CROSS RIVER RAIL

Environmental Impact Statement

Technical Reports

February 2017

Volume 4

Queensland Government

CROSS RIVER RAIL

Cross River Rail

Request for Project Change - Volume 4: Technical Reports

Contents

Appendices

Appendix A

Traffic impact analysis of Albert Street Closure

Appendix B

Analytical settlement estimate for Victoria Barracks and Quarry Street

Appendix C

CRR 2016 Station architecture

Appendix D

Review of Existing Air Quality

Appendix E

Construction - Southern Portal and Boggo Road Station Noise and Vibration Modelling Results

Appendix F

References

Appendix G

Glossary of terms

1 Technical Report: Transport

1.1 Introduction

The key aspects addressed in this technical report include strategic transport impacts and benefits, local transport impacts during project operations, and construction transport impacts. The key design changes that inform the transport assessment include:

- Cross River Rail (CRR) 2016 not providing additional rail track between Yeerongpilly and Salisbury. This removes the need for changes to the road network and land resumption for the additional track;
- CRR 2016 not providing additional rail track (in tunnel) between Yeerongpilly and Boggo Road. This removes the major construction impacts for this area, local property requirements and local road impacts associated with the construction and operation of the previously proposed Yeerongpilly Station. Passenger trains will now utilise the existing surface tracks in this section;
- Relocation of Albert Street Station and a proposal to pedestrianise Albert Street between Mary Street and Charlotte Street, and between Charlotte Street and Elizabeth Street (local vehicle access retained in this section);
- Relocation of Roma Street Station resulting in changes during Project operations to pedestrian movements and associated infrastructure requirements;
- Changes to the location of construction worksites resulting in changes to construction traffic movements and local traffic impacts;
- Changes to the proposed tunnelling construction approach, with the bulk of spoil being removed via the Woolloongabba Station site, thus changing overall construction traffic movements; and
- Changes to the proposed spoil placement sites resulting in altered construction traffic movements and potential local traffic impacts. The reduced tunnel length will also change the overall volume of spoil to be removed and number of associated truck movements.

Note that the assessment of transport construction impacts presented in this technical report is based on a CRR 2016 opening year of 2023 compared to the previously proposed opening year of 2020 for CRR 2011.

1.2 Strategic context

The overall strategic transport context underpinning the need for the Project has not changed since CRR 2011. However, the CRR 2016 design does respond to a number of changes in forecast passenger and freight demand since the transport assessment was undertaken for CRR 2011. These changes in demand do not affect the need for the project, but have influenced the timing of the project and aspects of the design. The design changes have in turn influenced the construction methodology and potential impacts. For example, the shorter tunnel resulted in a changed tunnel construction methodology (i.e. tunnel boring from Woolloongabba north, and mining between Woolloongabba Station and Boggo Road Station, with removal of spoil concentrated at the Woolloongabba worksite).

The CRR 2011 project responded to a number of key existing and future issues and constraints associated with the region’s transport network. The key transport problems identified for CRR 2011 and their relevance to CRR 2016 are summarised Table 1.1. The objectives that CRR 2016 addresses remain consistent with those of CRR 2011.

Table 1.1 Key transport problems identified for CRR 2011 – relationship to CRR 2016

Transport problems identified for CRR 2011	Need for the CRR 2016 project
Inner city rail capacity from the south would be reached by 2016.	• Inner city rail capacity constraints continue to underpin the need for CRR 2016 but over a different time horizon. • Demand forecasting for CRR 2016 indicates capacity from the south and the north will now be exceeded by 2021.
Progressively poorer levels of rail service, including high levels of crowding and reduced reliability.	• Key project need that continues to underpin CRR 2016. • Rail network optimisation initiatives have been implemented and are ongoing however adding new services will ultimately depend on addressing the constraints through the inner city.
Car dependency to access the inner city would increase.	• Key issue underpinning the need for CRR 2016. • New major developments (e.g. Queen's Wharf Brisbane) since CRR 2011 are providing a stronger impetus to address this issue.
The bus network would experience increasing levels of congestion.	• Reducing the reliance on the bus network to provide for growth in inner city access continues to be an aim for CRR 2016. • CRR 2016 provides the opportunity to progressively restructure parts of the bus network to feed to rail. • The bus network is unable to accommodate the forecast growth in longer distance commuter trips from outer areas to Brisbane's Central Business District (CBD), which are most suited to rail.
Transport objectives such as public transport mode share would not be met.	• Remains a critical strategic objective driving the need for CRR 2016.
Attractiveness of the inner city as an economic and employment centre would decline. Jobs growth and productivity would also be constrained. Inefficient inner city transport would lead to declining city lifestyle and liveability.	• Supporting economic growth in the region' primary activity centre remains a key objective for CRR 2016. • CRR 2016 is positioned as economic development opportunity.
Demand for rail freight.	• Based on updated freight forecasting and planning, the timing and options to address this issue have changed since CRR 2011. • CRR 2016 seeks to maintain existing freight capacity through the southern rail network. • Future investigations will consider options for a dedicated freight rail connection to the Port of Brisbane.

1.3 Strategic transport impacts and benefits of CRR 2016

1.3.1 Transport modelling methodologies

Transport demand forecasts developed for CRR 2016 are based on a new transport model specifically developed for the project and updated to reflect new demographic and planning information (e.g. bus and road network information). This model is calibrated using the latest electronic ticketing data whereas the previous (CRR 2011) model relied more on paper-based ticketing information supported by passenger load survey data.

The differences in the underpinning base demographic data (updated population and employment forecasts) and calibration data (electronic ticketing data) means that the two models are not directly comparable. The models were also calibrated to different years and run for different forecast horizons, also making direct comparison difficult.

For the purposes of the strategic transport assessment presented below, the original CRR 2011 project design (infrastructure, rail service plans, stopping patterns, service frequencies, and journey times) was run in the CRR 2016 transport model for the 2026 forecast year. Model runs were therefore undertaken for both the CRR 2011 and CRR 2016 project designs (and respective rail service plans) with all other assumptions held consistent (e.g. fares, demographics, bus services). This provided a more comparable assessment of the differences in transport patronage produced by the two projects. The key difference between the two designs in the transport model are the assumed future rail service plans, discussed below.

1.3.2 Future rail service plans

The indicative opening-year morning (AM) peak hour rail service plans[1] for CRR 2011 and CRR 2016 are illustrated in Figures 1.1 and 1.2.

The service planning principles underpinning the CRR 2016 rail operating strategy are generally consistent with those of CRR 2011. Rail service plans are developed based on demand for rail services linked to the proposed infrastructure. They are also influenced by the policies, planning frameworks, and service planning principles relevant at the time. The indicative CRR 2016 service plans are therefore a point-in-time and will evolve further before operations commence. This approach is consistent with CRR 2011.

For CRR 2011, the opening-year AM peak hour service plan proposed 102 trains through the CBD with 47 services approaching the CBD from the north, 19 from the west and 36 services from the south and east. Of the 36 trains from the south and east, 17 would travel via the CRR tunnel.

For CRR 2016, the 2026 AM peak one hour service plan would include 104 trains through the CBD with 50 services approaching the CBD from the north, 20 from the west and 34 services from the south and east. Of the 34 trains from the south and east, 18 would travel via the CRR tunnel.

Overall, there are a similar number of peak hour train services proposed in CRR 2016 compared to CRR 2011, with a small redistribution of services in response to changes in demographic forecasts and resulting demand. From a project change perspective the reduced infrastructure proposed in CRR 2016 (tunnel now commencing north of Dutton Park Station) would see an increase in the number of passenger trains running on surface in the section between Yeerongpilly and Dutton Park Station, compared to CRR 2011. This is due to passenger trains now running at surface rather than in tunnel as proposed for CRR 2011. While an increase in passenger trains is forecast, the number of freight trains forecast to use this section is lower than previously forecast for CRR 2011.

The noise and air quality effects of these changes are discussed in Technical Reports 11 (Air quality) and 12 (Noise and vibration).

[1] Note: the CRR 2011 opening-year (2021) service plan was used in the transport modelling to represent 2026.

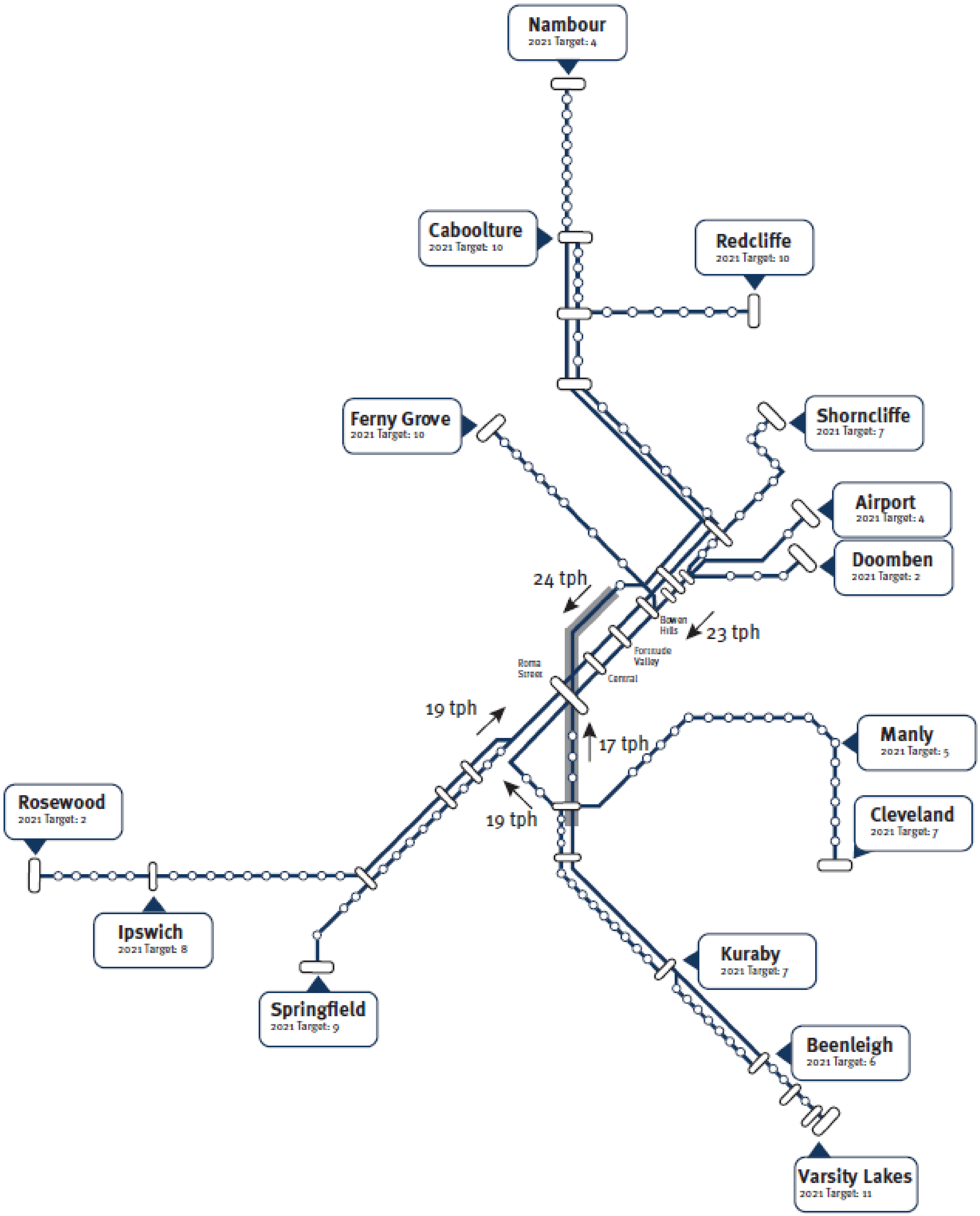


Figure 1.1 Indicative 2021 morning one-hour peak rail service plan with CRR 2011

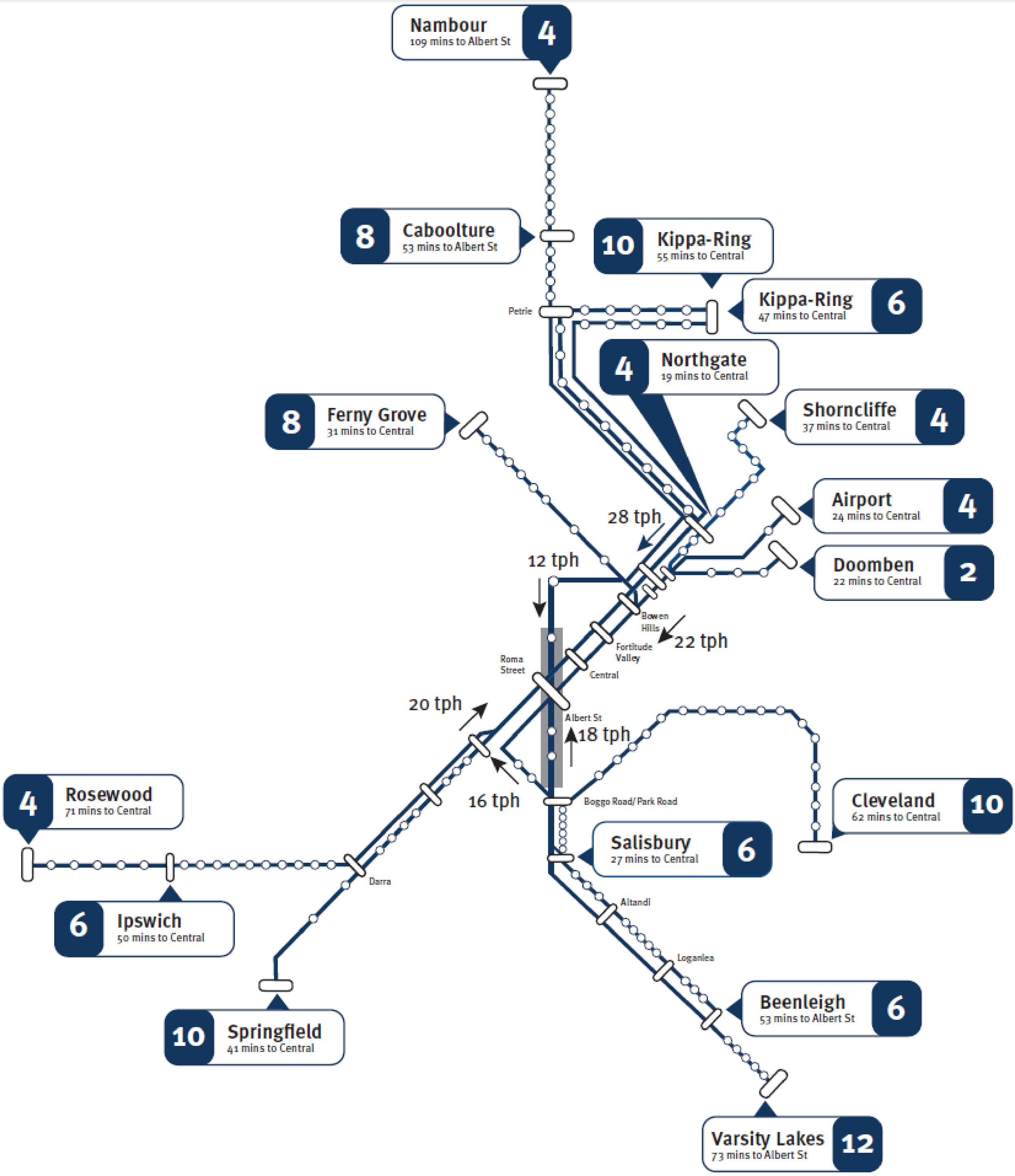


Figure 1.2 Indicative 2026 morning one-hour peak rail service plan with CRR 2016

1.3.3 Rail patronage

As noted in Section 1.3.1, the CRR 2016 strategic transport model was used to determine forecast patronage for both the CRR 2011 and CRR 2016 designs in the same transport model (CRR 2016 transport model). This provides a comparable assessment of forecast patronage changes.

Daily public transport and rail patronage for the Brisbane metropolitan area in 2026 (opening year) is illustrated in Table 1.2, and peak period rail patronage is illustrated in Table 1.3. Morning (AM) peak passenger activity at the new CRR stations is illustrated in Table 1.4.

The following observations are made regarding the results:

- There is an increase in total daily public transport trips with CRR 2016 in 2026 compared to without the project. The difference between the CRR 2011 and CRR 2016 model results is insignificant;
- CRR 2016 increases total daily and AM peak rail patronage by around 5% in 2026 compared to without the project. This change in patronage is comparable to the effect of CRR 2011 (in the new model) – the differences between the CRR 2011 and CRR 2016 results are not considered material;
- The forecast AM peak passenger demand for CRR 2016 at Albert Street Station and Roma Street Station are lower than those generated by the CRR 2011 design (in the new model). This relates to the different rail service plan assumptions and a resultant change in the distribution of activity at CBD rail stations e.g. higher patronage is seen at Central Station in CRR 2016 than CRR 2011; and
- The forecast AM peak passenger demands for CRR 2016 at Boggo Road Station, Woolloongabba Station, and Exhibition Station are similar to that generated by the CRR 2011 design, despite the different rail service plans.

Overall, there are no significant differences in rail patronage outcomes when the CRR 2011 design (infrastructure, rail service plans, stopping patterns, service frequencies, and journey times) is compared to the CRR 2016 design in the same strategic transport model (CRR 2016 transport model).

Table 1.2 Average weekday trip changes with and without CRR 2011 and CRR 2016

Parameter	2015	2026			Difference CRR 2016 to CRR 2011
		Without CRR	With CRR 2011	With CRR 2016	
Total person trips by car	6,354,000	7,210,000	7,207,000	7,203,000	-0.1%
Public transport trips	514,000	875,000	881,000	884,000	0.3%
Public transport mode share	6.8%	9.8%	9.8%	9.9%	1%
Total rail patronage	177,000	369,000	386,000	387,000	0.3%

Table 1.3 2026 AM peak rail patronage without and with CRR for CRR 2011 and CRR 2016

2026 AM peak period	Without CRR	With CRR 2011	With CRR 2016	Difference CRR 2016 to CRR 2011
Total rail patronage	104,000	109,400	110,100	0.6%

Table 1.4 2026 CRR Station AM peak passenger throughput (boardings and alightings)

CRR station	With CRR 2011	With CRR 2016
Boggo Road	5,900	5,400
Woolloongabba	4,300	3,500
Albert Street	23,200	17,700
Roma Street	16,800	10,500
Exhibition	3,200	2,800

1.3.4 Bus and ferry patronage

Bus patronage

Table 1.5 illustrates the forecast growth of rail versus bus from 2015 to 2026 (without CRR) demonstrating the key role rail has in addressing future demand for longer distance travel into the inner city. Demand for rail is expected to growth at a much greater rate than for bus. This trend continues to 2036 with an expected tripling in demand for rail.

Table 1.5 Total forecast rail and bus trips in the Brisbane metropolitan area

Average weekday (24 hours)	2015	2026 Without CRR	Growth
Total Rail trips	177,200	368,800	108%
Total Bus Trips	321,600	509,800	59%

Changes in overall modelled bus patronage across the Brisbane metropolitan area for CRR 2016 compared to CRR 2011 (in the new model) is summarised in Table 1.6. The comparison shows that in 2026, bus patronage is largely unchanged with CRR 2016 in place compared to a slight reduction in bus patronage for CRR 2016. The difference is not considered material.

It is noted that for the CRR 2016 transport modelling, only minor modifications were made to the bus network in the with-project scenario. These changes are much less extensive than those assumed for the transport modelling undertaken in 2011. The modelling assumptions adopted for CRR 2016 for the bus network are therefore considered to be very conservative, in light of the potential to strengthen bus / rail interchange across the network in response to the introduction of CRR.

Once operational, CRR offers a significant opportunity to progressively restructure targeted bus corridors (where there is a customer benefit) to more effectively feed buses to the rail network at key locations. This opportunity would potentially assist in alleviating bus network constraints in Brisbane's inner city and will be investigated further as the project progresses.

Table 1.6 2026 bus patronage comparison for CRR 2011 and CRR 2016

Average weekday (24 hours)	Without CRR	With CRR 2011	With CRR 2016	Difference CRR 2016 to CRR 2011
Total bus patronage	509,800	509,800	508,400	-0.3%

Ferry patronage changes

There are no noteworthy changes to ferry patronage resulting from the CRR project due to ferry and rail trips being largely non-competing and little or no transfer between modes. This outcome is consistent with CRR 2011.

1.3.5 Changes to the road network

The forecast total daily vehicle trips at project opening-year (2026) for CRR 2016 are illustrated in Table 1.7, including a comparison to the CRR 2011 design (in the new model).

At the regional level, CRR 2016 did not forecast a significant reduction in road traffic volumes across the network. While reductions in vehicle volumes (and consequently, kilometres travelled, fuel used and emission produced) are predicted on some key links, no material difference in the performance of the regional road network are expected. This outcome is consistent with CRR 2011 and the differences are considered insignificant.

Table 1.7 Total vehicle trips at opening (average weekday) for CRR 2011 and CRR 2016

Average weekday	2026 Without CRR	2026 With CRR 2011	2026 With CRR 2016	% Change CRR 2011 to CRR 2016
Total vehicle trips	5,285,000	5,282,000	5,279,000	-0.1%

1.3.6 Rail freight

Forecasts undertaken as part of CRR 2016 indicate that there will be a reduction in future freight movements compared to those forecast for CRR 2011. The CRR 2011 project forecast that the number of freight movements on the North Coast Line at opening year was expected to reach 264 movements a week compared to 114 freight movements forecast as part of CRR 2016. Table 1.8 provides a comparison of the freight demand forecasts for CRR 2011 and CRR 2016.

The decrease in forecast freight movements reflects the changing demand, particularly a reduction in intermodal trains on the North Coast Line travelling to Acacia Ridge. This may change in the future with the development of Inland Rail.

A number of alternatives to meet increasing rail freight demand have been considered. The Australian Rail Track Corporation (ARTC) has identified possible upgrades to the existing rail corridor extending to the Port of Brisbane that could progressively improve freight capacity. Long-term planning by others has identified a possible rail freight connection in a new corridor to the Port of Brisbane. This would provide for rail freight demand well into the future and free-up existing track to accommodate growth in passenger demand.

Table 1.8 Freight demand comparison for CRR 2011 and CRR 2016 (both directions)

Location	Freight Rail Demand (average per week)		
	CRR 2016 2015	CRR 2011 2021	CRR 2016 2026
North Coast (Total)	**90**	**264**	**114**
Including Salisbury – Tennyson (Intermodal)	40	172	48
Tennyson to Port (Total)	**154**	**275**	**223**
Tennyson – Port (Intermodal)	16	78	19

Location	Freight Rail Demand (average per week)		
	CRR 2016 2015	CRR 2011 2021	CRR 2016 2026
Tennyson – Port (Coal)	138	197	204

1.4 Local transport impacts of CRR 2016

1.4.1 Changes to local transport impacts

An assessment has been made of the effects on local traffic and pedestrian / cycle networks during operations resulting from changes to the project. In general, there is a reduction in local impacts compared to CRR 2011 due to the smaller scale of the project. For example, local road reconfigurations and impacts south of Dutton Park Station have been removed resulting in reduced overall operational transport impacts in this area. In other areas, the impacts are generally consistent with, or lower than CRR 2016, however may have changed location.

The assessment of changes to local traffic and pedestrian / cyclist networks is based on changes to project design and the forecast patronage at the new stations (at year of opening), as illustrated in Table 1.9. The following section details the changes to local transport impacts resulting from project changes.

Table 1.9 Forecast 2026 CRR station AM peak period passenger movements and mode of access

CRR station	CRR 2011*			CRR 2016		
	Car / Walk / Cycle	Transfer (Bus & Rail)	Total	Car / Walk / Cycle	Transfer (Bus & Rail)	Total
Boggo Road	900	5,000	5,900	700	4,700	5,400
Woolloongabba	1,900	2,400	4,300	1,700	1,800	3,500
Albert Street	22,900	300	23,200	17,500	200	17,700
Roma Street	5,100	11,700	16,800	3,600	6,900	10,500
Exhibition	2,500	700	3,200	2,300	500	2,800

* Patronage based on revised modelling (refer Section 1.3.1)

Stations south of Dutton Park Station

With CRR 2016 not extending south of Dutton Park Station, local road reconfigurations and impacts between Salisbury and Dutton Park are no longer applicable and there will be an overall reduction in operational transport impacts at these locations. In particular, impacts identified for CRR 2011 on Wilkie Street and other local roads around the previously proposed Yeerongpilly Station and Southern portal will no longer occur.

Boggo Road Station

CRR 2016 locates the Boggo Road Station east of Joe Baker Street in order to integrate with the existing Park Road Station and Eastern Busway. For CRR 2011, the station was located between Boggo Road Gaol and the Ecosciences building.

The key local transport effects of the new station location will be the need to provide:

- Taxi bays and passenger loading bays on Joe Baker Street by replacing existing on-street parking;
- A pedestrian connection from the new station to Park Road rail station and Boggo Road Busway Station;
- A pedestrian crossing of Joe Baker Street connecting the station with the Boggo Road Urban Village; and
- Pedestrian access from the station to the Princess Alexandra (PA) Hospital.

Woolloongabba Station

The CRR 2016 alignment locates the Woolloongabba Station on the existing GoPrint site adjacent to the Woolloongabba Busway Station. The new station location does not require changes to the local road network and the location now being adjacent to the existing busway station presents improved opportunities for the creation of an interchange facility.

The CRR 2011 design was able to accommodate pedestrian activity at the Woolloongabba Station after events at the nearby Gabba Stadium. The changes for CRR 2016 will not affect the capacity of the station to service the transport needs of events.

CRR 2011 identified that the Woolloongabba Priority Development Area (PDA) proposed a number of vehicular, pedestrian and cycle connectivity changes within the precinct, which would adequately support the location of the Woolloongabba Station. While this planning remains relevant, the new station location will need to be accommodated in a future revision to the PDA and planning for the surrounding area.

Albert Street Station

The CRR 2016 Albert Street Station has moved one block north-west compared to CRR 2011, which was located closer to Alice Street. The main change associated with the relocation of the station is the proposal for parts of Albert Street to be pedestrianised. CRR 2016 presents an opportunity to permanently close the section of Albert Street between Mary Street and Charlotte Street to vehicular traffic, and also between Charlotte Street and Elizabeth Street with some local vehicular access maintained.

As part of the opportunity to pedestrianise the section of Albert Street between Charlotte Street and Elizabeth Street, the existing Myer Centre car park exit would be closed or, if required, relocated to Charlotte Street between Albert Street and George Street.

While CRR 2011 did not propose permanently closing parts of Albert Street Station, there were some lane capacity reductions associated with footpath widening to cater for pedestrian demands. CRR 2011 also required removal of the left lane at Alice Street on the corner of Alice Street and Albert Street, which removed parking capacity. CRR 2016 does not directly affect Alice Street.

The proposal to permanently close Albert Street (between Mary Street and Elizabeth Street) to through-vehicle traffic will result in a local redistribution of traffic to other parts of the CBD network. Traffic redistribution is confined to local traffic accessing CBD establishments and would not impact the Riverside Expressway. As there are no bus services operating on this section of Albert Street, there would be no impacts on bus operations.

An assessment was undertaken of the potential impact of the partial closure of Albert Street. As part of the assessment, assumptions were made about the current routes of potentially impacted traffic and the redistribution of traffic after the road closure. Traffic counts were also carried out during peak periods on 27 April, 2016 and form the basis of the analysis. Traffic growth rates in the CBD was derived from the CRR 2016 transport model, which indicates a compounding growth rate of 0.64% between 2016 and 2023, and 0.38% between 2016 and 2033. These growth rates have been applied to estimate the traffic volumes at the opening year of 2023 and 10 years after opening in 2033.

Key intersections in the vicinity of the Albert Street closure were analysed for the AM and PM periods to assess possible traffic impacts in 2023 (year of opening) and 2033. The assessment indicated that impacts on the operation of the intersections are minor. Most intersections are forecast to operate well within acceptable levels for both peak periods. Only the intersection of George Street and Elizabeth Street was forecast to exceed capacity limits in both AM and PM peak periods as a result of traffic rerouting from Albert Street to George Street. The impact results from greater demand for the right turn movement from George Street into Elizabeth Street causing queuing and delays for this movement.

The proposed mitigation measure for the intersection of George Street and Elizabeth Street is to convert the centre lane into a shared through and right turn from George Street into Elizabeth Street. This will increase the available right turn capacity such that in the AM and PM peaks the intersection level of service will be within acceptable levels. There is minimal change in delay on the through movement (on George Street) as result of the mitigation measure.

The results of the intersection assessment are summarised in Tables 1.10 and 1.11 and documented in Appendix A1. Note that the proposed mitigation measure for the intersection of George Street and Elizabeth Street is included in these results.

