68 Railway Terrace, Dutton Park	Residential	57	72	52	59	49 - 67	46 - 60	-	10	18	-	
BOG_2	30 Joe Baker St (Ecosciencse Prec	Commercial	67	77	-	-	42 - 65	40 - 63	-	-	-	-	
BOG_3	11 Quarry St	Residential	47	57	42	49	37 - 49	35 - 48	-	2	6	-	
BOG_3	14 Quarry St	Residential	47	57	42	49	35 - 50	33 - 48	-	3	6	-	
BOG_3	15 Elliott St	Residential	47	57	42	49	38 - 58	35 - 56	-	11	14	-	
BOG_3	16 Quarry St	Residential	47	57	42	49	37 - 53	35 - 51	-	6	9	-	
BOG_3	17-19 Elliott St	Residential	47	57	42	49	42 - 58	39 - 56	-	11	14	-	
BOG_3	24 Elliott St	Residential	47	57	42	49	44 - 57	41 - 55	-	10	13	-	
BOG_3	26 Burke St, Dutton Park	Commercial	62	72	-	-	42 - 58	39 - 56	-	-	-	-	
BOG_3	2A Burke St, Dutton Park	Residential	47	57	42	49	41 - 57	39 - 55	-	10	13	-	
BOG_3	30 Albert St	Residential	47	57	42	49	40 - 52	38 - 50	-	5	8	-	
BOG_3	34 Albert St	Residential	47	57	42	49	42 - 52	39 - 50	-	5	8	-	
BOG_3	36 Albert St	Residential	47	57	42	49	39 - 51	36 - 49	-	4	7	-	
BOG_3	38 Albert St	Residential	47	57	42	49	41 - 53	38 - 50	-	6	8	-	
BOG_3	40 Albert St	Residential	47	57	42	49	43 - 56	41 - 54	-	9	12	-	
BOG_3	42 Albert St	Residential	47	57	42	49	54 - 58	52 - 56	-	11	14	-	
BOG_3	44 Albert St	Residential	47	57	42	49	41 - 58	39 - 55	-	11	13	-	
BOG_3	56 Merton Rd	Residential	47	57	42	49	34 - 35	32 - 33	-	-	-	-	
BOG_4	PA	Hospital	57	67	52	59	48 - 70	46 - 68	-	13	16	-	
BOG_4	PA Laundry	Commercial	62	72	-	-	51 - 70	48 - 67	-	8	-	-	
DUT_1	1 Tamar St, Annerley	Residential	47	57	42	49	36 - 54	33 - 52	-	7	10	-	
DUT_1	10 Cope St, Annerley	Residential	47	57	42	49	35 - 45	32 - 43	-	-	1	-	
DUT_1	10 Rusk St, Annerley	Residential	47	57	42	49	37 - 45	34 - 42	-	-	-	-	
DUT_1	15 Sampson St, Annerley	Residential	47	57	42	49	34 - 45	31 - 42	-	-	-	-	
DUT_1	211 Annerley Rd, Annerley	Residential	47	57	42	49	40 - 60	37 - 58	-	13	16	-	
DUT_1	3 Cope St, Annerley	Residential	47	57	42	49	43 - 60	41 - 57	-	13	15	-	
DUT_1	39 Cornwall St, Annerley	Residential	47	57	42	49	35 - 43	33 - 40	-	-	-	-	
DUT_1	41 Tamar St, Annerley	Residential	57	67	52	59	29 - 39	26 - 36	-	-	-	-	
DUT_1	53 Tamar St, Annerley	Residential	57	67	52	59	27 - 41	24 - 38	-	-	-	-	
DUT_1	6 Cope St, Annerley	Residential	47	57	42	49	38 - 49	35 - 47	-	2	5	-	
DUT_1	6 Rusk St, Annerley	Residential	47	57	42	49	36 - 42	33 - 40	-	-	-	-	
DUT_1	64 Annerley Rd, Annerley	Residential	47	57	42	49	34 - 48	31 - 46	-	1	4	-	
DUT_1	9 Cope St, Annerley	Residential	47	57	42	49	38 - 60	35 - 58	-	13	16	-	
DUT_2	13A Fenton St, Fairfield	Residential	57	67	52	59	29 - 47	27 - 44	-	-	-	-	
DUT_2	14 Princess St, Fairfield	Residential	57	67	52	59	34 - 47	32 - 44	-	-	-	-	
DUT_2	15 Cornwall St, Fairfield	Commercial	67	77	-	-	34 - 50	32 - 48	-	-	-	-	
DUT_2	18 Princess St, Fairfield	Residential	57	67	52	59	32 - 46	30 - 44	-	-	-	-	
DUT_2	6 Princess St, Fairfield	Residential	57	67	52	59	39 - 49	37 - 46	-	-	-	-	
DUT_2	8 Princess St, Fairfield	Residential	57	67	52	59	35 - 48	32 - 46	-	-	-	-	
DUT_3	6 Railway Terrace, Dutton Park	Commercial	67	77	-	-	50 - 58	48 - 56	-	-	-	-	
DUT_3	18 Pound St, Dutton Park	Residential	47	57	42	49	42 - 51	40 - 48	-	4	6	-	
DUT_3	22 Pound St, Dutton Park	Residential	47	57	42	49	41 - 51	39 - 48	-	4	6	-	
DUT_3	24 Railway Terrace, Dutton Park	Residential	47	57	42	49	44 - 58	42 - 56	-	11	14	-	
DUT_3	30 Pound St, Dutton Park	Residential	47	57	42	49	43 - 50	41 - 48	-	3	6	-	
DUT_3	31 Dutton St, Dutton Park	Residential	47	57	42	49	40 - 46	38 - 43	-	-	1	-	
DUT_3	34 Railway Terrace, Dutton Park	Residential	47	57	42	49	44 - 56	41 - 54	-	9	12	-	
DUT_3	35 Dutton St, Dutton Park	Residential	47	57	42	49	39 - 51	37 - 49	-	4	7	-	
DUT_3	36 Railway Terrace, Dutton Park	Residential	47	57	42	49	42 - 49	40 - 46	-	2	4	-	
DUT_3	38 Railway Terrace, Dutton Park	Residential	47	57	42	49	43 - 57	41 - 55	-	10	13	-	
DUT_3	39 Dutton St, Dutton Park	Residential	47	57	42	49	45 - 59	43 - 57	-	12	15	-	
DUT_4	PA TRICENTRE	Medical	57	67	52	59	38 - 67	36 - 65	-	10	13	-	
DUT_4	PA2	Medical	57	67	52	59	34 - 63	31 - 61	-	6	9	-	
DUT_5	1 Fenton St, Fairfield	Residential	47	57	42	49	34 - 45	31 - 42	-	-	-	-	
DUT_5	10 Cameron St, Fairfield	Residential	57	67	52	59	25 - 38	22 - 36	-	-	-	-	
DUT_5	2 Cottenham St, Fairfield	Residential	47	57	42	49	26 - 38	23 - 36	-	-	-	-	

DUT_5	2 Fenton St, Fairfield	Residential	47	57	42	49	30 - 44	28 - 42	-	-	-	-
DUT_5	47 Wilkins St W, Fairfield	Residential	47	57	42	49	26 - 42	23 - 40	-	-	-	-
DUT_5	46 Wilkins St W, Fairfield	Residential	47	57	42	49	24 - 41	21 - 38	-	-	-	-

Table C6E: Residual Receivers - STAGE 4 Excavation - 3 Months (construction works within Zones A, B, C, D & E)

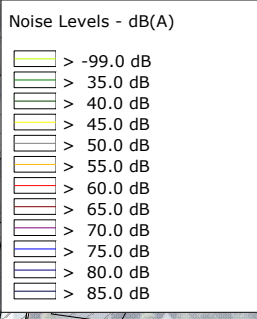
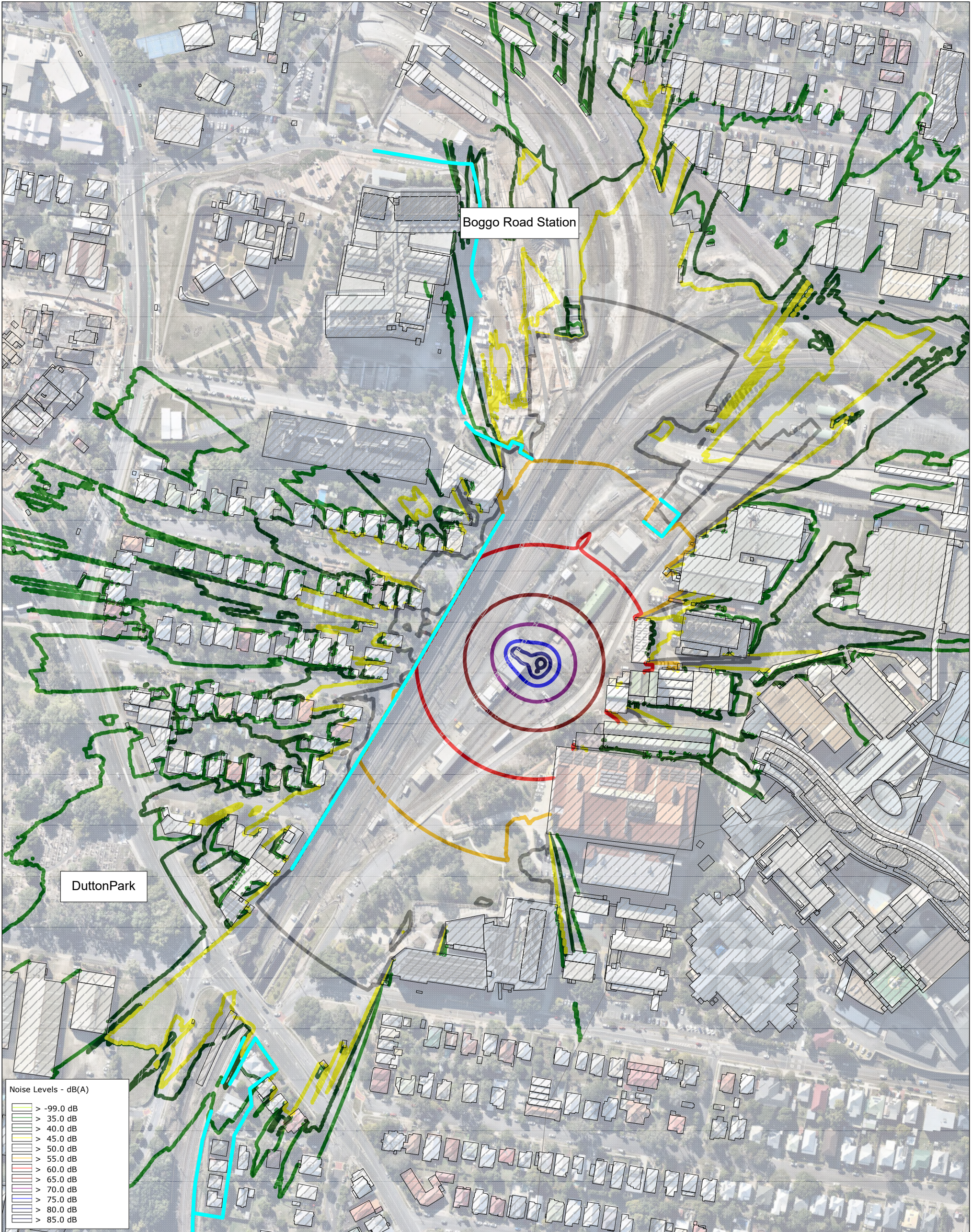
NCA	Address	Receiver Type	CNG, dB(A)				Predicted Noise Level, dB(A)						Exceedance, dB(A)		
			Day (LAeq 15min)	Day (LA10 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)
BOG_1	31 Peter Doherty St	Residential	62	72	57	59	45 - 71	42 - 69	53				9	12	-
BOG_1	40 Dutton St, Dutton Park	Residential	47	57	42	49	45 - 58	42 - 53	43				11	11	-
BOG_1	41 Peter Doherty St (Leukaemia Fo	Residential	62	72	57	59	55 - 81	52 - 74	54				19	17	-
BOG_1	44 Dutton St, Dutton Park	Residential	47	57	42	49	46 - 61	43 - 55	47				14	13	-
BOG_1	45 Rawnsley St, Dutton Park	Residential	47	57	42	49	55 - 68	51 - 61	50				21	19	1
BOG_1	46 Railway Terrace, Dutton Park	Residential	47	57	42	49	50 - 63	47 - 57	49				16	15	-
BOG_1	47 Rawnsley St, Dutton Park	Residential	47	57	42	49	57 - 68	54 - 61	50				21	19	1
BOG_1	48 Railway Terrace, Dutton Park	Residential	47	57	42	49	50 - 64	46 - 58	49				17	16	-
BOG_1	49 Rawnsley St, Dutton Park	Residential	47	57	42	49	56 - 69	52 - 62	51				22	20	2
BOG_1	50 Railway Terrace, Dutton Park	Residential	47	57	42	49	54 - 65	52 - 59	51				18	17	2
BOG_1	52 Rawnsley St, Dutton Park	Residential	47	57	42	49	58 - 68	54 - 60	49				21	18	-
BOG_1	56 Rawnsley St, Dutton Park	Residential	47	57	42	49	57 - 65	53 - 59	50				18	17	1
BOG_1	60 Railway Terrace, Dutton Park	Residential	47	57	42	49	57 - 72	53 - 65	50				25	23	1
BOG_1	68 Railway Terrace, Dutton Park	Residential	57	72	52	59	55 - 78	50 - 71	53				21	29	4
BOG_2	30 Joe Baker St (Ecosciencse Prec	Commercial	67	77	-	-	46 - 70	43 - 67	50				3	-	-
BOG_3	11 Quarry St	Residential	47	57	42	49	41 - 52	38 - 50	32				5	8	-
BOG_3	14 Quarry St	Residential	47	57	42	49	40 - 55	36 - 51	36				8	9	-
BOG_3	15 Elliott St	Residential	47	57	42	49	43 - 62	39 - 58	42				15	16	-
BOG_3	16 Quarry St	Residential	47	57	42	49	42 - 57	38 - 54	38				10	12	-
BOG_3	17-19 Elliott St	Residential	47	57	42	49	47 - 63	44 - 59	44				16	17	-
BOG_3	24 Elliott St	Residential	47	57	42	49	48 - 64	45 - 62	44				17	20	-
BOG_3	26 Burke St, Dutton Park	Commercial	62	72	-	-	46 - 67	43 - 65	47				5	-	-
BOG_3	2A Burke St, Dutton Park	Residential	47	57	42	49	46 - 60	42 - 56	41				13	14	-
BOG_3	30 Albert St	Residential	47	57	42	49	45 - 56	41 - 52	38				9	10	-
BOG_3	34 Albert St	Residential	47	57	42	49	46 - 55	43 - 52	37				8	10	-
BOG_3	36 Albert St	Residential	47	57	42	49	43 - 56	40 - 52	37				9	10	-
BOG_3	38 Albert St	Residential	47	57	42	49	45 - 58	42 - 55	40				11	13	-
BOG_3	40 Albert St	Residential	47	57	42	49	48 - 64	45 - 61	44				17	19	-
BOG_3	42 Albert St	Residential	47	57	42	49	58 - 61	54 - 58	41				14	16	-
BOG_3	44 Albert St	Residential	47	57	42	49	46 - 64	42 - 61	44				17	19	-
BOG_3	56 Merton Rd	Residential	47	57	42	49	39 - 40	35 - 36	21				-	-	-
BOG_4	PA	Hospital	57	67	52	59	53 - 74	49 - 69	64				17	17	5
BOG_4	PA Laundry	Commercial	62	72	-	-	55 - 76	51 - 69	49				14	-	-
DUT_1	1 Tamar St, Annerley	Residential	47	57	42	49	40 - 59	38 - 57	39				12	15	-
DUT_1	10 Cope St, Annerley	Residential	47	57	42	49	40 - 49	36 - 44	34				2	2	-
DUT_1	10 Rusk St, Annerley	Residential	47	57	42	49	41 - 49	38 - 47	32				2	5	-
DUT_1	15 Sampson St, Annerley	Residential	47	57	42	49	38 - 48	34 - 44	31				1	2	-
DUT_1	211 Annerley Rd, Annerley	Residential	47	57	42	49	44 - 63	40 - 58	48				16	16	-
DUT_1	3 Cope St, Annerley	Residential	47	57	42	49	47 - 63	43 - 57	45				16	15	-
DUT_1	39 Cornwall St, Annerley	Residential	47	57	42	49	40 - 48	36 - 45	31				1	3	-
DUT_1	41 Tamar St, Annerley	Residential	57	67	52	59	33 - 43	29 - 41	24				-	-	-
DUT_1	53 Tamar St, Annerley	Residential	57	67	52	59	32 - 46	28 - 42	27				-	-	-
DUT_1	6 Cope St, Annerley	Residential	47	57	42	49	42 - 53	39 - 47	36				6	5	-
DUT_1	6 Rusk St, Annerley	Residential	47	57	42	49	40 - 48	37 - 44	30				1	2	-
DUT_1	64 Annerley Rd, Annerley	Residential	47	57	42	49	39 - 52	35 - 48	33				5	6	-
DUT_1	9 Cope St, Annerley	Residential	47	57	42	49	42 - 63	39 - 58	48				16	16	-
DUT_2	13A Fenton St, Fairfield	Residential	57	67	52	59	33 - 50	29 - 44	35				-	-	-
DUT_2	14 Princess St, Fairfield	Residential	57	67	52	59	38 - 51	35 - 45	35				-	-	-
DUT_2	15 Cornwall St, Fairfield	Commercial	67	77	-	-	39 - 54	35 - 48	38				-	-	-
DUT_2	18 Princess St, Fairfield	Residential	57	67	52	59	37 - 50	33 - 45	35				-	-	-
DUT_2	6 Princess St, Fairfield	Residential	57	67	52	59	44 - 52	40 - 46	36				-	-	-
DUT_2	8 Princess St, Fairfield	Residential	57	67	52	59	39 - 52	36 - 46	36				-	-	-
DUT_3	6 Railway Terrace, Dutton Park	Commercial	67	77	-	-	55 - 61	49 - 55	47				-	-	-
DUT_3	18 Pound St, Dutton Park	Residential	47	57	42	49	46 - 57	42 - 50	42				10	8	-
DUT_3	22 Pound St, Dutton Park	Residential	47	57	42	49	45 - 55	42 - 50	43				8	8	-
DUT_3	24 Railway Terrace, Dutton Park	Residential	47	57	42	49	48 - 62	44 - 56	48				15	14	-
DUT_3	30 Pound St, Dutton Park	Residential	47	57	42	49	46 - 53	43 - 49	43				6	7	-
DUT_3	31 Dutton St, Dutton Park	Residential	47	57	42	49	44 - 50	40 - 46	38				3	4	-
DUT_3	34 Railway Terrace, Dutton Park	Residential	47	57	42	49	48 - 61	44 - 55	47				14	13	-
DUT_3	35 Dutton St, Dutton Park	Residential	47	57	42	49	43 - 54	40 - 50	46				7	8	-
DUT_3	36 Railway Terrace, Dutton Park	Residential	47	57	42	49	46 - 52	43 - 48	43				5	6	-
DUT_3	38 Railway Terrace, Dutton Park	Residential	47	57	42	49	48 - 60	44 - 55	48				13	13	-
DUT_3	39 Dutton St, Dutton Park	Residential	47	57	42	49	49 - 62	46 - 56	49				15	14	-
DUT_4	PA TRICENTRE	Medical	57	67	52	59	43 - 71	38 - 66	60				14	14	1
DUT_4	PA2	Medical	57	67	52	59	38 - 67	34 - 63	52				10	11	-
DUT_5	1 Fenton St, Fairfield	Residential	47	57	42	49	38 - 49	34 - 45	30				2	3	-
DUT_5	10 Cameron St, Fairfield	Residential	57	67	52	59	29 - 43	25 - 40	25				-	-	-
DUT_5	2 Cottenham St, Fairfield	Residential	47	57	42	49	30 - 43	27 - 40	24				-	-	-
DUT_5	2 Fenton St, Fairfield	Residential	47	57	42	49	35 - 48	32 - 44	32				1	2	-
DUT_5	47 Wilkins St W, Fairfield	Residential	47	57	42	49	30 - 46	26 - 43	27				-	1	-
DUT_5	46 Wilkins St W, Fairfield	Residential	47	57	42	49	28 - 45	24 - 42	27				-	-	-

Table C6F: Residual Receivers - STAGE 5 - 5 Months (construction works within Zones A, B, C, D & E)

NCA	Address	Receiver Type	CNG, dB(A)		Predicted Noise Level, dB(A)						Exceedance, dB(A)		
			Day (LAeq 15min)	Day (LA10 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)	Day (LAeq 15min)	OOH (LAeq 15min)	Night (LAMax)	
BOG_1	31 Peter Doherty St	Residential	62	72	57	59	29 - 54	26 - 52	-	-	-	-	
BOG_1	40 Dutton St, Dutton Park	Residential	47	57	42	49	35 - 44	33 - 43	-	-	1	-	
BOG_1	41 Peter Doherty St (Leukaemia Fo	Residential	62	72	57	59	38 - 65	34 - 55	-	3	-	-	
BOG_1	44 Dutton St, Dutton Park	Residential	47	57	42	49	37 - 47	37 - 47	-	0	5	-	
BOG_1	45 Rawnsley St, Dutton Park	Residential	47	57	42	49	40 - 50	39 - 50	-	3	8	-	
BOG_1	46 Railway Terrace, Dutton Park	Residential	47	57	42	49	42 - 51	42 - 49	-	4	7	-	
BOG_1	47 Rawnsley St, Dutton Park	Residential	47	57	42	49	43 - 50	40 - 50	-	3	8	-	
BOG_1	48 Railway Terrace, Dutton Park	Residential	47	57	42	49	41 - 51	41 - 49	-	4	7	-	
BOG_1	49 Rawnsley St, Dutton Park	Residential	47	57	42	49	41 - 53	39 - 51	-	6	9	-	
BOG_1	50 Railway Terrace, Dutton Park	Residential	47	57	42	49	43 - 53	41 - 51	-	6	9	-	
BOG_1	52 Rawnsley St, Dutton Park	Residential	47	57	42	49	40 - 49	37 - 49	-	2	7	-	
BOG_1	56 Rawnsley St, Dutton Park	Residential	47	57	42	49	39 - 50	37 - 50	-	3	8	-	
BOG_1	60 Railway Terrace, Dutton Park	Residential	47	57	42	49	40 - 58	39 - 50	-	11	8	-	
BOG_1	68 Railway Terrace, Dutton Park	Residential	57	72	52	59	38 - 55	35 - 53	-	-	11	-	
BOG_2	30 Joe Baker St (Ecosciencse Prec	Commercial	67	77	-	-	30 - 53	26 - 49	-	-	-	-	
BOG_3	11 Quarry St	Residential	47	57	42	49	26 - 36	23 - 33	-	-	-	-	
BOG_3	14 Quarry St	Residential	47	57	42	49	24 - 38	21 - 35	-	-	-	-	
BOG_3	15 Elliott St	Residential	47	57	42	49	27 - 46	24 - 42	-	-	-	-	
BOG_3	16 Quarry St	Residential	47	57	42	49	26 - 41	23 - 38	-	-	-	-	
BOG_3	17-19 Elliott St	Residential	47	57	42	49	31 - 46	29 - 44	-	-	2	-	
BOG_3	24 Elliott St	Residential	47	57	42	49	33 - 46	30 - 44	-	-	2	-	
BOG_3	26 Burke St, Dutton Park	Commercial	62	72	-	-	30 - 48	27 - 47	-	-	-	-	
BOG_3	2A Burke St, Dutton Park	Residential	47	57	42	49	30 - 44	27 - 41	-	-	-	-	
BOG_3	30 Albert St	Residential	47	57	42	49	29 - 40	26 - 37	-	-	-	-	
BOG_3	34 Albert St	Residential	47	57	42	49	31 - 40	28 - 37	-	-	-	-	
BOG_3	36 Albert St	Residential	47	57	42	49	28 - 40	25 - 37	-	-	-	-	
BOG_3	38 Albert St	Residential	47	57	42	49	30 - 42	27 - 39	-	-	-	-	
BOG_3	40 Albert St	Residential	47	57	42	49	32 - 46	30 - 44	-	-	2	-	
BOG_3	42 Albert St	Residential	47	57	42	49	42 - 45	40 - 41	-	-	-	-	
BOG_3	44 Albert St	Residential	47	57	42	49	30 - 47	27 - 44	-	-	2	-	
BOG_3	56 Merton Rd	Residential	47	57	42	49	23 - 24	20 - 20	-	-	-	-	
BOG_4	PA	Hospital	57	67	52	59	38 - 64	35 - 64	-	7	12	-	
BOG_4	PA Laundry	Commercial	62	72	-	-	38 - 56	34 - 50	-	-	-	-	
DUT_1	1 Tamar St, Annerley	Residential	47	57	42	49	26 - 42	23 - 40	-	-	-	-	
DUT_1	10 Cope St, Annerley	Residential	47	57	42	49	26 - 35	24 - 34	-	-	-	-	
DUT_1	10 Rusk St, Annerley	Residential	47	57	42	49	27 - 34	26 - 32	-	-	-	-	
DUT_1	15 Sampson St, Annerley	Residential	47	57	42	49	26 - 34	25 - 31	-	-	-	-	
DUT_1	211 Annerley Rd, Annerley	Residential	47	57	42	49	30 - 50	28 - 48	-	3	6	-	
DUT_1	3 Cope St, Annerley	Residential	47	57	42	49	34 - 48	32 - 45	-	1	3	-	
DUT_1	39 Cornwall St, Annerley	Residential	47	57	42	49	26 - 33	25 - 31	-	-	-	-	
DUT_1	41 Tamar St, Annerley	Residential	57	67	52	59	19 - 28	17 - 24	-	-	-	-	
DUT_1	53 Tamar St, Annerley	Residential	57	67	52	59	17 - 30	16 - 27	-	-	-	-	
DUT_1	6 Cope St, Annerley	Residential	47	57	42	49	29 - 38	28 - 36	-	-	-	-	
DUT_1	6 Rusk St, Annerley	Residential	47	57	42	49	27 - 33	25 - 30	-	-	-	-	
DUT_1	64 Annerley Rd, Annerley	Residential	47	57	42	49	25 - 36	23 - 33	-	-	-	-	
DUT_1	9 Cope St, Annerley	Residential	47	57	42	49	29 - 50	27 - 48	-	3	6	-	
DUT_2	13A Fenton St, Fairfield	Residential	57	67	52	59	22 - 37	20 - 35	-	-	-	-	
DUT_2	14 Princess St, Fairfield	Residential	57	67	52	59	27 - 37	26 - 36	-	-	-	-	
DUT_2	15 Cornwall St, Fairfield	Commercial	67	77	-	-	26 - 40	24 - 38	-	-	-	-	
DUT_2	18 Princess St, Fairfield	Residential	57	67	52	59	24 - 37	23 - 35	-	-	-	-	
DUT_2	6 Princess St, Fairfield	Residential	57	67	52	59	31 - 38	30 - 37	-	-	-	-	
DUT_2	8 Princess St, Fairfield	Residential	57	67	52	59	27 - 38	26 - 36	-	-	-	-	
DUT_3	6 Railway Terrace, Dutton Park	Commercial	67	77	-	-	40 - 48	38 - 47	-	-	-	-	
DUT_3	18 Pound St, Dutton Park	Residential	47	57	42	49	35 - 43	34 - 42	-	-	-	-	
DUT_3	22 Pound St, Dutton Park	Residential	47	57	42	49	33 - 44	32 - 43	-	-	1	-	
DUT_3	24 Railway Terrace, Dutton Park	Residential	47	57	42	49	36 - 49	35 - 48	-	2	6	-	
DUT_3	30 Pound St, Dutton Park	Residential	47	57	42	49	36 - 43	35 - 43	-	-	1	-	
DUT_3	31 Dutton St, Dutton Park	Residential	47	57	42	49	33 - 38	32 - 38	-	-	-	-	
DUT_3	34 Railway Terrace, Dutton Park	Residential	47	57	42	49	36 - 48	35 - 47	-	1	5	-	
DUT_3	35 Dutton St, Dutton Park	Residential	47	57	42	49	32 - 46	31 - 46	-	-	4	-	
DUT_3	36 Railwav Terrace, Dutton Park	Residential	47	57	42	49	37 - 43	35 - 43	-	-	1	-	
DUT_3	38 Railway Terrace, Dutton Park	Residential	47	57	42	49	36 - 49	35 - 48	-	2	6	-	
DUT_3	39 Dutton St, Dutton Park	Residential	47	57	42	49	38 - 50	38 - 49	-	3	7	-	
DUT_4	PA TRICENTRE	Medical	57	67	52	59	30 - 60	29 - 60	-	3	8	-	
DUT_4	PA2	Medical	57	67	52	59	25 - 53	24 - 52	-	-	-	-	
DUT_5	1 Fenton St, Fairfield	Residential	47	57	42	49	23 - 33	21 - 30	-	-	-	-	
DUT_5	10 Cameron St, Fairfield	Residential	57	67	52	59	15 - 27	13 - 25	-	-	-	-	
DUT_5	2 Cottenham St, Fairfield	Residential	47	57	42	49	16 - 27	14 - 24	-	-	-	-	
DUT_5	2 Fenton St, Fairfield	Residential	47	57	42	49	21 - 34	19 - 32	-	-	-	-	
DUT_5	47 Wilkins St W, Fairfield	Residential	47	57	42	49	17 - 30	15 - 27	-	-	-	-	
DUT_5	46 Wilkins St W, Fairfield	Residential	47	57	42	49	14 - 29	12 - 27	-	-	-	-	



legend: Point Source Line Source Railway Building Barrier Contour Line Receiver Building Evaluation Calculation Area	Client: CBGU D&C JV Level 3, North Tower 339 Coronation Drive Milton QLD 4064		Project: Cross River Rail Project, Southern Portal STAGE 1 - December 2020 - June 2021 (construction works within Zone F) DAY		Description: Construction Noise Contours LAeq (15min) at 4.6m AGL FIGURE C8	
	Consultant: RENZO TONIN & ASSOCIATES inspired to achieve		Noise levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.		Project No.: QB400-20	Produced by: DR & PJ
	PO Box 820, Spring Hill QLD 4004 P: 07 3367 3131 F: 07 3367 3121				Figure Ref: QB400-20	Grid Size: 1m x 1m
					Date: 2020.09.24	Scale: 1: 2744 A3



- Legend:
- Point Source
 - Line Source
 - Railway
 - Building
 - Barrier
 - Contour Line
 - Receiver
 - Building Evaluation
 - Calculation Area

Client:

CBGU D&C JV
Level 3, North Tower
339 Coronation Drive
Milton QLD 4064



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Project:

Cross River Rail Project, Southern Portal

STAGE 1 - December 2020 - June 2021
(construction works within Zone F)

EVENING

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Description:

Construction Noise Contours LAeq (15min)
at 4.6m AGL

FIGURE C9

Project No.:

QB400-20

Figure Ref:

QB400-20

Date:

2020.09.24

Produced by:

DR & PJ

Grid Size:

1m x 1m

Scale:

1: 2744 A3



legend: Point Source Line Source Railway Building Barrier Contour Line Receiver Building Evaluation Calculation Area
--

PO Box 820, Spring Hill QLD 4004

P: 07 3367 3131 F: 07 3367 3121



- Noise Levels - dB(A)
- > 85.0 dB
 - > 80.0 dB
 - > 75.0 dB
 - > 70.0 dB
 - > 65.0 dB
 - > 60.0 dB
 - > 55.0 dB
 - > 50.0 dB
 - > 45.0 dB
 - > 40.0 dB
 - > 35.0 dB
 - > 30.0 dB
- Legend:
- Point Source
 - Line Source
 - Railway
 - Building
 - Barrier
 - Contour Line
 - Receiver
 - Building Evaluation
 - Calculation Area

Client:

CBGU D&C JV
Level 3, North Tower
339 Coronation Drive
Milton QLD 4064

Consultant:

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Project:

Cross River Rail Project, Southern Portal

STAGE 2 - Staging July 2021 -
September 2021 (construction works within
Zones B, C, D & F)

Evening

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Description:	
Construction Noise Contours LAeq (15min) at 4.6m AGL	
FIGURE C11	
Project No.:	Produced by:
QB400-20	DR & PJ
Figure Ref:	Grid Size:
QB400-20	1m x 1m
Date:	Scale:
2020.09.24	1: 2744 A3



- Legend:
- Point Source
 - Line Source
 - Railway
 - Building
 - Barrier
 - Contour Line
 - Receiver
 - Building Evaluation
 - Calculation Area

Client:

CBGU D&C JV
Level 3, North Tower
339 Coronation Drive
Milton QLD 4064

Consultant:

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Project:

Cross River Rail Project, Southern Portal

STAGE 2 - Staging July 2021 -
September 2021 (construction works within
Zones B, C, D & F)

NIGHT

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Description:

Construction Noise Contours LAeq (15min)
at 4.6m AGL

FIGURE C12

Project No.:

QB400-20

Figure Ref:

QB400-20

Date:

2020.09.24

Produced by:

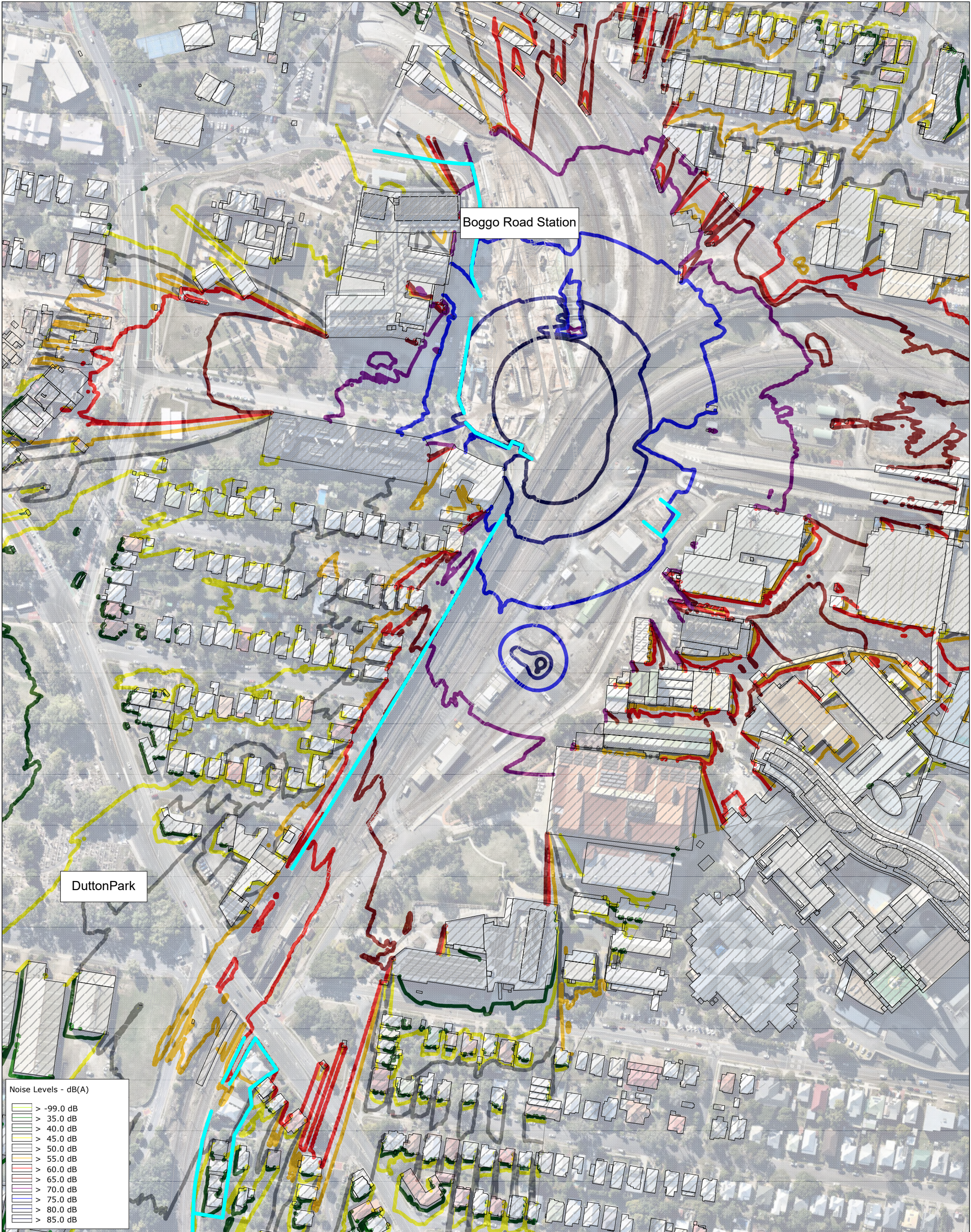
DR & PJ

Grid Size:

1m x 1m

Scale:

1: 2744 A3



- Noise Levels - dB(A)
- > 35.0 dB
 - > 40.0 dB
 - > 45.0 dB
 - > 50.0 dB
 - > 55.0 dB
 - > 60.0 dB
 - > 65.0 dB
 - > 70.0 dB
 - > 75.0 dB
 - > 80.0 dB
 - > 85.0 dB
- Legend:
- Point Source
 - Line Source
 - Railway
 - Building
 - Barrier
 - Contour Line
 - Receiver
 - Building Evaluation
 - Calculation Area

Client:

CBGU D&C JV
Level 3, North Tower
339 Coronation Drive
Milton QLD 4064

Consultant:

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& ASSOCIATES
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PO Box 820, Spring Hill QLD 4004
P: 07 3367 3131 F: 07 3367 3121

Project:

Cross River Rail Project, Southern Portal

STAGE 3 - Staging October 2021 -
January 2022 (construction works within
Zones A, B & C)

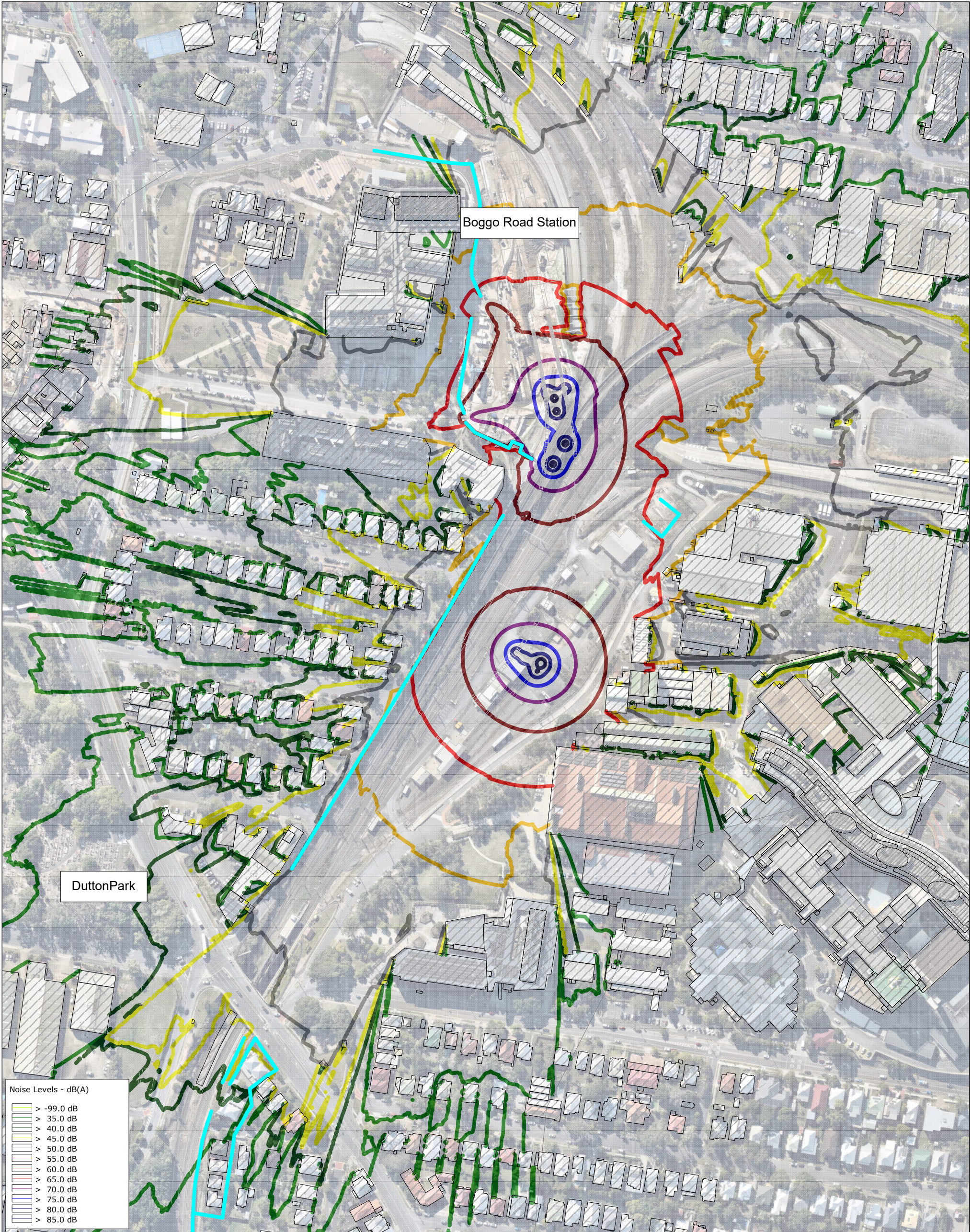
DAY

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be used for reference only.

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Description:	
Construction Noise Contours LAeq (15min) at 4.6m AGL	
FIGURE C13	
Project No.:	Produced by:
QB400-20	DR & PJ
Figure Ref:	Grid Size:
QB400-20	1m x 1m
Date:	Scale:
2020.09.24	1: 2744 A3



- Noise Levels - dB(A)
- > 35.0 dB
 - > 40.0 dB
 - > 45.0 dB
 - > 50.0 dB
 - > 55.0 dB
 - > 60.0 dB
 - > 65.0 dB
 - > 70.0 dB
 - > 75.0 dB
 - > 80.0 dB
 - > 85.0 dB
- Legend:
- Point Source
 - Line Source
 - Railway
 - Building
 - Barrier
 - Contour Line
 - Receiver
 - Building Evaluation
 - Calculation Area

Client:

CBGU D&C JV
Level 3, North Tower
339 Coronation Drive
Milton QLD 4064

Consultant:

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P: 07 3367 3131 F: 07 3367 3121

Project:

Cross River Rail Project, Southern Portal

STAGE 3 - Staging October 2021 - January 2022 (construction works within Zones A, B & C)

EVENING

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Description:

Construction Noise Contours LAeq (15min) at 4.6m AGL

FIGURE C14

Project No.:	Produced by:
QB400-20	DR & PJ
Figure Ref:	Grid Size:
QB400-20	1m x 1m
Date:	Scale:
2020.09.24	1: 2744 A3



- Legend:
- Point Source
 - Line Source
 - Railway
 - Building
 - Barrier
 - Contour Line
 - Receiver
 - Building Evaluation
 - Calculation Area

Client:

CBGU D&C JV
Level 3, North Tower
339 Coronation Drive
Milton QLD 4064

Consultant:

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Project:

Cross River Rail Project, Southern Portal

STAGE 4 Roof - Staging January 2022 - March 2022 (construction works within Zones A, B, C, D & E)

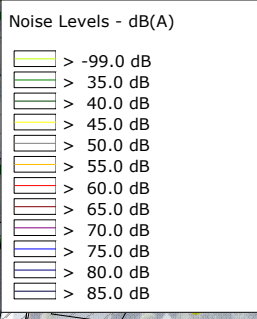
Evening

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Description:	
Construction Noise Contours LAeq (15min) at 4.6m AGL	
FIGURE C16	
Project No.:	Produced by:
QB400-20	DR & PJ
Figure Ref:	Grid Size:
QB400-20	1m x 1m
Date:	Scale:
2020.09.24	1: 2744 A3



- Legend:
- Point Source
 - Line Source
 - Railway
 - Building
 - Barrier
 - Contour Line
 - Receiver
 - Building Evaluation
 - Calculation Area

Client:

CBGU D&C JV
Level 3, North Tower
339 Coronation Drive
Milton QLD 4064

Consultant:

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Project:

Cross River Rail Project, Southern Portal

STAGE 4 Excavation - Staging January 2022 -
March 2022 (construction works within
Zones A, B, C, D & E)

EVENING

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be used for reference only.

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Description:

Construction Noise Contours LAeq (15min)
at 4.6m AGL

FIGURE C18

Project No.:

QB400-20

Figure Ref:

QB400-20

Date:

2020.09.24

Produced by:

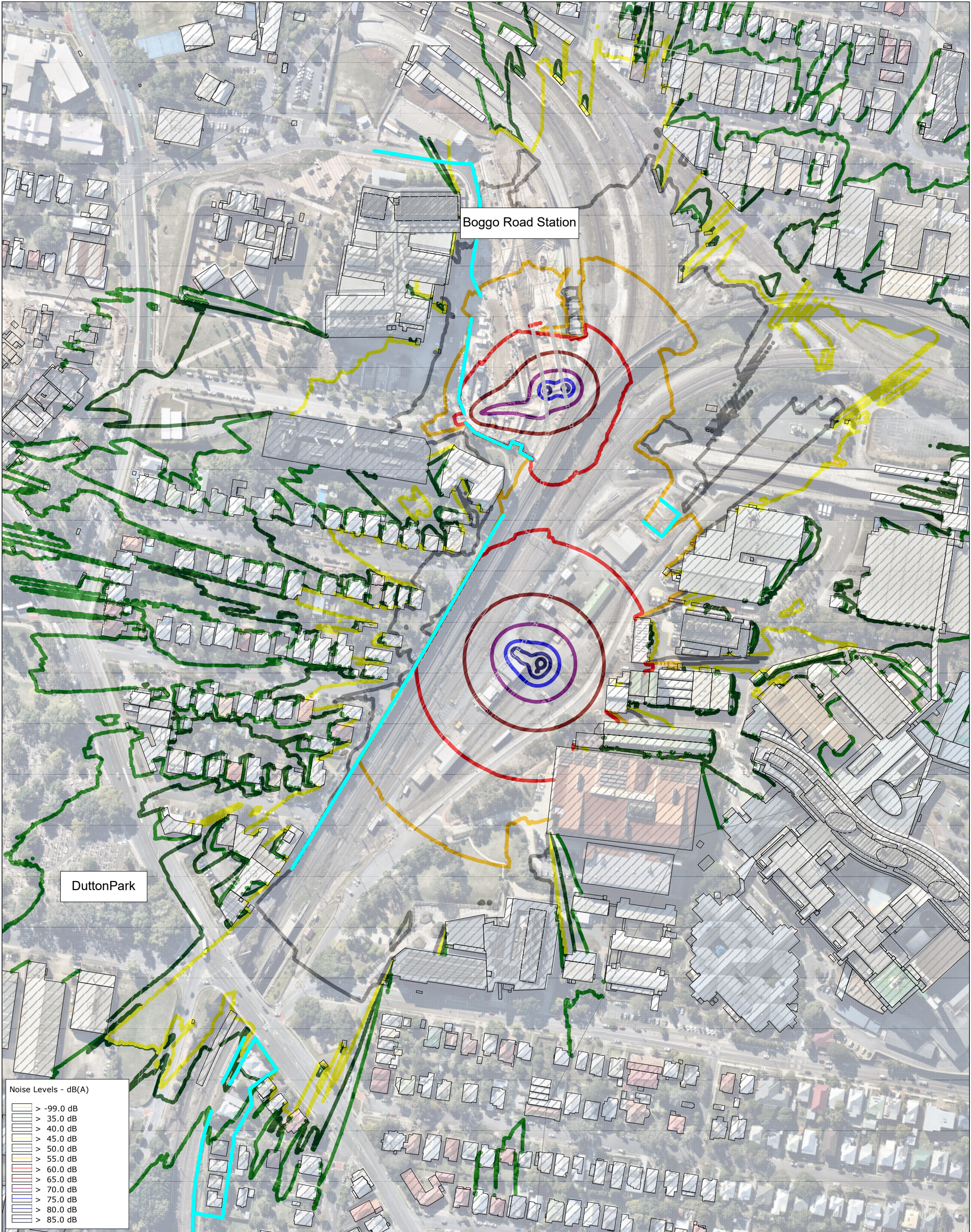
DR & PJ

Grid Size:

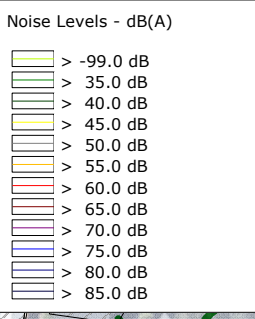
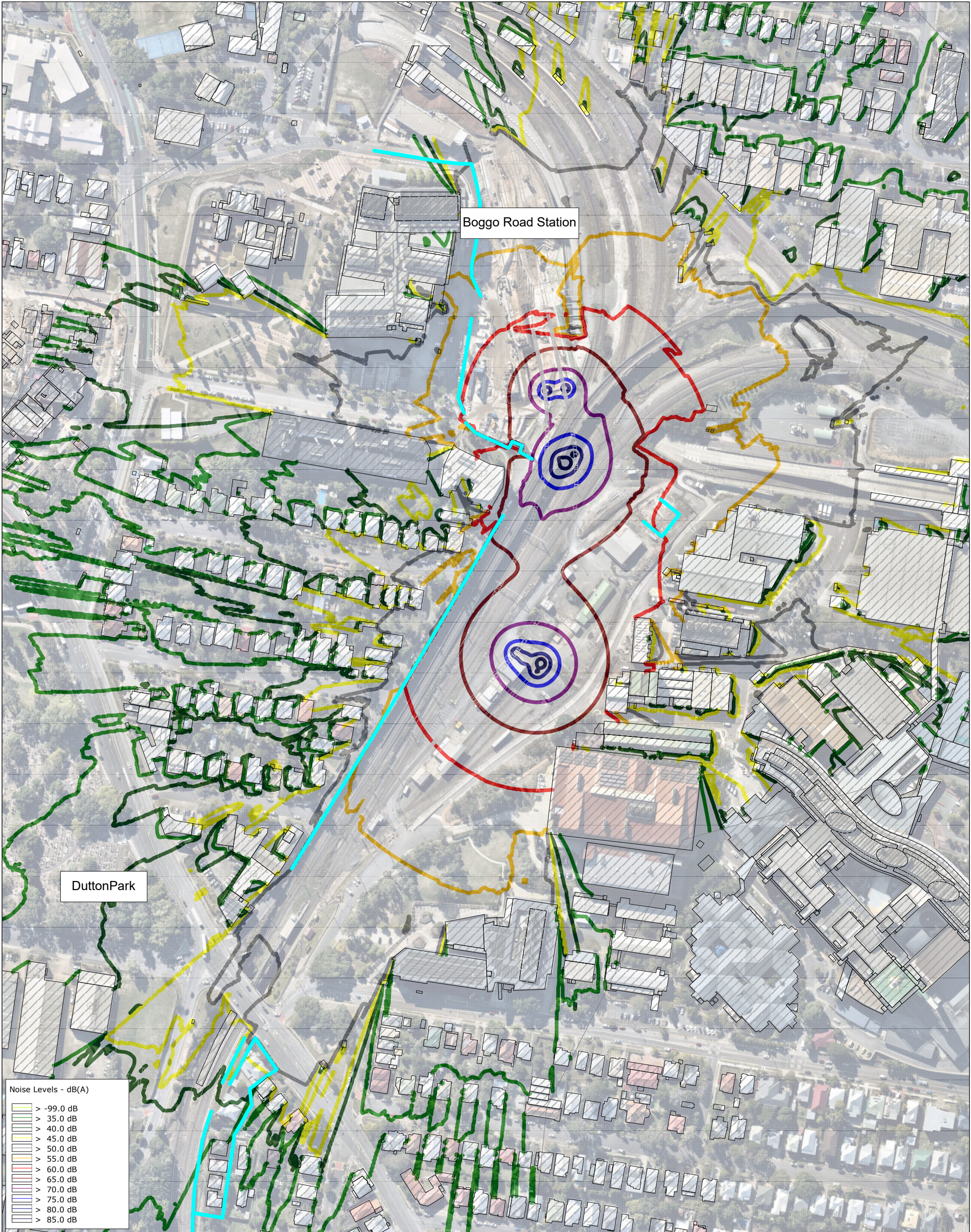
1m x 1m

Scale:

1: 2744 A3



legend:  Point Source  Line Source  Railway  Building  Barrier  Contour Line  Receiver  Building Evaluation  Calculation Area	Client: CBGU D&C JV Level 3, North Tower 339 Coronation Drive Milton QLD 4064	Project: Cross River Rail Project, Southern Portal STAGE 4 Excavation - Staging January 2022 - March 2022 (construction works within Zones A, B, C, D & E)	Description: Construction Noise Contours LAeq (15min) at 4.6m AGL FIGURE C19	
	Consultant:  PO Box 820, Spring Hill QLD 4004 P: 07 3367 3131 F: 07 3367 3121	NIGHT Noise levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.	Project No.: QB400-20 Figure Ref: QB400-20 Date: 2020.09.24	Produced by: DR & PJ Grid Size: 1m x 1m Scale: 1: 2744 A3



- Legend:
- Point Source
 - Line Source
 - Railway
 - Building
 - Barrier
 - Contour Line
 - Receiver
 - Building Evaluation
 - Calculation Area

Client:

CBGU D&C JV
Level 3, North Tower
339 Coronation Drive
Milton QLD 4064



PO Box 820, Spring Hill QLD 4004
P: 07 3367 3131 F: 07 3367 3121

Project:

Cross River Rail Project, Southern Portal

STAGE 5 - Staging April 2022 -
August 2022 (construction works within
Zones A, B, C, D & E)

DAY

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be used for reference only.

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Description:

Construction Noise Contours LAeq (15min)
at 4.6m AGL

FIGURE C20

Project No.:

QB400-20

Figure Ref:

QB400-20

Date:

2020.09.24

Produced by:

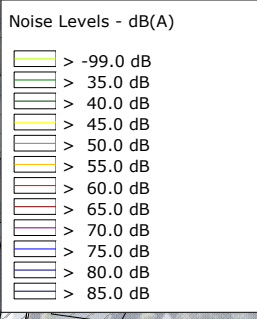
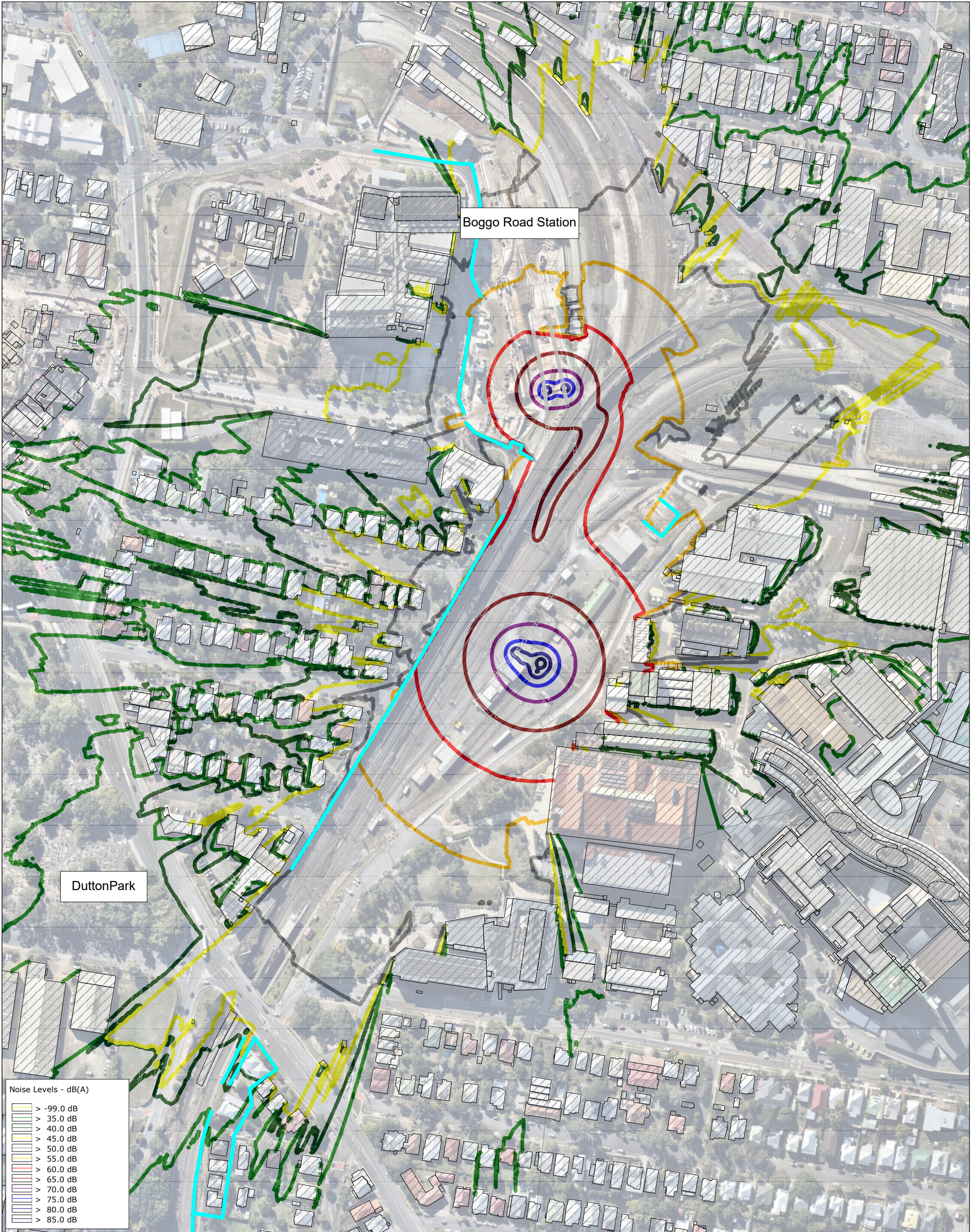
DR & PJ

Grid Size:

1m x 1m

Scale:

1: 2744 A3



- Legend:
- Point Source
 - Line Source
 - Railway
 - Building
 - Barrier
 - Contour Line
 - Receiver
 - Building Evaluation
 - Calculation Area

Client:

CBGU D&C JV
Level 3, North Tower
339 Coronation Drive
Milton QLD 4064

Consultant:

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inspired to achieve

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P: 07 3367 3131 F: 07 3367 3121

Project:

Cross River Rail Project, Southern Portal

STAGE 5 - Staging April 2022 - August 2022 (construction works within Zones A, B, C, D & E)

Evening

Noise levels are approximate due to interpolation of contours and should be used for reference only.

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Description:	
Construction Noise Contours LAeq (15min) at 4.6m AGL	
FIGURE C21	
Project No.:	Produced by:
QB400-20	DR & PJ
Figure Ref:	Grid Size:
QB400-20	1m x 1m
Date:	Scale:
2020.09.24	1: 2744 A3

APPENDIX D Risk Management

Risk management is an integral part of good management practice. AS/NZS 4360-1999 "Risk Management" has become part of our company's culture and therefore it permeates all aspects of the company's work and is actively promoted to our clients.

The risk management process can be applied to any situation where an undesired or unexpected outcome could be significant or where opportunities are identified. Our clients need to know about possible outcomes and the steps that can be taken to control any adverse impact.

There is an opportunity in the design process for the client to actively participate in risk management by providing input into risk reduction strategy. For example, the client may need to know that some aspects of risk reduction could involve passing those risks on to other entities in a better position to treat those risks. Some aspects of risk reduction may involve additional cost or time consequences. On the other hand, there may also be opportunities to avoid or avert risk at no cost to the client by rescheduling processes so that key information becomes available at a critical time.

When the client is properly informed, this supports better decision making by contributing a greater insight into risks and their impacts.

For this project, there are inherent risks in the design process and in the outcome where the designer is not in control of all processes. Accordingly, the Risk Assessment Table included here of this report identifies those risks, analyses the consequences, assesses the levels of risk and advises on the action taken or recommended to minimise them.

TABLE A1 - RISK ANALYSIS						
No	Item of Risk	Analyse Risk	Level	Treat Risk	Risk Allowance	
					Recommended	Used on this Project
	The design offered in this report assumes several factors which are outside the control of the designer. These include the following:	The client should be aware that the design tolerance chosen may not be adequate and some remedial measures may be required including, for example, modification to the plant, the provision of additional silencing treatment, construction of noise barriers or limitations in the time of use of equipment.	LOW/ MED/ HIGH	In order to reduce the risk of noise levels not complying with the design criteria, the following risk-reducing measures have been implemented or are recommended:		
1.	Engineering Design – Propagation in Environment	Modelling and calculating sound levels contain inaccuracies, for example, design assumptions relating to sound propagation on the site (including reflections from nearby buildings and surfaces).	MED	A tolerance of 3dB(A) is recommended in the final calculated sound level. The client may instruct Renzo Tonin & Associates to adopt a higher or lower design tolerance. Consider relocation of the plant to a location which minimises the risk.	3	0
2.	Engineering Design – Construction Form	Where an estimate or opinion is provided of the sound and/or impact insulation of a form of construction, this may be based on calculation and/or test results of similar constructions. This design process involves inherent inaccuracies.	HIGH	Adopt a design tolerance in the selection of the recommended form of construction to reduce the risk. The client may instruct Renzo Tonin & Associates to adopt a higher or lower design tolerance.		
				Noise Walls and Hoardings	3	0
				Noise Sheds	See 'Treat Risk	See 'Treat Risk
				Noise Enclosures		
3.	Construction airborne and ground-borne noise predictions	Modelling and calculating sound levels contain inaccuracies, for example assumptions relating to sound propagation on the site (including reflections from nearby buildings and surfaces), variability in the type and size of plant and ground conditions.	MED	A tolerance of 3dB(A) is recommended in the final calculated sound level. The client may instruct Renzo Tonin & Associates to adopt a higher or lower design tolerance. Consider relocation of the plant to a location which minimises the risk.	3	0
4.	Engineering Design – ground-borne vibration levels	Modelling and calculating ground-borne vibration levels contain inaccuracies, for example, design assumptions relating to vibration propagation between the source and receiver, building coupling loss, variation in source vibration levels.	LOW	Adopt a 2x design tolerance in the selection of the recommended form of construction to reduce the risk. The client may instruct Renzo Tonin & Associates to adopt a higher or lower design tolerance.	2x	0

TABLE A1 - RISK ANALYSIS

No	Item of Risk	Analyse Risk	Level	Treat Risk	Risk Allowance	
					Recommended	Used on this Project
5.	Construction of the Works	Construction involves many processes which are beyond the control of Renzo Tonin & Associates. Even when forms of construction have laboratory certification, the final installed product may not achieve the assumed design noise reduction.	HIGH	We recommend acoustic testing prior to construction of any works. We recommend the client allocates sufficient time for pre-testing programs. We recommend the client approves a rigorous inspection regime. We recommend the client allocates a budget for add-on options. We recommend the client allows for changes impacting on other areas, for example, detailing at joins.	See 'Treat Risk'	See 'Treat Risk'
6.	Estimated Variability of Noise Data Due to Measurement Uncertainties and Production Quality Control	Standards report that there is an uncertainty of 3-4dB(A) in the noise data of mechanical plant.	MED	If the client relies on the noise data as being guaranteed by the supplier then the appropriate risk allowance is 0dB(A), which has been assumed for this project. The client may instruct Renzo Tonin & Associates to adopt a higher or lower design tolerance.	3-4	0
7.	Background/ Ambient Noise Levels	Assumptions made in relation to the background/ ambient noise level adopted which cannot practically be determined with absolute certainty from a limited sample only.	LOW	Further background/ ambient noise level measurements have been proposed to confirm the noise goals. Arrangements for access by CPB are on-going.	See 'Treat Risk'	See 'Treat Risk'
8.	Inaudibility of Plant Noise (where applicable)	There are no standards which define inaudibility.	N/A	Inaudibility is assumed to mean a source level 5dB lower than the background noise level.	See 'Treat Risk'	Inaudibility is not a project requirement or commitment
9.	No. of Plant Operating Contemporaneously	The assumption that only some plant operate presents a risk of under-design. The assumption that all plant operate presents a potential over-design of acoustic treatment.	LOW	Modelling assumes all plant operate contemporaneously.	See 'Treat Risk'	See 'Treat Risk'

TABLE A1 - RISK ANALYSIS

No	Item of Risk	Analyse Risk	Level	Treat Risk	Risk Allowance	
					Recommended	Used on this Project
10.	Operating Mode of Plant (Capacity)	The assumption that plant operates at reduced capacity presents a risk of under-design. The assumption that plant operates at 100% capacity presents a potential over-design of acoustic treatment.	LOW	Assume plant operates at 100% capacity.	See 'Treat Risk'	See 'Treat Risk'
11.	Air Intake Design	Where air intake acoustic treatment is required, the use of louvers does not permit additional treatment should this be required. The extent of treatment may be limited by the small plant room space available.	MED	Silencers are used (where applicable) which are capable of being increased in length should this be required. Ensure sufficient space is available to accommodate changes.	See 'Treat Risk'	See 'Treat Risk'
12.	Exhaust Attenuators	If there are space restrictions, it may not be possible to increase the length of exhaust attenuators. If necessary a pod may need to be inserted should additional attenuating be required which will affect the pressure drop of the system and may impact on its performance.	MED	Where exhaust silencers are used, they are circular attenuators without a pod. Ensure sufficient space is available to accommodate changes and/or that plant can tolerate additional pressure drop.	See 'Treat Risk'	See 'Treat Risk'
13.	Acoustic Screens (Noise Barriers)	If there are height restrictions, it may not be possible to increase the height of acoustic screens.	MED	Where acoustic screens are used, ensure sufficient height is available and the acoustic screen design can accommodate changes.	See 'Treat Risk'	See 'Treat Risk'
14.	Site Noise Tests	Plant installed on site does not operate within the assumed design noise levels.	MED	Commission the consultant to undertake site noise tests during installation works and prior to commissioning of plant to confirm the assumptions described in this table and if necessary advise on remedial noise control measures. Allow for the time implications, cost and installation of the remedial treatment described above. Allow for possible reductions in plant operating during OOHW, e.g. reduce trucks operating at night.	See 'Treat Risk'	See 'Treat Risk'
15.	Condition of Approval restrictions	Following consultation and any reasonable arrangements, restrictive times or requirements may be placed on the project because of Conditions 10, 11 and 12 in the Coordinator-General's Report.	MED	Detailed design has aimed to minimise noise impacts on sensitive receivers, subject to CPB direction. Following the consultation process, the design will be reviewed and updated, if required.	See 'Treat Risk'	See 'Treat Risk'

TABLE A1 - RISK ANALYSIS							
No	Item of Risk	Analyse Risk	Level	Treat Risk	Risk Allowance		
					Recommended	Used on this Project	

EXPLANATION OF TABLE

The designs offered in this report assume a number of factors which are outside the control of Renzo Tonin & Associates.

The client accepts the risks identified in this document and is encouraged to minimize those risks by the methods described above.

The column marked "Level" identifies the level of risk as HIGH, MED, LOW or N/A. Where the risk is HIGH, the client is advised that if the design does not comply with the selected standards then the client may experience significant additional costs and delays in rectification works. Where the risk is MED, the client is advised that if the design does not comply with the selected standards then the client may experience some additional costs and/or delays in the rectification works. Where the risk is LOW, the client is advised that if the design does not comply with the selected standards then the client may experience delays in the rectification works. Where N/A is indicated, this means the item is not applicable to the project.

Attachment B: Technical Report - Traffic Noise

CROSS RIVER RAIL - SOUTHERN PORTAL WORKSITE

Construction Traffic Noise Assessment (Northern Access)

10 November 2020

CBGUJV

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1 Introduction

Renzo Tonin & Associates was engaged by CBGUJV to prepare a noise assessment for the Cross River Rail project-Southern Portal worksite for additional traffic along Joe Baker Street, Peter Doherty Street and Annerley Road to the north.

A previous assessment was conducted by Renzo Tonin & Associates for heavy vehicle movement along Annerley Road, Cornwall Street and Kent Street to enter the Southern Portal and Dutton Park worksites to the south (Our Ref: *QB400-18F03 Southern Portal-Construction Traffic Noise (r0)*, dated 11th August 2020).

This review focuses on the impacts from additional construction related road traffic from the Southern Portal worksite (Northern access) and addresses the noise goals, Imposed Conditions and recommendations of the following documents:

- Cross River Rail EIS-*Construction Noise and Vibration*, PART A (Report No: 20-2524-R2, dated 14th July 2011, Revision 1), Chapter 9.4.
- Cross River Rail – Coordinator-General's change report – *design refinements and condition changes 2020*, dated July 2020.
- Cross River Rail Project – Tunnel, Stations and Development Package (TSD), *Noise and Vibration Management Plan*, dated 14th September 2020.
- Cardno Traffic Impact Assessment Cross River Rail Southern Portal [Report Reference QTT20037 CRR – Phase 2 TIA 20201002].

It is noted that there are no specific Imposed Conditions related to construction traffic noise. Imposed Condition 14 (e) states:

Heavy construction vehicles use only designated routes for spoil haulage and deliveries of major plant, equipment and materials, in accordance with the Construction Environmental Management Plan. The designated haulage routes for each worksite must follow major or arterial roads to the extent practicable and be developed in consultation with the Department of Transport and Main Roads and the Brisbane City Council in preparation of the Construction Environmental Management Plan.

An aerial photograph of the site and the surrounding roads is shown below in Figure 1.



Figure 1: Locality Map

The proposed construction traffic routes (Blue lines) are shown below in Figure 2.

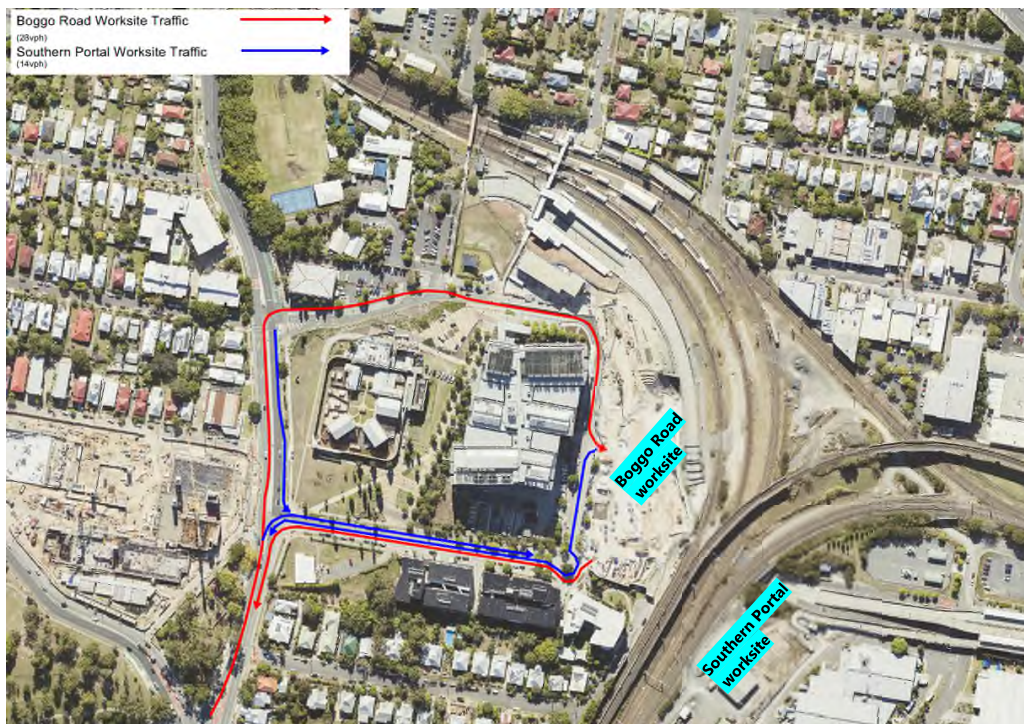


Figure 2: Proposed heavy vehicle access route

Construction related road traffic noise is assessed in accordance with the Transport Noise Management *Code of Practice: Volume 1 (Road Traffic Noise)*, Department of Transport and Main Roads, 2013.

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 Traffic noise goal

Section 2.2.6 *Construction Road Traffic Noise* of the EIS states:

Where the construction phase of CRR is adding heavy vehicles to the existing road network, it is appropriate to consider the incremental change in noise levels due to the changes in traffic volume.

A change of up to 3 dBA in the level of a dynamic noise, such as passing vehicles is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

It is acknowledged that people are likely to notice increased traffic based on visual clues and perception of vehicle pass-by frequency before they will objectively notice an increase in the average noise level.

For assessment purposes it is common to set the threshold of significance in relation to changes in the noise emission level from roads at 2 dBA. For the impact assessment of construction traffic noise the noise goal in Table 7 is recommended.

Table 7 Construction Road Traffic Noise Goal

Type of Roads	Goal
Existing Roads	2dBA change in existing $L_{A10(1hour)}$ ¹ , $L_{A10(12hour)}$ ² and $L_{A10(18hour)}$ ³

¹ $L_{A10(1hour)}$ for the peak number of heavy vehicle movements during any hour between 12midnight and 6am as stated in Section 9.4.2 of the EIS.

² $L_{A10(12hour)}$ is the average L_{A10} traffic noise level between the hours of 6:30am and 6:30pm as stated in Section 9.4.2 of the EIS.

³ $L_{A10(18hour)}$ is the average L_{A10} traffic noise level between the hours of 6am and 12midnight.

3 Existing traffic volumes

The traffic volumes were based on the following intersection counts conducted over a 24-hour period (as per data collected for the Cardno Traffic Impact Assessment Cross River Rail Southern Portal):

- Annerley Road/Peter Doherty intersection on Thursday 18th June 2020; and
- Annerley Road/Boggo Road intersection on Thursday 16th July 2020.

Appendix B shows the hourly calculated traffic volumes and a 24-hour summary is shown in Table 1 below. We note that at the time of preparing this report, Average Annual Daily Traffic (AADT) data for these roads were unavailable. Due to time constraints for data collection, the study used Average Daily Traffic Data, collected from a typical week day.

Table 1: Existing traffic volume – June 2020 & July 2020

Road Segment	24-hour day period	
	Existing Total	Existing Heavy Vehicles
Annerley Road	16,790	425 (2.5%)
Boggo Road	1,630	99 (6.1%)
Peter Doherty Street	1,184	66 (5.6%)
Joe Baker Street*	1,630	99 (6.1%)

* CBGUJV has advised to assume the same traffic data as Boggo Road

It is noted that the above data includes Boggo worksite heavy and light vehicles traffic.

4 Construction traffic volumes

4.1 Existing approved construction traffic volume for the Boggo worksite

It is understood that construction heavy vehicle traffic for the Boggo Road worksite currently arrives via Boggo Road from Annerley Road and depart via Peter Doherty Street and exit onto Annerley Road (see Red line in Figure 2 above). The peak traffic volume is approximately 24 heavy vehicles per hour as per RfPC #4. A typical breakdown of light and heavy vehicles for the Boggo worksite is shown in Table 2.

Table 2: Boggo worksite traffic

Construction Stage	Vehicle Classification	AM Peak (6:30am-9:00am)			Daytime off-peak (09:00am-2:30pm)			PM Peak (2:30pm-4:30pm)			Night-time off-peak (4:30pm-10pm)		
		Average per hour	Peak Per Hour	Total for Period	Average per hour	Peak per Hour	Total for Period	Average per hour	Peak per Hour	Total for Period	Average per hour	Peak per Hour	Total for Period
Stage 1	Light	5	8	12	2	4	16	4	6	10	2	10	20
	Heavy	0	0	0	6	16	44	0	0	0	4	10	20
	Total	5	8	12	8	20	60	4	6	10	6	20	40

4.2 Proposed additional construction traffic volume

The Cardno Traffic Impact Assessment Cross River Rail Southern Portal modelled various traffic scenarios around the Southern Portal area. This report builds in the Cardno Traffic Impact Assessment to assess the noise levels associated with the proposed option for access. The additional peak traffic volume is expected to be approximately 14 vehicles per hour for the Southern Portal worksite site. Traffic will enter and exit via Peter Doherty Street (see Blue line in Figure 2 above).

The forecast peak heavy and light vehicles associated with the Southern Portal worksite is shown in Table 3.

Table 3: Traffic volume increase forecast – Southern Portal worksite only

Road	Vehicle Classification	AM Peak (6:30am-9:00am) per hour	Daytime off-peak (9:00am-2:30pm) per hour	PM Peak (2:30pm-4:30pm) per hour	Night-time off-peak (4:30pm-10pm) per hour	Night (10pm-6:30am) per hour
Annerley Road	Light	14	4	14	7	7
	Heavy	0	10	0	7	7
Boggo Road	Light	0	0	0	0	0
	Heavy	0	0	0	0	0
Peter Doherty Street	Light	14	4	14	7	7
	Heavy	0	10	0	7	7
Joe Baker Street	Light	14	4	14	7	7
	Heavy	0	10	0	7	7

Based on the traffic data collected for the Cardno Traffic Impact Assessment, the expected construction 24-hour traffic volumes have been calculated as a peak or worst case basis assuming an additional 14 vehicles per hour, as shown in Table 4.

Table 4: Traffic volumes summary

Road Segment	24-hour day period					TOTAL	Heavy Vehicles
	Existing Total	Existing Heavy Vehicles	Additional Vehicles due to Southern Portal worksite				
			Vehicle increase	Heavy vehicle increase			
Annerley Road	16,790	425 (2.5%)	336	158	17,126	583 (3.4%)	
Boggo Road	1,630	99 (6.1%)	0	0	1,630	99 (6.1%)	
Peter Doherty Street	1,184	66 (5.6%)	336	158	1,520	224 (14.7%)	
Joe Baker Street	1,630	99 (6.1%)	336	158	1,966	257 (13.1%)	

5 Traffic noise assessment – Southern Portal worksite

5.1 Predicted construction traffic noise

Predicted changes in traffic noise are based on a method developed by the United Kingdom Department of Environment entitled “Calculation of Road Traffic Noise (1988)” known as the CoRTN (1988) method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board (ARRB) and as a result it is recognised and accepted by the Department of Transport and Main Roads (Queensland). The predicted increase in traffic noise on all assessed roads is detailed in Table 5 below.

As stated in the EIS, *the effect of construction related heavy vehicle traffic on the noise emission from roadways has been assessed by calculating how the additional truck traffic would alter the $L_{A10(12\text{hour})}$ level of noise emission from roadways using the CoRTN prediction algorithms. For the purpose of this analysis, the $L_{A10(12\text{hour})}$ is the average L_{A10} traffic noise level between the hours of 6:30am and 6:30 pm.*

This report adopts the same calculation methodology as the EIS.

Table 5: Predicted increase in traffic noise due to Southern Portal worksite only

Worksite	Road Segment	Predicted increase noise level, dBA		
		$L_{A10(12\text{hour})}$ (6:30am to 6:30pm)	$L_{A10(18\text{hour})}$ (6am to 12midnight)	$L_{A10(1\text{hour})}$ (12midnight to 6am)
		Day	Day & Evening	Night
Southern Portal	Annerley Road	+0.1	+0.1	+0.3
	Boggo Road	0	0	0
	Peter Doherty Street	+3	+2.8	+3.3
	Joe Baker Street	+0.2	+0.3	+0.3

Table 5 shows the predicted increase in road traffic noise levels due to the Southern Portal worksite is to be slightly greater than 2dBA for the overall $L_{A10(12\text{hour})}$, $L_{A10(18\text{hour})}$ and $L_{A10(1\text{hour})}$ noise parameters along Peter Doherty Street, when compared with existing June 2020/July 2020 traffic volumes.

As stated in Section 2.2.6 *Construction Road Traffic Noise* of the EIS, *a change of up to 3 dBA in the level of a dynamic noise, such as passing vehicles is difficult for most people to detect.*

Good practice measures should be adopted to minimise traffic noise impacts, utilising the existing environmental management framework inclusive of the Construction Environmental Management Plan and sub-plans.

6 Conclusion

Renzo Tonin & Associates was engaged by CBGUJV to prepare a noise assessment for the Cross River Rail project-Southern Portal worksite for additional traffic along Joe Baker, Peter Doherty and Annerley Road to the north.

The outcomes are as follows:

- Road traffic noise levels change due to the Southern Portal worksite is expected to be slightly greater than 2dBA, when compared with existing June 2020/July 2020 traffic. The expected change is 3dBA. As stated in Section 2.2.6 *Construction Road Traffic Noise* of the EIS, *a change of up to 3 dBA in the level of a dynamic noise, such as passing vehicles is difficult for most people to detect.*
- Good practice measures should be adopted to minimise traffic noise impacts.
- The assessment has been conducted in accordance with the Transport Noise Management Code of Practice: *Volume 1 (Road Traffic Noise)*, Department of Transport and Main Roads, 2013.

APPENDIX A Glossary of terminology

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

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).																																								
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.																																								
Assessment period	The period in a day over which assessments are made.																																								
Assessment Point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.																																								
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).																																								
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of common sounds in our daytime environment: <table><tr><td rowspan="2">threshold of hearing</td><td>0 dB</td><td>The faintest sound we can hear</td></tr><tr><td>10 dB</td><td>Human breathing</td></tr><tr><td rowspan="2">almost silent</td><td>20 dB</td><td></td></tr><tr><td>30 dB</td><td>Quiet bedroom or in a quiet national park location</td></tr><tr><td rowspan="2">generally quiet</td><td>40 dB</td><td>Library</td></tr><tr><td>50 dB</td><td>Typical office space or ambience in the city at night</td></tr><tr><td rowspan="2">moderately loud</td><td>60 dB</td><td>CBD mall at lunch time</td></tr><tr><td>70 dB</td><td>The sound of a car passing on the street</td></tr><tr><td rowspan="2">loud</td><td>80 dB</td><td>Loud music played at home</td></tr><tr><td>90 dB</td><td>The sound of a truck passing on the street</td></tr><tr><td rowspan="2">very loud</td><td>100 dB</td><td>Indoor rock band concert</td></tr><tr><td>110 dB</td><td>Operating a chainsaw or jackhammer</td></tr><tr><td rowspan="2">extremely loud</td><td>120 dB</td><td>Jet plane take-off at 100m away</td></tr><tr><td>130 dB</td><td></td></tr><tr><td>threshold of pain</td><td>140 dB</td><td>Military jet take-off at 25m away</td></tr></table>			threshold of hearing	0 dB	The faintest sound we can hear	10 dB	Human breathing	almost silent	20 dB		30 dB	Quiet bedroom or in a quiet national park location	generally quiet	40 dB	Library	50 dB	Typical office space or ambience in the city at night	moderately loud	60 dB	CBD mall at lunch time	70 dB	The sound of a car passing on the street	loud	80 dB	Loud music played at home	90 dB	The sound of a truck passing on the street	very loud	100 dB	Indoor rock band concert	110 dB	Operating a chainsaw or jackhammer	extremely loud	120 dB	Jet plane take-off at 100m away	130 dB		threshold of pain	140 dB	Military jet take-off at 25m away
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dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.																																								
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.																																								

Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L _{Max}	The maximum sound pressure level measured over a given period.
L _{Min}	The minimum sound pressure level measured over a given period.
L ₁	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L ₁₀	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L ₉₀	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L _{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain L _{eq} sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Traffic Data Hourly (Thursday 18th June 2020 & Thursday 16th July 2020)

Summary of the hourly traffic volumes.

Site	Hourly volumes								
	Annerley Road			Boggo Road		Peter Doherty Street		Joe Baker Street	
		Existing	HV	Existing	HV	Existing	HV	Existing	HV
Southern Portal Worksite	00:00-01:00	61	1	4	0	7	0	4	0
	01:00-02:00	55	9	2	1	3	2	2	1
	02:00-03:00	35	2	7	5	5	2	7	5
	03:00-04:00	39	3	1	0	3	0	1	0
	04:00-05:00	111	7	20	4	5	3	20	4
	05:00-06:00	307	14	46	3	27	1	46	3
	06:00-07:00	787	24	64	9	32	0	64	9
	07:00-08:00	1396	27	70	2	55	4	70	2
	08:00-09:00	1450	36	297	4	60	3	297	4
	09:00-10:00	946	26	91	3	48	0	91	3
	10:00-11:00	853	25	59	0	81	3	59	0
	11:00-12:00	820	20	49	0	57	0	49	0
	12:00-13:00	946	13	64	0	70	0	64	0
	13:00-14:00	812	7	41	0	89	0	41	0
	14:00-15:00	1021	15	89	0	81	0	89	0
	15:00-16:00	1530	28	157	1	107	0	157	1
	16:00-17:00	1527	22	80	1	73	1	80	1
	17:00-18:00	1396	5	84	0	59	0	84	0

18:00-19:00	867	3	58	0	40	0	58	0
19:00-20:00	560	0	33	0	0	0	33	0
20:00-21:00	345	0	0	0	2	0	0	0
21:00-22:00	336	0	19	0	3	0	19	0
22:00-23:00	207	3	25	0	9	0	25	0
23:00-00:00	121	2	9	0	6	0	9	0

Attachment C: Technical Report - Vibration

Report to



CBGU D&C JV

**Construction Vibration and
Regenerated Noise Impact Assessment
– Southern Portal**

Prepared By:

Heilig & Partners Pty. Ltd.

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EXECUTIVE SUMMARY

This Construction Vibration and Regenerated Noise Impact Assessment (CVRNIA) has been prepared to assess the level of vibration and the associated regenerated noise from the next phase of works at the Southern Portal Precinct, including the excavation activities for the initial section of the tunnel access and other ground support work including bored piles and vibratory sheeting. The report is structured to isolate those construction activities and equipment that may require mitigation to achieve the Coordinator Generals Imposed Conditions for Noise and Vibration at the sensitive receptors near to the construction site. The report identifies where CGBU (the Contractor) should focus, if necessary, their consultation regarding the construction works with the key stakeholders.

This CVRNIA outlines the Coordinator Generals Imposed Conditions for Noise and Vibration and Management Plans that govern the management of noise and vibration across the project. The methodologies set out within the EPRs have been used to establish noise and vibration target levels at various sensitive receptors across the precincts including residential, commercial, educational, and heritage.

During the construction period addressed in this technical review, works which could impact on the noise and vibration environment will be undertaken across the site. These works are limited to the vibratory sheeting, excavation and piling activities. Other construction and excavation works will necessarily occur concurrently with these planned works however they will generate very low levels of vibration and regenerated noise because of the equipment selection.

The modelling confirms that some of the excavation activities using hydraulic hammers to remove the competent rock sections will generate elevated levels of vibration and regenerated noise when compared to the existing pre-works environment. The vibration and regenerated noise values will however be compliant with Coordinator Generals Imposed Conditions for noise and vibration at properties along Railway Terrace. Other properties along Dutton Street, Rawnsley Street and Peter Doherty Street Avenue (streets perpendicular to Railway Terrace Street but further west) are modelled to receive lower levels of vibration than the Railway Terrace properties.

The Stage 1 excavation with the smaller 8 tonne and the larger 40 tonne excavator has been assessed. The area has been modelled with a matched hydraulic hammer. The vibration levels are minimal when works are with the excavator only and just approach perceptible levels at the properties on the western side of the rail corridor when the larger excavator and hammer is used. There is however no requirement to adjust practices to remain compliant with the noise and vibration conditions for damage or amenity protection.

For the Stage 2 works, the slightly more western footprint of the works increases the extent of the lower 0.5mm/s contour towards the properties on the western side of the site. Both excavators and smaller 8 tonne unit are modelled as being compliant with no requirements to adjust existing practices.

The extent of vibration assessment for the Stage 3 works show the use of the 30 tonne excavator with the 2000 kilogram hydraulic hammer will produce perceptible levels of vibration at the Leukemia Foundation ESA Village and if they are assessed as unacceptable, may require an adjustment to the practices, an adjustment to operating times or further discussions with the asset owners to implement suitable mitigation measures. The smaller non hammering options are compliant and will not require adjustments with respect to vibration control for damage and amenity.

The vibration assessment for the Stage 4 works highlight similar outcomes to the Stage 3 works with the higher energy 30 tonne excavator with the 2000-kilogram hammer potentially causing amenity related issues at the adjacent Leukemia Foundation ESA Village, but expected to be compliant based upon the hours of operation. The 20-tonne excavator and hydraulic hammer is modelled to be compliant.

The Stage 5 will not involve any hydraulic hammering works and are therefore modelled to be compliant with both damage and amenity criteria and no further mitigation options are expected to be necessary.

The modelling shows compliant levels of vibration at all key receptor locations around the works from the bored piles.

The expected extent of the vibration levels from the vibratory sheeting piles have been modelled. The extent of the 0.5mm/s contour (perceptible level) approaches the eastern corner of the Leukemia

Foundation ESA Village. The assessment suggests however that the activities will be compliant when an adjustment for the vibration propagating from the external ground mass into the building is considered.

The EcoSciences building varies from the works according to the excavation stages with Stage 1 works not closer than approximately 170 metres and the remaining stages all further than 90 metres from the closest north-east corner of the building. The sensitive TEM's equipment is an additional 70 metres. The separation distance is modelled to allow the vibration to reduce to values which will have no effect on the sensitive equipment serviceability.

The analysed data on which the above modelling outcomes are determined are presented as a series of vibration contours which can be interrogated to identify the ground level vibration and regenerated noise at any location around the works.

The planned construction methods are consistent with those assessed during the Requests for Project Change #1 and #4 and involve bored piles and vibratory sheeting for ground stabilisation and varying size excavators with hydraulic hammers for excavating the competent rock material within the dive structure. The re-alignment does not require any additional excavation methods or equipment types.

The assessment confirms that whilst some stages may require adjustments to the size of the hydraulic hammer to maintain compliant levels of vibration and regenerated noise at the adjacent residential properties and commercial buildings (Princess Alexandra TRI building, Leukemia Foundation building and the EcoSciences building), similar levels of impact were modelled for the RfP#4 alignment. The movement of the dive structure towards the east places the excavation closer to the Princess Alexandra TRI building than with the original alignment, however the difference in vibration and regenerated noise between the original and this modelled scenario is not significant.

The Leukemia Foundation building on the western side of the rail corridor is potentially affected by the re-alignment because of the extension of the works towards the north. The ground support works for the different alignments using the bored piles will be compliant with both vibration and regenerated noise criteria because of the low energy of the equipment with respect to induced vibration. The scheduled 24 hour works will therefore remain compliant with vibration and regenerated noise criteria.

The excavation works that involve using hydraulic hammers for establishing the box structures of the revised alignment at the northern end of the project will induce higher levels of vibration and regenerated noise than would have occurred with the previous alignment. When compared to the original alignment, the revised alignment is slightly closer to the Leukemia Foundation building and the impacts could be marginally greater than would have occurred with the original alignment. The increase will be dependent upon the propagation of the vibration through the Leukemia Foundation building and this will ultimately determine whether any changes to the excavation methods or scheduling of the works are required.

Vibration and noise monitoring during construction will be undertaken as required to inform the construction process, validate the modelling and demonstrate compliance with each of the conditions.

1 INTRODUCTION

1.1 Background to the Project

The Contactor has been contracted by the Pulse Partnership for the Cross River Rail Delivery Authority to design and construct the stations and tunnels for the Cross River Rail Project (the Project). Cross River Rail is a new 10.2 kilometre rail line from Dutton Park to Bowen Hills that includes 5.9 kilometres of twin tunnels under the Brisbane River and CBD. By removing the bottleneck at the core of the transport network, Cross River Rail will allow more trains to run more often to enable a turn-up-and-go transport system for the whole of South East Queensland.

Precincts at Boggo Road, Woolloongabba, Albert Street, Roma Street, and Exhibition will be significantly revitalised, to enable the project to achieve the proposed improvements.

1.2 Purpose of this Report

The Contractor requested Heilig & Partners to undertake an assessment of the planned works at the Southern Portal precinct to predict the vibration and regenerated noise impacts associated with the proposed activities, in comparison to the previously assessed RfPC #4. The assessment addresses both compliance with the projects goals as well as comparing the effects against the previously assessed RfPC#4 design.

Since RfPC-4 submission, further detailed planning has been undertaken on the Southern Area worksite. The planning considered the level of congestion within the rail corridor, including multiple commuter rail lines servicing the Gold Coast and Cleveland regions along with freight rail lines to the Port of Brisbane, the Boggo Road Busway that passes underneath the rail corridor and a grade separated rail freight flyover crossing above the rail corridor. These key features were then overlaid with the multiple intersections with utilities (power, stormwater and sewer) which need to be upgraded and / or relocated throughout the various stages of the work. Given the complexity of this area, the Project faced a number of technical challenges, particularly with rail alignment, rail geometry and utility constraints. The design has now been further developed to resolve these various technical issues.

As part of the construction of the Cross River Rail Project, a Construction Noise and Vibration Management Plan (CNVMP) has been developed. As part of the implementation of this CNVMP, individual Construction Noise and Vibration Impact Assessments (CVRNIAs) are necessary for each work sites as part of the main works undertaken by the Contractor.

This CVRNIA covers construction works for the hammering, boring, ground support, excavation activities for the Southern Portal works that will be undertaken in the Queensland Rail corridor and adjacent to the western section of the Princess Alexandra Hospital. Other works addressed in the previous assessments, or aspects specifically addressed as separate components of works, may yet to be completed. The main activities assessed in this CVRNIA include the ground support/improvement and excavation activities for the portal works associated with the mainline tunnels entries and exits.

The works area will involve multiple tasks for which only a few will involve activities that potentially generate elevated levels of vibration. The general area is as shown in the following Figure 1.

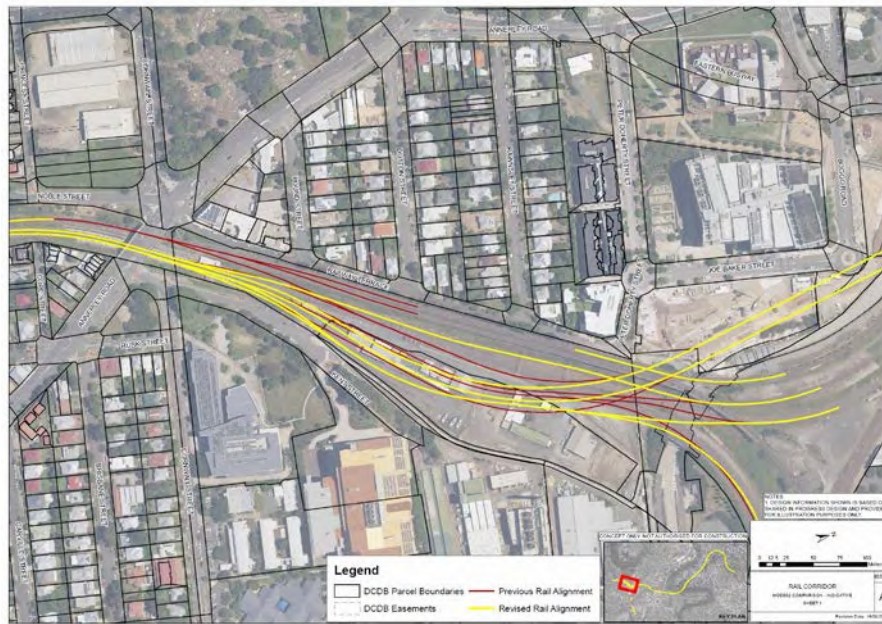


Figure 1: Southern Portal work area showing original and revised alignment

2 MAIN WORKS DESCRIPTION

2.1 Summary of Scheduling and Activities

During the construction period addressed in this technical review, works are planned for the Southern Portal which could impact on the existing noise and vibration environment. The construction team has divided the project works into multiple stages with each stage addressing a different area of the planned scope of works. In general, these works are limited to piling for ground stability and the excavation of the initial section of the stub tunnel. An overview of the Southern Portal work area is shown in Figure 2.



Figure 2: Overview of the Southern Portal work area

Other construction and excavation works will necessarily occur concurrently with these planned works however they will either generate very low levels of vibration and regenerated noise because of the equipment selection, or these works have been assessed separately. The following table (Table 1) lists the stages and activities that have been modelled.

<i>Works Description</i>	<i>Equipment</i>	<i>Assessed Implications</i>
Excavation of Stage 1	Multiple 8t to 40t excavators with and without hydraulic hammers	Building damage and amenity for residential properties along Railway Terrace, Leukemia Foundation building, the Princess Alexandra Hospital buildings and the EcoSciences building
Excavation of Stage 2	Multiple 8t to 40t excavators with and without hydraulic hammers	
Excavation of Stage 3	Multiple 20t to 30t excavators with and without hydraulic hammers	
Excavation of Stage 4	Multiple 20t to 30t excavators with and without hydraulic hammers	
Excavation of Stage 5	30t excavators and hydraulic hammers	
Bored piles for ground support	BG28 to BG40 Part of these works will be for a 40 day continues 24/7 operation	
Installation of vibratory sheeting ground support	Vibratory sheeting head	

Table 1 - Summary of works for Southern Portal Precinct

Stage 1 Excavation

Excavation for Stage 1 of the works will be completed using a small 8 tonne excavator or the larger 40 tonne unit. The smaller unit will be used for trimming of the excavation or in other locations where accessibility is limited. The following figure shows the planned location for the Stage 1 works.



Figure 3: Work area for excavation break at the Southern Portal

Where competent ground conditions are encountered, the use of the 8-tonne excavator coupled with a 500-kilogram hammer, such as the Caterpillar H75, has also been assessed. Modelling for the Stage 1 excavation has also addressed the use of the larger 40 tonne excavator with the 3300-kilogram hydraulic hammer.

Stage 2 Excavation

Stage 2 of the southern portal works utilises similar equipment to Stage 1 works with the 8 and 40 excavators, although over an expanded footprint that increases towards the northern section of the site. The assessment considers the same equipment both with and without hydraulic hammers. The hydraulic hammer size is consistent with the Stage 1 assessment. The following image shows the extent of the Stage 2 works.



Figure 4: Work area for the Stage 2 excavation activities at the Southern Portal

Stage 3 Excavation

The Stage 3 works involves excavation phases using either a 20 or 30 tonne excavator. The area of the works extends to the northern end of the portal site. Like Stages 1 and 2, any competent sections of the excavation may necessitate the use of a hydraulic hammer to achieve grade. The assessment has modelled the 30-tonne excavator with an attached 2000-kilogram hydraulic hammer.

The following image shows the extent of the Stage 3 works.

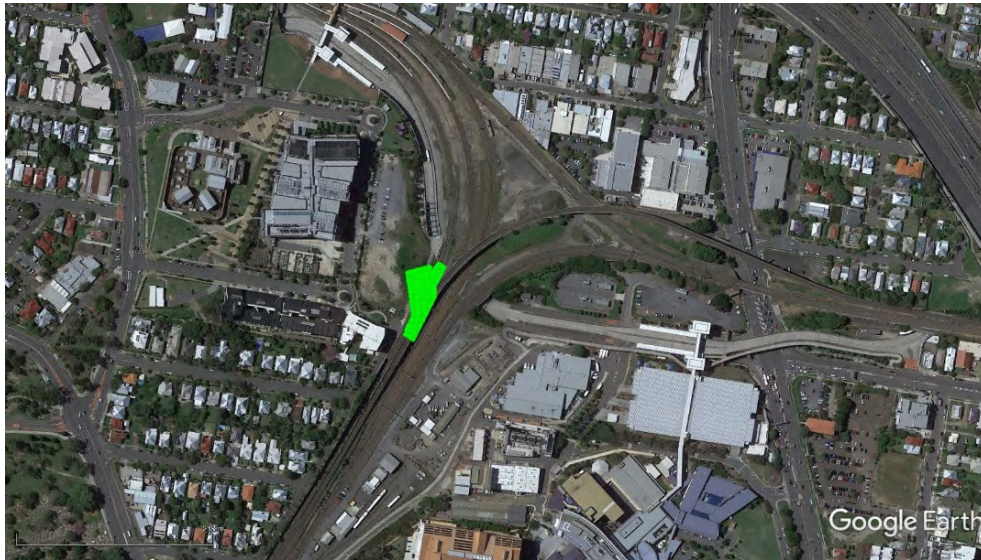


Figure 5: Work area for the Stage 3 excavation activities at the Southern Portal

Stage 4 Excavation

Stage 4 works involves the further assessment of excavation to the south of the Stage 3 works and is proposed to use the same equipment as the Stage 3 works. This includes the 20 and 30 tonne excavators, both including the option of the excavator coupled with the 1500 kilogram or 2000-kilogram hydraulic hammer respectively.

The following image shows the extent of the Stage 4 works.



Figure 6: Work area for the Stage 4 excavation activities at the Southern Portal

Stage 5 Excavation

The final Stage 5 excavation is limited to a footprint area that is similar to the Stage 4 works although with excavation works scheduled to use only a 30-tonne excavator without any requirements for a hydraulic hammer.

The following image shows the extent of the Stage 5 works.



Figure 7: Work area for the Stage 5 excavation activities at the Southern Portal

In addition to the assessment of vibration from each the five stages of the works for the different equipment and excavation options, the modelling has also addressed the level of regenerated noise that could occur from the same tasks.

Other Ground Improvement Works

In order to facilitate the excavation works and maintain stability of the surrounding ground conditions, a series of bored piles are scheduled required prior to the commencement of the earthworks in the stages above. The approximate location of the bored piles is shown in the adjacent image. The modelled diameter of the bored piles is 900mm. The location of the bored piles is shown in the following figure.



Figure 8: Work area for the installation of the bored piles at the Southern Portal

An additional section of works involves the installation of a 50 metre section of sheeting piles between the two rail tracks as shown in the following image. This is the only option to pile in this location due to

the constraints in the rail corridor. The effects of the sheeting piling on vibration and regenerated noise levels have been assessed.



Figure 9: Work area for the ground support activities with the vibratory sheeting at the Southern Portal

3 ENVIRONMENTAL PERFORMANCE REQUIREMENTS

3.1 Overview of EPRs

The Environmental Management Framework (EMF) has been developed by Cross River Rail Delivery Authority to address the noise and vibration requirements for the project. The EMF provides a transparent and integrated governance framework to manage environmental aspects associated with the design and construction phases of the Project, including those for noise and vibration. The requirements of the EMF and the EPRs will be enforced through the appropriate agencies.

Construction noise and vibration goals are defined in the Coordinator Generals Imposed Condition 11 which provides levels above which the management measures defined in the Construction Noise and Vibration Management Plan (CNVMP) will be implemented.

3.2 Relevant EPRs

The construction vibration goals specified in Condition 11 (Table 3) of the Coordinator Generals Imposed Conditions which guide the EPRs applicable to the Southern Portal Works are shown in Table 2.

Receiver Type	Cosmetic Damage			Human Comfort		Sensitive building contents
	Continuous Vibration	Transient Vibration	Blasting Vibration	Day	Night	
Residential	According to BS7385 reduced by 50%	According to BS7385	50mm/s	According to AS2670	0.5mm/s	
Commercial	According to BS7385 reduced by 50%	According to BS7385	50mm/s	According to AS2670	-	0.5mm/s
Heritage Structures	2mm/s	-	10mm/s	-	-	-

Table 2: EPRs applicable to Southern Portal Works

The levels presented in the Coordinator Generals Imposed Conditions refer to the peak particle velocity (PPV) which is the maximum level from the three orthogonal geophone elements. Some goals refer to the peak vector sum (PVS) which is a mathematically calculated value that considers the combined effect of all three sensors. The PVS value will always be greater than the PPV value.

The referenced Section 7.4.3 of the British Standard BS7385 indicates that the guide values relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low rise buildings. Where dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where the guide values apply, then the guide values may need to be reduced by up to 50%.

The potential effects of the different vibration level on human perception and disturbance are given in the following table (Based upon British Standard BS6472).

<i>RMS vibration level</i>	<i>Peak vibration level</i>	<i>Effect of vibration</i>
0.14 mm/s	0.4mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration
0.3 mm/s	0.7mm/s	Vibration might just be perceptible in residential environments
1.0 mm/s	3mm/s	It is very likely that vibration of this level in residential environments will cause complaint, but can be tolerated if warning and explanation has been given to residents
10 mm/s	25mm/s	Vibration would be intolerable for any more than a very brief exposure to this level (few seconds)

Table 3: Level of personal perception for vibration sources

Whilst there are no specific noise goals that apply to regenerated noise, given that it can be difficult to differentiate the varying construction noise sources, it is therefore appropriate to apply the construction airborne noise goals (CNGs) for the project. For continuous sources and for residential receivers, including areas within the ESA Leukaemia Centre, a 62dBA ($L_{eq, adj (1hr)}$) applies for daytime activities and 57dBA for out of hours works (6:30pm to 6:30am).

4 Baseline Environment

4.1 Existing environment

The Southern Portal construction site assessed in this document is located on the eastern side of Railway Terrace and largely within the existing rail network corridor. The key receptors around the works are the residential and commercial properties along Railway Terrace, with the latter further than 50 metres from the works area assessed in this document. In addition, other key receptors are the Princess Alexandra Hospital, Leukemia Foundation ESA Village, EcoSciences and PACE Health Sciences.

The existing environment along Railway Terrace is a public precinct which includes a range of land uses. The area along Railway Terrace and the adjacent perpendicular streets of Pound, Dutton, Rawnsley and Peter Doherty are quieter with respect to vibration and noise but with some background activities occurring from the train operation within the rail corridors. An overview of the site is shown in Figure 10.



Figure 10 - Overview of work areas for Southern Portal

4.2 Background vibration levels

Baseline vibration and noise information continues to be recorded as part of the ongoing monitoring process. The Contractor is continuing to undertake additional baseline noise and vibration measurements within the precinct as part of the works monitoring. The baseline noise and vibration levels measured from other precincts also provide an extensive baseline database from which to determine specific criteria.

The baseline measurements will very likely show some instances of elevated levels of vibration from the rail corridor activities. This is consistent with the results of the background vibration monitoring that has been completed as part of other works near the rail corridor. The sources of other elevated vibration are expected to be localised, and most likely due to traffic, but possibly could also occur through persons walking and working in the areas where the measurements are being undertaken. The dominant sources of elevated vibration will however occur as a result of vehicle movements along the adjacent roads as well as rail movements for those buildings closest to the rail corridors.

Additional background vibration data are being collected and being analysed as part of the monitoring associated with the works. Vibration measurements will continue to be undertaken in the absence of any construction activities to further confirm the existing environment.

4.3 Sensitive Receptors

A typical residential property located near to Railway Terrace and adjacent to where the works will be completed is shown in Figure 11.



Figure 11 – Typical Properties along Rawnsley Street adjacent to the area where portal works are required

As part of this assessment, modelling has been undertaken to predict the external vibration at the ground level at locations around the works areas, understanding that as vibration, and therefore regenerated noise, propagates upwards throughout the building floors, the vibration generally reduces in amplitude as a result of attenuation. Some properties, including the commercial buildings, will be occupied on the ground floor whilst other, like those shown in Figure 11 will only be occupied on the first floor above ground. The actual impacts of vibration and regenerated noise will therefore be dependent upon the building type as well as the equipment that is used for the works.

The modelling has also considered each building as one location, noting that there will also be variation across the building as a result of increasing separation distances to the vibration source. These data provide representative levels of vibration and regenerated noise to allow further screening and assessment of key receptors that may require further clarification of impacts.

4.4 Evaluated Project

The Southern Portal is generally in the same location as proposed for the Evaluated Project and within the rail corridor. The proposal however seeks to commence the trough structure approximately 40-50m east along the existing alignment, and the cut and cover to the south of Boggo Road Station. The proposal also includes minor changes to the surface tracks in this area and proposes cut and cover instead of a mined tunnel into Boggo Road Station (which reverts the construction method back to the delivery method proposed in RfPC #1 and RfPC #4).

The evaluated project as part of Request for Project Change #4 considered ground borne vibration impacts based on an excavator with hydraulic hammer. The ground borne noise and vibration levels were predicted to be below both the noise and vibration goals for the project. The differences in noise and vibration levels will be discussed in Section 7.

5 METHODOLOGY

5.1 Vibration Distance Relationships

As vibration from mechanical equipment, such as a hydraulic hammer, bored piling rig or vibratory sheeting equipment, propagates through the ground strata, regardless of its source, the amplitude decreases. High modulus, high competency rock types exhibit lower vibrational losses, while unconsolidated spoil types have high frictional losses and a more rapid attenuation of vibrational energy.

Equations used to describe the loss in amplitude of a vibration wave vary considerably, but an acceptable relationship to represent the level of vibration from a mechanical source simplifies to:

$$PPV = \frac{K}{d} e^{-\alpha d}$$

where:

- PPV is the velocity of vibration measured in mm/s
- d is the distance between the source of vibration and the point of measurement measured in metres, and
- K and α are site specific constants.

The rate of the decay in vibration generally varies for different types of operating equipment because of the different dominant vibration frequencies, although for high impact equipment like hydraulic hammers and vibratory sheeting, the variation in vibration levels is less pronounced and dominated more by the equipment energy. The rate of decay as well as the level of vibration as a function of the equipment energy in different rock masses have been collated from many hundred projects and this library of data has been consulted in assessing the impacts of the construction activities for the southern portal. The library has involved construction works around Brisbane and the assessment for this project has selected that which best corresponds to the Cross River Rail activities. Whilst similar items of plant can be scaled and assessed in this manner, a comparison of the vibration generated by the different equipment types based upon the source energy is not feasible and not used in the assessment.

A considerable amount of data is reviewing in the assessment of the vibration from hydraulic hammers, vibratory rollers, bored piles and so on. The vibration information used in the assessment is based upon multiple measurements at multiple distances with the vibration data regressed according to the above equation, rather than a simplified table of a vibration level at a reference distance.

Relationships between distance and vibration level were determined from other construction projects completed in similar rock masses. Although the level of vibration is affected by many factors, such as fracturing of the rock mass and the degree of water saturation, and can only be accurately estimated through site-specific measurements, a preliminary assessment can be completed based upon these derived relationships. The vibration distance relationship is shown in Figure 12 for some the equipment that is assessed for the Eastern portal area and other areas of the project.

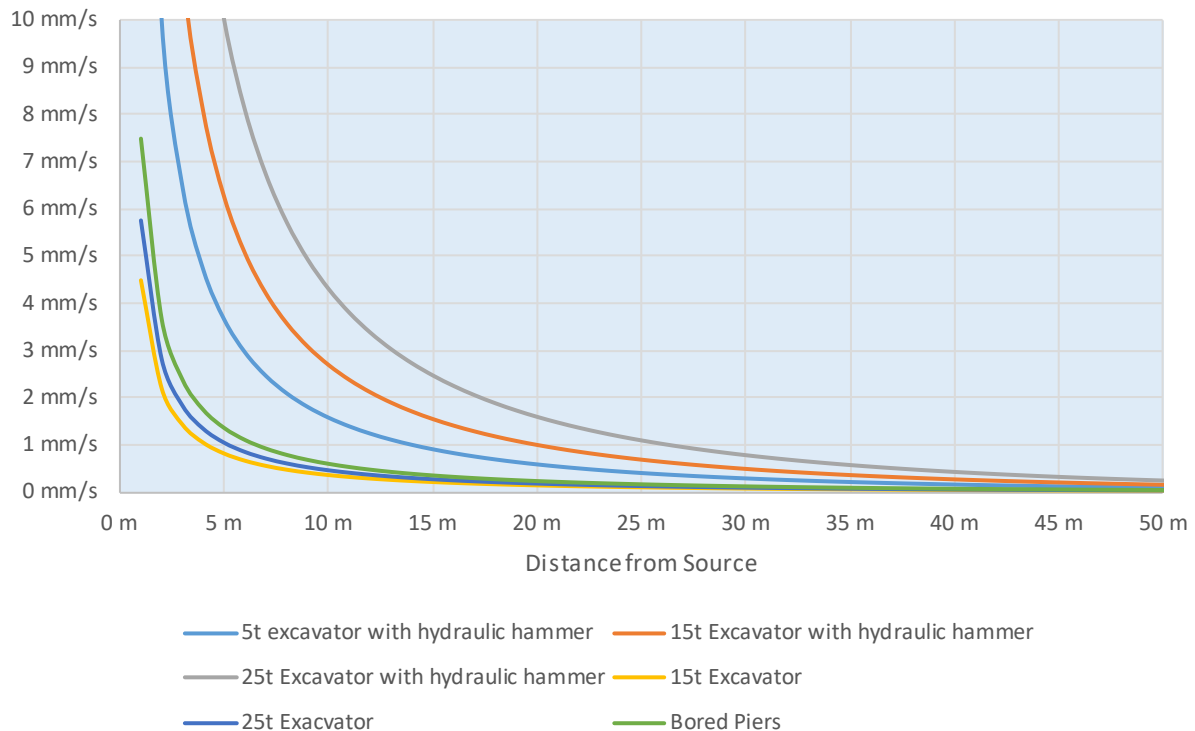


Figure 12 - Estimated level of vibration as a function of distance from the excavation equipment

The above relationships are considered a reasonable upper estimate of vibration as a function of distance and have been verified as appropriate but will be confirmed through on-site monitoring during the initial stages of the excavation works.

5.2 Vibration Modelling

The vibration and resulting regenerated noise predictions are estimated through a project specific model that has been developed and verified through other similar large-scale tunnelling and construction projects. The model is three dimensional and considers the source of the vibration (piling, vibratory head, hydraulic hammers and so forth) as a series of closely spaced sources from which vibration is propagated according to vibration/distance relationships. These relationships have been developed for the different equipment types and adjusted to reflect the different geology for the transmission paths. The degree of attenuation within the model considers the characteristics of through the rock mass through which the pulse travels.

The level of regenerated noise is estimated from the induced amplitude and frequency of vibration.

Vibration and regenerated noise contours are predicted using standard contouring algorithms for a regular net of points around the ground surface of the works areas. A digital elevation model developed from LIDAR data defines the surface elevation. The distance between each surface point and the source of the vibration is determined from the coordinates of the vibration inducing activity and the resulting level of vibration and regenerated noise calculated using the defined relationships.

The model to assess vibration and regenerated noise from the activities therefore considers the project as:

- A series of vibration sources including hydraulic hammers (of varying scale), bored piling rigs, tramping of equipment, vibratory heads and so on
- A series of receptors that may have varying levels of permissible vibration
- A series of geological blocks that exhibit different degrees of a vibration attenuation
- A surface DEM (digital elevation model).

There is some uncertainty in the source level, propagation and receptor amplifications. Consequently, conservative source levels and modelling parameters have been adopted for this screening assessment.

It is also known that the level of vibration generated by a construction activity varies throughout its operation. It varies as the equipment moves towards and recedes away from the sensitive receptor. It also varies because of the ground conditions. In addition, mobile equipment typically operates for periods of tens of minutes after which time the task is finished, or equipment temporarily stops. In a given one-hour period, it could be expected that the equipment operates closest to the sensitive receptor for a period of ten minutes where the maximum level of vibration is produced, at other locations where the vibration is reduced for another 30 minutes, and the remainder of the time the equipment produces no vibration. The level of vibration is therefore not consistently elevated but fluctuates with time and operating location.

The modelling results are exported as the peak level of vibration. This method is consistent with the existing data base of equipment vibration, distance and energy comparison that have been developed from other sites and have formed the basis of these predictions. The permissible vibration criteria for the project require assessment in several different metrics, such as dosage, peak level, RMS, accelerations for potentially sensitive etc and the comparison with these criteria are based upon the initially calculated peak levels of vibration. Key matters include:

- Calculation of the RMS level is based upon a conservative crest factor of 3. Other studies have shown that the crest factor (i.e. the ratio between the RMS level and the peak) could vary between 2 and 6. A value of 3 is an average value, but will necessarily equate to a higher RMS value than if a higher crest factor applies;
- The dosage estimates are based upon the duration of the event, the estimate of the peak vibration level and the calculated RMS value.

Smaller equipment potentially induces lower levels of vibration because of the reduced vibration energy, although it should be noted that the scheduling and duration of the works may be affected given the adjusted productivity. Although the smaller equipment for the project has not been modelled because of the low vibrational energies. Table 4 shows the expected separation distance that would be required to comply with the different vibration criteria for the smaller equipment that may be used on the project.

Plant Equipment	Minimum Working Distance (m)			
	Cosmetic Damage			Human Response ¹
	Residential and Light Commercial ²	Group 2 (Typical) ³	Group 3 (Structurally unsound)	
Mobile drill rig	1m	1m	1m	8m
Petrol powered road saw	<1m	<1m	<1m	3m
10,000L vacuum trucks	<1m	<1m	<1m	3m
Concrete trucks	<1m	<1m	<1m	3m

¹ Criteria referenced from EPA's Assessing Vibration: a technical guideline (DEC, 2006)

² Criteria referenced from British Standard BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2

³ Group 2 refers to dwellings and buildings of similar design and/or use. Group 3 refers to particularly sensitive structures (e.g.

historical with preservation orders). Criteria referenced from DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration

Plate compactor and small trench roller	1m	1m	1m	8m
3.5t excavator	<1m	<1m	<1m	3m
3.5t excavator with small hammer	1m	2m	3m	15m

Table 4 – Summary of predicted separation distances to comply with vibration criteria for low energy equipment

The distances given in Table 4 refer to the vector distance between the source and the receptor, but as noted previously do not account for vibration losses through the building as the vibration propagates from floor to floor. The data in Table 4 confirms that there is no requirement to consider the vibrational impacts from the low energy equipment.

5.3 Regenerated Noise

Regenerated noise, or ground-borne noise, is an associated effect of the small vibration related displacements that occur on generally hard surfaces within buildings. The surfaces could be walls, floors or ceilings. The measured regenerated value is affected by the amplitude and frequency of the vibration generated by the mechanical construction equipment as well as the internal characteristics of the building. Buildings with carpets, wall hangings, soft furniture and the like, will measure lower levels of regenerated noise when compared to other building fit-outs that do not have such elements, such as some commercial buildings with exposed concrete surfaces. An improved estimation of the level of regenerated noise is therefore difficult without some knowledge of the building characteristics.

Aside from the building design and style fit-out, the relationship between vibration level and regenerated noise is also dependent upon other aspects, including both equipment source characteristics. The noise data from studies completed at other tunnelling and construction sites within Australia have been analysed to best determine a relationship that could be applied to estimate regenerated noise effects. Based upon the type of vibration, and whether the source of the vibration occurs from a cutting action, such as road header, impact action such as a hydraulic hammer, or a vibratory source like a vibratory head, the predicted vibration level is converted to a regenerated noise value using the appropriate relationship shown in Figure 13. The vibration level refers to the peak level of vibration. The relationship presented in Figure 13 has been determined from mechanical sources of vibration like that produced from equipment types planned to be used in the Southern Portal area.

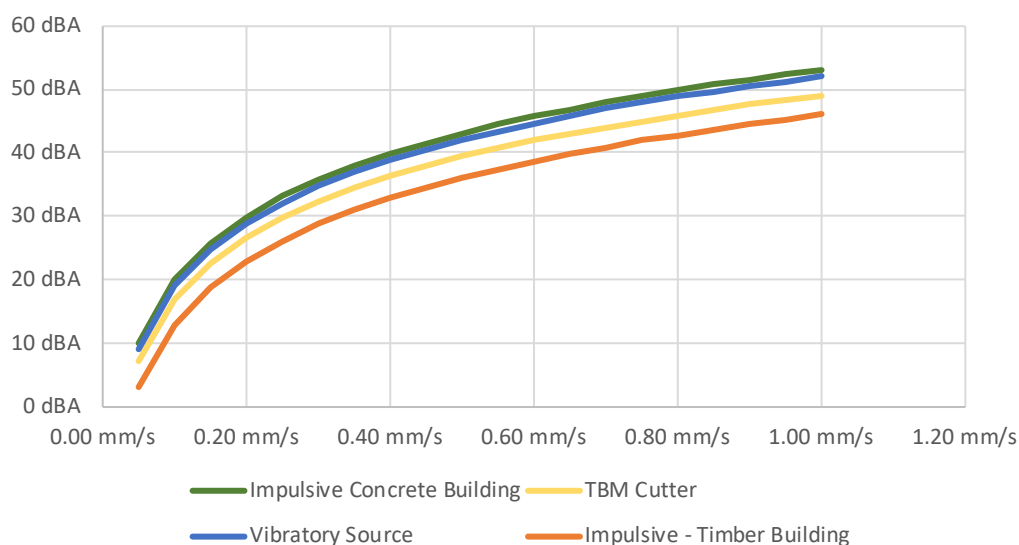


Figure 13 – Expected range of regenerated noise levels depending upon source vibration characteristics

A conservative approach is necessarily adopted where it is assumed that minimal internal attenuation exists which in most situations will lead to predicted values that are 5 to 10dB higher than actual

experienced conditions. The modelled results are also presented as “screening” data to identify possible areas where further site assessments could be required. In all cases, the predicted results will be confirmed through the outlined verification monitoring plan.

5.4 Assumptions and Notes

The following assumptions, input conditions and notes should be considered in the interpretation of the outcomes of the modelling assessment:

- Buildings and the Digital Elevation Model (DEM) are based on internal project reference library data and other information as provided by the coordinates identified by the Contractor
- Coordinates for the individual areas within a building are not available and the analyses have been based on the representative locations within a building. Depending upon the location within large footprint buildings, the predicted levels may vary from the measured values
- Estimating the level of regenerated noise is difficult without some knowledge of the building characteristics. A conservative approach is therefore adopted where it is assumed that minimal internal attenuation exists which in most situations will lead to predicted values that are 5 to 10 dB higher than actual experienced conditions
- The level of vibration and regenerated noise identified in the vibration contours is external to the building. It is generally expected that the internal vibration level will be less than the external vibration value, but dependent upon the building characteristics. A conservative value of 20% reduction should be applied to the reported values when calculating the internal values
- The level of vibration and regenerated noise typically attenuates as the vibration passes from one floor to another. Higher floors within a building therefore experience lower levels of vibration than the ground floor value
- Mobile plant, like excavators, will necessarily move from location to location within the works area. The modelled maximum levels of vibration and regenerated noise are therefore expected to occur only momentarily as the equipment operates nearest to the sensitive receptor
- The contours represent the maximum level of vibration and or regenerated noise during the undertaking of the modelled task. The maximum level will only be realised when the plant is operating at the closest point to the receptor
- Locations closer to the source than the contour will experience higher levels than that defined by the contour. At locations further from the contour, the predicted level of vibration will be less than stipulated value
- The contours do not include any significance of time. The peak level of vibration and or regenerated noise may occur for a short period, less than one minute, or for an extended period in those cases where the activity is necessarily prolonged. In both cases, providing the equipment source, geology and equipment location remains unchanged, the contours will be identical
- The levels of vibration and regenerated noise are dependent upon horizon at which the equipment is operating. As an example, when installing bored piles, the level of vibration experienced at ground level will be higher during the initial stages of piling over that experienced when the boring is at depth. This assumes that the ground conditions remain unchanged. The contours that show the level of vibration will therefore generally reflect worst case conditions with reductions in vibration and regenerated noise as the source of the vibration changes with depth (on the assumption that the ground conditions remain unchanged);
- The modelling is not based upon concurrent activities of multiple equipment types.

6 MODELLING RESULTS

6.1 Vibration and Regenerated Noise Levels

The vibration and regenerated noise levels at the sensitive receptors around the planned Southern Portal works have been modelled using the methodology set out in Section 5 of this assessment report. The excavation results are presented as a series of vibration and regenerated noise plates showing vibration contours varying between 0.5mm/s and 2.5mm/s and regenerated noise contours between 35 and 55dBA when measured externally. On the vibration plates, the vibration contours for both external values which reflect the level of vibration that would be measured outside of the property as well the level of vibration that would be expected if the measurements were taken inside the property. For the latter case, the contours show that the inside to outside vibration is approximately $\frac{1}{2}$. The 50% reduction is consistent, but generally conservative, with the findings of other projects and information presented in the international documents, such as the widely recognised Federal Transit Administration document⁴.

The regenerated noise values reflect the noise level that would be measured externally. An adjustment to this value should be made. The adjustment reflects the transfer of vibration from external to internal, with a further reduction representing the loss as the vibration propagates from floor to floor. It may also be necessary to apply a further adjustment to offset against the internal fit out of the building.

The external to internal vibration attenuation could vary from the proposed 50% as the building type and structure affects the transfer of the vibration from the ground to the building. Wood frame buildings, such as typical residential structures, are more easily excited by ground vibration than heavier buildings. In contrast, large masonry buildings with spread footings have a low response to ground vibration. When a building foundation is directly on the rock layer, there is no coupling loss due to the weight and stiffness of the building. The following factors in Table 5 are presented in the FTA document for vibration loss attributable to the coupling between the building foundation and the surrounding ground mass.

<i>Building Type</i>	<i>Vibration Adjustment in dB</i>	<i>Vibration as % of external ground level</i>
Wood frame houses	-5dB	55%
1 to 2 storey masonry	-7dB	45%
3 to 4 storey masonry	-10dB	30%
Large masonry on piles	-10dB	30%
Large masonry on spread footings	-13dB	20%
Foundation in rock	0dB	100%

Table 5 – FTA reported vibration loss as a result of the coupling between building foundation and ground mass

In general, the heavier the building construction, the greater the coupling loss.

For the commercial buildings adjacent to the proposed excavation works where the building construction is more substantial than a lighter weight residential property, the external to internal attenuation will be greater than the 50% value applied, and therefore the level of vibration inside the building will be less. As a result of the reduced vibration, the level of regenerated noise will also decrease. As noted in Section 5.3, measurements at other sites have also confirmed that regenerated noise levels may reduce further depending upon the internal building fit-out. Whilst not shown on the drawings, it is reasonable to expect that the regenerated noise values could reduce by potentially by 10 to 20dBA when these adjustments are applied to the contour values.

⁴ Hanson, C.E, Towers, D.A, Meister, L.D., (2006), Department of Transportation, United States of America, Federal Transit Administration, Office of Planning and Environment (2006), “*Transit noise and vibration impact assessment*”, May 2006, FTA-VA-1003-06

The results are shown in the Appendix A for each work area and for each equipment type and level of operation. Only those equipment types that are known to produce elevated levels of vibration have been modelled. The contour approach easily allows the expected maximum level of vibration at the ground floor level of each potentially sensitive receptor to be determined according to the varying contour values. The vibration contours show peak vibration levels in mm/s. The contours for the regenerated noise are $L_{Aeq,15min}$.

The modelling has been completed for key locations and for each of the works activities. The assessment is limited to those activities that could induce measurable levels of vibration and/or regenerated noise. The assessments have been based on three dimensional models that account for equipment types and ground conditions.

The analysed data on which the above modelling outcomes are determined are presented as a series of vibration contours which can be interrogated to identify the ground level vibration and regenerated noise at any location around the works. The following comments relate to the drawings presented in Appendix A.

Plates 1 to 4 show the Stage 1 excavation with the smaller 8 tonne and the larger 40 tonne excavator. The latter two of these plates show the options with a matched hydraulic hammer. The vibration levels are minimal with the excavator and only approach perceptible levels at the properties on the western side of the rail corridor when the larger excavator and hammer is used. There is however no modelled requirement to adjust current practices to remain compliant with the noise and vibration conditions for damage or amenity protection.

Plates 5 to 8 show similar effects to the Stage 2 works for the same equipment types. The footprint of works located slightly more to the west increases the extent of the lower 0.5mm/s contour towards the properties on the western side of the site. The two excavators and smaller 8 tonne unit are modelled as being compliant with no requirements to adjust these practices. The larger 40 tonne excavator may however require monitoring to confirm the levels at the closest properties however the initial modelling suggests the values will remain compliant with damage and amenity criteria.

Plates 9 to 11 identify the extent of vibration contours for the Stage 3 works and show that only the use of the 30 tonne excavator with the 2000 kilogram hydraulic hammer will produce perceptible levels of vibration at the Leukemia Foundation ESA Village and may therefore require an adjustment to practice and an adjustment to operating times coupled with further discussions with the asset owners in line with the mitigation measures set out in Section 6 of this report. The smaller non hammering options are compliant and will not require adjustments with respect to vibration control for damage and amenity.

Plates 12 to 14 show the vibration contours for the Stage 4 works and highlight similar outcomes to the Stage 3 works with the higher energy 30 tonne excavator with the 2000 kilogram hammer potentially causing amenity related issues at the adjacent Leukemia Foundation ESA Village. The 20-tonne excavator and hydraulic hammer is modelled to be compliant. Further monitoring and discussion with the property manager for the Leukemia Village operator would be required during the Stage 4 activities.

Plate 15 shows the final Stage 5 activities. As no hammering is proposed, the Stage 5 works are modelled to be compliant with both damage and amenity criteria and no further mitigation options are expected to be necessary.

Plate 16 highlights the vibration from the bored piles activities. The modelling shows compliant levels of vibration at all key receptor locations around the works

Plate 17 indicates the expected extent of the vibration levels from the vibratory sheeting works. The extent of the 0.5mm/s approaches the eastern corner of the Leukemia Foundation ESA Village and should be verified through additional monitoring. The assessment suggests however that the activities will be compliant when an adjustment for the vibration propagating from the external ground mass into the building is accounted for.

Similarly numbered Plates are also presented after the vibration drawings showing the expected levels of regenerated noise from the same equipment types. The modelling indicates that regenerated noise levels are generally low although become elevated where the excavation utilises that larger hydraulic hammers. In these instances, whilst the regenerated noise is elevated and audible the levels are compliant with the airborne Construction Noise Goals for the project.

Vibration and noise monitoring will be undertaken as required to inform the construction process, validate the modelling and demonstrate compliance with each of the noise and vibration conditions.

To lessen any impact on sensitive receptors, measures such as management controls (e.g. working hours, respite periods), source controls (e.g. equipment selection, use and siting of plant), and other site-specific measures will be utilised where the modelling has underestimated impacts and there are requirements to reduce vibration and regenerated noise levels at sensitive receptors.

6.2 Variation Between Assessed Project

The assessed RfP#9 project presented in this report differs from the originally evaluated project with the re-aligning the dive structures slightly towards the east by approximately 30 metres and extending the portal area further towards the north. In broad terms, the works move nearer to the Princess Alexandra Hospital infrastructure but in some sections further from the residential properties along Railway Terrace by up to 15 metres. The Leukemia Foundation ESA Village on the western side of the railway corridor is closer to northern part of the works.

The planned RfP#9 construction methods are consistent with those initially assessed during the initial project alignment and involve bored piles and vibratory sheeting for ground stabilisation and varying size excavators with hydraulic hammers for excavating the competent rock material within the dive structure. The re-alignment does not require any additional methods that would produce elevated levels of vibration over those methods identified for the original assessment.

Table 6 lists the modelled impacts at the three representative locations, including the Railway Terrace residential properties, the Princess Alexandra TRI building, the Leukemia Foundation ESA Village building and the EcoSciences building, and how these compare with the assessed RfP#4 design.

Stage and Activity	Construction Method	Sensitive Receptor	Potential impact to evaluated project	Significance of change
Excavation of Stage 1	Multiple 8t to 40t excavators with and without hydraulic hammers	Railway Terrace	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity. No impact on structural integrity	No appreciable change to noise and vibration levels
		Leukemia Foundation		
		TRI Building		
Excavation of Stage 2	Multiple 8t to 40t excavators with and without hydraulic hammers	Railway Terrace	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity. No impact on structural integrity	No appreciable change to noise and vibration levels
		Leukemia Foundation	Increase in vibration and regenerated noise levels may require adjustment to equipment size or other controls	Increase in vibration and regenerated noise impacts
		TRI Building	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity. No impact on structural integrity	No appreciable change to noise and vibration levels
		EcoSciences	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity.	No appreciable change to noise and vibration levels

			No impact on structural integrity	
Excavation of Stage 3	Multiple 20t to 30t excavators with and without hydraulic hammers	Railway Terrace	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity. No impact on structural integrity	No change to noise and vibration levels
		Leukemia Foundation	Increase in vibration and regenerated noise levels may require adjustment to equipment size or other controls	Slight increase in vibration and regenerated noise impact
		TRI Building	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity. No impact on structural integrity	No change to noise and vibration levels
		EcoSciences	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity. No impact on structural integrity	No appreciable change to noise and vibration levels
Excavation of Stage 4	Multiple 20t to 30t excavators with and without hydraulic hammers	Railway Terrace	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity. No impact on structural integrity	No change to noise and vibration levels
		Leukemia Foundation	Small increase in vibration and regenerated noise levels may require adjustment to equipment size or other controls	Slight increase in vibration and regenerated noise impact
		TRI Building	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity. No impact on structural integrity	No change to noise and vibration levels
Excavation of Stage 5	30t excavators and hydraulic hammers	Railway Terrace	Very low vibration and regenerated noise. Compliant with noise and vibration conditions for amenity. No impact on structural integrity	No change to noise and vibration levels
		Leukemia Foundation		
		TRI Building		
		EcoSciences Building		
Bored piles for ground support	BG28 to BG40	Railway Terrace	Very low vibration and regenerated noise. Compliant with noise and vibration	No change to noise and vibration levels
		Leukemia Foundation		
		TRI Building		
		EcoSciences Building		

			conditions for amenity. No impact on structural integrity	
Installation of vibratory sheeting ground support	Vibratory sheeting head	Railway Terrace	Very low vibration and regenerated noise.	No change to noise and vibration levels
		Leukemia Foundation	Compliant with noise and vibration conditions for amenity.	
		TRI Building	No impact on structural integrity	
		EcoSciences Building		

Table 6 – Variation between changed and originally evaluated project

The assessment confirms that whilst some stages of the works may require that the size of the hydraulic hammer is limited to maintain compliant levels of vibration and regenerated noise at the adjacent residential properties and commercial buildings, the same degree of impacts were modelled for the original RfP#1 and RfP#4 alignments. The movement of the dive structure towards the east places the excavation closer to the TRI building than with the original alignment, however the difference in vibration and regenerated noise between the original and this modelled scenario is insignificant.

The Leukemia Foundation building on the western side of the rail corridor is potentially affected by the re-alignment because of the extension of the works towards the north. The ground support works with the bored piles will be compliant with both vibration and regenerated noise criteria because of the low energy of the equipment with respect to induced vibration. The scheduled 24 hour works will therefore remain compliant with vibration and regenerated noise criteria.

Stages 2, 3 and 4 excavation works involve using hydraulic hammers for establishing the box structures of the revised alignment at the northern end of the project will induce slightly higher levels of vibration and regenerated noise at the Leukemia Foundation building than would have occurred with the previous alignment. The levels are however compliant. When compared to the original alignment, the revised alignment is slightly closer to the Leukemia Foundation building and the impacts could be marginally worse than would have occurred with the original alignment. The extent of the impact will be dependent upon the propagation of the vibration through the Leukemia Foundation building and this will ultimately determine whether any changes to the excavation methods or scheduling of the works are required.

The EcoSciences building varies from the works according to the excavation stages with Stage 1 works not closer than approximately 170 metres and the remaining stages all further than 90 metres from the closest north-east corner of the building. The sensitive TEM's equipment is an additional 70 metres. The separation distance is modelled to allow the vibration to reduce to values which will have no effect on the sensitive equipment serviceability.

7 MANAGEMENT AND MITIGATION

The following are overall project controls. The Environmental Manager / Coordinator, Supervisor and Project Engineer will be responsible for implementing actions outlined in the following sections, in accordance with the project wide Construction Environment Management Plan (CEMP).

Management and control measures will be consistent with those applied elsewhere on the project. These will be implemented where necessary to minimise the effect of any construction activities on the adjacent residential and commercial occupancies. The control measures will include the following:

- Management controls
- Source controls (adjustments to the equipment generating the elevated levels of vibration)
- Path controls (adjustments to the vibration path between the source and the receptor)

7.1 Management Controls

The vibration and regenerated noise mitigation management measures outlined in the following table. Table 7 will be implemented to reduce the disturbance to the nearby receptors during the project.

Action Required	Applies	Details
Working hours	Vibration and regenerated noise	Construction activities will be only undertaken during standard hours unless otherwise approved. To be included in Project Induction and Pre-Start Briefings, Toolbox Talks etc.
Scheduling of work	Vibration and regenerated noise	Discussions with residents regarding the modelling that has identified elevated level of vibration when compared with the guideline values. Discussions will be undertaken to determine if there are preferred operating periods that will minimise the impact.
Adjustment to equipment type	Vibration and regenerated noise	Where elevated levels of vibration or regenerated noise are predicted and cannot be mitigated through adjustments to the schedule, the use of alternative lower energy equipment types will be reviewed.
Relocation of equipment	Vibration and regenerated noise	Should sensitive equipment be affected by the works and the level of vibration cannot be reduced, and rescheduling of equipment usage cannot be successfully implemented, the feasibility or temporary relocation of the equipment will be considered
Implement community consultation measures	Vibration and regenerated noise	• Periodic notification (monthly letterbox drops or equivalent) • Website • Project Infoline • Email distribution list • Community Based Forums (if required by approval conditions).
Site inductions and Training	Vibration and regenerated noise	All employees, contractors and subcontractors will receive an environmental induction or training. The induction will at least include: • All relevant project specific and standard vibration and regenerated noise mitigation measures. • Relevant licence and approval conditions. • Permissible hours of work. • Any limitations on high vibration and/or regenerated noise generating activities. • Location of nearest sensitive receptors. • Equipment operating periods and/or preferred scheduling of activities • Environmental incident response processes.

Action Required	Applies	Details
Monitoring	Vibration	A monitoring program will be carried out for the duration of the works The level of regenerated noise as a function of the level of vibration established to confirm the relationship applied in the modelling. Remodelling undertaken where necessary. The level of vibration from the different excavating methods monitored at several locations to confirm the vibration attenuation relationship. Remodelling of expected effects to be completed where necessary The vibration from the excavating equipment assessed during initial stages to confirm the floor to floor attenuation

Table 7 - Vibration and regenerated noise mitigation management procedures

7.2 Source Controls

The source mitigation measures outlined in Table 8 will be implemented to reduce the disturbance to the nearby receptors during the project.

Action Required	Applies	Details
Equipment selection	Vibration and regenerated noise	Equipment at the work sites will be selected and best suited to minimising impact via the level of vibration as well as appropriately sized to allow the task to be completed as quickly as possible. Sub-contractors will be made aware of the plant requirements during the tender process.
Construction Method	Vibration and regenerated noise	Less vibration emitting construction methods will be used where feasible and reasonable. As an example, small hydraulic hammers vs large hydraulic hammers, bored piles are preferred to driven piles. Static roller preferred to vibratory rollers. Sub-contractors will be made aware of the plant requirements during the tender process. The vibration emitted from plant and equipment items are to be considered in equipment selection and scheduling decisions. Plant that will be used to confirm to the modelled types and sizes. Any variations in the equipment type and or size would be further assessed before being used
Plant assessment	Vibration and regenerated noise	All plant utilised on site to be assessed to ensure it complies with supplier specifications and not affected by sub-standard maintenance
Simultaneous use of plant	Vibration and regenerated noise	Simultaneous operation of vibration intensive plant within a small distance of each other will be avoided where the activity is close to sensitive receptors Where possible, the offset distance between plant generating vibration and adjacent sensitive receptor is to be maximised. Weekly inspections will be undertaken by the environmental teams to ensure plant are not emitting excess noise or vibration.
Start-up procedures	Vibration and regenerated noise	The Contractor will ensure all plant and equipment are switched on away from sensitive spaces and brought slowly into position (where practicable and safe to do so), to minimise any elevated levels during start up, introducing the associated vibration and regenerated noise gradually. As an example for piling, the drilling apparatus will be operated at a slow linear speed (vertically) to avoid any excessive force associated with collisions between the drilling apparatus and the ground.