Table 1.10 AM peak degree of saturation (DOS) and level of service (LOS) at key CBD intersections with and without Albert Street closure.[2]

Intersection	2016 Existing[3]		2023 No Closure		2023 With Closure		2033 No Closure		2033 With Closure	
	DOS[4]	LOS[5]	DOS	LOS	DOS	LOS	DOS	LOS	DOS	LOS
George St-Elizabeth Street[6]	0.71	C	0.75	C	0.85	C	0.77	C	0.87	C
George St-Charlotte Street	0.38	A	0.42	A	0.49	A	0.43	A	0.52	A
George St-Mary Street	0.48	A	0.52	A	0.73	C	0.54	A	0.75	C
George St-Margaret Street	0.52	A	0.56	A	0.56	A	0.57	A	0.57	A
George St-Alice Street	0.65	B	0.68	B	0.71	C	0.69	B	0.73	C
Albert St-Elizabeth Street	0.64	B	0.69	B	0.61	B	0.71	C	0.62	B
Albert St-Charlotte Street	0.59	A	0.72	C	0.35	A	0.73	C	0.37	A
Albert St-Mary Street	0.53	A	0.56	A	0.55	A	0.59	A	0.56	A
Albert St-Margaret Street	0.45	A	0.50	A	0.49	A	0.51	A	0.50	A

[2] Signal timings derived from www.data.brisbane.qld.gov.au - accessed July 2016.
[3] 27th April 2016.
[4] DoS is the ratio of volume to capacity
[5] Level of service (using SIDRA Method) values based on highest (worst movement/lane) degree of saturation for the intersection: DoS ≤ 0.60 – A; 0.60 < DoS ≤ 0.70 – B; 0.70 < DoS ≤ 0.90 – C; 0.90 < DoS ≤ 0.95 – D; 0.95 < DoS ≤ 1.00 – E; and DoS > 1.00 – F.
[6] Includes reconfiguration of George Street – Elizabeth Street intersection

Intersection	2016 Existing[3]		2023 No Closure		2023 With Closure		2033 No Closure		2033 With Closure	
	DOS[4]	LOS[5]	DOS	LOS	DOS	LOS	DOS	LOS	DOS	LOS
Albert St-Alice Street	0.29	A	0.31	A	0.27	A	0.32	A	0.28	A

Table 1.11 PM peak DOS and LOS at key CBD intersections with and without Albert Street closure.

Intersection	2016 Existing[7]		2023 No Closure		2023 With Closure		2033 No Closure		2033 With Closure	
	DOS	LOS	DOS	LOS	DOS	LOS	DOS	LOS	DOS	LOS
George St-Elizabeth Street[8]	0.59	A	0.65	B	0.75	C	0.67	B	0.79	C
George St-Charlotte Street	0.39	A	0.43	A	0.82	C	0.46	A	0.86	C
George St-Mary Street	0.49	A	0.53	A	0.66	B	0.55	A	0.69	B
George St-Margaret Street	0.45	A	0.48	A	0.58	A	0.49	A	0.59	A
George St-Alice Street	0.77	C	0.81	C	0.86	C	0.82	C	0.88	C
Albert St-Elizabeth Street	0.56	A	0.62	B	0.68	B	0.65	B	0.70	B
Albert St-Charlotte Street	0.53	A	0.61	B	0.49	A	0.65	B	0.44	A
Albert St-Mary Street	0.39	A	0.43	A	0.42	A	0.44	A	0.43	A
Albert St-Margaret Street	0.33	A	0.37	A	0.22	A	0.38	A	0.23	A
Albert St-Alice Street	0.67	B	0.70	C	0.48	A	0.72	C	0.50	A

Roma Street Station

CRR 2016 relocates the Roma Street Station approximately 150m to the site of the existing Brisbane Transit Centre (BTC) West Tower. This will necessitate the closure and relocation of the long distance coach terminal from its existing site and also the demolition of the existing car park with the loss of approximately 600 car parking spaces.

The existing BTC car park is principally used by tenants of the transit centre office buildings as well as some paid car parking for CBD commuters. With the demolition of the office buildings, there will be reduced car parking demand. Alternative commercial car parking is available locally and this is not expected to impact on parking in the local area.

The existing long distance coach terminal would need to be relocated prior to demolition. Further investigation will be undertaken by the Proponent, in consultation with the operators, to find a suitable site for the coach terminal.

[7] 27th April 2016.
[8] Includes reconfiguration of George Street – Elizabeth Street intersection

In terms of pedestrian access, passengers will be able to access the new station from two entrances facing Roma Street and one on the eastern side facing the Transit Centre. The eastern entrance will provide a convenient route for passengers transferring to/from bus and surface rail platforms and for passengers walking to destinations in the CBD. The dominant movement from the station is expected to be alighting passengers heading south-east across Roma Street towards George Street from the existing station entrance.

In the 2026 AM peak (7-9am) there are forecast to be around 12,000 passengers walking to and from the Roma Street Station complex (new CRR station, existing surface rail station, and busway station). To accommodate these movements, improvements will be required to local pedestrian facilities. Figure 1.3 illustrates a possible conceptual layout for the Roma Street area to improve the pedestrian environment.

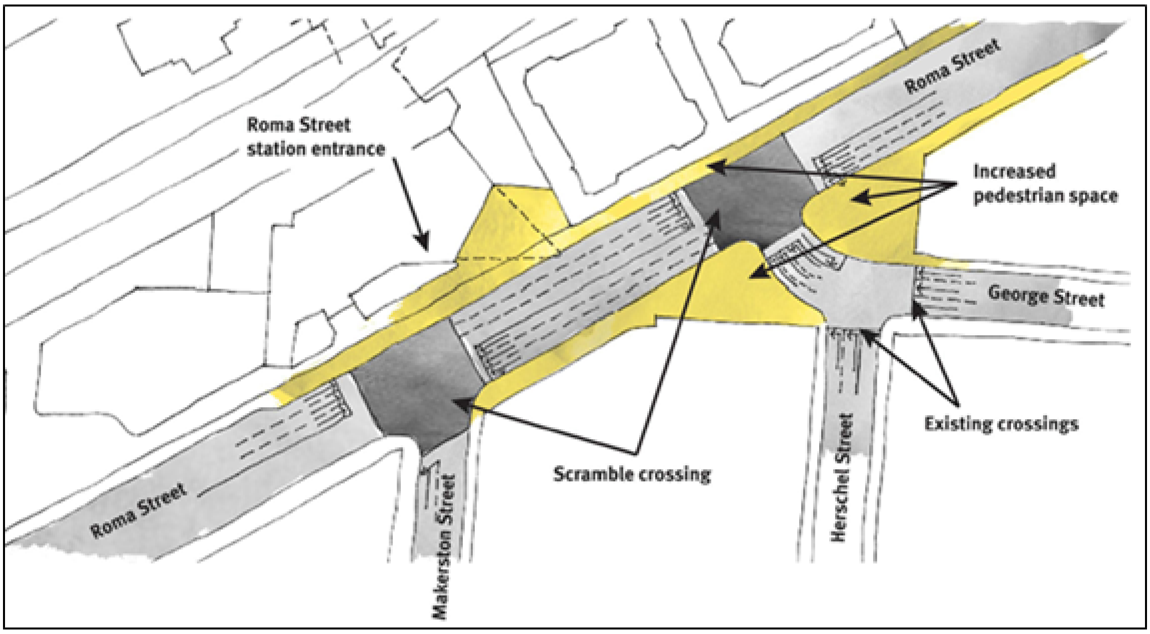


Figure 1.3 Roma Street Station – concept layout for pedestrian footpath treatments and crossing facilities

The conceptual layout includes the creation of a signalised T-intersection of George Street and Roma Street that will include a scramble pedestrian crossing. The T-intersection would be created through the re-alignment of George Street at Roma Street and the removal of the short section of Herschel Street between George Street and Roma Street. The layout has the following key features:

- Maintains two lanes on Roma Street in the eastbound direction from Makerston Street;
- Maintains three lanes on Roma Street from Parklands Boulevard through to Countess Street;
- Allows a left turn from Roma Street to George Street to access Herschel Street;
- Movements from Herschel Street to Roma Street eastbound have been removed;
- Retains the bus-only right turn from Roma Street to George Street;
- Retains the driveway access to the car park and hotel associated with the eastern end of the Transit Centre;
- Retains the cycle lanes on George Street and Roma Street; and
- Provision of pedestrian scramble crossings at new intersection of Roma Street with George Street and of Roma Street with Makerston Street.

The changes to the road network and pedestrian facilities proposed at Roma Street would result in localised changes to traffic operations. It is noted that the concept has previously been subject to a traffic assessment,[9] however the layout would require further consultation with Brisbane City Council (BCC).

Exhibition Station

The CRR 2016 Exhibition Station will be located further west compared to CRR 2011. Enhanced pedestrian connectivity will be provided between the station and both Bowen Bridge Road and O'Connell Terrace. Access to Exhibition Station by other transport modes will be similar to CRR 2011.

1.5 Changes to construction transport impacts

1.5.1 Existing rail services

The majority of the proposed surface works at the southern and Northern portals interface and potentially impact on the existing operational rail network. Delivery of the works will need to be staged into manageable, safe and reliable increments acceptable to the Railway Manager (QR) and these works will be subject to the railway manager's corridor safety requirements.

Where possible, surface rail works will be carried out off-line which may involve temporary slewing of tracks. Other works will typically be carried out during evenings or weekend possessions. This is consistent with CRR 2011.

1.5.2 Construction worksites

Construction of CRR 2016 will require a number of construction worksites, some of which have changed location since CRR 2011. A summary of these changes is provided in Table 1.12 and illustrated in Figures 1.4 to 1.17. This section discusses how these changes have altered construction traffic impacts in and around worksites.

Table 1.12 Comparison of worksites (CRR 2011 and CRR 2016)

Location	CRR 2011 location	CRR 2016 location
Salisbury to Yeerongpilly	Station worksites at Salisbury, Moorooka and Yeerongpilly.	No works proposed for CRR 2016.
Southern ventilation shaft	Worksite at Fairfield Road and Bledisloe Street.	No works proposed for CRR 2016.
Southern portal	Worksite at Yeerongpilly Station with access off Wilkie Street.	Worksite within the existing Queensland Rail (QR) compound between PA Hospital and rail corridor.
Boggo Road Station	Worksite between Boggo Road Gaol and the Ecosciences building.	Worksite located between the rail corridor and Joe Baker Street.
Woolloongabba Station	Worksite at the existing GoPrint site.	Worksite positioned at the existing GoPrint site, Landcentre building and Dental Clinic.
Albert Street Station	Worksite off Albert Street, between Alice Street and Charlotte Street.	Worksite on Albert Street, between Mary Street and Elizabeth Street.
Roma Street Station	Worksite at eastern end of existing Roma Street Station.	Worksite at BTC (West Tower) and additional laydown area within car park area (off Parkland Crescent)

[9] As part of the BaT project environmental impact assessment.

Location	CRR 2011 location	CRR 2016 location
Northern portal	Worksite at existing BCC temporary staging facility and QR workshop shed at eastern end of Victoria Park.	Main worksite within the rail corridor near the Northern portal and a smaller worksite at existing BCC temporary staging facility. Additional laydown area off Gilchrist Avenue.
Exhibition Station	Worksite at O'Connell Terrace at east of road-over-rail bridge.	Worksite slightly smaller to CRR 2011.

Southern portal construction worksite

The Southern portal dive structure for CRR 2016 is located north of Dutton Park Station, compared to CRR 2011 which was located near Yeerongpilly Station between Stamford Street and Crichton Street.

The CRR 2016 Southern portal construction worksites will be located primarily within the existing rail corridor bounded by Dutton Park Station, Kent Street and the Eastern Busway as shown in Figure 1.4. Access to the worksite will primarily be through the provision of a temporary bridge located adjacent to the rail overpass over the Eastern Busway. This bridge will be utilised by construction vehicles to access the worksite and will connect to Ipswich Road via O'Keefe Street, reducing the impact on the PA Hospital and Cornwall Street. A secondary access to the site will be via Cornwall Street onto Kent Street (for light vehicles only). This secondary access will be utilised by workers' vehicles coming off Annerley Road. Whilst in a different location to CRR 2011, it is considered that comparatively the impacts on the local road network will be reduced as access will be provided off two major arterial roads (Annerley Road and Ipswich Road).

Some of the existing railway infrastructure and buildings on the QR land, proposed for the construction worksite, will need to be demolished. Given the relatively low number of truck movements during demolition, the transport of demolition waste is expected to have minimal impact on existing traffic. Spoil haulage access routes for the site will be via the temporary bridge to O'Keefe Street, connecting to major arterials and ultimately to the spoil placement sites (refer Section 1.5.3).

Heavy vehicle movements to and from the Southern portal worksite are forecast to peak at around three trucks per hour at peak spoil haulage times. This is less than the peak haulage movements forecast in CRR 2011, which found impacts on the surrounding road network to be minor[10] and would not require mitigation.

Additional traffic from workers arriving on site will contribute to inbound morning movements but these will generally be arriving on site before the AM peak period. As the worksite's primary access will be directly to Ipswich Road and the number of trucks is relatively small, it is expected that construction traffic will have no discernible impacts on surrounding traffic conditions.

Car parking for workers is provided within the CRR 2016 worksite for the Southern portal. CRR 2011 worksites proposed a total of 464 parking spaces compared to up to 115 car parking spaces for CRR 2016. With the reduced scale of car parking around the Southern portal for CRR 2011, traffic impacts would also be reduced.

[10] Minor is defined as less than 5 seconds additional average intersection delay

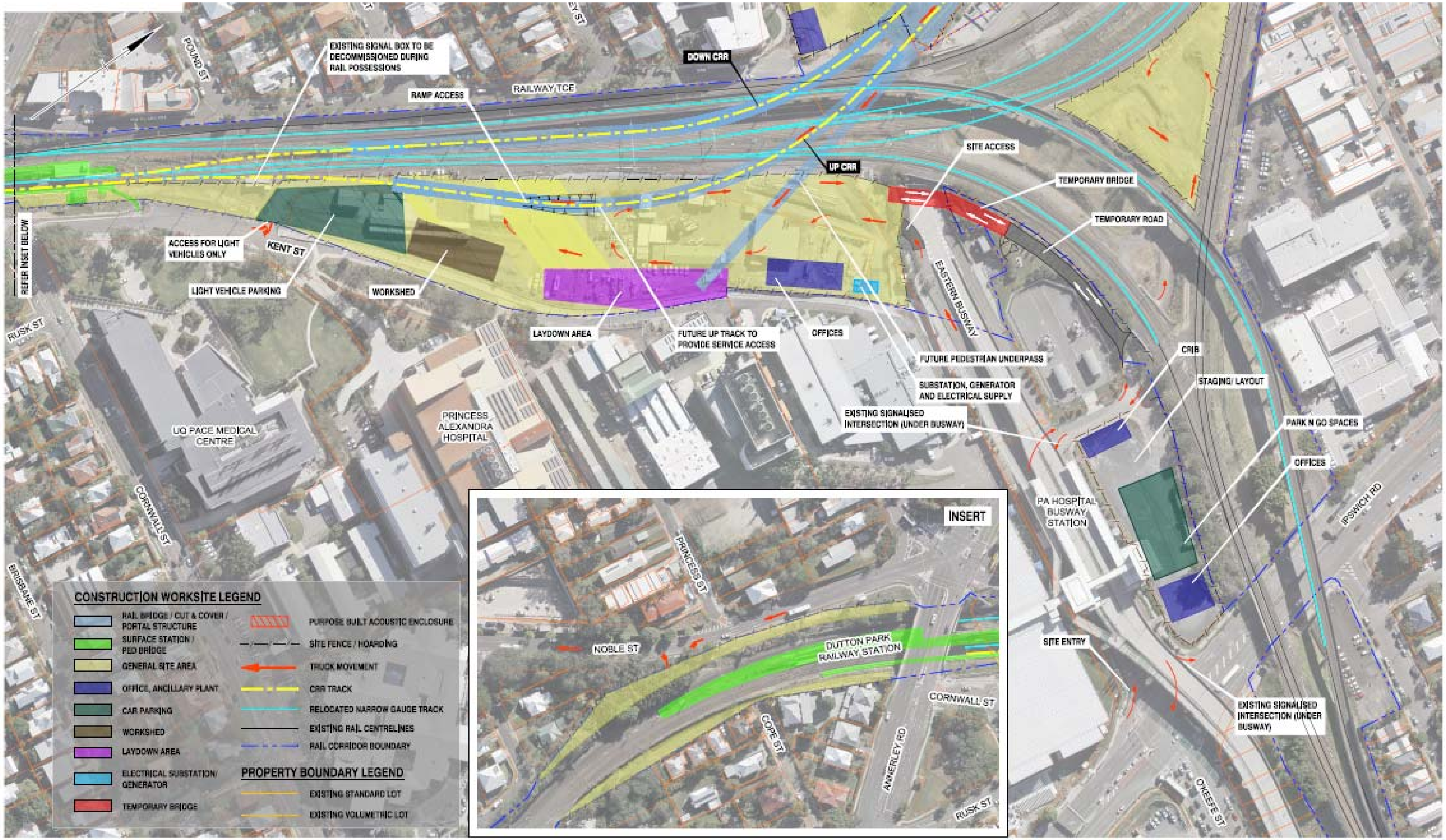


Figure 1.4 CRR 2016 Southern portal worksite

Boggo Road Station construction worksite

For CRR 2016, Boggo Road Station has been relocated to between Joe Baker Street and the rail corridor, compared to CRR 2011, which was located between Boggo Road Gaol and the Ecosciences building. The worksites for both CRR 2011 and CRR 2016 are shown in Figures 1.5 and 1.6.

The assessment of the CRR 2016 construction worksite is based on technical assessment undertaken for the Bus and Train (BaT) project[11]. The main worksite will be located within the between the rail corridor and Joe Baker Street (on Lot 2) with a smaller, auxiliary site primarily used as a general worksite and parking located between Merton Road and Quarry Street, adjacent Park Road Railway Station.

Where possible, the main site will be accessed via Cornwall Street and Annerley Road with a one-way circulation into Peter Doherty Street, Joe Baker Street and exit out of Boggo Road. The right turn access to this worksite from Annerley Road into Peter Doherty Street will require a short right turn bay to be provided at this intersection. This one-way circulation system provides for controlled management of truck movements through the precinct. Spoil haulage access to Ipswich Road will be via Annerley Road and Cornwall Street and through to Ipswich Road, connecting to spoil placement sites (refer Section 1.5.3).

The Boggo Road Station worksite will primarily affect local traffic within the Boggo Road Urban Village precinct with minimal impacts on Annerley Road and Cornwall Street. The construction worksite is not expected to impact on the wider road network beyond the intersections of Peter Doherty Street and Boggo Road with Annerley Road.

Heavy vehicle movements to and from the Boggo Road Station worksite are forecast to peak at around six trucks per hour at peak spoil haulage times. This is less than the peak haulage movements forecast in CRR 2011, which found impacts on the surrounding road network would be minor[12].

In relation to impacts on Boggo Road Busway Station, there may be short-term temporary closures required of the busway during construction. Where possible, closures will occur during off-peak periods and be coordinated with TransLink.

Workers will arrive at this worksite by accessing the designated car parking area (located between Merton Road and Quarry Street) from Annerley Road onto Park Road. Workers arriving on site will contribute to inbound morning movements but will generally be arriving on site before the AM peak period. The car parking spaces for workers at this location for CRR 2016 is estimated to be up to 45, which is greater than the CRR 2011 provision of 30 car parking spaces.

[11] Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Chapter 3.
[12] Minor is defined as less than 5 seconds additional average intersection delay.

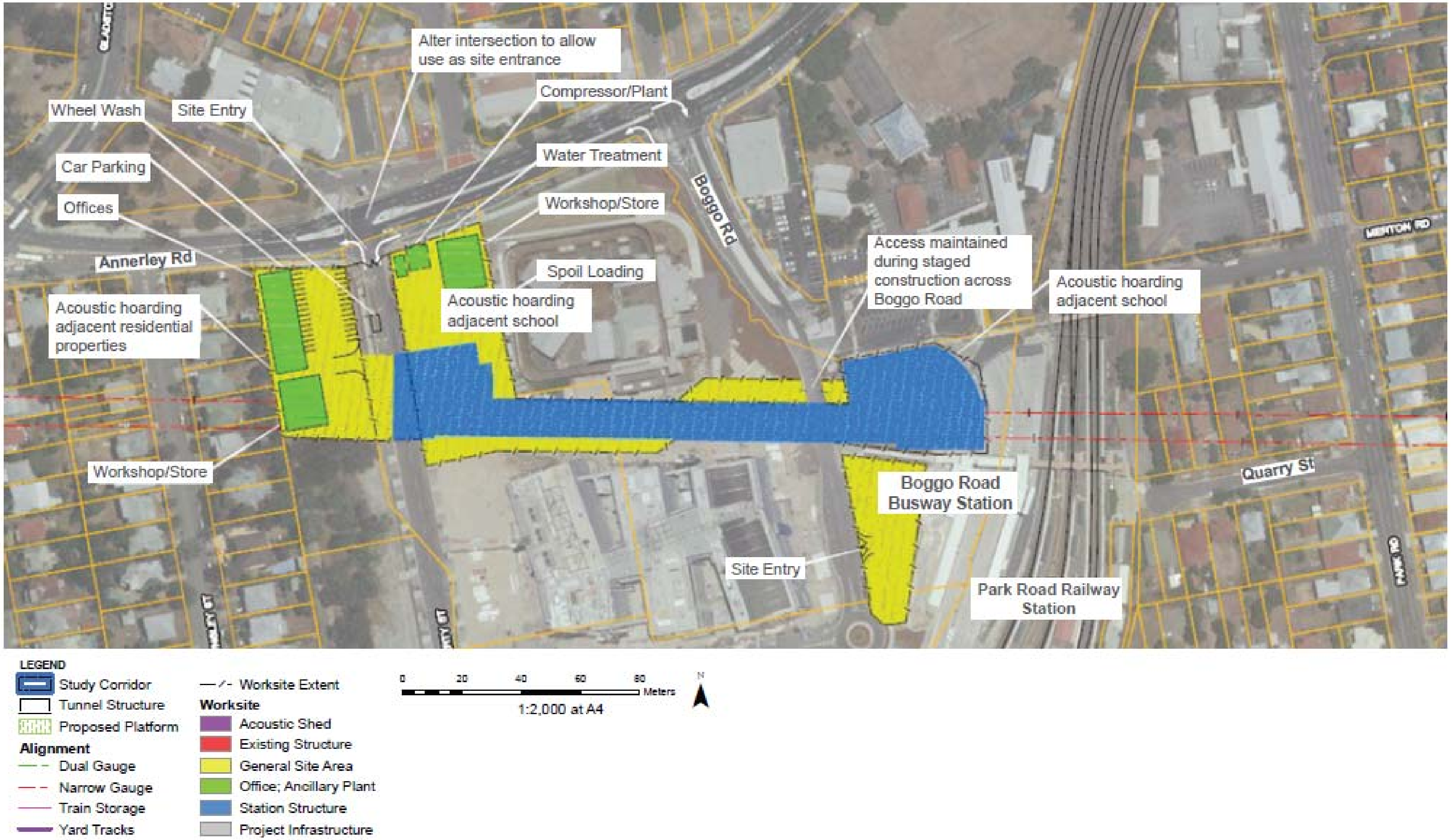


Figure 1.5 CRR 2011 Boggo Road Station worksite

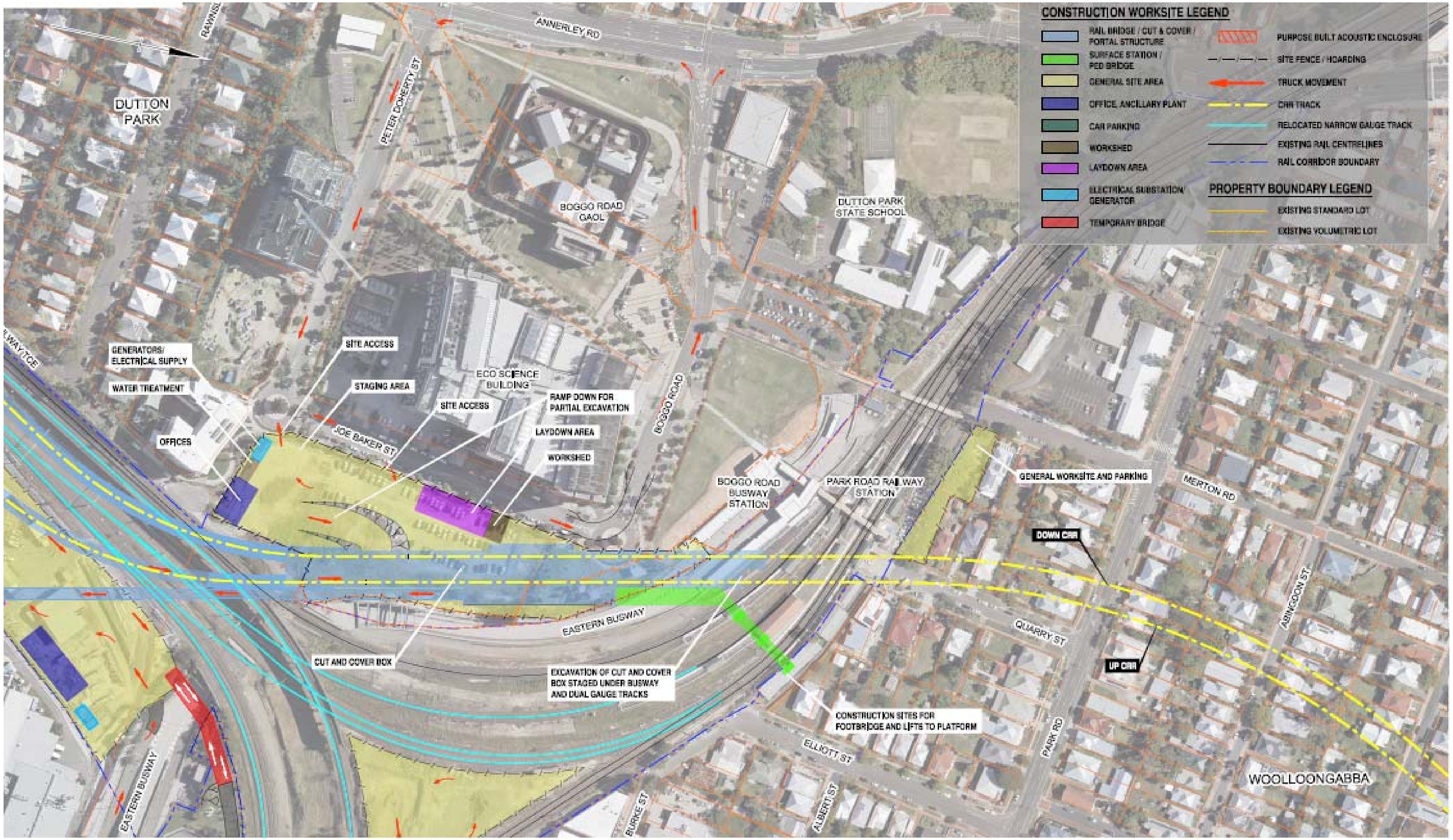


Figure 1.6 CRR 2016 Boggo Road worksite

Woolloongabba Station construction worksite

The CRR 2016 construction worksite for the Woolloongabba Station is in a similar location to CRR 2011 as shown in Figures 1.7 and 1.8.

The CRR 2016 Woolloongabba construction worksite will support the operation of the Tunnel Boring Machines (TBMs) driving north and mined tunnel construction advancing to the south. It requires the demolition of the GoPrint building, the Landcentre and Dental Clinic. The Landcentre and Dental Clinic were not proposed to be demolished for CRR 2011.

Estimated quantities of demolition waste generated from this worksite will be greater than that of the CRR 2011 with the inclusion of the latter two buildings. As tunnelling will not commence until demolition works have been completed, initially demolition waste will make up the haulage traffic from this worksite. As detailed in the CRR 2011 Environmental Impact Station (EIS), demolition occurs for a relatively short period and the frequency of truck movements are not expected to exceed that of the excavation stage. Overall it is considered that the access arrangements for CRR 2016 have improved from CRR 2011 with additional access now available to/from Leopard Street as a result of the change in design.

Heavy vehicles will access into the worksite from various directions including Vulture Street in the north, Main Street in the east and Leopard Street in the west. Worksite egress (out of the site) will also be via Vulture Street, Main Street and Leopard Street. Heavy vehicle movements to and from this worksite are forecast to peak at around 11 trucks per hour at peak spoil haulage times. This is less than the peak haulage movements forecast in CRR 2011. With the reduced peak haulage traffic, impacts on the surrounding road network are expected to be minor[13]. CRR 2016 will utilise the spoil routes described in Section 1.5.3 to transport spoil to placements sites. Further detail on construction traffic generated, daily spoil and delivery trips at Woolloongabba is also included in Section 1.5.3.

For CRR 2011, the worksite was contained within the GoPrint site and impacts on the Woolloongabba Busway Station were minimised, resulting in no direct effect on busway operations. For CRR 2016, there may be temporary impacts on busway operations to allow for construction of the pedestrian footbridge from Stanley Street at the western end of the busway station. This may involve piling and placing of deck structures which may require busway closures or traffic management. It is anticipated that busway interruptions would be for short periods (typically days) and would (where possible) occur during off-peak periods to minimise disruption to services. There may also be temporary minor delays to buses traveling along Main Street and Vulture Street with construction vehicles entering and exiting the worksite.