Table 8: Potential measures that may be implemented to control vibration at the equipment source

7.3 Path Controls

The vibration and noise mitigation path controls outlined in Table 9 could be implemented to reduce the disturbance to the nearby receptors during the project. Adjustments to the vibration path as a control measure are only considered as a final measure after other mitigation options have been exhausted.

Action Required	Applies	Details
Introduction of open discontinuity between the source and the sensitive receptor.	Vibration	Open discontinuities that are positioned close to the vibration source or the sensitive receptor can be used to attenuate the level of vibration and the associated level of regenerated noise. An example of a discontinuity is an open trench. The effectiveness of the trench is related to the depth versus the proximity of the works or the receptor. Where the works are undertaken at a distance more than twice the depth of the trench, the benefit is limited. The discontinuity must remain open and not filled with water
Vibration isolation devices	Vibration	Passive vibration isolation systems can be used to reduce the level of vibration, including an adjustment of the dominant frequency bands of vibration. The systems can be simple rubber units where they absorb some of the vibration, mechanical springs which reduce the passage of certain frequencies. The transmissibility is dependent upon the vibration characteristics and the receptor. The method could be applied for isolation of specific equipment, but not appropriate for building wide reductions or personal amenity reduction

Table 9 - Potential measures that may be implemented to control vibration between the source and the receptor

7.4 Monitoring

Monitoring of the equipment to confirm the site vibration relationships is required to ensure appropriate selections have been made with respect to maintaining the integrity of the buildings and sensitive equipment so they are not affected by the construction works.

7.4.1 Verification of Predicted Results

During the initial stages of any works with a new equipment type, an attended site verification survey may be completed. The survey will involve vibration being simultaneously monitored at multiple locations to permit data to be recorded in a form that can be regressed to establish a site-specific vibration relationship between distance and vibration levels for each equipment type.

Monitoring of these levels at key locations will be required to confirm the accuracy of the modelling, and better inform subsequent modelling. Where required, it will also identify the requirement for any revised modelling predictions where there is enough discrepancy to warrant remodelling.

7.4.2 Unattended Monitoring

The unattended vibration and regenerated noise monitoring programme will be undertaken as described in the approved CNVMP. The minimum monitoring requirements to be covered by the program for this site have been outlined in the CVMP.

Locations for monitoring equipment will be determined in consultation with potentially affected stakeholders.

In the event of an alarm notification of a management target exceedance from the monitoring system which is confirmed because of site activities an investigation will be undertaken to identify the reason for the non-compliance.

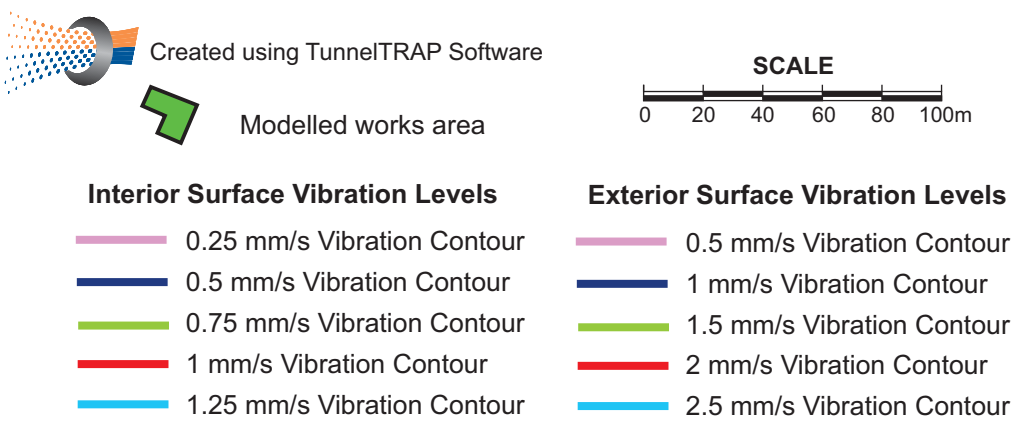
7.4.3 Attended Monitoring

In addition to the verification survey, attended vibration surveys may be undertaken for the following:

- After the commencement of construction on site or a new item of plant arrives on site, vibration measurements may be undertaken near the most affected receptor to confirm the vibration levels and provide subjective comment. The aim of the monitoring will be to:
 - o To refine construction methods to minimise vibration and regenerated noise.
 - o To differentiate between construction vibration sources and other sources (e.g. road, pedestrian, rail. traffic).
 - o Confirm predicted vibration levels
- In the event of a justified complaint, attended monitoring may be undertaken to confirm the location is not anomalous with respect to the predicted levels of vibration and/or regenerated noise
- To assess internal levels within buildings

Vibration monitoring will be carried out by a suitably qualified person. Monitoring information will be stored within the Project specific network.

8 APPENDIX A – Vibration and Regenerated Noise Contours for Southern Portal Works



PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 1 - Modelled level of vibration from a 8 tonne excavator. Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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Plate No. 1

Revision History
R1: Original

Date Drawn: 5 August 2020

Ref No: CRR Southern Portal

Job No: HP1906-1

In preparing this drawing, HP have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request were complete, accurate and up to date. Where we have obtained information from a Government register or database, we have assumed that the information is accurate. Where a assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware why any of the assumptions are incorrect.



 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Interior Surface Vibration Levels

- 0.25 mm/s Vibration Contour
- 0.5 mm/s Vibration Contour
- 0.75 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.25 mm/s Vibration Contour

Exterior Surface Vibration Levels

- 0.5 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.5 mm/s Vibration Contour
- 2 mm/s Vibration Contour
- 2.5 mm/s Vibration Contour

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 1 - Modelled level of vibration from a 40 tonne excavator. Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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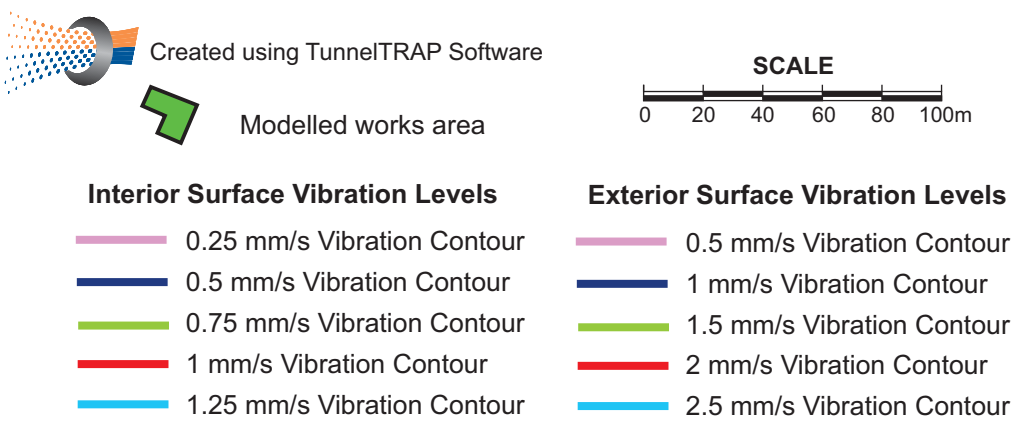
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Plate No. 2	Date Drawn: 5 August 2020
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PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 1 - Modelled level of vibration from a 8 tonne excavator with a 500kg hydraulic hammer (CATH75 or equivalent). Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Interior Surface Vibration Levels

- 0.25 mm/s Vibration Contour
- 0.5 mm/s Vibration Contour
- 0.75 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.25 mm/s Vibration Contour

Exterior Surface Vibration Levels

- 0.5 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.5 mm/s Vibration Contour
- 2 mm/s Vibration Contour
- 2.5 mm/s Vibration Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 1 - Modelled level of vibration from a 40 tonne excavator with 3300kg hydraulic hammer (CATH160 or equivalent). Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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Plate No. 4

Revision History

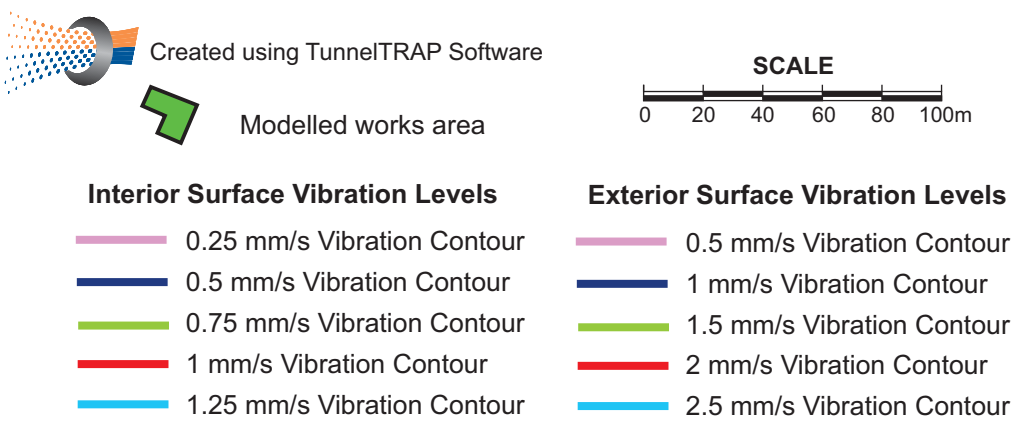
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Job No: HP1906-1

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PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 2 - Modelled level of vibration from a 8 tonne excavator. Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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Plate No. 5

Revision History

R1: Original
R2: Revised Modelling

Date Drawn: 10 September 2020

Ref No: CRR Southern Portal

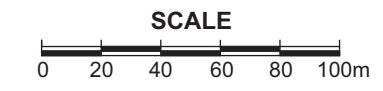
Job No: HP1906-1

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Created using TunnelTRAP Software

Modelled works area



- | Interior Surface Vibration Levels | Exterior Surface Vibration Levels |
|-----------------------------------|-----------------------------------|
| 0.25 mm/s Vibration Contour | 0.5 mm/s Vibration Contour |
| 0.5 mm/s Vibration Contour | 1 mm/s Vibration Contour |
| 0.75 mm/s Vibration Contour | 1.5 mm/s Vibration Contour |
| 1 mm/s Vibration Contour | 2 mm/s Vibration Contour |
| 1.25 mm/s Vibration Contour | 2.5 mm/s Vibration Contour |

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 2 - Modelled level of vibration from a 40 tonne excavator. Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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	Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Interior Surface Vibration Levels

- 0.25 mm/s Vibration Contour
- 0.5 mm/s Vibration Contour
- 0.75 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.25 mm/s Vibration Contour

Exterior Surface Vibration Levels

- 0.5 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.5 mm/s Vibration Contour
- 2 mm/s Vibration Contour
- 2.5 mm/s Vibration Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 2 - Modelled level of vibration from a 8 tonne excavator with 500kg hydraulic hammer (CATH75 or equivalent). Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Interior Surface Vibration Levels

- 0.25 mm/s Vibration Contour
- 0.5 mm/s Vibration Contour
- 0.75 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.25 mm/s Vibration Contour

Exterior Surface Vibration Levels

- 0.5 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.5 mm/s Vibration Contour
- 2 mm/s Vibration Contour
- 2.5 mm/s Vibration Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 2 - Modelled level of vibration from a 40 tonne excavator with 3300kg hydraulic hammer (CATH160 or equivalent). Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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Plate No. 8

Revision History

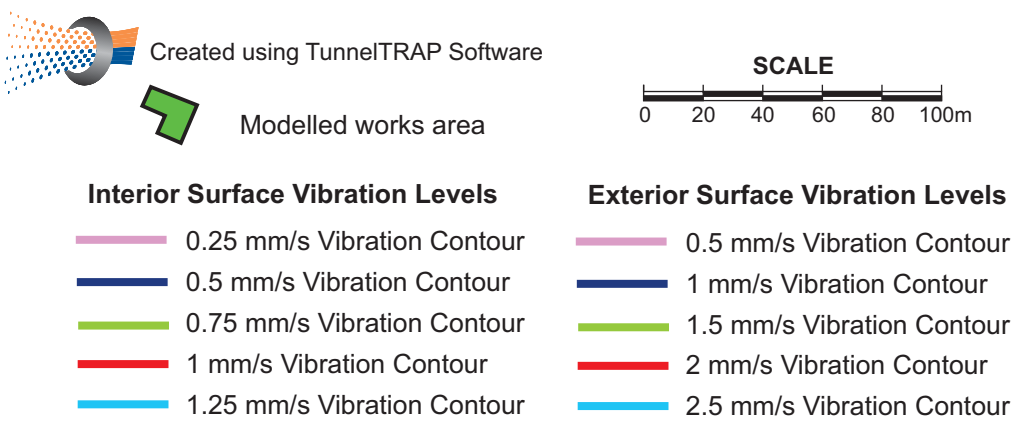
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Job No: HP1906-1

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PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 3 - Modelled level of vibration from a 20 tonne excavator. Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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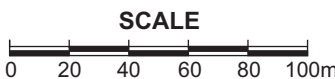
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Revision History R1: Original	Ref No: CRR Southern Portal
	Job No: HP1906-1

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Created using TunnelTRAP Software

Modelled works area



- | Interior Surface Vibration Levels | Exterior Surface Vibration Levels |
|-----------------------------------|-----------------------------------|
| 0.25 mm/s Vibration Contour | 0.5 mm/s Vibration Contour |
| 0.5 mm/s Vibration Contour | 1 mm/s Vibration Contour |
| 0.75 mm/s Vibration Contour | 1.5 mm/s Vibration Contour |
| 1 mm/s Vibration Contour | 2 mm/s Vibration Contour |
| 1.25 mm/s Vibration Contour | 2.5 mm/s Vibration Contour |

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 3 - Modelled level of vibration from a 30 tonne excavator. Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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Plate No. 10

Revision History
R1: Original

Date Drawn: 5 August 2020

Ref No: CRR Southern Portal

Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Interior Surface Vibration Levels

- 0.25 mm/s Vibration Contour
- 0.5 mm/s Vibration Contour
- 0.75 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.25 mm/s Vibration Contour

Exterior Surface Vibration Levels

- 0.5 mm/s Vibration Contour
- 1 mm/s Vibration Contour
- 1.5 mm/s Vibration Contour
- 2 mm/s Vibration Contour
- 2.5 mm/s Vibration Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 3 - Modelled level of vibration from a 30t tonne excavator with 1500kg hydraulic hammer (CAT H140 or equivalent). Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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Plate No. 11

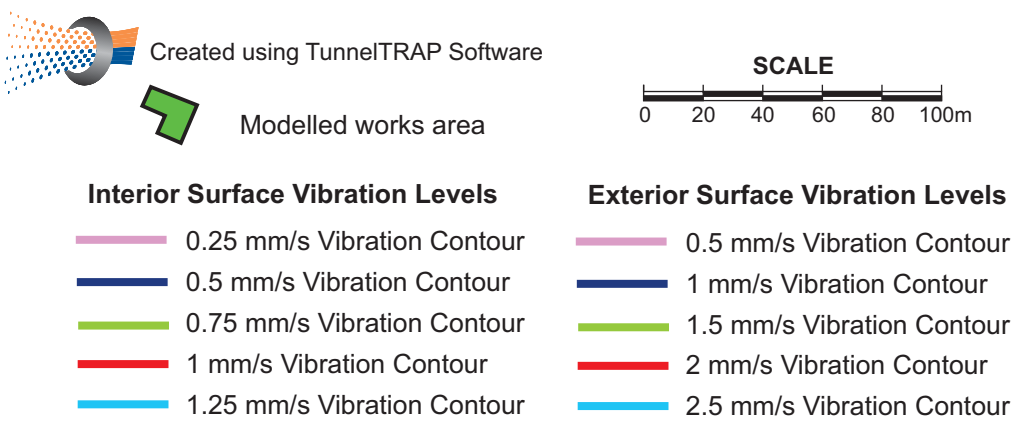
Revision History
R1: Original

Date Drawn: 5 August 2020

Ref No: CRR Southern Portal

Job No: HP1906-1

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PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 4 - Modelled level of vibration from a 30 tonne excavator. Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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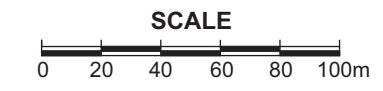
Plate No. 12	Date Drawn: 5 August 2020
Revision History R1: Original	Ref No: CRR Southern Portal
	Job No: HP1906-1

In preparing this drawing, HP have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request were complete, accurate and up to date. Where we have obtained information from a Government register or database, we have assumed that the information is accurate. Where a assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware why any of the assumptions are incorrect.



Created using TunnelTRAP Software

Modelled works area



- | Interior Surface Vibration Levels | Exterior Surface Vibration Levels |
|-----------------------------------|-----------------------------------|
| 0.25 mm/s Vibration Contour | 0.5 mm/s Vibration Contour |
| 0.5 mm/s Vibration Contour | 1 mm/s Vibration Contour |
| 0.75 mm/s Vibration Contour | 1.5 mm/s Vibration Contour |
| 1 mm/s Vibration Contour | 2 mm/s Vibration Contour |
| 1.25 mm/s Vibration Contour | 2.5 mm/s Vibration Contour |

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 4 - Modelled level of vibration from a 20 tonne excavator with a 1500kg hydraulic hammer (CATH120 or equivalent). Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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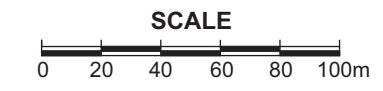
Plate No. 13	Date Drawn: 5 August 2020
Revision History R1: Original	Ref No: CRR Southern Portal
	Job No: HP1906-1

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Created using TunnelTRAP Software

Modelled works area



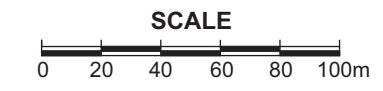
- | Interior Surface Vibration Levels | Exterior Surface Vibration Levels |
|-----------------------------------|-----------------------------------|
| 0.25 mm/s Vibration Contour | 0.5 mm/s Vibration Contour |
| 0.5 mm/s Vibration Contour | 1 mm/s Vibration Contour |
| 0.75 mm/s Vibration Contour | 1.5 mm/s Vibration Contour |
| 1 mm/s Vibration Contour | 2 mm/s Vibration Contour |
| 1.25 mm/s Vibration Contour | 2.5 mm/s Vibration Contour |

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 4 - Modelled level of vibration from a 30 tonne excavator with a 1500kg hydraulic hammer (CATH140 or equivalent). Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.			
 HEILIG & PARTNERS Engineered Excellence Telephone +61 7 3715 7599 P.O. Box 1176 Mobile 0419 196 369 Mt. Ommaney Facsimile +61 7 3715 7588 QLD. 4074. Australia Email john@heiligandpartners.com.au		 CPB CONTRACTORS bam Ghella UGL CBGU D&C JV	
Plate No. 14		Date Drawn: 5 August 2020	
Revision History R1: Original		Ref No: CRR Southern Portal	
		Job No: HP1906-1	
In preparing this drawing, HP have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request were complete, accurate and up to date. Where we have obtained information from a Government register or database, we have assumed that the information is accurate. Where a assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware why any of the assumptions are incorrect.			



Created using TunnelTRAP Software

Modelled works area



- | Interior Surface Vibration Levels | Exterior Surface Vibration Levels |
|-----------------------------------|-----------------------------------|
| 0.25 mm/s Vibration Contour | 0.5 mm/s Vibration Contour |
| 0.5 mm/s Vibration Contour | 1 mm/s Vibration Contour |
| 0.75 mm/s Vibration Contour | 1.5 mm/s Vibration Contour |
| 1 mm/s Vibration Contour | 2 mm/s Vibration Contour |
| 1.25 mm/s Vibration Contour | 2.5 mm/s Vibration Contour |

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 5 - Modelled level of vibration from a 30 tonne excavator. Vibration contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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Plate No. 15

Revision History
R1: Original

Date Drawn: 5 August 2020

Ref No: CRR Southern Portal

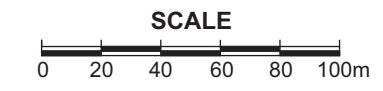
Job No: HP1906-1

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Created using TunnelTRAP Software

Modelled works area



- | Interior Surface Vibration Levels | Exterior Surface Vibration Levels |
|-----------------------------------|-----------------------------------|
| 0.25 mm/s Vibration Contour | 0.5 mm/s Vibration Contour |
| 0.5 mm/s Vibration Contour | 1 mm/s Vibration Contour |
| 0.75 mm/s Vibration Contour | 1.5 mm/s Vibration Contour |
| 1 mm/s Vibration Contour | 2 mm/s Vibration Contour |
| 1.25 mm/s Vibration Contour | 2.5 mm/s Vibration Contour |

PROJECT DESCRIPTION

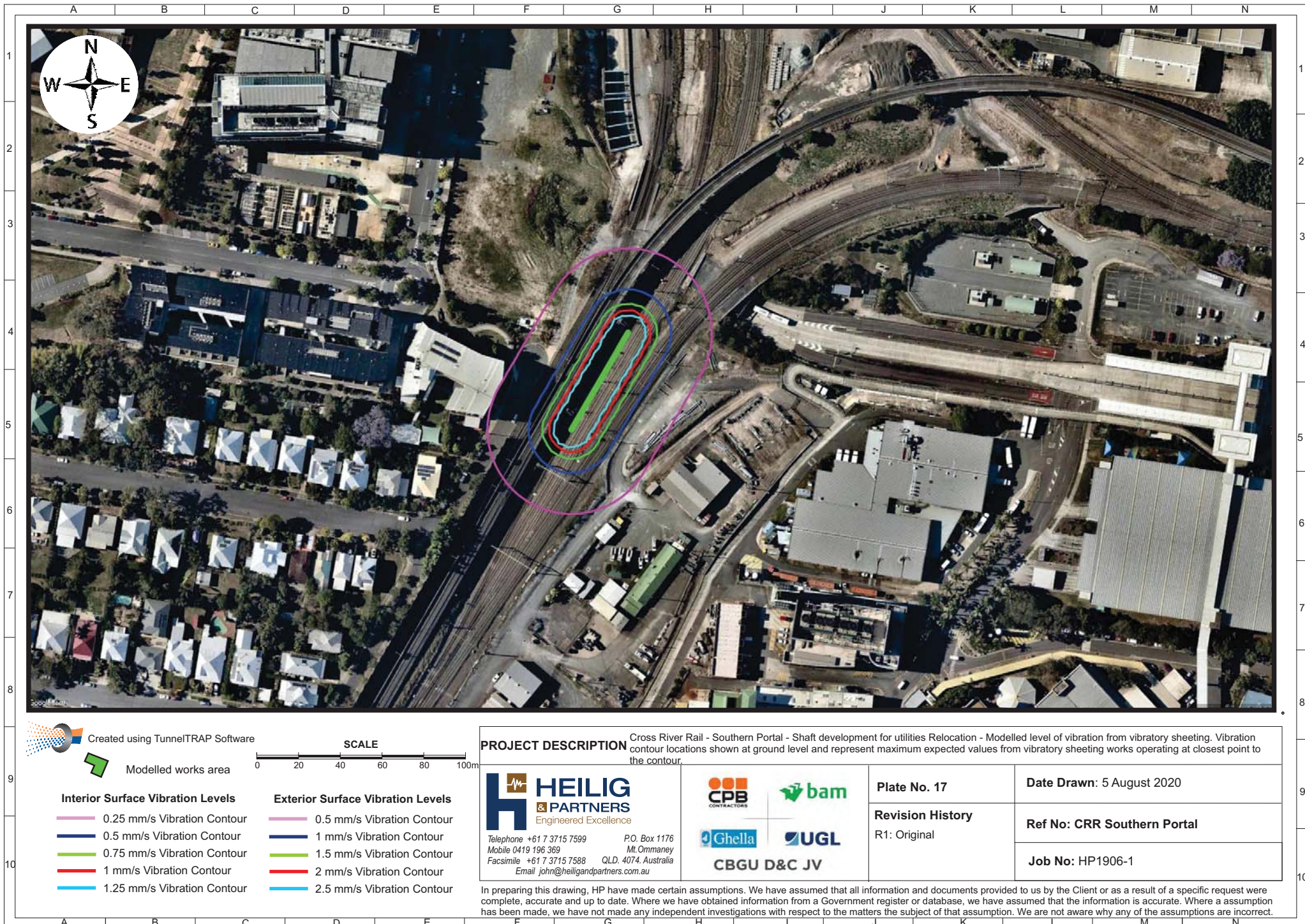
Cross River Rail - Southern Portal - Modelled level of vibration from 900mm bored piers. Vibration contour locations shown at ground level and represent maximum expected values from piling works operating at closest point to the contour.

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Plate No. 16	Date Drawn: 5 August 2020
Revision History R1: Original	Ref No: CRR Southern Portal
	Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 1 - Modelled level of regenerated noise from a 8 tonne excavator. Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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Plate No. 1	Date Drawn: 5 August 2020
Revision History	Ref No: CRR Southern Portal
R1: Original	Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 1 - Modelled level of regenerated noise from a 40 tonne excavator. Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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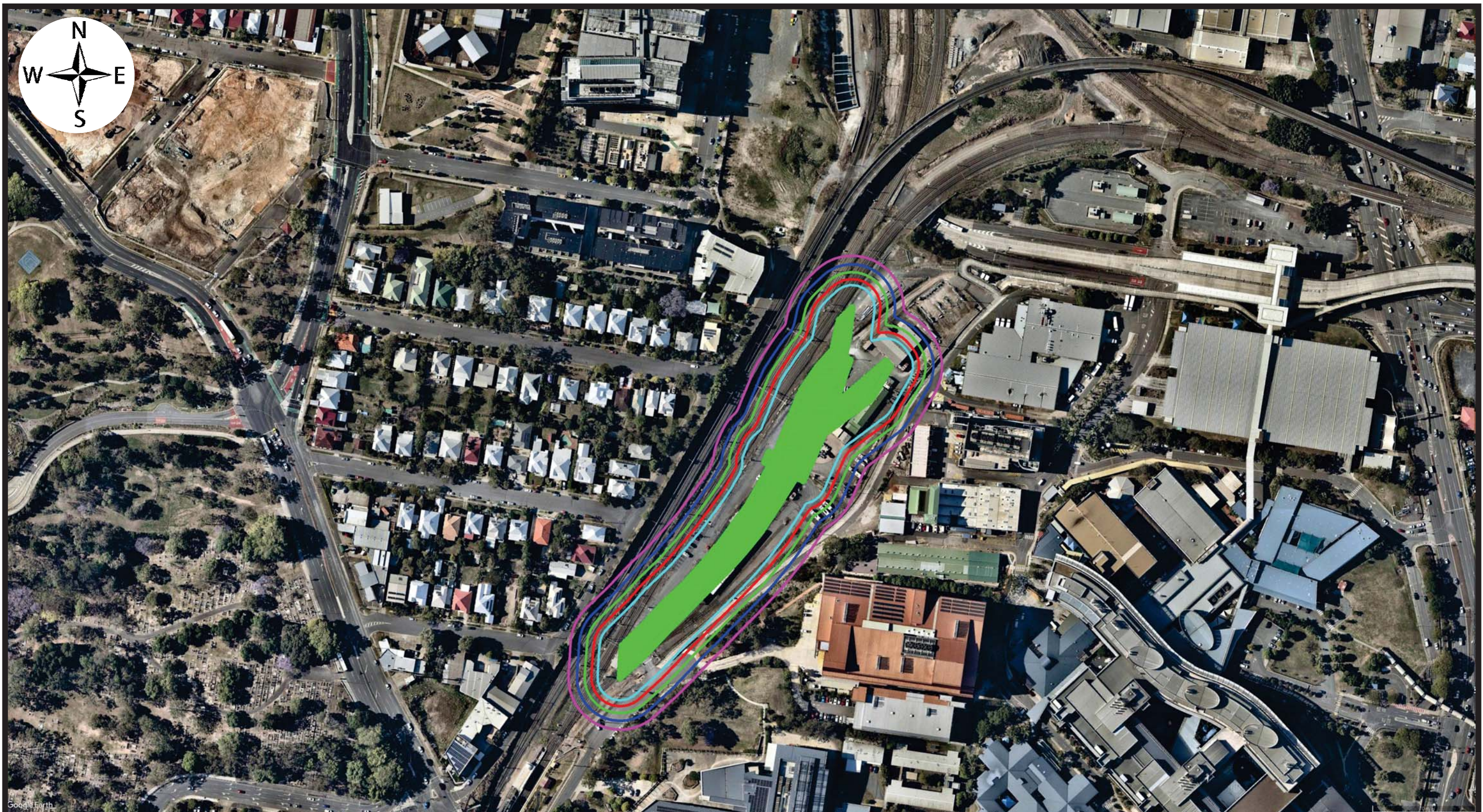
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Plate No. 2	Date Drawn: 5 August 2020
Revision History R1: Original	Ref No: CRR Southern Portal
	Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 1 - Modelled level of regenerated noise from a 8 tonne excavator with a 500kg hydraulic hammer (CATH75 or equivalent). Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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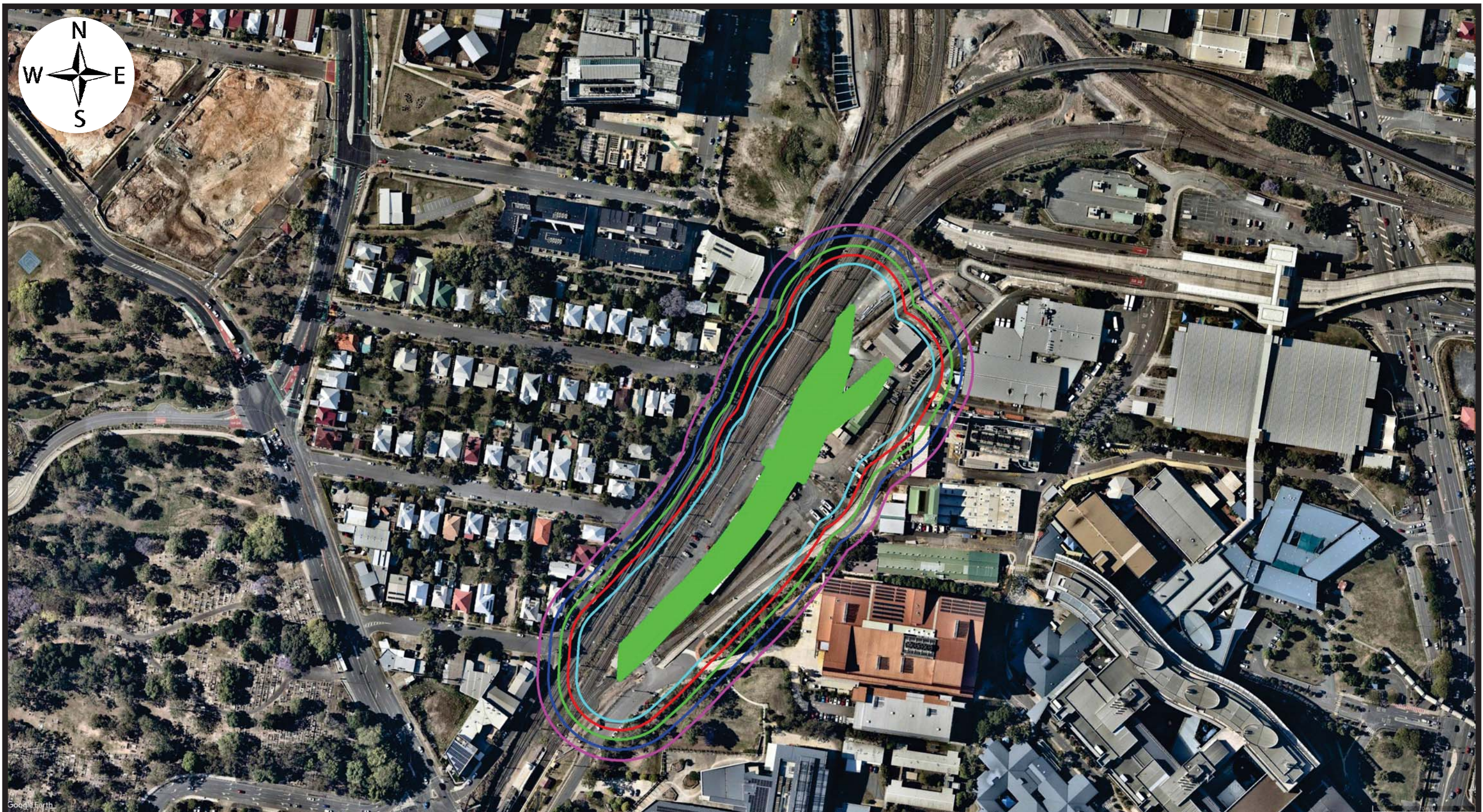
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Plate No. 3	Date Drawn: 5 August 2020
Revision History R1: Original	Ref No: CRR Southern Portal
	Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 1 - Modelled level of regenerated noise from a 40 tonne excavator with 3300kg hydraulic hammer (CATH160 or equivalent). Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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Plate No. 4

Revision History

R1: Original

Date Drawn: 5 August 2020

Ref No: CRR Southern Portal

Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 2 - Modelled level of regenerated noise from a 8 tonne excavator. Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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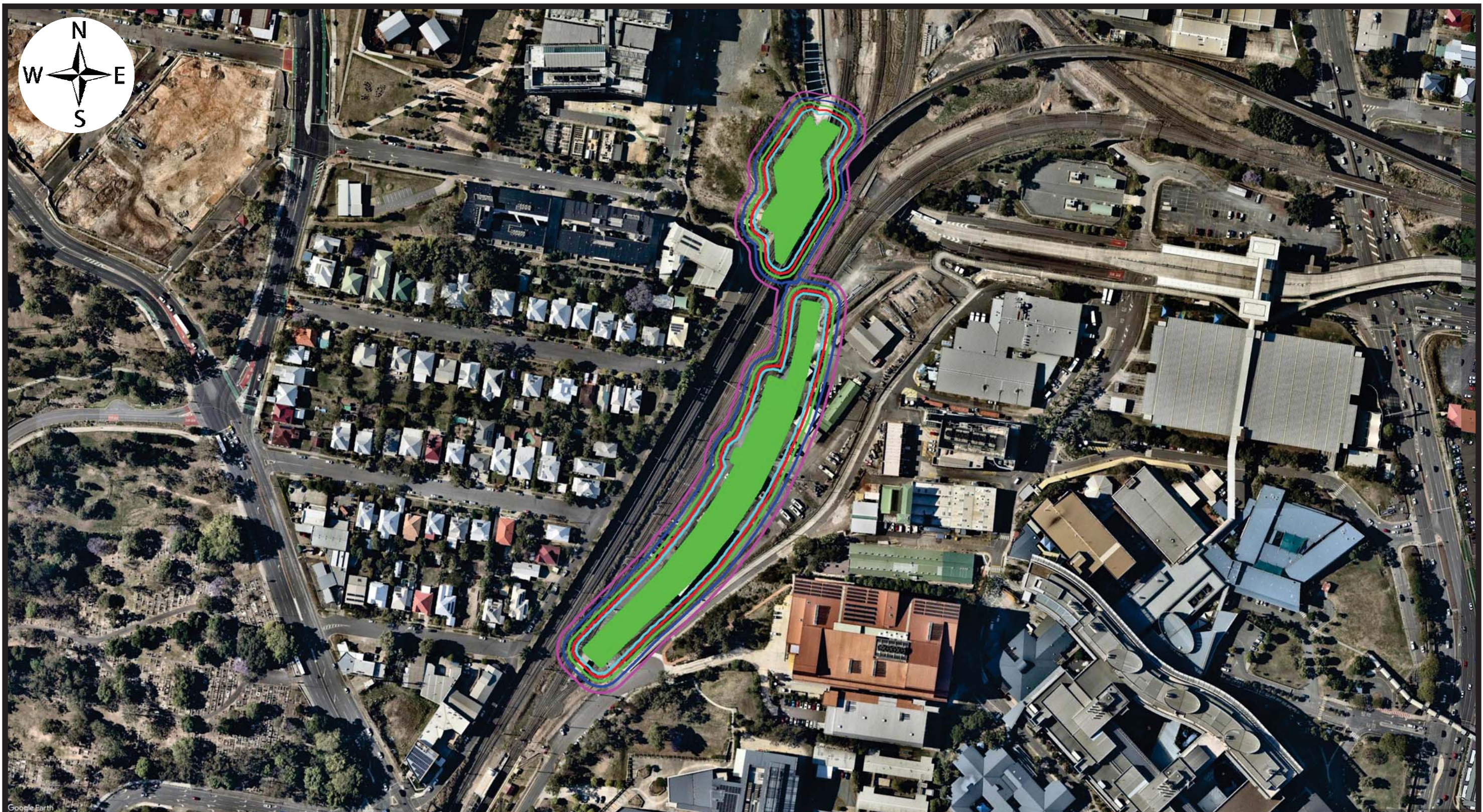
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Plate No. 5	Date Drawn: 10 September 2020
Revision History R1: Original R2: Revised Modelling	Ref No: CRR Southern Portal
	Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 2 - Modelled level of regenerated noise from a 40 tonne excavator. Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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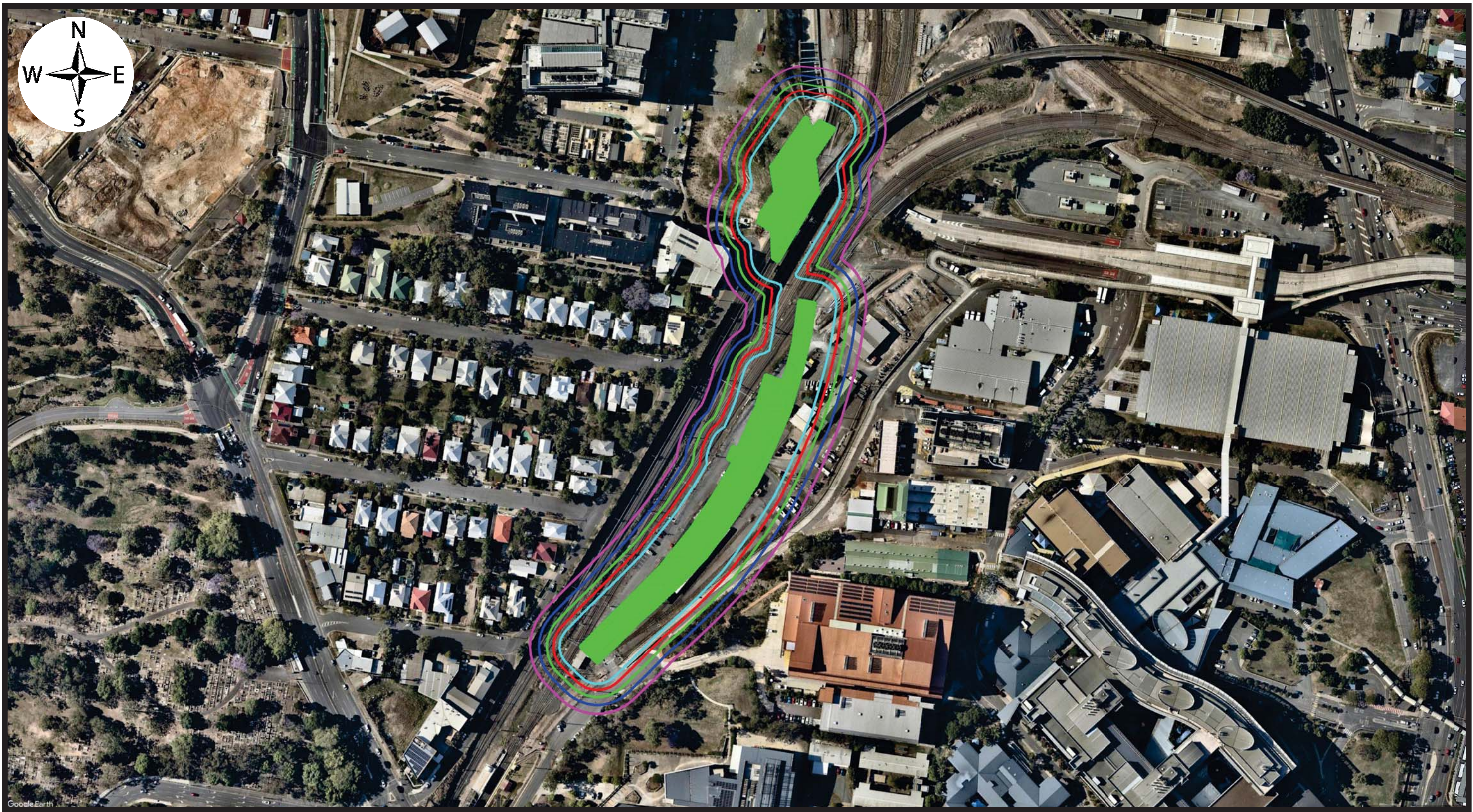
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Plate No. 6	Date Drawn: 10 September 2020
Revision History R1: Original R2: Revised Modelling	Ref No: CRR Southern Portal
	Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 2 - Modelled level of regenerated noise from a 8 tonne excavator with 500kg hydraulic hammer (CATH75 or equivalent). Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



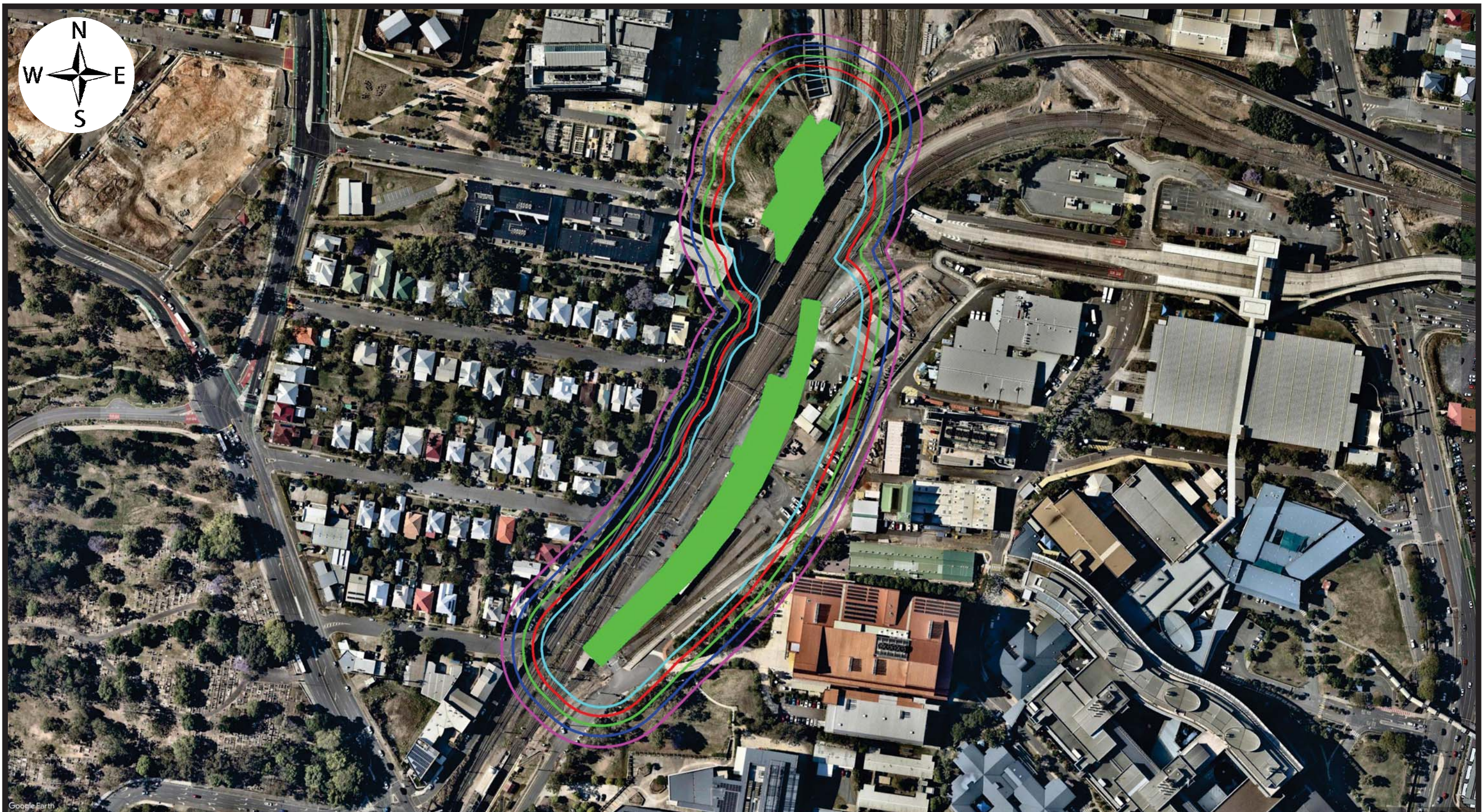
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Plate No. 7	Date Drawn: 10 September 2020
Revision History R1: Original R2: Revised Modelling	Ref No: CRR Southern Portal
	Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 2 - Modelled level of regenerated noise from a 40 tonne excavator with 3300kg hydraulic hammer (CATH160 or equivalent). Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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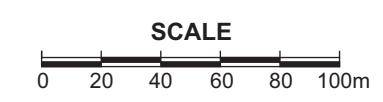
Plate No. 8	Date Drawn: 10 September 2020
Revision History	Ref No: CRR Southern Portal
R1: Original R2: Revised Modelling	Job No: HP1906-1

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Created using TunnelTRAP Software

 Modelled works area



PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 3 - Modelled level of regenerated noise from a 20 tonne excavator. Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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**CPB**
CONTRACTORS

**bam**

**Ghella**

**UGL**

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Plate No. 9

Revision History

R1: Original

Date Drawn: 5 August 2020

Ref No: CRR Southern Portal

Job No: HP1906-1

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 3 - Modelled level of regenerated noise from a 30 tonne excavator. Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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Plate No. 10	Date Drawn: 5 August 2020
Revision History R1: Original	Ref No: CRR Southern Portal
	Job No: HP1906-1

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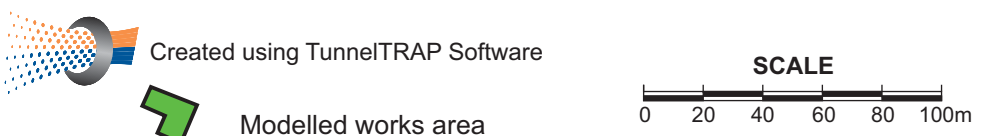
 Modelled works area

SCALE

0 20 40 60 80 100m

- Surface Regenerated Noise Levels**
- 35 dBA Regenerated Noise Contour
 - 40 dBA Regenerated Noise Contour
 - 45 dBA Regenerated Noise Contour
 - 50 dBA Regenerated Noise Contour
 - 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 3 - Modelled level of regenerated noise from a 30t tonne excavator with 1500kg hydraulic hammer (CAT H140 or equivalent). Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.			
 HEILIG & PARTNERS Engineered Excellence Telephone +61 7 3715 7599 P.O. Box 1176 Mobile 0419 196 369 Mt.Ommaney Facsimile +61 7 3715 7588 QLD. 4074. Australia Email john@heiligandpartners.com.au	    CBGU D&C JV	Plate No. 11 Revision History R1: Original	Date Drawn: 5 August 2020 Ref No: CRR Southern Portal Job No: HP1906-1
In preparing this drawing, HP have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request were complete, accurate and up to date. Where we have obtained information from a Government register or database, we have assumed that the information is accurate. Where a assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware why any of the assumptions are incorrect.			



- Surface Regenerated Noise Levels**
- 35 dBA Regenerated Noise Contour
 - 40 dBA Regenerated Noise Contour
 - 45 dBA Regenerated Noise Contour
 - 50 dBA Regenerated Noise Contour
 - 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 4 - Modelled level of regenerated noise from a 30 tonne excavator. Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.

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Plate No. 12

Revision History
R1: Original

Date Drawn: 5 August 2020

Ref No: CRR Southern Portal

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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 4 - Modelled level of regenerated noise from a 20 tonne excavator with a 1500kg hydraulic hammer (CATH120 or equivalent). Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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Plate No. 13

Revision History
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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 4 - Modelled level of regenerated noise from a 30 tonne excavator with a 1500kg hydraulic hammer (CATH140 or equivalent). Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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Plate No. 14

Revision History
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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION

Cross River Rail - Southern Portal - STAGE 5 - Modelled level of regenerated noise from a 30 tonne excavator. Regenerated noise contour locations shown at ground level and represent maximum expected values from excavator works operating at closest point to the contour.



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 Created using TunnelTRAP Software

 Modelled works area

SCALE

0 20 40 60 80 100m

Surface Regenerated Noise Levels

- 35 dBA Regenerated Noise Contour
- 40 dBA Regenerated Noise Contour
- 45 dBA Regenerated Noise Contour
- 50 dBA Regenerated Noise Contour
- 55 dBA Regenerated Noise Contour

PROJECT DESCRIPTION Cross River Rail - Southern Portal - STAGE 5 - Modelled level of regenerated noise from 900mm bored piers. Regenerated noise contour locations shown at ground level and represent maximum expected values from piling works operating at closest point to the contour.



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Attachment D: Technical Report - Traffic and Transport

Traffic Impact Assessment

Cross River Rail Southern Portal

QTT20037



Prepared for
CBGU

10 November 2020

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1 Introduction

Cardno has been commissioned by CBGU on behalf of the Cross River Rail Delivery Authority (CRRDA) to undertake a Traffic Impact Assessment (TIA) in relation to the proposed construction activities for the Cross River Rail Southern Portal project.

The purpose of this assessment is to evaluate the impact of the proposed Heavy Vehicle (HV) routes associated with construction activities. The assessment has been prepared with regards to road design, safety and traffic operations.

1.1 Context

The Southern Area of the Cross River Rail Project Tunnels and Stations Development (TSD) is where the Southern Portal for the Cross River Rail Tunnel is located. This area is bounded by the Princess Alexandra Hospital to the east and the existing Dutton Park Railway Station to the south, and is a congested rail corridor with multiple commuter rail lines servicing the Gold Coast and Cleveland regions along with freight rail lines to the Port of Brisbane. Furthermore, the Boggo Road Busway crossing passes underneath, and a grade separated freight flyover crossing above the rail corridor and whole Southern Portal is bounded and intersected by utilities (power, stormwater and sewer).

Since Request for Project Change (RfPC) #4 submission, further detailed planning has been undertaken on the Southern Area worksite. The planning considered the level of congestion within the rail corridor, including multiple commuter rail lines servicing the Gold Coast and Cleveland regions along with freight rail lines to the Port of Brisbane, the Boggo Road Busway that passes underneath the rail corridor and a grade separated rail freight flyover crossing above the rail corridor. These key features were then overlaid with the multiple intersections with utilities (power, stormwater and sewer) which need to be upgraded and / or relocated throughout the various stages of the work. Given the complexity of this area, the Project faced a number of technical challenges, particularly with rail alignment, rail geometry and utility constraints. The design has now been further developed to resolve these various technical issues.

1.2 References

The following documents have been referred to in preparing this assessment:

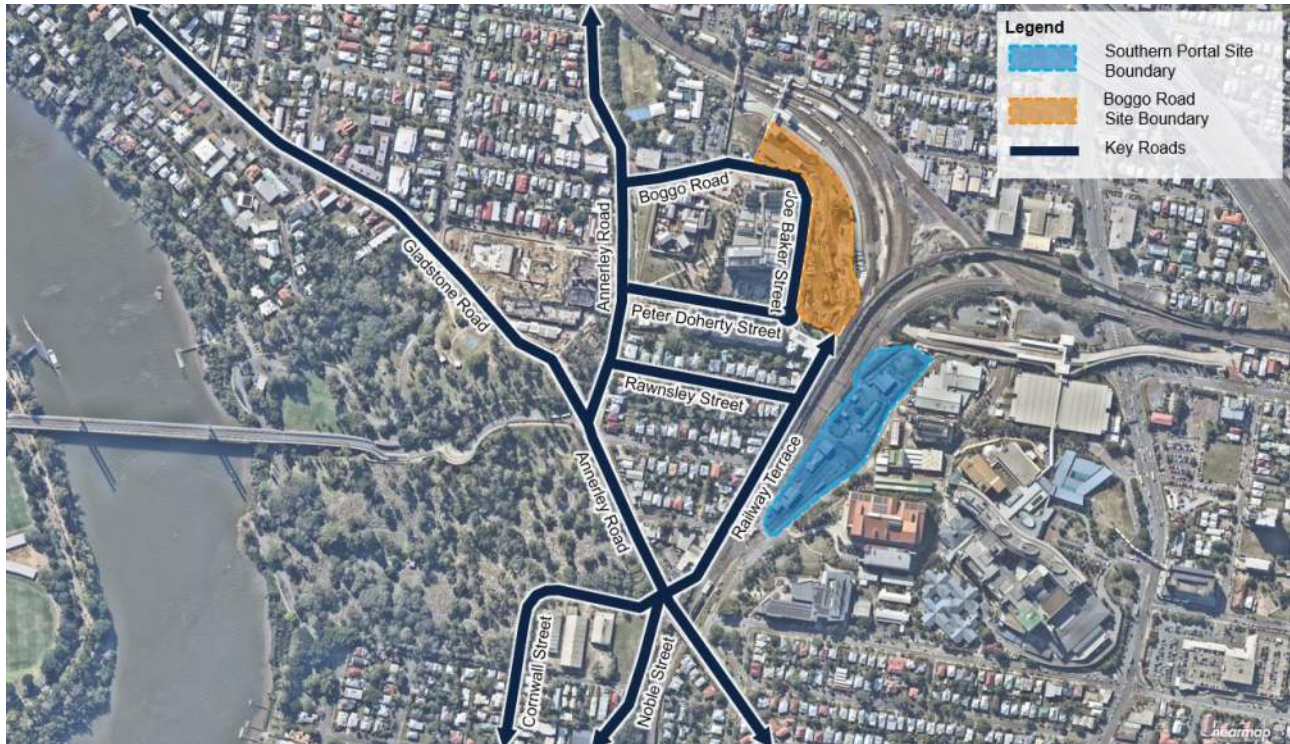
- > Australian Standard 2890.1 Parking Facilities: Off-street parking
- > Austroads Guide to Road Design, Part 4A: Unsignalised and Signalised Intersections
- > Austroads Guide to Road Safety Part 6: Managing Road Safety Audits
- > Austroads Guide to Road Safety Part 6A: Implementing Road Safety Audits
- > Brisbane City Council City Plan 2014 Interactive Mapping (2020)
- > Department of Transport and Main Road Guidelines for Assessment of Road Impacts of Development
- > Department of Transport and Main Road Guide to Traffic Impact Assessments
- > Queensland Government Queensland Globe (2020)

2 Existing Situation

2.1 Site Location

The location of the site and the surrounding road network is illustrated on Figure 2-1.

Figure 2-1 Site Location



Source: Nearmap

2.2 Existing Road Network

2.2.1 Road Hierarchy

In accordance with Brisbane City Council's road hierarchy mapping, the road classification for each of the study roads is outlined in Table 2-1.

Table 2-1 Road Hierarchy

Road Names	Road Hierarchy
Annerley Road	Arterial road
Boggo Road	Neighbourhood road
Peter Doherty Street	Neighbourhood road
Joe Baker Street	Neighbourhood road
Rawnsley Street	Neighbourhood road
Cornwall Street	Arterial road
Noble Street	Arterial road
Railway Terrace	Neighbourhood road

Figure 2-2 illustrates the road hierarchy in context with the site.

Figure 2-2 Road Hierarchy

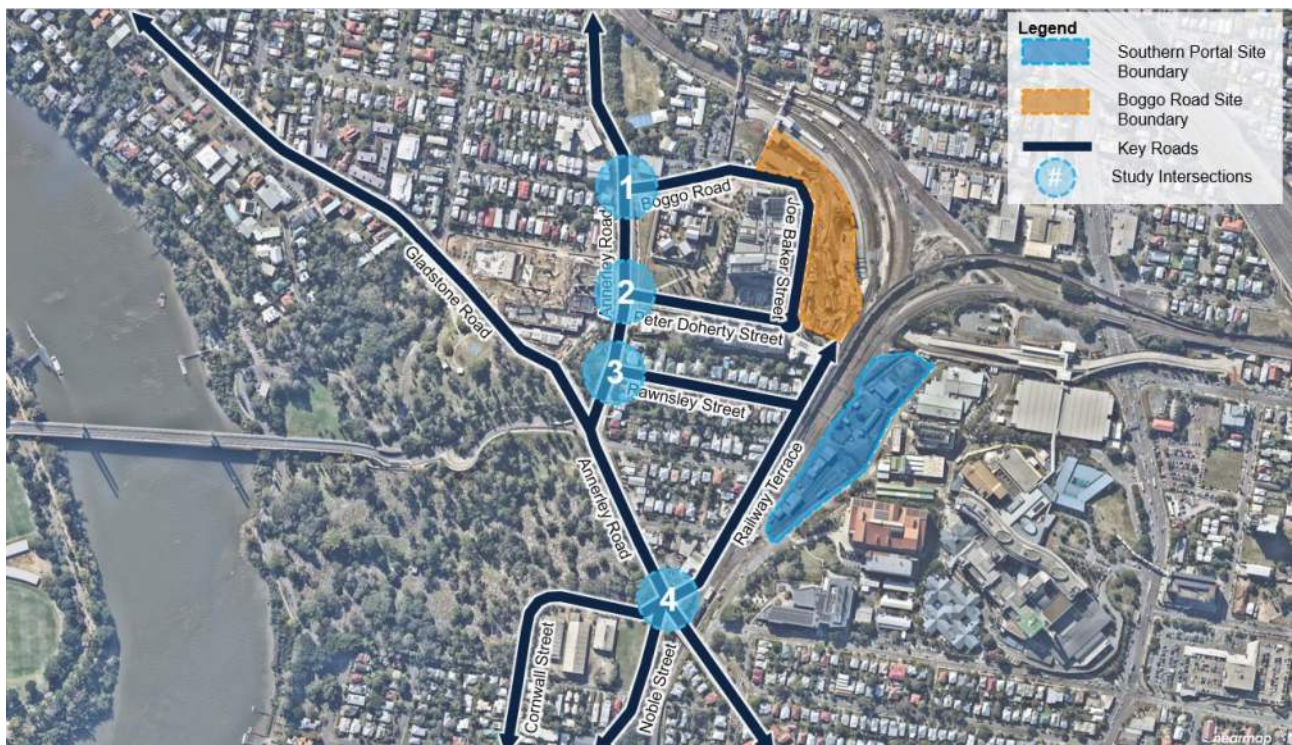


Source: Nearmap

2.2.2 Key Intersections

Four key intersections have been include in this assessment. Figure 2-3 illustrates the locations of these intersections while Table 2-2 provides a summary of each intersection in its existing form.

Figure 2-3 Key Intersections



Source: Nearmap

Table 2-2 Existing Intersections

ID	Intersections	Existing Intersection Form	Comment
1	Annerley Road / Boggo Road		▪ Signalised three way intersection with on-road cycle lanes along Annerley Road
2	Annerley Road / Peter Doherty Street		▪ Signalised three way intersection with on-road cycle lanes along Annerley Road ▪ Right turn into Peter Doherty Street is not permitted
3	Annerley Road / Rawnsley Street		▪ Unsignalised three way intersection with on-road cycle lanes along Annerley Road
4	Annerley Road / Cornwall Street / Noble Street / Railway Terrace		▪ Signalised five way intersection with no on-road cycle lanes ▪ Cornwall Street is one way only, entering into the intersection ▪ Railway Terrace is one way only, exiting from the intersection ▪ Noble Street is one way only, exiting from the intersection

Image source: Nearmap

2.2.3 Heavy Vehicle Routes

Following review of the heavy vehicle route restrictions outlined in Queensland Globe mapping system, vehicles larger than 19m AV are not permitted to use the study roads.

3 Proposed Development

3.1 Site Access

Four site access locations were indicated for the site. These have been summarised in Table 3-1 and the locations of each access illustrated on Figure 3-1.

Table 3-1 Access Locations

Access	Location	Movements
A	Boggo Road	Entry only
B	Joe Baker Street	Entry and exit
C	Peter Doherty Street	Entry and exit
D	Railway Terrace	Entry and exit

Figure 3-1 Access Locations



Source: Nearmap

4 Options Assessment

4.1 Options for Review

Cardno undertook a swept path analysis of four potential access options for the project. These options are as follows:

- > **Option 1** Construction vehicle access and egress via Peter Doherty Street (intersection upgrade)
- > **Option 2** Construction vehicles access and egress via Peter Doherty Street (left in left out) via Stanley Street and Annerley Road
- > **Option 3** Construction vehicles access and egress via Boggo Road and egress via Peter Doherty Street
- > **Option 4** Construction vehicles access via Railway Terrace (via Stanley Street, Annerley Road, Rawnsley Street) egress via Railway Terrace (Dutton Street and Annerley Road)

The design vehicle for this assessment was a 19m Articulated Vehicle (AV) and a 19m Truck and Dog. The 19m AV has the wider turning path (the 19m Truck and Dog is more manoeuvrable) and therefore this was used as the worst case design vehicle for all swept path assessment.

The swept paths prepared for this review are enclosed at **Appendix A**.

4.1.1 Option 1

The first option utilises access from the south of Peter Doherty Street for both entry and exit. Both access points have clear design requirements with no alternatives required. Figure 4-1 illustrates the route option.

Figure 4-1 Option 1 Route

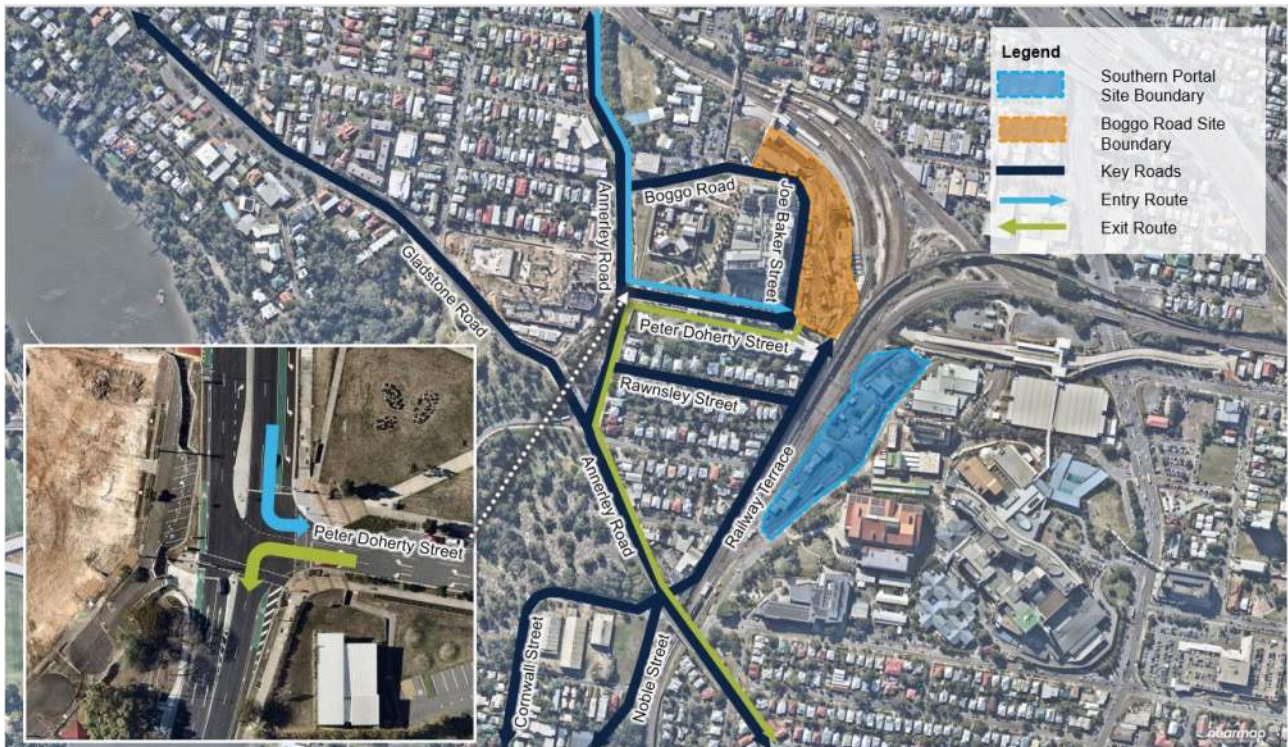


Source: Nearmap

4.1.2 Option 2

The second option utilises access from the north of Peter Doherty Street for entry and south of Peter Doherty Street for exit. Figure 4-2 illustrates the route option.

Figure 4-2 Option 2 Route



Source: Nearmap

4.1.3 Option 3

The third option utilises access from the south of Boggo Road for entry and south of Peter Doherty Street for exit. Figure 4-3 illustrates this route option. It is noted that this is the current access route for the Boggo Road worksite.

Figure 4-3 Option 3 Route

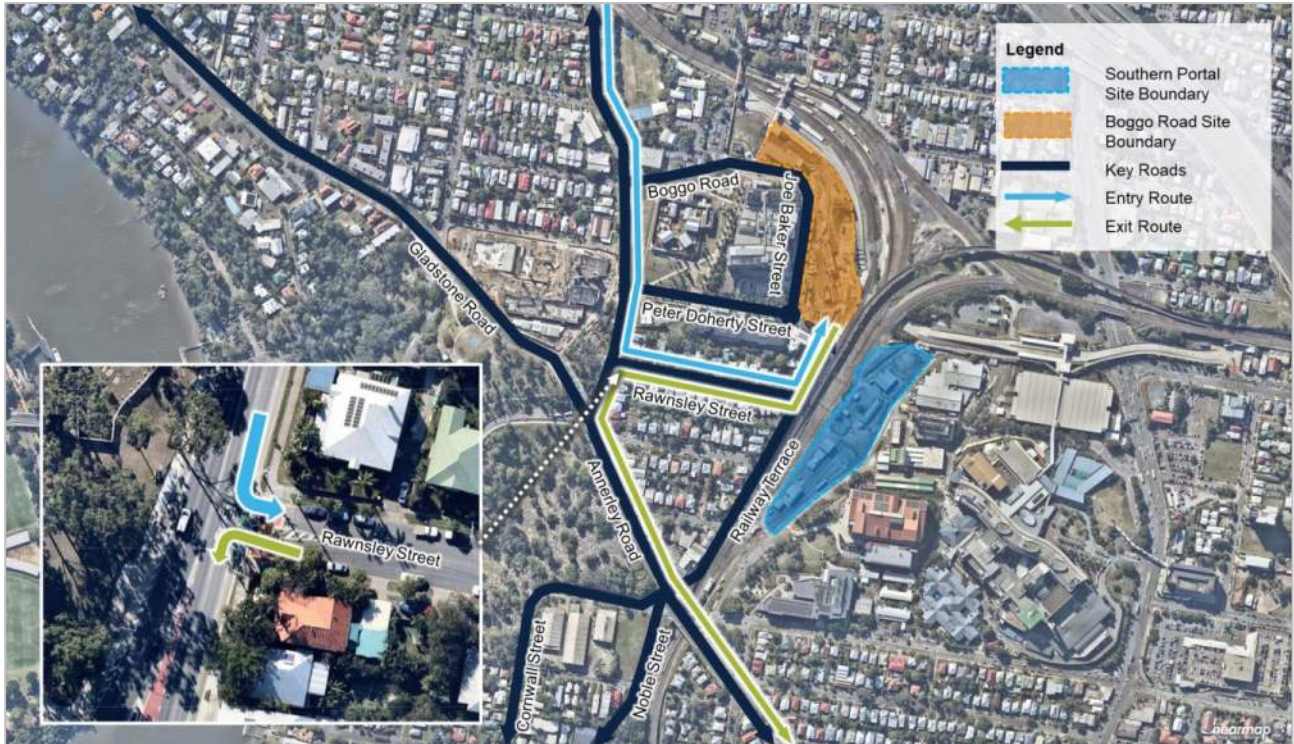


Source: Nearmap

4.1.4 Option 4

The fourth option utilises access from the south of Railway Terrace for both entry and exit. To gain access to Railway Terrace, the local roads consisting of Rawnsley Street, Dutton Street and Pound Street were all assessed. Figure 4-4 illustrates the route option using Rawnsley Street as an example.

Figure 4-4 Option 4 Route



Source: Nearmap

4.2 Design Review

An initial review of the options was undertaken from a design perspective to understand the extent of road modifications required to implement each option. The concept drawings prepared for the review are attached at **Appendix A**. Following this initial review, short listed options were determined and refined further to better understand the impacts of each option.