Other construction worksite impacts such as pedestrian and cyclist access, local parking, local access, emergency vehicle access and special events will be consistent with CRR 2011.

In relation to workforce car parking arrangements, CRR 2016 provides approximately 300 car parking spaces compared to 72 spaces for CRR 2011, reflective of the Woolloongabba worksite being the main spoil extraction site. Traffic from workers arriving on site will contribute to greater inbound morning traffic movements but these will generally be arriving on site before the AM peak period.

[13] Minor is defined as less than 5 seconds additional average intersection delay

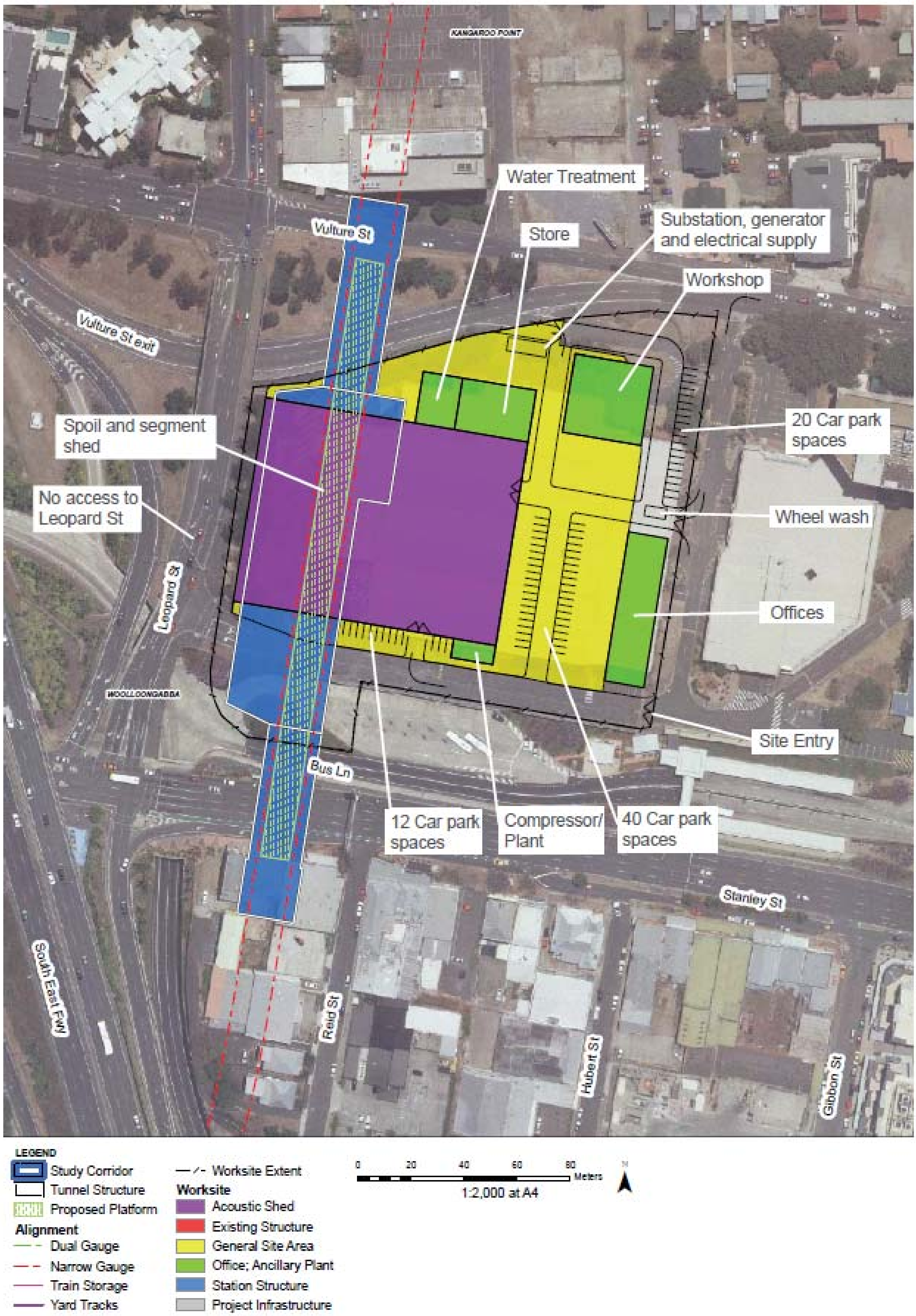


Figure 1.7 CRR 2011 Woolloongabba Station worksite

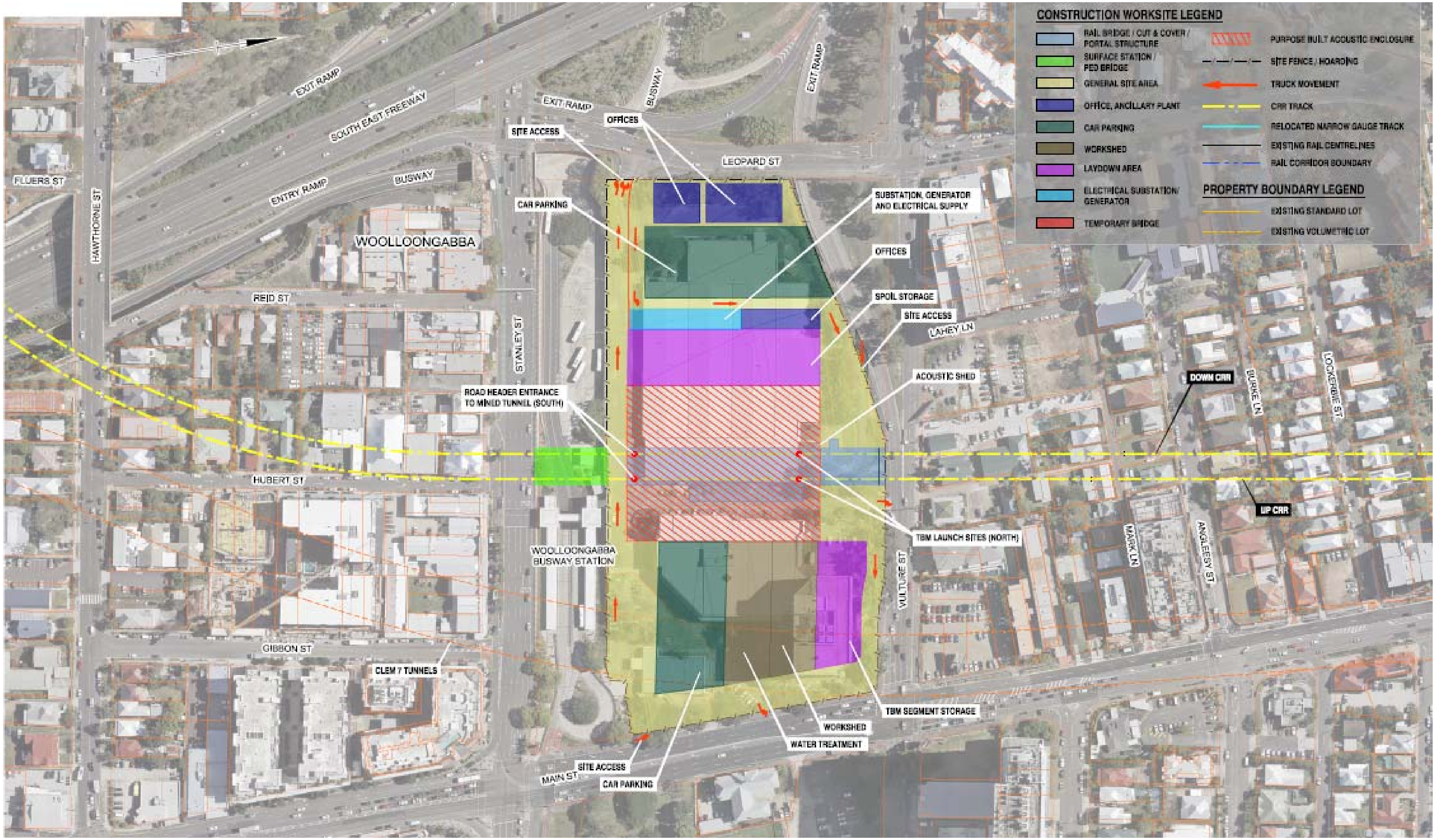


Figure 1.8 CRR 2016 Woolloongabba Station worksite

Albert Street Station construction worksite

The construction worksite for the CRR 2016 Albert Street Station will be located between Mary Street and Elizabeth Street. For CRR 2011, two worksites were proposed, one located between Alice Street and Margaret Street and the other located between Mary Street and Charlotte Street. The worksites for CRR 2011 and CRR 2016 are shown in Figures 1.9 and Figure 1.10. The CRR 2016 construction worksite will require the demolition of properties located north of the intersection with Mary Street on either side of Albert Street.

Given the low number of truck movements during demolition, the transport of demolition waste is well within capacity of the existing network and expected to have minimal impact on existing traffic.

The potential relocation of the Myer Centre exit ramp (if required) to Charlotte Street between Albert Street and George Street will result in temporary lane closures within the vicinity of the Albert Street and Charlotte Street intersection. If required, the relocation of the ramp would be implemented in stages. As a result, various lane closures and vehicle access conditions and diversions are identified for each stage of construction. Not all the construction stages would directly impact intersection traffic as some stages are undertaken underground.

If required, the relocation would be completed prior to the construction of the Albert Street Station. As a consequence, traffic impacts will be predominantly centred at the intersection of Albert Street and Charlotte Street. To minimise the impacts associated with each stage of the relocation, a traffic management plan for each stage of construction will need to be implemented. It is anticipated that temporary removal of on-street car parking on the right-most-lane of the northern and southern legs of Charlotte Street would be required.

Intersection assessment indicates that there would be a minor impact on intersection operation on Albert Street and Charlotte Street resulting from the relocation of the ramp. Some construction stages will experience flow improvements as a result of reduced intersection movements.

The sequencing of the station excavation and construction will be such that pedestrian access will always be maintained through Albert Street. Conflicts between pedestrians and construction traffic will be carefully managed.

Establishment of the worksite is likely to involve site hoardings at or near the back of footpaths allowing pedestrian access to be maintained along frontage footpaths, where possible. Some temporary disruption would also be caused by construction vehicles crossing footpaths to access work sites. Haulage vehicles will need to traverse the north-west footpath of Mary Street to access and exit the worksite.

Heavy vehicle movements to and from this worksite are forecast to peak at around five trucks per hour at peak spoil haulage times. This is less than the peak haulage movements forecast in CRR 2011, which found impacts on the surrounding road network to be minor[14]. Intersection assessment undertaken for the operational phase of the project (refer Section 1.4.1) indicated that the intersection of Albert Street and Mary Street will be able to accommodate additional traffic with the partial closure of Albert Street during construction. CRR 2016 will utilise the spoil routes through the CBD described in Section 1.5.3 to transport spoil to placements sites.

For CRR 2016, construction workers will be encouraged to access the site via public transport or commercial car parks as no on-site car parking facilities will be provided. This is consistent with general construction activities in the city e.g. construction of buildings. There will be reduced local traffic impacts from workers arriving at Albert Street Station compared to CRR 2011 which provided some worksite car parking.

[14] Minor is defined as less than 5 seconds additional average intersection delay.

The CityCycle station near the corner of Albert Street and Mary Street will need to be relocated in coordination with BCC. Most cycle parking and other street furniture on Albert Street between Mary Street and Elizabeth Street will be temporarily removed during construction.

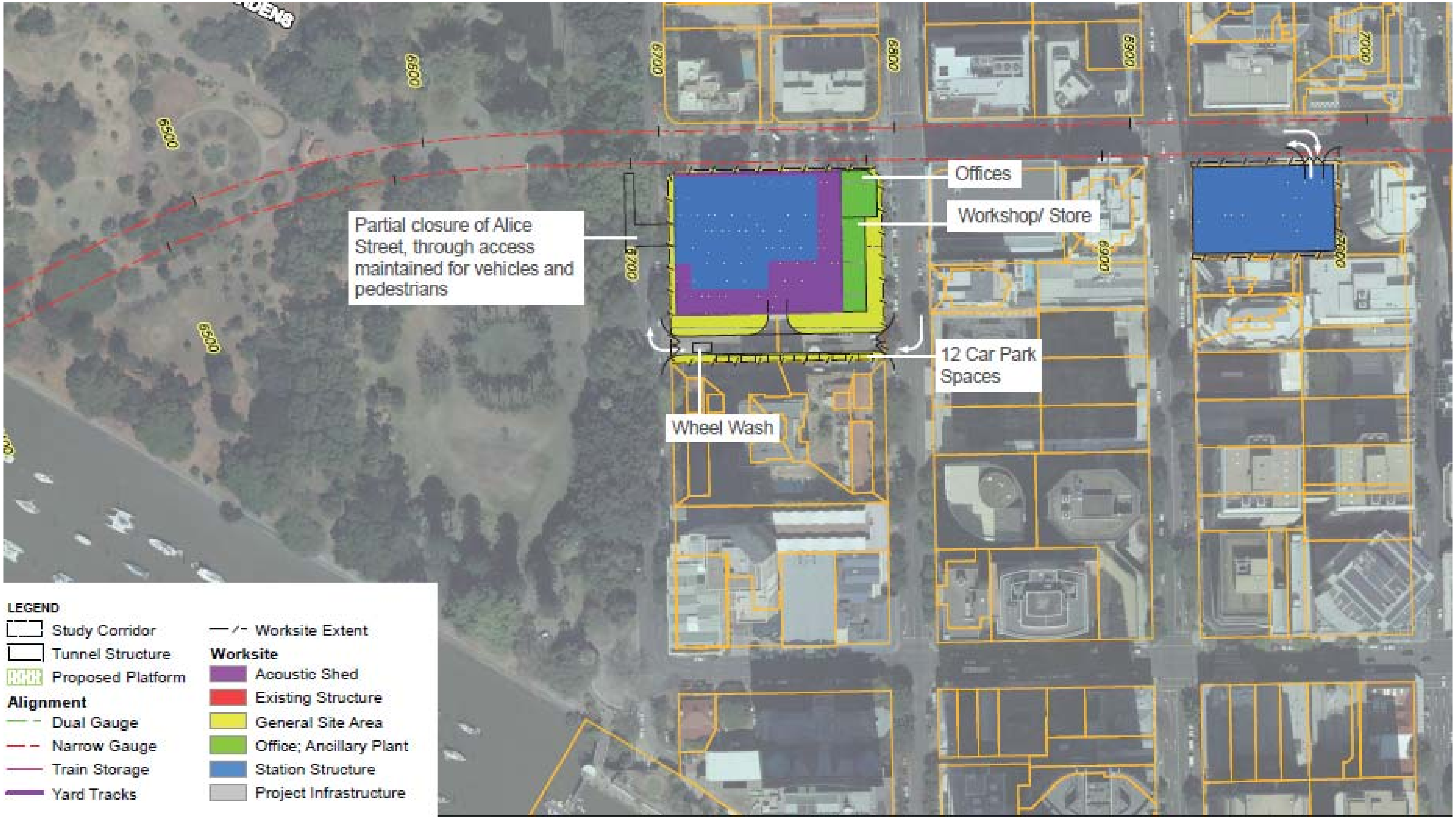


Figure 1.9 CRR 2011 Albert Street Station worksite

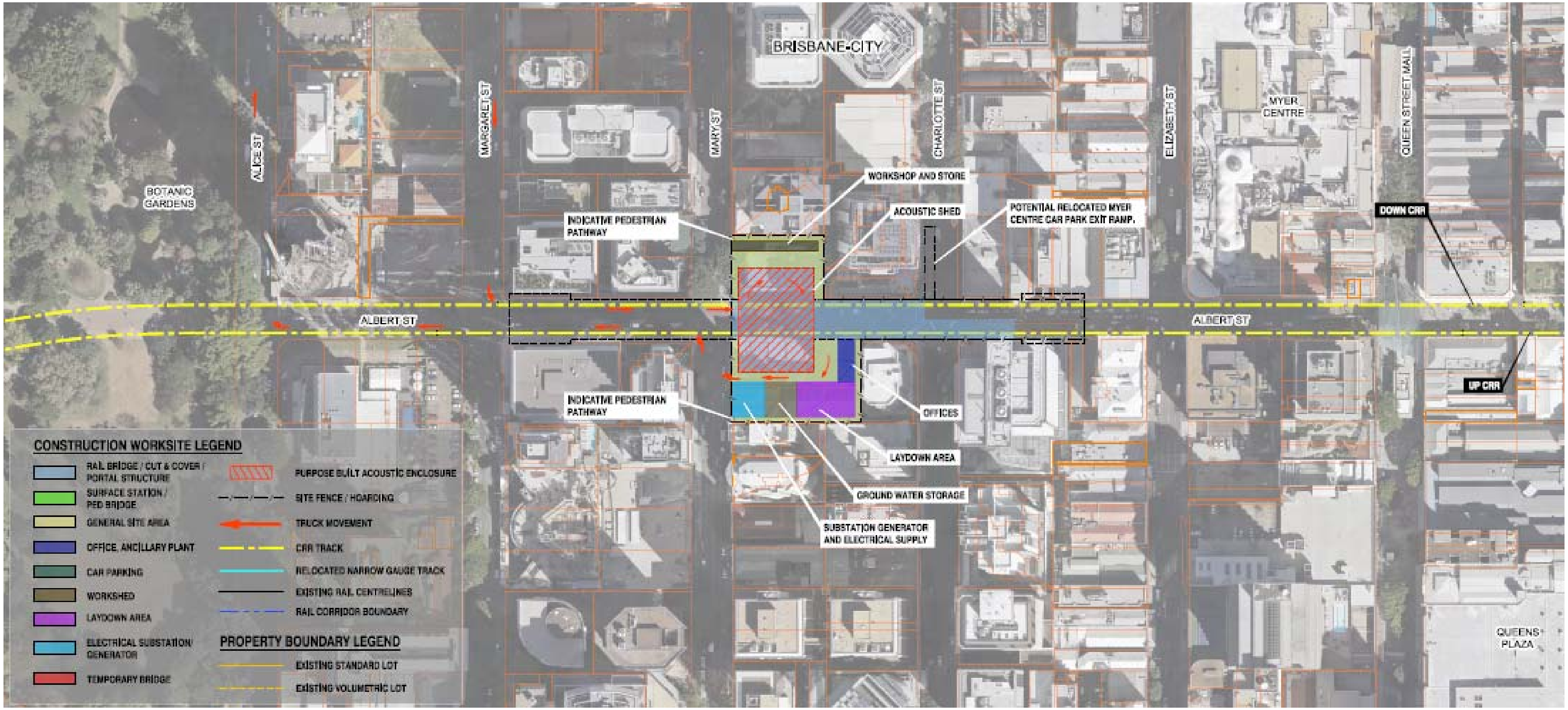


Figure 1.10 CRR 2016 Albert Street Station worksite

Roma Street Station construction worksite

The CRR 2011 Roma Street Station worksite consisted of three separate locations, as shown in Figure 1.11. The CRR 2016 construction worksite is located between the Inner Northern Busway and Roma Street covering the BTC West Tower and coach ramps. A satellite site is also located between the Inner City Bypass (ICB) and Roma Street Parklands (i.e. the existing car park area off Parkland Crescent) and a laydown area is located at the end of Roma Street Railway Station (i.e. the existing car park area between Parkland Boulevard and Crescent). CRR 2016 worksite is shown in Figure 1.12.

The worksite will require the demolition of the BTC West Tower and coach ramps. The transport of demolition waste is expected to have minimal impact on existing traffic as demolition truck activity is unlikely to coincide with the main construction activities. Demolition of the BTC West Tower and ramps is expected to generally take place within the confines of the worksite. Establishment of the worksite for demolition is likely to involve site hoardings at or near the back of footpaths allowing pedestrian and cyclist access to be maintained along frontage footpaths. This will include demolition of the existing long distance coach terminal. Alternative arrangements will need to be identified for the existing long distance coach terminal which is used by a number of major coach services, commercial tenancies and tourist operators.

The inbound bus stop at Roma Street adjacent to the worksite will need to be relocated in coordination with TransLink during the demolition phase. This may include moving the bus stop further east along Roma Street in front of the BTC East Tower for buses continuing along Roma Street. Services travelling via Herschel Street may temporarily be unable to stop at Roma Street. Establishment of the construction worksite may also result in temporary disruption to the Inner Northern Busway adjacent to Roma Street Station. This will need to be managed in consultation with TransLink and BCC. The CityCycle station in front of the BTC West Tower will need to be relocated in coordination with BCC.

During construction there will be two access points to the worksite off Roma Street, one at either end of the worksite. Some delays to pedestrian and cycle movements will be caused by vehicles crossing footpaths to access the worksite along Roma Street.

For the additional laydown area located between Parkland Boulevard and Parkland Crescent this may require occupation of the westbound lane of Parkland Crescent, between the long distance platform and the Parkland Boulevard intersection. Management of this closure may include utilising the eastbound lane in a contraflow[15] traffic arrangement. Should the worksite close the pedestrian footpath on the southern side of Parkland Crescent, a pedestrian detour would be provided. This worksite is not anticipated to impact cycle activity, although cyclists will have to follow detours put in place for vehicles due to the closure of the westbound lane of Parkland Crescent. Car parking displaced by the worksite may be relocated to the existing car park at the north western corner of Roma Street Parklands.

Heavy vehicle movements to and from this worksite are forecast to peak at around six trucks per hour at peak spoil haulage times. This is less than the peak haulage movements forecast in CRR 2011, which found impacts on the surrounding road network would be minor[16]. CRR 2016 will utilise the spoil routes described in Section 1.5.3 to transport spoil to placements sites.

---

[15] Temporary traffic arrangement whereby one side of the road is used for travelling in both directions while the other side is being repaired.
[16] Minor is defined as less than 5 seconds additional average intersection delay.

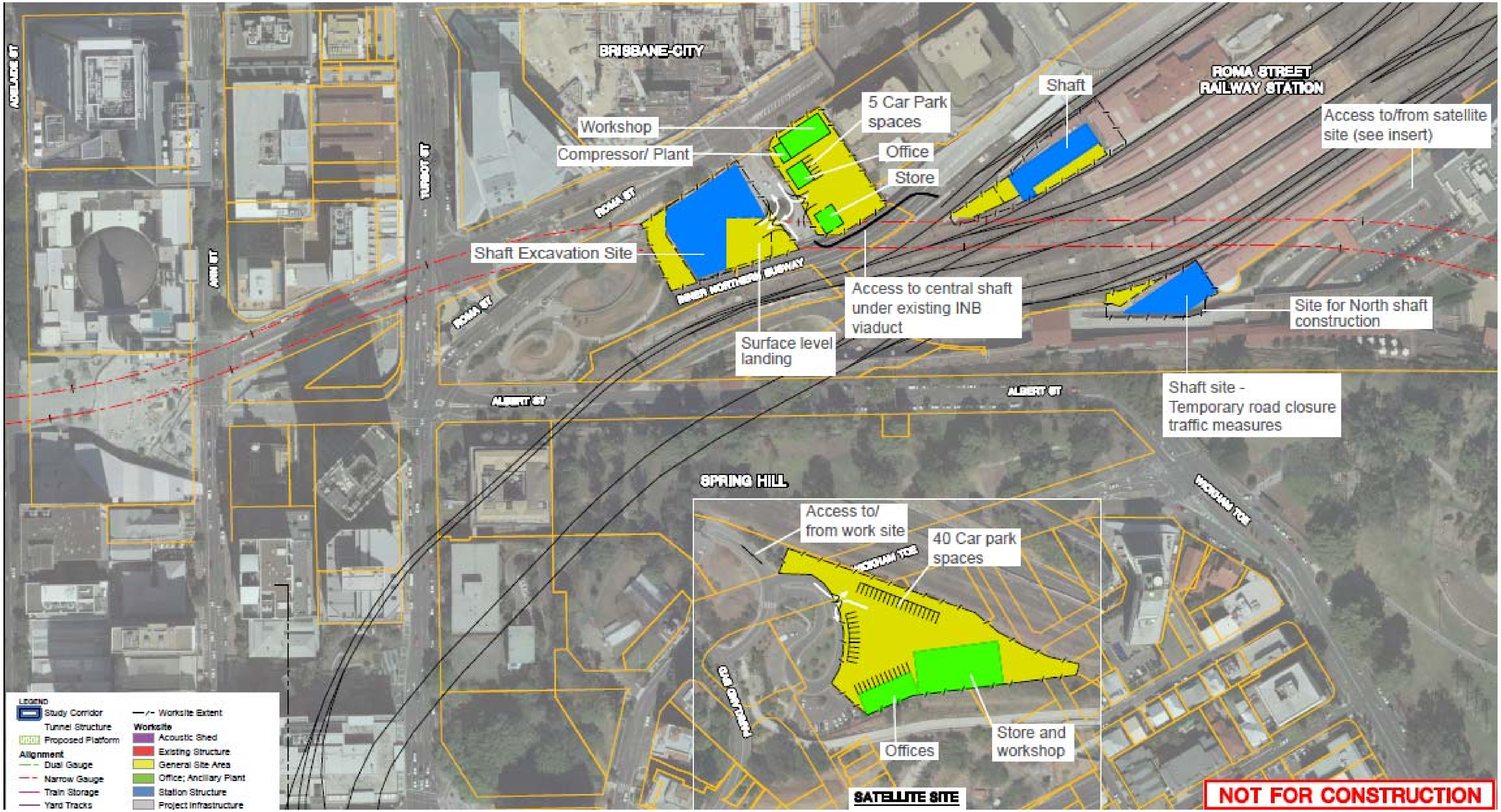


Figure 1.11 CRR 2011 Roma Street Station worksite

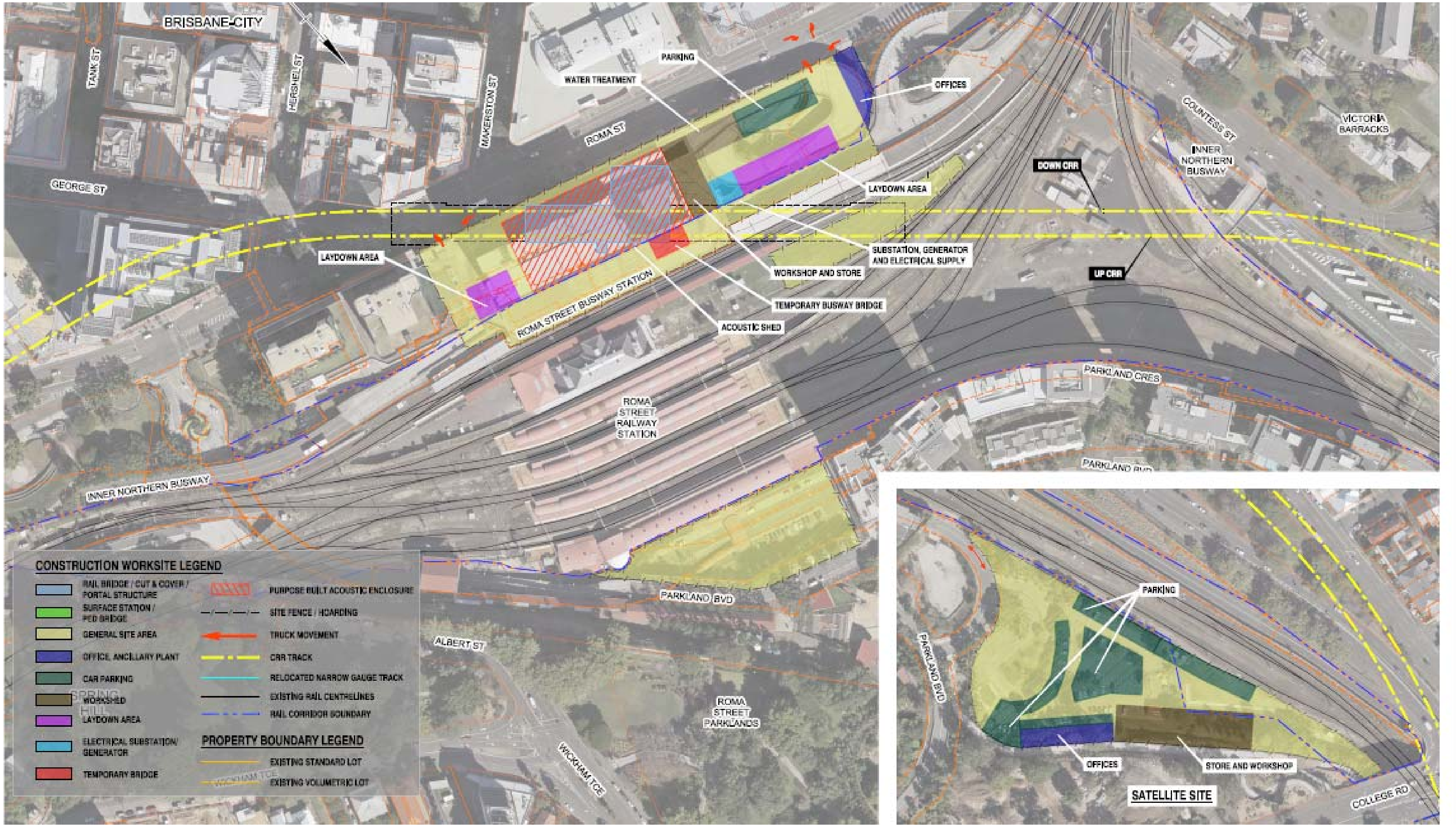


Figure 1.12 CRR 2016 Roma Street Station worksite

Northern portal construction worksite

The dive structure and Northern portal for CRR 2016 is located in the Exhibition Line rail corridor. The Northern portal worksite extends from Bowen Bridge Road to College Road and along the Exhibition Line. The worksite plans for CRR 2011 and CRR 2016 are shown in Figures 1.13 and 1.14.

The construction worksite requirement within Victoria Park has been significantly reduced compared to CRR 2011 to minimise impact on the park. Worksite requirements are limited to land at and near the existing BCC temporary staging facility. There will be some demolition of existing structures at this worksite, however the transport of demolition waste is expected to have minimal impact on existing traffic.

Land will also be utilised on the opposite side of the ICB off Gilchrist Avenue for car parking and construction laydown. The car parking provision is greater than CRR 2011, which was provided within the worksite area in Victoria Park. The estimated car parking spaces for workers at this location for CRR 2016 is approximately 154 compared to 80 for CRR 2011. Additional traffic from workers arriving on site will contribute to greater inbound morning traffic movements but these will generally be arriving on site before the AM peak period. As such, local traffic impacts on Gregory Terrace will be reduced as car parking and construction laydown traffic will be diverted to other roads such as the ICB Herston off-ramp, Herston Road and Bowen Bridge Road.

The BCC temporary staging facility is more than 1 kilometre (km) from the Northern portal dive structure. As such, a nominated temporary construction area off the ICB, within the existing rail corridor will be used for materials handling and logistics. Truck access and egress to this worksite will be via Bowen Bridge Road (immediately south of the Northern Busway access point) and access to worksite currently accommodating the BCC temporary staging facility will be via Gregory Terrace. This access points is similar to CRR 2011.

Heavy vehicle movements to and from this worksite are forecast to peak at around five trucks per hour at peak spoil haulage times. This is less than the peak haulage movements forecast in CRR 2011, which found impacts on the surrounding road network to be minor[17]. CRR 2016 will utilise the spoil routes described in Section 1.5.3 to transport spoil to placements sites.

Other construction worksite impacts will be consistent with CRR 2011, including the temporary diversion of the bikeway along the southern area of the worksite.

[17] Minor is defined as less than 5 seconds additional average intersection delay.

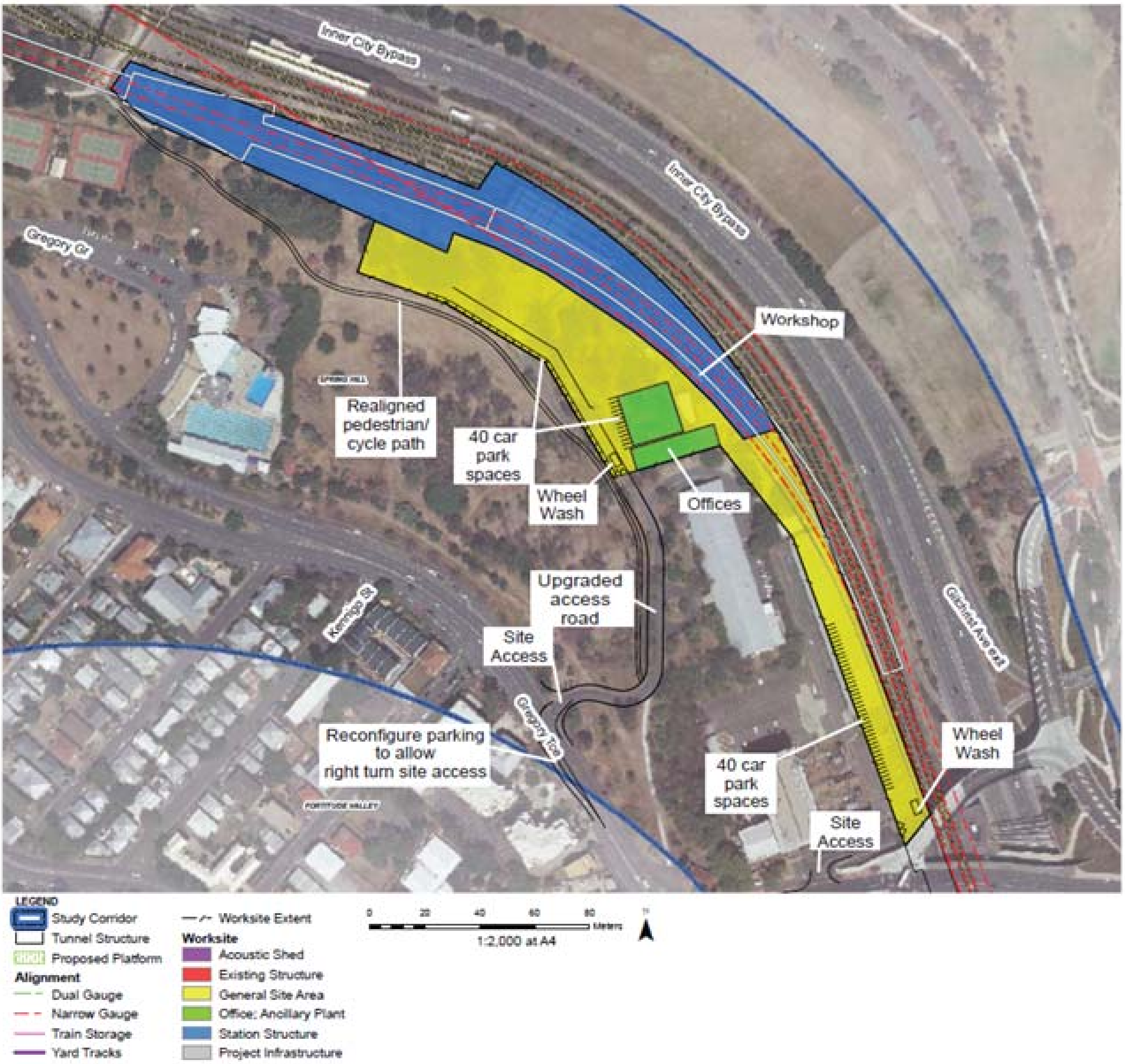


Figure 1.13 CRR 2011 Northern portal worksite

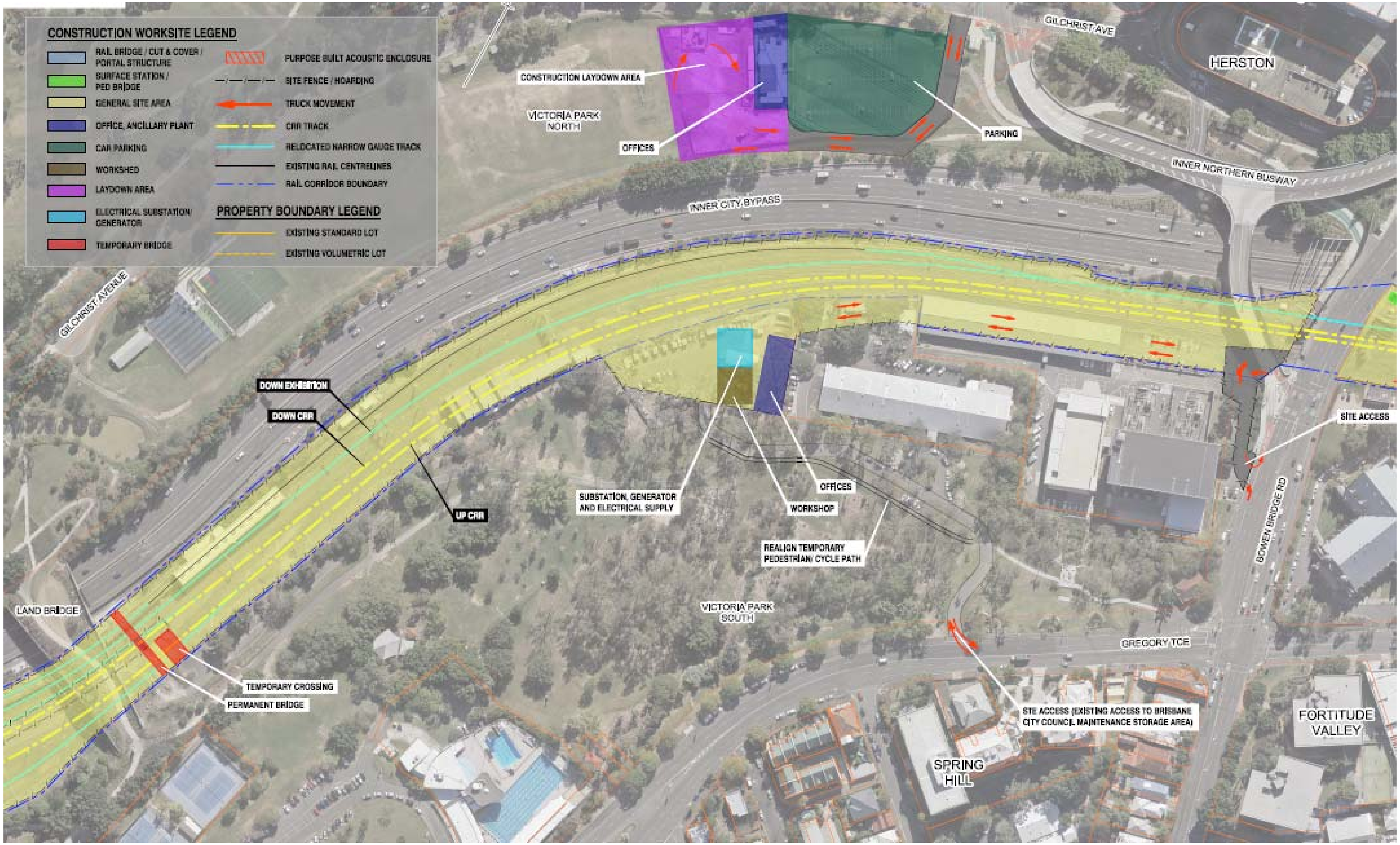


Figure 1.14 CRR 2016 Northern portal worksite

Exhibition Station and O'Connell Terrace construction worksites

Land to be utilised as construction worksites for CRR 2016 will be slightly smaller than CRR 2011. The site area on the corner of Sneyd Street and O'Connell Terrace, identified for CRR 2011, will not be required for CRR 2016 and areas for parking, workshop/storage will now be provided within the existing Royal National Agriculture and Industrial Association (RNA) showgrounds. The CRR 2011 and CRR 2016 construction worksites are illustrated in Figures 1.15 and 1.16.

Compared with CRR 2011, CRR 2016 will not require raising of the O'Connell Terrace bridge. This will further reduce disruptions to traffic along O'Connell Terrace during construction. CRR 2011 worksite access was located opposite Lanham Street along O'Connell Terrace, whereas construction traffic access for CRR 2016 will be predominately from O'Connell Terrace (near Bowen Park) with a minor access off Bowen Bridge Road.

Heavy vehicle movements to and from this worksite are forecast to peak at around four trucks per hour at peak haulage times. This is the same as the peak haulage movements forecast in CRR 2011, which found impacts on the surrounding road network including O'Connell Terrace and Bowen Bridge Road to be minor[18]. CRR 2016 will utilise the spoil routes described in Section 1.5.3 to transport spoil to placements sites.

For CRR 2016, access for construction worker parking will be off Lanham Street. Car parking space is generally consistent between CRR 2011 and CRR 2016.

Changes to worksite size and location will have minor impacts similar to those previously identified for CRR 2011 on truck access, parking, local access and emergency services access disruption. Therefore CRR 2016 is considered to be consistent with CRR 2011 at this location.

[18] Minor is defined as less than 5 seconds additional average intersection delay

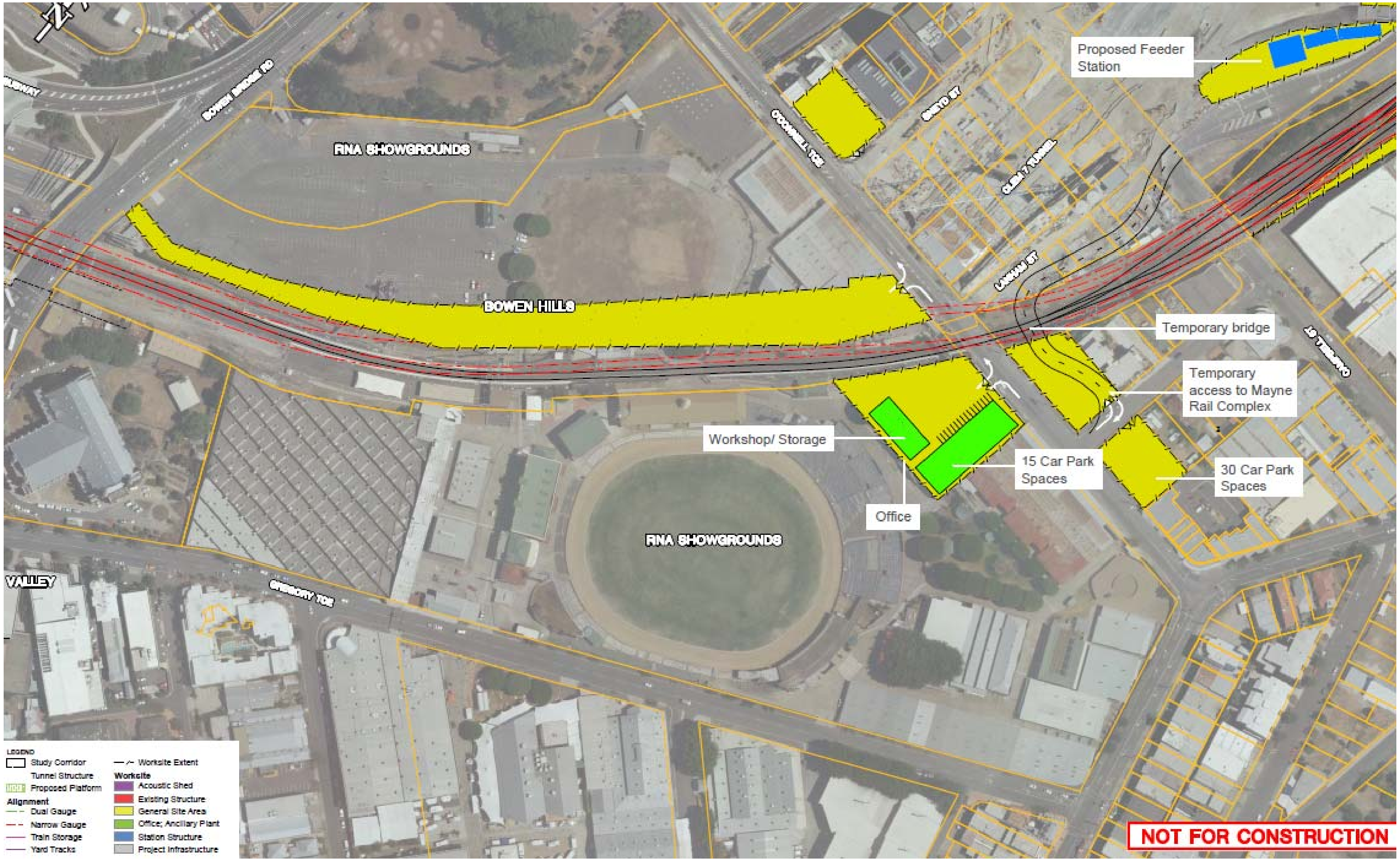


Figure 1.15 CRR 2011 Exhibition Station worksite

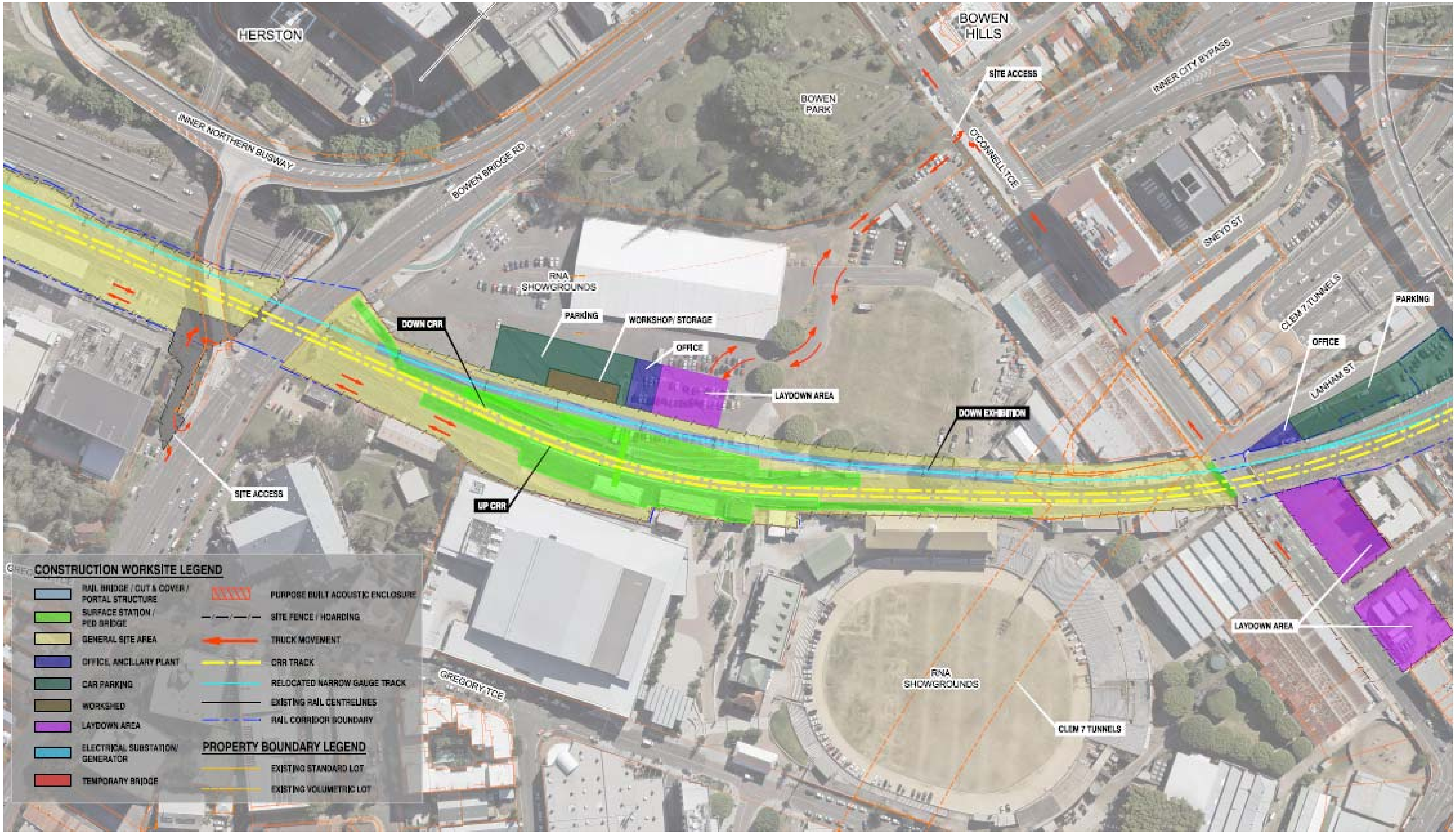


Figure 1.16 CRR 2016 Exhibition Station worksite

Mayne Yard construction worksite

The Mayne Yard construction worksite is similar to CRR 2011 and contained within the existing rail corridor. Site access would be off Abbotsford Road and O'Connell Terrace as shown in Figure 1.17. The main truck access to the worksite will be via Lanham Street/O'Connell Terrace.

Peak truck movements for CRR 2016 are estimated to be 8 trucks per hour including deliveries (6) and spoil disposal (2). This compares to 9 trucks per hour for deliveries for CRR 2011. This is due to the change in design from a viaduct (for CRR 2011) to an underpass construction (for CRR 2016). Heavy vehicle movements to and from this worksite for CRR 2016 are therefore forecast to be less than the peak haulage movement forecast for CRR 2011, which found impacts on the surrounding road network to be minor[19]. Spoil haulage routes for this worksite are further detailed in Section 1.5.3.

At the Mayne Yard worksite for CRR 2016, there are no new impacts on traffic staging, worksite parking, local and emergency services access. This is consistent with CRR 2011.

[19] Minor is defined as less than 5 seconds additional average intersection delay.

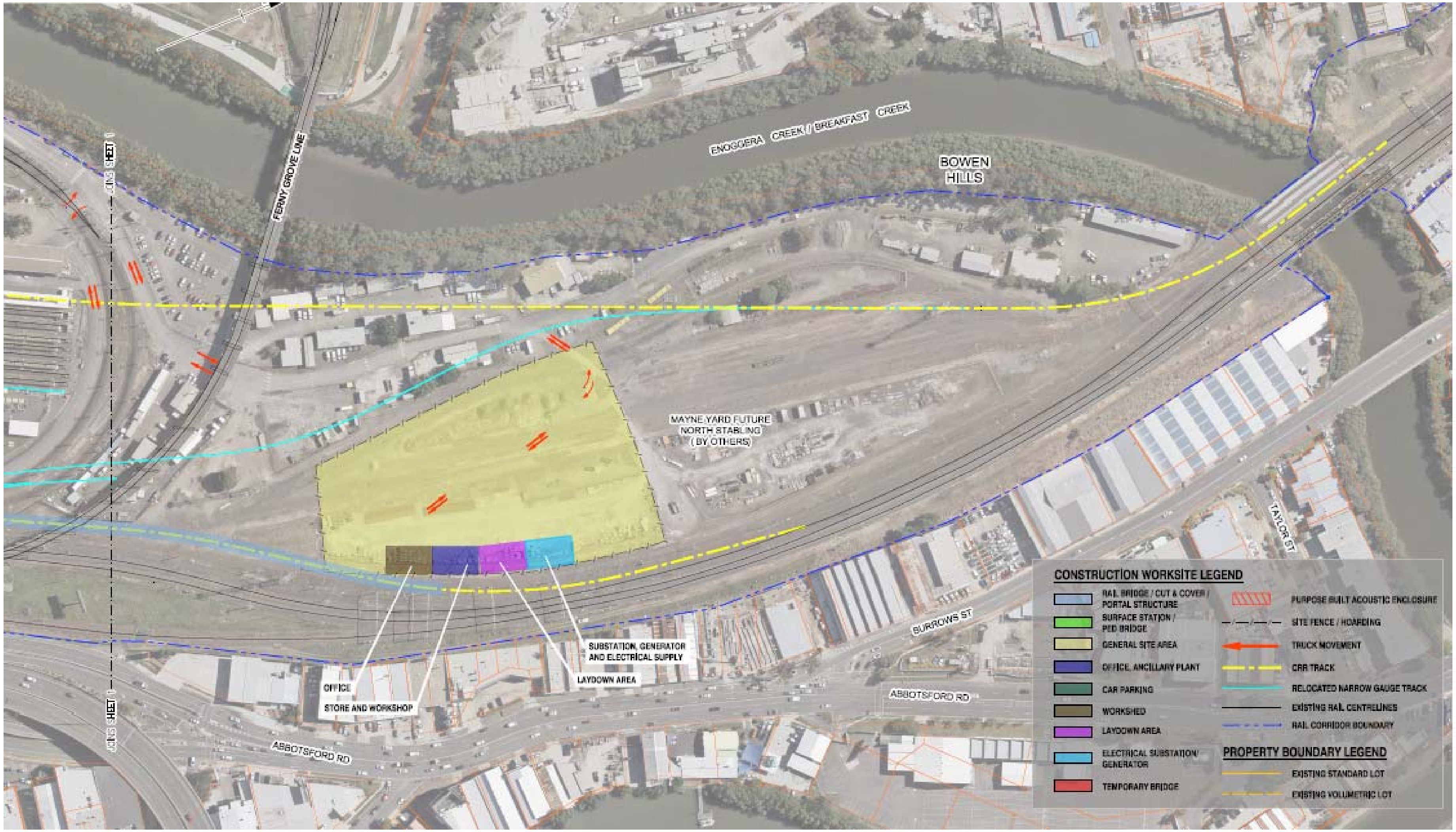


Figure 1.17 CRR 2016 Mayne Yard worksite

1.5.3 Construction traffic trip generated and traffic operation assessment

Overall, construction of CRR 2016 is expected to result in impacts to existing traffic conditions from additional construction vehicles using the road network, consistent with CRR 2011. As spoil from the tunnel and excavation activities is expected to be transported to the spoil placement sites by road, the additional heavy vehicle movements may change existing traffic conditions, however the impacts would not exceed those of CRR 2011.

Construction traffic generation

The total amount of spoil generated by CRR 2016 is less than CRR 2011 due to the shortened tunnel length. The estimated spoil quantities are compared in Table 1.13.

Table 1.13 Estimated spoil quantity comparison

Location	CRR 2011 spoil quantity (volume m^3)	CRR 2016 Spoil quantity (volume m^3)[20]
Southern portal	Yeerongpilly 375,000 + Ventilation shaft/building 11,500	Near Dutton Park Station – 39,000
Boggo Road Station	155,000	119,000
Woolloongabba Station	437,000	470,000
Albert Street Station	190,000	135,000
Roma Street Station	161,000	112,000
Northern portal	96,000	65,000
Mayne Yard	-	36,000
TOTAL	**1,400,000**	**976,000**

CRR 2016 spoil volumes and haulage rates were calculated using the same set of assumptions used to calculate the CRR 2011 volumes and haulage rates[21]. The peak daily spoil truck movements will generally be lower than CRR 2011 as shown in Table 1.14. The exception to this is Mayne Yard, which increases due to excavation of the underpass. In addition, the daily peak spoil movements at Woolloongabba Station are lower due to the revised sequencing of construction activities, which will involve extraction of spoil from the mined tunnel followed by the bored tunnel. Overall this means that the peak spoil movements are less as these activities do not overlap

Peak daily delivery vehicle demands are also compared in Table 1.14. Delivery vehicle demands for CRR 2016 and CRR 2011 are assumed to be similar, except for Mayne Yard, which is reduced due to a change in scope from a viaduct to an underpass construction.

Note that demolition waste truck movement haulage is not included in Table 1.14. For both CRR 2011 and CRR 2016 it is assumed that demolition will only be for a relatively short period and the frequency of truck movements are expected not to exceed that of the excavation stage.

Peak hourly total truck movements for CRR 2011 and CRR 2016 are compared in Table 1.15. For all worksites, the peak generated by the construction are forecast to be lower than CRR

[20] The same assumptions identified in the CRR 2011 EIS have been adopted here with reference to a 1.5 bulk factor.
[21] CRR 2011 assumptions include: spoil volume being based on in-situ volumes, spoil haulage rates relating to one-way trips, estimated density of in-situ material at 2.4 tonnes/m^3, peak rates multiplied at 2.5, spoil haulage undertaken 7 days/week and truck capacity at 30 tonnes/truck.

2011. Given this assessment, the overall impacts of CRR 2016 from construction traffic trips are expected to be reduced compared to CRR 2011.

Table 1.14 Comparison of peak daily spoil and delivery trip generation from each worksite (one way movements)

Construction worksites	**Peak spoil movements (trucks/day)**		**Peak delivery (trucks/day)**	
	CRR 2011	**CRR 2016**	**CRR 2011**	**CRR 2016**[22]
Core (tunnel worksites)				
Southern portal	214	12	57	20
Ventilation & Emergency Access (Fairfield)	29	n/a	8	n/a
Boggo Road	89	46	24	24
Woolloongabba	214	142	57	57
Albert Street	80	32	21	21
Roma Street	103	39	27	27
Northern portal	75	31	20	20
Non-core (surface worksites)				
Clapham Yard	-	-	143	-
Mayne Yard	-	20	143	100
Exhibition	-	-	60	60

Table 1.15 Peak total hourly trip generation from each worksite (one way movements)

Construction worksites	**Peak total (trucks/hour)**	
	CRR 2011	**CRR 2016**
Core (tunnel worksites)		
Southern portal	15	3
Ventilation & Emergency Access	3	n/a
Boggo Road	9	6
Woolloongabba	14	11
Albert Street	8	5
Roma Street	10	6
Northern portal	8	5
Non-core (surface worksites)		
Clapham Rail Yard	9	n/a
Mayne Yard	9	8
Exhibition	4	4

Spoil placement sites and haulage routes

[22] Assumed to be similar to CRR 2011, except at Mayne Yard which was reduced due to a change in scope (viaduct to underpass construction)

There are five potential spoil placement sites proposed for CRR 2016 compared to one for CRR 2011. The five sites for CRR 2016 include:

- Brisbane Airport (Lomandra Drive & Sugarmill Road);
- Swanbank, Swanbank Road;
- Pine Mountain, Pine Mountain Road;
- Larapinta, Paradise Road; and
- Port of Brisbane, Port Drive.