4.2.1 Option 1

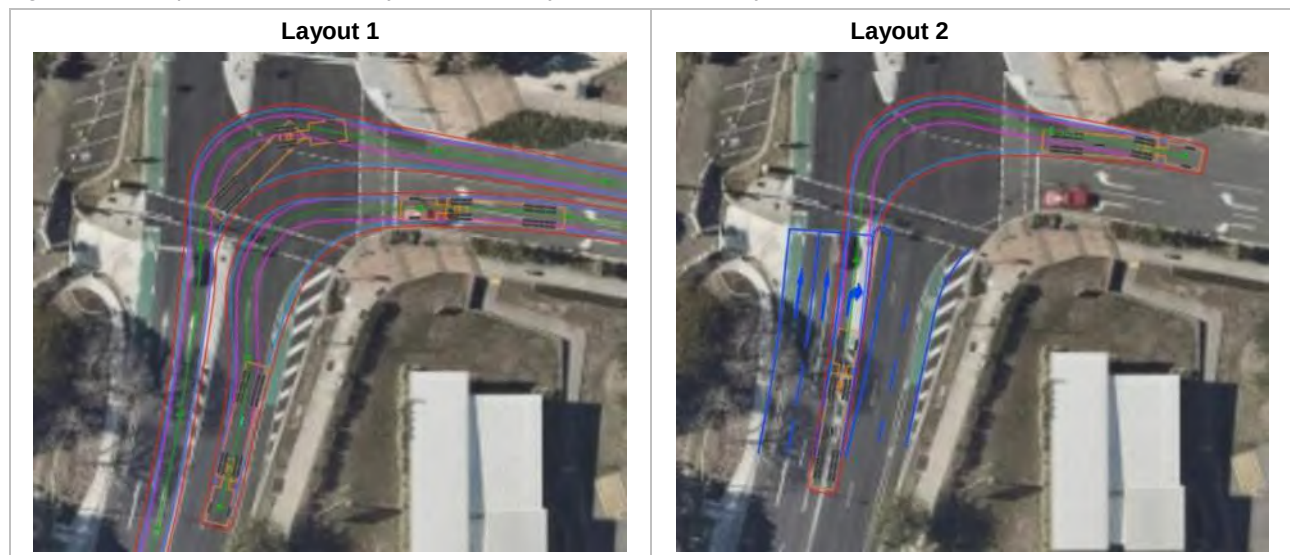
For Option 1, which requires the addition of a right turn movement on Annerley Road southern approach, the intersection form will need to be amended to include this movement.

Two layouts have been analysed for the addition of right turn lanes, the first being the right turn shared with the through lane, and the second being provision of a dedicated right turn lane.

For the second layout, a right turn lane concept was prepared for the Peter Doherty Street / Annerley Road intersection to consider a temporary right turn lane on the southern approach. Initially, this concept removed the existing cycle lanes to accommodate the right turn lane which may not be supported as it is detrimental to existing active transport provisions. It is noted that since this initial concept was prepared, the design has been developed to retain the bicycle lanes. The revised concept is reviewed in Section 6.

Figure 4-5 illustrates the two layouts assessed for the option.

Figure 4-5 Option 1 – Assessed Layouts for Annerley Road / Peter Doherty Street



Source: Nearmap

Table 4-1 outlines a summary of initial design review outcomes.

Table 4-1 Option 1 – Design Review Summary

Access	Street	Entry / Exit	Drawing No.	Advantages / Disadvantages
C	Peter Doherty Street	Entry	QTT20037-SK01-A	No civil works required to accommodate design vehicle swept path Phasing plan requires investigation to incorporate right turn
C	Peter Doherty Street	Exit	QTT20037-SK01-A	No changes to infrastructure required
B	Peter Doherty Street	Entry	QTT20037-SK02-A	If internal manoeuvring within the site requires vehicles to use access B on Joe Baker Street, then the existing roundabout median requires modification on the eastern approach Peter Doherty Street / Site Access intersection Traffic management required to allow for AV to travel northbound on Joe Baker Street
B / C	Peter Doherty Street	Entry	QTT20037-SK14-A	Dedicated right turn lane at the Peter Doherty Street / Annerley Road intersection Significant works required to remove existing cycle lanes and provide right turn lane – <i>Note that this change is no longer pursued</i> Reduced active transport connectivity along priority active transport route - <i>Note that the revised option does not remove the cycle lane</i> Easier incorporation of right turn into signal phasing plan

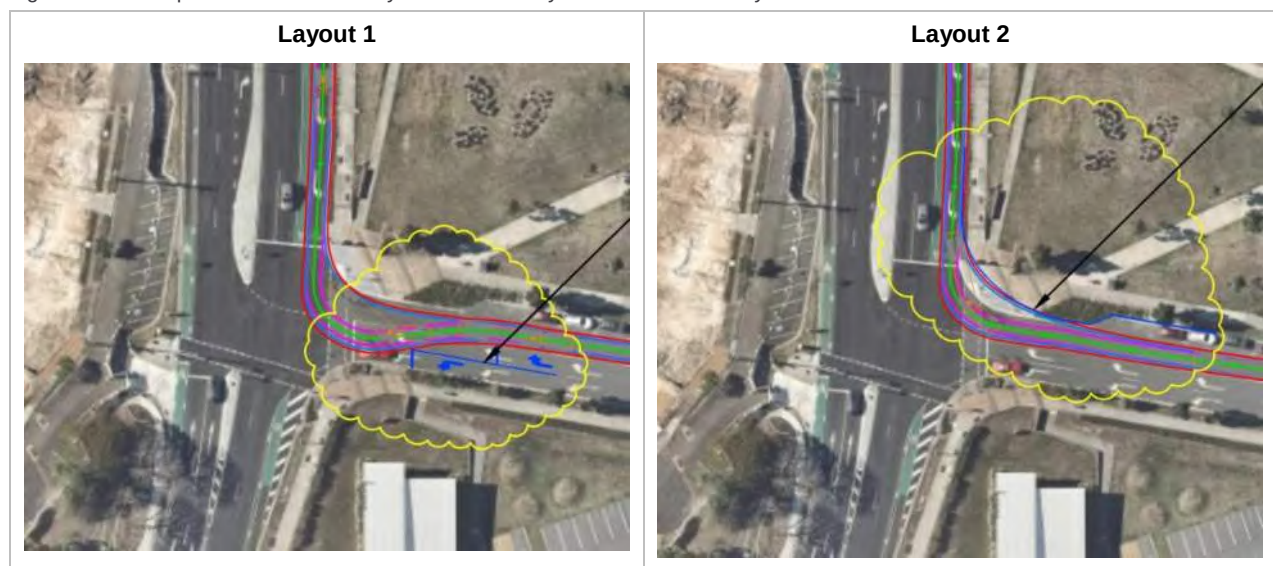
4.2.2 Option 2

The entry manoeuvre from Annerley Road north required a left turn manoeuvre to be undertaken by the 19m AV which is not able to be accommodated by existing infrastructure. Two alternatives were prepared for consideration.

The first alternative focused on moving line marking to accommodate the 19m AV while not impacting on the existing kerb. With this option, signal poles will need to be relocated. The second alternative did the opposite and required kerb amendments without impacting any of the existing line marking.

Figure 4-6 illustrates the two layouts assessed for the option.

Figure 4-6 Option 2 – Assessed Layouts for Annerley Road / Peter Doherty Street



Source: Nearmap

Table 4-2 outlines a summary of design review outcomes.

Table 4-2 Option 2 – Design Review Summary

Access	Street	Entry / Exit	Drawing No.	Advantages / Disadvantages
C	Peter Doherty Street	Entry – layout 1	QTT20037-SK03-A	Relocation of line marking on the eastern approach of Peter Doherty Street / Annerley Road intersection The relocation of line marking requires additional green time for traffic on the eastern approach to undertake movement and will also require relocation of signal poles to meet design requirements
C	Peter Doherty Street	Entry – layout 2	QTT20037-SK03-A	Modification of kerb required on the eastern approach of Peter Doherty Street / Annerley Road intersection The modification of kerb requires the relocation of existing signal poles No modification required to existing phasing plan, although the pedestrian crossing times will need to be revised to account for the increased crossing distance
B	Peter Doherty Street	Entry – layout 1	QTT20037-SK04-A	If internal manoeuvring within the site requires vehicles to access the access point half way up Joe Baker Street, then the existing roundabout median requires modification on the eastern approach Peter Doherty Street / Site Access roundabout Traffic management required to allow for AV to travel northbound on Joe Baker Street Relocation of line marking on the eastern approach of Peter Doherty Street / Annerley Road intersection The relocation of line marking requires additional green time for traffic on the eastern approach to undertake movement.
B	Peter Doherty Street	Entry – layout 2	QTT20037-SK04-A	If internal manoeuvring within the site requires vehicles to access the access point half way up Joe Baker Street, then the existing roundabout median requires modification on the eastern approach Peter Doherty Street / Site Access intersection Traffic management required to allow for AV to travel northbound on Joe Barker Street Modification of kerb required on the eastern approach of Peter Doherty Street / Annerley Road intersection The modification of kerb requires the relocation of existing signal poles No modification required to existing phasing plan

4.2.3 Option 3

Option 3 involves construction vehicles turning right into Boggo Road to enter the site and exit the site via Peter Doherty Street. The exit path has been assessed as part of Option 1 and 2. No physical changes are required for this option. The route is shown on Figure 4-7.

Figure 4-7 Option 3



Source: Nearmap

Table 4-3 outlines a summary of design review outcomes.

Table 4-3 Option 3 – Design Review Summary

Access	Street	Entry / Exit	Drawing No.	Advantages / Disadvantages
B	Boggo Road	Entry	QTT20037-SK05-A	No changes to infrastructure required No modification required to existing phasing plan
A	Boggo Road	Entry	QTT20037-SK06-A	No changes to infrastructure required No modification required to existing phasing plan

4.2.4 Option 4

Option 4 involves construction vehicles accessing the site via Railway Terrace, using access D. Entry was assessed via three different local street, Rawnsley Street, Dutton Street and Pound Street. The Rawnsley Street entry manoeuvre has clear design requirements with traffic management / control required when turning onto Railway Terrace. Figure 4-8 illustrates the Rawnsley Street route option.

Figure 4-8 Option 4 – Rawnsley Street Route



Source: Nearmap

The Dutton Street exit manoeuvre has clear design requirements kerb modification required for the left turn onto Annerley Road. This is to ensure the left turn onto Annerley Road does not impact any traffic turn left onto Dutton Street and the existing median on Annerley Road is not impacted. Figure 4-9 illustrates the Dutton Street route option.

Figure 4-9 Option 4 –Dutton Street Route



Source: Nearmap

The Pound Street entry manoeuvre has clear design requirements and does not impact on any existing medians as the Annerley Road / Pound Street intersection has a painted median. However, the exit manoeuvre on Pound Street has two alternatives prepared for the left turn onto Annerley Road. The first alternative requires no amendments but the 19m Articulated Vehicle encroaches into three lanes of traffic. While the second option modifies the existing kerb to reduce the level of encroachment on the existing Annerley Road traffic lanes. Figure 4-10 illustrates the Pound Street route option.

Figure 4-10 Option 4 –Pound Street Route



Source: Nearmap

Table 4-4 outlines a summary of design review outcomes.

Table 4-4 Option 4 – Design Review Summary

Access	Street	Entry / Exit	Drawing No.	Advantages / Disadvantages
D	Rawnsley Street	Entry	QTT20037-SK07-A	Removal of median required on the eastern approach of the Rawnsley Street / Annerley Road intersection Parking restrictions required along Railway Terrace Traffic control / management required for design vehicles travelling into and out of Railway Terrace
D	Dutton Street	Exit	QTT20037-SK08-A	Modification of kerb required on the eastern approach of the Dutton Street / Annerley Road intersection Parking restrictions required along Railway Terrace

				Traffic control / management required for design vehicles travelling into and out of Railway Terrace
D	Pound Street	Entry	QTT20037-SK09-A	Existing kerbs and medians are maintained Parking restrictions required along Railway Terrace Traffic control / management required for design vehicles travelling into and out of Railway Terrace
D	Pound Street	Exit – layout 1	QTT20037-SK10-A	Existing kerbs and medians are maintained Exit manoeuvre encroaches into three traffic lanes Parking restrictions required along Railway Terrace Traffic control / management required for design vehicles travelling into and out of Railway Terrace
D	Pound Street	Exit – layout 2	QTT20037-SK10-A	Modification of kerb required on the eastern approach of the Pound Street / Annerley Road intersection Parking restrictions required along Railway Terrace Traffic control / management required for design vehicles travelling into and out of Railway Terrace

4.3 Assessment Outcomes

An assessment of four access options was undertaken to determine design requirements for the project construction vehicles. Each of the four options required amendments to the existing road network to accommodate the anticipated construction vehicles with the exception of Option 3.

Two layouts were prepared for **Option 1** to accommodate the new right turn movement into Peter Doherty Street. The first option (providing the right turn movement as a shared movement with the through lane) would not involve any intersection modifications at the Annerley Road / Peter Doherty Street intersection. However, operational efficiency may be compromised due to the delays for northbound through vehicles on Annerley Road being blocked by the right turning traffic. This could be mitigated by the second option (providing a dedicated right turn lane on the southern approach) however this would require physical modifications to the Annerley Road / Peter Doherty Street intersection.

Option 2 does not utilise any local roads, similarly to Option 1 and 3, which limits the potential for noise complaints and does not require additional traffic control / management for construction vehicles entering / exiting the site. While some intersection modifications are required at the Annerley Road / Peter Doherty Street intersection, two alternatives were prepared. The first option (retaining the kerb and pulling back stop lines on Peter Doherty Street) would require modifications to the signal timing and relocation of signal poles to meet design requirements. The second option (redesigning the kerb while retaining the stop line positions on

Peter Doherty Street) would require signal poles to be relocated in order to accommodate the new kerb line, as well as revised pedestrian crossing times for the increased crossing distance.

Option 3 requires construction vehicles to enter the site via access A or B and exit via access C. The option is in line with driver expectations with the right turn from Annerley Road onto Boggo Road already a permitted movement as opposed to the existing Annerley Road / Peter Doherty Street intersection for access C. This route is already utilised for the Boggo Road site, with the traffic surveys identifying that between one and three heavy vehicles were recorded turning right into Boggo Road during the road peaks. It has been advised that up to 24 heavy vehicles and four concrete trucks per hour will be using this route to access the Boggo Road site. It is understood that this route will be impinged by the need for more capacity as the construction at the Southern Portal progresses which is constrained by the school lock out period currently imposed for heavy vehicles, and is not be a feasible option to proceed with.

Option 4 requires significant intersection modifications to the Rawnsley Street, Dutton Street and Pound Street intersections. With the use of local residential streets, there is a risk of noise complaints and issues from residents with regards to safety. Furthermore, traffic control / management is required for construction vehicles manoeuvring into and out of Railway Terrace. Further investigation, and liaison with CBGU, has identified that Pound St will have a utilities trench along its length. This will restrict the operating width of the street and the ability to run two way heavy vehicles along it and therefore access will not work. This is the same along Railway Terrace, which has a utility trench at the entry to site and therefore access will not be viable using this option.

5 Short Listed Options

Based on the above assessment, the following options have been short listed for further investigation:

- > **Option 1** Construction vehicle access and egress via Peter Doherty Street (intersection upgrade)
- > **Option 2** Construction vehicles access and egress via Peter Doherty Street (left in left out) via Stanley Street and Annerley Road

The following sections outline the operational and safety reviews associated for these two options. With regards to safety, a road safety assessment has been prepared to understand the risks arising from each option. These risks focus on road users, including pedestrians and cyclists.

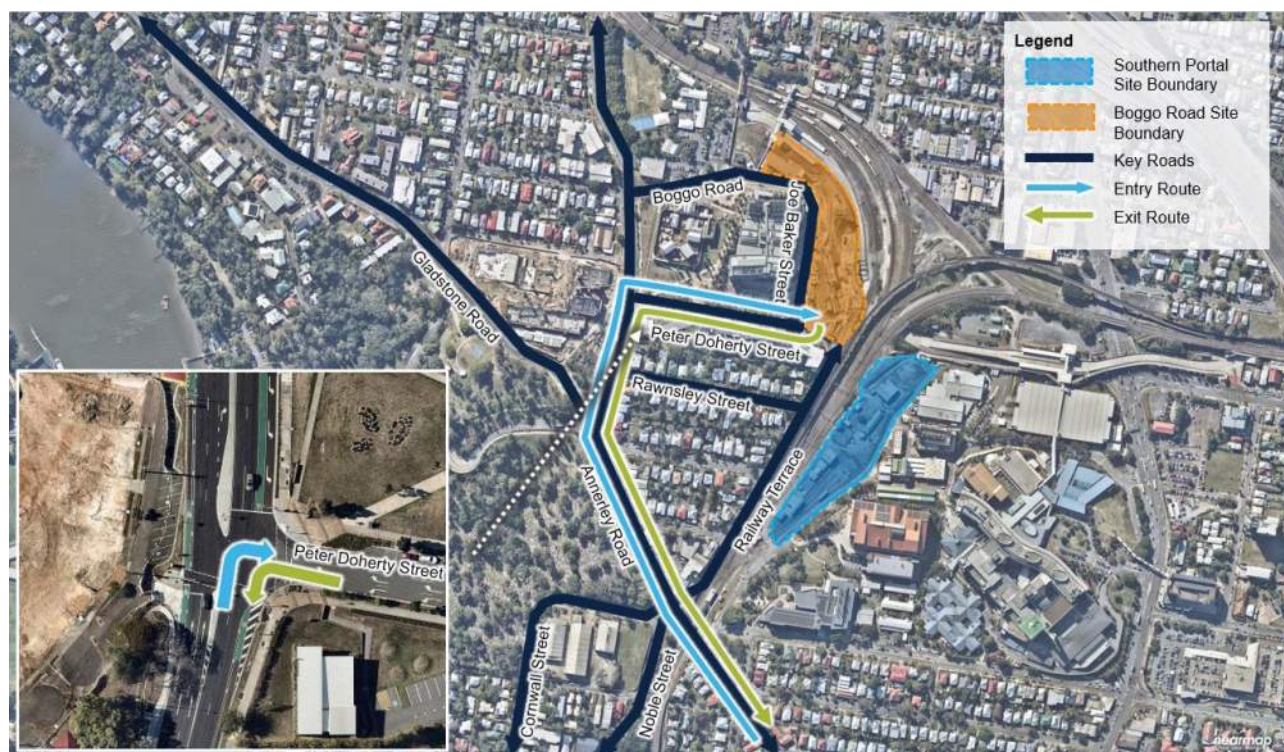
Following the road safety assessment, proposed mitigation measures were identified to respond to the identified risks. These have been incorporated into updated concept drawings, which have been assessed in the following Section 6 and 7.

In terms of the operational assessment, detailed traffic analysis has been undertaken using SIDRA to understand the network efficiency impacts from these changes.

5.1 Option 1

Figure 5-1 illustrates the routes assessed for Option 1.

Figure 5-1 Option 1 Route



Source: Nearmap

Two different layout options were prepared for the Annerley Road / Peter Doherty Street intersection, to understand the impacts of providing the additional right turn movement into Peter Doherty Street. Figure 5-2 presents layout 1 version where the right turn is added to the through lane, to make it a shared lane.

Figure 5-3 presents layout 2 where a dedicated right turn lane is provided. Amendments have been made to this layout to retain the cycle facilities along Annerley Road. This option requires significant civil works will be required to accommodate the additional lane, including demolition and reconstruction of the Annerley Road medians, relocation of signal infrastructure and kerb amendments.

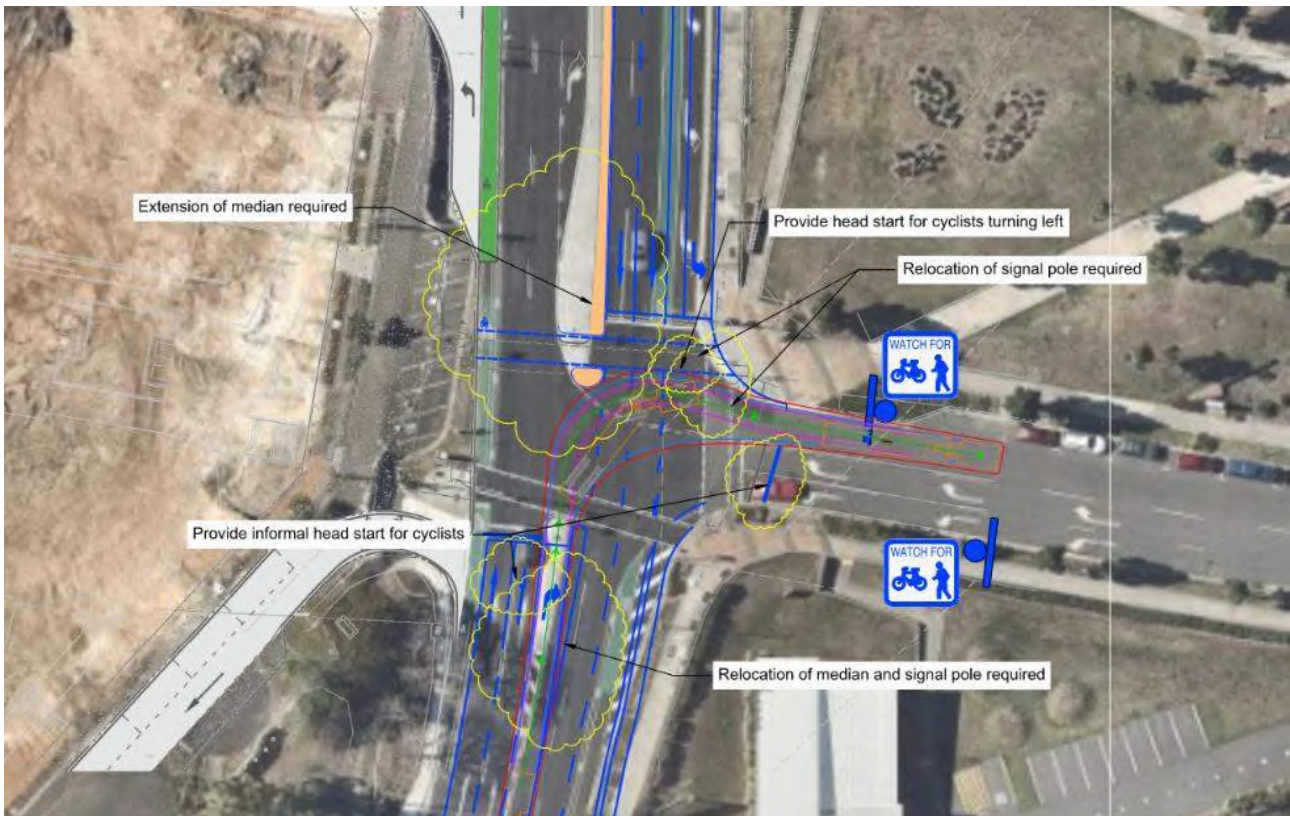
It is noted that signage will be required to indicate to drivers that the right turn movement is for construction vehicles only.

Figure 5-2 Option 1 – Layout 1 for Annerley Road / Peter Doherty Street



Source: Nearmap

Figure 5-3 Option 1 – Layout 2 for Annerley Road / Peter Doherty Street

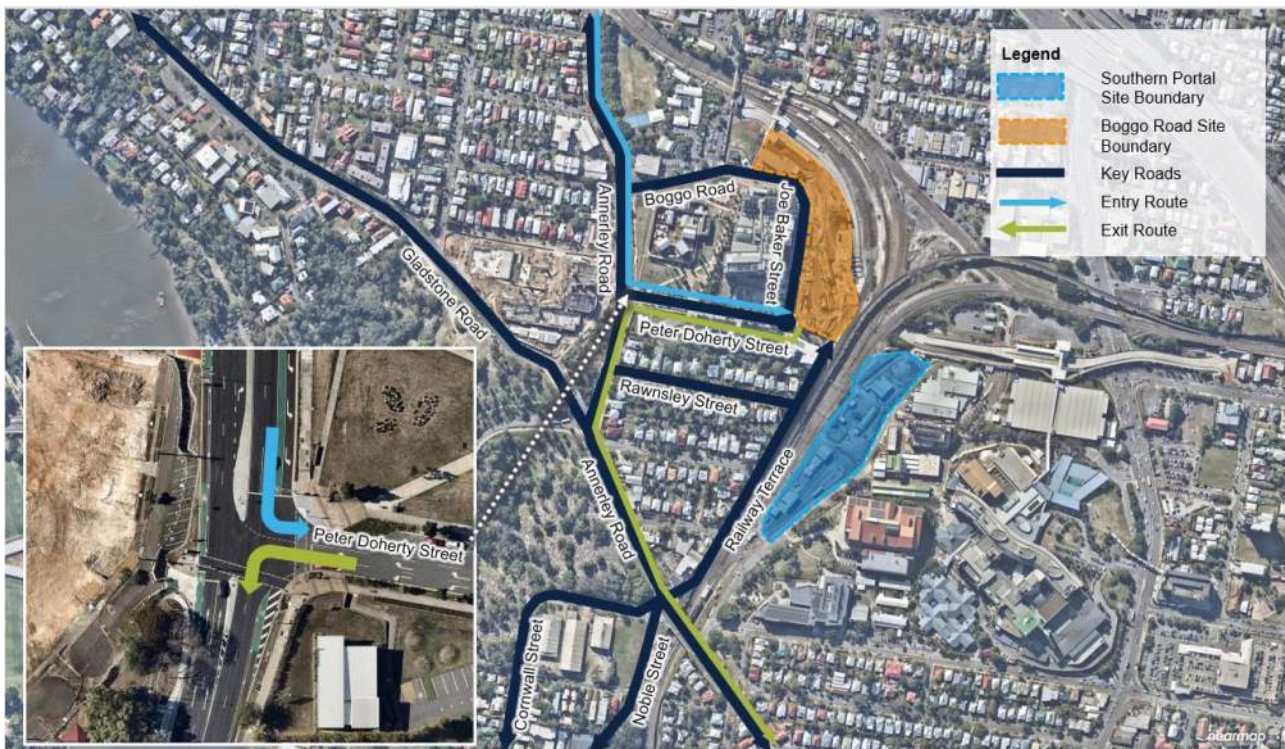


Source: Nearmap

5.2 Option 2

Figure 5-4 illustrates the routes assessed for Option 2.

Figure 5-4 Option 2 Route



Source: Nearmap

Two different layout options were prepared for the Annerley Road / Peter Doherty Street intersection, to understand the impacts of allowing construction vehicles to turn left into Peter Doherty Street.

Figure 5-5 presents layout 1 version where the kerb at the north-eastern corner of the intersection is retained. This impacts on the lanes at Peter Doherty Street, which would need to have the stop lines relocated to avoid collisions between vehicles.

Figure 5-6 presents layout 2 where the kerb at the north-eastern corner is amended to accommodate the left turn manoeuvre. This allows the Peter Doherty Street approach to be unaffected. This shows that civil works will be required to accommodate the turn movement, including demolition and reconstruction of the kerb and relocation of signal infrastructure.

Figure 5-5 Option 2 – Layout 1 for Annerley Road / Peter Doherty Street



Source: Nearthmap

Figure 5-6 Option 2 – Layout 2 for Annerley Road / Peter Doherty Street



Source: Nearthmap

6 Safety Review

6.1 Road Safety Review Overview

The Cardno Road Safety team has been commissioned by the CBGU Joint Venture to undertake a Road Safety Review in accordance to current guidelines for conducting road safety audits on the preliminary design for the proposed construction vehicles access to the Cross River Rail Southern Portal.

A road safety audit is a formal, systematic assessment of the potential road safety risks associated with, in this case, new intersection preliminary design, conducted by an independent qualified audit team. The assessment considers all road users and suggests measures to eliminate or mitigate any risks identified by the audit.

The Road Safety Audit has been undertaken in accordance with the requirements of Austroads' Guide to Road Safety Part 6: Managing Road Safety Audits – Edition 1.2 (February 2019) and Guide to Road Safety Part 6A: Implementing Road Safety Audits – Edition 1.2 (February 2019). The following sections identify the audit findings and recommendations.

All the findings described in Section 2.7 of this report are considered by the audit team to require action in order to improve the safety of the proposed project and to minimise the risk of crash occurrence and reduce potential crash severity.

The audit team has examined and reported only on the road safety implications of the project as presented and has not examined or verified the compliance of the design to any other criteria.

6.1.1 Safe System Findings

The aim of Safe System Findings is to focus the RSA process on considering safe speeds and by providing forgiving roads and roadsides. This is to be delivered through the Road Safety Audit process by accepting that people will always make mistakes and by considering the known limits to crash forces the human body can tolerate. This is to be achieved by focusing the Road Safety Audit on particular crash types that are known to result in higher severity outcomes at relatively lower speed environments to reduce the risk of fatal and serious injury crashes.

The additional annotation "IMPORTANT" is used to provide emphasis to the road safety audit finding that has the potential to result in fatal or serious injury or findings that are likely to result in the following crash types above the related speed environment:

- > head on (>70km/h);
- > right angle (>50km/h);
- > run off road impact object (>40km/h); and
- > crashes involving vulnerable users (>30km/h)

As these crash types are known to result in higher severity outcomes at relatively lower speed environments.

The exposure and likelihood of crash occurrence shall then be considered for all findings deemed "IMPORTANT" and evaluated based on the auditor's professional judgement. Auditors should consider factors as traffic volumes and movements, speed environment, crash history and the road environment and apply road safety engineering and crash investigation experience to determine the likelihood of crash occurrence. The likelihood of crash occurrence shall be considered either VERY HIGH, HIGH, MODERATE or LOW and this additional annotation shall be displayed following the IMPORTANT annotation on applicable findings.

6.1.2 Responding to the Audit Report

As set out in the road safety audit guidelines, responsibility for the road design always rests with the client, and not with the auditing team. A client is under no obligation to accept all the audit recommendations. Also, it is not the role of the auditor to agree or approve of the client's response to the audit. Rather, the audit provides the opportunity to highlight potential problems and have them formally considered by the client, in conjunction with all the other project considerations.

This formal road safety audit report should be responded in writing, giving reasons for each rejection of an audit finding or recommendation. Acceptance of a recommendation may require no further comment, but explanation of how or when the action will be taken may be useful.

6.1.3 Previous Road Safety Audits

No previous RSA have been provided to Cardno road safety team.

6.1.4 Supplied Documentation

The Road Safety Audit team has been presented with the following concept design drawings:

- > QTT20037 – SK01 – CRR Southern Portal TIA Option 1 Access Review Peter Doherty Street Entry / Exit Access 1 – 19m AV Swept Path
- > QTT20037 – SK02 – CRR Southern Portal TIA Option 1 Access Review Peter Doherty Street Entry Access 2 – 19m AV Swept Path
- > QTT20037 – SK03 – CRR Southern Portal TIA Option 2 Access Review Peter Doherty Street Entry Access 1 – 19m AV Swept Path
- > QTT20037 – SK11 – CRR Southern Portal TIA Option 1-3 Access Review Peter Doherty Street Intersection Modifications Design Vehicle Amendment Options
- > QTT20037 – SK12 – CRR Southern Portal TIA Option 1-3 Upgraded School Access Review Peter Doherty Street Intersection Modifications Design Vehicle Amendment Options
- > QTT20037 – SK13 – CRR Southern Portal TIA Option 1-3 Access Review Peter Doherty Street Intersection Modifications Right Turn Lane Concept – Revision B
- > QTT20037 – SK14 – CRR Southern Portal TIA Option 1-3 Access Review Site Access Intersection Modifications Concept Amendments
- > QTT20037 – SK18 – CRR Southern Portal TIA Access 1 Review Sight Distance Check
- > QTT20037 – SK19 – CRR Southern Portal TIA Access 2 Review Sight Distance Check

The provided drawings are presented in **Appendix A**.

6.2 Site Visits

A site visit was undertaken on 22nd September 2020 with the purpose of collecting as much information about the location, exiting road infrastructure and operation, adjacent commercial and residential properties, etc. as required for completing the risk assessment and option analysis.

A series of photos and video recordings have been taken and used for evaluating the risk of the proposed options of this project.

6.3 Risk Assessment

Audit findings were established and comments are provided based on the information collected during the site visits and desktop investigation based on Google Map and Near Map views. The findings focus on road safety for all road users, from a road use and network issues perspective, auditing the road safety elements as set out in the Austroads Guide to Road Safety Part 6A: Implementing Road Safety Audits (2019).

The findings are presented by general location; hence the findings are not presented in order of relative safety importance or priority for treatment.

6.3.1 Risk Assessment Criteria

For each identified issue, a risk rating has been determined. This has been based on the Austroads Guide to Road Safety Audit Part 6A, Implementing Road Safety Audits, as shown in Table 6-1.

Table 6-1 Safety Risk Score Matrix

	Frequent	Probable	Occasional	Improbable
Catastrophic	Intolerable	Intolerable	Intolerable	High
Serious	Intolerable	Intolerable	High	Medium
Minor	Intolerable	High	Medium	Low
Limited	High	Medium	Low	Low

The risk rating descriptors are defined as per Table 6-2.

Table 6-2 Risk Rating Descriptors

Rating Measure	Descriptor
Potential Likelihood of Incident Occurring	
Frequent	Once or more per week
Probable	Once or more per year (but less than once a week)
Occasional	Once every five or ten years
Improbable	Less often than once every ten years
Potential Consequence of Incident Occurring	
Catastrophic	Likely multiple deaths
Serious	Likely death or serious injury
Minor	Likely minor injury
Limited	Likely trivial injury or property damage only
Treatment Approach	
Intolerable	Must be corrected
High	Should be corrected or the risk significantly reduced, even if the treatment costs is high
Medium	Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high
Low	Should be corrected or the risk reduced, if the treatment cost is low

6.3.2 Treatment Options

Treatment options have been recommended for each identified safety issue. As many of the issues are recurring, a suite of standardised treatment has been developed and assigned to hazards that are common and generic.

Where a safety issue warrants a unique treatment, this has been described accordingly.

The treatment options have been developed with the aim to deliver a consistent message to path users, improve general safety of the paths and to be realistic in terms of costs versus benefit of the recommended treatment.

6.3.3 Specific Issues and Recommendations

Audit findings were established and comments are provided based on a desktop review of the available maps (Nearmap and Google) and the preliminary design drawings provided to the road safety team. The findings focus on road safety for all road users, from a road use and network issues perspective, auditing the road safety elements as set out in the Austroads Guide to Road Safety Part 6A: Implementing Road Safety Audits (2019).

The findings are presented by general location; hence the findings are not presented in order of relative safety importance or priority for treatment. The Road Safety Review has documented its findings by numbered issues referenced to locations within the study area. Recommendations for potential remedial treatments have been identified and each issue is allocated with a priority, as shown in Table 6-3.

6.3.4 Existing Risks on the Network

Currently, there are no on-road cycle facilities along Peter Doherty Drive to support safe on-road cycling and is considered an existing safety risk. Wide off-road paths along Peter Doherty Drive provides an alternative option for cyclist along this route.

Annerley Road is a primary cycle route in Brisbane which experiences high volumes of cyclist between the CBD and UQ. On-road cycling facilities were recently upgraded and widened to include line-marked separation. However, the lack of physical separation from high volumes and high-speed vehicle traffic still presents a safety risk to on-road cyclist along this route. Increased volumes of heavy vehicle traffic would increase the potential for conflict over this route, which means that Option 2 access arrangements are not preferred.

Two cyclist fatalities, involving heavy vehicles, have occurred on Annerley Road. In 2013, a truck travelling along Annerley Road collided with the rail bridge overpass near Park Road before rolling and striking a cyclist. In 2014, a cyclist turning right from Stanley Street onto Annerley Road was struck by heavy vehicle also turning onto Annerley Road. Current construction impacts of the Brisbane South State Secondary College on the corner of Annerley Road and Gladstone Road has caused temporary impacts to on-road cycling lanes, which has raised wider community concerns for cycling along these corridors

Considering the existing active transport context, Option 1 is the preferred access arrangement at is considered to limit the potential for conflict between heavy vehicles and cyclists.

A key consideration is the existing rail bridge located at Annerley Road and Park Road, approximately 300m north of Boggo Road. This impacts the Option 2 route as vehicles would need to pass under bridge to access the site. Figure 6-1 presents a street view image of this bridge with the designate clearance height of 3.7m shown.

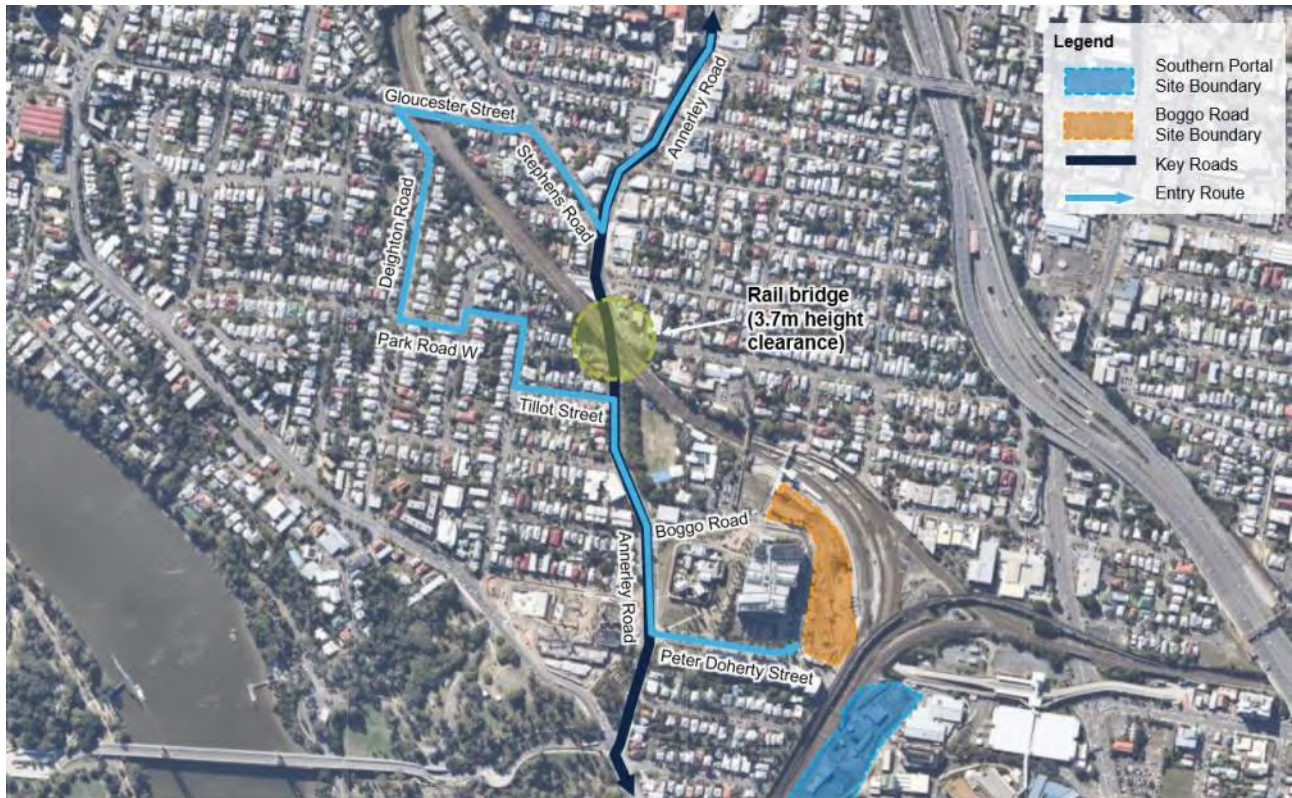
Figure 6-1 Annerley Road Rail Bridge – Low Clearance (3.7m) Point



Source: Google Street View

As this constraint point is close to the Southern Portal site, there are no convenient alternative routes to avoid the rail bridge, without using circuitous and narrow local streets. One potential alternative route is illustrated on Figure 6-2, which shows a number of acute turns required to access Peter Doherty Street from the north. This has been provided as an example but all other alternate route have similar issues. Therefore, unless construction vehicles are limited in size to ensure that the 3.7m clearance can be negotiated safely, Option 2 will not be feasible.

Figure 6-2 Alternative Option 2 Route – Avoiding Annerley Road Rail Bridge



Source: Nearthmap

Table 6-3 Road Safety Review

Reference	Drawing	Description of the identified issue	Comments	Priority	Design Response
Road Safety Review/Audit					
Option 1 Access B and C					
1	QTT20037-SK01 Rev A and QTT20037-SK02 Rev A	The right turn movement from Annerley Road into Peter Doherty Street is not permitted in the current arrangement for the intersection operation. Allowing this movement permanently for the duration of the project might pose a few capacity issues	Investigate the intersection capacity in order to determine whether allowing permanent right turn movements into Peter Doherty Road can be achieved within the acceptable LOS. Current phasing of the traffic signals will need to be altered in order to accommodate this movement	Medium	This has been assessed and discussed in Section 7. Phasing has been amended where required in the analysis, refer to section 7.4.
2	QTT20037-SK01 Rev A and QTT20037-SK02 Rev A	Swept path analysis for the 19m AV construction vehicle access is showing that the right turn into and the left turn out of Peter Doherty Street are possible in the current layout of the intersection but it is constrained to a certain path which, if not achieved, could lead to damage of the roadside infrastructure, crashes with pedestrians, cyclists, parked vehicles.	If this option is to be adopted, prepare a detailed Vehicle Movement Plan, which will include specific instructions on the construction vehicles movement through the intersection.	Medium	Recommend that a Vehicle Movement Plan is prepared and adopted. It is acknowledged that guide lines were considered however determined to be unsuitable as this will not restrict private vehicles from undertaking the right turn movement.
3	QTT20037-SK01 Rev A and QTT20037-SK02 Rev A	Swept path analysis shows that, at the Peter Doherty Street roundabout, the construction vehicles are required to access the existing semi-mountable raised roundabout.	Consider removing the existing roundabout and/or provide delineation markers (bollards or cones) to demarcate the construction vehicles path	Medium	Recommend including delineation markers at the roundabout to direct traffic paths.
4	QTT20037-SK01 Rev A and QTT20037-SK02 Rev A	Signage has not been included in the concept design	It is recommended that suitable signage to be installed at the construction site access ways, at the approaches to the construction site advising drivers of the construction work and the presence of the construction vehicles, as per current standards	Medium	To be completed as part of a Construction Management Plan

Reference	Drawing	Description of the identified issue	Comments	Priority	Design Response
5	QTT20037-SK13 Rev A	A concept design which includes a designated right turn lane on Annerley Road approach to Peter Doherty Street intersection. It is not clear whether this proposed intersection layout will allow for the construction vehicles turning movements. Also, the proposed design for the southbound carriage has not been completed, therefore it is not clear how the bicycle path will be included	Check the swept path for the design construction vehicle throughout the intersection Provide details of the bicycle path and connections throughout the intersection <i>Note that this review was completed on Revision A of the concept drawings. Since then, the drawings have been revised to provide more details on the indicated intersection works.</i>	Medium	Swept paths have been checked and confirmed to be suitable, refer to Appendix B. Bike paths are proposed to be retained, however are recommended to be realigned in sections to maintain safe movements with heavy vehicles. The existing lane widths are proposed to be retained.
Option 2 Access B and C					
6	QTT20037-SK03 Rev A and QTT20037-SK11 Rev A	Alternative 1 is proposing to relocate the stopping line at the Peter Doherty Street approach to the Annerley Road intersection further to the east in order to accommodate swept path of the construction vehicles turning left into Peter Doherty Street. This alternative does not seem to comply with the sight distance requirements. There is a risk of drivers missing the stopping line as they don't expect to be situated as far from the intersection and the construction vehicle path crosses in front of the approaching vehicles.	This alternative is not considered to be meeting the safety requirements for this type of intersection, therefore it should be reconsidered or totally eliminated.	High	Recommend a hatched treatment and Keep Clear linemarking to better designate the no stopping area in front of the stop lines on Peter Doherty Street. It is noted that sight distance requirements are not applicable during normal operations for signals, however are required in situations where the signals fail. For this reason, the safety risks are considered to remain high even with the proposed hatched treatment.

Reference	Drawing	Description of the identified issue	Comments	Priority	Design Response
7	QTT20037-SK03 Rev A and QTT20037-SK11 Rev A	Swept path analysis for the 19m AV construction vehicle access is showing that the left turn into and the left turn out of Peter Doherty Street are not able to pass without conflicting with each other.	It is recommended that the two movements for construction vehicles left turn into and left out of Peter Doherty Street to be included in separate phases so they don't occur simultaneously.		Signal phasing for this option has been assessed to ensure that the left turn movements do not occur in the same phase, refer section 7.4.
8	Annerley Road north of Boggo Road	The construction vehicle route on Annerley Road approaching the construction site from north (Option 2) is potentially required to travel under the low clearance (3.7m) railway overbridge located at the intersection of Annerley Road and Park Road.	Ensure the construction vehicles traveling on Annerley Road meet the clearance requirements of the overbridge, or investigate alternative routes to avoid the rail overbridge.	High	The rail bridge is a major constraint for Option 2. Alternative options to avoid this are unacceptable and therefore, Option 2 is not feasible.
Active Transport Safety Review					
Option 1					
9	QTT20037 - SK01 Rev A	On-road cyclist may use proposed right turn lane on Annerley Road to access Peter Doherty Drive and the Boggo Road Precinct. While cycle demand for this right turn may be low, users may complete this manoeuvre as opposed to using crossing facility where two crossing movements are required.	Include a "Head Start Box/ Bike Box" in the right turn lane to improve safety and visibility of cyclists – especially for heavy vehicles. Alternatively provide the standard distance between the stop line and the pedestrian crossing to informally allow cyclists to store ahead of the vehicles.	High	Propose to provide increased distance between stop line and pedestrian crossing to more safely allow cyclists to store at the new right turn lane into Peter Doherty Street.
Option 2					
10	QTT20037 - SK03 Rev A	Increased risk/conflict point between continuing on-road cyclist and heavy vehicles entering the left-turn lane on Annerley Road. This section of Annerley Road is uphill, which means on-road cyclist may be slower and will require the full cycle lane width.	Consider installing cycle transition ramp prior to the left-turn lane to allow on-road cyclist to access off-road facilities.	High	Recommend installation of bike transition ramp on Annerley Road prior to the Peter Doherty Street intersection.

Reference	Drawing	Description of the identified issue	Comments	Priority	Design Response
11	QTT20037 - SK03 Rev A QTT20037 - SK11 Rev A QTT20037 - SK12 Rev A	Risk that on-road cyclist will not stop at proposed stop bar, instead store closer to Annerley Road in the swept path of heavy vehicles. Additionally, proposed set-back of the left and right turn lane on Peter Doherty Street increases the intersection crossing distance for on-road cyclist and conflict with vehicles.	Not recommend to progress with this option.	High	As per item 6, recommend a hatched treatment to better designate the no stopping area in front of the stop lines on Peter Doherty Street. Recommend addition of signage to warn cyclist not to stop in hatched zone.
12	QTT20037 - SK01 Rev A QTT20037 - SK02 Rev A QTT20037 - SK03 Rev A QTT20037 - SK11 Rev A QTT20037 - SK12 Rev A	No cyclist storage space on through/left-turn lanes at Annerley Road intersection (southbound lanes). Risk that drivers in heavy vehicles may not see on-road cyclists or pedestrians crossing.	Consider installing "Head Start Box/ Bike Box" in front of left turn and cycle lane on Annerley Road (southbound lanes).	High	Recommend stop lines are relocated (3m from pedestrian line) to provide informal storage area for cyclists, as indicated. Recommend installing linemarking to show head start box across left turn lane on Annerley Road turning into Peter Doherty Street.
Options 1 and 2					
13	QTT20037 - SK01 Rev A QTT20037 - SK03 Rev A QTT20037 - SK02 Rev A QTT20037 - SK11 Rev A	Heavy vehicles turning left from Peter Doherty Street to Annerley Road may encroach on-road cycle lane and painted chevron.	Consider minor relocation of on-road cycle lane towards kerb (reducing painted chevron area) and installing vertical separation devices (similar to Gladstone Road).	High	Recommend realignment of the on-road cycle lane and installation of vertical separation devices.

Reference	Drawing	Description of the identified issue	Comments	Priority	Design Response
14	QTT20037 - SK01 Rev A QTT20037 - SK02 Rev A QTT20037 - SK03 Rev A	Limited storage capacity for pedestrians and cyclists in the pedestrian refuge at Peter Doherty Street / Joe Baker Street roundabout. Current design offers limited separation or protection from heavy vehicles due to low kerb profile.	Upgrade pedestrian refuge crossing / median on Peter Doherty Street / Joe Baker Street roundabout.	High	Recommend reconstructing the pedestrian refuge with standard kerb.
15	QTT20037 - SK02 Rev A QTT20037 - SK03 Rev A	Risk of cyclist exiting the cycle track (at Eco Science Precinct) directly onto Joe Baker Street. Cyclist may not see, or be visible to heavy vehicle traffic.	Install "Slow down watch for vehicles" sign at the end of the cycle track. Consider installing wayfinding signage at the end of cycle track, encouraging users to continue off-road. Inform building management of increases in heavy vehicle traffic as part of CRR, and potential impacts to people walking/cycling and using end-of-trip facilities.	Low	Recommend installing warning signage for cyclists as indicated. Recommend liaising with building management of proposed changes and impacts for pedestrians / cyclists.
16	General	Annerley Road is a major cycle route in Brisbane, experiencing high-volumes of on-road cyclist. Increases in heavy vehicle traffic increases the potential conflicts with cyclist, especially where no physical separation is provided along this section of Annerley Road or where cycle lanes are narrow.	Driver awareness / education of cycle route and associated risks on Annerley Road for construction vehicle drivers.	Low	Recommend driver awareness / education program to be included as part of a Construction Management Plan and rolled out for construction vehicle drivers.

6.4 Summary of Safety Assessment

6.4.1 Road Safety Review

A key constraint identified for Option 2 is the rail bridge over Annerley Road, at Park Road 300m north of Boggo Road, which has a low clearance height of 3.7m. This conflicts with the design vehicles which require clearance of 4.5m. Being so close to the Southern Portal site, there are no convenient alternative routes to avoid the rail bridge, without using circuitous and narrow local streets. This is not an acceptable solution. Therefore, unless construction vehicles are limited in size to ensure that the 3.7m clearance can be negotiated safely, Option 2 is not feasible. If smaller vehicles are utilised, load capacity will be restricted which will increase the volumes of trucks required. This will impact on a number of factors, including the traffic analysis and ability to accommodate the increase in vehicles on-site.

Regardless, should Option 2 be able to be implemented, identification of the risks for the study network has been reviewed.

No road safety risks were identified for Option 2 layout 2 where the kerb is proposed to be amended.

For Option 2 layout 1, where the stop lines of Peter Doherty Road were proposed to be relocated to accommodate the turning path of the design vehicle, this presented the highest risk scenario out of the options. This is due to the compromised sight lines for the Peter Doherty Street approach, which will present a safety issue if the signals fail. A potential mitigation for this is to prepare and implement traffic control immediately at the intersection to ensure traffic movements operate safely.

The risks outlined for Option 1 are able to be managed with the proposed design responses. These include preparation of a Vehicle Movement Plan, a Construction Management Plan and temporary traffic management measure.

Option 1 would be required to minimise the road safety risks identified.

6.4.2 Active Transport Safety Review

In terms of active transport user safety risks, both options 1 and 2 present High risks. However, it is noted that Option 2 layout 1 has been recommended to not proceed on the basis of safety concerns associated with the unconventional stop line locations and potential clashes with construction. This is consistent with the findings of the road safety review. The design response proposed for this to clearly hatch the no stopping area and install warning signage, however there is a risk that cyclists will not obey these warnings leading to the potential for serious injury or death.

With regards to Option 1 and Option 2 layout 2, the risks to cyclists and pedestrians can be minimised through the proposed mitigation measures. These include stop line changes at the Annerley Road / Peter Doherty Street intersection, installation of cycle lane separator devices to protect cyclists on the bike lane, installation of cyclist facilities including a head start box at the left turn lane into Peter Doherty Street and bike transition ramps on Annerley Road, as well as warning signage for cyclists and drivers.

As Option 2 is not feasible due to the rail bridge constraint, preference is for Option 1, to minimise the active transport user safety risks identified.

Appendix B shows the updated concept plans outlining the design responses proposed to respond to the risks outlined for Options 1 and 2.

7 Traffic Analysis

7.1 Project Traffic Volumes

It has been advised that the number of construction vehicles expected for the project are 14 vehicles per hour (vph). A conservative assessment has been prepared whereby it has been assumed that 14 vph access the site in each direction.

Furthermore, the baseline construction vehicles utilising the Boggo Road worksite have been advised as 24 heavy vehicles and four concrete trucks per hour. As these vehicles were not captured in the traffic surveys, the assessment has included these trips as baseline traffic for the intersections. The four concrete trucks per hour have been included in the traffic assessment to ensure all vehicle traffic associated with the project is captured, to understand the impact on the intersection operations.

7.2 Assessed Intersections

As outlined in Figure 2-1, the following intersections formed the scope of this study:

1. Annerley Road / Boggo Road
2. Annerley Road / Peter Doherty Street
3. Annerley Road / Rawnsley Street
4. Annerley Road / Cornwall Street / Noble Street / Railway Terrace

7.3 Background Traffic Volumes

Survey data for each of the intersections was collected to understand the baseline traffic volumes. The data was collected at different times through mid-2020. Table 7-1 outlines the dates which each of the intersection surveys were conducted.

With respect to potential impacts of COVID on the traffic counts, it is noted that the all surveys were undertaken during the COVID period meaning any change in traffic patterns from pre-COVID times would be consistently captured at all intersections. Furthermore, the during-COVID traffic patterns are considered to be long term and therefore, using survey data during-COVID is considered to provide a reasonable basis for future traffic volumes.

Table 7-1 Background Traffic Surveys

ID	Intersection	Survey Day
1	Annerley Road / Boggo Road	Thu, 16 th Jul 2020
2	Annerley Road / Peter Doherty Street	Thu, 18 th Jun 2020
3	Annerley Road / Rawnsley Street	Wed, 26 th Aug 2020
4	Annerley Road / Cornwall Street / Noble Street / Railway Terrace	Thu, 18 th Jun 2020

It is noted that at the time of the surveys, the heavy vehicles associated with the Boggo Road worksite were not captured. As this is an approved arrangement, these trips have been added to the survey volumes to form the baseline traffic scenario.

The road network peak period has been assessed for this study. The peak periods were identified as follows:

- > AM peak: 7:30 – 8:30am
- > PM peak: 3:00 – 4:00pm

7.4 Signal Phasing

Signal plans have been reviewed to inform the SIDRA analysis for the three signalised intersections:

- > Annerley Road / Boggo Road
- > Annerley Road / Peter Doherty Street
- > Annerley Road / Cornwall Street / Noble Street / Railway Terrace

Timing data has also been reviewed to understand the cycle times implemented at each intersection. The average cycle times during the peak hours has been adopted for the baseline traffic scenarios.

It is noted that for Option 1, the phasing for the Annerley Road / Peter Doherty Street intersection has been amended to accommodate the new right turn movement from Annerley Road south. Three different phasing arrangements have been investigated.

The phasing arrangements are illustrated on Figure 7-1.

Figure 7-1 Amended Annerley Road / Peter Doherty Street Phasing – Option 1



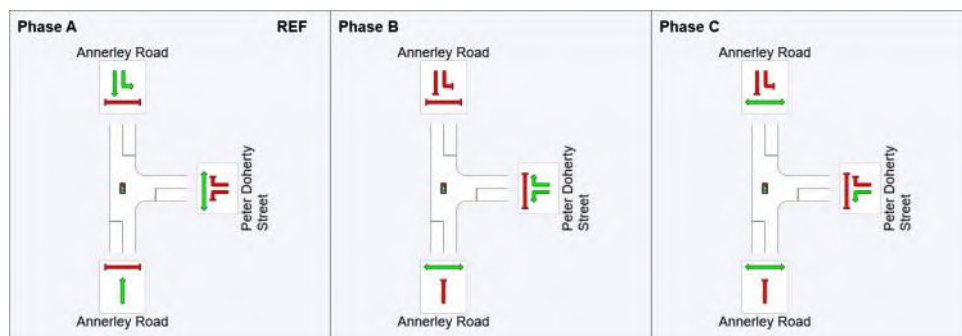
The phasing involves the following options:

- > **Split phasing:** each intersection approach runs in a separate phase, with northern and southern pedestrians running together (phase C)
- > **Leading right:** Annerley Road movements run led by the southern approach right turn (phase A), with all pedestrian crossings running together as a scramble crossing (phase C)
- > **Leading right with filter:** As per the leading right phasing, with the right turn from Annerley Road south added as a filtering movement to phase B.

It is noted that for safety reasons, right turn filtering is not generally supported when opposed by two or more through lanes when there is likely to be a high proportion of heavy vehicles. Therefore, the third phasing option is not recommended to proceed from a safety perspective.

With regards to Option 2, where construction vehicles will be turning left into and out of Peter Doherty Street, truck paths will conflict in the layout where no kerb amendments are provided and stop lines are relocated. In this situation, the phasing will need to be amended to ensure that the movements are in separate phases. Figure 7-2 illustrates the adopted phasing for this option.

Figure 7-2 Amended Annerley Road / Peter Doherty Street Phasing – Option 2



7.5 Assessment Scenarios

The following assessment scenarios have been adopted for this assessment:

- > 2020 Background (without Boggo Road worksite traffic) – volumes as per surveys
- > 2020 Background (with Boggo Road worksite traffic) – survey volumes with the addition of Boggo Road worksite volumes as advised
- > 2020 Background with Option 1 – background volumes with Boggo Road worksite traffic with the addition of Option 1 traffic volumes
- > 2020 Background with Option 2 – background volumes with Boggo Road worksite traffic with the addition of Option 2 traffic volumes

7.6 Assessment Criteria

The performance of the study intersections have been analysed using SIDRA Intersection 8.0 (SIDRA). SIDRA is an industry recognised analysis tool that estimates the capacity and performance of intersections based on input parameters, including geometry and traffic volumes, and provides estimates of an intersection's Degree of Saturation (DOS), queues and delays.

7.6.1 Intersection Delay

The TMR Guide to Traffic Impact Assessments (GTIA) recognises the intersection delay as a greater indicator of intersection performance in comparison to the previous TMR Guidelines for Assessment of Road Impacts of Development (GARID) significance on the degree of saturation (DOS).

The desired outcome outlined by the GTIA is to ensure that the sum of all intersection delays on the base traffic within the study area does not significantly worsen (i.e. does not increase average delays by more than 5% in aggregate) as a result of the development. The proposed development should seek to achieve no net worsening to efficiency across the impact assessment area.

Intersection mitigation measures (avoid, manage or mitigate) must be considered where the sum of all intersection delays on the base traffic is greater than 5% in aggregate. Furthermore, for priority controlled intersections, where the average peak hour delays for any movement exceeds 42 seconds, the intersection should be upgraded for safety reasons.

7.6.2 Intersection Degree of Saturation

While the movement delay is considered to provide a better indication of intersection performance and safety for priority controlled intersections and roundabouts, the DOS should still be considered when assessing the performance of the intersection. Table 7-2 provides the DOS thresholds adopted for the assessment.

Table 7-2 Adopted Intersection Performance Threshold – Degree of Saturation

Intersection Treatment	
Priority controlled intersections	Less than or equal to 0.80
Signalised intersections	Less than or equal to 0.90

Source: TMR Guidelines for Assessment of Road Impacts Development

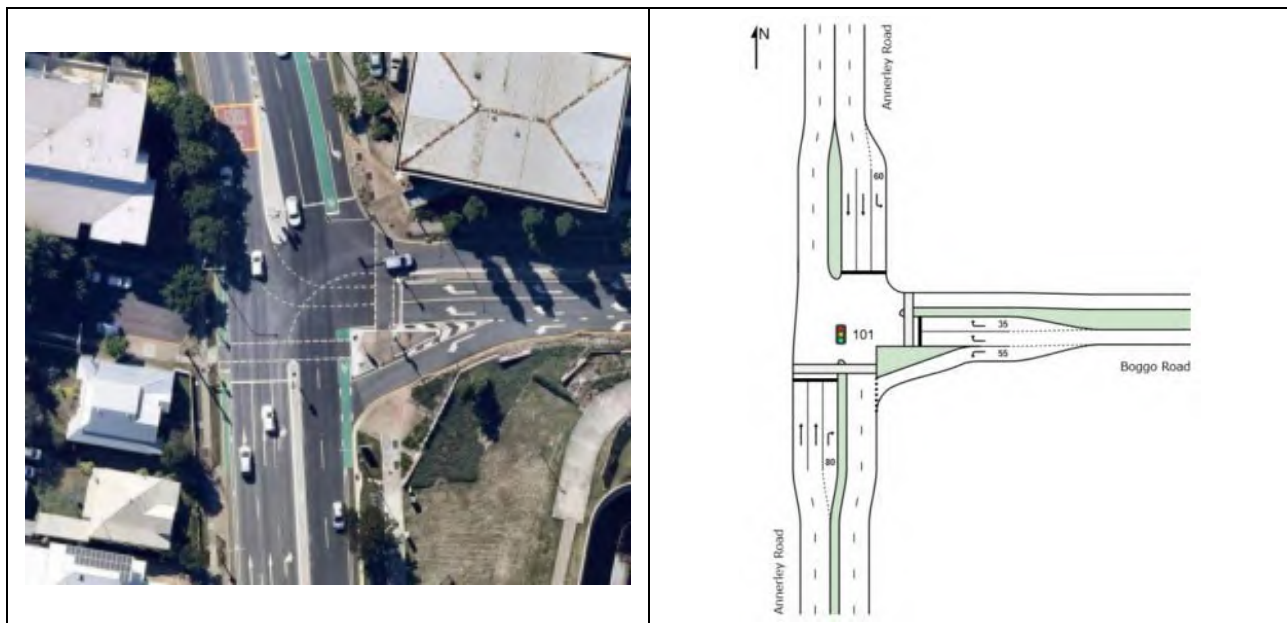
The guideline notes that a DOS exceeding the values indicated in Table 7-2 indicates that an intersection is nearing its practical capacity and upgrade works may be required. Above these threshold values, users of the intersection are likely to experience increasing delays and queueing.

7.7 Operational Assessment

7.7.1 Annerley Road / Boggo Road

The current configuration of this intersection is a three way signalised arrangement. The aerial and SIDRA assessed layout are illustrated on Figure 7-3.

Figure 7-3 Layout - Annerley Road / Boggo Road



The results of the SIDRA assessment, for all assessed scenarios, are summarised in Table 7-3.

Table 7-3 SIDRA Results – Annerley Road / Boggo Road

Scenarios	AM Peak			PM Peak		
	DOS	Delay	95 th %ile Queue	DOS	Delay	95 th %ile Queue
2020 Background (without Boggo Rd site)	0.421	9.8 sec	57.3 m	0.555	11.9 sec	81.4 m
2020 Background (with Boggo Rd site)	0.421	10.9 sec	57.3 m	0.569	12.5 sec	81.4 m
2020 Background with Option 1	0.421	10.9 sec	57.3 m	0.569	12.5 sec	81.4 m
2020 Background with Option 2	0.421	10.9 sec	57.3 m	0.569	12.6 sec	84.4 m

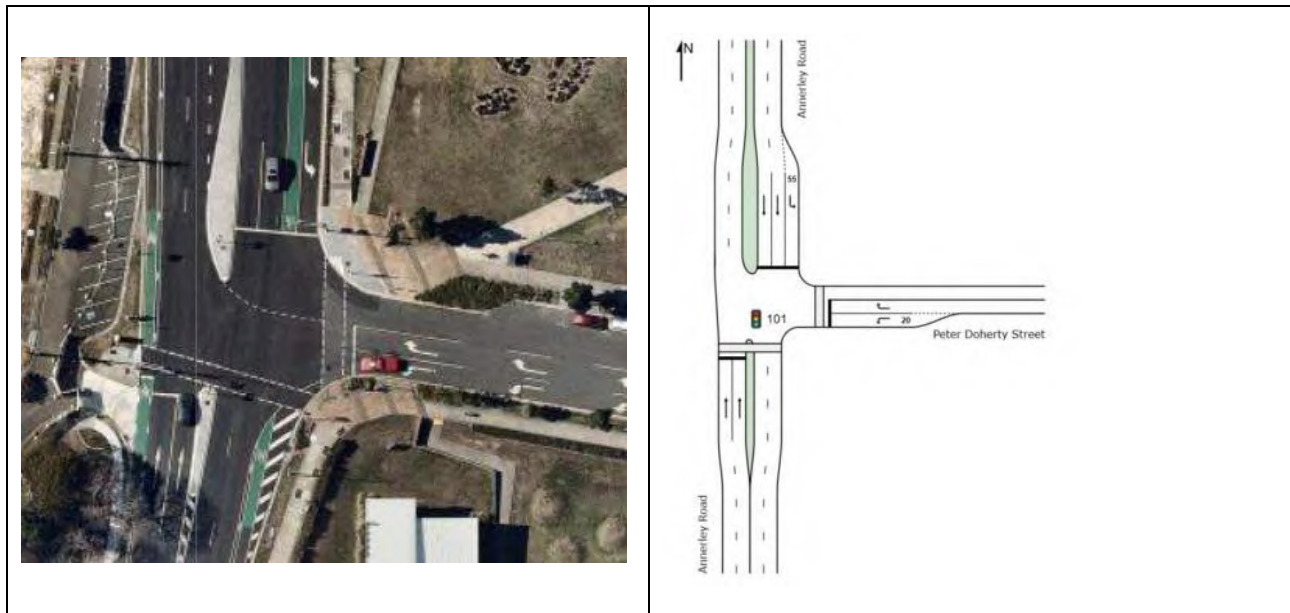
The results indicate that the impact of the proposed options do not have a significant impact to the operations of the intersection. The intersection is shown to operate within acceptable thresholds for all assessed scenarios.

The results indicate that the intersection operates reasonably well, with DOS less than 0.60 and delays less than 13 seconds overall. From a cursory review, this would appear to be quite low given Annerley Road is an arterial road with high traffic volumes. However, when examined in further detail, it is evident that the low turning volumes into and out of Boggo Road mean that the major road through movements are able to get the majority of the green time, resulting in highly efficient traffic capacity operations.

7.7.2 Annerley Road / Peter Doherty Street

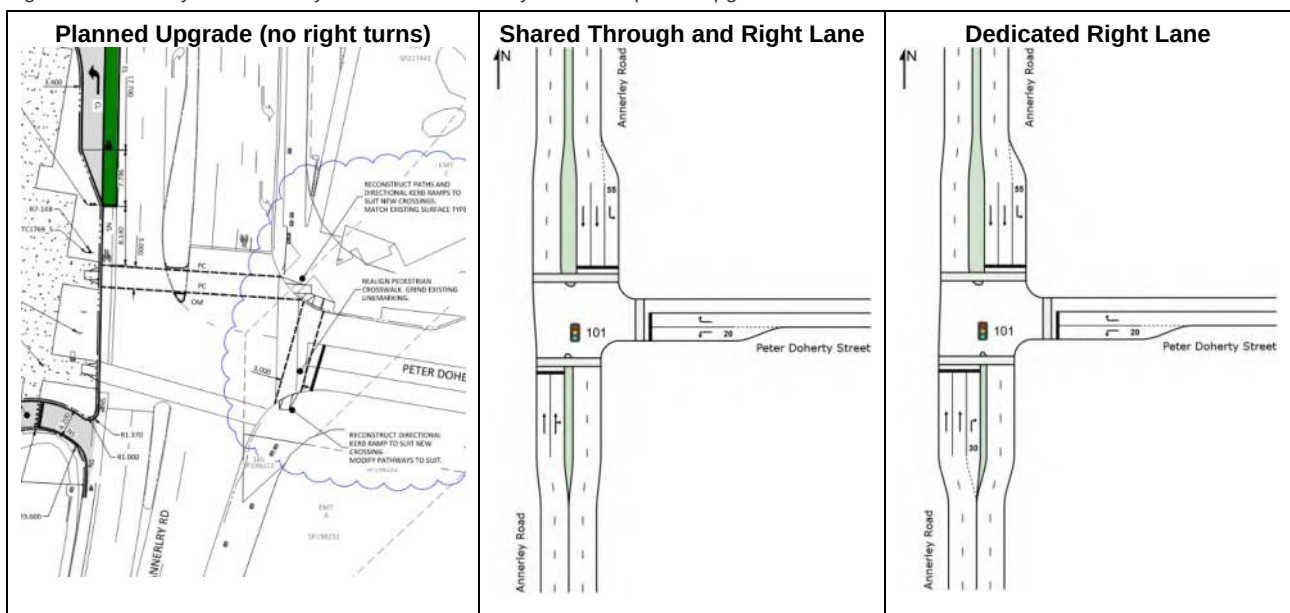
The current configuration of this intersection is a three way signalised arrangement. The aerial and SIDRA assessed layout for the existing form are illustrated on Figure 7-4.

Figure 7-4 Layout - Annerley Road / Peter Doherty Street - Existing



For Option 1, which requires the addition of a right turn movement on Annerley Road southern approach, the intersection form will need to be amended to include this movement. Figure 7-5 illustrates the proposed upgraded form of this intersection. Two options have been analysed for the addition of right turn lanes, the first being the right turn shared with the through lane, and the second being provision of a dedicated right turn lane.

Figure 7-5 Layout - Annerley Road / Peter Doherty Street – Option1 Upgrade



With regards to Option 2, where two layouts have been prepared. The SIDRA analysis has been prepared to allow for the following changes:

- > Option 2 layout 1 (Peter Doherty Street stop lines relocated): clearance times increased on Peter Doherty Street to account for increased distance for vehicles to clear the intersection
- > Option 2 layout 2 (north-east corner kerb amended): pedestrian crossing distances increased to account for the kerb relocation

The results of the SIDRA assessment, for all assessed scenarios, are summarised in Table 7-4.