These five spoil placement sites are based on general availability, size of the land, retaining environmental values, haul route length and proximity to sensitive receptors. Although five sites are now proposed for CRR 2016, not all sites will be used during construction. Contingency is provided in the event that commercial or environmental reasons require future adjustment. The construction contractor will have firmer details as to the quantity of spoil, its rate of excavation or production, and how it will be placed at any of the nominated spoil placement sites.

Based on previous assessment[23], the preferred spoil placement sites for CRR 2016 are Brisbane Airport, Swanbank and Pine Mountain (Mount Gravatt) with Larapinta and Port of Brisbane used as alternative sites, should the other sites be unavailable. The general haulage routes for the CRR 2016 preferred spoil sites and back up sites are listed below and illustrated in Figures 1.18 to 1.22.

Primary spoil sites haulage routes:

- Brisbane Airport site - the proposed spoil truck routes vary depending on the origin worksite but would generally make use of CLEM7, Airport Link, East-West Arterial Road, Airport Drive, Lomandra Drive and Sugarmill Road;
- Swanbank site - Spoil haulage from the worksites will be primarily via Ipswich Road and Ipswich Motorway for worksites south of the Brisbane River or via ICB, Milton Road/Legacy Way, Western Freeway and Centenary Highway for worksites north. Both routes will continue on to Ipswich Motorway, Cunningham Highway and Swanbank Road;
- Pine Mountain site - Spoil haulage from the construction worksites to the Pine Mountain Quarry site will be as follows:
  - Southern portal, Boggo Road and Woolloongabba worksites are via Ipswich Road, O'Keefe Street, Old Cleveland Road, Creek Road and Pine Mountain Road; and
  - North of the Brisbane River worksites are via ICB, Hale St, Riverside Expressway, Vulture Street, Ipswich Road, O'Keefe St, Old Cleveland Road, Creek Road and Pine Mountain Road.

Alternative spoil sites haulage routes:

- Larapinta site - Spoil haulage from the construction worksites to the Larapinta site will be as follows:
  - ICB, Legacy Way, Western Freeway, Centenary Highway, Centenary Highway and Logan Motorway; and
  - Pacific Motorway, Logan Road, Gateway Motorway and Logan Motorway.
- Port of Brisbane - Spoil haulage from the construction worksites to the Port of Brisbane site will be as follows:

[23] Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Chapter 4.

- Ipswich Road, O'Keefe Street, Old Cleveland Road, Gateway Motorway and Port of Brisbane Motorway; and
- Riverside Expressway, Vulture Street, Wellington Road, Wynnum Road, Lytton Road and Port of Brisbane Motorway.

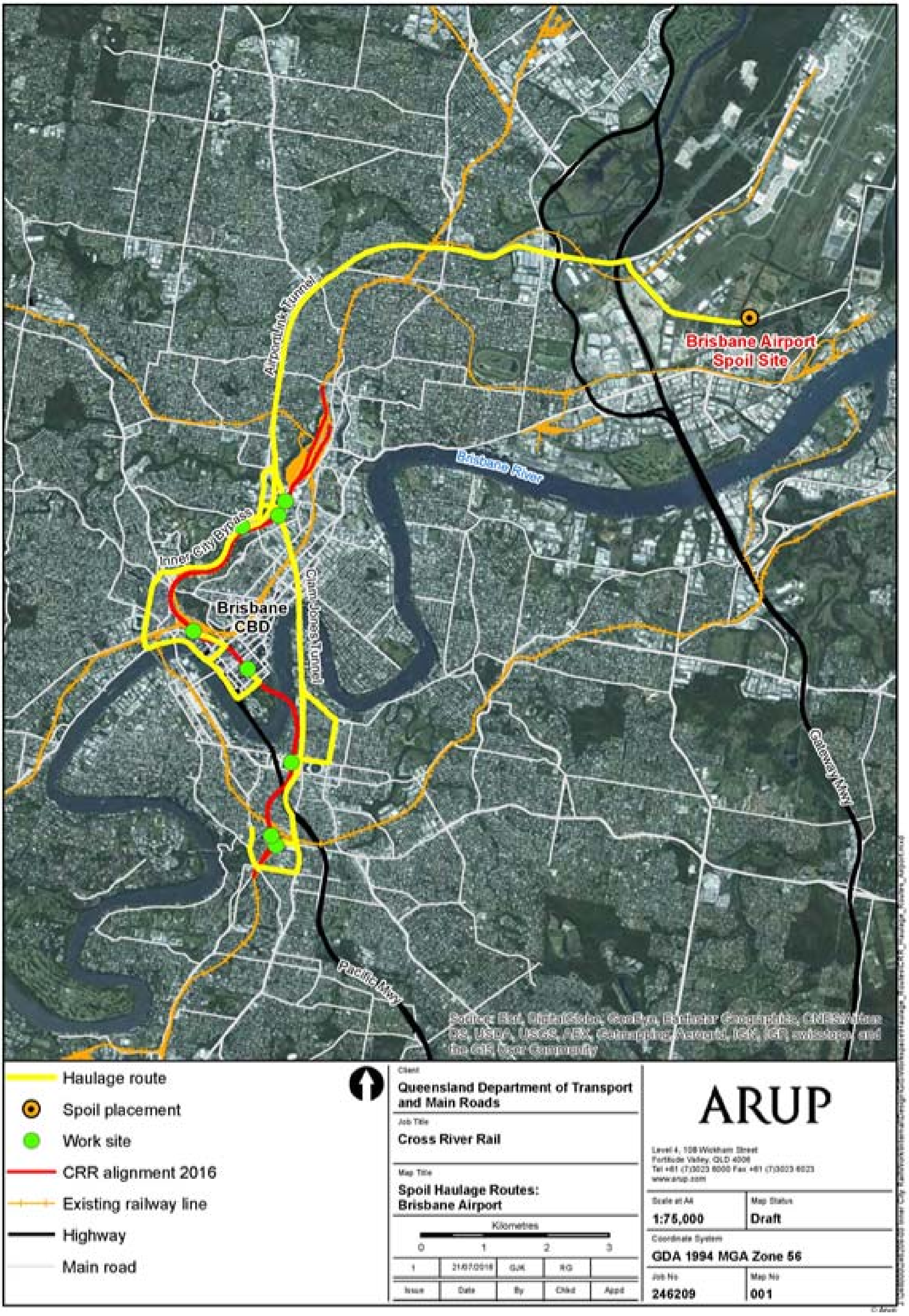


Figure 1.18 Brisbane Airport spoil haulage route

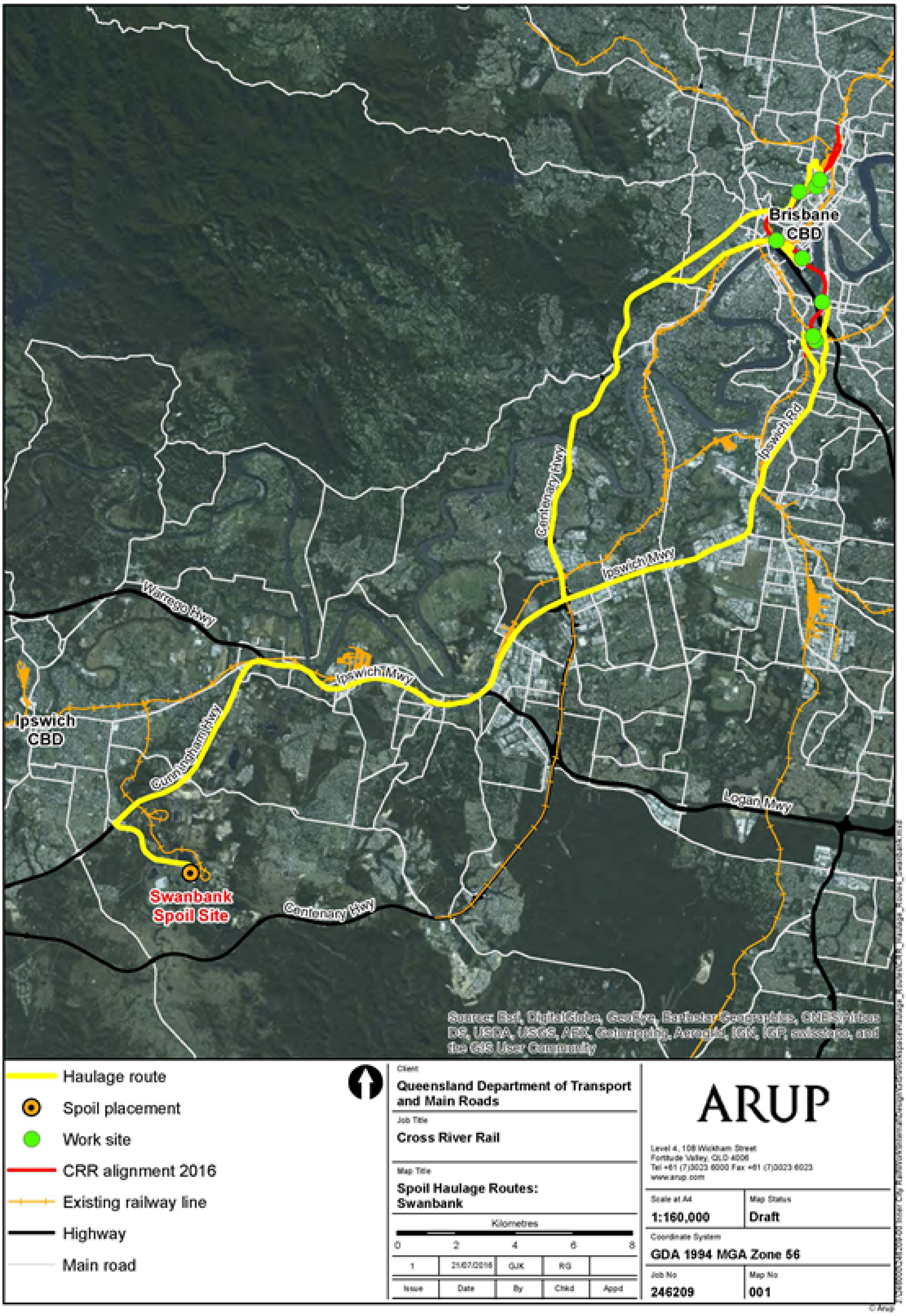


Figure 1.19 Swanbank site spoil haulage route

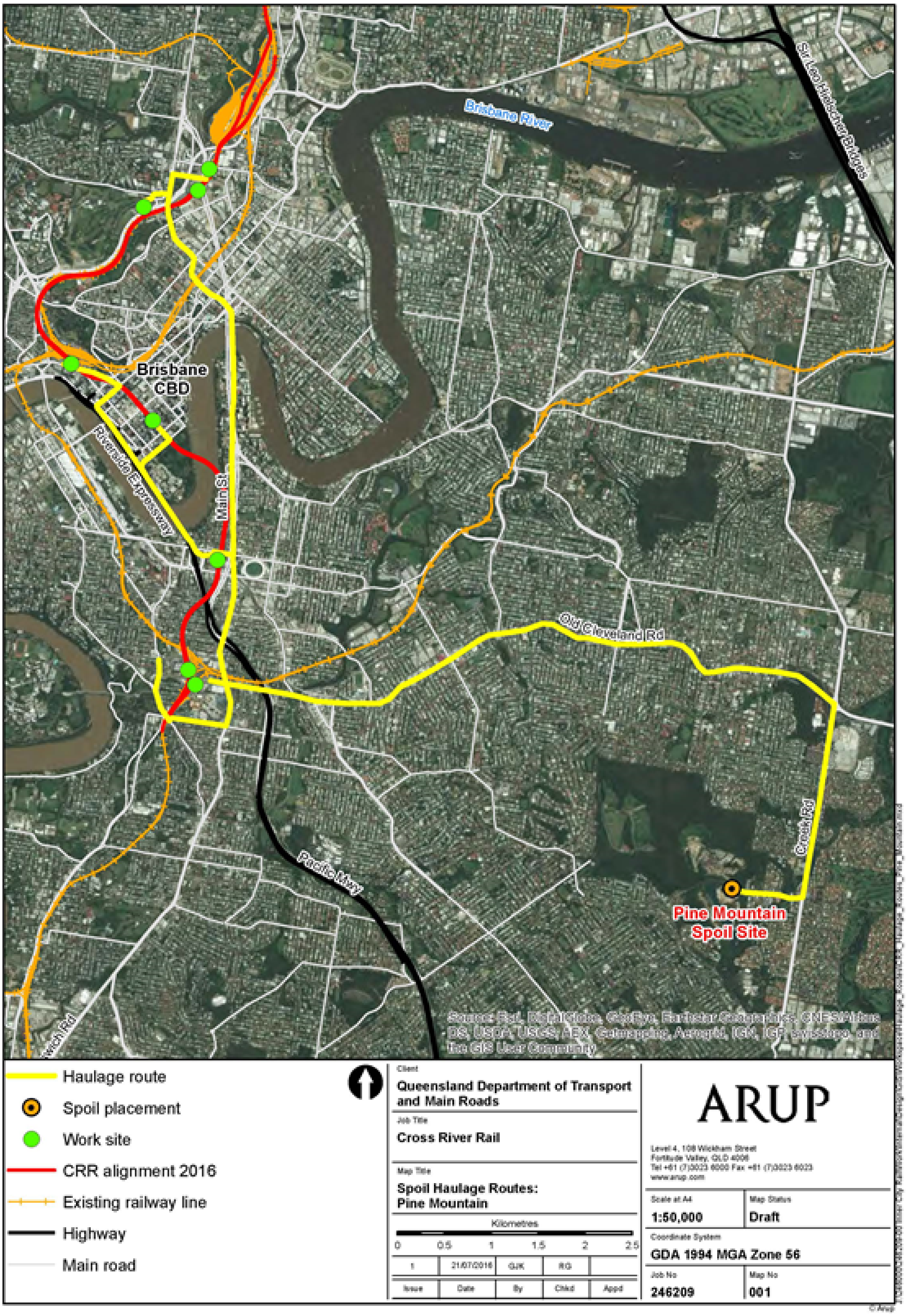


Figure 1.20 Pine Mountain site spoil haulage route

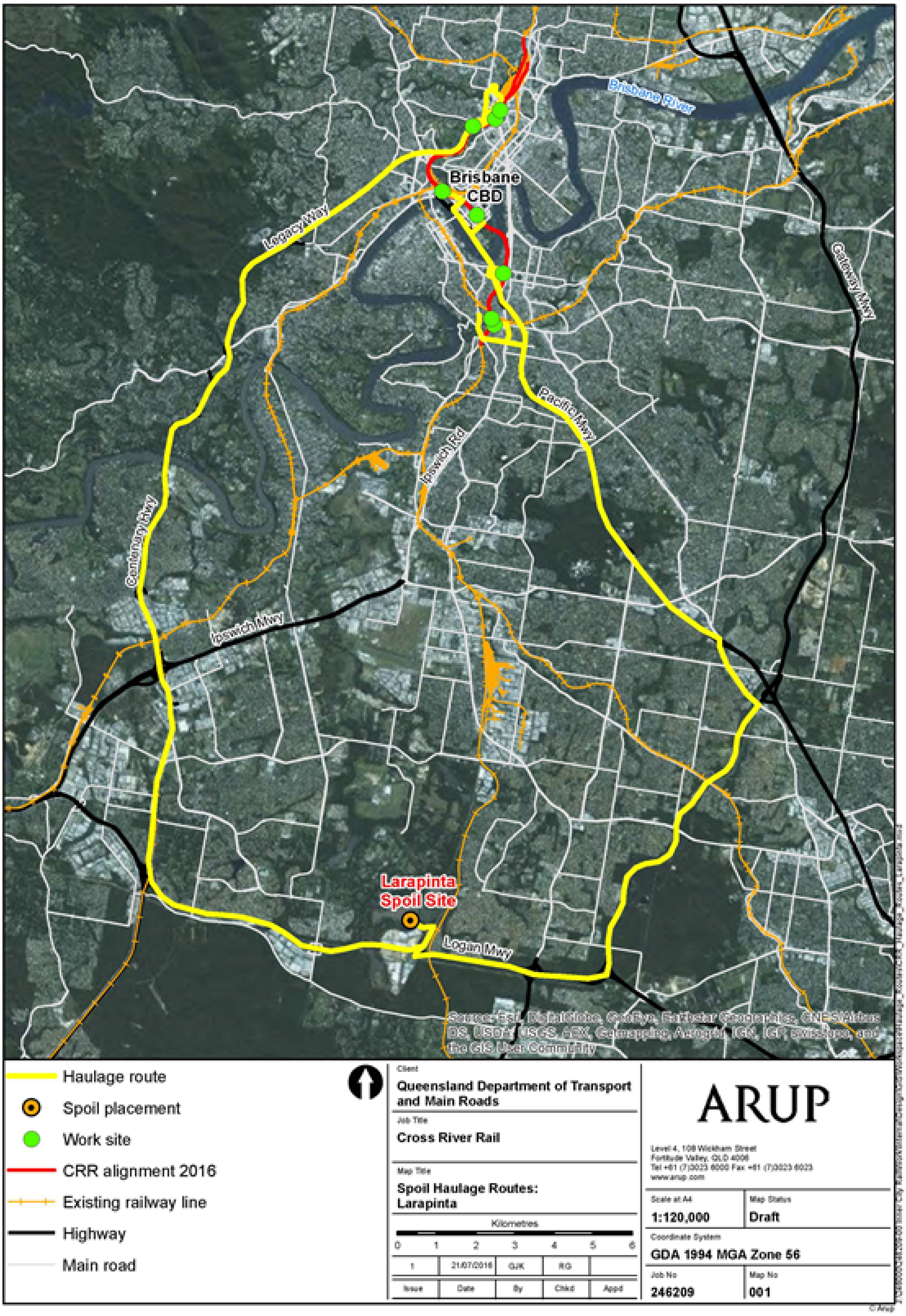


Figure 1.21 Larapinta site spoil haulage routes

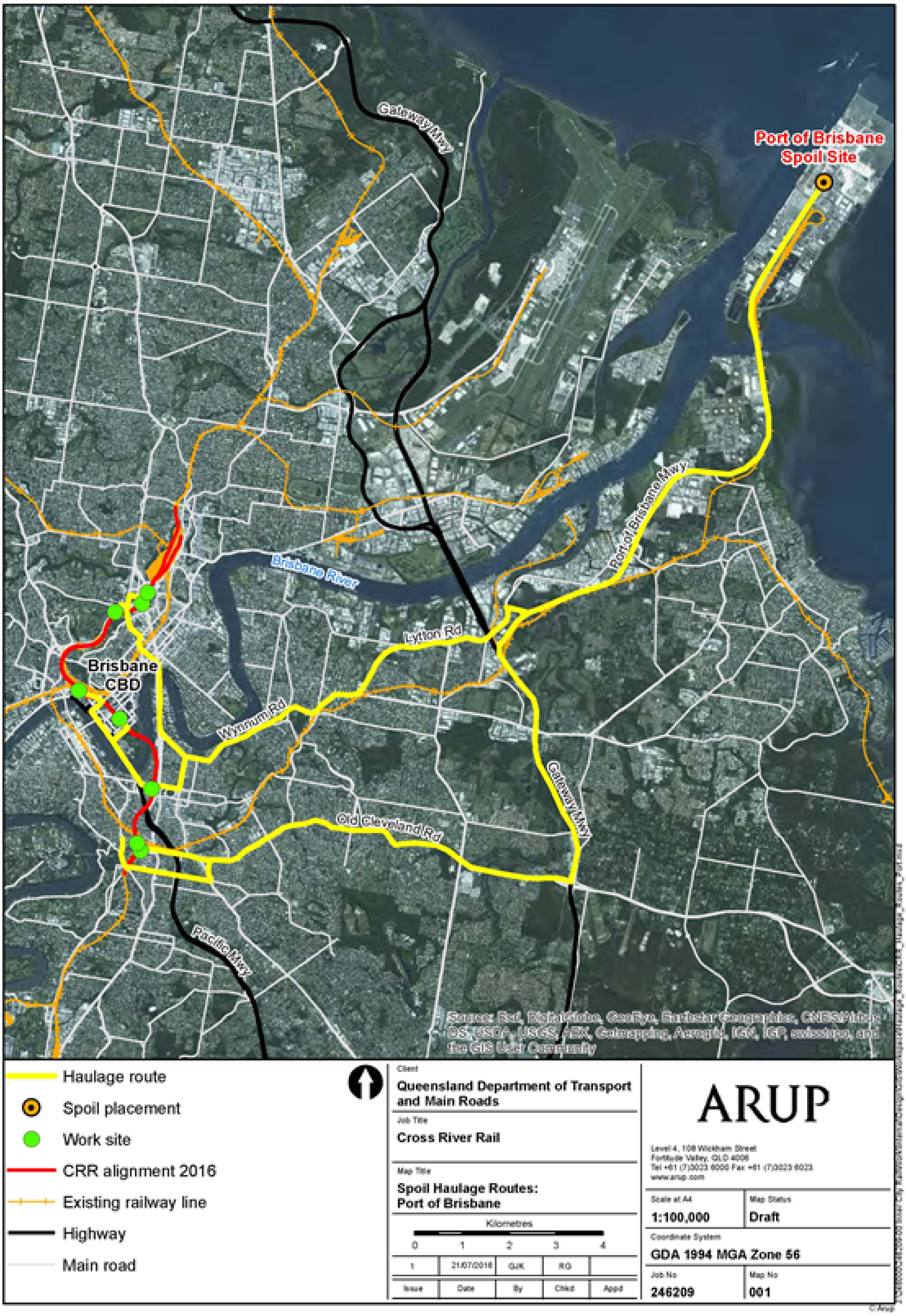


Figure 1.22 Port of Brisbane spoil haulage routes

Haulage routes intersection analysis

For the CRR 2011 project, the worst case scenario assumed existing peak hour traffic plus the peak rate of haulage movements with all worksites operating at full capacity concurrently accessing the Swanbank spoil placement site. An intersection analysis was undertaken for CRR 2011 by examining all intersections along the haul route to determine critical intersections. Twelve intersections were identified and detailed intersection analysis completed. Where the average intersection delay increase was unacceptable (greater than 5 seconds), mitigation measures were recommended.

For CRR 2016, the assessment was based on previous technical investigation for the BaT project, which adopted the same five spoil sites. The assessment analysed the haul routes of the three preferred spoil placement sites (Brisbane Airport, Swanbank and Pine Mountain) using cumulative volumes to test whether all of the spoil could be delivered to any one site. Given that the total peak hourly trip generation for CRR 2016 is lower than CRR 2011 and the BaT project, it is estimated that construction traffic impacts will also be reduced.

1.6 Changes to mitigation measures

1.6.1 Rail corridor mitigation measures

Mitigation measures which are consistent with CRR 2011 include the following:

- Construction works in the rail corridor will need to be staged into manageable, safe and reliable increments acceptable to QR. QR will need to be consulted to plan and agree the operational interfaces between the new and existing rail infrastructure during the planning, demolition and construction phases. Some of the surface rail works will be carried out through rail shutdowns and track possessions conforming to QR policies;
- Bus replacement services are to be provided where passenger rail operations are interrupted, such as during rail network shutdown periods or temporary closures of stations;
- Disruption to rail passenger services is to be avoided to the extent reasonable and practicable during major events, such as the Ekka (Exhibition Station), and Suncorp Stadium (Roma Street Station). Where disruptions are unavoidable, bus shuttle services are provided between appropriate stations to the major event venues, or to bypass the disrupted section in the network;
- Rail network shutdowns are to be agreed with QR through the Scheduled Closure Access System, prior to the commencement of works within the rail corridor, to minimise disruption to the rail network;
- Early and on-going notification is to be provided to QR, TransLink, rail passengers, rail freight operators and local communities of the timing and duration of rail shutdowns, likely disruptions to rail services and alternative arrangements to be implemented;
- Pedestrian access for QR staff between Mayne Yard and Bowen Hills Station is to be maintained;
- Road access to and within Mayne Yard is maintained during construction works; and
- To the extent reasonable and practicable, existing access to the rail corridor for maintenance and emergency service vehicles is to be maintained. Where necessary, alternative access arrangements are to be provided in consultation with QR and other rail operators.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to:

- Disruption to rail passenger services for the Brisbane International tennis tournament (Yeerongpilly Station);
- Bus replacement services will not be needed for Yeerongpilly, Moorooka, Rocklea and Salisbury Stations; and
- To provide temporary alternative passenger facilities including toilets at Roma Street and baggage handling facility at Roma Street where disrupted for the duration of construction works.

1.6.2 Road network mitigation measures

Mitigation measures which are consistent with CRR 2011 include the following:

- Each construction worksite for CRR 2016 will have a Construction Traffic Management Plan (CTMP) prepared to implement measures that avoid where practicable, or minimise traffic problems arising during the construction phase. Prior to implementation of the CTMP this will be subject to agreement by the relevant agencies (i.e. BCC, Transport and Main Roads (TMR), Queensland Police Service, etc.);
- Local communities and road users are to be notified of proposed changes to local traffic access arising from Project works. This includes, but is not limited to, the provision of clear signage identifying changed traffic conditions, and public advertisements (local and regional newspapers, Project website) describing the proposed changes, the duration of the changes, and possible alternative routes to avoid the impacts of the proposed changes;
- Temporary disruption to Inner Northern Busway adjacent to Roma Street Station and the Eastern Busway adjacent to Boggo Road Station and adjacent to Woolloongabba Busway Station will be managed in consultation with TransLink and BCC.
- Project works in or near road corridors are to be screened with solid barriers to minimise distractions for motorists;
- Access to properties adjoining or near to the Project is to be maintained. Where changes to property access are required, alternative access arrangements are to be identified in consultation with property owners and occupants;
- Access for delivery vehicles to local businesses near the Project is to be maintained. Where changes to access for delivery vehicles are required, alternative access arrangements are to be identified in consultation with local businesses. In particular, access for delivery vehicles is to be maintained to businesses, where possible, at:
  - O’Connell Terrace, Bowen Hills;
  - Roma, Charlotte and Mary Streets in the Brisbane CBD;
  - Stanley and Vulture Streets at Woolloongabba; and
  - Boggo Road Urban Village off Annerley Road, Dutton Park.
- Access for emergency services vehicles is to be maintained for the duration of construction works to:
  - Royal Brisbane Women’s Hospital (RBWH) via O’Connell Terrace;
  - PA Hospital, via Cornwall Street; and
  - Mater Hospital, via Stanley Street.
- Safe and functional access for pedestrians and cyclists is to be maintained near the Project, including for the elderly, children and people with mobility difficulties including vision and

hearing impairments. This measure is to consider relevant Crime Prevention through Environmental Design (CPTED) principles;

- Safe and functional pedestrian and cycle access is to be maintained to public transport facilities near Project works. This measure will address the needs of children, elderly and people with mobility difficulties including vision and hearing impairments;
- Safe pedestrian and cycle access is to be maintained near construction works to community facilities, such as schools, child care facilities, churches, aged care accommodation, open space, sport and recreation, health care and shopping facilities. This is to consider the particular needs of children, elderly and people with mobility difficulties, including vision and hearing impairments;
- In areas of high pedestrian and cycle activity such as Albert Street worksites, articulated or truck and trailer vehicles could present a hazard to road users, due to the manoeuvring paths and vehicles tracking across kerbs at intersections, as well as road users failing to observe the trailer component of the vehicle when crossing the road. CTMPs for these locations should limit use of dog trailers;
- The design of driveways for the Project will take into consideration the potential for truck/pedestrian conflicts and the design of road narrowing will take into consideration cycle safety; and
- Where pedestrian and cycle access to community facilities is changed, local access strategies are to be developed in consultation with local communities, community facility managers and relevant stakeholder groups, including Vision Australia.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to:

- Access for delivery vehicles to local business no longer required for:
  - The industrial area between Ipswich Road and Moolabin Creek at Moorooka; and
  - The area between Fairfield Road and Clapham Rail Yard, Yeerongpilly.
- Two lanes of traffic are to be retained in each direction on Fairfield Road during peak periods.

Additional mitigation measures now relevant to CRR 2016 include:

- Inbound bus stops along Roma Street in front of BTC West Tower will need to be temporarily relocated in coordination with TransLink during the demolition works on the tower and coach ramps;
- Safe, alternative access is to be provided for bikeways disturbed by construction works, including but not limited to the bikeway in the southern area of the Northern portal worksite in Victoria Park and the bikeway along Kent Street, Dutton Park and the PA Hospital bikeway; and
- Cycle facilities including CityCycle stations in front of the BTC West Tower and at the corner of Albert and Mary Streets will need to be relocated in coordination with BCC during the construction stage of CRR 2016.