Table 7-4 SIDRA Results – Annerley Road / Peter Doherty Street

Scenarios	AM Peak			PM Peak		
	DOS	Delay	95 th %ile Queue	DOS	Delay	95 th %ile Queue
2020 Background (without Boggo Rd site)	0.357	7.0 sec	76.9 m	0.328	8.5 sec	68.5 m
2020 Background (with Boggo Rd site)	0.426	12.5 sec	113.6 m	0.391	14.4 sec	101.5 m
Option 1 - Split Phasing						
2020 Background with Option 1 (shared through and right lane)	0.750	44.9 sec	217.2 m	0.735	46.9 sec	193.1 m
2020 Background with Option 1 (dedicated right turn lane)	0.753	44.7 sec	215.1 m	0.747	47.2 sec	193.1 m
Option 1 - Leading Right						
2020 Background with Option 1 (shared through and right lane)	0.529	29.7 sec	157.3 m	0.541	28.5 sec	154.8 m
2020 Background with Option 1 (dedicated right turn lane)	0.498	21.0 sec	144.1 m	0.550	26.6 sec	157.1 m
Option 1 - Leading Right with Filter						
2020 Background with Option 1 (shared through and right lane)	0.625	28.4 sec	139.3 m	0.661	30.9 sec	180.9 m
2020 Background with Option 1 (dedicated right turn lane)	0.498	20.5 sec	144.1 m	0.550	26.2 sec	157.1 m
Option 2						
2020 Background with Option 2 (Peter Doherty stop lines relocated)	0.436	13.8 sec	118.8 m	0.421	15.3 sec	104.1 m
2020 Background with Option 2 (north-east kerb relocated)	0.452	15.1 sec	126.7 m	0.421	16.5 sec	111.2 m

For detailed SIDRA results, a copy of the movement summaries for each scenario has been provided at **Appendix C**.

The results indicate that the intersection will operate within acceptable DOS thresholds for all assessed scenarios. Similarly to the Annerley Road / Boggo Road intersection operations, the baseline results show that the intersection operates reasonably well. Again, this is due to the low turning movements into and out of Peter Doherty Street, in addition to the restricted right turn movement, which allows the intersection to maintain good operations.

7.7.2.2 Option 1 Operations

Option 1 will significantly impact on the operations of the intersection with an increase in DOS, delays and queues across both peak periods. However, it is noted that the extent of the impact varies with the phasing arrangement adopted.

During the AM peak, the queues will extend past the upstream Annerley Road / Rawnsley Street intersection (with the *split phasing* and *leading right* phasing arrangements only), while in the PM peak, queues will extend back through the Annerley Road / Boggo Road intersection in all tested phasing scenarios. While the *leading right with filter* phasing arrangement will not cause queues to extend past Rawnsley Street, as mentioned above, this arrangement is not recommended on the basis of driver safety.

The queue spillback at Rawnsley Street is not of major concern as this is a local street with Keep Clear access, although this may affect efficiency for the project. On the other hand, the queues extending back to

Boggo Road on the north may pose a safety concern, particularly with the potential for vehicles to queue through the intersection, which may trigger unsafe driver manoeuvres. It is noted that the baseline scenarios do not show these queuing issues, and thus this is a direct consequence of the construction activities.

Furthermore, comparing the impact of the additional right turn lane (layout 2), delays are generally reduced for the overall intersection, although it is noted that this is not necessarily reduced for the southern approach which is not always the critical approach. Queues on the southern approach are also generally reduced with the additional lane.

7.7.2.3 Option 2 Operations

Both layouts analysed for Option 2 will have a lesser impact on the intersection operations compared to Option 1. Only a minor increase in delays and queues are expected to result. It is noted that no queue spillback is expected to occur for either layout of Option 2.

Comparing the two layout options, the relocated stop lines on Peter Doherty Street provide a slightly lower impact than the kerb amendment option, however the improvement is only minor.

7.7.3 Annerley Road / Rawnsley Street

The current configuration of this intersection is a three way unsignalised arrangement. The aerial and SIDRA assessed layout are illustrated on Figure 7-6.

Figure 7-6 Layout - Annerley Road / Rawnsley Street



The results of the SIDRA assessment, for all assessed scenarios, are summarised in Table 7-5.

Table 7-5 SIDRA Results – Annerley Road / Rawnsley Street

Scenarios	AM Peak			PM Peak		
	DOS	Delay	95 th %ile Queue	DOS	Delay	95 th %ile Queue
2020 Background (without Boggo Rd site)	0.300	99.8 sec	5.5 m	0.222	47.9 sec	5.2 m
2020 Background (with Boggo Rd site)	0.321	129.1 sec	6.9 m	0.266	58.2 sec	6.3 m
2020 Background with Option 1	0.359	148.4 sec	7.7 m	0.292	64.6 sec	6.9 m
2020 Background with Option 2	0.337	137.3 sec	7.2 m	0.280	61.6 sec	6.7 m

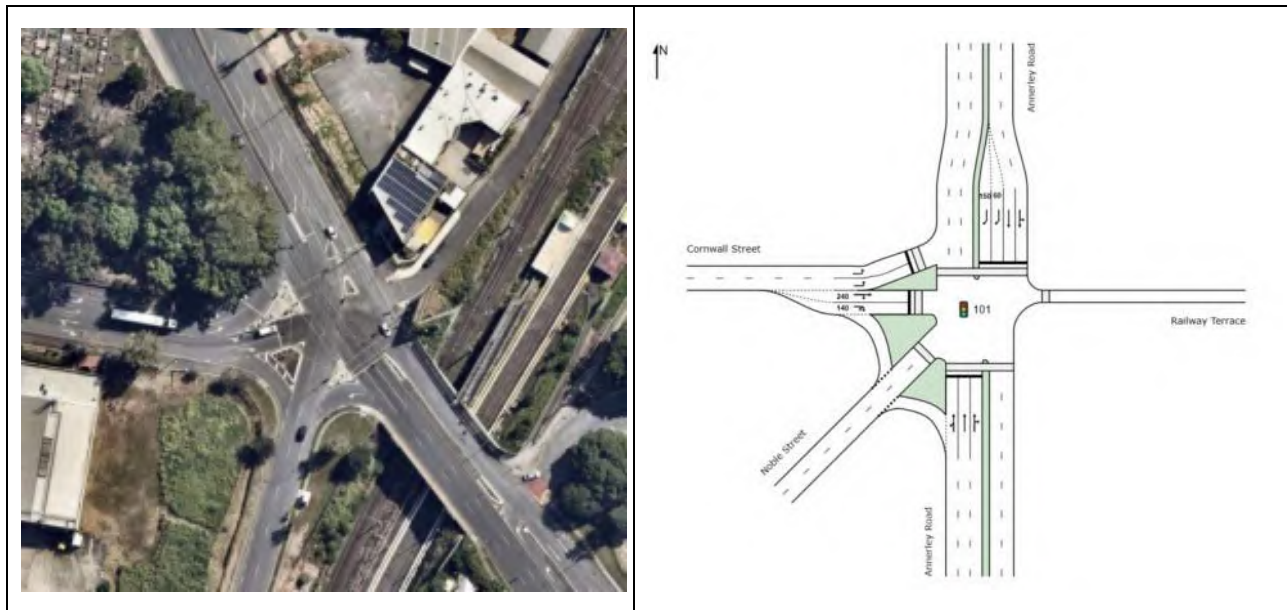
The results indicate that the intersection will operate within acceptable DOS and queue thresholds for all assessed scenarios, however delays are shown to exceed the accepted threshold of 42 seconds. The delays relate to the right turn out of Rawnsley Street, being the minor approach at the intersection. While the options do not add to this movement, the additional through traffic on Annerley Road reduces the available gaps for the minor approach vehicles. The maximum queue lengths, which are all less than 8m and relate to the Rawnsley Street approach, indicate that the delays affect only a few vehicles.

In comparing Options 1 and 2, Option 1 presents a slightly worse impact on the intersection.

7.7.4 Annerley Road / Cornwall Street / Noble Street / Railway Terrace

The current configuration of this intersection is a five way signalised arrangement. The aerial and SIDRA assessed layout are illustrated on Figure 7-7.

Figure 7-7 Layout - Annerley Road / Cornwall Street / Noble Street / Railway Terrace



The results of the SIDRA assessment, for all assessed scenarios, are summarised in Table 7-6.

Table 7-6 SIDRA Results – Annerley Road / Cornwall Street / Noble Street / Railway Terrace

Scenarios	AM Peak			PM Peak		
	DOS	Delay	95 th %ile Queue	DOS	Delay	95 th %ile Queue
2020 Background (without Boggo Rd site)	0.825	25.7 sec	108.6 m	0.948	51.3 sec	330.7 m
2020 Background (with Boggo Rd site)	0.891	26.3 sec	110.1 m	0.979	57.5 sec	365.4 m
2020 Background with Option 1	0.891	26.7 sec	114.7 m	0.985	60.7 sec	395.3 m
2020 Background with Option 2	0.891	26.4 sec	110.3 m	0.985	60.8 sec	395.6 m

The results indicate that the intersection currently operates above DOS and queue thresholds in the PM peak. The addition of the project traffic provides a minor worsening of the intersection operations, indicated by an increase in DOS, delays and queue lengths. Queues in the PM peak relate to the northern Annerley Road approach, which are shown to extend back towards the Annerley Road / Gladstone Road intersection.

In comparing Options 1 and 2, Option 1 presents a slightly worse impact on the intersection during the AM peak however Option 2 presents a slightly worse impact during the PM peak. The extent of the difference in operations is only minor and both options should be considered comparable overall. This minor difference is attributed to the comparably low difference in construction vehicle volumes between the two options at this intersection.

7.8 Summary of Operational Assessment

Following review of the operational analysis results, a summary of the outcomes has been prepared to compare the options side by side. The impact of each option at each intersection with respect to the worsened operations has been compared to the baseline scenarios.

For the purposes of this assessment, the following threshold criteria have been adopted to understand the comparative extent of impacts for each option. Three different outcomes have been proposed, negligible, moderate and significant impacts. The assessment assigns the highest impact level which has been triggered for the parameters to each intersection.

Table 7-7 Adopted Assessment Thresholds

Parameter	Negligible Impact	Moderate Impact	Significant Impact
DOS	<0.05 increase in DOS	<0.1 increase in DOS	>0.1 increase in DOS
Delay	<5 sec increase in delays	<10 sec increase in delays	>10 sec increase in delays
Queues	<19m increase in queues (equivalent to one design vehicle)	<38m increase in queues (equivalent to two design vehicles)	>38m increase or causes queue blockage (equivalent to two design vehicles)

Based on these thresholds, the following outcomes have been determined.

Table 7-8 Summary of SIDRA Results

Intersection	Option 1		Option 2	
Annerley Road / Boggo Road	Negligible impact		Negligible impact	
Annerley Road / Peter Doherty Street	Shared through and right Significant impact	Dedicated right turn Significant impact	Peter Doherty stop lines Negligible impact	Kerb Amendment Negligible impact
Annerley Road / Rawnsley Street	Significant impact		Moderate impact	
Annerley Road / Cornwall Street / Noble Street / Railway Terrace	Moderate impact		Moderate impact	

The results indicate that the options have a largely similar impact on the intersections with the exception of the Annerley Road / Peter Doherty Street and Annerley Road / Rawnsley Street intersections which will be significantly impacted by Option 1 as opposed to only having a negligible or moderate impact from Option 2.

With respect to the Rawnsley Street intersection, the significant impact from Option 1 is due to the increase in delays at the minor approach, which increase by 19 seconds in the AM peak.

On the basis of the above, Option 2 is preferable from a strictly capacity perspective given its lesser impact overall. However, Option 2 has operational and safety constraints associated with it and its safety impacts are much greater than Option 1.

8 Conclusions and Recommendations

Cardno has prepared this traffic impact assessment to document the options analysis process and outcomes for the identified construction vehicle access routes for the Southern Portal site.

8.1 Design Review

An initial review of four options was undertaken from a design perspective to understand the extent of road modifications required to implement each option. This identified proposed works required to accommodate each of the four options. While there was no clear preferred option based on the review, two options were able to be eliminated based on feasibility issues.

Therefore, the short listed options (Option 1 and 2) were progressed to the next review stage, which looked at operational impacts and safety impacts.

8.2 Safety Review

A key constraint identified for Option 2 is the rail bridge over Annerley Road, at Park Road 300m north of Boggo Road, which has a low clearance height of 3.7m. This conflicts with the design vehicles which require clearance of 4.5m. Being so close to the Southern Portal site, there are no convenient alternative routes to avoid the rail bridge, without using circuitous and narrow local streets. This is not an acceptable solution. Therefore, unless construction vehicles are limited in size to ensure that the 3.7m clearance can be negotiated safely, Option 2 is not feasible. If smaller vehicles are utilised, load capacity will be restricted which will increase the volumes of trucks required. This will impact on a number of factors, including the traffic analysis and ability to accommodate the increase in vehicles on-site.

The risks outlined for Option 1 are able to be managed with the proposed design responses. These include preparation of a Vehicle Movement Plan, a Construction Management Plan and temporary traffic management measure.

In terms of active transport user safety risks, both options 1 and 2 present High risks. However, it is noted that Option 2 layout 1 has been recommended to not proceed on the basis of safety concerns associated with the unconventional stop line locations and potential clashes with construction. This is consistent with the findings of the road safety review. The design response proposed for this to clearly hatch the no stopping area and install warning signage, however there is a risk that cyclists will not obey these warnings leading to the potential for serious injury or death.

With regards to Option 1, the risks to cyclists and pedestrians can be minimised through the proposed mitigation measures. These include stop line changes at the Annerley Road / Peter Doherty Street intersection, installation of cycle lane separator devices to protect cyclists on the bike lane, installation of cyclist facilities including a head start box at the left turn lane into Peter Doherty Street and bike transition ramps on Annerley Road, as well as warning signage for cyclists and drivers.

Therefore, preference would be for Option 1, to minimise the active transport user safety risks identified.

8.3 Traffic Analysis

Following review of the operational analysis results, a summary of the outcomes has been prepared to compare the two short listed options side by side. Table 8-1 identifies the impact of each option at each intersection with respect to the worsened operations compared to the baseline scenarios.

Table 8-1 Summary of SIDRA Results

Intersection	Option 1		Option 2	
Annerley Road / Boggo Road	Negligible impact		Negligible impact	
Annerley Road / Peter Doherty Street	Shared through and right Significant impact	Dedicated right turn Significant impact	Peter Doherty stop lines Negligible impact	Kerb Amendment Negligible impact
Annerley Road / Rawnsley Street	Significant impact		Moderate impact	
Annerley Road / Cornwall Street / Noble Street / Railway Terrace	Moderate impact		Moderate impact	

The results indicate that the options have a largely similar impact on the intersections with the exception of the Annerley Road / Peter Doherty Street and Annerley Road / Rawnsley Street intersections which will be significantly impacted by Option 1 as opposed to only having a negligible or moderate impact from Option 2.

On the basis of the above traffic analysis results, Option 2 is preferable given its lesser impact overall.

8.4 Overall Summary

Option 2 has been identified as limited by the height clearance constraint presented by the Annerley Road rail bridge, north of the site, and is subject to operational constraints. Therefore, Option 1 will need to proceed.

Of the two layout options presented for this option at the Annerley Road / Peter Doherty Street intersection, the safer and more efficient option is to provide the dedicated right turn lane on Annerley Road southern approach. This requires significant civil works to accommodate the additional lane, including demolition and reconstruction of the Annerley Road medians, relocation of signal infrastructure and kerb amendments.

APPENDIX

A

INITIAL DESIGN REVIEW CONCEPTS

OPTION 1 REVIEW

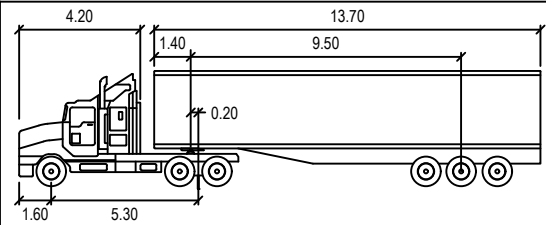


Option 1 Access C

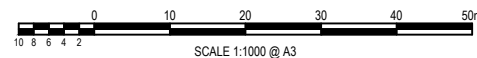
9m min driveway width for passing AVs

SWEPT PATH LEGEND

- VEHICLE BODY
- FRONT TIRES
- VEHICLE PATH
- VEHICLE CLEARANCE (500mm)
- VEHICLE



19M AV	
Tractor Width	: 2.50
Trailer Width	: 2.50
Tractor Track	: 2.50
Trailer Track	: 2.50
Lock to Lock Time	: 6.0
Steering Angle	: 27.7
Articulating Angle	: 70.0



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CBGU Joint Venture CRR Southern Portal TIA Option 1 Access Review Peter Doherty Street Entry / Exit Access A - 19m AV Swept Path			
Drawn T.Anang	Date 30/10/2020	Scale 1:1000	Size A3
Drawing Number QTT20037 - SK01			Revision A

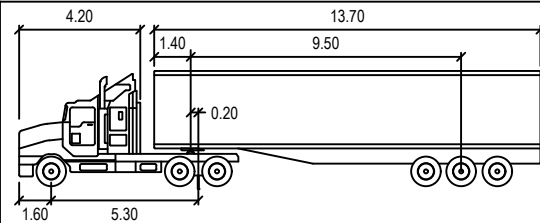


Option 1 Access B

Modify existing median and upgrade to standard kerb

SWEPT PATH LEGEND

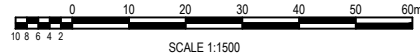
- VEHICLE BODY
- FRONT TIRES
- VEHICLE PATH
- VEHICLE CLEARANCE (500mm)
- VEHICLE



19M AV

- Tractor Width : 2.50
- Trailer Width : 2.50
- Tractor Track : 2.50
- Trailer Track : 2.50
- Lock to Lock Time : 6.0
- Steering Angle : 27.7
- Articulating Angle : 70.0

Meters



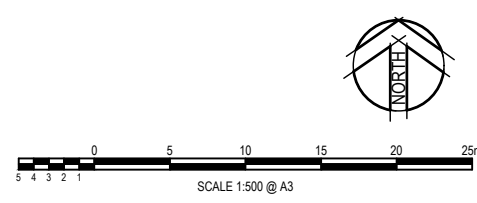
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Option 1 Access Review			
Peter Doherty Street Entry			
Access 2 - 19m AV Swept Path			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:1500	A3
Drawing Number			Revision
QTT20037 - SK02			A



CAD File: G:\QTT20037 - CRR Southern Portal TIA\6 ACAD\QTT20037 - SK01 - SK02 - D.dwg
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CBGU Joint Venture CRR Southern Portal TIA Option 2 Access Review Peter Doherty Street Intersection Modifications Right Turn Lane Concept			
Drawn T.Anang	Date 30/10/2020	Scale 1:500	Size A3
Drawing Number QTT20037 - SK13			Revision A

OPTION 2 REVIEW



Option 2 Access 2 Alternative 2



SWEPT PATH LEGEND

- VEHICLE BODY
- FRONT TIRES
- VEHICLE PATH
- VEHICLE CLEARANCE (500mm)
- VEHICLE

19M AV

Tractor Width	: 2.50
Trailer Width	: 2.50
Tractor Track	: 2.50
Trailer Track	: 2.50
Lock to Lock Time	: 6.0
Steering Angle	: 27.7
Articulating Angle	: 70.0

Meters

SCALE 1:1500

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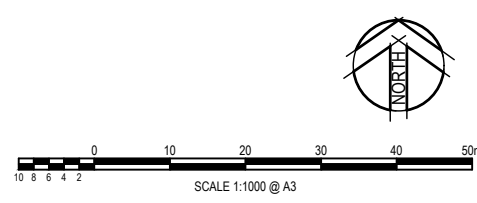
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CRR Southern Portal TIA
Option 2 Access Review
Peter Doherty Street Entry
Access 2 - 19m AV Swept Path

Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:1500	A3
Drawing Number	Revision		
QTT20037 - SK03			A



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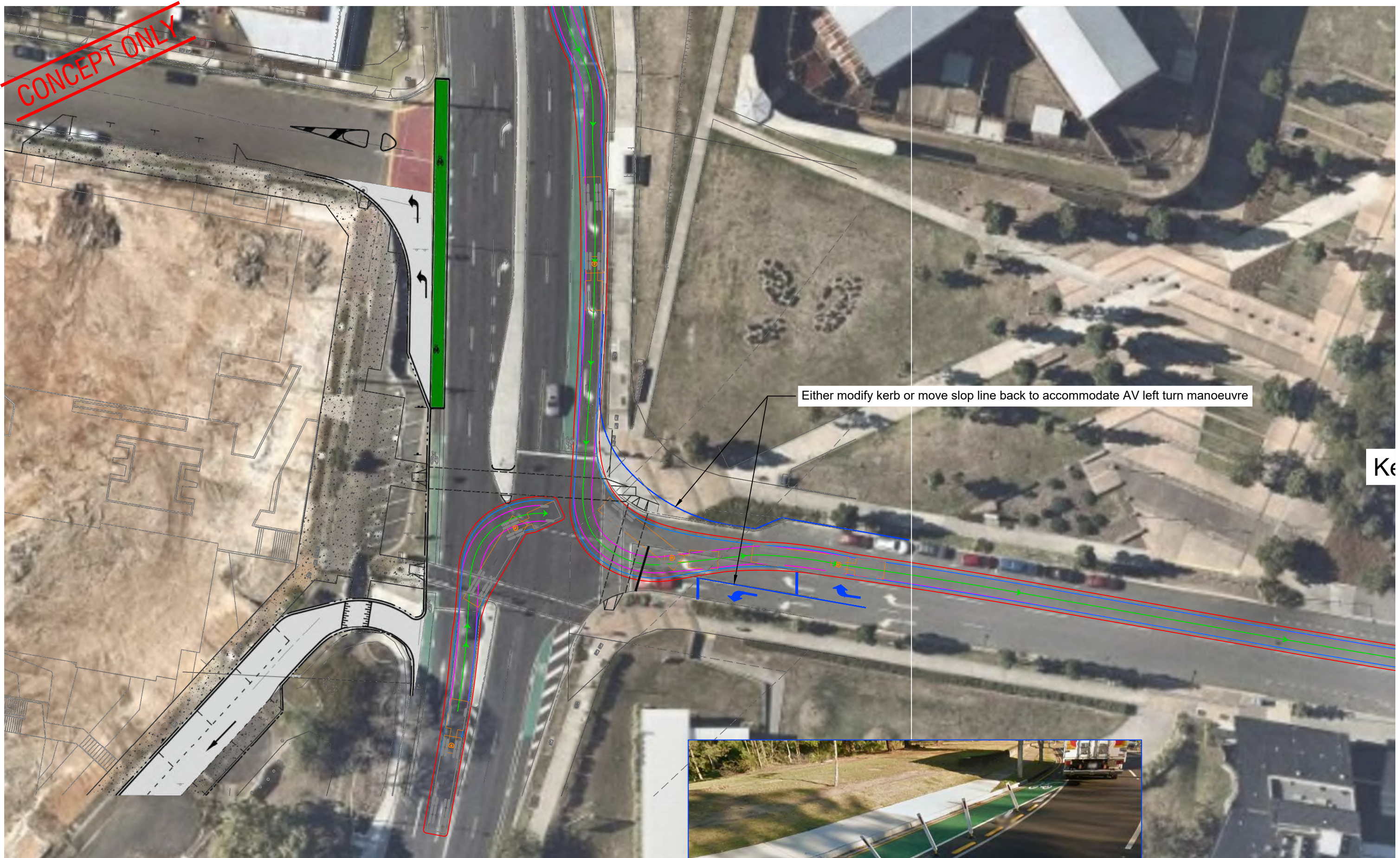


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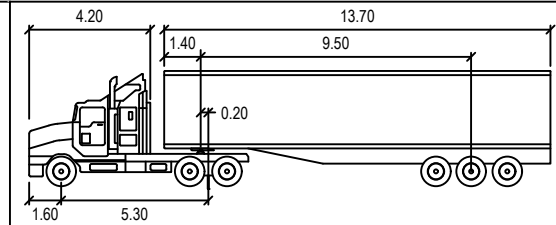
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CRR Southern Portal TIA			
Option 1-3 Access Review			
Peter Doherty Street Intersection Modification			
Design Vehicle Amendmnet Option			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:1000	A3
Drawing Number			Revision
QTT20037 - SK11			A

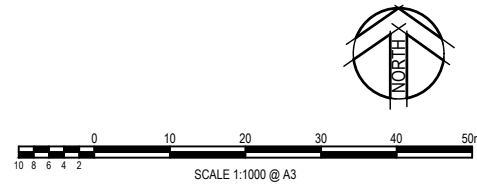


CAD File: G:\QTT20037 - CRR Southern Portal TIA\6. ACAD\QTT20037 - SK01 - SK02 - D.dwg
Imagery supplied by nearmap, October 2020

SWEPT PATH LEGEND	
	VEHICLE BODY
	FRONT TIRES
	VEHICLE PATH
	VEHICLE CLEARANCE (500mm)
	VEHICLE



19M AV	
Tractor Width	: 2.50
Trailer Width	: 2.50
Tractor Track	: 2.50
Trailer Track	: 2.50
Lock to Lock Time	: 6.0
Steering Angle	: 27.7
Articulating Angle	: 70.0



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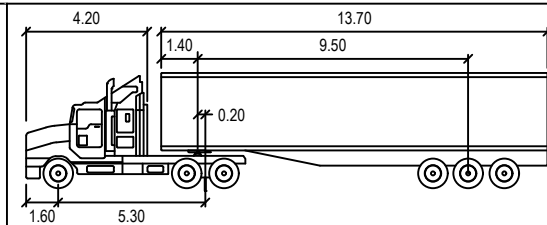
CBGU Joint Venture			
CRR Southern Portal TIA			
Option 1-3 Upgraded Scholl Access Review			
Peter Doherty Street Intersection Modifications			
Design Vehicle Amendment Options			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:1000	A3
Drawing Number			Revision
QTT20037 - SK12			A

OPTION 3 REVIEW



SWEPT PATH LEGEND

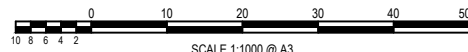
- VEHICLE BODY
- FRONT TIRES
- VEHICLE PATH
- VEHICLE CLEARANCE (500mm)
- VEHICLE



19M AV

Tractor Width	: 2.50
Trailer Width	: 2.50
Tractor Track	: 2.50
Trailer Track	: 2.50
Lock to Lock Time	: 6.0
Steering Angle	: 27.7
Articulating Angle	: 70.0

Meters



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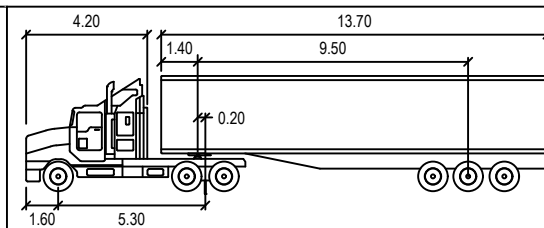
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CRR Southern Portal TIA				
Option 3 Access Review				
Boggo Road Entry				
Access 2 - 19m AV Swept Path				
Drawn	Date	Scale	Size	
T.Anang	30/10/2020	1:1000	A3	
Drawing Number	Revision			
QTT20037 - SK05	A			



SWEPT PATH LEGEND

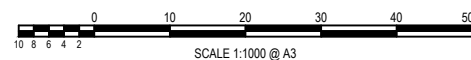
- VEHICLE BODY
- FRONT TIRES
- VEHICLE PATH
- VEHICLE CLEARANCE (500mm)
- VEHICLE



19M AV

- Tractor Width : 2.50
- Trailer Width : 2.50
- Tractor Track : 2.50
- Trailer Track : 2.50
- Lock to Lock Time : 6.0
- Steering Angle : 27.7
- Articulating Angle : 70.0

Meters



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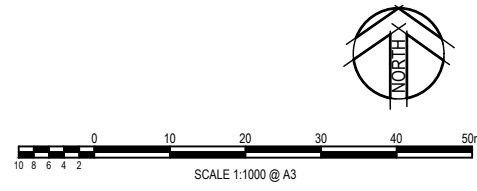
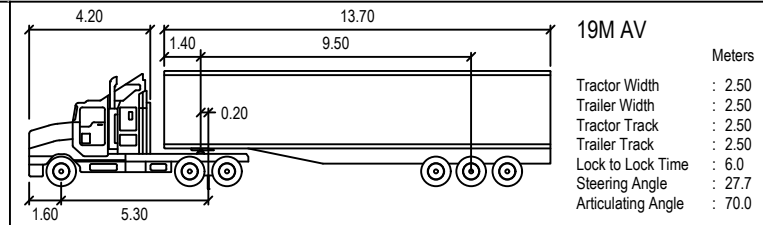
CBGU Joint Venture			
CRR Southern Portal TIA			
Option 3 Access Review			
Boggo Road Entry			
Access 3 - 19m AV Swept Path			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:1000	A3
Drawing Number	Revision		
QTT20037 - SK06	A		

OPTION 4 REVIEW



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SWEEP PATH LEGEND	
	VEHICLE BODY
	FRONT TIRES
	VEHICLE PATH
	VEHICLE CLEARANCE (500mm)
	VEHICLE



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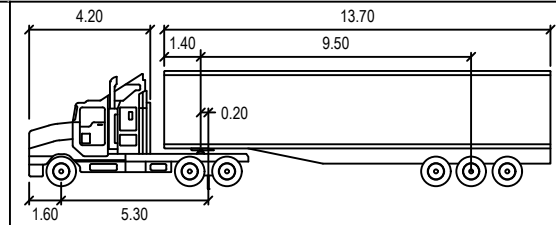


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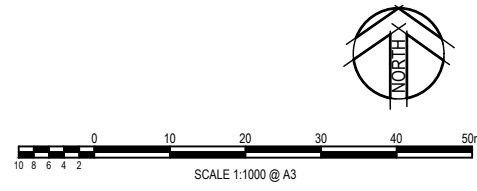
CBGU Joint Venture			
CRR Southern Portal TIA			
Option 4 Access Review			
Rawnsley Street Entry			
Access 4 - 19m AV Sweep Path			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:1000	A3
Drawing Number			Revision
QTT20037 - SK07			A



SWEEP PATH LEGEND	
	VEHICLE BODY
	FRONT TIRES
	VEHICLE PATH
	VEHICLE CLEARANCE (500mm)
	VEHICLE



19M AV	
Tractor Width	: 2.50
Trailer Width	: 2.50
Tractor Track	: 2.50
Trailer Track	: 2.50
Lock to Lock Time	: 6.0
Steering Angle	: 27.7
Articulating Angle	: 70.0



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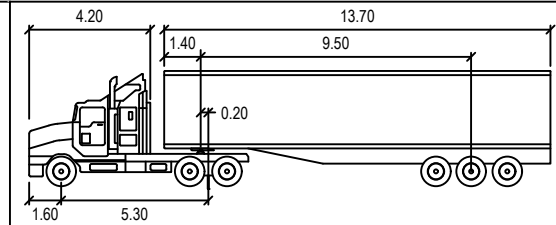
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CRR Southern Portal TIA			
Option 4 Access Review			
Dutton Street Exit			
Access 4 - 19m AV Swept Path			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:1000	A3
Drawing Number			Revision
QTT20037 - SK08			A

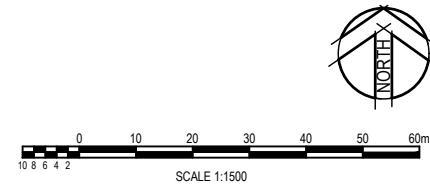


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SWEEP PATH LEGEND	
	VEHICLE BODY
	FRONT TIRES
	VEHICLE PATH
	VEHICLE CLEARANCE (500mm)
	VEHICLE



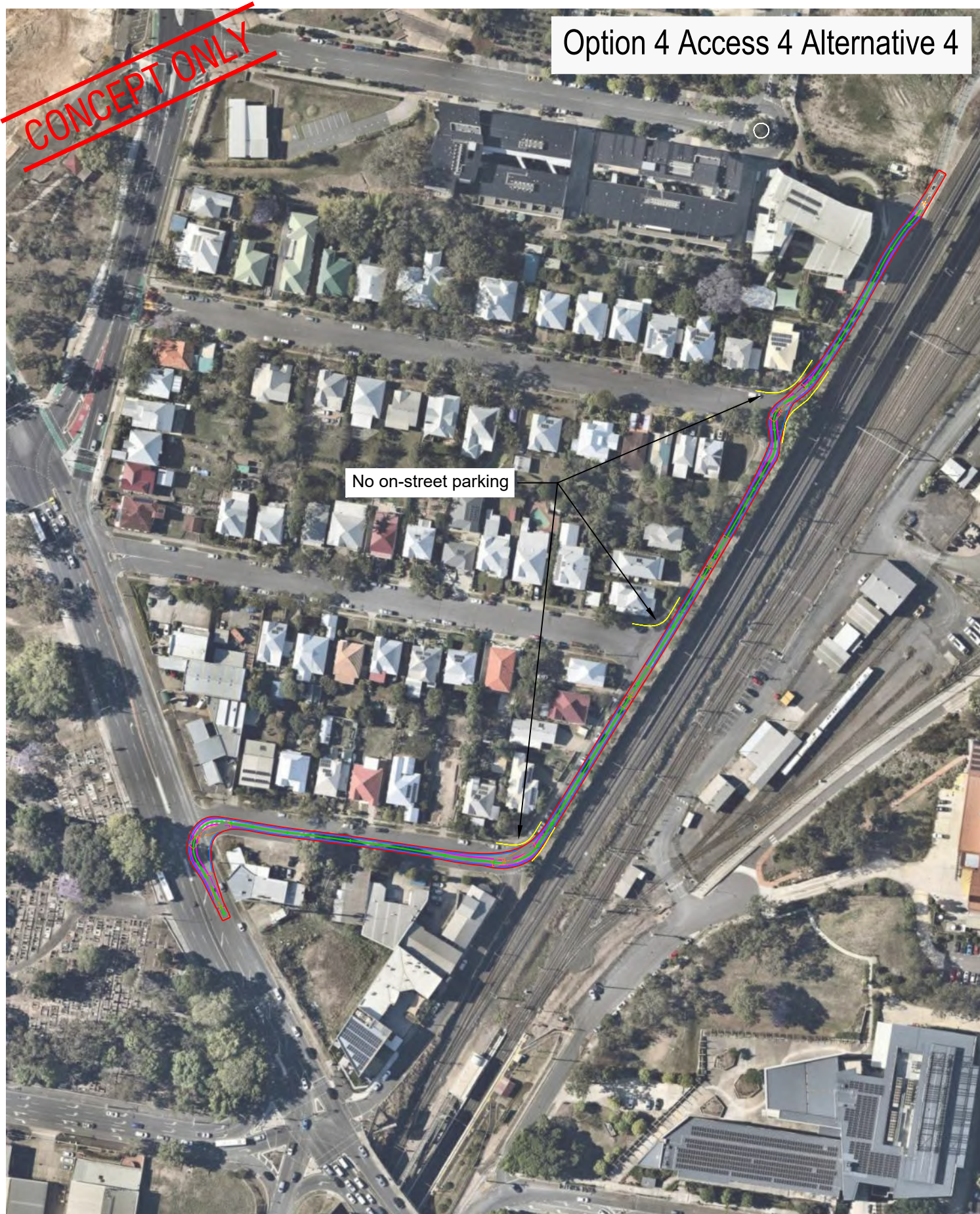
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Trailer Width	: 2.50
Tractor Track	: 2.50
Trailer Track	: 2.50
Lock to Lock Time	: 6.0
Steering Angle	: 27.7
Articulating Angle	: 70.0



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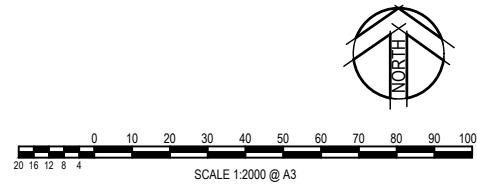
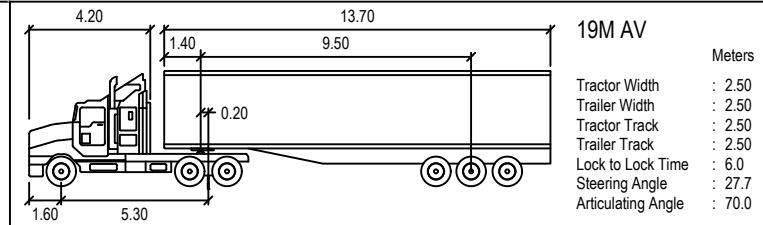
CBGU Joint Venture			
CRR Southern Portal TIA			
Option 4 Access Review			
Pound Street Entry			
Access 4 - 19m AV Sweep Path			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:1500	A3
Drawing Number	Revision		
QTT20037 - SK09	A		



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SWEPT PATH LEGEND

	VEHICLE BODY
	FRONT TIRES
	VEHICLE PATH
	VEHICLE CLEARANCE (500mm)
	VEHICLE



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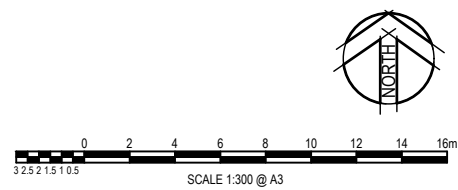
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Option 4 Access Review			
Pound Street Exit			
Access 4 - 19m AV Swept Path			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:2000	A3
Drawing Number	Revision		
QTT20037 - SK10	A		



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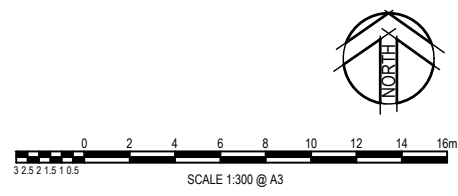
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Option 4 Access Review			
Rawnsley Street Intersection Modifications			
Design Vehicle Amendment Options			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:300	A3
Drawing Number			Revision
QTT20037 - SK15			A



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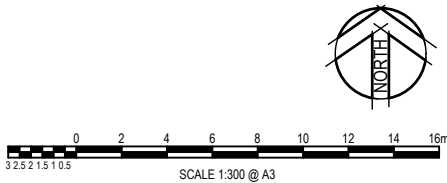
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CRR Southern Portal TIA			
Option 4 Access Review			
Dutton Street Intersection Modifications			
Concept Amendment			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:300	A3
Drawing Number			Revision
QTT20037 - SK16			A



Modify kerb to enable AV left turn manoeuvre to reduce encroachment into through traffic lanes

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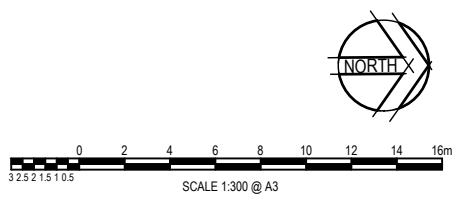
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CRR Southern Portal TIA			
Option 4 Access Review			
Dutton Street Intersection Modifications			
Concept Amendment			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:300	A3
Drawing Number			Revision
QTT20037 - SK17			A

SIGHT LINE REVIEW



44m Max Achievable MGSD for 30km/hr 85th Percentile Speed

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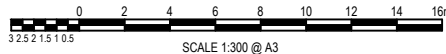

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Drawn T.Anang	Date 30/10/2020	Scale 1:300	Size A3
Drawing Number QTT20037 - SK18			Revision A



CONCEPT ONLY

55m Desirable SSD for 40km/hr Frontage Road Speed



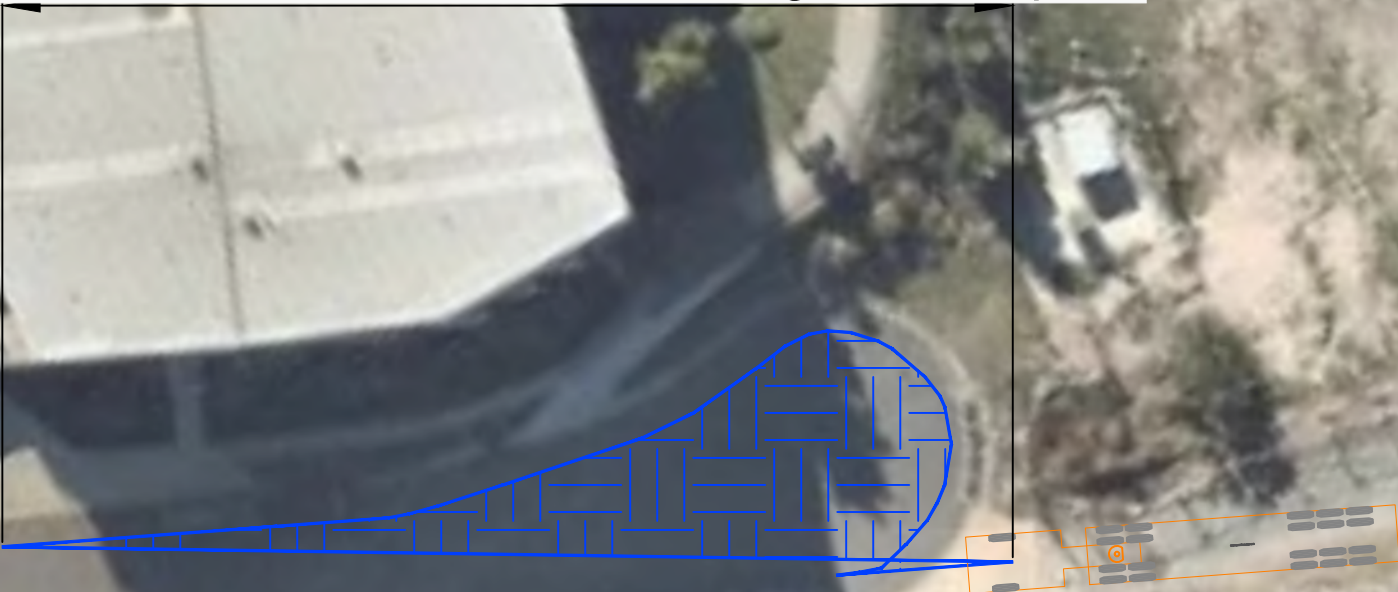
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CRR Southern Portal TIA			
Access 2 Review			
Sight Distance Check			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:300	A3
Drawing Number			Revision
QTT20037 - SK19			A

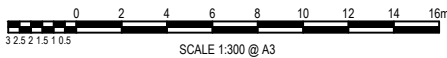
CONCEPT ONLY

55m Desirable SSD for 40km/hr Frontage Road Speed



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CRR Southern Portal TIA			
Access 4 Review			
Sight Distance Check			
Drawn T.Anang	Date 30/10/2020	Scale 1:300	Size A3
Drawing Number QTT20037 - SK20			Revision A

APPENDIX

B

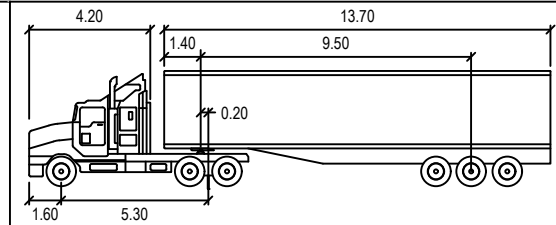
REVISED OPTION CONCEPTS

OPTION 1 REVIEW

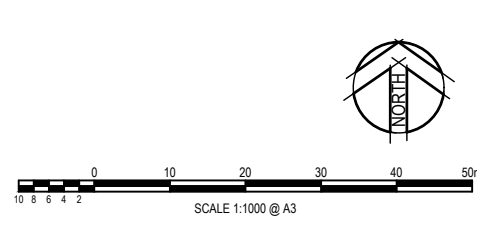


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SWEEP PATH LEGEND	
	VEHICLE BODY
	FRONT TIRES
	VEHICLE PATH
	VEHICLE CLEARANCE (500mm)
	VEHICLE



19M AV	
Tractor Width	: 2.50
Trailer Width	: 2.50
Tractor Track	: 2.50
Trailer Track	: 2.50
Lock to Lock Time	: 6.0
Steering Angle	: 27.7
Articulating Angle	: 70.0



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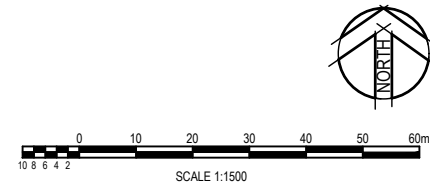
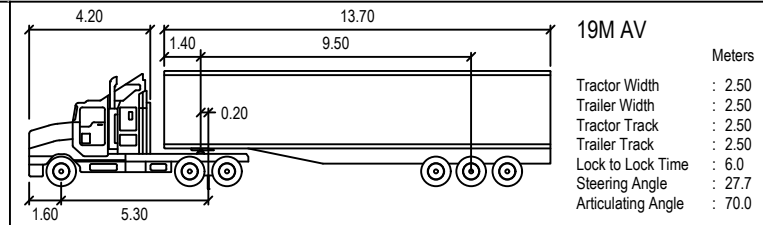
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Drawn T.Anang	Date 24/09/2020	Scale 1:1000	Size A3
Drawing Number QTT20037 - SK01			Revision B



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SWEEP PATH LEGEND	
	VEHICLE BODY
	FRONT TIRES
	VEHICLE PATH
	VEHICLE CLEARANCE (500mm)
	VEHICLE



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CRR Southern Portal TIA			
Option 1 Access Review			
Peter Doherty Street Entry			
Access B - 19m AV Swept Path			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:1500	A3
Drawing Number			Revision
QTT20037 - SK02			B

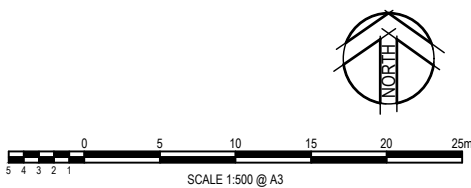


Option 1 Existing Intersection Modifications Layout 1

CONCEPT ONLY

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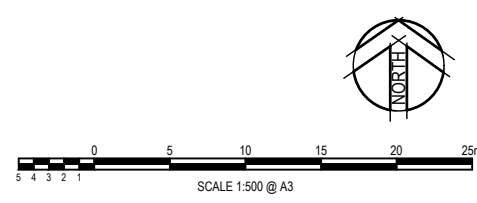
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Option 2 Upgraded School Access Review			
Peter Doherty Street Intersection Modifications			
Design Vehicle Amendments Layout 2			
Drawn	Date	Scale	Size
T.Anang	24/09/2020	1:500	A3
Drawing Number	Revision		
QTT20037 - SK11	B		



Option 1 School Upgrade Intersection Modifications Layout 1

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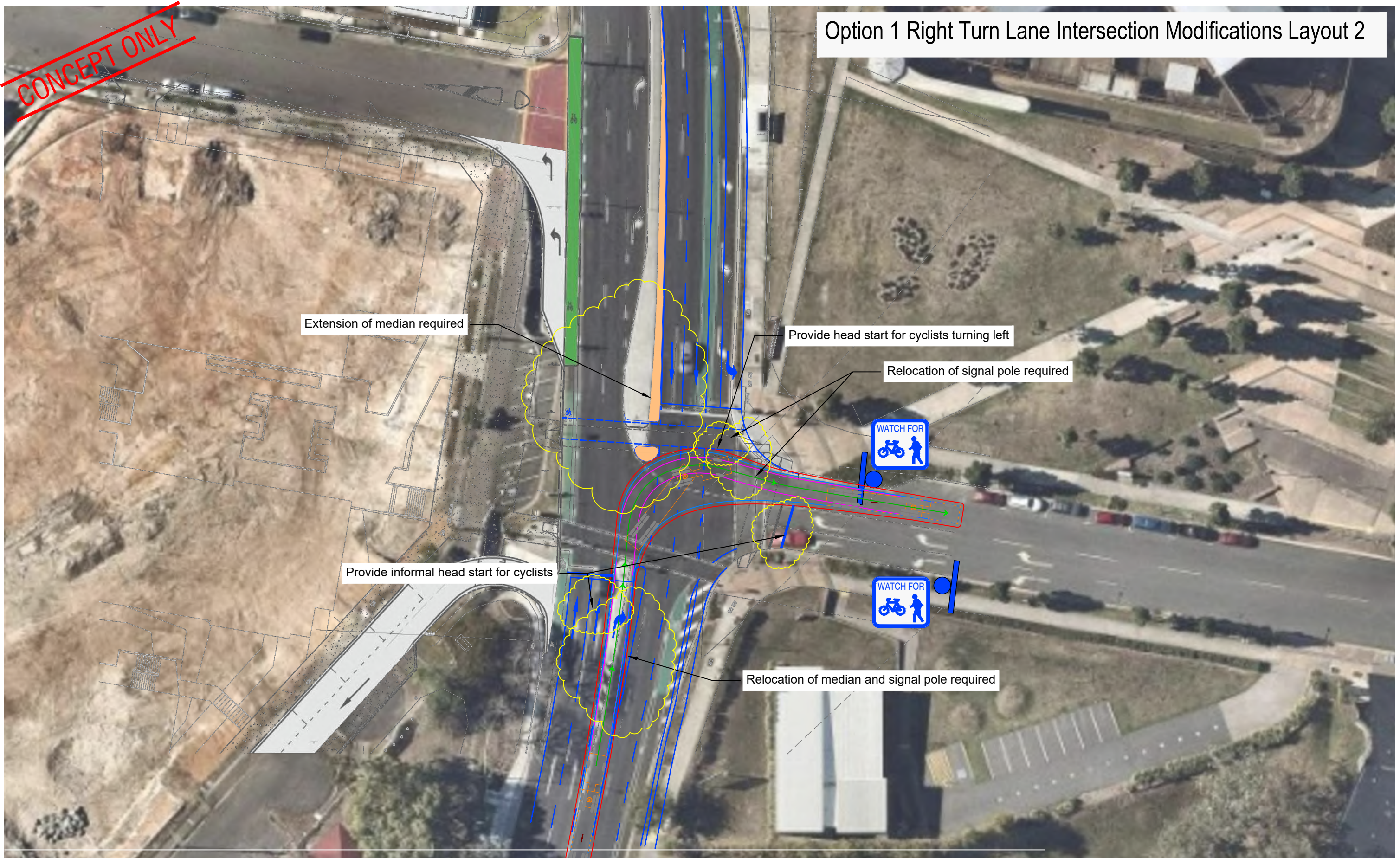


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CRR Southern Portal TIA			
Option 2 Upgraded School Access Review			
Peter Doherty Street Intersection Modifications			
Design Vehicle Amendments Layout 2			
Drawn	Date	Scale	Size
T.Anang	24/09/2020	1:500	A3
Drawing Number			Revision
QTT20037 - SK12			B



Option 1 Right Turn Lane Intersection Modifications Layout 2

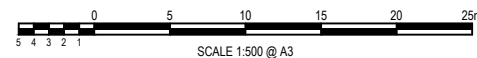
Extension of median required

Provide head start for cyclists turning left

Relocation of signal pole required

Provide informal head start for cyclists

Relocation of median and signal pole required

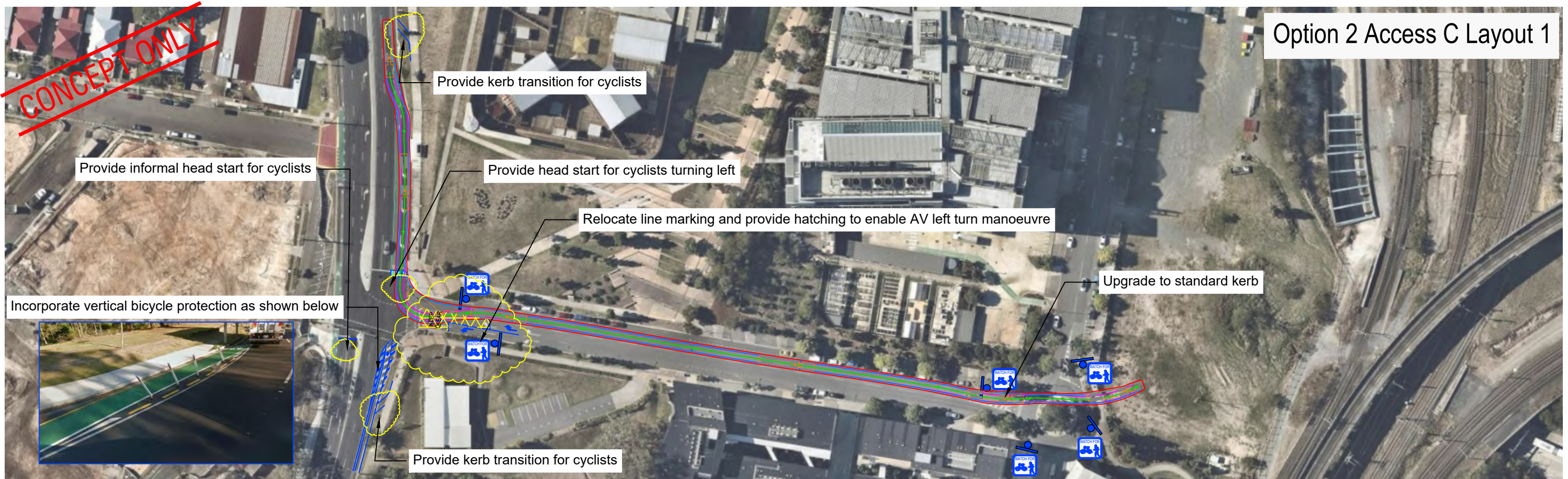


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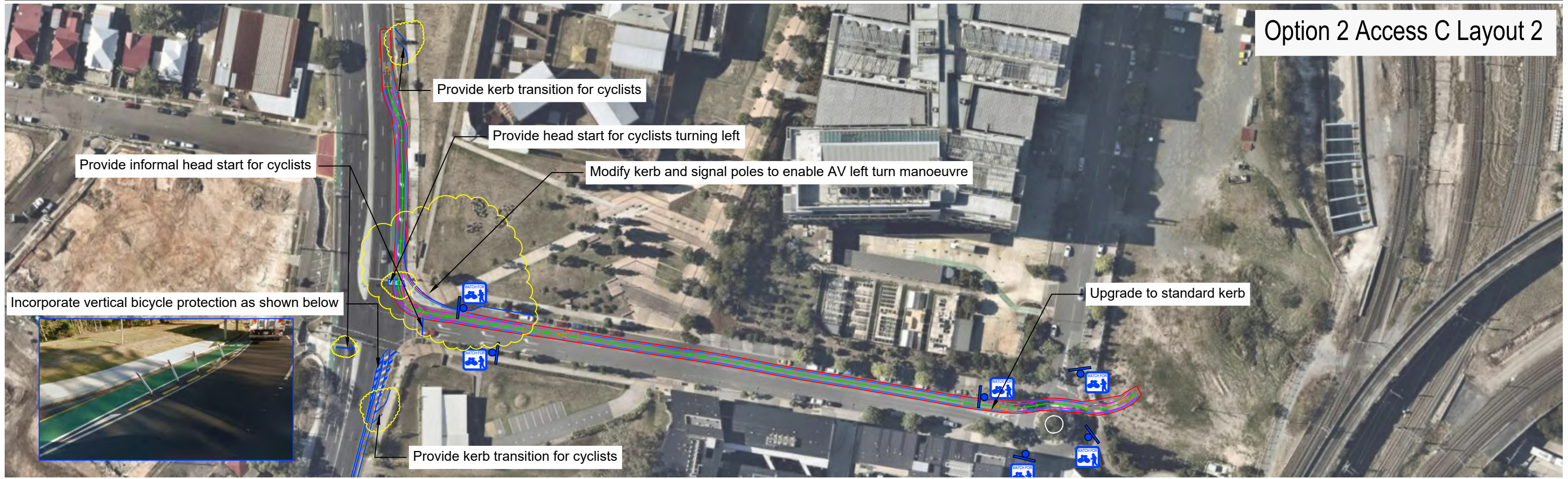
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CRR Southern Portal TIA			
Option 1-3 Access Review			
Peter Doherty Street Intersection Modifications			
Right Turn Lane Concept			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:500	A3
Drawing Number			Revision
QTT20037 - SK13			D

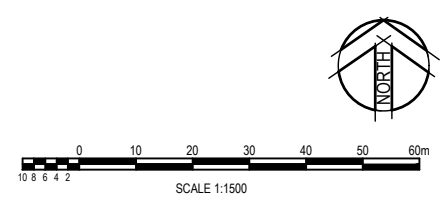
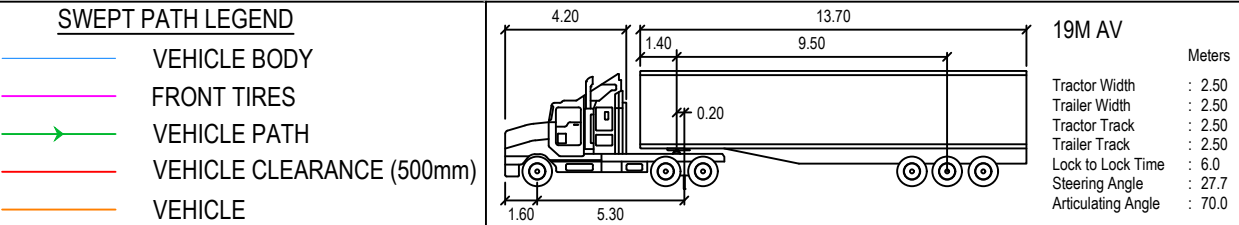
OPTION 2 REVIEW



Option 2 Access C Layout 1



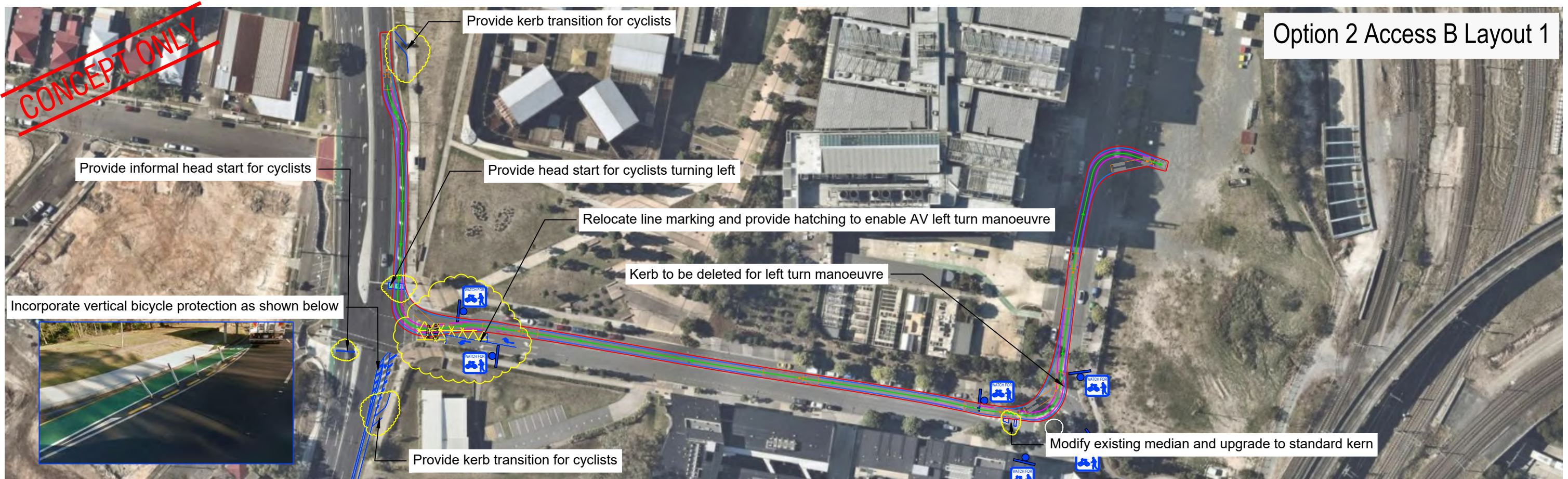
Option 2 Access C Layout 2



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Option 2 Access Review			
Peter Doherty Street Entry			
Access C - 19m AV Swept Path			
Drawn	Date	Scale	Size
T.Anang	24/09/2020	1:1500	A3
Drawing Number			Revision
QTT20037 - SK03			B



Option 2 Access B Layout 1



Option 2 Access B Layout 2

SWEPT PATH LEGEND

- VEHICLE BODY
- FRONT TIRES
- VEHICLE PATH
- VEHICLE CLEARANCE (500mm)
- VEHICLE

19M AV

Tractor Width	: 2.50
Trailer Width	: 2.50
Tractor Track	: 2.50
Trailer Track	: 2.50
Lock to Lock Time	: 6.0
Steering Angle	: 27.7
Articulating Angle	: 70.0

Meters

SCALE 1:1500

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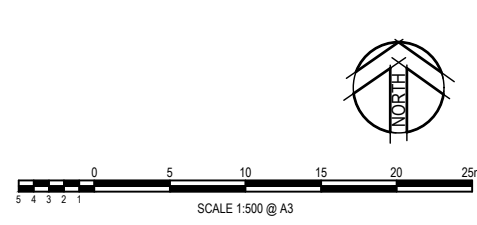
CBGU Joint Venture
CRR Southern Portal TIA
Option 2 Access Review
Peter Doherty Street Entry
Access C - 19m AV Swept Path

Drawn	Date	Scale	Size
T.Anang	24/09/2020	1:1500	A3
Drawing Number	Revision		
QTT20037 - SK04			B



Option 2 Existing Intersection Modifications Layout 1

CAD File: G:\QTT20037 - CRR Southern Portal TIA\6 ACAD\QTT20037 - SK01 - SK02 - D.dwg
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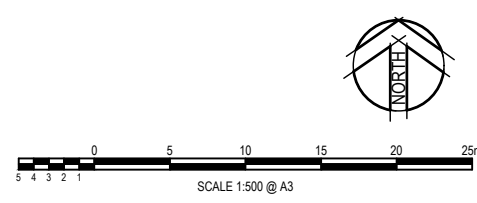


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CRR Southern Portal TIA			
Option 2 Access Review			
Peter Doherty Street Intersection Modifications			
Design Vehicle Amendments Layout 1			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:500	A3
Drawing Number			Revision
QTT20037 - SK21			A



CAD File: G:\QTT20037 - CRR Southern Portal TIA\6 ACAD\QTT20037 - SK01 - SK02 - D.dwg
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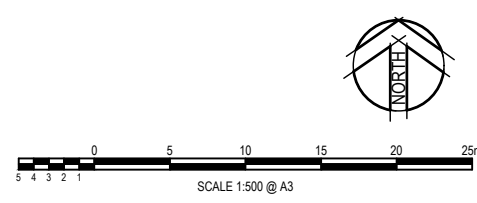


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Option 2 Access Review			
Peter Doherty Street Intersection Modifications			
Design Vehicle Amendments Layout 2			
Drawn	Date	Scale	Size
T.Anang	24/09/2020	1:500	A3
Drawing Number			Revision
QTT20037 - SK22			A



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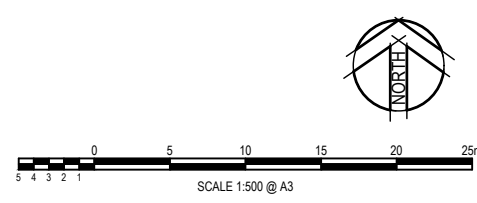


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Option 2 Access Review			
Peter Doherty Street Intersection Modifications			
Design Vehicle Amendments Layout 1			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:500	A3
Drawing Number			Revision
QTT20037 - SK23			A



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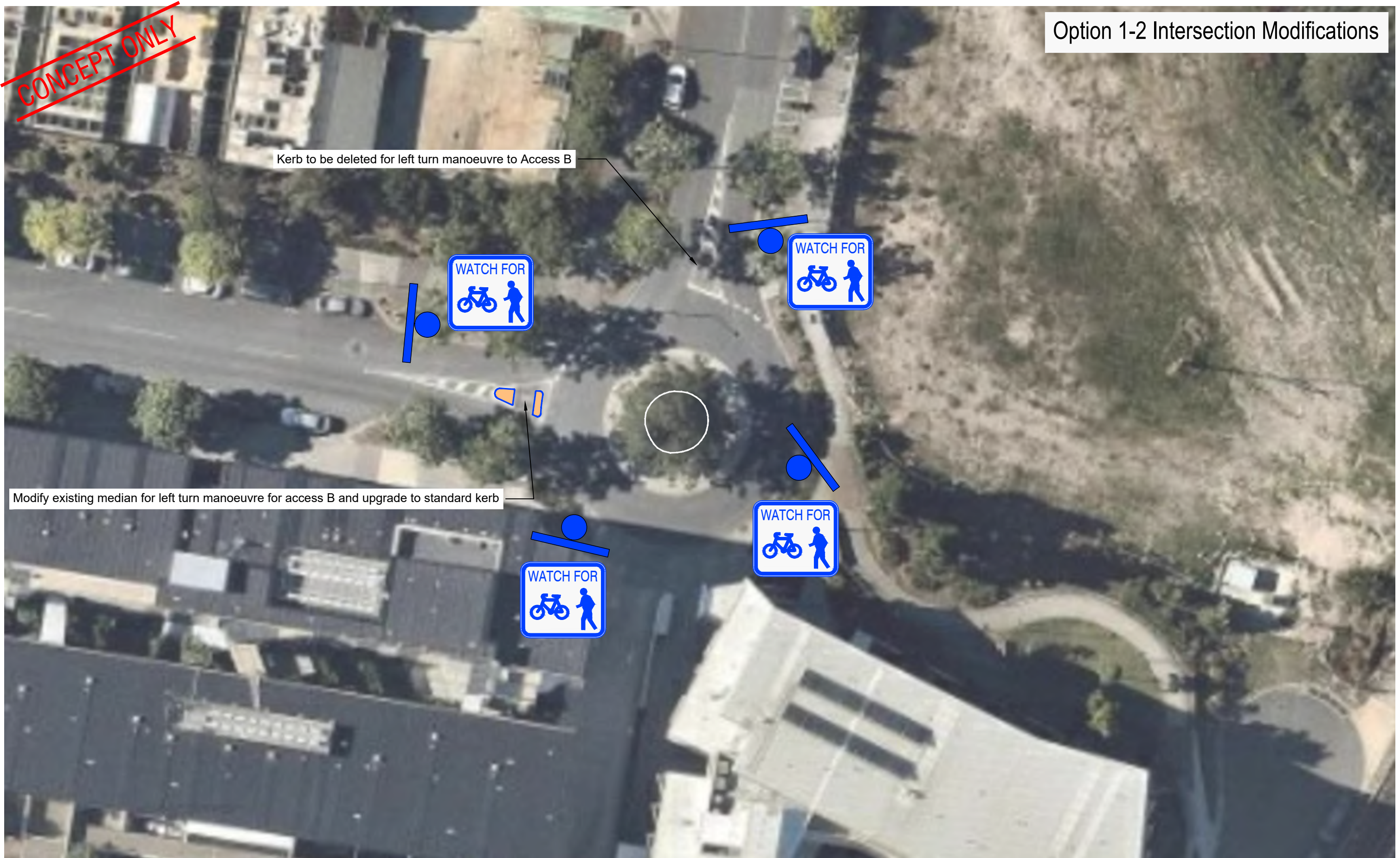
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Option 2 Access Review			
Peter Doherty Street Intersection Modifications			
Design Vehicle Amendments Layout 2			
Drawn	Date	Scale	Size
T.Anang	30/10/2020	1:500	A3
Drawing Number			Revision
QTT20037 - SK24			A

OPTION 1 AND 2 – LOCAL ROAD REVIEW



Option 1-2 Intersection Modifications

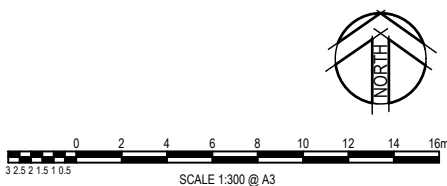
CONCEPT ONLY

Kerb to be deleted for left turn manoeuvre to Access B

Modify existing median for left turn manoeuvre for access B and upgrade to standard kerb

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Option 1-2 Access Review			
Site Access Intersection Modifications			
Concept Amendments			
Drawn	Date	Scale	Size
T.Anang	02/09/2020	1:300	A3
Drawing Number			Revision
QTT20037 - SK14			A

APPENDIX

C

SIDRA RESULTS – ANNERLEY RD /
PETER DOHERTY RD

Option 1 Layout 1 (Split Phasing)