1.6.3 Local operational traffic, pedestrian and cycle mitigation measures

Additional mitigation measures now relevant to CRR 2016 include:

- Providing taxi bays and passenger loading bays on Joe Baker Street at Boggo Road Station;
- Providing pedestrian facilities connecting Boggo Road Station to the PA Hospital and Boggo Road Urban Village;
- The existing Myer Centre car park exit on Albert Street between Elizabeth Street and Charlotte Street will be closed or, if required, relocated to Charlotte Street between Albert Street and George Street in consultation with the relevant stakeholders;
- In consultation with the BCC, upgrade the intersection of George Street and Elizabeth Street to accommodate additional right turning traffic rerouting from Albert Street;
- Further investigation will be undertaken, in consultation with the operators, to find a suitable site for the existing long distance coach terminal at Roma Street. The terminal will be relocated prior to demolition; and
- Reconfiguration of the George Street and Roma Street intersection and upgrade of the pedestrian crossing facilities at Roma Street Station including at the Makerston Street and Roma Street intersection. Detailed design will be carried out in consultation with BCC and consider:
  - Pedestrian demands due to the Project and other developments in the precinct;
  - Traffic operations including bus services, kerb side activity and property access; and
  - Impact on existing trees.

1.7 Conclusion

Overall, there is a general reduction in forecast passenger and freight train numbers for CRR 2016 compared to CRR 2011 as a result of changes to forecast passenger and freight demand. Changes to bus and ferry patronage, as well as road network performance, are generally consistent with those of CRR 2011. No material difference in the performance of the regional road network are expected as a result of CRR.

There is a general reduction in local operational impacts for CRR 2016 compared to CRR 2011. Local road reconfigurations and impacts south of Dutton Park Station have been removed resulting in reduced overall operational transport impacts. Of the four new underground stations, Albert Street and Roma Street will have different local traffic impacts as a result of their new station locations compared to CRR 2011. For these stations, new mitigation measures are identified to address and minimise adverse local operational traffic, pedestrian and cycle impacts.

The construction transport impacts for CRR 2016 are of the same order as those identified for CRR 2011. The general reduction in spoil generated from tunnelling will result in reduced construction traffic impacts compared with CRR 2011.

Where additional impacts have been identified, appropriate mitigation measures have been proposed. Specifically, each construction worksite for CRR 2016 will have an updated CTMP prepared to avoid, where practicable, or minimise traffic impacts arising during the construction phase, similar to CRR 2011.

Refer to Volume 2 for the Draft Outline Environmental Management Plan (EMP) which identifies the mitigation measures proposed to prevent and manage environmental impacts associated with this Project.

Appendix A

Traffic impact analysis of Albert Street Closure

A1 Traffic impact analysis of Albert Street closure

Traffic impact of Albert Street closure

As part of the CRR 2016 Albert Street Station, Albert Street is proposed to be closed and pedestrianisation between Mary Street and Charlotte Street and pedestrianised between Charlotte and Elizabeth Street with some local traffic access. If required, the existing Myer car park exit at Albert Street between Elizabeth Street and Charlotte Street may be relocated to Charlotte Street between Albert Street and George Street. As a result, it is anticipated there would be changes to vehicle access and circulation. Currently there is no bus service operating on this road section, and therefore no impact to bus operations is anticipated.

Traffic circulation changes

The closure of Albert Street (between Mary Street and Elizabeth Street) will result in a redistribution of traffic to other parts of the CBD network. Traffic redistribution is confined to local traffic accessing CBD establishments and does not impact the Riverside Expressway.

For the purpose of this study, assumptions were made to understand the current routes of the potentially impacted traffic and the likely detour routes after the road closure. Based on the observed turning proportions from existing traffic count undertaken on 27th April 2016, it was assumed that 90% of the Myer car park exit traffic will head south via George Street/ Alice Street intersection and the other 10% will head west via George Street / Elizabeth Street intersection. There will be no traffic heading north as traffic can utilise the Elizabeth Street car park exit. The changes to traffic routes for the current southbound traffic on Albert Street is illustrated in Figure A-1. The solid lines indicate the current routes and the dash lines indicate the likely detour routes. In order to model the worst case scenario, it assumes traffic will travel through the network and not park.

The current northbound traffic on Albert Street is composed of left turn traffic from Mary Street west, through traffic from Albert Street south and right turn traffic from Mary Street east. The through traffic from Albert Street south is composed of the total traffic flow with around 60% share.

This assumes 100% of traffic from Mary Street turns left and 50% of traffic from Albert Street through and Mary Street turn right and will head north via Elizabeth Street / Albert Street. The majority of the remaining traffic (48%) will head west via George Street / Elizabeth Street, and a minor proportion (2%) will access Myer car park via Elizabeth Street / Albert Street. Figure A-2 illustrates the current routes as well as the likely detour routes.

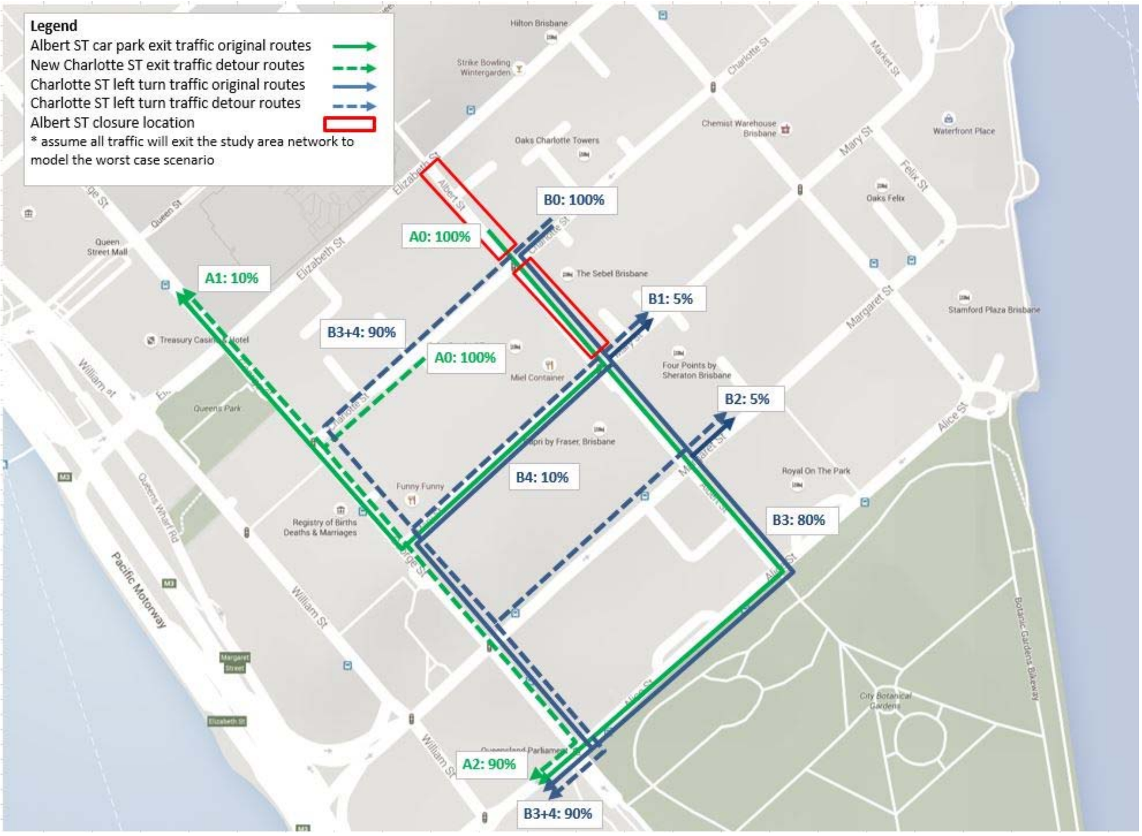


Figure A-1 Changes to traffic circulation routes for southbound traffic on Albert Street

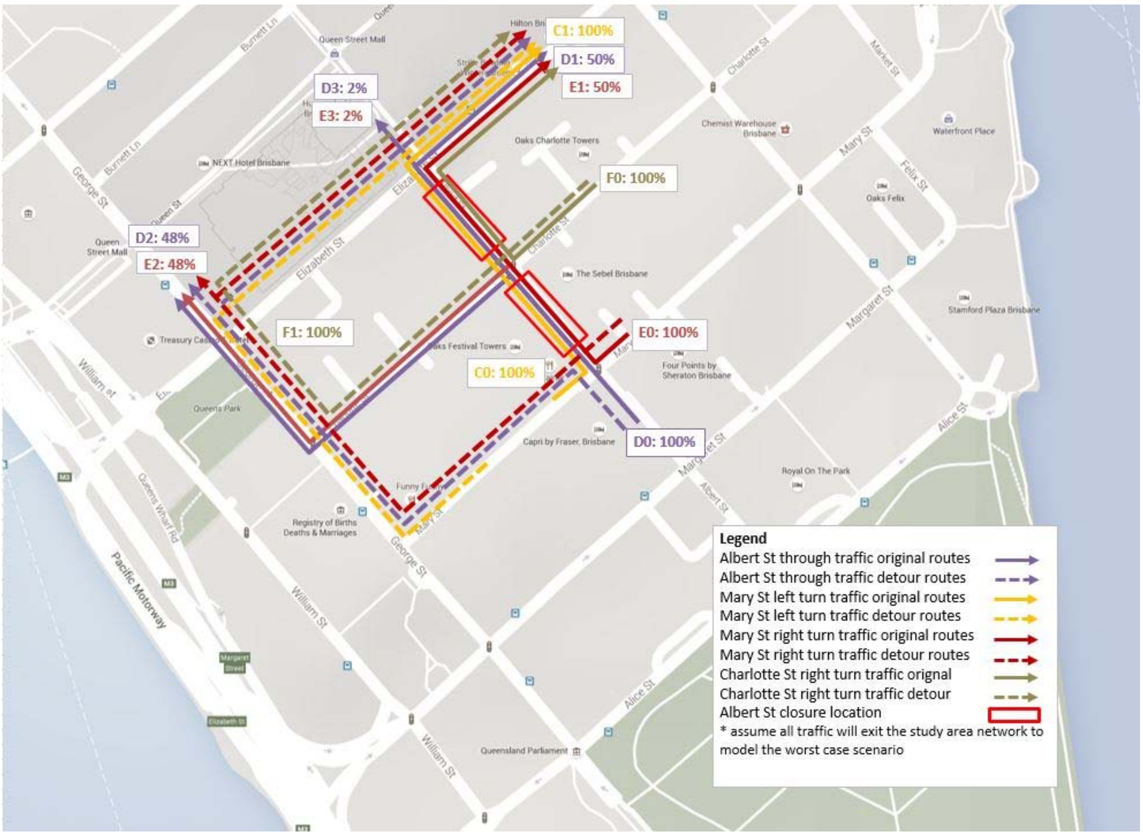


Figure A-2 Changes to traffic circulation routes for northbound traffic on Albert Street

Intersection turning counts

Intersection turning counts have been undertaken at 7.30am - 9:30am and 4.00pm – 6.30pm on 27th April, 2016. The counts differentiate vehicle types in light vehicles, heavy vehicles and buses. Pedestrian volumes at each intersection were also recorded for Signalised and un-signalised Intersection Design and Research Aid (SIDRA) modelling inputs. Based on the overall traffic counts, it indicates the AM peak hour is between 8.00am and 9.00 am and the PM peak hour is between 5.00pm and 6.00pm. The peak hour volumes have been input into SIDRA for the 2016 existing year model.

Future year traffic growth rates

The proposed opening year for CRR 2016 is 2023. The design horizon year will therefore be 2033, 10 years after the opening.

CRR 2016 strategic transport model results have been utilised to calculate future year traffic growth in the CBD in order to estimate the future year traffic demand in SIDRA. Table A-1 summarises the peak period car volumes into the CBD at different modelled years from the strategic model.

Table A-1 Peak period car volumes into Brisbane CBD

Model Year	Peak period car volume*	Compounding growth to previous year modelled
2015	40,000	-
2021	41,500	0.62%
2026	43,000	0.71%
2036	42,900	-0.02%

*CRR 2016 Transport Model

Based on values in the above table, there is a compounding growth rate of 0.64% between 2016 and 2023, and 0.38% between 2016 and 2033. These growth rates have been applied in the SIDRA model to test the future year intersection performance. It is noted the traffic growth in the CBD is low which is due to network congestion and car parking constraints.

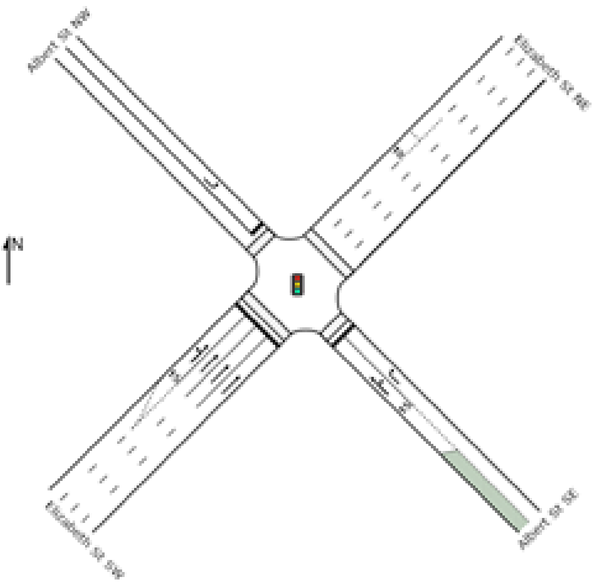
SIDRA results

Intersection analysis has been undertaken using SIDRA 6.1 to assess the traffic impacts of closure of Albert Street.

The intersection layouts of Albert Street / Elizabeth Street, Albert Street / Charlotte Street and Albert Street / Mary Street will be changed due to the proposed road closure. A comparison of intersection layouts for with and without road closure scenarios is shown in Figure’s A-3, A-4 and A-5. Layouts of all the other tested intersections were initially assumed to be maintained as per the existing layout.

The signal cycle time was obtained from BCC website’s real time signal information. It is observed that all of the studied intersections have a similar signal cycle time around 90 seconds with 3 seconds plus / minus. To simplify the modelling process, 90 seconds cycle time has been applied at all intersections. The adaptive signal phase strategy has also been applied in SIDRA to mimic the signal self-optimisation due to the implementation of SCATS system.

The SIDRA model results are summarised in Table A-2 and Table A-3 for the AM and PM peak respectively.



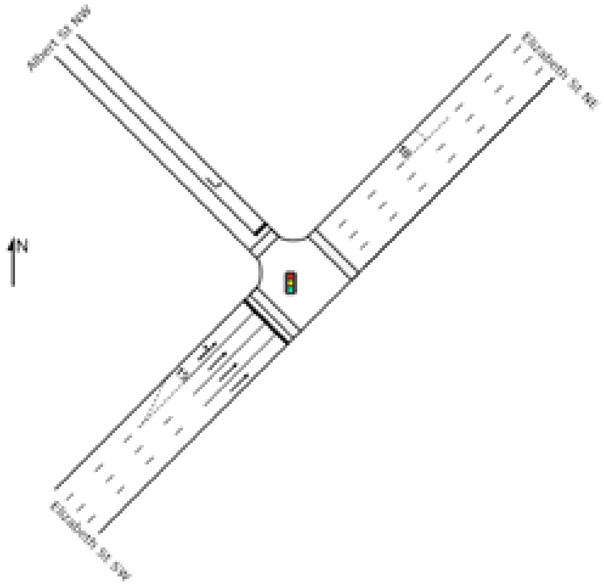
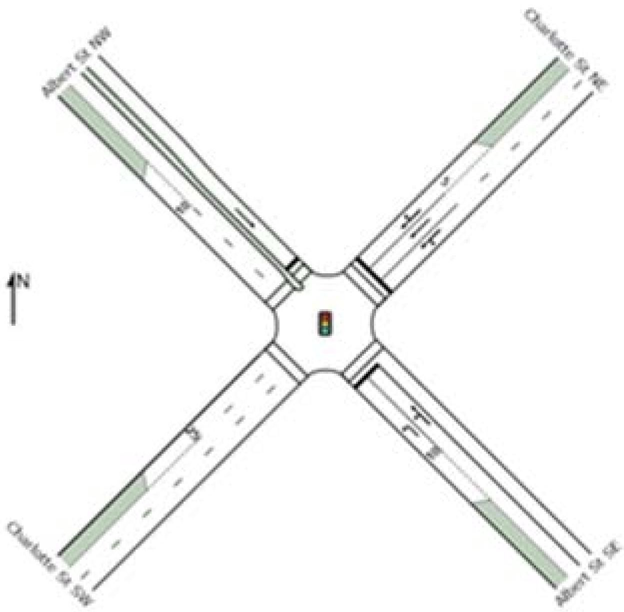


Figure A-3 Intersection layout comparison of Albert and Elizabeth Streets with & without Albert Street closure



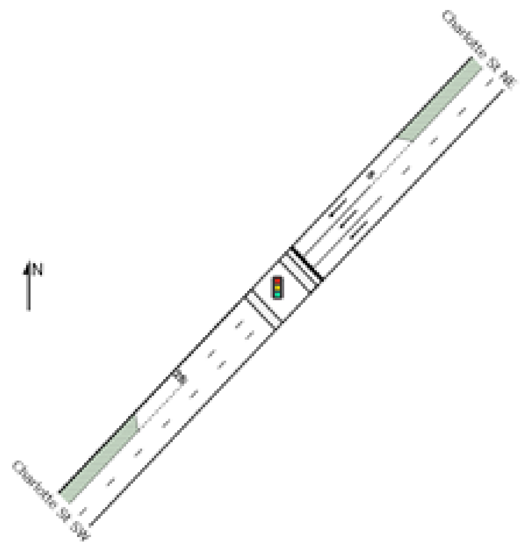


Figure A-4 Intersection layout comparison of Albert and Charlotte Streets with & without Albert Street closure

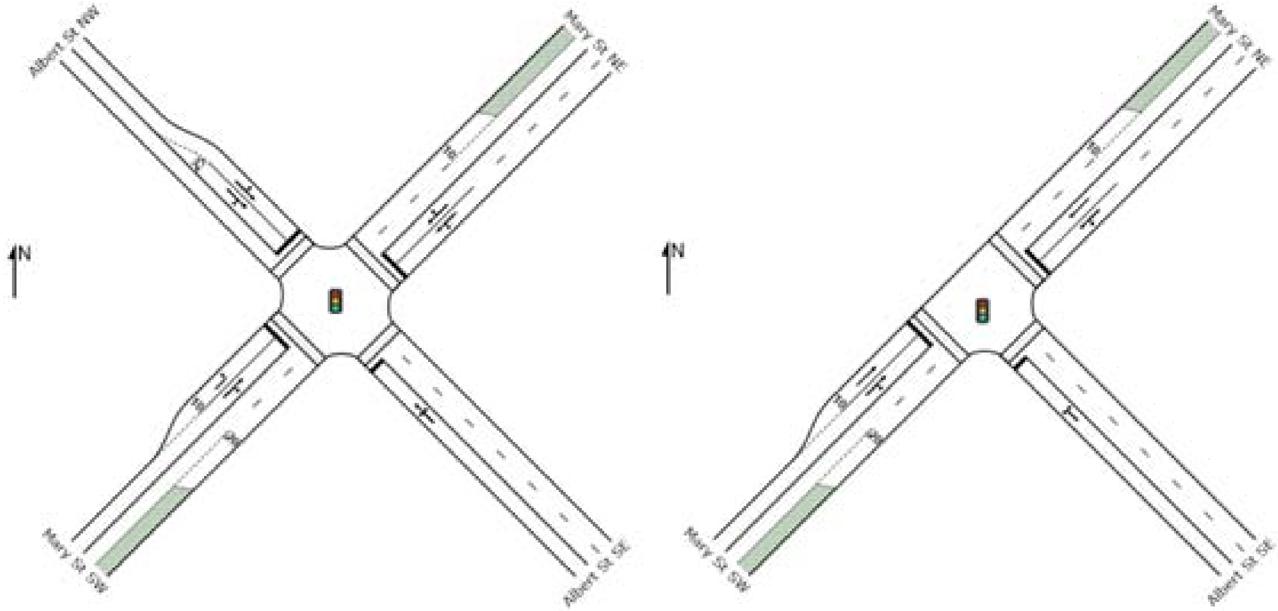


Figure A-5 Intersection layout comparison of Albert and Mary Streets with & without Albert Street closure

Table A-2 AM peak intersection performance with & without Albert Street closure (without mitigation)

Site Name	**2016 Existing**		**2023 No closure**		**2023 with Closure**		**2023 No closure**		**2033 with Closure**	
	DOS	LOS	DOS	LOS	DOS	LOS	DOS	LOS	DOS	LOS
George Street – Elizabeth Street	0.71	C	0.75	C	1.57	F	0.77	C	1.6	F
George Street – Charlotte Street	0.38	A	0.42	A	0.49	A	0.43	A	0.52	A
George Street – Mary Street	0.48	A	0.52	A	0.73	C	0.54	A	0.75	C
George Street – Margaret Street	0.52	A	0.56	A	0.56	A	0.57	A	0.57	A
George Street – Alice Street	0.65	B	0.68	B	0.71	C	0.69	B	0.73	C
Albert Street – Elizabeth Street	0.64	B	0.69	B	0.61	B	0.71	C	0.62	B
Albert Street – Charlotte Street	0.59	A	0.72	C	0.35	A	0.73	C	0.37	A
Albert Street – Mary Street	0.53	A	0.56	A	0.55	A	0.59	A	0.56	A
Albert Street – Margaret Street	0.45	A	0.50	A	0.49	A	0.51	A	0.50	A
Albert Street – Alice Street	0.29	A	0.31	A	0.27	A	0.32	A	0.28	A

Table A-3 PM Peak intersection performance with & without Albert Street closure (without mitigation)

Site Name	**2016 Existing**		**2023 No closure**		**2023 with Closure**		**2023 No closure**		**2033 with Closure**	
	DOS	LOS	DOS	LOS	DOS	LOS	DOS	LOS	DOS	LOS
George Street – Elizabeth Street	0.59	A	0.65	B	1.02	F	0.67	B	1.07	F
George Street – Charlotte Street	0.39	A	0.43	A	0.82	C	0.46	A	0.86	C
George Street – Mary Street	0.49	A	0.53	A	0.66	B	0.55	A	0.69	B
George Street – Margaret Street	0.45	A	0.49	A	0.58	A	0.49	A	0.59	A
George Street – Alice Street	0.77	C	0.81	C	0.86	C	0.82	C	0.88	C
Albert Street – Elizabeth Street	0.56	A	0.62	B	0.68	B	0.65	B	0.70	B
Albert Street – Charlotte Street	0.53	A	0.61	B	0.49	A	0.65	B	0.44	A
Albert Street – Mary Street	0.39	A	0.43	A	0.42	A	0.44	A	0.43	A
Albert Street – Margaret Street	0.33	A	0.37	A	0.22	A	0.38	A	0.23	A
Albert Street – Alice Street	0.67	B	0.70	C	0.48	A	0.72	C	0.50	A

Without closure of Albert Street, the SIDRA results indicate all of the modelled intersections will operate below capacity in both project opening year 2023 and horizon year 2033. The DOS of each intersection becomes slightly worse due to the gradual increase of background traffic. The George Street / Elizabeth Street intersection will be the worst performing intersection in the AM peak with DOS 0.77 and a LOS C. The George Street / Alice Street intersection will be the worst performing intersection in the PM peak with DOS 0.82 and a LOS C. Both intersections are considered to operate below capacity.

With the Albert Street closure, the intersection of George Street/ Elizabeth Street will be over capacity in the AM peak in both 2023 and 2033. This is due to the change of vehicle circulation which leads to more right turning vehicles on the George Street approach. The DOS of this intersection will become 1.57 with LOS F in the opening year 2023.

The intersection performance of George Street / Charlotte Street, George Street / Mary Street, and George Street / Alice Street will become slightly worse at LOS C due to the diverted traffic flow. However, all of these intersections will still operate below capacity. The intersections of Albert Street / Elizabeth Street, Albert Street / Charlotte Street and Albert Street / Alice Street will have improved LOS due to the closure of the Albert Street approach. This will end up reallocating the extra green time to the remaining approaches and/or pedestrian movements.

Mitigation measures at George Street / Elizabeth Street intersection

The intersection of George Street / Elizabeth Street will experience the largest impact due to Albert Street closure. It will operate over capacity under the existing layout in both project opening year 2023 and horizon year 2033 in the AM peak hour. Improvement of intersection performance can be achieved by changing the lane marking to allow shared through and right movements in the middle lane on the George Street approach. With the change of lane marking, the performance of this intersection will be improved significantly to below capacity in both modelled years. The modelling results are summarised in Table A-4 and the layout comparison is shown in Figure A-6.

Table A-4 Improved intersection performance of George Street / Elizabeth Street

Site Name	**Period**	**2023 with Closure with mitigation measures**		**2033 with Closure with mitigation measures**	
		DOS	LOS	DOS	LOS
George Street – Elizabeth Street	AM	0.85	C	0.87	C
	PM	0.75	C	0.79	C

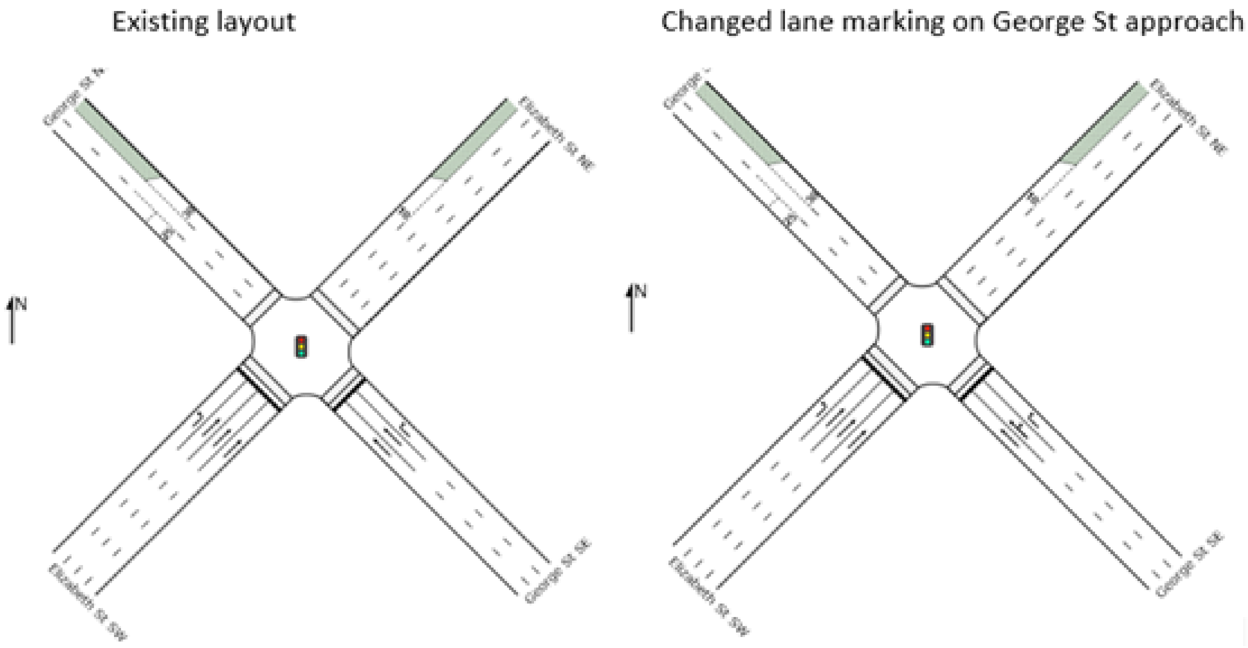


Figure A-6 Intersection layout comparison changed lane marking on George Street approach

Summary

Results from the SIDRA intersection assessments indicate that there are minor impacts on relevant intersection operations throughout the CBD due to the Albert Street closure with most intersections operating well within acceptable levels for both morning and afternoon peak periods. Only the intersection of George Street and Elizabeth Street will exceed capacity limits in both morning and afternoon peaks as a result of traffic rerouting from Albert Street to George Street. As such, the proposed mitigation measure for this intersection is to convert the centre lane into a shared through and right turn from George Street into Elizabeth Street. This is predicted to improve the intersection operation such that in the morning and afternoon peaks the intersection level of service will be C, well within acceptable levels. All the modelled intersections will operate below capacity with highest LOS at C in project horizon year 2033.

2 Technical Report: Climate change and sustainability

2.1 Introduction

The key aspects addressed in this technical report include climate change, energy consumption and greenhouse gas emissions, and sustainability outcomes. Overall, CRR 2016 results in changes consistent with those identified for CRR 2011. These are discussed in the following sections.

2.2 Climate change

2.2.1 Changes to potential impacts

The CRR 2016 Project addresses similar design issues to those identified for CRR 2011 in response to climate change risks, including the potential for:

- Higher intensity, frequency and duration of rainfall events causing inundation of critical infrastructure;
- Surface infrastructure being effected by wind speed and direction;
- Higher temperature related events leading to increased power supply and usage;
- Heat impacts on mechanical and electrical systems;
- Accelerated deterioration of facilities and infrastructure due to changed operating conditions as a result of temperature increases (such as the numbers of days of extreme heat, over 35°C); and
- Impacts from sea level rise and storm surges on critical infrastructure, such as at Mayne Yard, where there is a tidal creek (Breakfast/Enoggera Creek) that has the potential to be subject to sea level rise and intensification of storm tide events.

2.2.2 Changes to potential mitigation measures

To respond to potential climate change risks, CRR 2016 has incorporated the following design components which are consistent with CRR 2011:

- The Project is to be designed to accommodate conditions that may arise as a result of climate change including the possible sea level rise of approximately 1.0m by 2100;
- Raised station entry points at the surface to protect underground stations against local flooding;
- A protection system for flood events at low lying stations;
- Dedicated flood protection measures for Albert Street Station for a 1 in 100, 1 in 800 and 1 in 10,000 year flood event;
- Station entries that are designed to respond to the existing and future warmer climate with a combination of adjustable panels, louvres and shading;
- Entrance coverings for stations that can be progressively closed and secured in severe weather conditions;
- The use of platform screen doors to maintain temperatures of 26°C at the platform level; and

- Feeder station and electrical substation to provide the required power for the Project, including an independent supply for traction power in the event of a localised power failure.

Additional mitigation measures now relevant to CRR 2016 include the development of emergency management systems and plans. These are incorporated within the CRR 2016 Draft Outline EMP (Volume 2).

In accordance with AS/NZ ISO 31000 Risk Management - Principles and Guidelines 2009, climate change risks will be reviewed during detailed design and construction, to ensure that all key risks are captured and mitigation and adaptation options identified.

In summary, the proposed changes for CRR 2016 have maintained consistency with the above design philosophy and approach and therefore remain consistent with the outcomes identified for climate change adaptation.

2.3 Energy consumption and greenhouse gas emissions

2.3.1 Changes to energy consumption and greenhouse gas emissions

Opportunities for the Project to further reduce energy use and greenhouse gas (GHG) emissions will follow the same hierarchy as identified in CRR 2011, including:

- Reduce demand through energy efficient layout and design;
- Reduce demand by designing energy efficient mechanical and electrical systems and technologies; and
- Develop and implement asset management strategies that encourage efficient use of energy.

Measures relevant to the CRR 2016 design component, consistent with CRR 2011 include the following:

- Train stations – explore opportunities to design the station layout to maximise the use of natural lighting through glass roofing, use of solar panels, purchasing green power;
- Limit station air conditioning to platform only cooling and seasonal use;
- Investigate solar power and adoption of new technology for control system component selection;
- Investigate station management options for vertical transportation; and
- Identify potential energy efficiency opportunities for network operations.

CRR 2016 will explore opportunities to further reduce energy and GHG emissions during the detailed design and delivery phases of the Project. This is consistent with outcomes for CRR 2011.

2.4 Changes to sustainability outcomes

A number of sustainability measures identified by CRR 2011 have been incorporated into the design of CRR 2016. The design actions which have changed and an explanation for these alterations is provided in Table 2.1.

Table 2.1 Agreed sustainability actions

Action title	CRR 2011 actions	Changes to CRR 2016 design
Reducing energy demand	Single track tunnels for the river crossing tunnels were to be as shallow	The depth of the CRR 2016 alignment differs in places to CRR 2011, although with

Action title	CRR 2011 actions	Changes to CRR 2016 design
and minimise lifecycle energy consumption	as possible (rather than two track tunnels, which required a wider diameter tunnel and thus a higher level of energy consumption). Single track tunnels reduced the required gradient and therefore the level of energy consumption required for the construction of the tunnel and the operation of trains. This reduced gradient level allowed for comparatively shallow stations, for example, at the Woolloongabba and Boggo Road Stations or cavern construction methodologies could be used.	a similar maximum gradient of 3%, The CRR 2016 Project will be consistent with CRR 2011 in relation to energy demand per unit length of tunnel, however its overall energy demand will be reduced given its shorter tunnel length.
	Pressure changes were to be managed through platform screen doors, which physically separated the track from the platform station environment and improved air-conditioning efficiency at underground stations.	Design is consistent with CRR 2011.
Water efficiency/reduction (using potable water, protecting existing resources and reducing flood risk)	Waterproofing and water treatment was proposed for the Woolloongabba Station to avoid movement of contaminated groundwater.	Waterproofing and water treatment will be consistent with CRR 2011 at Woolloongabba Station.
	Use of prefabricated segments for TBM minimised water leakage and therefore reduced the amount of seepage water pumping required.	Design is consistent with CRR 2011.
Integrate facilities with existing transport nodes and other infrastructure	Connected the Albert Street end of the CBD to the existing rail network.	Outcome is consistent with CRR 2011.
	Provided the opportunity for future upgrades to the Woolloongabba Busway Station.	Consistent with CRR 2011, Woolloongabba Station will allow interchange with the Woolloongabba Busway Station and Roma Street Station will integrate with the existing Roma Street Rail and Busway Station. Boggo Road Station will provide enhanced connectivity with Boggo Road Busway Station and Park Road Railway Station. CRR 2016 does not preclude upgrades to the Woolloongabba Busway Station.
	Provided enhanced connectivity between other transport modes, for example, at Boggo Road (to Boggo Road Busway Station), Roma Street Station (to Roma Street Busway Station) and the Woolloongabba Station (to Woolloongabba Busway Station).	
Measures which increase health and social wellbeing	As far as technically feasible, vertical station depth was reduced, which improved passenger access to the rail network.	Design is consistent with CRR 2011.
	To avoid pedestrian overcrowding at the Woolloongabba Station, the station was designed to cope with 20,000 passengers per hour after events at the Woolloongabba (Gabba) Stadium.	Consistent with CRR 2011, Woolloongabba Station will service the transport needs of events at the Gabba Stadium.
Infrastructure compatibility	Clapham Rail Yard was proposed to be used for stabling.	No works proposed for Clapham Rail Yard as part of CRR 2016.

Action title	CRR 2011 actions	Changes to CRR 2016 design
with existing land uses	The opportunity to use trains for removal of spoil.	Consistent with CRR 2011, spoil haulage to the spoil placement sites has been assumed to be by road. Spoil placement sites have been revised and are discussed further in Technical report 1 (Transport).
	New station facilities at Yeerongpilly.	No works proposed for Yeerongpilly Station as part of CRR 2016.
	Albert Street and the Woolloongabba Stations were designed to support future high rise development at surface.	Design is consistent with CRR 2011.
Increase safety and security through design	Upgrade of Rocklea and Moorooka stations to improve disability access and safety.	No works proposed as part of CRR 2016.
	Improved access to stations through the use of lifts and elevators.	
	Positioning of Boggo Road Station entrance as close as possible to Annerley Road to improve access and legibility for users.	CRR 2016 has been moved further east from the CRR 2011 design. The new rail station location improves interchange function and will ensure good access and legibility is maintained.
	Improved access to QUT and the City Botanic Gardens from the proposed Albert Street Station via an underground pedestrian access beneath Alice Street.	Albert Street Station has been moved one block further north than CRR 2011. The new position improves pedestrian outcomes by providing an opportunity to pedestrianise part of Albert Street.
	Used Crime Prevention through Environmental Design measures for station designs.	Consistent with CRR 2011.
Minimise the Project's contributions towards climate change by reducing GHG emissions and incorporating latest climate change scenarios into the design	Undertaking a GHG emissions inventory in line with the GHG protocol for all stages of the Project.	CRR 2016 will pursue an Infrastructure Sustainability Council of Australia (ISCA) Sustainability Rating (Design). This will incorporate a GHG emissions inventory.
	Track elevation at Mayne Yard was designed in response to the floodplain modelling undertaken in this area.	The proposed surface works for the CRR 2016 alignment will not impinge on the current floodplain or flood behaviour of Breakfast/Enoggera Creek.
	Undertaking a detailed climate change risk assessment.	Consistent with CRR 2011. CRR 2016 will also pursue an ISCA Sustainability Rating (Design) that incorporates climate change assessment.
Contribute towards economic growth in Brisbane through improvements in the public transport network and accessibility to	Upgraded station facilities at Yeerongpilly to improve links and access between future Transit Oriented Development (TOD) and industrial areas.	No works proposed as part of CRR 2016.

Action title	CRR 2011 actions	Changes to CRR 2016 design
areas with mixed land uses		

2.5 Conclusion

The CRR 2016 Project design maintains consistent climate change and sustainability outcomes with those identified for CRR 2011. Ongoing review and development of the sustainability assessment framework will capture changes to policy and legislation and ensure that sustainability remains a focus of the delivery and operation of the Project.

Since CRR 2011, the Project has registered with ISCA and it is proposed that the Project will seek an Infrastructure Sustainability Rating (Design). This will incorporate a GHG emissions inventory and climate change assessment.

In 2016, the State Infrastructure Plan (March 2016) identified that “all state government projects of greater than $100 million in value will include a sustainability assessment”. This will be addressed through the ongoing review and development of the sustainability assessment framework and obtaining the proposed ISCA Infrastructure Sustainability Rating (Design).

The CRR 2016 Draft Outline EMP (Volume 2) identifies the various stages that sustainability measures will be incorporated into the Project and the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

3 Technical Report: Topography, geology, geomorphology and soils

3.1 Introduction

The key aspects addressed in this technical report include settlement risk, erosion risk and acid sulfate soils. The potential effects on these elements have changed as a result of differences in the CRR 2016 design such as different portal locations, modified station locations and changes to the vertical profile of the Project and hence depth to tunnel and stations.

The CRR 2016 underground alignment has been located within suitable geology while achieving an appropriate design gradient for rail operations. In addition, the location of surface structures (i.e. stations, station access locations) have been influenced by topography. A comparison of alignment depth at the underground stations is presented in Table 3.1.

Table 3.1 Alignment depth comparison

Location	CRR 2016 (depth) comparison[24]
Boggo Road Station	Similar depth to CRR 2011.
Woolloongabba Station	Similar depth to CRR 2011.
Albert Street Station	Similar depth to CRR 2011.
Roma Street Station	Similar depth to CRR 2011.

3.2 Changes to potential impacts

3.2.1 Settlement risk

For CRR 2016, a preliminary settlement analysis was undertaken along the alignment, using the Oasys program Xdisp version 19.3. Xdisp calculates the ground movements induced by tunnelling, embedded wall excavations or mining works in terms of three dimensional displacements and horizontal strains. It also allows subsequent building and utility damage assessments to be carried out from the calculated displacements. The results of this preliminary analysis, including a comparison with CRR 2011, is presented in Table 3.2.

The preliminary settlement analysis, which assessed the worst case scenario, identified that the potential settlement estimates will be slightly greater than CRR 2011 at locations north of Roma Street (near Victoria Barracks) and around Park Road Railway Station (near Quarry Street). Further analytical settlement estimates were undertaken at these two locations and a Building Damage Assessment was calculated and is documented in Appendix B1 and B2. The analysis for these two sites is discussed below.

Victoria Barracks

The analysis of the TBM bored tunnel concluded that although CRR 2016 passes closer to the Victoria Barracks than the CRR 2011 alignment, the estimated damage category is assessed as ‘negligible’ as the tunnel boring works are still sufficiently far away from the buildings.

[24] Measurement taken from tunnel crown level, allowing for a 5.5m rail to crown level.

Quarry Street

The analysis of the mined tunnel at this location indicated that the excavation is of sufficient depth beneath the majority of affected buildings such that the estimated damage category is assessed as 'slight'[25]. This is based on the building being a masonry structure type and not a typical "Queenslander" i.e. timber framed and weatherboard clad structure, which are not as sensitive to differential ground movement.

[25] 'Slight' refers to the building/structure damage risk classification as detailed in Appendix B1 and B2

Table 3.2 CRR 2016 estimated settlements

Description of surface structure(s)	CRR 2016 Chainage [m]#	Depth to design level [m]	Description of Cross River Rail structure	Estimated maximum settlement [mm]	Estimated settlement trough width [m]	Change from CRR 2011
Within rail corridor at Dutton Park Station	1100 – 1450	0 – 10	CRR 2016 southern entrance: dive structures, portal, cut & cover tunnels	25 - 50	25m from tunnel wall	Alignment different to CRR 2011, however settlement magnitude anticipated to be less than that estimated for the CRR 2011 southern entrance(1)*.
Ecosciences precinct	1450 – 1690	10 – 14	Boggo Road Station	25 - 50	25m from shaft wall	Alignment and station configuration different to CRR 2011, however settlement magnitude not anticipated to exceed that estimated for CRR 2011 Boggo Road Station(2)*.
Park Road Railway Station, Queenslanders and single and two storey housing (near Quarry Street)	1690 – 1870	14 – 18	Mined running tunnels (Support Type 2)	30 – 35	40 – 50	Alignment different to CRR 2011; settlement anticipated to be slightly greater than CRR 2011.
Queenslanders and single and two storey housing (Quarry Street to Stanley Street)	1870 – 2660	14 – 29	Mined running tunnels (Support Type 1)	15 – 30	50 – 80	Alignment different to CRR 2011, however settlement anticipated to be of similar magnitude to CRR 2011*.
Woolloongabba Busway Station	2660 – 2940	27 – 29	Woolloongabba Station	10 - 25	25m from shaft wall	Alignment and station configuration different to CRR 2011, however settlement anticipated to be of similar magnitude to CRR 2011(3)*.

Description of surface structure(s)	CRR 2016 Chainage [m][#]	Depth to design level [m]	Description of Cross River Rail structure	Estimated maximum settlement [mm]	Estimated settlement trough width [m]	Change from CRR 2011
Multi-storey Structures, Queenslanders	2940 – 3500	27 – 50	TBM running tunnels	0 – 10	100 – 150	Alignment different to CRR 2011, however settlement anticipated to be of similar magnitude to CRR 2011[(3)*].
Brisbane River Crossing, City Botanic Gardens	3500 – 4500	25 – 50	TBM running tunnels	0 – 10	100 – 150	Similar to CRR 2011. No change anticipated [(4) ^].
Residential and Commercial Multistorey Structures	4500 – 4790	31 – 33	Albert Street Station	25 – 50	30m from shaft wall	Station configuration different to CRR 2011, however settlement anticipated to be of similar magnitude to CRR 2011[(3) ^].
Residential and commercial multistorey structures, Queen Street Busway Station, City Hall, S1 Sewer, King George Busway Station	4790 – 5300	33 – 29	TBM running tunnels	0 – 10	100 – 150	Similar to CRR 2011. No change anticipated [(4) ^].
Law Courts, Commercial multistorey buildings	5300 – 5610	29 – 24	TBM running tunnels	0 – 10	100 – 150	Alignment different to CRR 2011, however settlement anticipated to be of similar magnitude to CRR 2011[(3)*].
Crosses busway and railway station	5610 – 5890	24 – 31	Roma Street Station	10 – 25	25m from shaft wall	Alignment and station configuration different to CRR 2011, however settlement anticipated to be of similar magnitude to CRR 2011[(3)*].

Description of surface structure(s)	CRR 2016 Chainage [m]#	Depth to design level [m]	Description of Cross River Rail structure	Estimated maximum settlement [mm]	Estimated settlement trough width [m]	Change from CRR 2011
Roma Street rail yard, Northern Busway, Countess Street (near Victoria Barracks)	5890 – 6200	21 – 31	TBM running tunnels	20 – 25	70 – 80	Alignment different to CRR 2011, settlement anticipated to be slightly greater than CRR 2011.
Petrie Terrace, Countess Street, Northern Busway, College Road	6200 – 6600	26 – 31	TBM running tunnels	15 – 20	70 – 80	Alignment different to CRR 2011, however settlement anticipated to be of similar magnitude to CRR 2011.
Rail corridor, western edge of Brisbane Grammar School car park	6600 – 7070	12 – 26	TBM running tunnels	25 – 30	50 – 70	Alignment different to CRR 2011, however settlement anticipated to be of similar magnitude to CRR 2011.
In rail corridor	7070 – 7500	0 – 12	Cut & cover tunnel, portal, dive structures	25 – 50	25m from shaft wall	Alignment different to CRR 2011, however settlement magnitude anticipated to be less than that estimated for the CRR 2011 northern entrance (1).

Notes

1. Based on better ground conditions (i.e. higher rock level, reduced depth of residual soil), similar maximum depths and similar excavation methodologies
2. Based on similar ground conditions but with significantly lower cut and cover excavation depth
3. Based on similar ground conditions, similar maximum span / width / depths and similar excavation methodologies
4. Based on the same alignment, ground conditions, tunnel geometry and excavation methodology

* Extent over which the CRR 2016 alignment maps to the previously proposed BaT 2014 alignment

^ Extent over which the CRR 2016 alignment maps to the previously proposed CRR 2011 alignment.

\# Refer to Reference Design Drawings (Volume 3).

3.2.2 Erosion risk

CRR 2011 identified higher erosion risk where surface and subsurface soils would be disturbed on steep slopes (greater than 10%), such as at Exhibition Station, the Northern portal and the Southern portal (Yeerongpilly). For CRR 2016, Dutton Park Station and the Southern portal have been identified as having a low erosion risk based on soil type, Boggo Road Station a low to moderate risk, Woolloongabba Station a low risk, Roma Street Station a low to moderate risk, the Northern portal a moderate to high risk and Exhibition Station will be consistent with CRR 2011.

Overall, the risk of erosion has reduced for all of the CRR 2016 station/portal locations, except for Exhibition Station and the Northern portal.

3.2.3 Acid sulfate soils

CRR 2011 had identified potential for disturbance of acid sulfate soils (ASS) at Albert Street Station and Mayne Yard. With the proposed excavation of a trough (underpass) at Mayne Yard for CRR 2016, the potential for disturbing ASS will be similar to CRR 2011 at this location, which had proposed bored piles for the viaduct construction. At the other CRR 2016 station locations, the potential for exposure of ASS from excavation is considered low[26].

3.3 Changes to mitigation measures

3.3.1 Settlement risk

Mitigation measures which are consistent with CRR 2011 include the following:

- Comprehensive geotechnical and groundwater investigations to be undertaken to confirm subsurface conditions and verify locations of potential settlement impacts relating to excavated induced settlement, groundwater drawdown induced settlement and local ground relaxation settlement;
- Undertake predictive modelling to identify the settlement trough footprint,
- Surveys and other monitoring will be used to identify the effects of settlement, if any, as a consequence of the Project;
- Monitoring will be conducted from the commencement of underground construction works and dewatering; and
- If there is a concern that any subsequent ground settlement was caused by the Project, an independent consultant may be engaged to prepare a new building condition survey report and recommendations for repairing building damage established. The actual settlements will be compared to predicted settlements and further mitigating measures implemented where required.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to geotechnical investigations and settlement treatment south of Dutton Park Station.

Additional mitigation measures now relevant to CRR 2016, include:

---

[26] Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Chapter 6.

- Where predictive modelling indicates settlement may be likely, design and construction measures are to be implemented to manage and mitigate the identified impacts. Detailed design and construction planning is to incorporate measures to limit settlement generally to 25mm or to 50mm in a worst case event, measured at any location within 50 m of the route centreline or the outer walls of an underground station or excavated structure (excluding designated worksites and surface properties owned by the proponent);
- If necessary, carry out building specific underpinning, strengthening or other protective measures prior to commencement of tunnel construction; and
- Establish and implement a monitoring plan, including building monitoring points. This regime is to reference predicted settlements and provide a corresponding action plan.

3.3.2 Erosion risk

Mitigation measures which are consistent with CRR 2011 include the following:

- A site specific Erosion and Sediment Control Plan (ESCP) to be developed;
- The Construction ESCP will be based on the information gathered during site-specific soil investigations at each of the worksites prior to construction; and
- Information gathered through these investigations will include confirmation of soil landscapes, soil depth, presence of fill and soil chemical properties. Site-specific soil investigations will, in turn, inform an erosion risk assessment to quantify the erosion potential for each soil type expected to be disturbed during construction.

Consistent with CRR 2011, the proposed erosion control measures will be based upon the objective of reducing the risk of erosion during construction by:

- Avoiding disturbance of vulnerable surface and subsurface soils;
- Minimising construction worksite clearing and the extent and duration of soil exposure;
- Identifying proposed spoil storage locations at construction worksites;
- Installing spoil enclosure sheds at construction worksites, where required;
- Diverting clean waters around disturbed surfaces and spoil storage locations;
- Monitoring the effectiveness of installed control measures;
- Progressive stabilisation and revegetation of disturbed areas, using stored topsoil where practicable; and
- Any damaged erosion and sediment control measures will be repaired or replaced following rainfall events. Additional monitoring and maintenance will be conducted in accordance with the measures specified in the Draft Outline EMP.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to undertaking of soil sampling and analysis and developing an ESCP at locations south of Dutton Park Station.

3.3.3 Acid sulfate soils

Mitigation measures which are consistent with CRR 2011 include the following:

- Further ASS investigations to be undertaken in combination with additional geotechnical surveys focusing on areas below 5 metres (m) Australian Height Datum (AHD), where excavation is proposed or there is soil disturbance; and
- If further investigations determine the presence of ASS, management and monitoring practices will be implemented including completion of an ASS Management Plan.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011), include implementation of an ASS Management Plan for Clapham Yard and the Southern portal at Yeerongpilly.

Additional mitigation measures now relevant to CRR 2016, include:

- The ASS Management Plan will include corrective actions for incident management and remediation and requirements for validation and verification testing of soils and potentially affected waters prior to release from the construction worksite. These management strategies may include:
  - Neutralising the soils with alkaline material, such as lime;
  - Hydraulic separation via sluicing and/ or hydrocloning;
  - Strategic reburial below groundwater table; and
  - Stormwater/ groundwater collection, control and treatment measures.

3.4 Conclusion

Overall, the potential impacts for CRR 2016 associated with settlement, erosion and acid sulfate soils have generally reduced compared to those previously identified for CRR 2011.

Settlement analysis for locations at Victoria Barracks (north of Roma Street) and Quarry Street (near Park Road Station) has concluded that the potential for settlement and building damage in these locations for CRR 2016 is ‘negligible’ and ‘slight’, respectively. Nevertheless, based on updated technical information, mitigation measures will still apply and be tailored to manage settlement risk along the alignment.

The erosion risk has changed due to the altered alignment, station and portal locations for CRR 2016, although areas with steeper slopes are still prone to erosion and similar mitigation measures to CRR 2011 will apply. The potential to encounter acid sulfate soils is considered similar to CRR 2011, although based on updated technical information, additional management strategies now apply.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

Appendix B

Analytical settlement estimate for Victoria Barracks and Quarry Street

B1 Analytical settlement estimate of Victoria Barracks

Technical Note

ARUP

Level 4, 108 Wickham Street
Fortitude Valley
QLD 4006
GPO Box 685 Brisbane QLD 4001
Australia
www.arup.com

t +61 7 3023 6000
f +61 7 3023 6023

Project title	Cross River Rail	Job number	246209
cc		File reference	
Prepared by		Date	5 September 2016
Subject	Analytical Settlement Estimate for Victoria Barracks		

1 Introduction and Background

North of Turbot Street, the CRR 2016 tunnels are realigned to the west of the previous CRR 2011 alignment to avoid encroaching on Victoria Park including passing beneath it as shown in Figure B1.

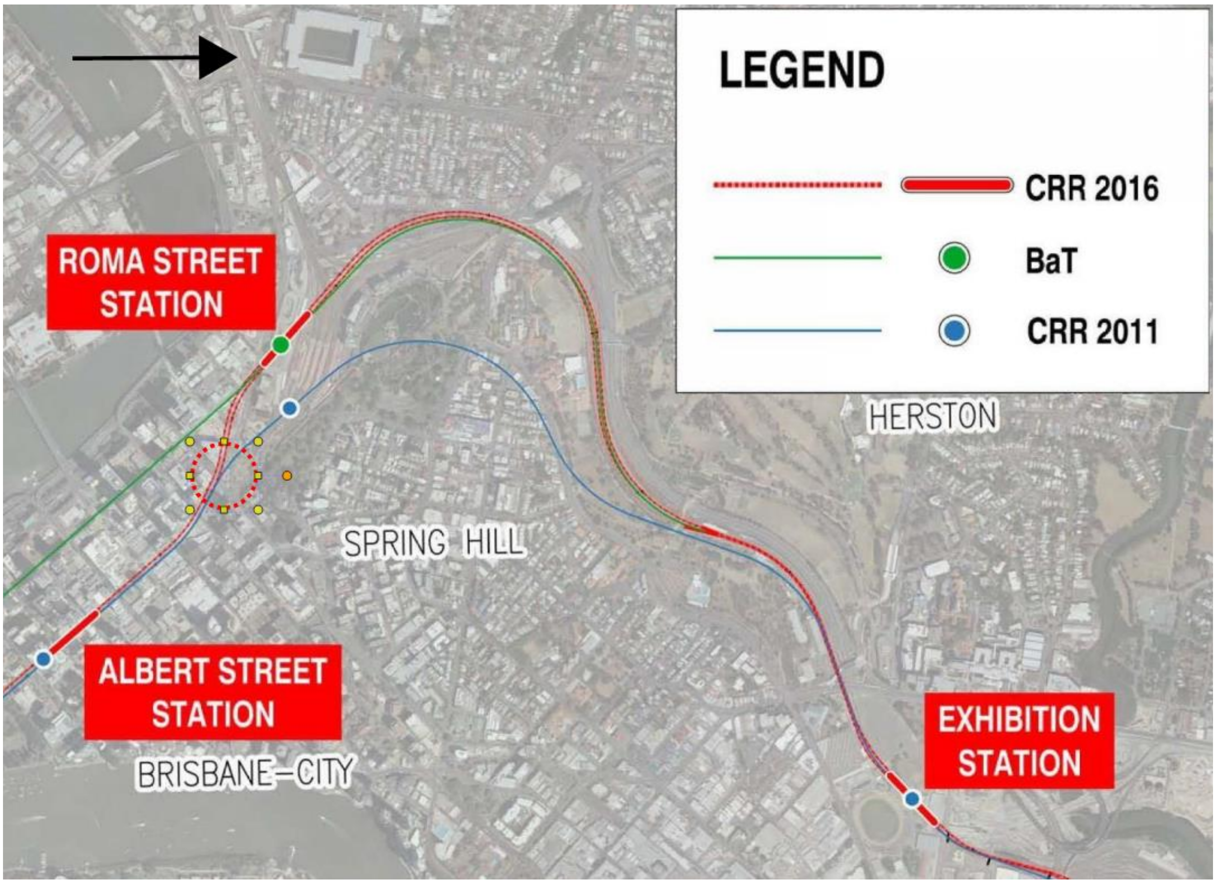


Figure B1 CRR2016 alignment north of Turbot Street

The CRR 2016 alignment crosses beneath Countess Street near the intersection with Secombe Street where it approaches the north-east corner of the Victoria Barracks precinct. It then curves around to the north, passing beneath Hardgrave Park where it approaches Petrie Terrace near the intersection with Wellington Street. These proximate ‘pinch point’ locations are shown in Figure B2.

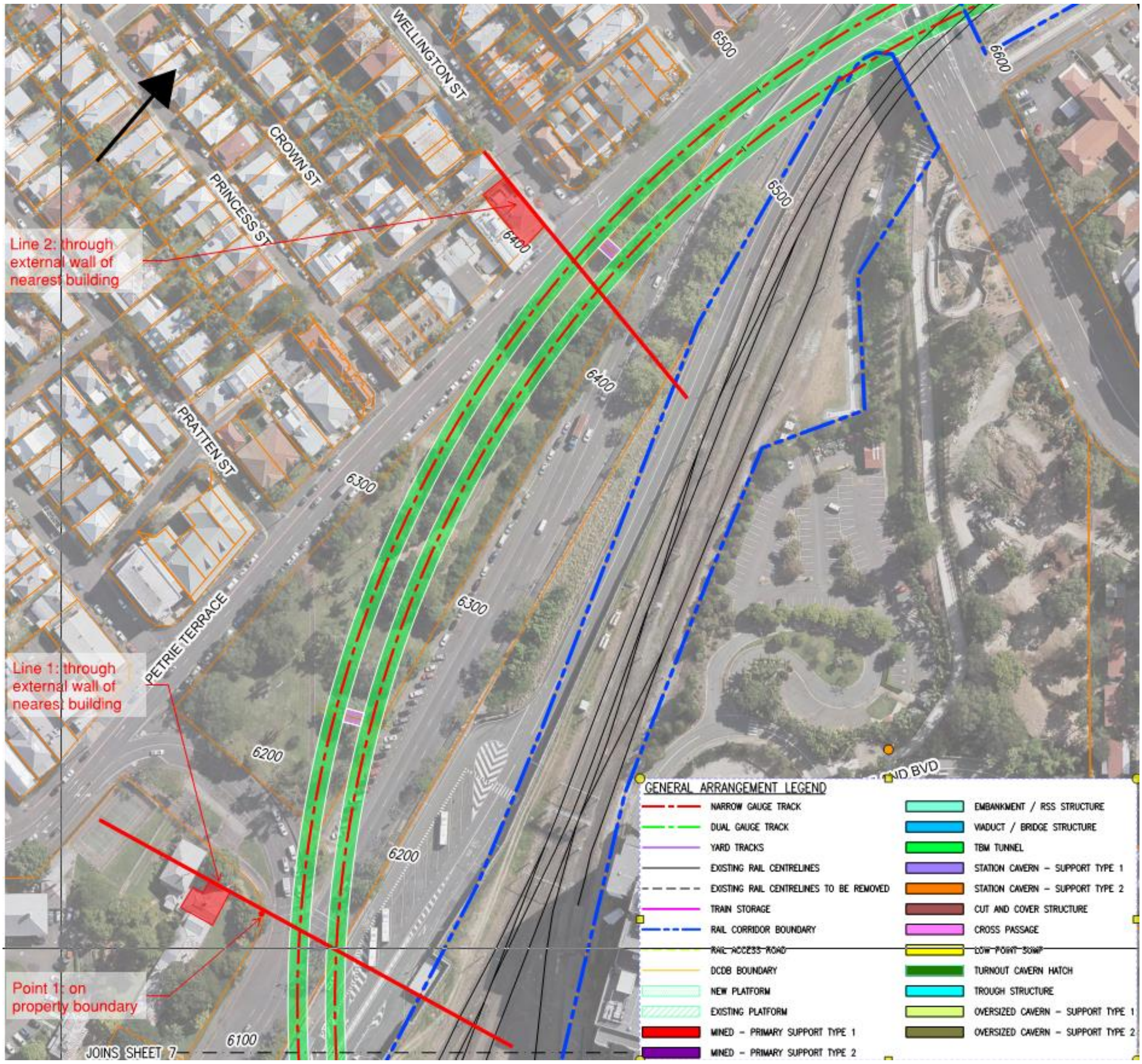


Figure B2 Query locations and tunnel proximity at Victoria Barracks and Petrie Terrace

The westernmost TBM tunnel approaches to within approximately 25m of the nearest Victoria Barracks building on query line 1 and to within approximately 13m of the nearest Petrie Terrace building on query line 2. Due to the close proximity of the CRR 2016 tunnel alignment to the locations identified above, the locations may experience an increased level of tunnelling induced ground movement compared to CRR 2011.