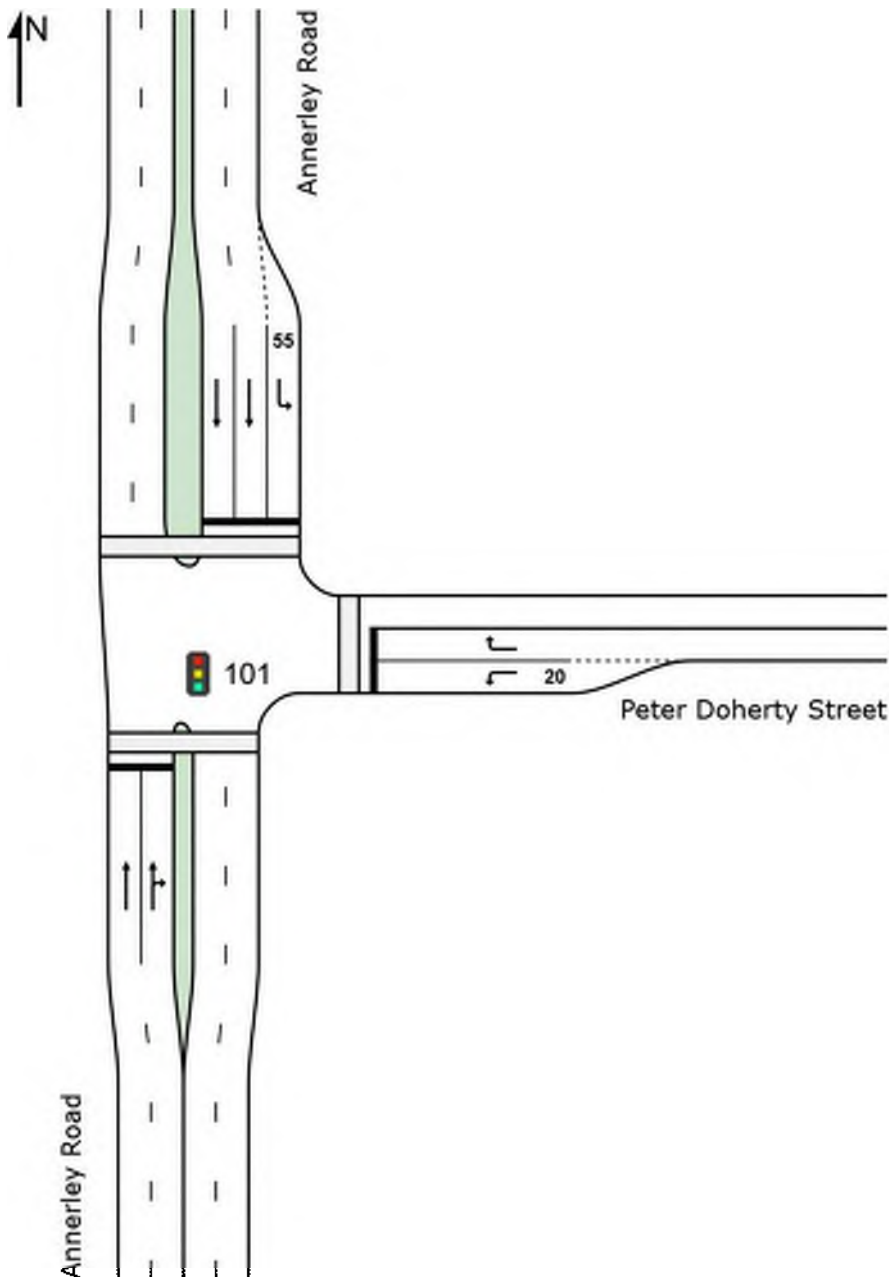
SITE LAYOUT

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated



MOVEMENT SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	1064	5.0	0.750	37.0	LOS D	29.7	216.9	0.93	0.83	0.93	19.7
3	R2	15	100.0	0.750	43.1	LOS D	29.1	217.2	0.93	0.83	0.93	19.7
Approach		1079	6.3	0.750	37.2	LOS D	29.7	217.2	0.93	0.83	0.93	19.7
East: Peter Doherty Street												
4	L2	69	63.6	0.683	74.1	LOS E	4.6	50.3	1.00	0.84	1.15	13.0
6	R2	24	13.0	0.168	67.3	LOS E	1.5	11.5	0.96	0.71	0.96	14.2
Approach		94	50.6	0.683	72.4	LOS E	4.6	50.3	0.99	0.80	1.10	13.3
North: Annerley Road												
7	L2	9	0.0	0.030	53.8	LOS D	0.5	3.5	0.86	0.67	0.86	16.8
8	T1	543	3.3	0.742	55.4	LOS E	16.9	121.3	1.00	0.88	1.05	14.8
Approach		553	3.2	0.742	55.4	LOS E	16.9	121.3	1.00	0.88	1.05	14.9
All Vehicles		1725	7.7	0.750	44.9	LOS D	29.7	217.2	0.96	0.84	0.98	17.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

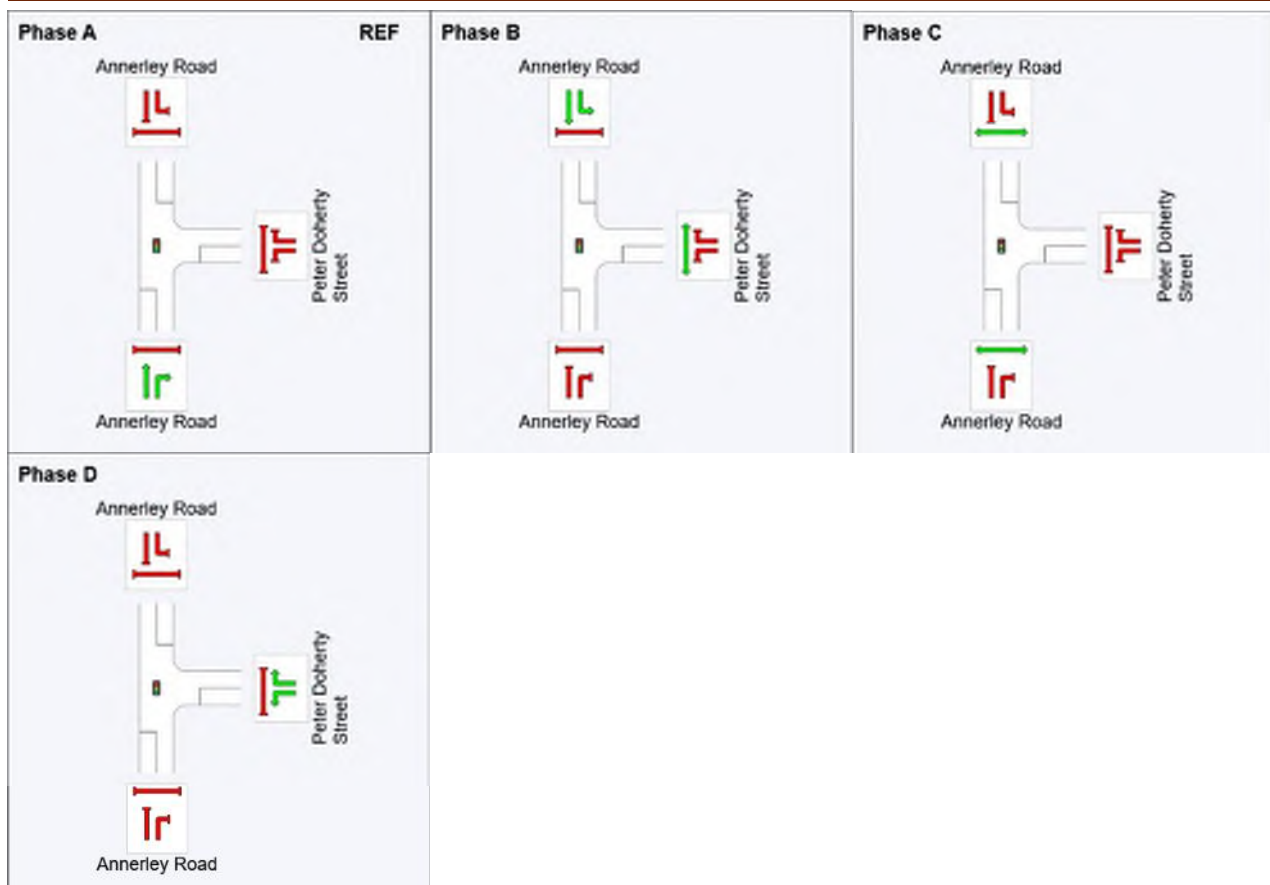
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	56	87	113
Green Time (sec)	50	25	20	11
Phase Time (sec)	56	31	26	17
Phase Split	43%	24%	20%	13%

See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



MOVEMENT SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP1 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	543	7.0	0.735	53.7	LOS D	17.4	129.1	0.99	0.87	1.04	15.2
3	R2	16	93.3	0.735	60.5	LOS E	16.8	129.7	0.99	0.87	1.04	14.9
Approach		559	9.4	0.735	53.9	LOS D	17.4	129.7	0.99	0.87	1.04	15.2
East: Peter Doherty Street												
4	L2	98	45.2	0.731	71.5	LOS E	6.5	62.7	1.00	0.86	1.17	13.5
6	R2	42	0.0	0.211	63.9	LOS E	2.5	17.5	0.95	0.74	0.95	14.9
Approach		140	31.6	0.731	69.2	LOS E	6.5	62.7	0.98	0.82	1.10	13.9
North: Annerley Road												
7	L2	18	0.0	0.030	37.2	LOS D	0.8	5.3	0.71	0.68	0.71	21.4
8	T1	972	1.8	0.735	39.8	LOS D	27.2	193.1	0.94	0.83	0.94	18.8
Approach		989	1.8	0.735	39.7	LOS D	27.2	193.1	0.93	0.83	0.93	18.9
All Vehicles		1688	6.8	0.735	46.9	LOS D	27.2	193.1	0.96	0.84	0.98	16.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP1 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

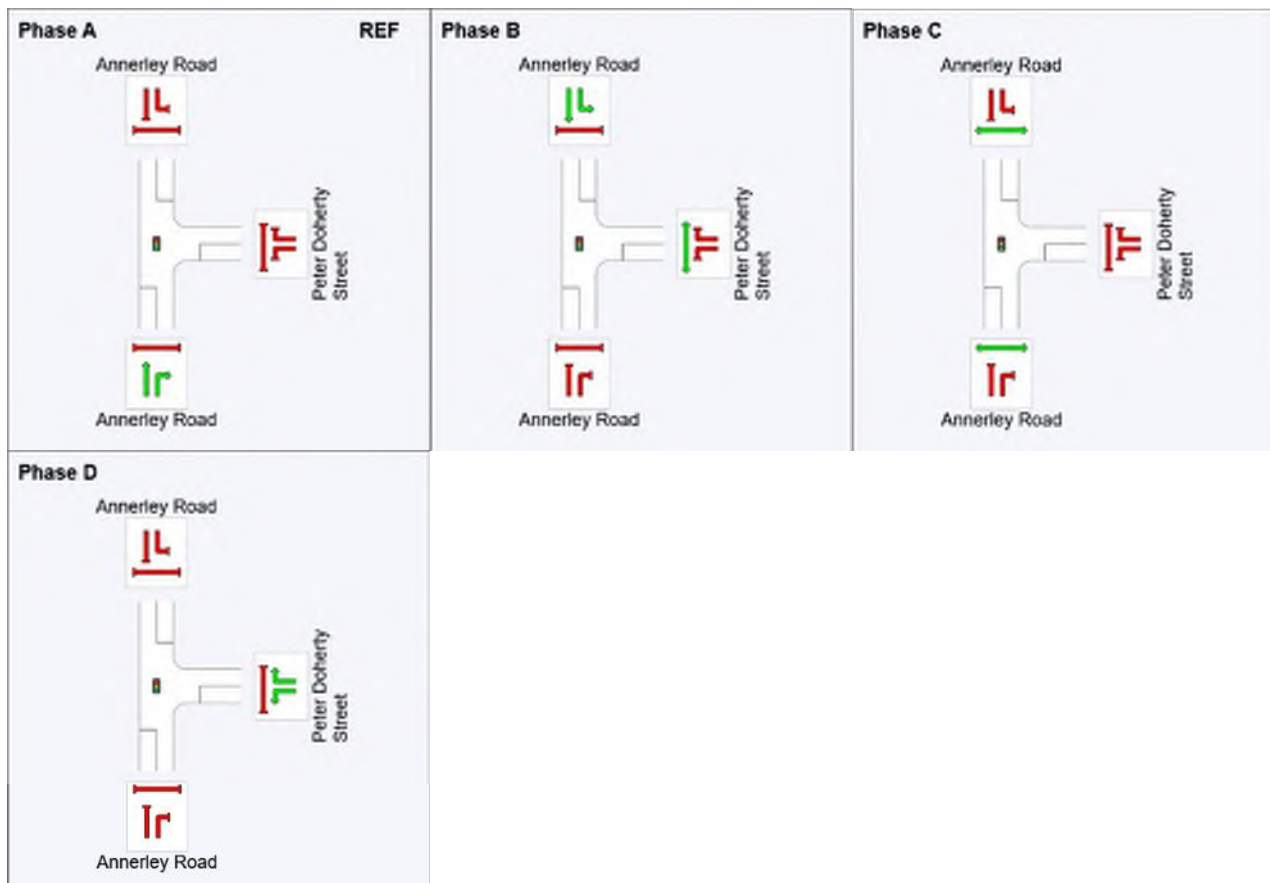
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	33	84	110
Green Time (sec)	27	45	20	14
Phase Time (sec)	33	51	26	20
Phase Split	25%	39%	20%	15%

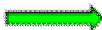
See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase

	Normal Movement		Permitted/Opposed
	Slip/Bypass-Lane Movement		Opposed Slip/Bypass-Lane
	Stopped Movement		Turn On Red

Option 1 Layout 1 (Leading Right Phasing)

MOVEMENT SUMMARY



Site: 101 [2020BG Road Peak AM - OP1 Layout 1 - leading right]

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	1064	5.0	0.524	19.3	LOS B	21.5	157.3	0.68	0.61	0.68	29.0
3	R2	15	100.0	0.524	28.9	LOS C	20.7	154.5	0.72	0.65	0.72	25.1
Approach		1079	6.3	0.524	19.5	LOS B	21.5	157.3	0.68	0.61	0.68	29.0
East: Peter Doherty Street												
4	L2	69	63.6	0.498	67.0	LOS E	4.3	46.8	0.98	0.78	0.98	14.0
6	R2	24	13.0	0.123	62.4	LOS E	1.4	10.9	0.93	0.71	0.93	15.0
Approach		94	50.6	0.498	65.8	LOS E	4.3	46.8	0.97	0.76	0.97	14.2
North: Annerley Road												
7	L2	9	0.0	0.019	42.4	LOS D	0.4	3.0	0.76	0.67	0.76	19.8
8	T1	543	3.3	0.529	43.6	LOS D	14.7	105.8	0.91	0.77	0.91	17.7
Approach		553	3.2	0.529	43.5	LOS D	14.7	105.8	0.90	0.77	0.90	17.7
All Vehicles		1725	7.7	0.529	29.7	LOS C	21.5	157.3	0.76	0.67	0.76	22.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 1 - leading right]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

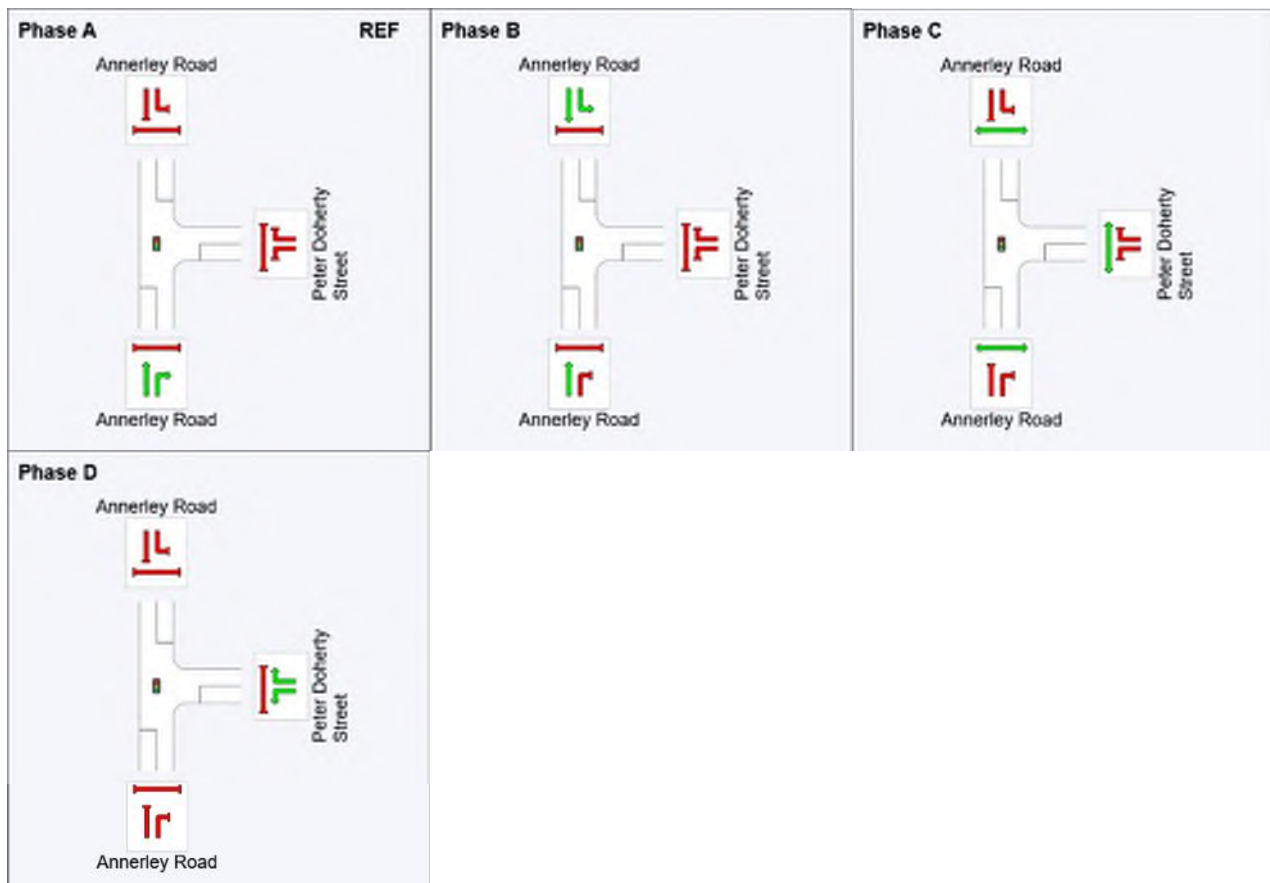
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	42	83	109
Green Time (sec)	36	35	20	15
Phase Time (sec)	42	41	26	21
Phase Split	32%	32%	20%	16%

See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase

	Normal Movement		Permitted/Opposed
	Slip/Bypass-Lane Movement		Opposed Slip/Bypass-Lane
	Stopped Movement		Turn On Red

MOVEMENT SUMMARY



Site: 101 [2020BG Road Peak PM - OP1 Layout 1 - leading right]

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	543	7.0	0.438	23.7	LOS C	16.6	123.3	0.68	0.59	0.68	26.0
3	R2	16	93.3	0.438	64.2	LOS E	6.0	49.4	0.97	0.77	0.97	14.3
Approach		559	9.4	0.438	24.9	LOS C	16.6	123.3	0.69	0.59	0.69	25.3
East: Peter Doherty Street												
4	L2	98	45.2	0.534	62.7	LOS E	5.9	57.2	0.96	0.79	0.96	14.8
6	R2	42	0.0	0.155	58.3	LOS E	2.4	16.5	0.91	0.73	0.91	15.9
Approach		140	31.6	0.534	61.4	LOS E	5.9	57.2	0.95	0.77	0.95	15.2
North: Annerley Road												
7	L2	18	0.0	0.021	24.9	LOS C	0.6	4.1	0.56	0.66	0.56	26.9
8	T1	972	1.8	0.541	26.0	LOS C	21.8	154.8	0.76	0.68	0.76	24.7
Approach		989	1.8	0.541	26.0	LOS C	21.8	154.8	0.76	0.68	0.76	24.8
All Vehicles		1688	6.8	0.541	28.5	LOS C	21.8	154.8	0.75	0.66	0.75	23.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP1 Layout 1 - leading right]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

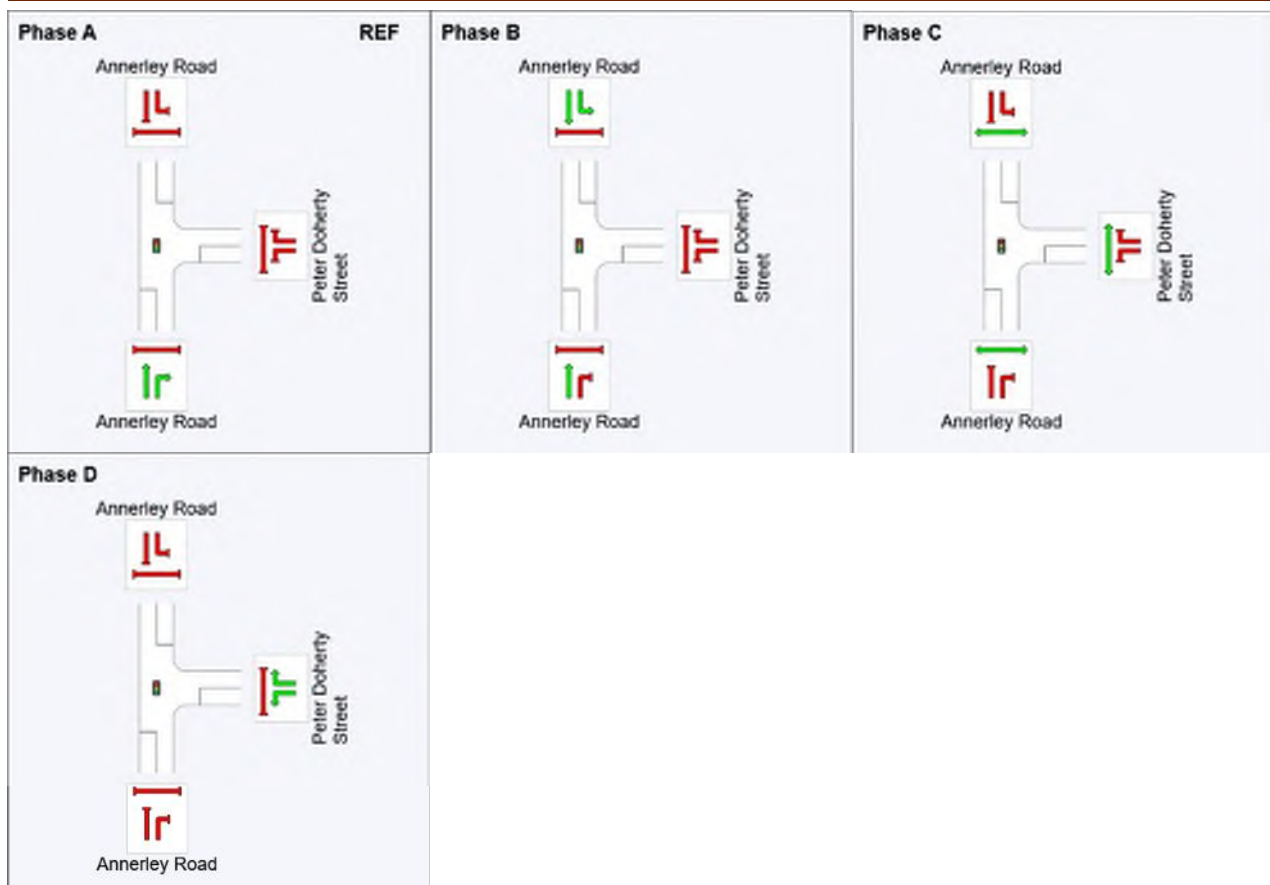
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	12	79	105
Green Time (sec)	6	61	20	19
Phase Time (sec)	12	67	26	25
Phase Split	9%	52%	20%	19%

See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



Option 1 Layout 1

(Leading Right with Filter Phasing)

MOVEMENT SUMMARY



Site: 101 [2020BG Road Peak AM - OP1 Layout 1 - leading right filter]

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	1064	5.0	0.483	14.4	LOS B	19.1	139.3	0.60	0.54	0.60	33.3
3	R2	15	100.0	0.483	20.6	LOS C	17.5	130.8	0.62	0.54	0.62	29.6
Approach		1079	6.3	0.483	14.6	LOS B	19.1	139.3	0.60	0.54	0.60	33.3
East: Peter Doherty Street												
4	L2	69	63.6	0.625	71.9	LOS E	4.5	49.2	1.00	0.81	1.08	13.3
6	R2	24	13.0	0.154	66.0	LOS E	1.5	11.3	0.95	0.71	0.95	14.4
Approach		94	50.6	0.625	70.4	LOS E	4.5	49.2	0.99	0.78	1.05	13.6
North: Annerley Road												
7	L2	9	0.0	0.022	46.5	LOS D	0.5	3.2	0.80	0.67	0.80	18.6
8	T1	543	3.3	0.618	48.5	LOS D	15.6	112.1	0.95	0.81	0.95	16.4
Approach		553	3.2	0.618	48.5	LOS D	15.6	112.1	0.95	0.80	0.95	16.4
All Vehicles		1725	7.7	0.625	28.4	LOS C	19.1	139.3	0.74	0.64	0.74	23.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 1 - leading right filter]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

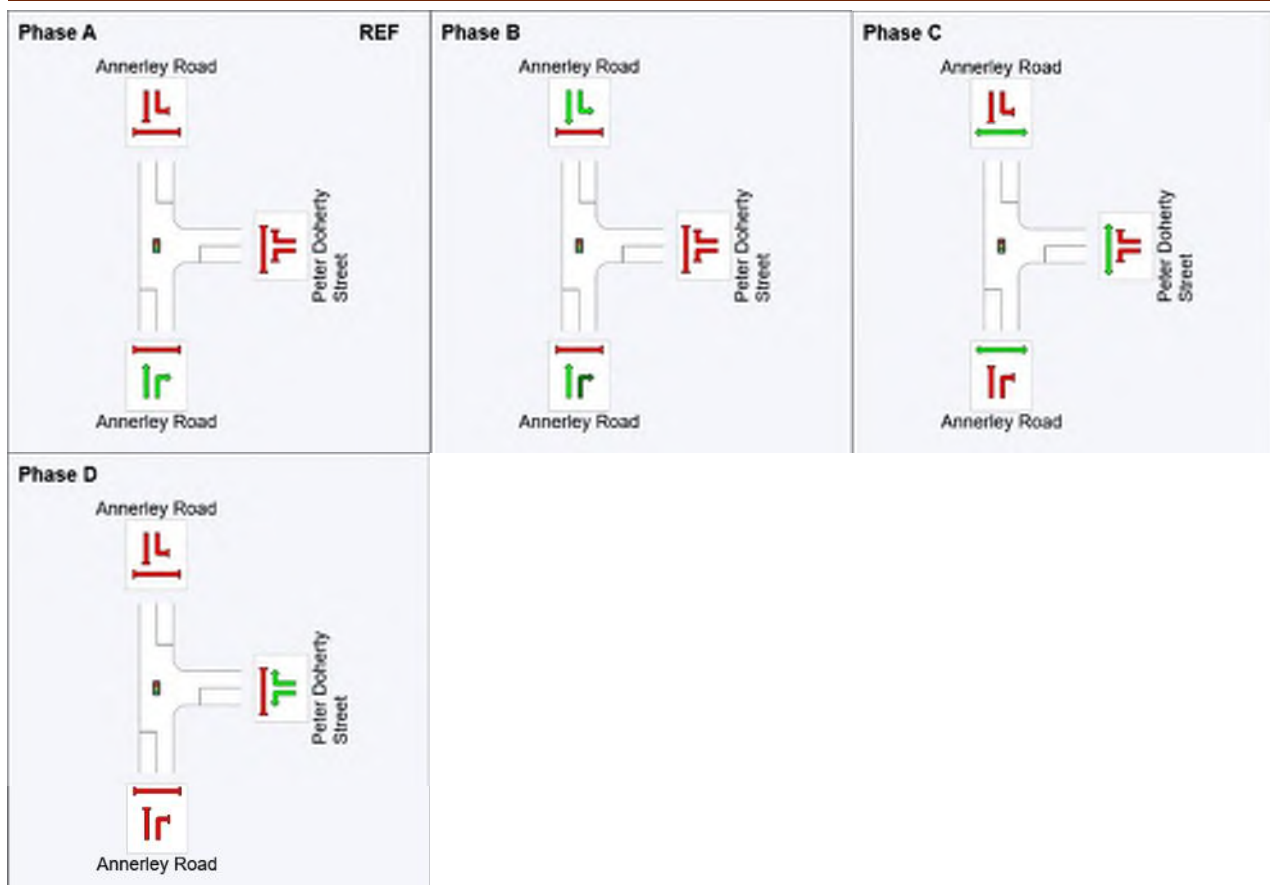
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	50	86	112
Green Time (sec)	44	30	20	12
Phase Time (sec)	50	36	26	18
Phase Split	38%	28%	20%	14%

See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



MOVEMENT SUMMARY



Site: 101 [2020BG Road Peak PM - OP1 Layout 1 - leading right filter]

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	543	7.0	0.298	14.7	LOS B	10.2	75.3	0.58	0.50	0.58	33.2
3	R2	16	93.3	0.298	21.8	LOS C	7.3	56.5	0.64	0.55	0.64	26.2
Approach		559	9.4	0.298	14.9	LOS B	10.2	75.3	0.58	0.50	0.58	32.9
East: Peter Doherty Street												
4	L2	98	45.2	0.638	67.1	LOS E	6.2	59.9	0.99	0.81	1.05	14.2
6	R2	42	0.0	0.184	61.6	LOS E	2.4	17.1	0.93	0.74	0.93	15.3
Approach		140	31.6	0.638	65.5	LOS E	6.2	59.9	0.97	0.79	1.01	14.5
North: Annerley Road												
7	L2	18	0.0	0.025	31.6	LOS C	0.7	4.8	0.65	0.67	0.65	23.6
8	T1	972	1.8	0.661	35.1	LOS D	25.4	180.9	0.88	0.78	0.88	20.5
Approach		989	1.8	0.661	35.1	LOS D	25.4	180.9	0.88	0.78	0.88	20.5
All Vehicles		1688	6.8	0.661	30.9	LOS C	25.4	180.9	0.79	0.69	0.79	22.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP1 Layout 1 - leading right filter]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

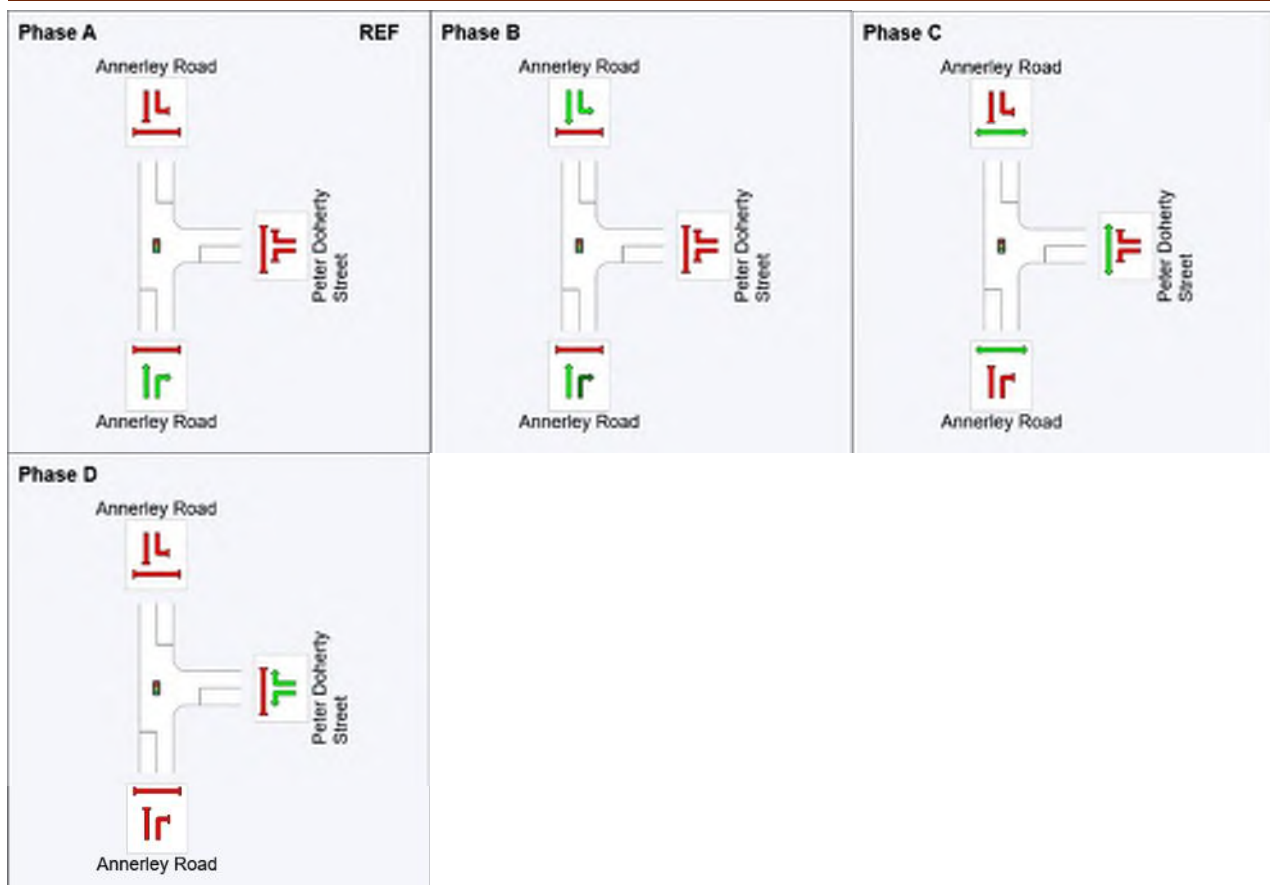
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	26	82	108
Green Time (sec)	20	50	20	16
Phase Time (sec)	26	56	26	22
Phase Split	20%	43%	20%	17%

See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



Option 1 Layout 2 (Split Phasing)

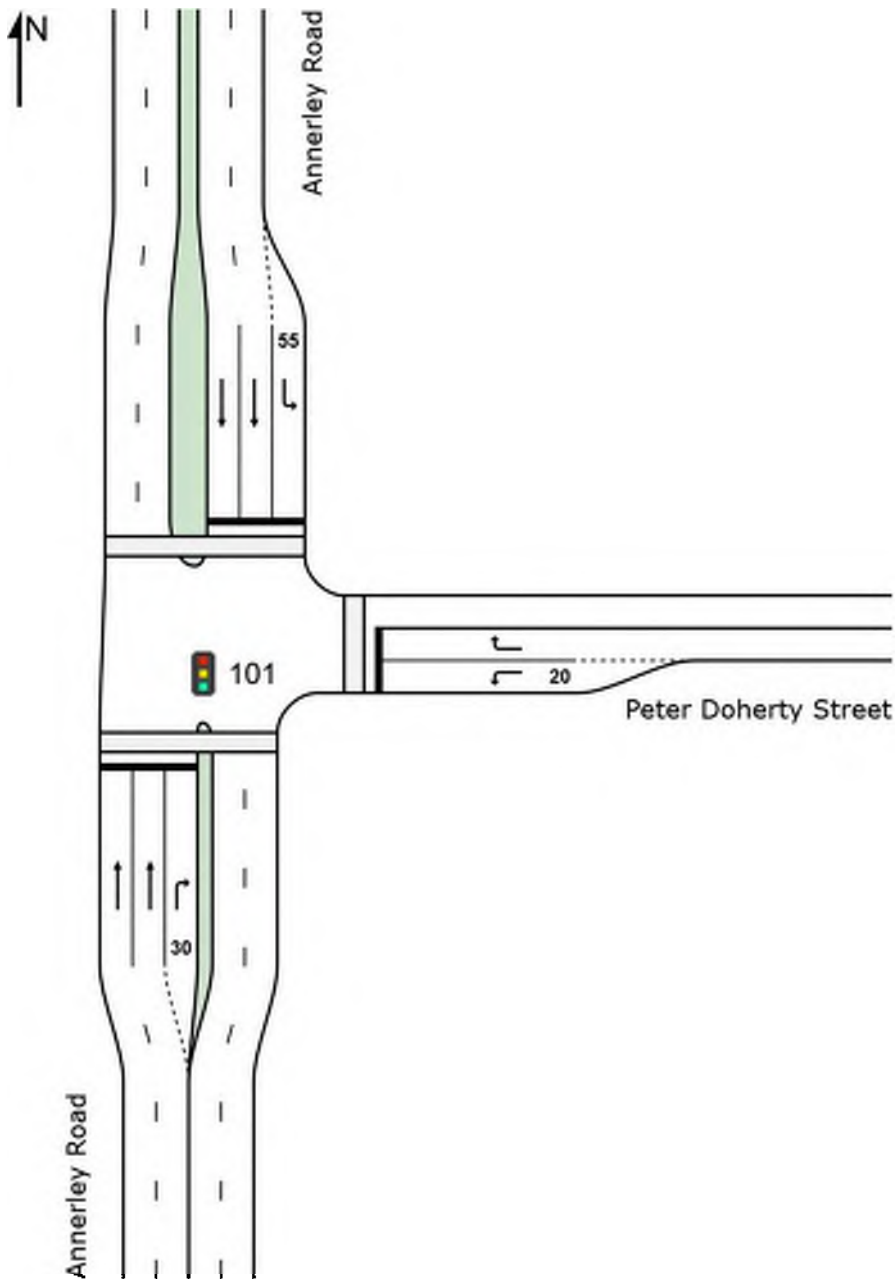
SITE LAYOUT

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated



MOVEMENT SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	1064	5.0	0.746	36.6	LOS D	29.4	215.1	0.92	0.82	0.92	19.9
3	R2	15	100.0	0.035	32.7	LOS C	0.6	7.5	0.65	0.68	0.65	21.4
Approach		1079	6.3	0.746	36.6	LOS D	29.4	215.1	0.92	0.82	0.92	19.9
East: Peter Doherty Street												
4	L2	69	63.6	0.753	77.1	LOS E	4.8	51.7	1.00	0.88	1.25	12.6
6	R2	24	13.0	0.185	68.6	LOS E	1.5	11.6	0.97	0.71	0.97	14.0
Approach		94	50.6	0.753	74.9	LOS E	4.8	51.7	0.99	0.83	1.18	13.0
North: Annerley Road												
7	L2	9	0.0	0.030	53.8	LOS D	0.5	3.5	0.86	0.67	0.86	16.8
8	T1	543	3.3	0.742	55.4	LOS E	16.9	121.3	1.00	0.88	1.05	14.8
Approach		553	3.2	0.742	55.4	LOS E	16.9	121.3	1.00	0.88	1.05	14.9
All Vehicles		1725	7.7	0.753	44.7	LOS D	29.4	215.1	0.95	0.84	0.97	17.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

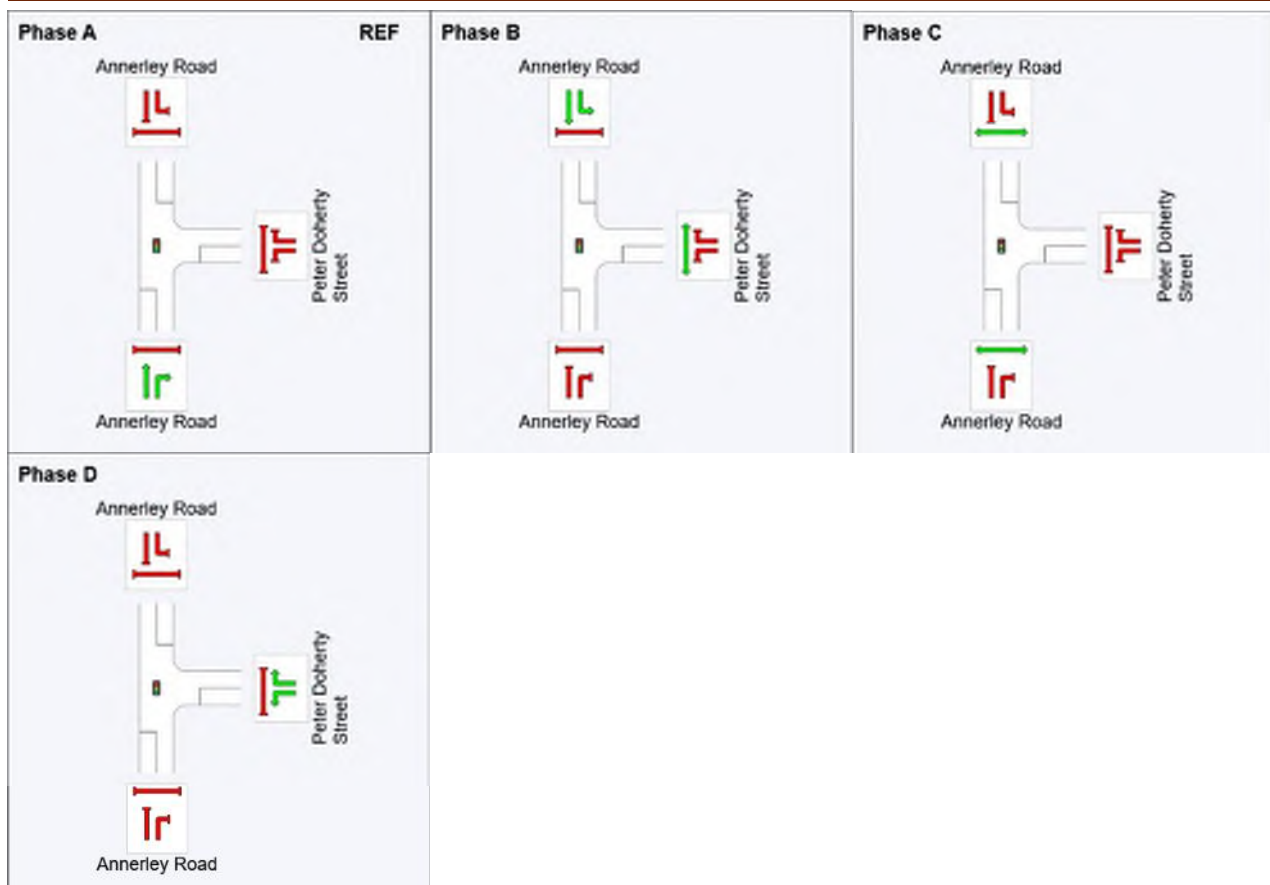
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	56	87	114
Green Time (sec)	50	25	21	10
Phase Time (sec)	56	31	27	16
Phase Split	43%	24%	21%	12%

See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



MOVEMENT SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP1 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	543	7.0	0.747	54.8	LOS D	17.3	128.0	0.99	0.88	1.05	15.0
3	R2	16	93.3	0.071	52.7	LOS D	0.8	10.4	0.84	0.70	0.84	15.3
Approach		559	9.4	0.747	54.7	LOS D	17.3	128.0	0.99	0.88	1.05	15.0
East: Peter Doherty Street												
4	L2	98	45.2	0.731	71.5	LOS E	6.5	62.7	1.00	0.86	1.17	13.5
6	R2	42	0.0	0.211	63.9	LOS E	2.5	17.5	0.95	0.74	0.95	14.9
Approach		140	31.6	0.731	69.2	LOS E	6.5	62.7	0.98	0.82	1.10	13.9
North: Annerley Road												
7	L2	18	0.0	0.030	37.2	LOS D	0.8	5.3	0.71	0.68	0.71	21.4
8	T1	972	1.8	0.735	39.8	LOS D	27.2	193.1	0.94	0.83	0.94	18.8
Approach		989	1.8	0.735	39.7	LOS D	27.2	193.1	0.93	0.83	0.93	18.9
All Vehicles		1688	6.8	0.747	47.2	LOS D	27.2	193.1	0.96	0.84	0.99	16.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP1 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

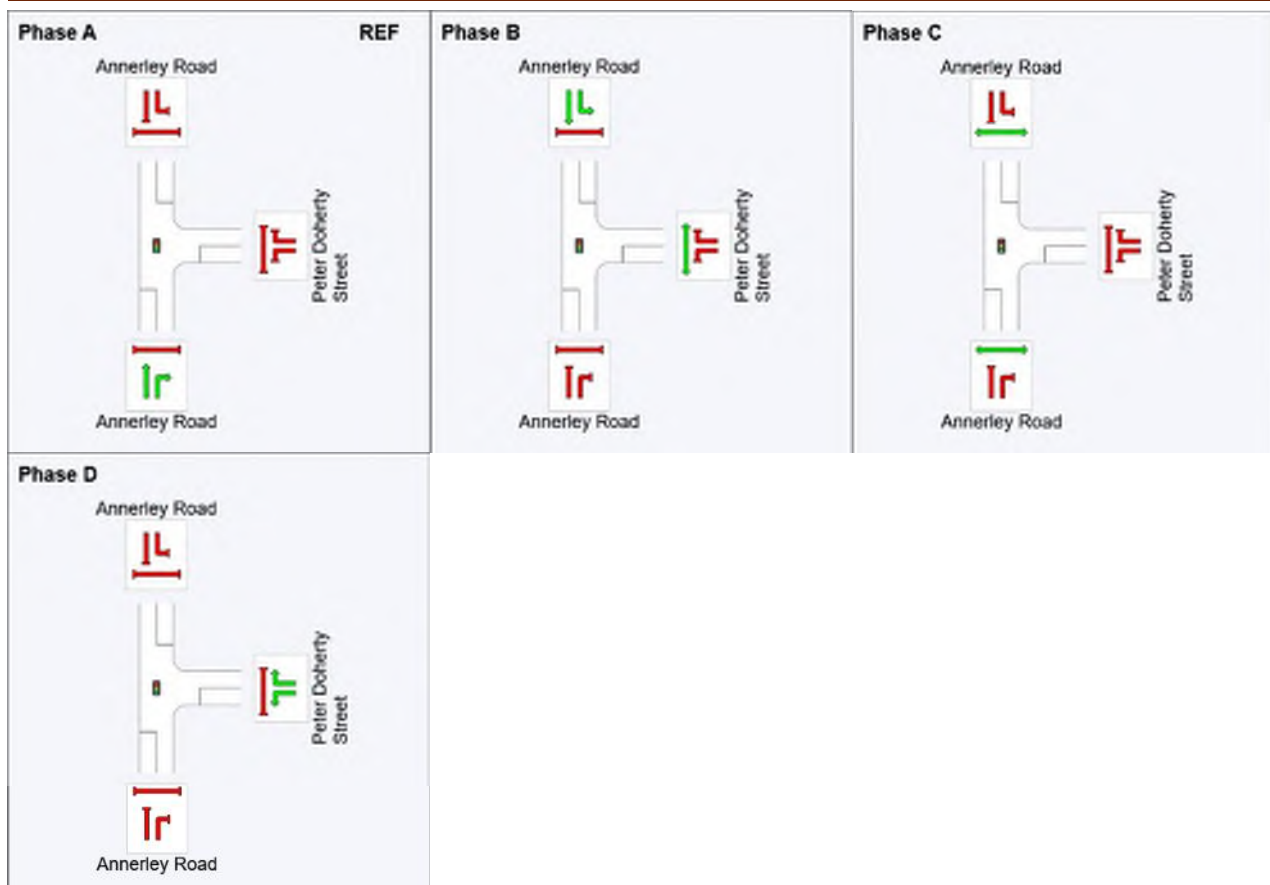
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	32	83	110
Green Time (sec)	26	45	21	14
Phase Time (sec)	32	51	27	20
Phase Split	25%	39%	21%	15%

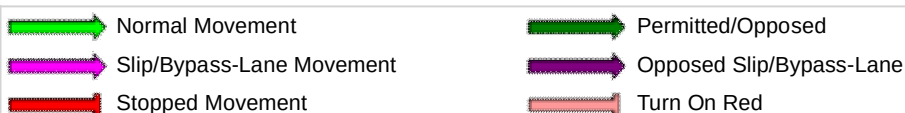
See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



Option 1 Layout 2 (Leading Right Phasing)

MOVEMENT SUMMARY



Site: 101 [2020BG Road Peak AM - OP1 Layout 2 - leading right]

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	1064	5.0	0.492	16.5	LOS B	19.7	144.1	0.62	0.56	0.62	31.5
3	R2	15	100.0	0.294	77.7	LOS E	1.0	13.0	1.00	0.70	1.00	12.4
Approach		1079	6.3	0.492	17.3	LOS B	19.7	144.1	0.63	0.56	0.63	30.7
East: Peter Doherty Street												
4	L2	69	63.6	0.498	67.0	LOS E	4.3	46.8	0.98	0.78	0.98	14.0
6	R2	24	13.0	0.123	62.4	LOS E	1.4	10.9	0.93	0.71	0.93	15.0
Approach		94	50.6	0.498	65.8	LOS E	4.3	46.8	0.97	0.76	0.97	14.2
North: Annerley Road												
7	L2	9	0.0	0.010	23.1	LOS C	0.3	2.1	0.53	0.64	0.53	28.0
8	T1	543	3.3	0.289	20.6	LOS C	10.0	72.0	0.63	0.54	0.63	28.1
Approach		553	3.2	0.289	20.7	LOS C	10.0	72.0	0.63	0.54	0.63	28.1
All Vehicles		1725	7.7	0.498	21.0	LOS C	19.7	144.1	0.65	0.57	0.65	27.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 2 - leading right]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

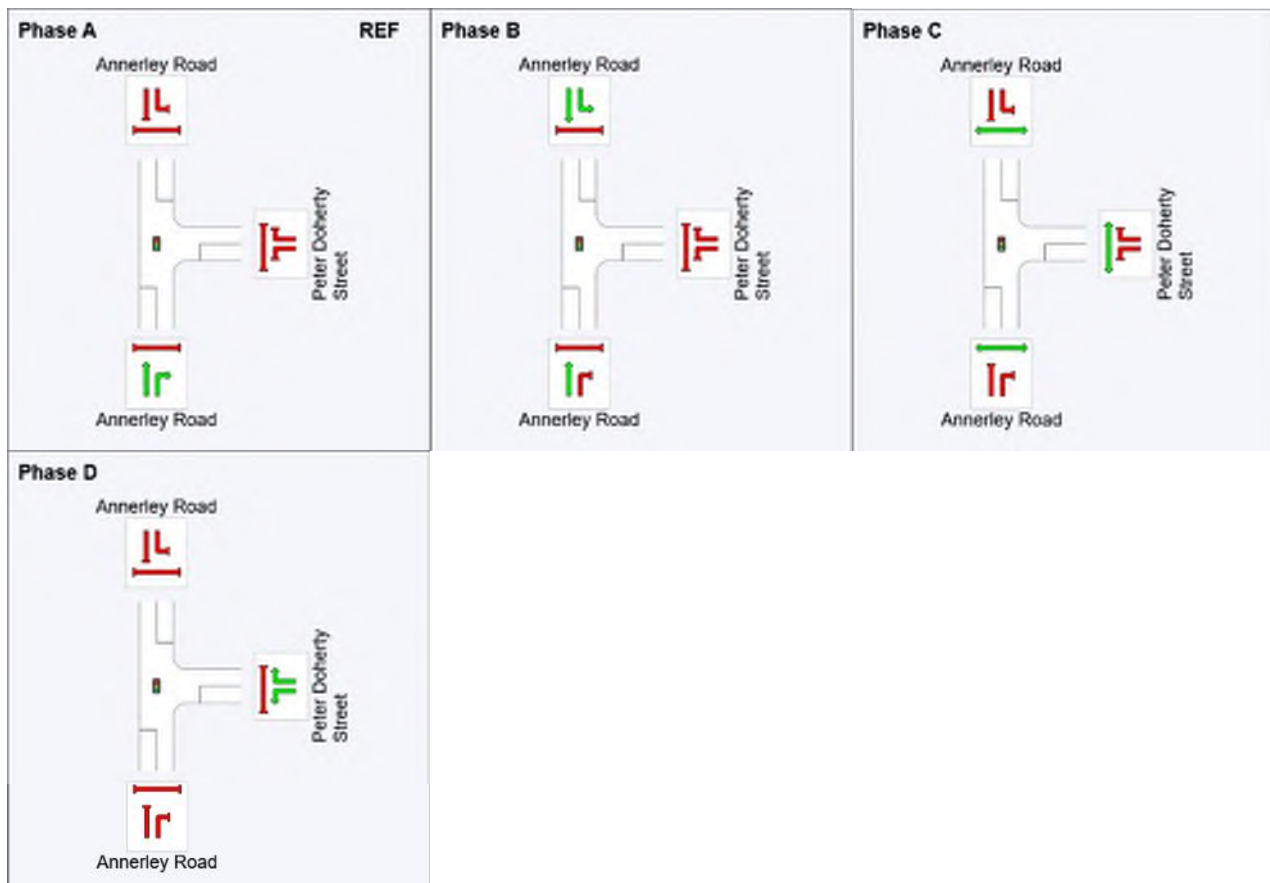
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	12	82	109
Green Time (sec)	6	64	21	15
Phase Time (sec)	12	70	27	21
Phase Split	9%	54%	21%	16%

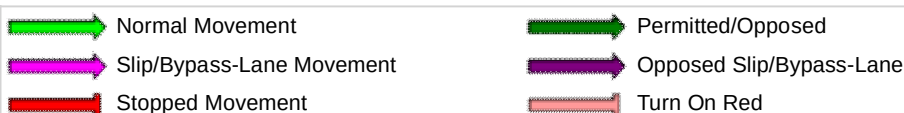
See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



MOVEMENT SUMMARY



Site: 101 [2020BG Road Peak PM - OP1 Layout 2 - leading right]

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	543	7.0	0.274	16.0	LOS B	9.3	68.7	0.56	0.48	0.56	32.0
3	R2	16	93.3	0.307	78.1	LOS E	1.1	13.5	1.00	0.71	1.00	11.9
Approach		559	9.4	0.307	17.7	LOS B	9.3	68.7	0.57	0.49	0.57	30.2
East: Peter Doherty Street												
4	L2	98	45.2	0.534	62.7	LOS E	5.9	57.2	0.96	0.79	0.96	14.8
6	R2	42	0.0	0.155	58.3	LOS E	2.4	16.5	0.91	0.73	0.91	15.9
Approach		140	31.6	0.534	61.4	LOS E	5.9	57.2	0.95	0.77	0.95	15.2
North: Annerley Road												
7	L2	18	0.0	0.022	27.2	LOS C	0.6	4.4	0.59	0.67	0.59	25.7
8	T1	972	1.8	0.550	26.7	LOS C	22.1	157.1	0.77	0.69	0.77	24.3
Approach		989	1.8	0.550	26.8	LOS C	22.1	157.1	0.77	0.69	0.77	24.3
All Vehicles		1688	6.8	0.550	26.6	LOS C	22.1	157.1	0.72	0.63	0.72	24.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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PHASING SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP1 Layout 2 - leading right]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

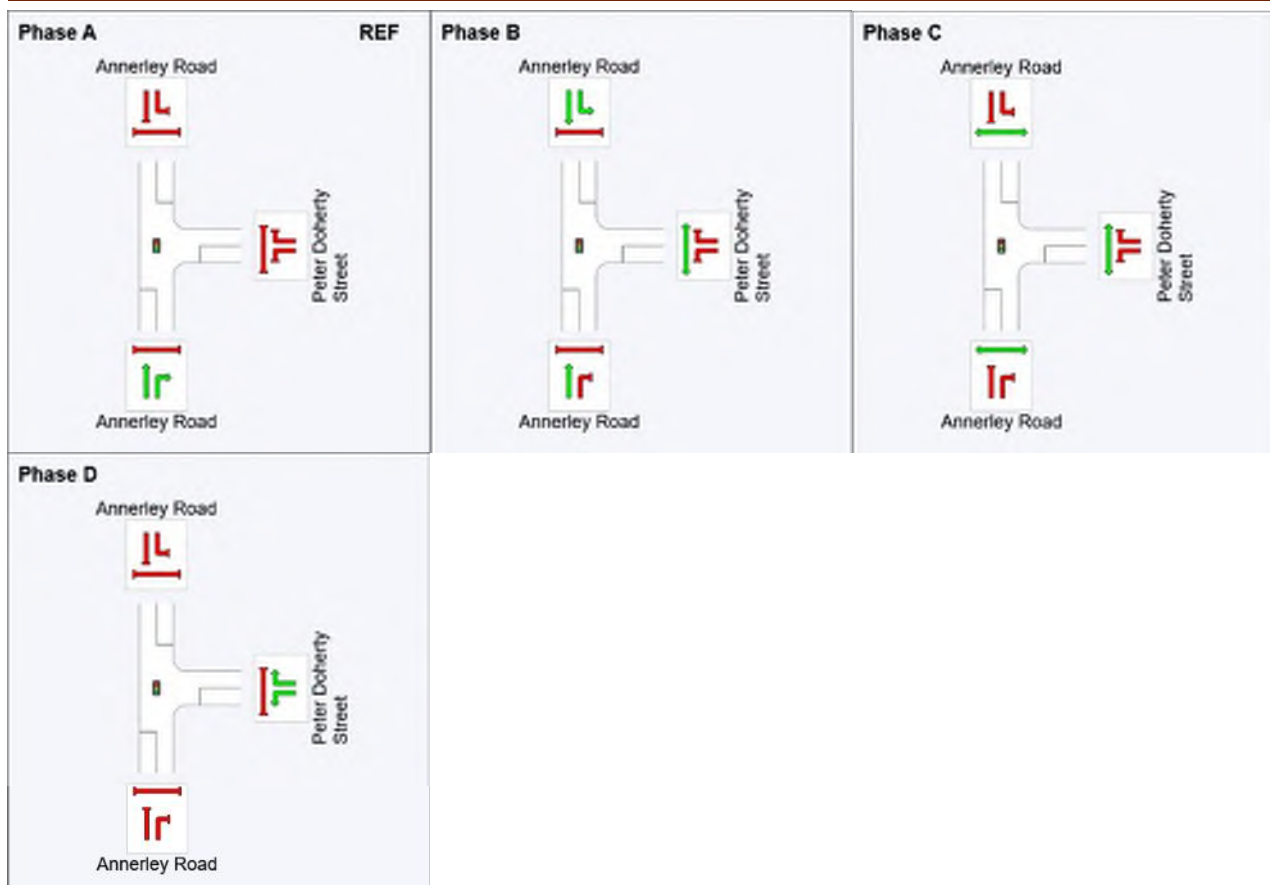
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	12	78	105
Green Time (sec)	6	60	21	19
Phase Time (sec)	12	66	27	25
Phase Split	9%	51%	21%	19%

See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



Option 1 Layout 2 (Leading Right with Filter Phasing)

MOVEMENT SUMMARY



Site: 101 [2020BG Road Peak AM - OP1 Layout 2 - leading right filter]

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	1064	5.0	0.492	16.5	LOS B	19.7	144.1	0.62	0.56	0.62	31.5
3	R2	15	100.0	0.060	20.8	LOS C	0.4	5.7	0.57	0.65	0.57	26.5
Approach		1079	6.3	0.492	16.6	LOS B	19.7	144.1	0.62	0.56	0.62	31.4
East: Peter Doherty Street												
4	L2	69	63.6	0.498	67.0	LOS E	4.3	46.8	0.98	0.78	0.98	14.0
6	R2	24	13.0	0.123	62.4	LOS E	1.4	10.9	0.93	0.71	0.93	15.0
Approach		94	50.6	0.498	65.8	LOS E	4.3	46.8	0.97	0.76	0.97	14.2
North: Annerley Road												
7	L2	9	0.0	0.010	23.1	LOS C	0.3	2.1	0.53	0.64	0.53	28.0
8	T1	543	3.3	0.289	20.6	LOS C	10.0	72.0	0.63	0.54	0.63	28.1
Approach		553	3.2	0.289	20.7	LOS C	10.0	72.0	0.63	0.54	0.63	28.1
All Vehicles		1725	7.7	0.498	20.5	LOS C	19.7	144.1	0.64	0.57	0.64	28.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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Project: G:\QTT20037 - CRR Southern Portal TIA\5_PROJECT ANALYSIS\Analysis\SIDRA\2_Annerley Road Peter Doherty Street-TO PRINT.sip8

PHASING SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP1 Layout 2 - leading right filter]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

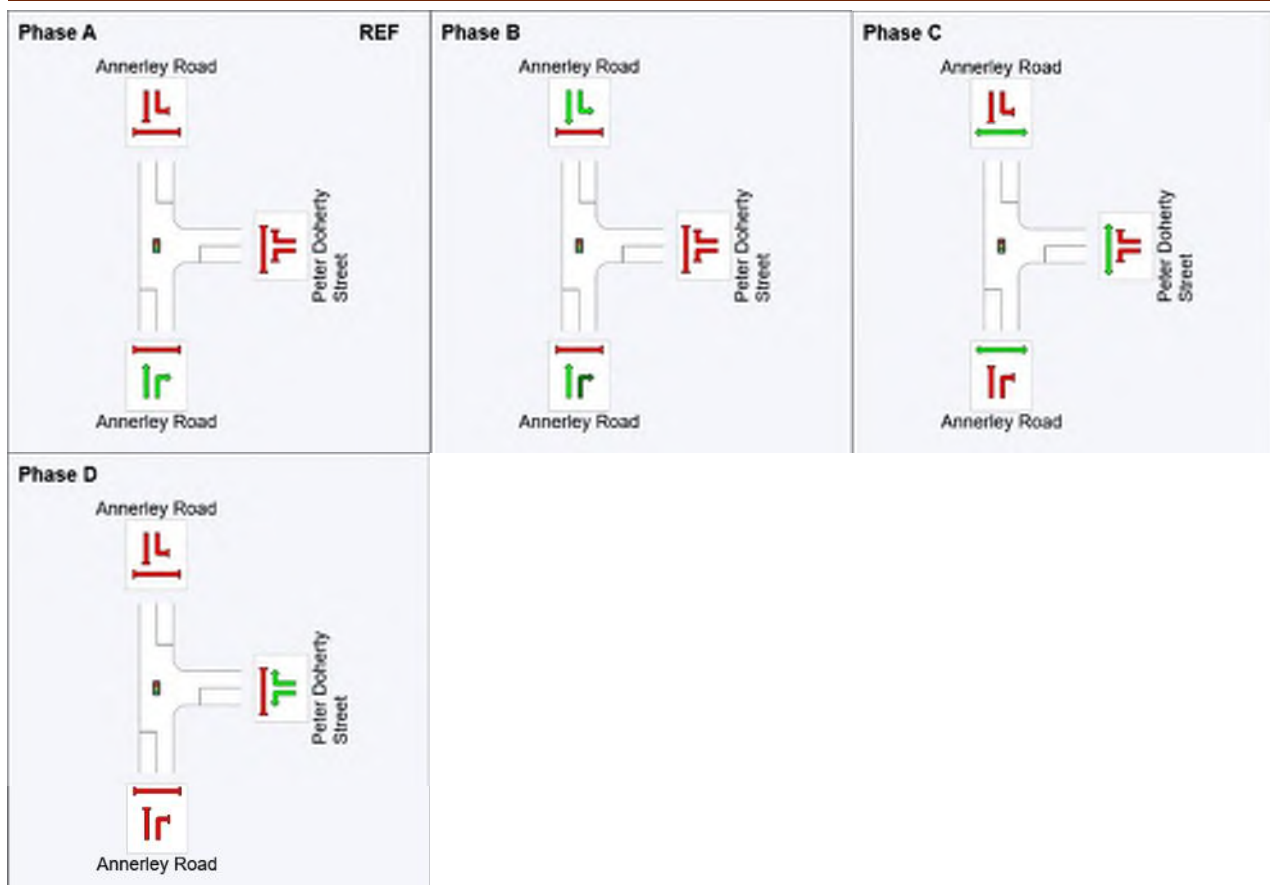
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	12	82	109
Green Time (sec)	6	64	21	15
Phase Time (sec)	12	70	27	21
Phase Split	9%	54%	21%	16%

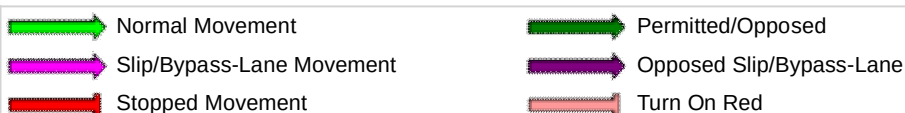
See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



MOVEMENT SUMMARY



Site: 101 [2020BG Road Peak PM - OP1 Layout 2 - leading right filter]

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	543	7.0	0.274	16.0	LOS B	9.3	68.7	0.56	0.48	0.56	32.0
3	R2	16	93.3	0.109	26.2	LOS C	0.5	6.3	0.71	0.68	0.71	22.0
Approach		559	9.4	0.274	16.3	LOS B	9.3	68.7	0.56	0.49	0.56	31.5
East: Peter Doherty Street												
4	L2	98	45.2	0.534	62.7	LOS E	5.9	57.2	0.96	0.79	0.96	14.8
6	R2	42	0.0	0.155	58.3	LOS E	2.4	16.5	0.91	0.73	0.91	15.9
Approach		140	31.6	0.534	61.4	LOS E	5.9	57.2	0.95	0.77	0.95	15.2
North: Annerley Road												
7	L2	18	0.0	0.022	27.2	LOS C	0.6	4.4	0.59	0.67	0.59	25.7
8	T1	972	1.8	0.550	26.7	LOS C	22.1	157.1	0.77	0.69	0.77	24.3
Approach		989	1.8	0.550	26.8	LOS C	22.1	157.1	0.77	0.69	0.77	24.3
All Vehicles		1688	6.8	0.550	26.2	LOS C	22.1	157.1	0.72	0.63	0.72	24.7

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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Project: G:\QTT20037 - CRR Southern Portal TIA\5_PROJECT ANALYSIS\Analysis\SIDRA\2_Annerley Road Peter Doherty Street-TO PRINT.sip8

PHASING SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP1 Layout 2 - leading right filter]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Split Phasing

Reference Phase: Phase A

Input Phase Sequence: A, B, C, D

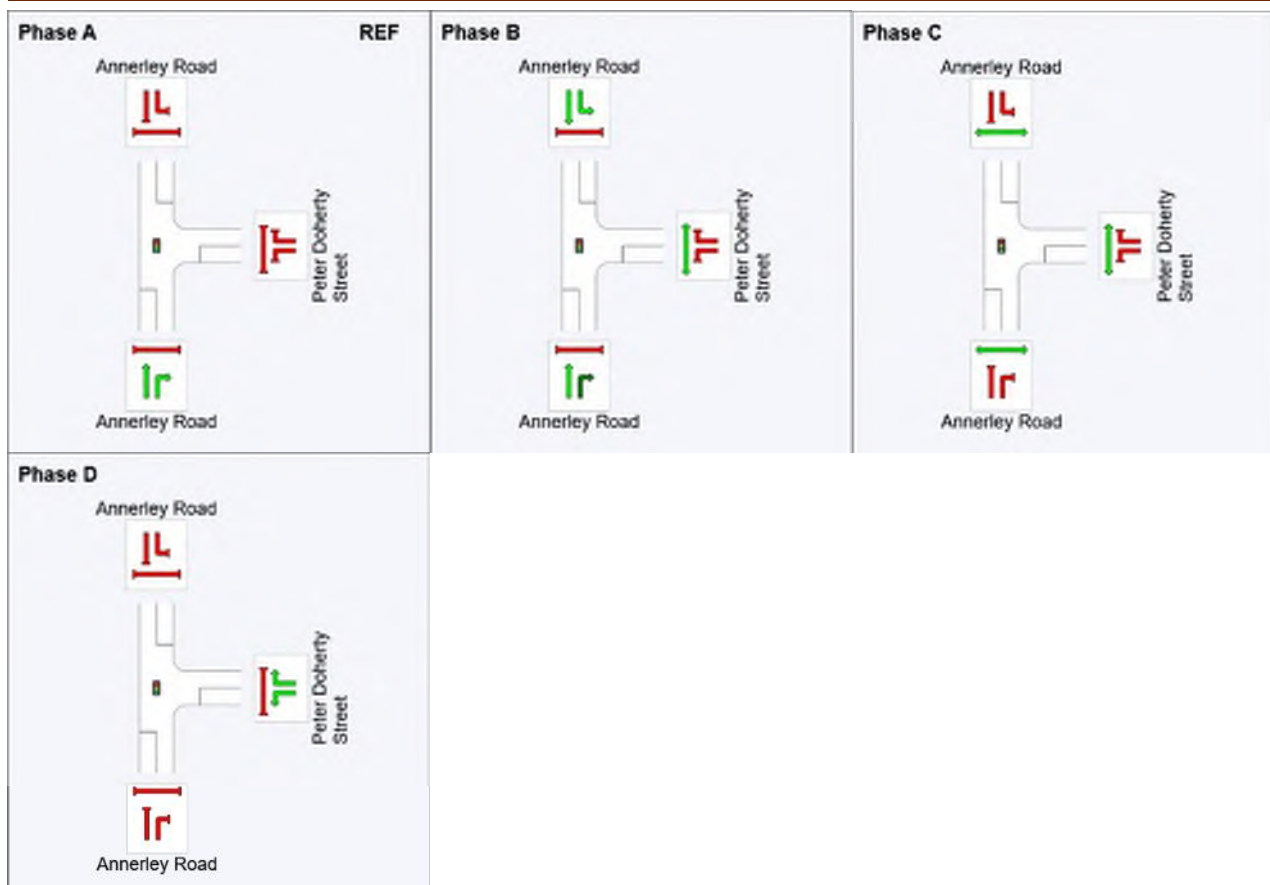
Output Phase Sequence: A, B, C, D

Phase Timing Summary

Phase	A	B	C	D
Phase Change Time (sec)	0	12	78	105
Green Time (sec)	6	60	21	19
Phase Time (sec)	12	66	27	25
Phase Split	9%	51%	21%	19%

See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase

	Normal Movement		Permitted/Opposed
	Slip/Bypass-Lane Movement		Opposed Slip/Bypass-Lane
	Stopped Movement		Turn On Red

Option 2 Layout 1

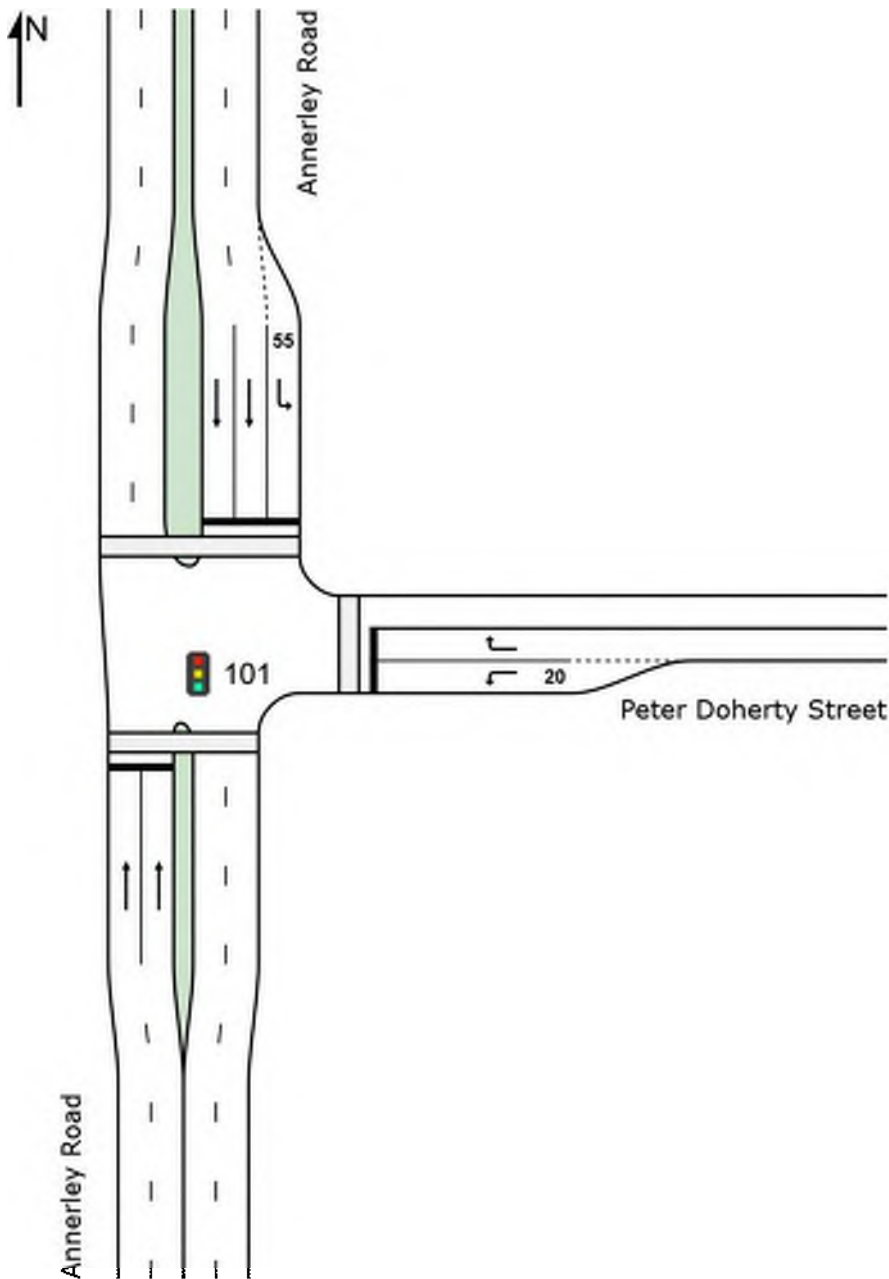
SITE LAYOUT

 **Site: 101 [2020BG Road Peak AM - OP2 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated



MOVEMENT SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP2 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back Vehicles veh	Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	1064	5.0	0.436	11.9	LOS B	16.3	118.8	0.53	0.48	0.53	36.2
Approach		1064	5.0	0.436	11.9	LOS B	16.3	118.8	0.53	0.48	0.53	36.2
East: Peter Doherty Street												
4	L2	69	63.6	0.252	50.7	LOS D	3.6	39.3	0.85	0.76	0.85	16.9
6	R2	24	13.0	0.309	75.0	LOS E	1.6	12.4	1.00	0.71	1.00	13.1
Approach		94	50.6	0.309	57.0	LOS E	3.6	39.3	0.89	0.75	0.89	15.7
North: Annerley Road												
7	L2	24	60.9	0.030	16.1	LOS B	0.6	6.1	0.40	0.64	0.40	28.1
8	T1	543	3.3	0.220	10.0	LOS A	6.9	49.9	0.44	0.38	0.44	38.8
Approach		567	5.8	0.220	10.2	LOS B	6.9	49.9	0.44	0.39	0.44	38.0
All Vehicles		1725	7.7	0.436	13.8	LOS B	16.3	118.8	0.52	0.46	0.52	33.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Queue Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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Project: G:\QTT20037 - CRR Southern Portal TIA\5_PROJECT ANALYSIS\Analysis\SIDRA\2_Annerley Road Peter Doherty Street.sip8

PHASING SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP2 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Variable Phasing - Upgrade

Reference Phase: Phase A

Input Phase Sequence: A, B, C

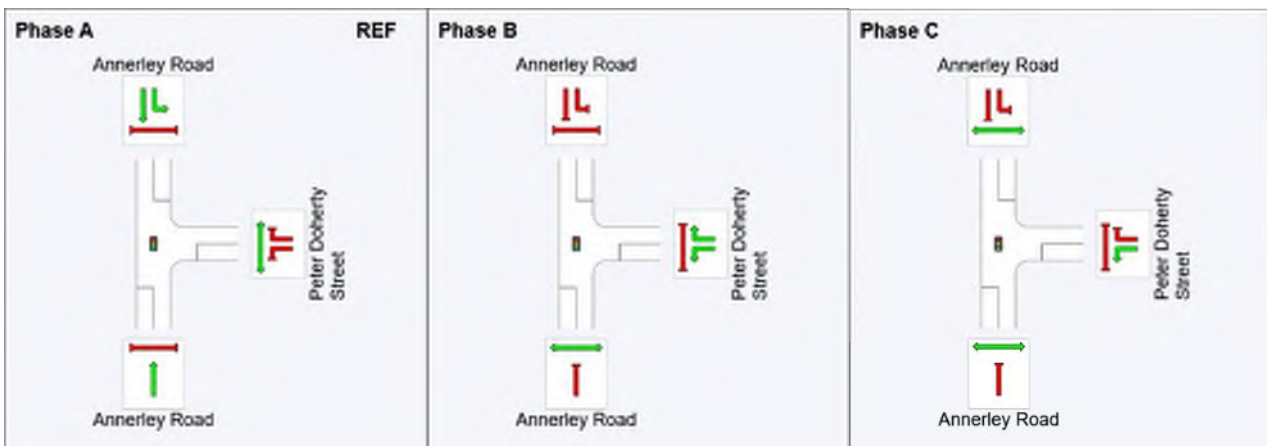
Output Phase Sequence: A, B, C

Phase Timing Summary

Phase	A	B	C
Phase Change Time (sec)	0	91	103
Green Time (sec)	84	6	20
Phase Time (sec)	90	13	27
Phase Split	69%	10%	21%

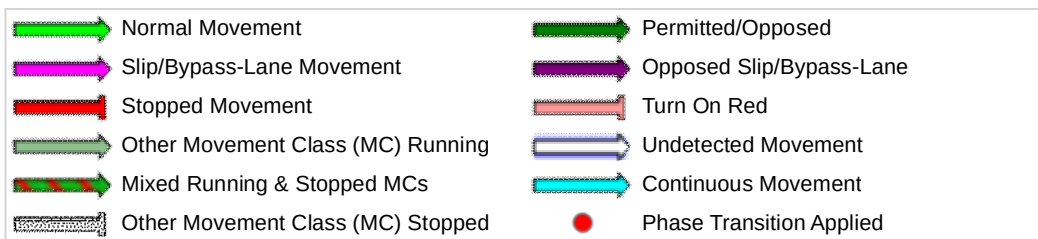
See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



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MOVEMENT SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP2 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back Vehicles veh	Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	543	7.0	0.228	10.4	LOS B	7.1	52.8	0.45	0.39	0.45	38.1
Approach		543	7.0	0.228	10.4	LOS B	7.1	52.8	0.45	0.39	0.45	38.1
East: Peter Doherty Street												
4	L2	98	45.2	0.332	50.2	LOS D	5.1	49.9	0.86	0.77	0.86	17.3
6	R2	42	0.0	0.421	73.7	LOS E	2.7	19.2	1.00	0.74	1.00	13.4
Approach		140	31.6	0.421	57.2	LOS E	5.1	49.9	0.90	0.76	0.90	15.9
North: Annerley Road												
7	L2	33	45.2	0.038	16.4	LOS B	0.8	7.7	0.41	0.65	0.41	29.0
8	T1	972	1.8	0.396	12.0	LOS B	14.6	104.1	0.52	0.47	0.52	36.2
Approach		1004	3.2	0.396	12.1	LOS B	14.6	104.1	0.52	0.47	0.52	35.9
All Vehicles		1687	6.8	0.421	15.3	LOS B	14.6	104.1	0.53	0.47	0.53	32.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back Pedestrian ped	Queue Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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Project: G:\QTT20037 - CRR Southern Portal TIA\5_PROJECT ANALYSIS\Analysis\SIDRA\2_Annerley Road Peter Doherty Street.sip8

PHASING SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP2 Layout 1]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Variable Phasing - Upgrade

Reference Phase: Phase A

Input Phase Sequence: A, B, C

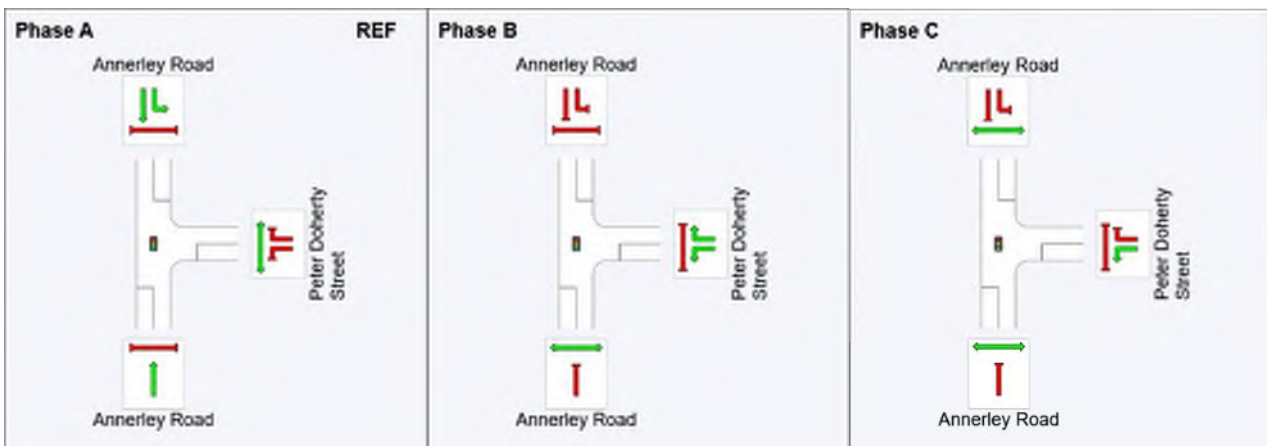
Output Phase Sequence: A, B, C

Phase Timing Summary

Phase	A	B	C
Phase Change Time (sec)	0	90	103
Green Time (sec)	83	7	20
Phase Time (sec)	89	14	27
Phase Split	68%	11%	21%

See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase

	Normal Movement		Permitted/Opposed
	Slip/Bypass-Lane Movement		Opposed Slip/Bypass-Lane
	Stopped Movement		Turn On Red
	Other Movement Class (MC) Running		Undetected Movement
	Mixed Running & Stopped MCs		Continuous Movement
	Other Movement Class (MC) Stopped		Phase Transition Applied

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Option 2 Layout 2

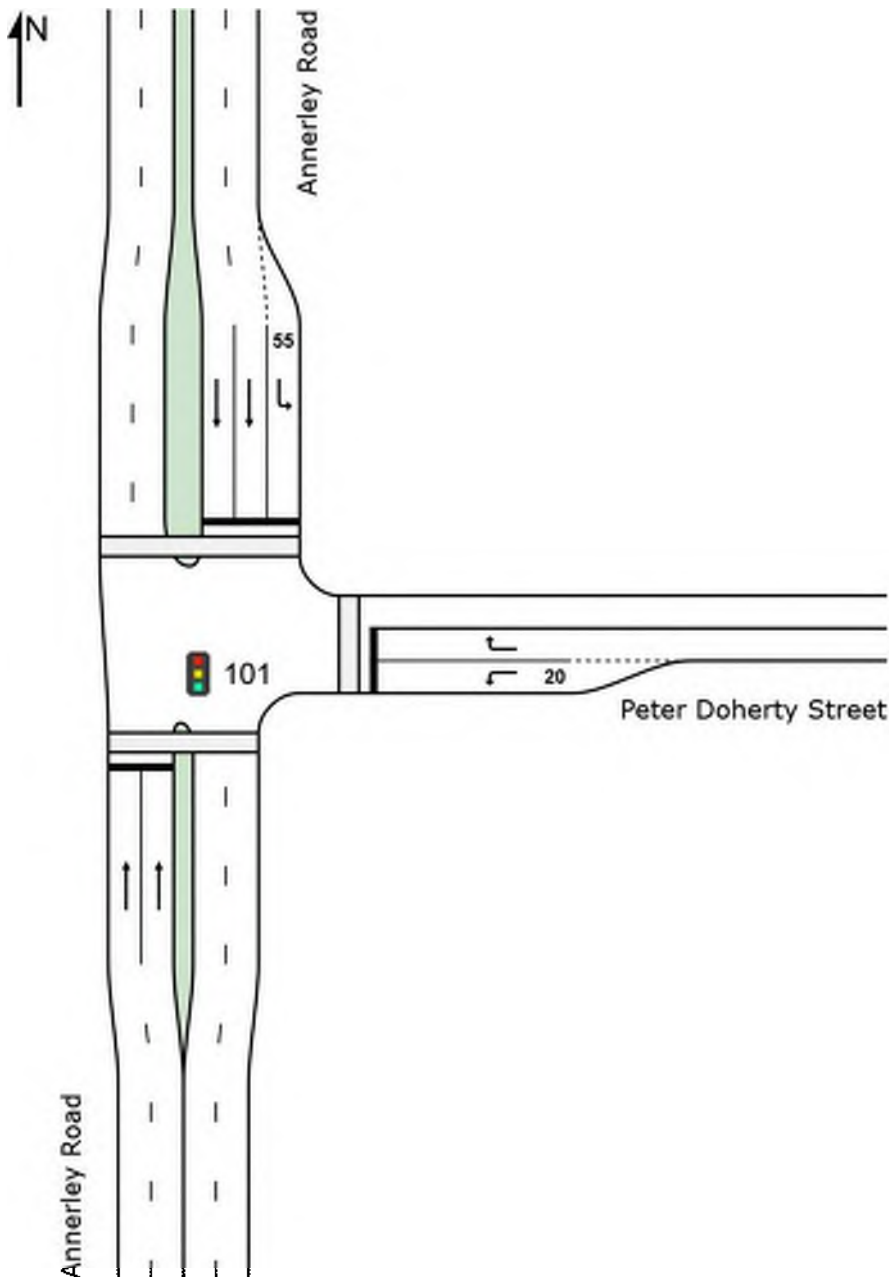
SITE LAYOUT

 **Site: 101 [2020BG Road Peak AM - OP2 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated



MOVEMENT SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP2 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	1064	5.0	0.452	13.6	LOS B	17.3	126.7	0.57	0.51	0.57	34.4
Approach		1064	5.0	0.452	13.6	LOS B	17.3	126.7	0.57	0.51	0.57	34.4
East: Peter Doherty Street												
4	L2	69	63.6	0.222	47.0	LOS D	3.5	37.6	0.82	0.75	0.82	17.7
6	R2	24	13.0	0.309	75.0	LOS E	1.6	12.4	1.00	0.71	1.00	13.1
Approach		94	50.6	0.309	54.2	LOS D	3.5	37.6	0.87	0.74	0.87	16.2
North: Annerley Road												
7	L2	24	60.9	0.031	17.4	LOS B	0.6	6.5	0.43	0.65	0.43	27.3
8	T1	543	3.3	0.228	11.3	LOS B	7.4	53.2	0.47	0.41	0.47	37.0
Approach		567	5.8	0.228	11.6	LOS B	7.4	53.2	0.47	0.42	0.47	36.4
All Vehicles		1725	7.7	0.452	15.1	LOS B	17.3	126.7	0.55	0.49	0.55	32.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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Project: G:\QTT20037 - CRR Southern Portal TIA\5_PROJECT ANALYSIS\Analysis\SIDRA\2_Annerley Road Peter Doherty Street.sip8

PHASING SUMMARY

 **Site: 101 [2020BG Road Peak AM - OP2 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Variable Phasing - Upgrade

Reference Phase: Phase A

Input Phase Sequence: A, B, C

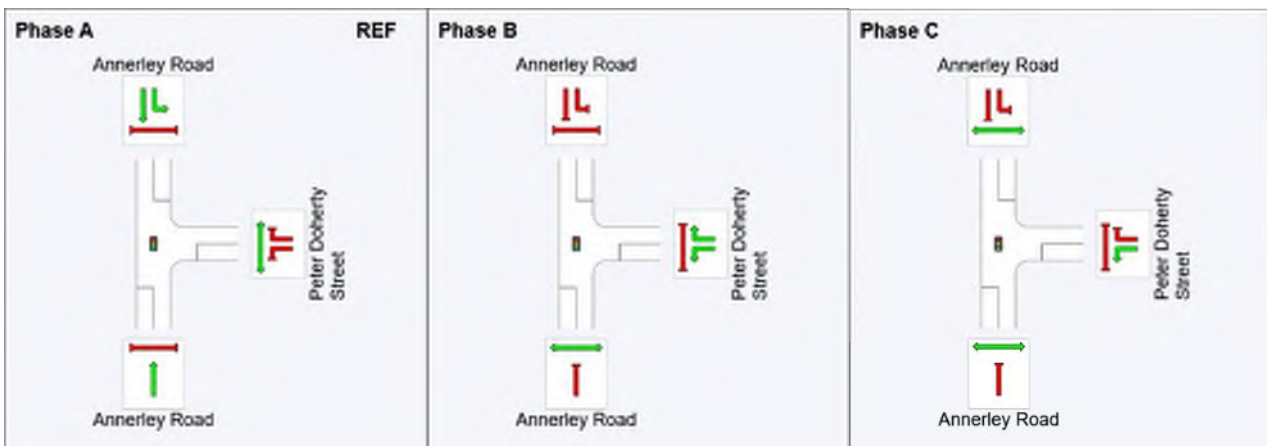
Output Phase Sequence: A, B, C

Phase Timing Summary

Phase	A	B	C
Phase Change Time (sec)	0	87	99
Green Time (sec)	81	6	25
Phase Time (sec)	87	12	31
Phase Split	67%	9%	24%

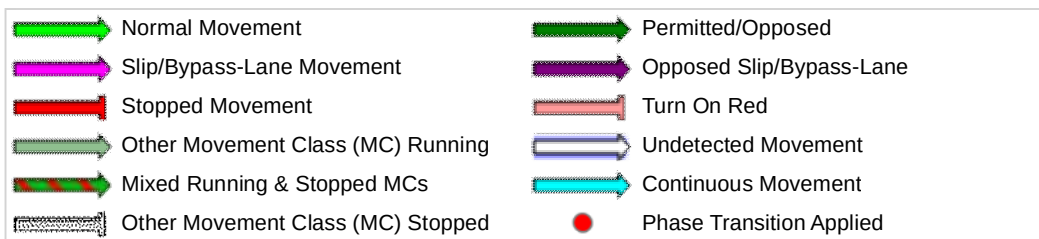
See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



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Project: G:\QTT20037 - CRR Southern Portal TIA\5_PROJECT ANALYSIS\Analysis\SIDRA\2_Annerley Road Peter Doherty Street.sip8

MOVEMENT SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP2 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Annerley Road												
2	T1	543	7.0	0.237	11.8	LOS B	7.6	56.2	0.48	0.42	0.48	36.4
Approach		543	7.0	0.237	11.8	LOS B	7.6	56.2	0.48	0.42	0.48	36.4
East: Peter Doherty Street												
4	L2	98	45.2	0.295	46.5	LOS D	4.9	47.6	0.83	0.77	0.83	18.1
6	R2	42	0.0	0.421	73.7	LOS E	2.7	19.2	1.00	0.74	1.00	13.4
Approach		140	31.6	0.421	54.6	LOS D	4.9	47.6	0.88	0.76	0.88	16.4
North: Annerley Road												
7	L2	33	45.2	0.039	17.7	LOS B	0.8	8.2	0.44	0.66	0.44	28.2
8	T1	972	1.8	0.412	13.5	LOS B	15.6	111.2	0.55	0.49	0.55	34.4
Approach		1004	3.2	0.412	13.7	LOS B	15.6	111.2	0.55	0.50	0.55	34.1
All Vehicles		1687	6.8	0.421	16.5	LOS B	15.6	111.2	0.56	0.49	0.56	31.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Intersection and Approach LOS values are based on average delay for all vehicle movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians									
Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate	
P1	South Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P2	East Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
P3	North Full Crossing	53	59.3	LOS E	0.2	0.2	0.96	0.96	
All Pedestrians		158	59.3	LOS E			0.96	0.96	

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)

Pedestrian movement LOS values are based on average delay per pedestrian movement.

Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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Project: G:\QTT20037 - CRR Southern Portal TIA\5_PROJECT ANALYSIS\Analysis\SIDRA\2_Annerley Road Peter Doherty Street.sip8

PHASING SUMMARY

 **Site: 101 [2020BG Road Peak PM - OP2 Layout 2]**

Annerley Road / Peter Doherty Street

Site Category: (None)

Signals - Fixed Time Isolated Cycle Time = 130 seconds (Site User-Given Cycle Time)

Timings based on settings in the Site Phasing & Timing dialog

Phase Times determined by the program

Phase Sequence: Variable Phasing - Upgrade

Reference Phase: Phase A

Input Phase Sequence: A, B, C

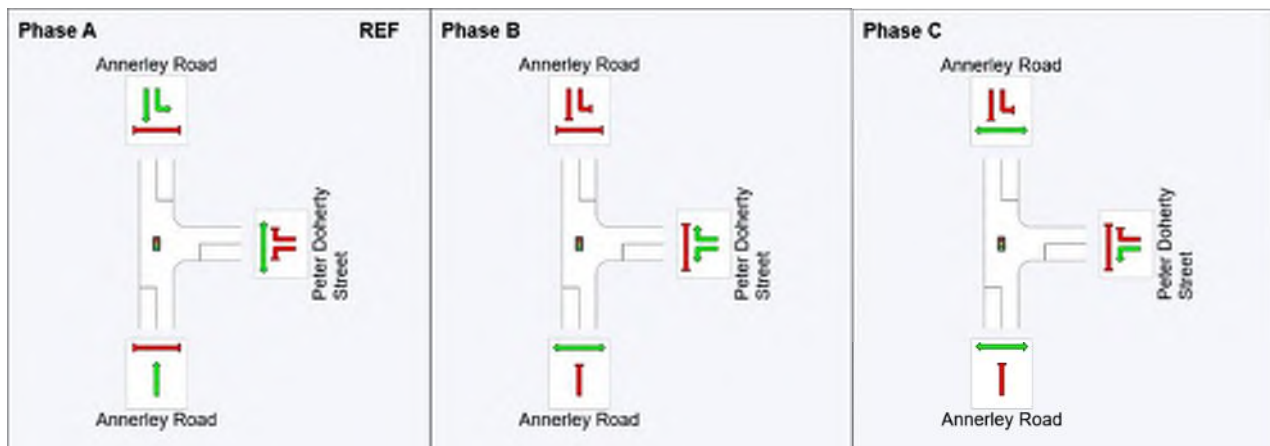
Output Phase Sequence: A, B, C

Phase Timing Summary

Phase	A	B	C
Phase Change Time (sec)	0	86	99
Green Time (sec)	80	7	25
Phase Time (sec)	86	13	31
Phase Split	66%	10%	24%

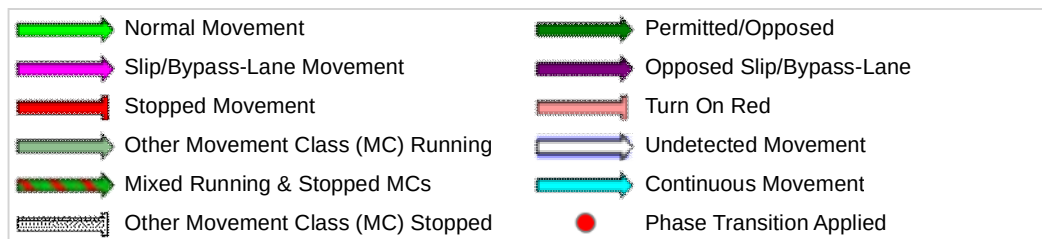
See the Phase Information section in the Detailed Output report for more detailed information including input values of Yellow Time and All-Red Time, and information on any adjustments to Intergreen Time, Phase Time and Green Time values in cases of Pedestrian Actuation, Phase Actuation and Phase Frequency values (user-specified or implied) less than 100%.

Output Phase Sequence



REF: Reference Phase

VAR: Variable Phase



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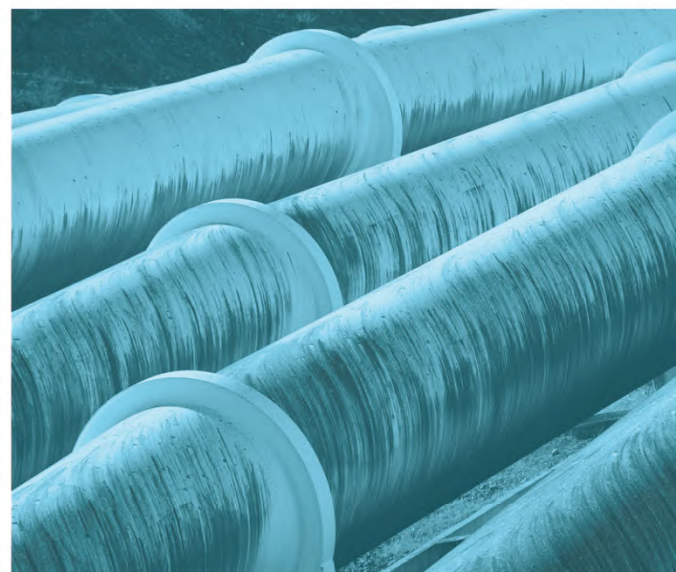
Attachment E: Technical Report - Air Quality



Cross River Rail - Southern Portal worksite

Air quality impact assessment

Prepared for CBGU JV
November 2020





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Executive Summary

This air quality impact assessment (AQIA) was prepared to assess the changes to Cross River Rail's Southern Portal construction activities (the 'project'). The AQIA has been prepared in general accordance with the QLD *Environmental Protection (Air) Policy 2019 (EPP (Air))*. Results have been assessed against criteria provided in the *EPP (Air)* and the Imposed Conditions for the CRR project.

Existing environmental conditions were quantified using data from the Bureau of Meteorology's (BoM) Brisbane station. Background air quality (ie particulate matter) levels were established using meteorological data from the Queensland Department of Environment and Science (DES) Woolloongabba air quality monitoring station.

Emissions estimation and dispersion modelling was completed for a worst-case construction scenario. Emissions of total suspended particulates (TSP), particulate matter less than 10 micrometres (μm) in aerodynamic diameter (PM_{10}), particulate matter less than 2.5 μm in aerodynamic diameter ($\text{PM}_{2.5}$) were estimated and modelled.

The atmospheric dispersion of air pollutant emissions from construction was simulated using the CALPUFF model.

The nearest sensitive locations to the project were identified in the previous AQIA completed for the Southern Portal area in 2019. The AQIA formed part of the Environmental Impact Statement (EIS) prepared for the Request for Project Change 4 (RfPC-4) (CRR 2019). These locations as well as an additional four were included in the dispersion modelling of the project. The assessment locations are representative locations surrounding the Southern Portal and include a mixture of workplace/commercial and residential properties.

The results of the dispersion modelling indicated that the predicted concentrations and deposition rates for incremental particulate matter (TSP, PM_{10} , $\text{PM}_{2.5}$ and dust deposition) were below the applicable air quality objectives at all assessment locations. Cumulative impacts (project, plus neighbouring construction sites, plus background) indicated that predicted concentrations and deposition rates for all pollutants and averaging periods are below the applicable air quality objectives at all assessment locations. The 2019 AQIA also showed that all assessment locations were predicted to be below the air quality objectives for all pollutants apart from dust deposition at one location.

There are a number of mitigation measures employed on site to minimise the level of dust emissions. These include measures to reduce wheel-generated dust on roads, water sprays on construction activities and the use of water carts on exposed areas. It is noted that there are some additional mitigation measures proposed for the project as compared to those assumed in the 2019 AQIA. These include:

- materials disturbed by bulldozer will be wetted with water sprays and operations will generally be under a tunnel roof. From January 2022, operations will be entirely under the cut and cover roof;
- water sprays will be used when loading trucks, on the rock breaker and on the piling rig; and
- a binding agent will be used on exposed areas (as well as water sprays).

In addition, the Air Quality Management Plan (AQMP) for the CRR project includes details of the mitigation measures employed at the project, compliance management including training, incidents and emergencies (incorporating complaints management), details of air quality monitoring, reporting including greenhouse gas emissions and incident reporting, and documentation and communication protocols.

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1 Introduction

1.1 The project

Cross River Rail (CRR) is a 10.2 kilometre (km) rail line that runs from Dutton Park to Bowen Hills. It includes a 5.9 km twin tunnel which runs underneath the Brisbane River and Central Business District (CBD). The CRR project will deliver four new underground stations at Boggo Road, Woolloongabba, Albert Street and Roma Street.

An Environmental Impact Statement (EIS) for a *Request for Project Change 4* (RfPC-4) for the CRR was completed in April 2019 (CRR 2019). The project change application was approved by the Coordinator-General (CG) in June 2019. The EIS for RfPC-4 included an air quality impact assessment (AQIA) (hereafter referred to as the '2019 AQIA'). The AQIA assessed results against the *EPP (Air)* and the Imposed Conditions for the CRR project. The most recent Imposed Conditions for the project related to air quality are given in the *Cross River Rail project, Coordinator-General's change report – design refinements and condition changes 2020* (DSDTI 2020).

The proponent, CPB Contractors, BAM, Ghella and UGL Joint Venture (CBGU JV) has identified some changes to the construction activities at the Southern Portal worksite (hereafter referred to as the 'project') located in the Southern Area. Figure 1.1 shows the location of the project.

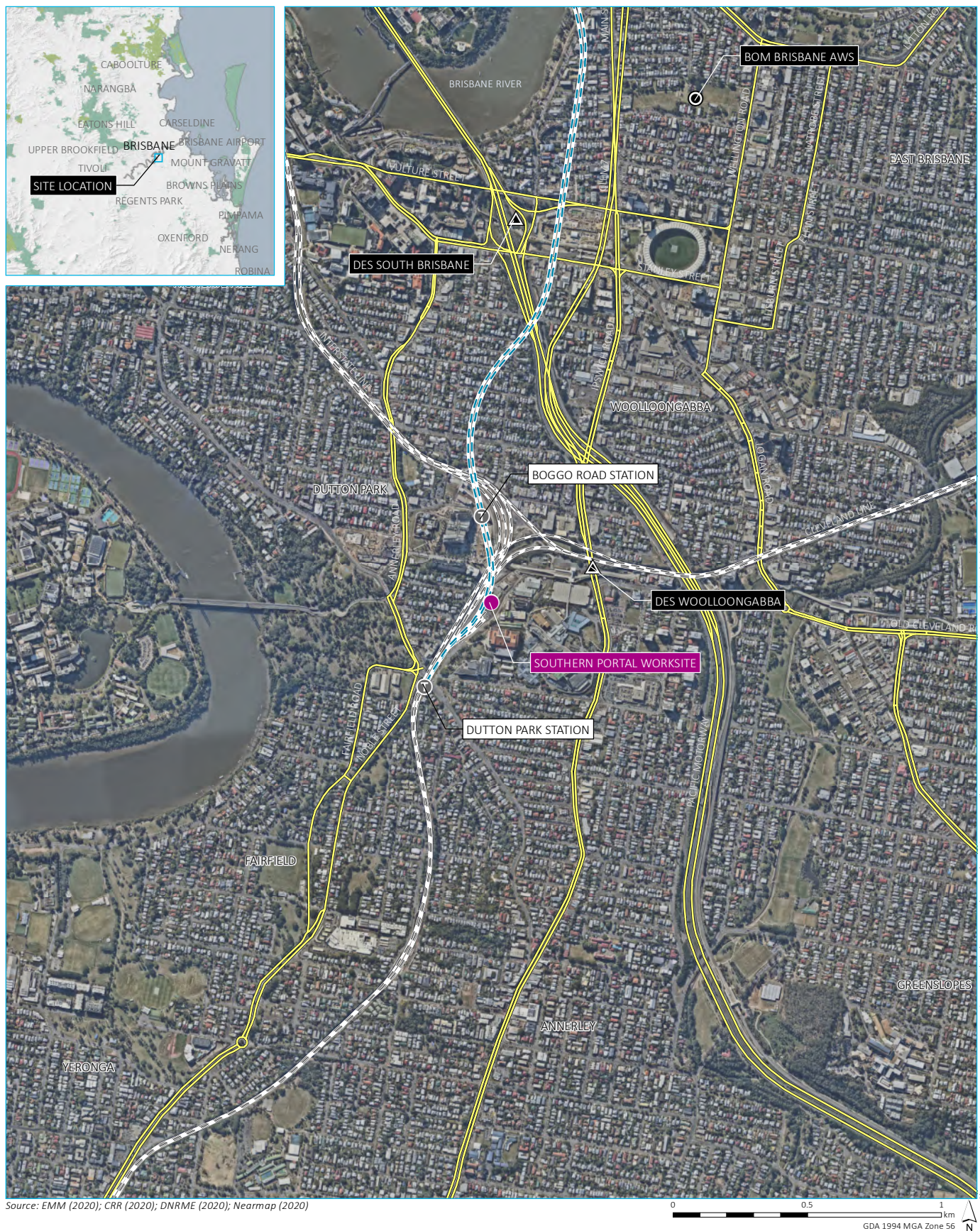
CBGU JV has requested that EMM Consulting (EMM) prepare an AQIA to assess the changes at this site.

1.2 Purpose of this report

This AQIA consists of the following sections:

- a description of the local setting and surrounds of the project;
- the pollutants which are relevant to the assessment, and the applicable air quality objectives (criteria);
- a description of the existing environment, specifically:
 - the meteorology and climate; and
 - the existing air quality environment;
- a detailed air pollutant emissions inventory for the project;
- atmospheric dispersion modelling for the quantified emissions, including cumulative impacts accounting for baseline air quality; and
- an overview of mitigation measures employed at the site.

The AQIA has been prepared in general accordance with the QLD *Environmental Protection (Air) Policy 2019 (EPP (Air))*.



KEY

- Southern Portal worksite
- ⊙ Meteorological station
- △ Air quality station
- Ⓣ Train station
- Cross River Rail line
- Existing rail line
- Major road
- Reserve (refer to inset)
- State forest (refer to inset)

Southern Portal worksite location

Cross River Rail
Southern Portal Mod
Air quality impact assessment
Figure 1.1

2 Project and site description

2.1 Project overview

The Southern Portal of the CRR Tunnel is located to the south of the CRR Tunnels and Station Development (TSD) area. The area is bounded by the Princess Alexandra Hospital to the east and the existing Dutton Park Railway Station to the south, and is a congested rail corridor with multiple commuter rail lines servicing the Gold Coast and Cleveland regions along with freight rail lines to the Port of Brisbane. The Boggo Road Busway crossing lies underneath and a grade-separate freight flyover crossing above both the rail corridor and the Southern Portal is bounded and intersection by utility (ie powerlines, stormwater and sewer facilities).

Since the Request for Project Change 4 (RfPC-4) submission, further detailed planning has been undertaken on the Southern Area worksite. The planning considered the level of congestion within the rail corridor, including multiple commuter rail lines servicing the Gold Coast and Cleveland regions along with freight rail lines to the Port of Brisbane, the Boggo Road Busway that passes underneath the rail corridor, and a grade separated rail freight flyover crossing above the rail corridor. These key features were then overlaid with multiple intersections with utilities (power, stormwater and sewer) which need to be upgraded and / or relocated throughout the various stages of the work. Given the complexity of this area, the project faced a number of technical challenges, particularly with rail alignment, rail geometry and utility constraints. The design has now been further developed to resolve these technical issues.

The change of rail alignment associated with the project is shown in Figure 2.1.

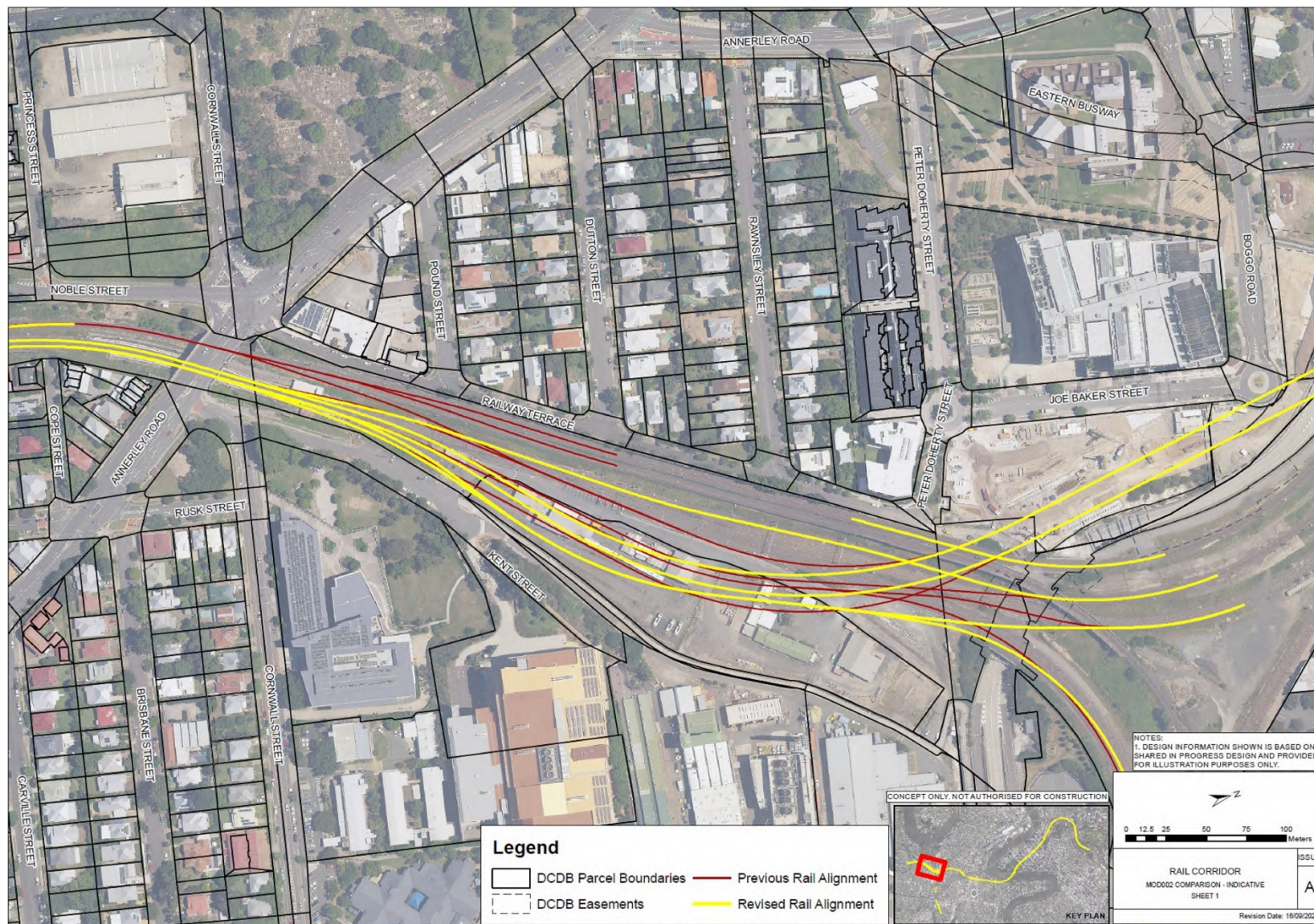


Figure 2.1 Southern Portal revised rail alignment

2.2 Site and surrounding area

The project is located between Dutton Park and Woolloongabba approximately 2.5 km south of the Brisbane Central Business District (CBD). It is bounded by the existing railway line to the west and Kent Street to the east.

Land use surrounding the project consists predominantly of commercial, industrial and residential properties.

CBGU JV also operates two other construction worksites related to the CRR tunnel in the vicinity of the project. The Boggo Road Station and Dutton Park Station worksites are shown on Figure 1.1. CBGU JV has indicated that the Boggo Road Station works would be occurring at the same time as the project and that it is possible that the Dutton Park Station works may also occur at the same time however, this is not yet certain and any potential cross-over period is unknown at this point.

As construction activities may occur at all three worksites concurrently, the Boggo Road Station and Dutton Park Station sites have been included in the cumulative assessment (see Section 7.3).

The project is located within a slight channel at an elevation of approximately 21 m Australian Height Datum (AHD). Elevations increase to around 30 to 40 m directly surrounding the project and then decrease to approximately 10 m towards the west where the land meets the Brisbane River.

The nearest representative air quality sensitive locations to the project were identified in the 2019 AQIA for the purpose of assessing potential air quality impacts in proximity to the Southern Portal and Boggo Road worksites. Details are provided in Table 2.1 and their locations are shown in Figure 2.2. The locations taken from the 2019 AQIA are shown as S1 to S6. Four additional locations (S7 to S10) were included in the vicinity of Dutton Park Station in order to assess cumulative impacts as discussed above. These locations are referred to in this report as 'assessment locations'.

Table 2.1 Air quality assessment locations

ID	Assessment location type	Easting	Northing
S1	Workplace/commercial	502918	6958683
S2	Workplace/commercial	503138	6958397
S3	Residential	502979	6958494
S4	Residential	502752	6958474
S5	School	502842	6958872
S6	Residential	503012	6958547
S7	Workplace/commercial	502963	6958175
S8	Workplace/commercial	502833	6958220
S9	Residential	502860	6958084
S10	Residential	502744	6958048



Source: EMM (2020); CRR (2020); DNRME (2020); Nearmap (2020)

KEY

- Southern Portal worksite
- Ⓣ Train station
- Cross River Rail track
- Existing rail line
- Assessment locations
- Residential
- Workplace/commercial
- School

Air quality assessment locations

Cross River Rail
Southern Portal Mod
Air quality impact assessment
Figure 2.2

3 Pollutant and assessment criteria

3.1 Introduction

The project has the potential to generate emissions of various air pollutants to the atmosphere. Air pollution emission sources will comprise of a mixture of the following:

- fugitive sources of particulate matter, such as material handling activities, movement of mobile plant and equipment on paved surfaces, and wind erosion of exposed surfaces and storage piles; and
- combustion sources, such as exhaust emissions from the construction equipment fleet.

A detailed description of the emission sources associated with the project is presented in Section 6.

3.2 Potential air pollutants

The construction phase of the project will generate emissions of:

- particulate matter, specifically:
 - total suspended particulate matter (TSP);
 - particulate matter less than 10 micrometres (μm) in aerodynamic diameter (PM_{10}); and
 - particulate matter less than 2.5 μm in aerodynamic diameter ($\text{PM}_{2.5}$).
- gaseous pollutants, specifically:
 - oxides of nitrogen (NO_x)¹, including nitrogen dioxide (NO_2);
 - sulfur dioxide (SO_2);
 - carbon monoxide (CO); and
 - volatile organic compounds (VOCs).

Of the above listed pollutants, this assessment will focus on emissions and impacts from particulate matter (TSP, PM_{10} and $\text{PM}_{2.5}$). These pollutants are considered key indicators for potential effects on human health and amenity based on the types and intensity of activities proposed during the project.

¹ By convention, NO_x = nitrous oxide (NO) + NO_2 .

3.3 Applicable air quality assessment criteria

Air quality objectives (or criteria) related to human health are specified in the Queensland EPP (Air).

There are no formal dust nuisance guidelines stated in the EPP (Air). However, the QLD Government has recommended the following criteria (QLD Government 2017):

- a dust deposition rate of 120 mg/m²/day averaged over 30 days.

In addition, the construction of the CRR project includes a set of 'Project Imposed Conditions from the Coordinator General' (hereafter referred to as the 'Project Imposed Conditions'). These provide air quality goals under which construction works should abide by. The most recent Imposed Conditions for the project related to air quality are given in the *Cross River Rail project, Coordinator-General's change report – design refinements and condition changes 2020* (DSDTI 2020).

The air quality objectives and the Project Imposed Conditions relevant to the assessment of this project are presented in Table 3.1 below. It is noted that the Project Imposed Conditions do not include PM_{2.5} air quality goals.

Table 3.1 Air quality objectives relevant to the project

PM metric	Averaging period	Impact assessment criterion	Source
Human health			
TSP	Annual	90 µg/m ³	EPP Air 2019 and Project Imposed Conditions (DSDTI 2020)
PM ₁₀	24-hours	50 µg/m ³	EPP Air 2019 and Project Imposed Conditions (DSDTI 2020)
	Annual	25 µg/m ³	EPP Air 2019 and Project Imposed Conditions (DSDTI 2020)
PM _{2.5}	24-hours	25 µg/m ³	EPP Air 2019
	Annual	8 µg/m ³	EPP Air 2019
Nuisance impacts			
TSP	24-hours	80 µg/m ³	EPP Air 2019 and Project Imposed Conditions (DSDTI 2020)
Dust deposition	30 days	120 mg/m ² /day	QLD Government ² and Project Imposed Conditions (DSDTI 2020)

Notes: µg/m³: micrograms per cubic metre; mg/m²/day: milligram per square metre per day

² <https://www.qld.gov.au/environment/pollution/monitoring/air/air-pollution/pollutants/particles>

4 Meteorology and climate

4.1 Introduction

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. To adequately characterise the dispersion meteorology of a region, information is needed on the prevailing wind regime, ambient temperature, rainfall, relative humidity, mixing depth and atmospheric stability.

Meteorological data from the Bureau of Meteorology's (BoM) Brisbane automatic weather station (AWS) (station number 40913) were analysed for purposes of this assessment. The station is located approximately 700 m north-east of the project (see Figure 1.1). The BoM Brisbane AWS records a range of meteorological parameters including wind speed, wind direction, temperature, relative humidity and station-level pressure.

It is noted that the DES operates a monitoring station located in Woolloongabba approximately 300 m east of the project. The station records weather and air quality data. Data were only available from this station for 2018 and 2019 and therefore, five years of data could not be analysed to establish a representative year for modelling. For this reason, data from this station were not included in the modelling however, the 2018 data were compared to the BoM Brisbane AWS in the following section. It is noted that the use of the BoM Brisbane AWS data is also consistent with that used in the 2019 AQIA.

4.2 Selection of a representative year

Meteorological data recorded by the BoM Brisbane AWS for the period between 2015 and 2019 were analysed for the purposes of selecting a representative year for dispersion modelling.

Annual wind roses created from wind speed and direction data collected at the BoM Brisbane AWS from 2015 to 2019 are presented in Figure A.1. The wind roses show a similarity across years in both wind speed and wind direction. The winds recorded by the BoM Brisbane AWS across all five years were predominately from the south-west and north-east. Annual average wind speeds ranged between 1.6 m/s and 1.7 m/s. The annual average frequency of calm conditions (wind speeds less than 0.5 m/s) ranged between 10.1% and 14.5%.

Data availability for all years was between 96% and 100% across the most important parameters for modelling.

Seasonal and diurnal wind roses for the BoM Brisbane AWS for 2015 to 2019 are shown in Figure A.2. The mean wind speed ranges from 1.4 m/s in winter to 1.9 m/s in summer. The annual percentage of calm conditions ranged from 8% in summer and 14.6% in winter. The annual wind patterns in spring and summer were very similar displaying dominant north-easterly winds. In autumn and winter, the dominant winds were from the south-west.

Variation in wind patterns was more pronounced on a diurnal basis. Diurnal wind roses for the BoM Brisbane AWS are shown in Figure A.3. North-easterlies were prominent during daytime hours and south-westerlies were prominent during night-time hours. The average wind speed during the day was 2 m/s compared to 1.2 m/s at night-time. The percentage of calms during the day was 4.8% compared to 19.4% at night.

The 2018 calendar year was adopted as the 12-month modelling period for the purpose of this AQIA given the data availability, consistency of the data year-on-year and the similarity to the DES Woolloongabba station data. The modelling year was also chosen with regard to background air quality which is discussed in Section 5.

The annual wind rose for the BoM Brisbane AWS for 2018 is shown in Figure 4.1. The wind rose displays the same characteristics as that described above with dominant winds from the south-west and north-east.

As discussed above, data from the DES Woolloongabba monitoring station were excluded from the CALMET modelling due to data availability however, an annual wind rose for the DES Woolloongabba station in 2018 was generated (Figure 4.1) to compare to the BoM Brisbane AWS wind rose shown in the same figure. When compared to the BoM Brisbane wind rose, the general wind patterns recorded at the DES Woolloongabba station are very similar with dominant winds occurring from the south-west. The DES Woolloongabba station shows a slightly higher frequency of winds from the south-east. The annual average wind speed between the two sites is similar (1.6 m/s at BoM Brisbane compared to 1.4 m/s at DES Woolloongabba) and the annual percentage of calms is higher at BoM Brisbane.

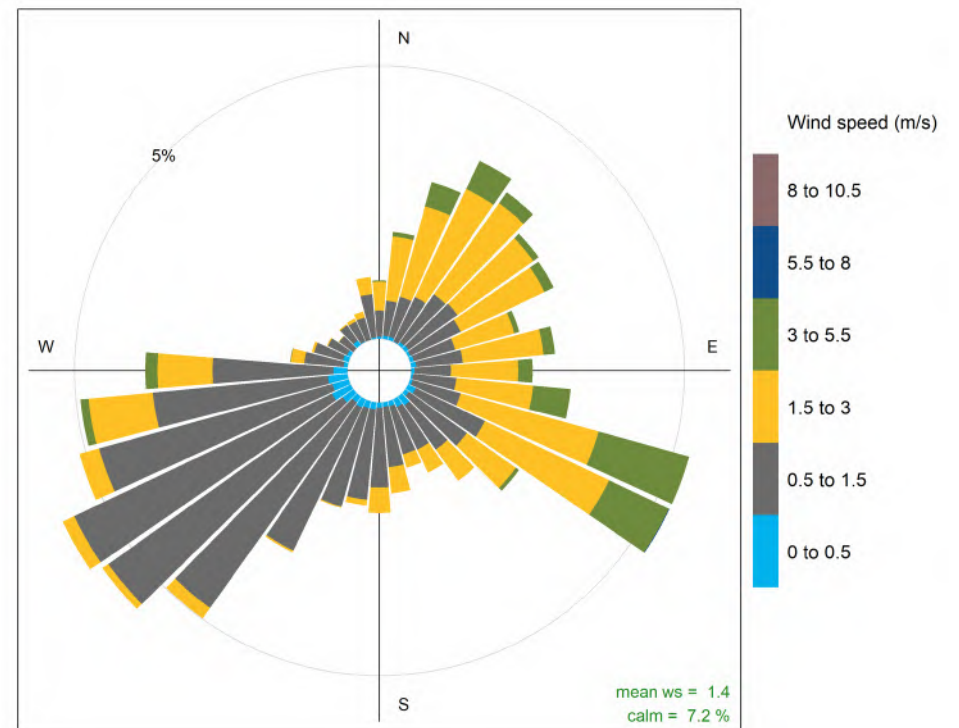
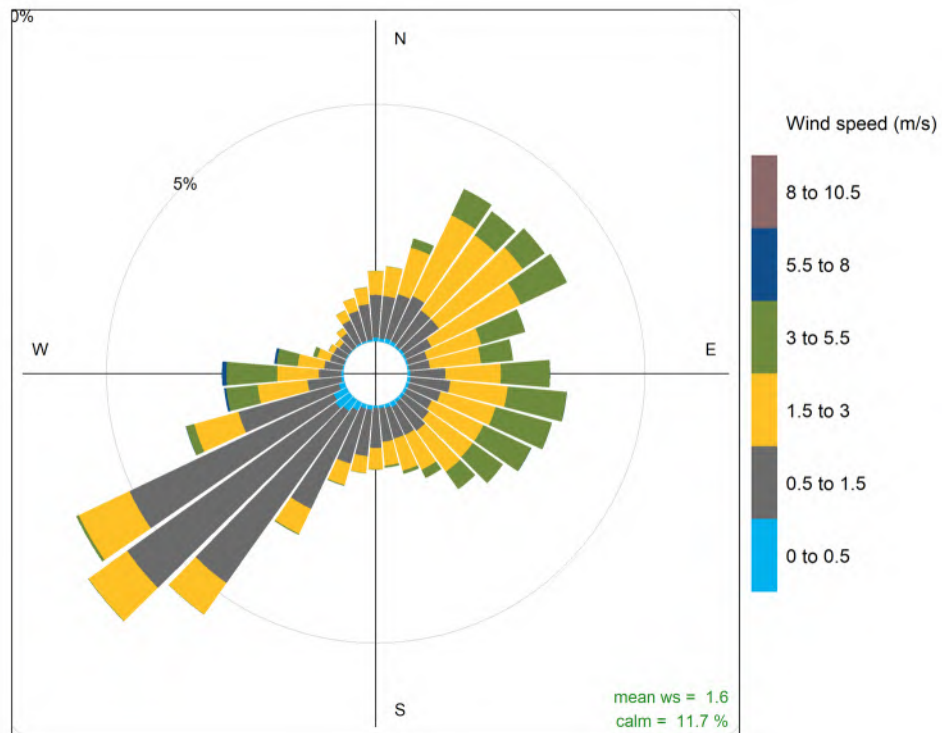


Figure 4.1 Annual wind rose for BoM Brisbane AWS 2018 and DES Woolloongabba 2018

4.3 Meteorological modelling

Atmospheric dispersion modelling for this assessment has been completed using The Air Pollution Model (TAPM) and the CALMET/CALPUFF model suite. A brief description of these models is provided in Section A.2.

Hourly average meteorological data from the BoM Brisbane AWS were used as observations in the TAPM and CALMET modelling. Cloud amount and cloud height data are not measured at this site and therefore these data were incorporated in CALMET through the use of the prognostic 3-dimensional data extracted from TAPM.

Further details of the TAPM and CALMET meteorological modelling is presented in Section A.2.

5 Baseline air quality

5.1 Introduction

The local airshed surrounding the project will be influenced by:

- local commercial and industrial operations;
- wind generated dust from exposed areas;
- dust entrainment and tailpipe emissions from vehicle movements along local roads; and
- long-range transport of fine particles into the region.

More remote sources which contribute episodically to suspended particulates in the region include dust storms and bushfires. It is considered that all of the above emission sources are accounted for in the monitoring data analysed in the following sections of this report.

The DES operates several air quality monitoring stations in the wider Brisbane area. The closest station to the project is DES Woolloongabba located approximately 300 m east of the construction worksite (see Figure 1.1). The station is located 10 m from the kerb of a busy, main road (Ipswich Road) and therefore, concentrations measured at this station will include contribution from traffic sources along this road. The DES South Brisbane station is located approximately 1.4 km north of the project in a green space further from main roads (see Figure 1.1).

Hourly average concentrations of PM₁₀ and PM_{2.5} for the DES Woolloongabba and South Brisbane stations were analysed for the available periods below.

5.2 Background air quality

5.2.1 PM₁₀

A summary of key statistics for the two years of analysed data from the DES Woolloongabba station is presented in Table 5.1. Exceedances of the air quality objective of 50 µg/m³ were recorded in both years. There is also a clear increase in concentrations in 2019.

Table 5.1 Statistics for PM₁₀ concentrations – DES Woolloongabba – 2018–2019 (µg/m³)

Parameter	2018	2019
Data recovery	91%	94%
Maximum 24-hour average	313.8	895.5
Annual average	18.8	22.7
70 th percentile	21.3	22.7
Days > 50 µg/m ³	107	457

As discussed above, the DES also measures air quality data in South Brisbane, approximately 1.4 km north of the project. A summary of key statistics for the four years of analysed data from the DES South Brisbane station is presented in Table 5.2. Exceedances of the air quality objective of 50 µg/m³ were recorded in all four years with an upward trend in concentrations seen from 2016.

The data shows that the DES Woolloongabba site records higher PM₁₀ concentrations than at the DES South Brisbane site. This is likely due to the fact that the DES Woolloongabba station is highly influenced by traffic along Ipswich Road. The DES South Brisbane station is located further away from a main road and is therefore deemed more representative of conditions immediately surrounding the project. For this reason, data from the DES South Brisbane station were selected for use in the cumulative assessment.

Table 5.2 Statistics for PM₁₀ concentrations – DES South Brisbane – 2016–2018 (µg/m³)

Parameter	2016	2017	2018	2019
Data recovery	94%	89%	99%	98%
Maximum 24-hour average	66.7	84.9	403.2	897.7
Annual average	15.9	15.3	17.3	23.0
70 th percentile	18.7	18.0	18.5	22.4
Days > 50 µg/m ³	4	22	168	446

A time series of recorded 24-hour average PM₁₀ concentrations at the DES South Brisbane station for the period between 2015 to 2019 is presented in Figure 5.1. The recorded 24-hour average PM₁₀ concentrations fluctuated throughout the period however there is a clear upward trend of concentration since 2016. It is assumed that the increase in concentrations from the later part of 2018 and throughout 2019 are attributed to intensive drought and smoke from major bushfires and hazard reduction burns across Australia during this time. An analysis of rainfall data collected at the BoM Brisbane AWS between 2015 and 2019 also showed that there was a steady decrease in rainfall between 2015 and 2019. As a result, 2019 was not considered for use in the dispersion modelling for this assessment.

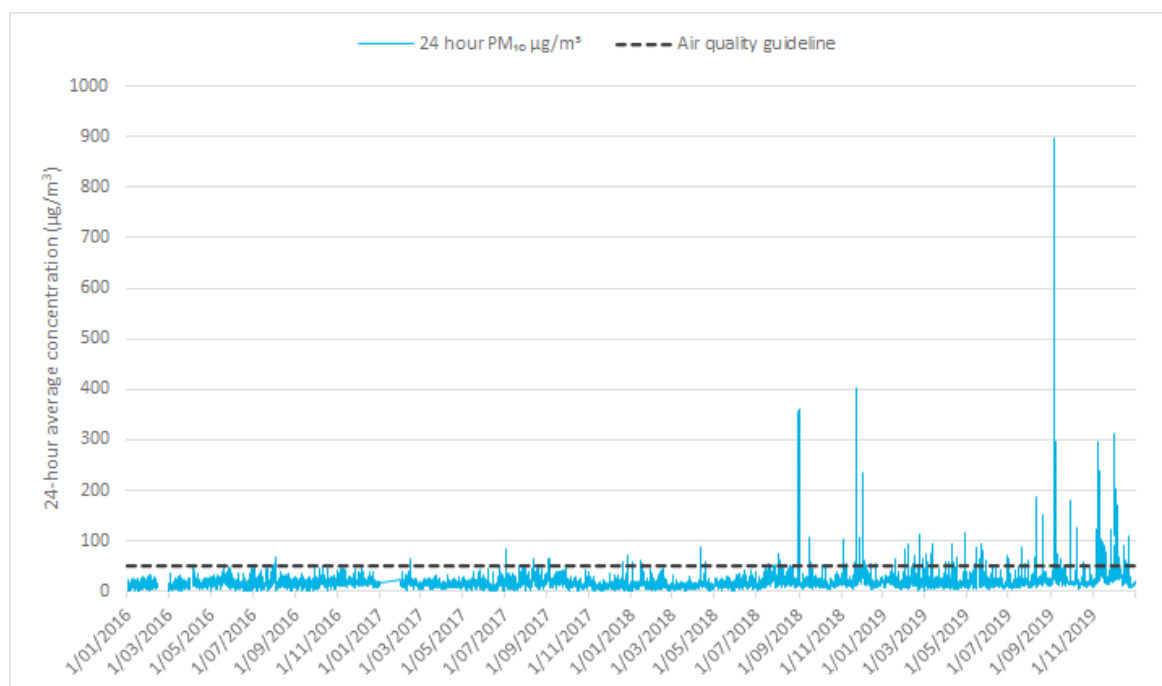


Figure 5.1 Time series of 24-hour average PM₁₀ concentrations – DES South Brisbane – 2015–2019

5.2.2 PM_{2.5}

A summary of key statistics for the two years of analysed PM_{2.5} data from the DES Woolloongabba station is presented in Table 5.3. Exceedances of the air quality objective of 25 µg/m³ were recorded in both years. Similar to the PM₁₀ concentrations, there is also a clear increase in concentrations in 2019. It is noted that the annual average PM_{2.5} concentrations recorded in both years, is above the annual average air quality objective of 8 µg/m³. This is likely due to the station's location next to a main road.

Table 5.3 Statistics for PM_{2.5} concentrations – DES Woolloongabba – 2018–2019 (µg/m³)

Parameter	2018	2019
Data recovery	91%	94%
Maximum 24-hour average	74.0	238.8
Annual average	9.6	10.2
70 th percentile	11.4	10.1
Days > 50 µg/m ³	180	451

A summary of key statistics for the four years of analysed data from the DES South Brisbane station is presented in Table 5.4. Similar to the PM₁₀ measurements, exceedances of the air quality guideline of 25 µg/m³ were recorded in all four years with an upward trend in concentrations seen from 2016. The annual average PM_{2.5} concentration for 2018 is 7.3 µg/m³.

Table 5.4 Statistics for PM_{2.5} concentrations – DES South Brisbane – 2016–2018 (µg/m³)

Parameter	2016	2017	2018	2019
Data recovery	94%	89%	99%	98%
Maximum 24-hour average	66.7	58.7	61.1	217
Annual average	8.3	7.7	7.3	9.8
70 th percentile	9.8	8.9	8.3	9.5
Days > 25 µg/m ³	88	99	147	366

A time series of recorded 24-hour average PM_{2.5} concentrations at the DES South Brisbane station for the period between 2016 to 2019 is presented in Figure 5.2. The PM_{2.5} concentrations again show an upward trend in concentrations since the beginning of the monitoring period.

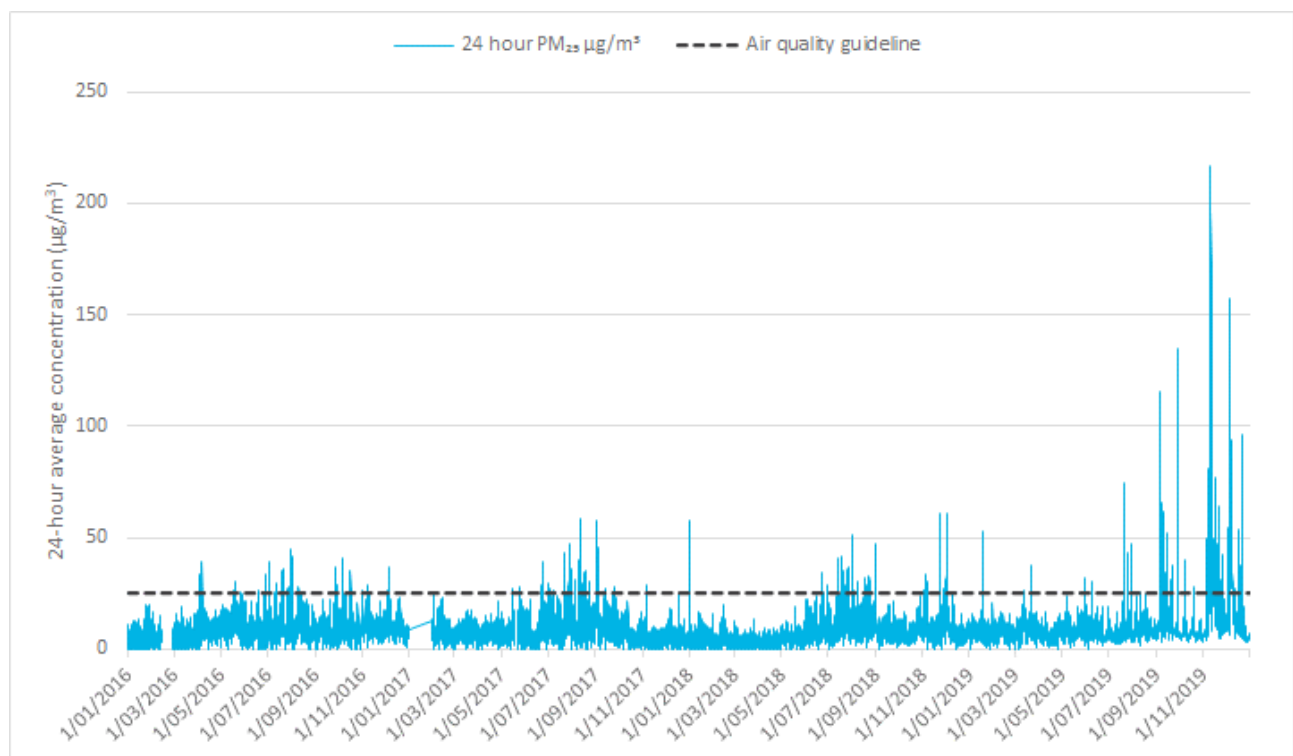


Figure 5.2 Time series of 24-hour average PM_{2.5} concentrations – DES South Brisbane – 2016 to 2019

5.2.3 TSP and dust deposition

TSP concentrations are not recorded at the DES South Brisbane monitoring station. The 2019 AQIA included other worksites in the CRR project. The AQIA included TSP data from the DES Cannon Hill monitoring station (located approximately 6.8 km north-east of the Woolloongabba Station worksite).

For this assessment a ratio of 40% PM₁₀:TSP was assumed using the 70th percentile 24-hour measured PM₁₀ concentration and the annual average concentration. This is a common approach used in AQIAs where TSP data are not available.

Measured dust deposition data is also not available within the project area. A background value of 60 mg/m²/day has been adopted per the 2019 AQIA.

5.3 Assumed background concentrations

In summary, the following background values were adopted for cumulative assessment:

- 24-hour PM₁₀ concentration – 70th percentile value of 18.5 µg/m³;
- annual average PM₁₀ concentration – 17.3 µg/m³;
- 24-hour PM_{2.5} concentration – 70th percentile value of 8.3 µg/m³;
- annual average PM_{2.5} concentration – 7.3 µg/m³;
- 24-hour TSP concentration – 46.3 µg/m³;
- annual average TSP concentration – 43.3 µg/m³; and
- annual average dust deposition – 60 mg/m²/day.

It is noted that the 24-hour PM₁₀ and PM_{2.5} background concentrations were calculated using the 70th percentile from the 2018 dataset. This approach is recommended under the *Brisbane City Council Air Quality Planning Scheme Policy*³. This approach is also consistent with the 2019 AQIA.

³ <http://eplan.brisbane.qld.gov.au/CP/AirQualityPSP>

6 Emissions inventory

6.1 Introduction

In order to quantify peak air pollution emissions and associated impacts in the surrounding environment from the project's activities, a worst-case emissions scenario has been configured. This scenario assumes that all construction activities at the project would be occurring at the same time continuously for a full year, rather than the actual staged progression of construction activities. This is a very conservative assumption that will return an upper estimate of potential air quality emissions and associated impacts from the project.

6.2 Emissions estimates

6.2.1 Southern Portal

Fugitive dust sources associated with the operations of the project were quantified through the application of US-EPA AP-42 emission factor equations. Particulate matter emissions were quantified for the three size fractions – TSP, PM₁₀ and PM_{2.5}. Emission rates for coarse particles (PM₁₀) and fine particles (PM_{2.5}) were estimated using ratios for the different particle size fractions available in the literature (principally the US-EPA AP-42).

The calculated annual TSP, PM₁₀ and PM_{2.5} emissions for each construction activity occurring at the worksite are shown in Table 6.1. Each activity has been represented in the modelling as line-volume sources. Site diesel combustion was attributed equally to all activities (except wind erosion). It is noted that the calculated emissions shown in Table 6.1 incorporate particulate matter management measures detailed in Section 6.3).

A detailed description of the assumptions and emission factors adopted in the development of the emissions inventory are provided in Appendix B.

Table 6.1 **Calculated annual TSP, PM₁₀ and PM_{2.5} emissions – Southern Portal**

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM ₁₀	PM _{2.5}
Drilling	5.3	2.8	0.16
Excavators/FELs	43	20	3
Bulldozers on spoil	7,591	1,834	797
Loading trucks	43	20	3
Wheel-generated dust (paved roads)	270	52	13
Rock breaker	21.5	10.2	1.5
Piling rig	46	24	1
Wind erosion	0.36	0.18	0.03
Site diesel combustion	220	220	202
Total	8,240	2,184	1,021

Note: Emission totals incorporate particulate matter management measures (refer Section 6.3).

6.2.2 Neighbouring construction emission sources

As discussed in Section 2.2, there are two CRR construction sites in the vicinity of the project. The Boggo Road Station site is located approximately 140 m north-east of the project, and the Dutton Park Station site is located directly south of the project and connecting into a continuous area. Figure 1.1 shows the location of the three worksites.

CBGU JV has indicated that the Boggo Road Station construction works would be occurring concurrently with the project works. CBGU has indicated that whilst the Dutton Park Station construction works could also occur at the same time, the extent of the overlapping period in works is currently unknown at this point. For conservative purposes, both the Boggo Road Station and Dutton Park Station have been included as concurrent construction activities for cumulative assessment purposes.

Emissions of TSP, PM₁₀ and PM_{2.5} were estimated based on information provided by CBGU JV for the two neighbouring worksites. The calculated annual TSP, PM₁₀ and PM_{2.5} emissions for each construction activity occurring at the Boggo Road and Dutton Park Station worksites are shown in Table 6.2 and Table 6.3 respectively. The emissions include dust mitigation measures such as water sprays when drilling, handling materials and on exposed areas, fencing/hoardings around activities and watering and binding agents applied on equipment haul routes.

Similar to the modelling of the project activities, each activity for the two neighbouring worksites has been represented in the modelling as line-volume sources. Site diesel combustion was attributed equally to all activities (except wind erosion).

Table 6.2 **Calculated annual TSP, PM₁₀ and PM_{2.5} emissions – Boggo Road Station**

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM ₁₀	PM _{2.5}
Drilling	3.5	1.8	0.11
Blasting	2	1	0.1
Excavators/FELs	84	40	6
Loading trucks	84	40	6
Wheel-generated dust (paved roads)	1,407	270	65
Rock breaker	322.8	63.7	9.6
Piling rig	31	16	1
Wind erosion	2	1	0
Site diesel combustion	399	399	366
Total	2,336	833	454

Note: Emission totals incorporate particulate matter management measures mentioned in the section above.

Table 6.3 **Calculated annual TSP, PM₁₀ and PM_{2.5} emissions – Dutton Park Station**

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM ₁₀	PM _{2.5}
Drilling	8.1	4.2	0.24
Excavators/FELs	4	2	0.3
Loading trucks (direct load-out)	4	2	0.3
Rock breaker	2.6	0.5	0.1
Piling rig	71	37	2
Wind erosion	0.18	0.09	0.01
Site diesel combustion	15	15	14
Total	106	61	17

Note: Emission totals incorporate particulate matter management measures mentioned in the section above.

6.3 Management measures

In order to manage particulate matter emissions from the project, a range of mitigation measures and management practices are required.

The dust mitigation measures applied at the site are shown in Table 6.4. The corresponding control factors applied in the emissions estimation and dispersion modelling is also shown. These factors have been accounted for in the emissions estimates shown in Table 6.1. Emission control factors were determined based on the Katestone best practice document (Katestone 2011).

Table 6.4 Mitigation measures and control factors applied in the assessment

Construction activity	Mitigation measure	Control factor
Drilling	Water sprays	70%
Excavators/FELs	Water sprays and fencing	65%
Bulldozers on spoil	Water sprays and 3 sides & roof	85%
Loading trucks	Water sprays and fencing	65%
Wheel-generated dust (paved roads)	Paved roads and water sprays	50%
Rock breaker	Water sprays and fencing	65%
Piling rig	Water sprays and fencing	65%
Wind erosion	Water sprays and chemical binding agent	90%
Site diesel combustion	-	-

It is noted that there is a higher degree of mitigation measures proposed for the Southern Portal worksite than that assumed in the 2019 AQIA. For example:

- bulldozers will now operate with a fence/shade cloth, water sprays and operations will generally be under a tunnel roof (CBGU JV has indicated that from January 2022, operations will be entirely under the cut and cover roof);
- water sprays will be used when loading trucks, on the rock breaker and on the piling rig; and
- a binding agent will be used on exposed areas (as well as water sprays).

There will also be no blasting at the project site.

An Air Quality Management Plan (AQMP) also exists for the entire Cross River Rail Project (CBGU D&C JV 2020). The plan includes:

- details of mitigation measures;
- compliance management including training, incidents and emergencies (incorporating complaints management);
- details of air quality monitoring and auditing;
- reporting including greenhouse gas emissions and incident reporting; and
- documentation and communication protocols.

7 Air dispersion modelling

7.1 Dispersion model selection and configuration

Dispersion modelling for this assessment uses the CALPUFF modelling system, which is commonly used for applications where non-steady state conditions may occur (ie complex terrain or coastal locations) or when calm wind conditions are important (ie for odour assessment). In the absence of available upper air measurements, CALMET (the meteorological pre-processor for CALPUFF) can be run using prognostic upper air data (as a three-dimensional '3D.dat' file). Gridded upper air data were derived using The Air Pollution Model (TAPM), which is then used in CALMET to derive an initial wind field (known as the Step 1 wind field). CALMET then incorporates mesoscale and local scale effects, including surface observations, to adjust the wind field. This modelling approach is known as the 'hybrid' approach (TRC 2011) and has been adopted for this assessment. TAPM and CALMET model settings are described in Section A.2 and selected in accordance with recommendations in NSW EPA (2016) and TRC (2011). Surface observations are included in the modelling (referred to as data assimilation) and are discussed and described in Section 4.

In addition to the ten individual assessment locations (documented in Section 3), air pollutant concentrations were predicted over a 1.2 km (x direction) by 1.5 km (y direction) domain with 100 m resolution.

Simulations were undertaken for the 12-month period of 2018.

7.2 Incremental (project-only) results

Predicted incremental TSP, PM₁₀, PM_{2.5}, and dust deposition levels from the project are presented in Table 7.1 for each of the assessment locations. It is noted that dust deposition rates were predicted by CALPUFF from TSP emissions. Incremental results for Boggo Road Station and Dutton Park Station are provided in Appendix C for information only.

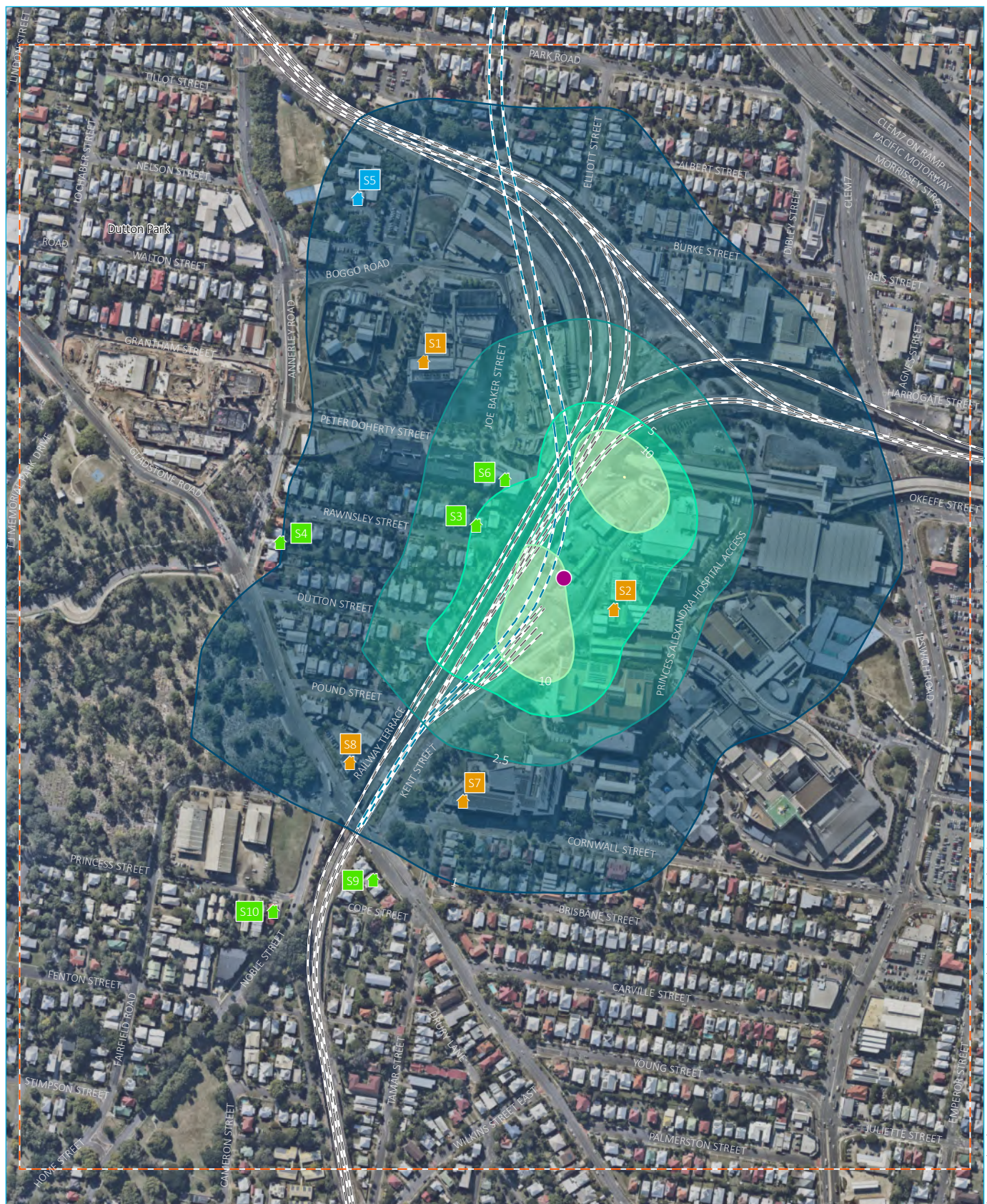
The predicted concentrations and deposition rates for all pollutants and averaging periods are below the applicable air quality objective at all assessment locations. The air quality objectives listed are applicable to cumulative concentrations and are shown for comparative purposes only. Analysis of cumulative impact compliance is presented in Section 7.3. Table 7.1 shows that the maximum 24-hour PM₁₀ concentration predicted as a result of the Southern Portal construction activities was 7.8 µg/m³ at assessment location S2 which is located within 30 m of the project and is a workplace/commercial location. This result is well below the cumulative air quality objective of 50 µg/m³. All other assessment locations are below 5 µg/m³. The maximum 24-hour PM_{2.5} concentration of 3.8 µg/m³ was also predicted at assessment location S2. Again, this is well below the cumulative air quality objective of 25 µg/m³. All other assessment locations were predicted to be below 2.5 µg/m³.

Contour plots, illustrating spatial variations in project-related incremental TSP, PM₁₀ and PM_{2.5} concentrations and dust deposition rates are provided in Figure 7.1 to Figure 7.7 below. Isopleth plots of the maximum 24-hour average concentrations presented do not represent the dispersion pattern on any day, but rather, the maximum daily concentration that was predicted to occur at each model calculation point given the range of meteorological conditions occurring over the 2018 modelling period. It is noted that only incremental contours have been shown in this report.

Table 7.1 Incremental (project only) concentration and deposition results

Assessment location ID	Predicted incremental concentration (µg/m³) and deposition rate (mg/m²/day)						
	TSP		PM ₁₀		PM _{2.5}		Dust deposition
	24-hour maximum	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Monthly maximum
Air quality objectives	80	90	50	25	25	8	120
S1	2.8	0.4	2.0	0.2	1.1	0.1	2.1
S2	20.3	3.5	7.8	1.3	3.8	0.6	22.1
S3	9.0	2.0	4.8	0.9	2.4	0.4	11.1
S4	1.2	0.3	0.9	0.2	0.5	0.1	1.4
S5	1.4	0.1	1.1	0.1	0.7	0.0	0.7
S6	8.1	1.7	4.4	0.8	2.3	0.4	10.0
S7	2.3	0.4	1.7	0.2	0.9	0.1	1.8
S8	1.8	0.3	1.5	0.2	0.8	0.1	1.5
S9	1.1	0.2	1.0	0.1	0.5	0.1	0.8
S10	0.7	0.1	0.6	0.1	0.3	0.0	0.5

Note: Air quality objectives are applicable to cumulative (increment + background). These are provided for comparison purposes only.



Source: EMM (2020); CRR (2020); DNRME (2020); Nearmap (2020)

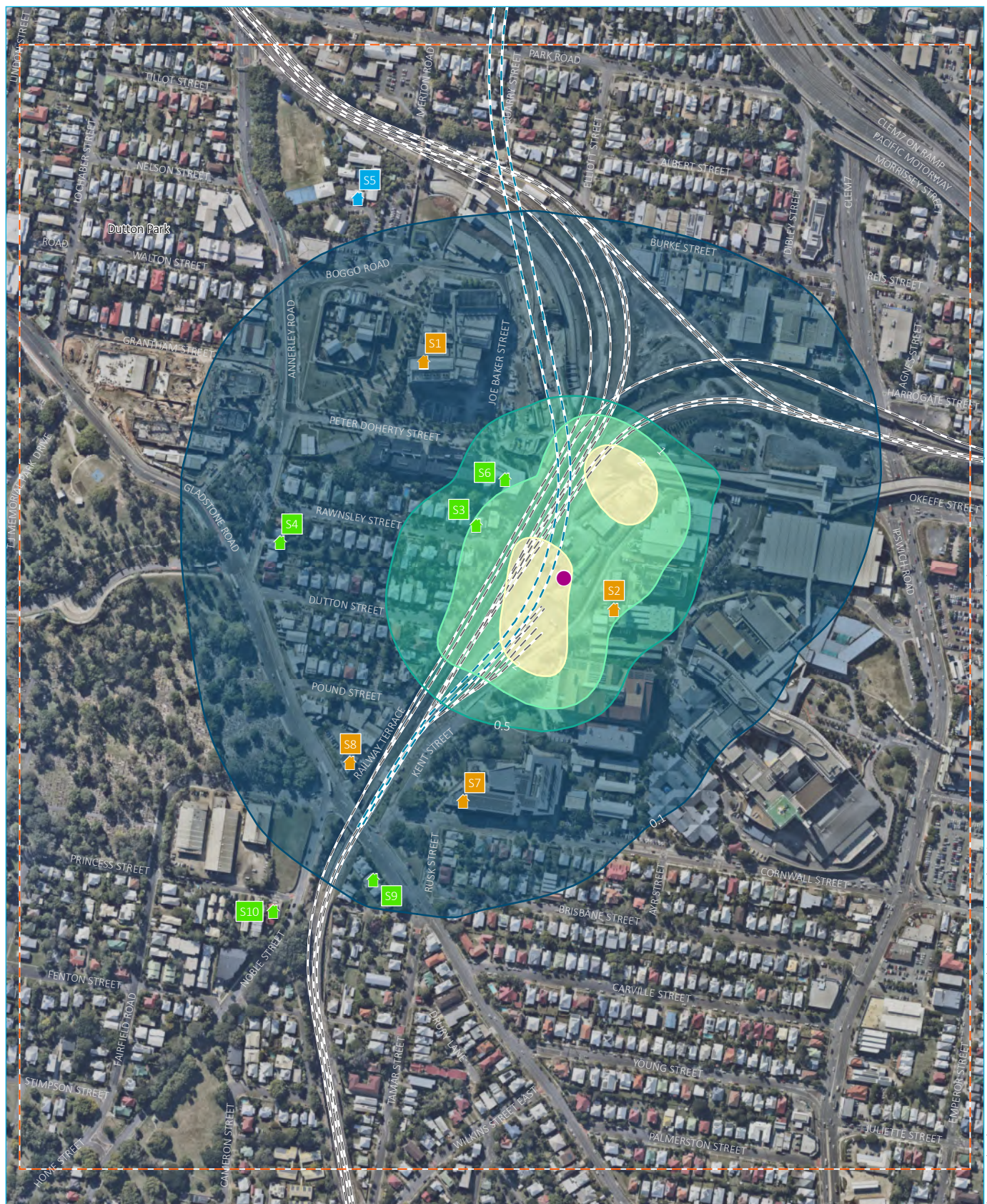
0 100 200
m
GDA 1994 MGA Zone 56

KEY

- Southern Portal worksite
- Cross River Rail track
- Existing rail line
- Model extent
- Assessment locations
- Residential
- Workplace/commercial
- School
- PM₁₀ concentration (µg/m³)
- 1
- 2.5
- 5
- 10
- 20

Maximum predicted 24-hour
average PM₁₀ concentrations - project only

Cross River Rail
Southern Portal Mod
Air quality impact assessment
Figure 7.1



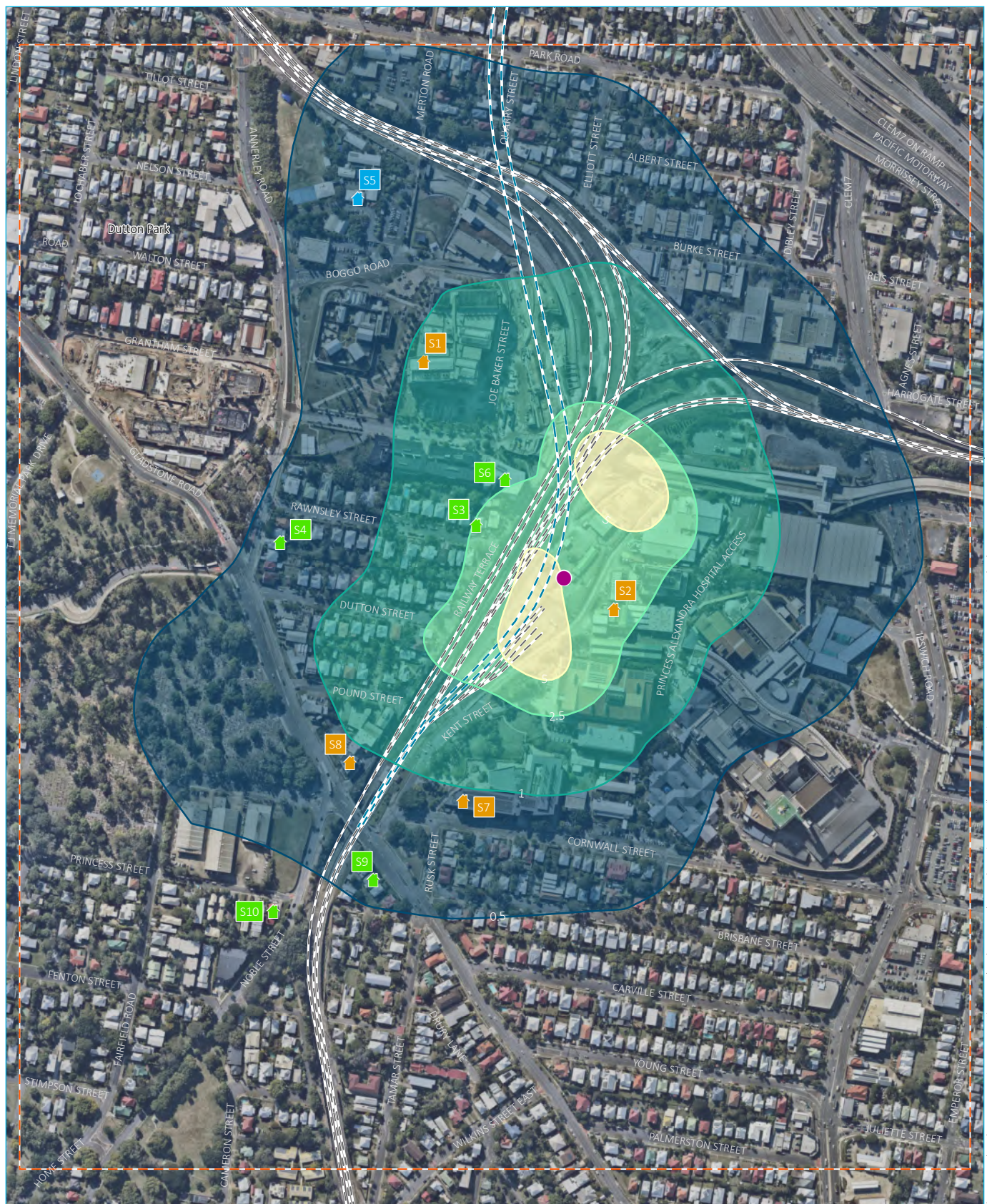
Source: EMM (2020); CRR (2020); DNRME (2020); Nearmap (2020)

KEY

- Southern Portal worksite
- Cross River Rail track
- Existing rail line
- ▭ Model extent
- Assessment locations
- Residential
- Workplace/commercial
- School
- Contour
- 0.1
- 0.5
- 1
- 2

Predicted annual average
PM₁₀ concentrations - project only

Cross River Rail
Southern Portal Mod
Air quality impact assessment
Figure 7.2



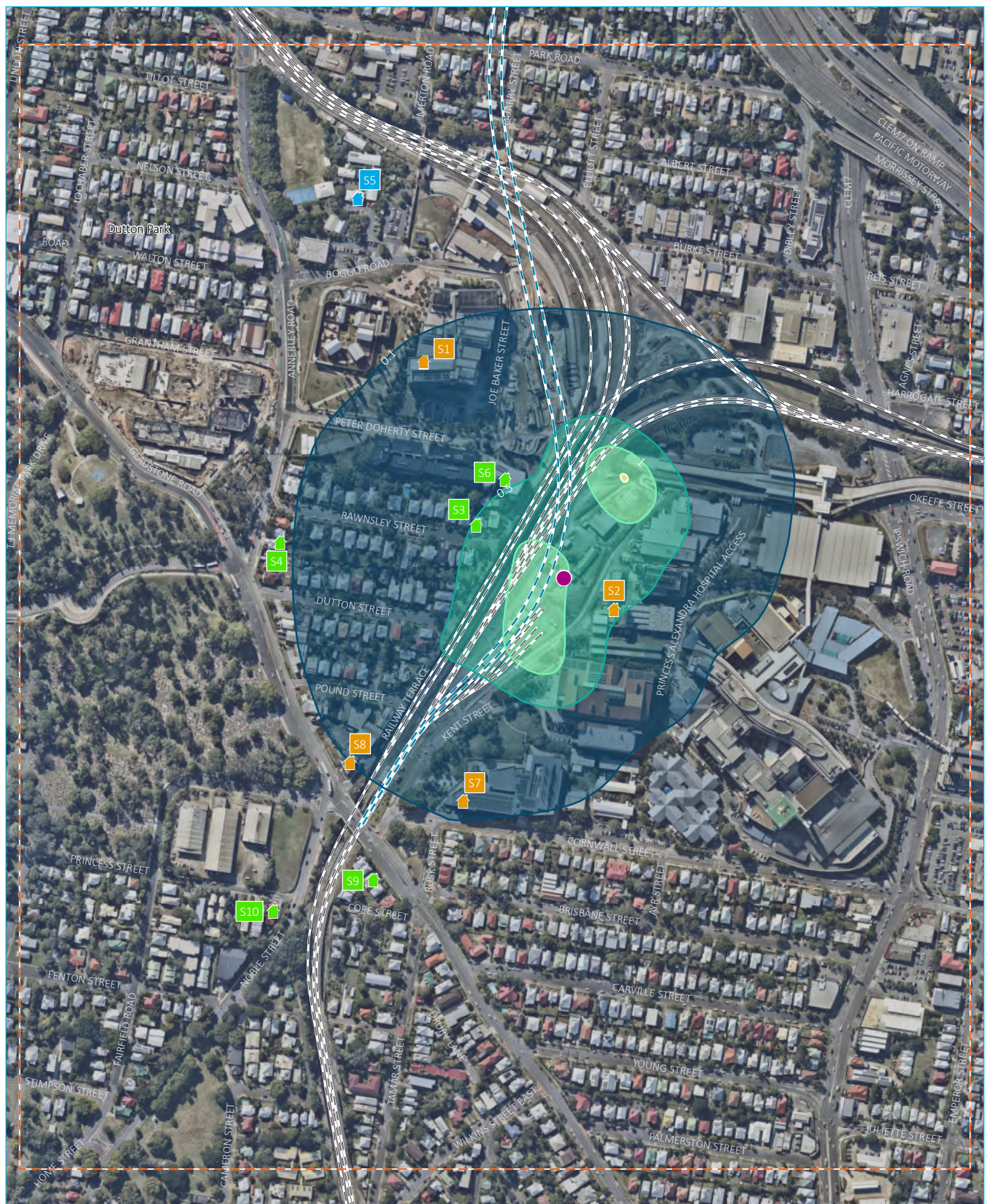
Source: EMM (2020); CRR (2020); DNRME (2020); Nearmap (2020)

KEY

- Southern Portal worksite
- Cross River Rail track
- Existing rail line
- - - Model extent
- Assessment locations
- Residential
- Workplace/commercial
- School
- Contour
- 0.5
- 1
- 2.5
- 5

Maximum predicted 24-hour average
PM_{2.5} concentrations - project only

Cross River Rail
Southern Portal Mod
Air quality impact assessment
Figure 7.3



Source: EMM (2020); CRR (2020); DNRME (2020); Nearmap (2020)

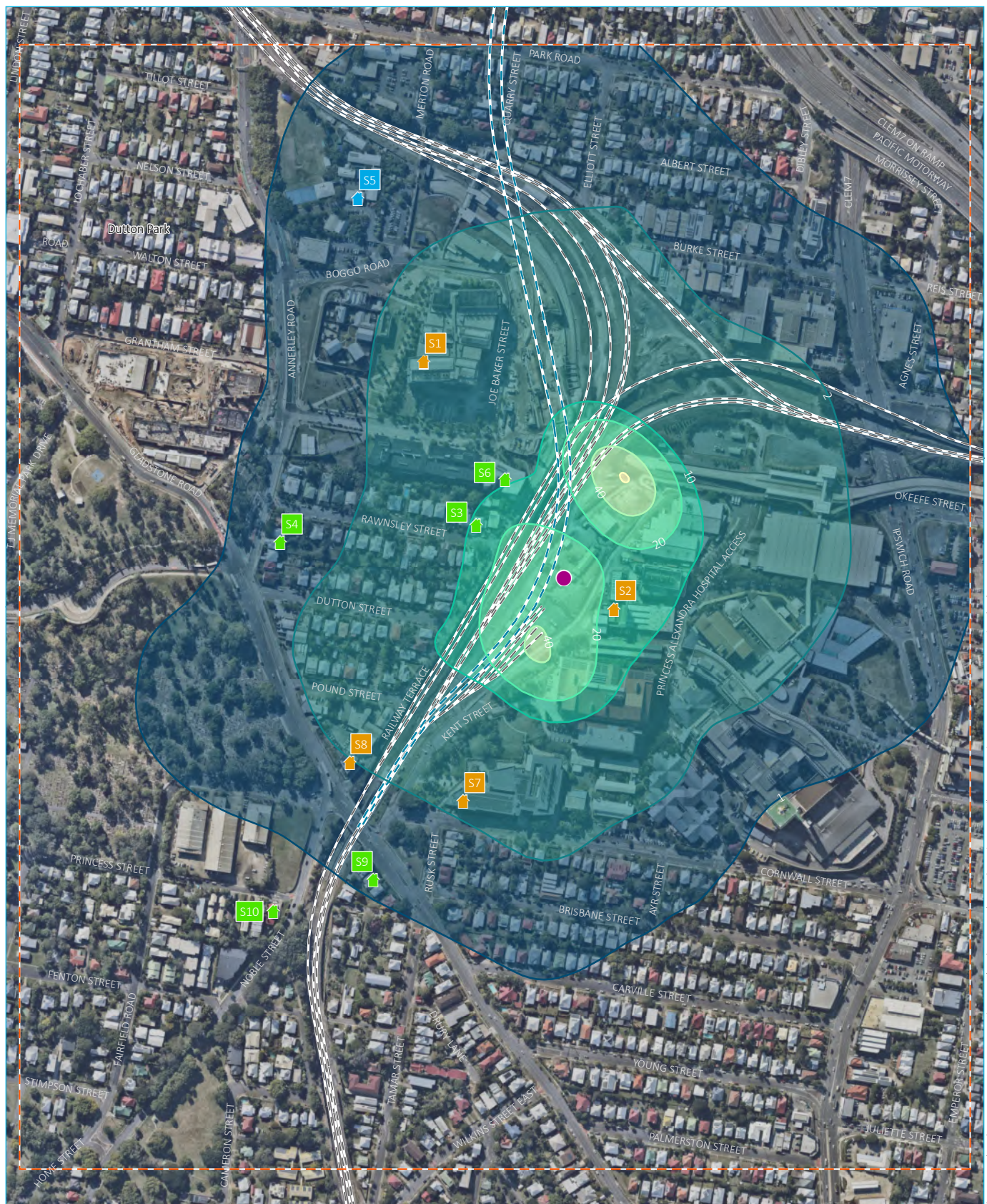
KEY

- Southern Portal worksite
- Cross River Rail track
- Existing rail line
- Model extent
- Assessment locations
- Residential
- Workplace/commercial
- School

- PM_{2.5} concentration (µg/m³)
- 0.1
- 0.5
- 1
- 1.5

Predicted annual average
PM_{2.5} concentrations - project only

Cross River Rail
Southern Portal Mod
Air quality impact assessment
Figure 7.4

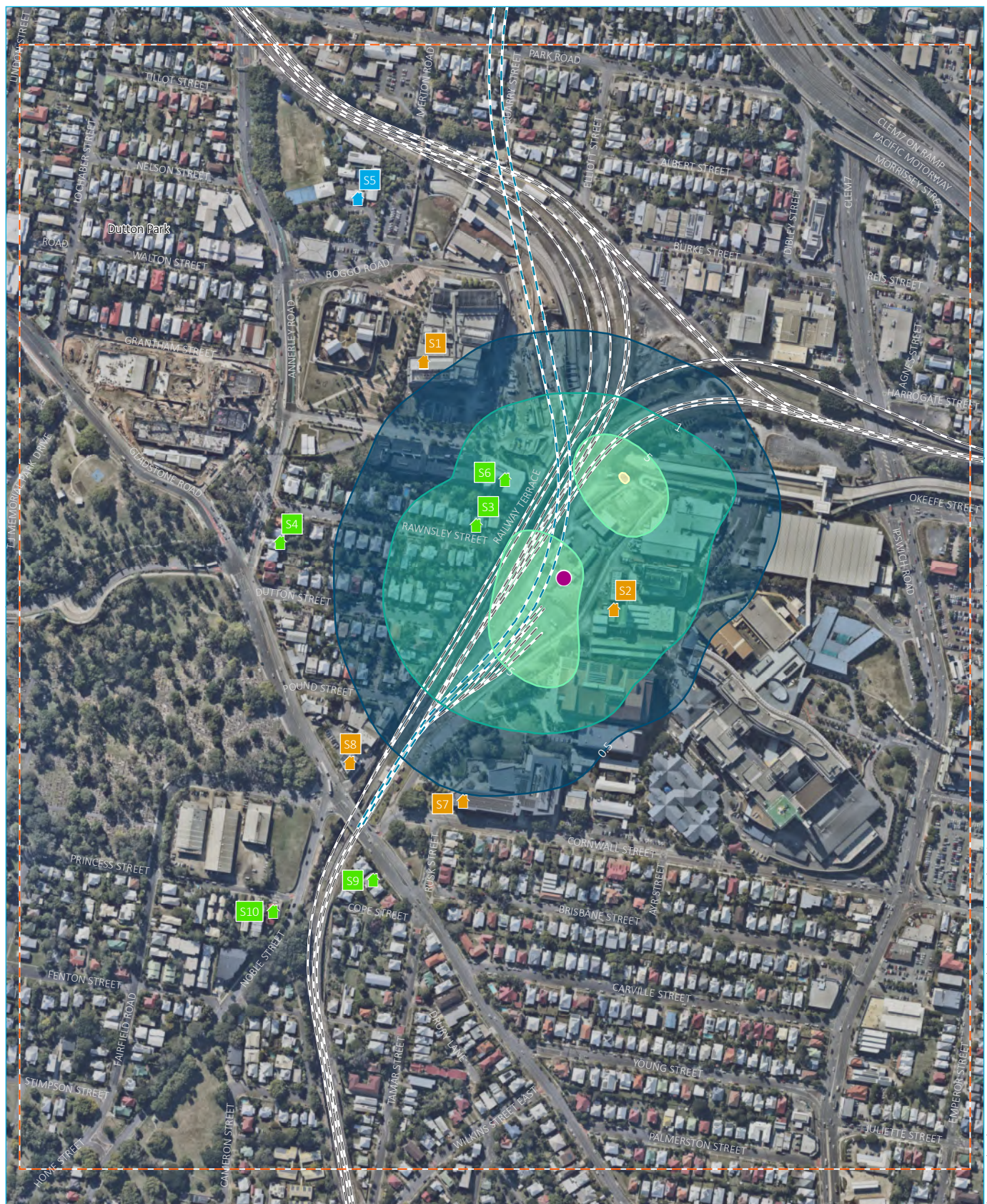


KEY

- Southern Portal worksite
 - Cross River Rail track
 - Existing rail line
 - Model extent
 - Assessment locations
 - Residential
 - Workplace/commercial
 - School
- | TSP concentration ($\mu\text{g}/\text{m}^3$) |
|--|
| 1 |
| 2 |
| 10 |
| 20 |
| 40 |
| 60 |

Predicted 24-hour average
TSP concentrations - project only

Cross River Rail
Southern Portal Mod
Air quality impact assessment
Figure 7.5



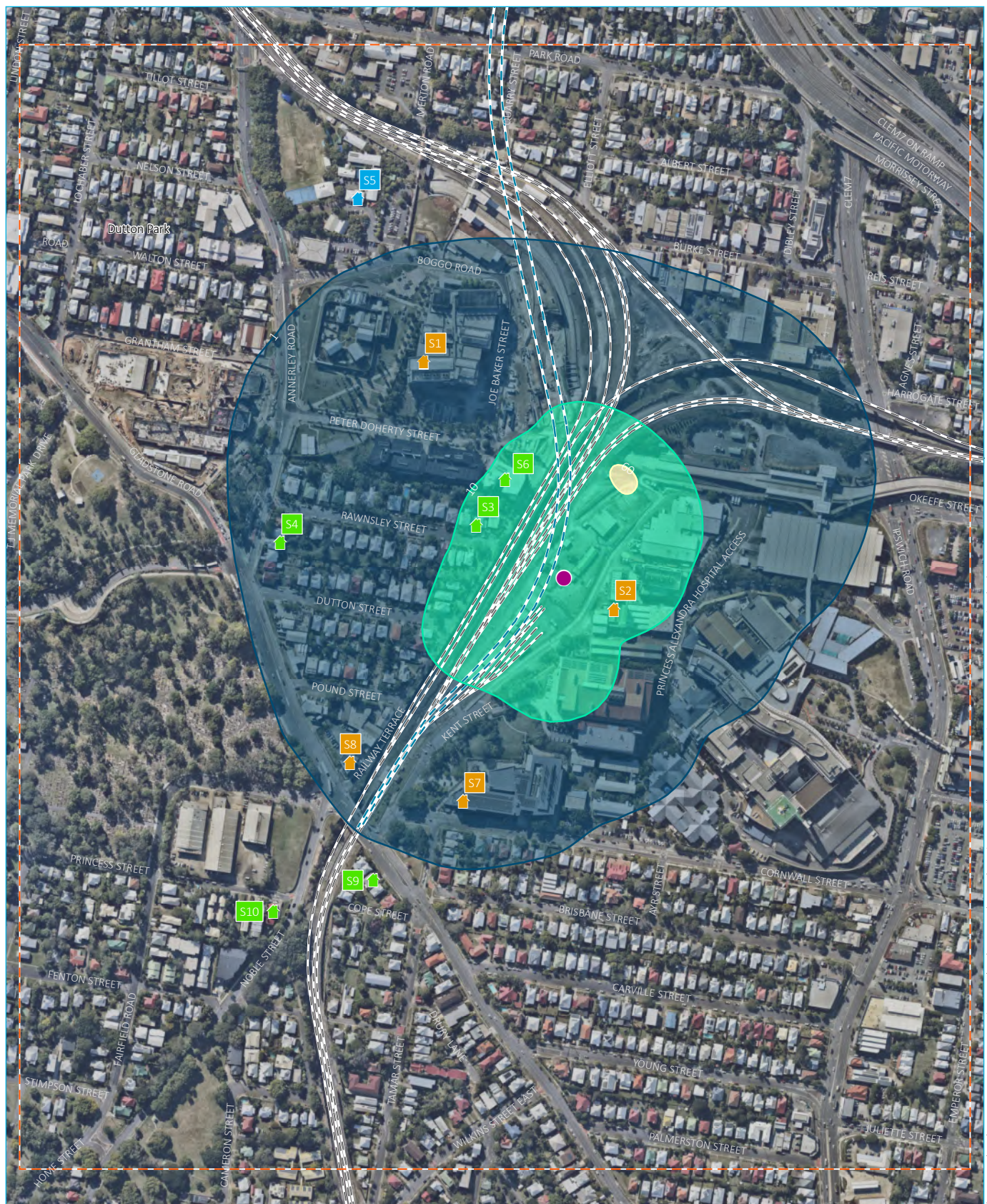
Source: EMM (2020); CRR (2020); DNRME (2020); Nearmap (2020)

KEY

- Southern Portal worksite
- Cross River Rail track
- Existing rail line
- Model extent
- Assessment locations
 - Residential
 - Workplace/commercial
 - School
- TSP concentration ($\mu\text{g}/\text{m}^3$)
 - 0.5
 - 1
 - 5
 - 10

Predicted annual average
TSP concentrations - project only

Cross River Rail
Southern Portal Mod
Air quality impact assessment
Figure 7.6



KEY

- Southern Portal worksite
- Cross River Rail track
- Existing rail line
- Model extent
- Assessment locations
 - Residential
 - Workplace/commercial
 - School
- Deposition level ($\text{g}/\text{m}^2/\text{day}$)
 - 1
 - 10
 - 60

Predicted annual average
dust deposition levels - project only

Cross River Rail
Southern Portal Mod
Air quality impact assessment
Figure 7.7

7.3 Cumulative (project plus other sources and background) results

Cumulative impacts (ie the project plus other sources and background) at each assessment location have been assessed using the following methodology:

- for 24-hour average concentrations - each daily-varying predicted 24-hour average concentration for PM₁₀ and PM_{2.5} from the project has been combined with the corresponding daily predicted concentrations from the Boggo Road Station and Dutton Park Station worksites. The adopted 2018 background concentration (70th percentile, see Section 5.3) was then added; and
- for annual average concentrations - the predicted annual average concentrations from the project have been paired with the annual predictions from Boggo Road Station, Dutton Park Station and the corresponding background annual average concentration (see Section 5.3).

Predicted cumulative TSP, PM₁₀, PM_{2.5}, and dust deposition levels from the project are presented in Table 7.2 for each of the assessment locations. The cumulative results show that the predicted concentrations and deposition rates for all pollutants and averaging periods are below the applicable air quality objectives at all assessment locations.

Table 7.2 shows that the maximum cumulative 24-hour PM₁₀ concentration predicted was 26.8 µg/m³ at assessment location S2. This result is well below the air quality objective of 50 µg/m³. It is noted that the PM₁₀ annual average measured background concentration was 17 µg/m³ (per Section 5.3). All other assessment locations are below 5 µg/m³. The maximum cumulative 24-hour PM_{2.5} concentration of 12.5 µg/m³ was also predicted at assessment location S2. Again, this is well below the air quality objective of 25 µg/m³. The PM_{2.5} annual average measured background concentration was 7.3 µg/m³ (per Section 5.3) which is already almost at the criterion of 8 µg/m³.

For the reasons stated above, it is unlikely that the project would results in adverse air quality impacts at the assessment locations assessed.

Table 7.2 Cumulative (project plus background) concentration and deposition results

Assessment location ID	Predicted cumulative concentration (µg/m³) and deposition rate (mg/m²/day)						
	TSP		PM ₁₀		PM _{2.5}		Dust deposition
	24-hour maximum	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Daily maximum
Air quality objectives	80	90	50	25	25	8	120
S1	52.2	44.8	22.3	18.1	10.6	7.7	67.4
S2	67.1	46.8	26.8	18.6	12.5	8.0	82.4
S3	55.3	45.8	23.3	18.5	10.7	7.9	73.5
S4	48.4	43.7	20.3	17.6	9.5	7.5	61.9
S5	49.0	43.6	20.7	17.5	9.6	7.4	61.6
S6	55.2	46.4	23.2	18.7	11.0	8.0	76.8
S7	49.0	43.7	20.7	17.6	9.5	7.5	62.1
S8	48.5	43.7	20.4	17.6	9.4	7.5	62.0
S9	48.0	43.6	20.0	17.5	9.2	7.4	61.3

7.4 Comparison to the 2019 AQIA

It is difficult to directly compare predicted concentrations to the 2019 AQIA as that assessment did not provide incremental (ie Southern Portal only) results. The 2019 AQIA provides cumulative results only which includes Boggo Road Station (included in the dispersion modelling) plus background.

As discussed in Section 2.2, the dispersion modelling for this assessment includes the Southern Portal, Boggo Road Station and Dutton Park Station worksites given that all three may be operating concurrently. Incremental results (ie Southern Portal only) however, have been shown in Section 7.2.

It is noted that there are also other differences between the assessments. For example, the 2019 AQIA developed the background air quality values based on data from a combination of monitoring sites in the wider area (ie Cannon Hill, Brisbane CBD, South Brisbane and Rocklea). This was likely due to the fact that other worksites in the wider area were also modelled within the same model simulations. As the focus of this study was the Southern Portal worksite, the closest and most representative monitoring station (ie DES South Brisbane) was chosen for background.

As discussed in Section 2.2, this study also included an additional four assessment locations to represent potential impacts from the Dutton Park Station worksite.

For the reasons stated above, it would not be accurate to directly compare the results of the two studies. However, it may be useful to compare them in an indicative way only. The 2019 AQIA predicted an exceedance of the cumulative dust deposition criterion at S2 only. All other assessment locations were below their respective assessment criterion. The maximum cumulative PM₁₀ 24-hour average concentration was predicted at location S3 with a result of 32.8 µg/m³. This is higher than the maximum prediction of 26.8 µg/m³ for this project (at S2) as provided in Table 7.2. The maximum cumulative PM_{2.5} 24-hour average concentration was predicted at location S2 with a result of 11.3 µg/m³. This is slightly lower than the maximum prediction of 12.5 µg/m³ for this project as provided in Table 7.2. This difference is likely due to the annual average PM_{2.5} concentrations assumed in the two studies (ie 7.3 µg/m³ used here and 6.5 µg/m³ used in the 2019 AQIA).

When comparing the results between the two studies, it is clear that some assessment locations are predicted to be higher and some are lower. This is not completely unexpected given the differences between the studies as described above. This study has shown however that proposed changes to the Southern Portal worksite are predicted to result in concentrations below the air quality objectives at all assessment locations.

8 Conclusions

Dispersion modelling has been completed for a worst-case construction scenario at the Southern Portal worksite as part of the CRR project. Atmospheric dispersion modelling was completed using the CALPUFF model system. Hourly meteorological observations from 2018, collected at the BoM Brisbane AWS were used as inputs into the dispersion model.

The results of the modelling show that the predicted concentrations and deposition rates for incremental particulate matter (TSP, PM₁₀, PM_{2.5} and dust deposition) were below the applicable air quality objectives provided in the EPP (Air) and the project Imposed Conditions at all assessment locations.

Cumulative impacts were assessed by combining modelled project impacts with modelled construction activities at two nearby CRR worksites (ie Boggo Road Station and Dutton Park Station). Recorded ambient background levels from the DES South Brisbane monitoring station were then added to these results. The cumulative results show that the predicted concentrations and deposition rates for all pollutants and averaging periods were below the applicable air quality objectives at all assessment locations. The 2019 AQIA also showed that all assessment locations were predicted to be below the air quality objectives for all pollutants apart from dust deposition at one location.

There are a number of mitigation measures employed on site to minimise the level of dust emissions. These include measures to reduce wheel-generated dust on roads, water sprays on construction activities and the use of water carts on exposed areas. It is noted that there are some additional mitigation measures proposed for the project as compared to those assumed in the 2019 AQIA. These include:

- materials disturbed by bulldozer will be wetted with water sprays and operations will generally be under a tunnel roof. From January 2022, operations will be entirely under the cut and cover roof;
- water sprays will be used when loading trucks, on the rock breaker and on the piling rig; and
- a binding agent will be used on exposed areas (as well as water sprays).

In addition, the AQMP for the CRR project includes details of the mitigation measures employed at the project, compliance management including training, incidents and emergencies (incorporating complaints management), details of air quality monitoring, reporting including greenhouse gas emissions and incident reporting, and documentation and communication protocols.

References

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National Pollutant Inventory 2008, *NPI Emission Estimation Technique Manual for Combustion Engines*

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Queensland Government 2019, *Environmental Protection (Air) Policy 2019 (EPP (Air))*

CRR 2019, *Environmental Impact Statement Request for Project Change 4, Volume 3: Technical Reports*, April 2019

TRC 2011, *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW'*, prepared for the Office of Environment and Heritage by TRC

US-EPA 1998, AP-42 Chapter 11.9 – *Western surface coal mining*

US-EPA 2006a, AP-42 Chapter 13.2.4 – *Aggregate Handling and Storage Piles*

US-EPA 2016, *Nonroad Compression-Ignition Engines: Exhaust Emission Standards (EPA-420-B-16-022, March 2016)*

Abbreviations

AHD	Australian height datum
AQIA	Air quality impact assessment
BoM	Bureau of Meteorology
CBGU JV	CPB Contractors, BAM, Ghella and UGL Joint Venture
CRR	Cross River Rail
DES	Department of Environment and Science
NO _x	oxides of nitrogen
PM ₁₀	particulate matter less than 10 microns in aerodynamic diameter
PM _{2.5}	particulate matter less than 2.5 microns in aerodynamic diameter
TAPM	The Air Pollution Model
TSP	Total Suspended Particulate
US-EPA	United States Environmental Protection Agency



Appendix A

Meteorological processing and modelling



A.1 Annual, seasonal and diurnal wind roses for BoM Brisbane AWS 2015 to 2019

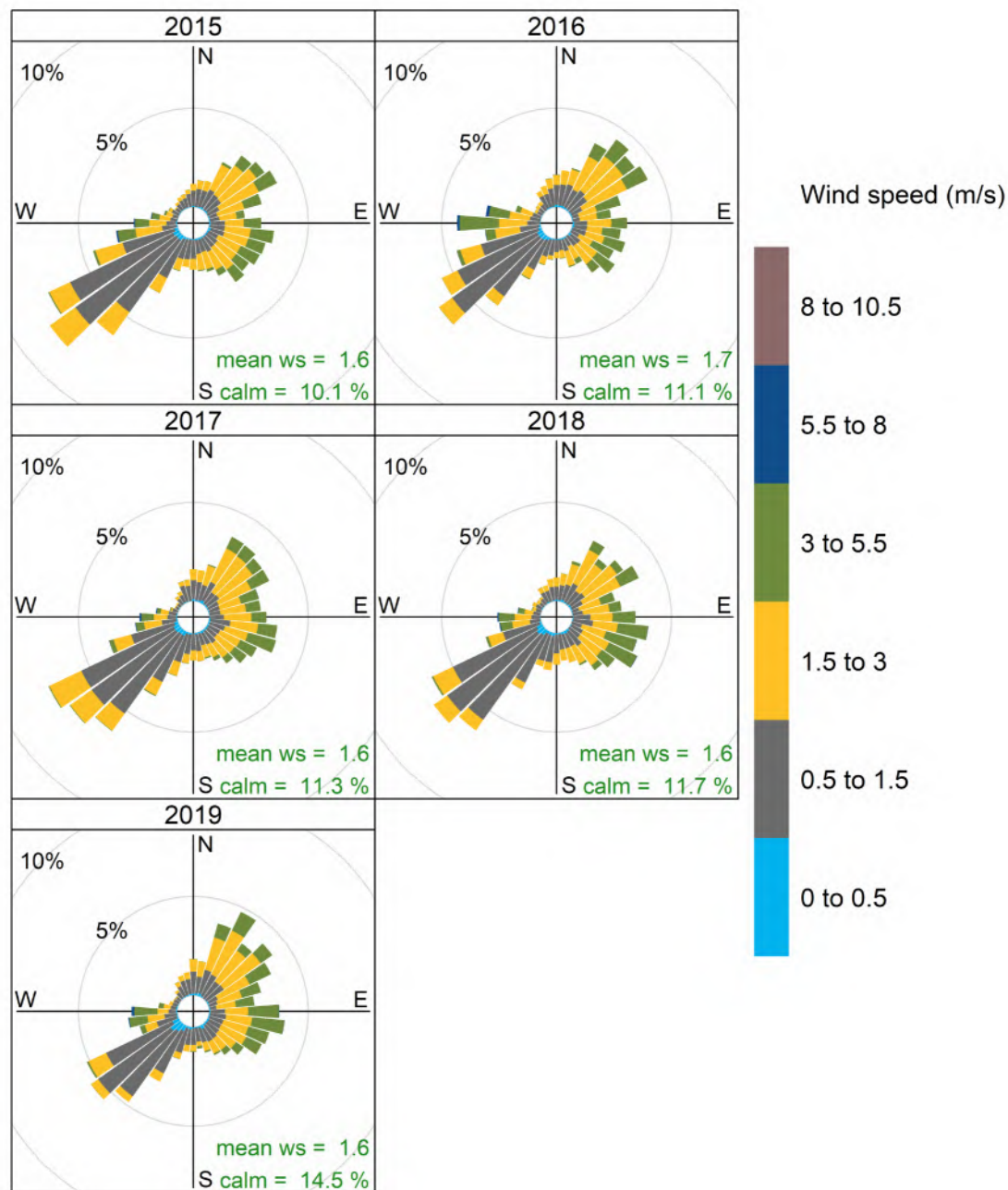


Figure A.1 Inter-annual comparison of recorded wind speed and direction – BoM Brisbane AWS – 2015 to 2019

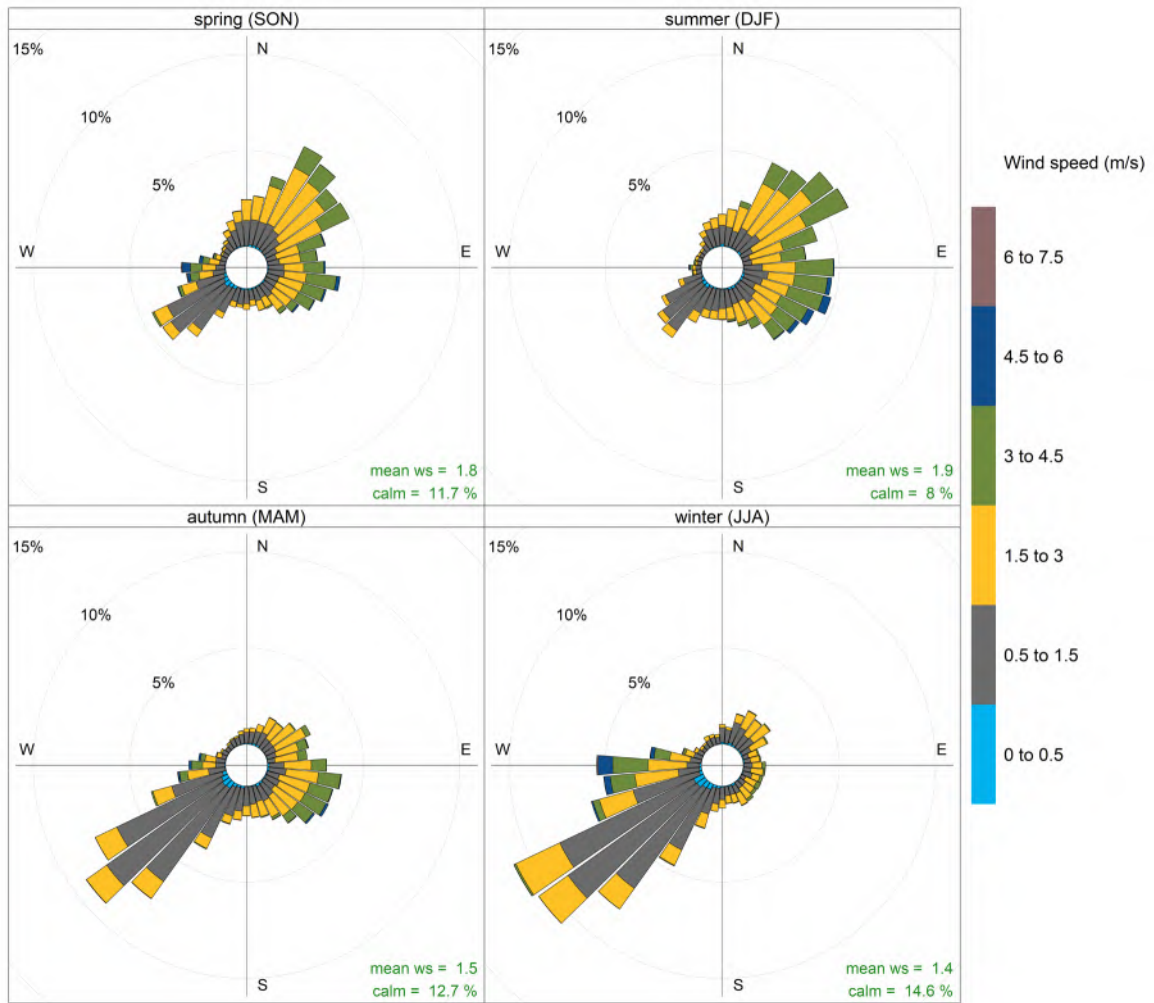


Figure A.2 Seasonal wind speed and direction – BoM Brisbane AWS – 2015 to 2019

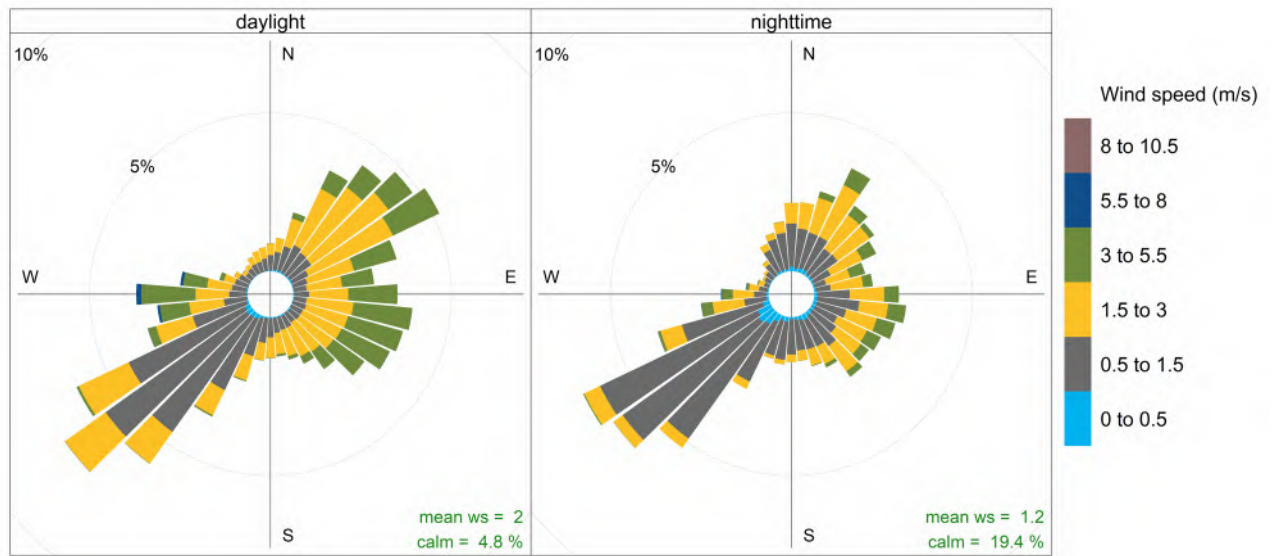


Figure A.3 Diurnal wind speed and direction – BoM Brisbane AWS – 2015 to 2019

A.2 Meteorological modelling

i TAPM modelling

To supplement the meteorological monitoring datasets adopted for this assessment, the Commonwealth Scientific and Industry Research Organisation (CSIRO) prognostic meteorological model The Air Pollution Model (TAPM) was used to generate required parameters that are not routinely measured, specifically cloud content and height data.

TAPM was configured and run as follows:

- TAPM version 4.0.5;
- inclusion of high resolution (90 m) regional topography (improvement over default 250 m resolution data);
- grid domains with cell resolutions of 30 km, 10 km and 3 km. Each grid domain features 25 x 25 horizontal grid points and 35 vertical levels;
- TAPM default databases for land use, synoptic analyses and sea surface temperature;
- TAPM defaults for advanced meteorological inputs; and
- two 'spin-up' days allowed at the beginning and end of the run.

A surface observations file was included in TAPM with meteorological data from the BoM Brisbane AWS for 2018.

The CALMET/CALPUFF model suite was chosen for this study. CALMET was used to produce 3-dimensional meteorological fields for use in the CALPUFF model.

In the absence of upper air measurements, CALMET can be run using prognostic upper air data (as a three-dimensional '3D.dat' file), which is used to derive an initial wind field (known as the Step 1 wind field in the CALMET model). The model then incorporates mesoscale and local scale effects, including surface observations, to adjust the wind field. This modelling approach is known as the 'hybrid' approach (TRC 2011) and is adopted for this assessment. TAPM was used to generate gridded upper air data for each hour of the model run period, for input into CALMET.

A CALMET grid of 5 km by 5 km was run with a resolution of 100 m. Surface meteorological data from the BoM Brisbane AWS were incorporated in the modelling. Missing data were filled using an interpolation method. Cloud amount and cloud height data were incorporated in CALMET through the use of the prognostic 3-dimensional data extracted from TAPM.

The observations at the BoM Brisbane AWS provided the dominant influence on the derived wind field and the resultant dispersion meteorology within the model. The distance at which the observation influences the model (radius of influence) is determined by the CALMET setting 'RMAX'. The relative importance of the observation in the model (relative weighting of the Step 1 wind field and the observation) is determined by the CALMET setting 'R1'.

An RMAX of 3 km and R1 of 1.5 km was assigned in the model to reflect the local scale topographical influence seen in the observational data.

The detailed CALMET model options used are presented in Table A.1. These were selected in accordance with recommendations in in TRC (2011). Surface observations were included in the modelling (referred to as data assimilation) to provide real-world observations and improve the accuracy of the wind fields.

Table A.1 CALMET model options used

Flag	Descriptor	Default	Value used
IEXTRP	Extrapolate surface wind observations to upper layers	Similarity theory	Similarity theory
BIAS (NZ)	Relative weighting given to vertically extrapolated surface observations versus upper air data	No default	-1, -0.989, -0.971, -0.937, -0.868, -0.731, -0.479, -0.089, 0.427, 1.0
TERRAD	Radius of influence of terrain	No default (typically 5-15 km)	2
RMAX1 and RMAX2	Maximum radius of influence over land observations in layer 1 and aloft	No default	3, 3
R1 and R2	Distance from observations in layer 1 and aloft at which observations and Step 1 wind field are weighted equally	No default	1.5, 1.5



Appendix B

Emissions inventory detail



B.1 Introduction

Particulate matter emissions from the project and nearby worksites were quantified through the application of accepted published emission estimation factors, collated from a combination of United States Environmental Protection Agency (US-EPA) AP-42 Air Pollutant Emission Factors and US-EPA Exhaust Emissions Standards, including the following:

- US-EPA AP-42 Chapter 11, Table 11.9-4 – Drilling overburden (US-EPA 1998);
- US-EPA AP-42 Chapter 11, Table 11.9-2 – Blasting coal or overburden (US-EPA 1998a);
- US-EPA AP-42 Chapter 13.2.4.4 – Aggregate handling and storage piles (US-EPA 2006);
- US-EPA AP-42 Chapter 13.2.1.3 – Paved roads (US-EPA 2011);
- US-EPA AP-42 Chapter 11, Table 11.9-4 – Wind erosion of exposed areas (US-EPA 1998b); and
- UE-EPA Nonroad Compression-Ignition Engines: Exhaust Emission Standards (EPA-420-B-16-022, March 2016).

Annual projections of diesel consumption for the project were sourced from CBUG JV. Assumptions adopted were:

- the proposed construction equipment fleet comprised primarily of equipment with an engine power greater than 130 kW;
- for engines greater than 130 kW, the corresponding USEPA (USEPA 2016) Tier 2 emission standards for PM of 0.2 g/kWh was selected;
- the g/kWh emission standard was converted to g per litre of diesel by applying a scaling factor of 3, as per the notes for Table 35 in *NPI Emission Estimation Technique Manual for Combustion Engines* (NPI, 2008); and
- the PM emission standard is assumed to correspond to PM₁₀, with PM_{2.5} emissions derived from the relationship between PM₁₀ and PM_{2.5} emission factors presented in Table 35 in NPI, 2008 (91.7%).

Particulate releases were quantified for TSP, PM₁₀ and PM_{2.5} as documented in subsequent sections.

B.2 Particulate matter emissions inventory

The emissions inventory developed for the project is presented in Table B.1.

Emissions developed for the Boggo Road Station and Dutton Park Station worksites are shown in Table B.2 and Table B.3.

Table B.1 Emissions inventory – Southern Portal

Source name	Emission estimate TSP (kg/year)	Emission estimate PM ₁₀ (kg/year)	Emission estimate PM _{2.5} (kg/year)	Activity rate	Units	TSP emission factor	PM ₁₀ emission factor	PM _{2.5} emission factor	Unit	Parameter 1	Unit	Parameter 2	Unit	Parameter 3	Unit	Parameter 4	Unit	Reduction factor	Emission control	Emission factor source
Drilling	5.3	2.8	0.16	30	holes/y	0.5900	0.3068	0.01770	kg/hole									0.70	Watering	USEPA AP-42 11.9-4 - Drilling EF
Excavators/FELs	43	20	3	150,000	t/y	0.0008	0.0004	0.00006	kg/t	1.7	Average wind speed (m/s)	2	Moisture content (%)					0.65	Watering & fencing	USEPA AP-42 13.2.4 - Materials handling equation
Bulldozers on spoil	7,591	1,834	797	3,024	h/y	16.74	4.04	1.76	kg/h	2.0	Moisture content (%)	10	Silt content (%)					0.85	Watering and 3 sides & roof	USEPA AP-42 11.9 - Bulldozer on material other than coal
Loading trucks	43	20	3	150,000	t/y	0.0008	0.0004	0.00006	kg/t	1.7	Average wind speed (m/s)	2	Moisture content (%)					0.65	Watering & fencing	USEPA AP-42 13.2.4 - Materials handling equation
Wheel-generated dust (paved roads)	270	52	13	938	VKT/year	0.5751	0.1104	0.0267	kg/VKT	4.8	Road silt loading (g/m ²)	0.2	Return haul distance (km)	4,688	Loads/year	36	Average weight (t)	0.50	Watering	USEPA AP-42 13.2.1 - Paved roads
Rock breaker	21.5	10.2	1.5	75,000	t/y	0.0008	0.0004	0.00006	kg/t	1.7	Average wind speed (m/s)	2	Moisture content (%)					0.65	Watering & fencing	USEPA AP-42 13.2.4 - Materials handling equation
Piling rig	46	24	1	225	holes/y	0.59	0.3068	0.01770	kg/hole									0.65	Watering & fencing	USEPA AP-42 11.9-4 - Drilling EF
Wind erosion	0.36	0.18	0.03	0.6	Area (ha)	0.4	0.2	0.03	kg/ha/h	15	hours/y							0.90	Watering & chemicals	NPI for Mining EET Table 2
Site diesel combustion	220	220	202																	
Total	8,240	2,184	1,021																	

Table B.2 Emissions inventory – Boggo Road Station

Source name	Emission estimate TSP (kg/year)	Emission estimate PM ₁₀ (kg/year)	Emission estimate PM _{2.5} (kg/year)	Activity rate	Units	TSP emission factor	PM ₁₀ emission factor	PM _{2.5} emission factor	Unit	Parameter 1	Unit	Parameter 2	Unit	Parameter 3	Unit	Parameter 4	Unit	Reduction factor	Emission control	Emission factor source
Drilling	3.5	1.8	0.11	20	holes/y	0.5900	0.3068	0.01770	kg/hole									0.70	Watering	USEPA AP-42 11.9-4 - Drilling EF
Blasting	2	1	0.1	3	blasts/y	1.1432	0.5944	0.03429	kg/blast	300	Area of blast (m ²)							0.30	Hoardings/fencing	USEPA AP-42 11.9-2 - Blasting equation
Excavators/FELs	84	40	6	294,000	t/y	0.0008	0.0004	0.00006	kg/t	1.7	Average wind speed (m/s)	2	Moisture content (%)					0.65	Watering & fencing	USEPA AP-42 13.2.4 - Materials handling equation
Loading trucks	84	40	6	294,000	t/y	0.0008	0.0004	0.00006	kg/t	1.7	Average wind speed (m/s)	2	Moisture content (%)					0.65	Watering & fencing	USEPA AP-42 13.2.4 - Materials handling equation
Wheel-generated dust (paved roads)	1,407	270	65	5,266	VKT/year	0.53	0.10	0.02	kg/VKT	4.8	Road silt loading (g/m ²)	0.6	Return haul distance (km)	8,776	Loads/year	34	Average weight (t)	0.50	Watering	USEPA AP-42 13.2.1 - Paved roads
Rock breaker	322.8	63.7	9.6	235,200	t/y	0.0020	0.0004	0.00006	kg/t	1.7	Average wind speed (m/s)	2	Moisture content (%)					0.30	Hoardings/fencing	USEPA AP-42 13.2.4 - Materials handling equation
Piling rig	31	16	1	150	holes/y	0.59	0.3068	0.01770	kg/hole									0.65	Watering & fencing	USEPA AP-42 11.9-4 - Drilling EF
Wind erosion	2	1	0	0.9	Area (ha)	0.4	0.2	0.03	kg/ha/h	15	hours/y							0.65	Watering & fencing	NPI for Mining EET Table 2
Site diesel combustion	399	399	366																	
Total	2,336	833	454																	

Table B.3 Emissions inventory – Dutton Park Station

Source name	Emission estimate TSP (kg/year)	Emission estimate PM ₁₀ (kg/year)	Emission estimate PM _{2.5} (kg/year)	Activity rate	Units	TSP emission factor	PM ₁₀ emission factor	PM _{2.5} emission factor	Unit	Parameter 1	Unit	Parameter 2	Unit	Reduction factor	Emission control	Emission factor source
Drilling	8.1	4.2	0.24	46	holes/y	0.59	0.3068	0.01770	kg/hole					0.70	Watering	USEPA AP-42 11.9-4 - Drilling EF
Excavators/FELs	4	2	0.3	15,000	t/y	0.0008	0.0004	0.00006	kg/t	1.7	Average wind speed (m/s)	2	Moisture content (%)	0.65	Watering & fencing	USEPA AP-42 13.2.4 - Materials handling equation
Loading trucks (direct load-out)	4	2	0.3	15,000	t/y	0.0008	0.0004	0.00006	kg/t	1.7	Average wind speed (m/s)	2	Moisture content (%)	0.65	Watering & fencing	USEPA AP-42 13.2.4 - Materials handling equation
Rock breaker	2.6	0.5	0.1	3,750	t/y	0.0020	0.0004	0.00006	kg/t	1.7	Average wind speed (m/s)	2	Moisture content (%)	0.65	Watering & fencing	USEPA AP-42 13.2.4 - Materials handling equation
Piling rig	71	37	2	344	holes/y	0.59	0.3068	0.01770	kg/hole					0.65	Watering & fencing	USEPA AP-42 11.9-4 - Drilling EF
Wind erosion	0.18	0.09	0.01	0.3	Area (ha)	0.4	0.2	0.03	kg/ha/h	15	hours/y			0.90	Watering & chemicals	NPI for Mining EET Table 2
Site diesel combustion	15	15	14													
Total	106	61	17													

B.3 Project-related input data used for particulate matter emission estimates

The material property inputs used in the emission estimates for Southern Portal and surrounding worksites are summarised below:

- spoil moisture content of 2% adopted. Site-specific data were not available, therefore 2% was assumed per spoil moisture used in other similar projects;
- paved road silt loading of 4.8% adopted. Site-specific data were not available, therefore 4.8% was assumed per US-EPA AP-42 Chapter 13, Table 13.2.2-1 for 'sand and gravel processing – plant road';
- number of drill holes, blasts, blast dimensions and piling rig holes provided by CBGU JV;
- exposed areas provided by CBGU JV and as observed from aerial photographs;
- total site diesel consumption rate of 550,000 L/year at Southern Portal as provided by CBGU JV;
- number of spoil truck loads per year, truck specifications and haul distances provided by CBGU JV;
- spoil volumes provided by CBGU JV;
- average wind speed value calculated from CALMET extract at project site; and
- all dust mitigation measures provided by CBGU JV.



Appendix C

Boggo Road Station and Dutton Park Station incremental results



C.1 Boggo Road Station and Dutton Park Station incremental (project only) results

As discussed in previous sections, the CRR construction worksites at Boggo Road Station and Dutton Park Station were included in the cumulative modelling for the project. Emissions were estimated based on information provided by CBGU JV for both sites. The following tables provide the incremental results for these worksites for information only.

Table C.1 Incremental (project only) concentration and deposition results – Boggo Road Station

Assessment location ID	Predicted incremental concentration ($\mu\text{g}/\text{m}^3$) and deposition rate ($\text{mg}/\text{m}^2/\text{day}$)						
	TSP		PM ₁₀		PM _{2.5}		Dust deposition
	24-hour maximum	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Monthly maximum
Air quality objectives	80	90	50	25	25	8	120
S1	5.0	1.1	3.2	0.5	2.0	0.3	5.2
S2	1.4	0.1	1.1	0.1	0.7	<0.1	0.3
S3	3.2	0.6	2.3	0.3	1.4	0.2	2.4
S4	1.0	0.1	0.9	0.1	0.7	0.1	0.5
S5	1.3	0.2	1.1	0.1	0.7	0.1	1.0
S6	7.5	1.4	3.8	0.6	2.2	0.4	6.7
S7	0.6	0.1	0.6	0.0	0.4	<0.1	0.1
S8	0.6	0.1	0.6	0.1	0.4	<0.1	0.2
S9	0.4	<0.1	0.4	<0.1	0.3	<0.1	0.1
S10	0.4	<0.1	0.4	<0.1	0.3	<0.1	0.1

Note: Air quality objectives are applicable to cumulative (increment + background). These are provided for comparison purposes only.

Table C.2 Incremental (project only) concentration and deposition results – Dutton Park Station

Assessment location ID	Predicted incremental concentration ($\mu\text{g}/\text{m}^3$) and deposition rate ($\text{mg}/\text{m}^2/\text{day}$)						
	TSP		PM ₁₀		PM _{2.5}		Dust deposition
	24-hour maximum	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Monthly maximum
Air quality objectives	80	90	50	25	25	8	120
S1	0.04	<0.01	0.03	<0.01	0.01	<0.01	<0.01
S2	0.04	<0.01	0.04	<0.01	0.01	<0.01	0.01
S3	0.05	<0.01	0.04	<0.01	0.02	<0.01	0.01
S4	0.07	0.01	0.06	0.01	0.02	<0.01	0.02
S5	0.03	<0.01	0.02	<0.01	0.01	<0.01	<0.01
S6	0.03	<0.01	0.03	<0.01	0.01	<0.01	0.01
S7	0.24	0.03	0.17	0.02	0.06	0.01	0.11
S8	0.45	0.08	0.31	0.05	0.09	0.01	0.30
S9	0.92	0.11	0.56	0.06	0.16	0.02	0.46
S10	0.35	0.08	0.26	0.05	0.08	0.01	0.27

Note: Air quality objectives are applicable to cumulative (increment + background). These are provided for comparison purposes only.