An analytical settlement analysis and building damage assessment was therefore carried out between CH6000 and CH6600 (CRR Southbound) to establish a preliminary estimate of the tunnelling induced impacts at the locations of interest.

2 Analysis Methodology

The preliminary settlement analysis and building damage assessment was carried out using the Oasys program Xdisp version 19.3. Xdisp calculates the ground movements induced by tunnelling, embedded wall excavations or mining works, in terms of three dimensional displacements and horizontal strains. It also allows subsequent building and utility damage assessments to be carried out from the calculated displacements.

Tunnels are taken as cylindrical excavations in soil. Several methods of solution are available to define the profile of the settlement curves. The equations used are based on the normal probability (Gaussian) distribution theory. The user is required to define the estimated Volume Loss (VL) above the tunnel due to deformation. Xdisp will then use this to define the settlement profile at the surface or specified depth.

Building Damage Assessment is calculated using the Burland (1995) assessment method. Sub-structures are specified by their locations and bending properties and associated with lines of displacement points and a set of damage category tensile strains that define the thresholds of each damage category.

3 Inputs and assumptions

The key assumptions and inputs upon which the preliminary settlement analysis and building damage assessment is based are summarised in Table B1.

Table B1 Key inputs and assumptions

Key Input / Assumption	Value adopted
Horizontal alignment	Refer CRR-0001-AL-GA-106 General arrangement sheet 8 (Request for Project Change Report – Volume 3)
Vertical alignment	Refer CRR-0001-AL-LS-154 Longitudinal Section – Southbound Track Sheet 4. (Request for Project Change Report – Volume 3)
Settlement analysis type	Analytical i.e. normal probability (Gaussian) distribution theory in which the shape of the surface settlement trough takes the form of a Gaussian curve with trough volume expressed as a percentage of the theoretical excavated tunnel volume (Volume Loss, V) and trough width related to ground type by the trough width parameter (K).
Volume Loss, V	1.0%
Settlement trough parameter (k) derivation	O’Reilly & New
Query Line 1	Through external wall of nearest Victoria Barracks building. (Refer Figure B2)
Query Line 2	Through external of nearest Petrie Terrace building. (Refer Figure B2)
Building damage assessment methodology	Burland, 1995
Assumed wall height	10m
Assumed structure type	Masonry (i.e. E/G = 2.6)

4 Analysis Results

The estimated settlement corresponding to the inputs and assumptions summarised in Table B1 is shown graphically in Figure B3.

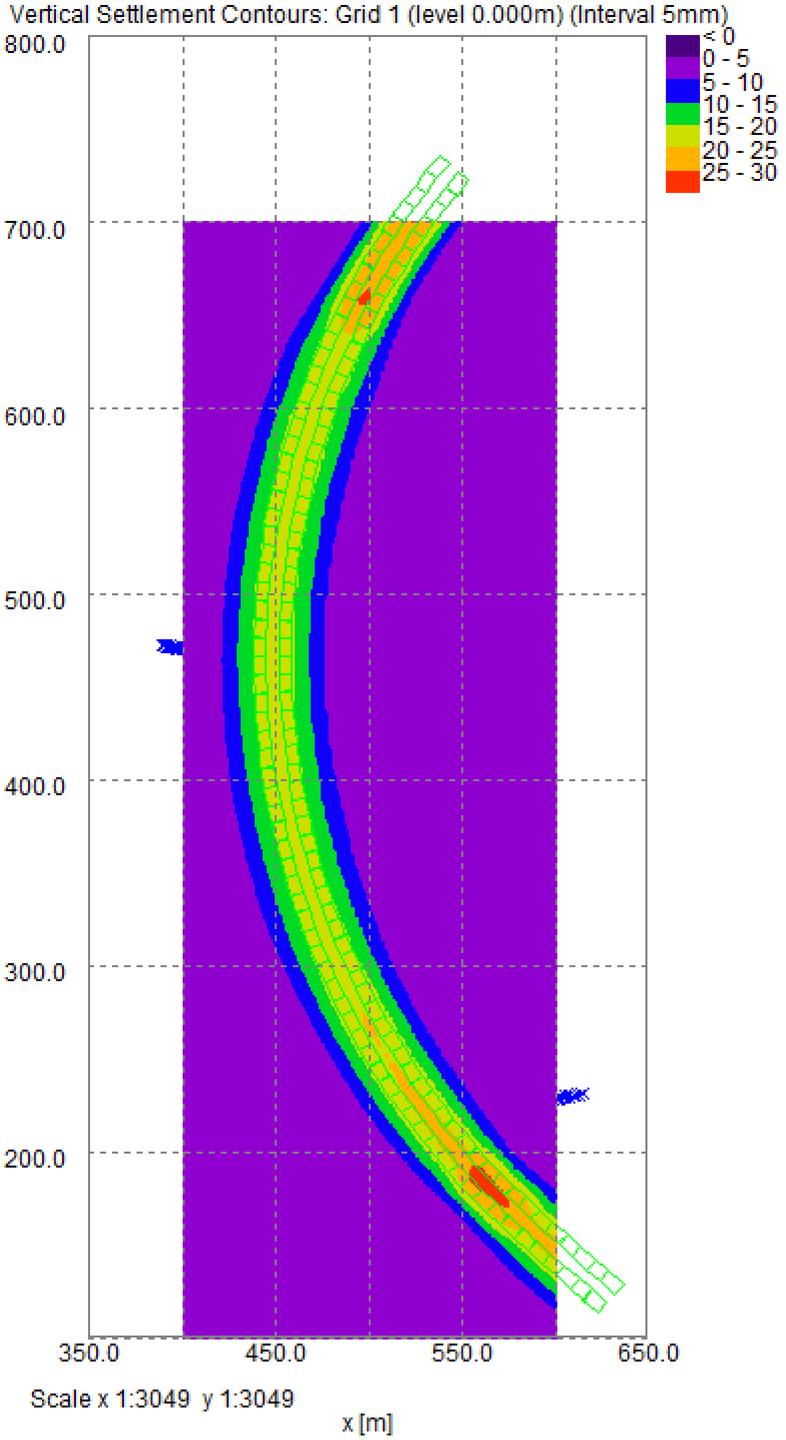


Figure B3 Vertical settlement contours, CH6000 – 6700 (CRR Southbound)

The resultant maximum settlement, slope and estimated damage category (in accordance with Burland 1995) for the query locations identified in Figure B2 are summarised in Table B2.

Table B2 Selected settlement and building damage assessment results (CH6000-CH6600)

Query No. (& type)	**Location**	**Max settlement [mm]**	**Max slope**	**Estimated damage category**
Point 1	Point on Victoria Barracks property boundary nearest to tunnel	7	-	-
Line 1	Through external wall of nearest Victoria Barracks building	2	-1 in 4138	Negligible
Line 2	Through external wall of nearest Petrie Terrace building	7	-1 in 1736	Negligible

As identified in Section 3, the approach adopted to assessing the risk settlement induced damage to buildings and structures is as per that described by Burland 1995. The methodology considers the structure being assessed to act as a linear elastic beam and uses the concept of limiting tensile strain derived from the approach proposed by Burland and Wroth, 1974 and Boscardin and Cording, 1989 to assign anticipated damage to one of six categories ranging from negligible (0) to Very Severe (5).

The commonly adopted relationship between limited tensile strain and damage category is shown in Table B3 below. This relationship is based on masonry construction as masonry construction is more susceptible to movement induced damage (cracking) than timber construction.

For the purposes of this high level assessment, all structures are conservatively assumed to be masonry (E/G=2.6) with a wall height of 10m to provide a robust initial estimate of the anticipated damage category. It is expected that subsequent, more detailed analysis carried out in later design stages would refine the volume loss (and/or ground movement), structure type and wall heights currently adopted, thereby reducing the estimated induced tensile strain in existing buildings within the influence zone. In any case the robust initial assessment described in this technical note indicates an estimated damage category of **'negligible'** for the selected buildings.

Table B3 Building / Structure Damage Risk Classification (Burland 1997)

Damage Category	Category of damage	Description of typical damage* (Ease of repair is underlined)	Approx. crack width* (mm)	Limiting tensile strain (%)
0	Negligible	Hairline cracks	< 0.1	< 0.05
1	Very Slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in buildings. Cracks in external brickwork visible on inspection.	< 1	0.05 - 0.075
2	Slight	Cracks easily filled. Redecorating probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weather tightness. Doors and windows may stick slightly.	< 5	0.075 - 0.15
3	Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weather tightness often impaired.	5 - 15 or a number of cracks > 3	0.15 – 0.3
4	Severe	Extensive repair work involving breaking out and replacing sections of walls, especially over doors and windows. Windows and door frames distorted, floor sloping noticeably. Walls leaning and bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15 - 25 but also depends on number of cracks	> 0.3
5	Very Severe	This requires a major repair job involving partial or complete rebuilding. Beams lose bearing, walls lean badly and require shoring. Windows broken due to distortion. Danger of instability.	Usually > 25 but depends on number of cracks.	-

5 Conclusion

The CRR 2016 alignment passes closer to the Victoria Barracks and Petrie Terrace than the previous CRR 2011 project. However, on the basis that the estimated damage category is assessed as **negligible**, the preliminary settlement analysis and building damage assessment indicates that the tunnel excavation is still sufficiently far away from the selected critical buildings.

Furthermore as is typical for underground infrastructure projects of this type and magnitude, it is anticipated that some or all of the following mitigation measures will be adopted as part of the project's detailed design and construction phase:

- Where predictive modelling indicates settlement may be likely, design and construction measures are to be implemented to manage and mitigate the identified impacts. Detailed design and construction planning is to incorporate measures to limit settlement generally to 25mm or to 50mm in a worst case event, measured at any location within 50 m of the route centreline or the outer walls of an underground station or excavated structure (excluding designated worksites and surface properties owned by the proponent);
- If necessary, carry out building specific underpinning, strengthening or other protective measures prior to commencement of tunnel construction; and
- Establish and implement a monitoring plan, including building monitoring points. This regime is to reference predicted settlements and provide a corresponding action plan.

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name			
Signature			

B2 Analytical settlement estimate for Quarry Street

Technical Note

ARUP

Level 4, 108 Wickham Street
Fortitude Valley
QLD 4006
GPO Box 685 Brisbane QLD 4001
Australia
www.arup.com

t +61 7 3023 6000
f +61 7 3023 6023

Project title	Cross River Rail	Job number	246209
cc		File reference	
Prepared by		Date	5 August 2016
Subject	Analytical Settlement Estimate north of Boggo Road Station – Quarry Street		

1 Introduction and Background

South of the Brisbane River, the CRR 2016 alignment differs from that of the previous CRR 2011 alignment as shown in Figure B4. Key changes include the reduced length of the CRR 2016 project and associated tie-in to the existing surface rail network at Dutton Park Station as well as the revised location of the proposed new Boggo Road underground station. This Technical Note resents an initial analytical settlement analysis for the area immediately north of Boggo Road Station where the minimum cover to tunnel crown is in the order of approximately 8m.

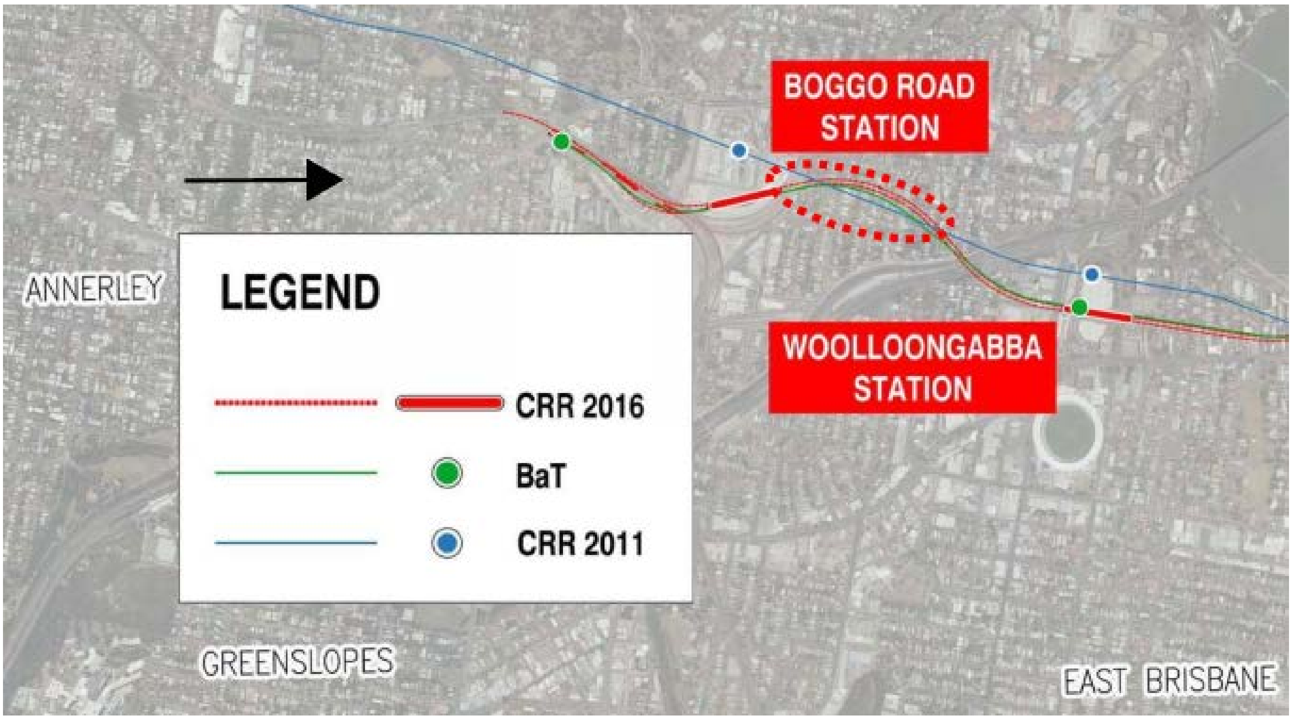


Figure B4 CRR2016 alignment south of Brisbane River

Technical Note

246209 5 August 2016

North of the proposed new Boggo Road Station, the CRR 2016 alignment crosses beneath the existing Park Road Railway Station and continues beneath a largely residential precinct toward the proposed new Woolloongabba Station which is located beneath the eastern side of the Go-Print site.

Due to a range of geometric constraints, the vertical alignment north of Boggo Road Station results in a depth of cover to tunnel crown of approximately 8m (just over one tunnel diameter) beneath the Quarry Street cul-de-sac immediately adjacent to the northern boundary of Park Road Railway Station. The vertical alignment dives continuously at the maximum permissible grade from Boggo Road Station towards Woolloongabba Station so that by the time it passes beneath Park Road the depth of cover has increased to approximately 13m (~2 tunnel diameters). The area of interest between the northern boundary of Park Road Railway Station and Park Road is shown in Figure B5.

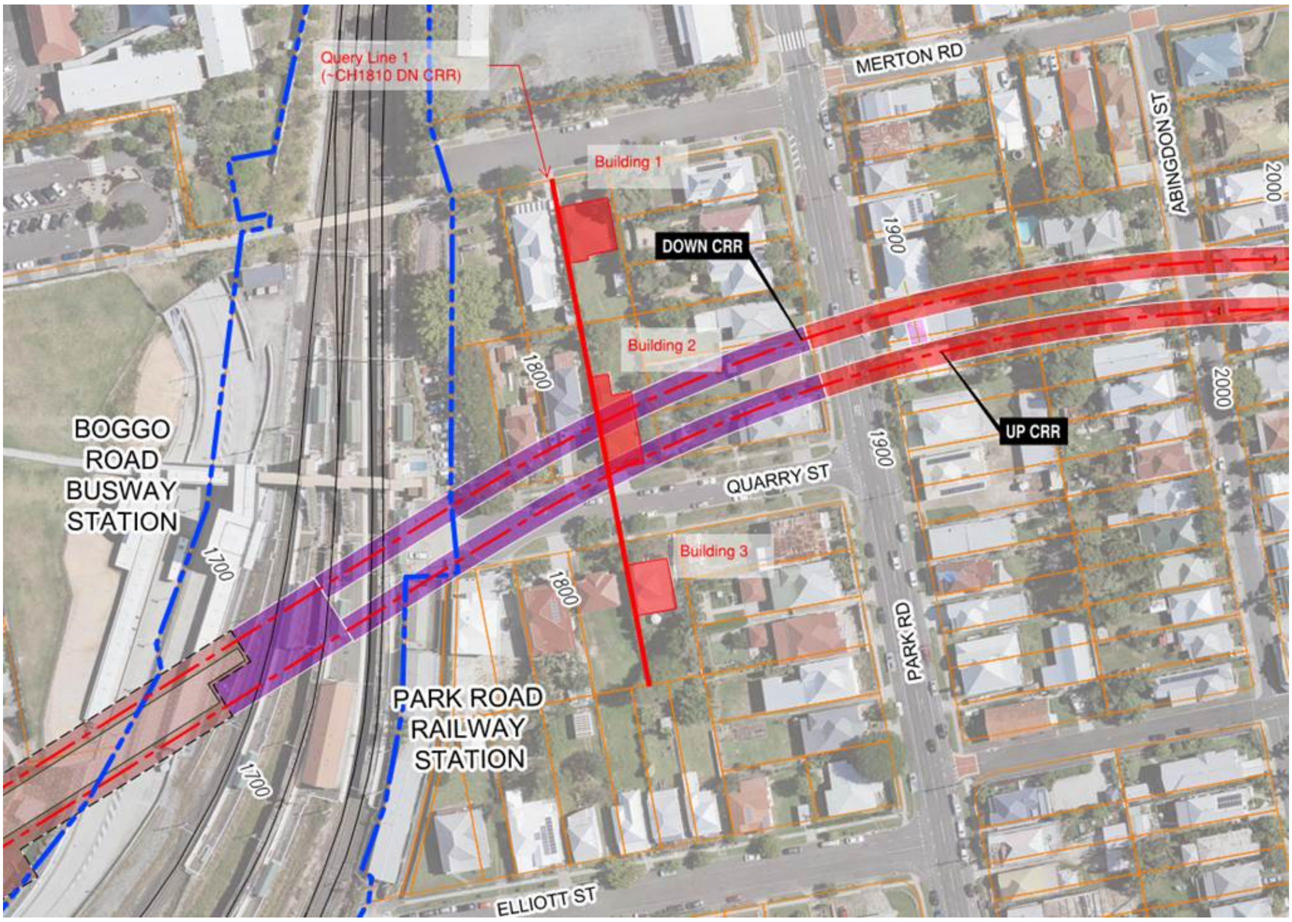


Figure B5 Tunnel alignment and query line location in low cover area immediately north of Park Road Railway Station

The tunnel alignment passes directly beneath several residential properties with a cover of between 9 and 13m (approximately) in the block bounded by the existing at-grade Park Road Railway Station, Park Road to the north, Quarry Street to the East and Merton Road to the West. Due to the proximity of the CRR 2016 tunnel alignment to the locations identified above, the locations may experience an increased level of tunnelling induced ground movement compared to CRR 2011. An analytical settlement analysis and building damage assessment was therefore carried out for the low cover section of twin mined tunnel south of Park Road to establish a preliminary estimate of the tunnelling induced impacts at the locations of interest.

2 Analysis Methodology

The preliminary settlement analysis and building damage assessment was carried out using the Oasys program Xdisp version 19.3. Xdisp calculates the ground movements induced by tunnelling, embedded wall excavations or mining works, in terms of three dimensional displacements and horizontal strains. It also allows subsequent building and utility damage assessments to be carried out from the calculated displacements.

Tunnels are taken as cylindrical excavations in soil. Several methods of solution are available to define the profile of the settlement curves. The equations used are based on the normal probability (Gaussian) distribution theory. The user is required to define the estimated Volume Loss (VL) above the tunnel due to deformation. Xdisp will then use this to define the settlement profile at the surface or specified depth.

Building Damage Assessment is calculated using the Burland (1995) assessment method. Sub-structures are specified by their locations and bending properties and associated with lines of displacement points and a set of damage category tensile strains that define the thresholds of each damage category.

3 Inputs and assumptions

The key assumptions and inputs upon which the preliminary settlement analysis and building damage assessment is based are summarised in Table B4.

Table B4 Key inputs and assumptions

Key Input / Assumption	Value adopted
Horizontal alignment	Refer CRR-0001-AL-GA-102 General arrangement sheet 8 (Request for Project Change Report – Volume 3)
Vertical alignment	Refer CRR-0001-AL-LS-151 Longitudinal Section – Southbound rack Sheet 1 (Request for Project Change Report – Volume 3)
Settlement analysis type	Analytical i.e. normal probability (Gaussian) distribution theory in which the shape of the surface settlement trough takes the form of a Gaussian curve with trough volume expressed as a percentage of the theoretical excavated tunnel volume (Volume Loss, V) and trough width related to ground type by the trough width parameter (K).
Volume Loss, V	1.0%
Settlement trough parameter (k) derivation	O'Reilly & New
Query Line 1	Through external walls of residential properties between Park Road Railway Station and Park Road. (Refer Figure B5)
Building damage assessment methodology	Burland, 1995
Assumed wall height	6m
Assumed structure type	Masonry (i.e. E/G = 2.6)

4 Analysis Results

The estimated settlement corresponding to the inputs and assumptions summarised in Table B4 is shown graphically in Figure B6 for the twin mined tunnel extent between Woolloongabba and Boggo Road Stations. Please note that this preliminary assessment does not include the effects of the station excavations at either end of the mined tunnel extent. The influence of the station excavations will be to increase the settlement magnitude and width of the settlement trough locally at the northern and southern ends of the mined tunnel extents. The affected length is anticipated to be in the order of 20-30m beyond the extent of station excavation. This effect is not shown in Figure B6 below.

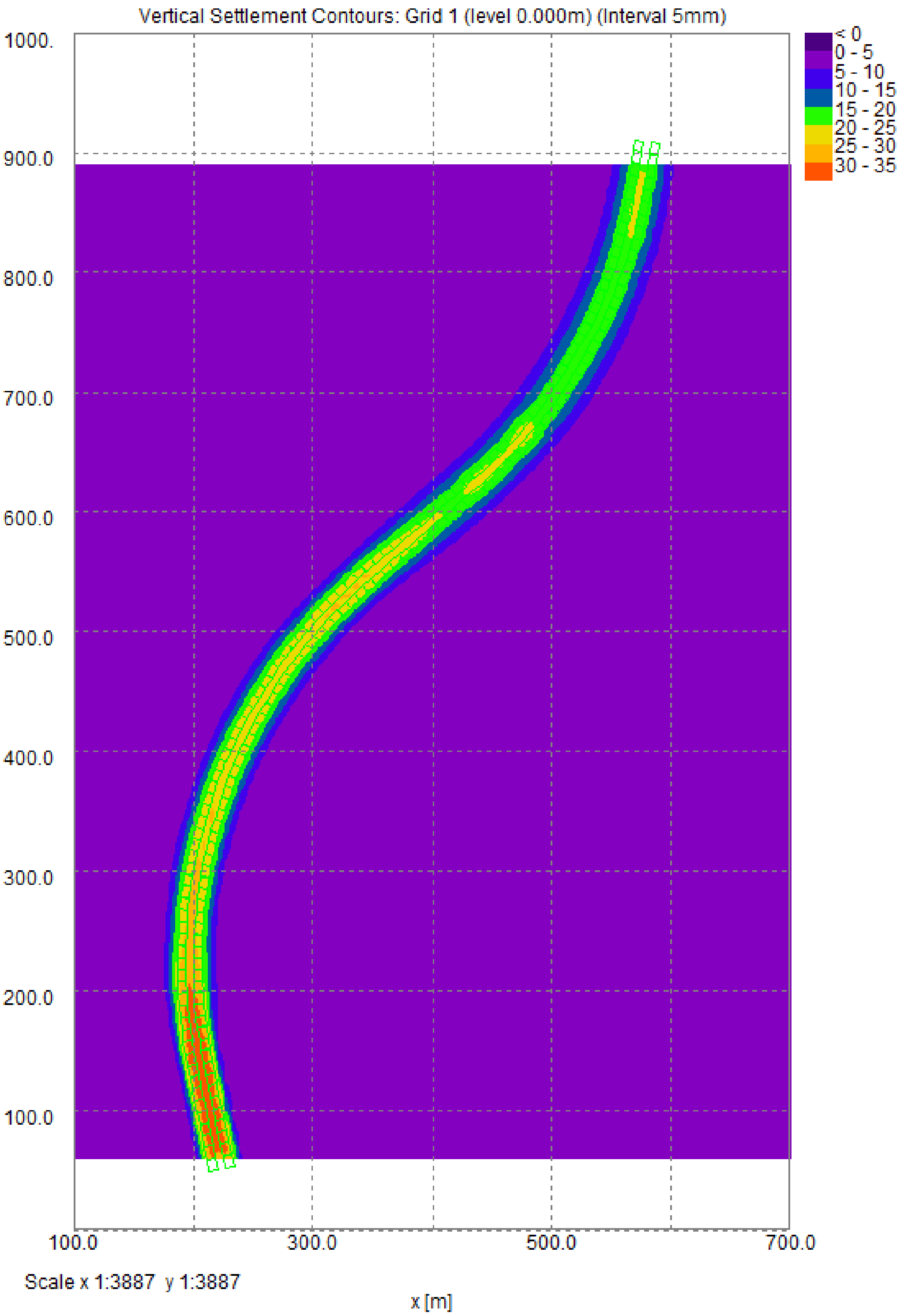


Figure B6 XDISP Vertical settlement contours between Boggo Road and Woolloongabba Stations

The resultant maximum settlement, slope and estimated damage category (in accordance with Burland 1995) for the query locations identified in Figure B5 are summarised in Table B5.

Table B5 Selected settlement and building damage assessment results (approximate CH1810 on CRR Southbound)

Query No. (& type)	Location	Max settlement [mm]	Max slope	Estimated damage category
Query line 1 (Building 1)	Through external wall of Building 1	Less than settlement trough sensitivity	-	-
Query line 1 (Building 1)	Through external wall of Building 2	33	1 in 412	Slight
Query line 1 (Building 1)	Through external wall of Building 3	Less than settlement trough sensitivity	-	

As identified in Section 3, the approach adopted to assessing the risk settlement induced damage to buildings and structures is as per that described by Burland 1995. The methodology considers the structure being assessed to act as a linear elastic beam and uses the concept of limiting tensile strain derived from the approach proposed by Burland and Wroth, 1974 and Boscardin and Cording, 1989 to assign anticipated damage to one of six categories ranging from negligible (0) to Very Severe (5). The commonly adopted relationship between limited tensile strain and damage category is shown in Table B6 below. This relationship is based on masonry construction as masonry construction is more susceptible to movement induced damage (cracking) than timber construction.

For the purposes of this high level assessment, all structures are conservatively assumed to be masonry (E/G=2.6) with a wall height of 6m to provide a robust initial estimate of the anticipated damage category. It is expected that subsequent, more detailed analysis carried out in later design stages would refine the volume loss (and/or ground movement), structure type and wall heights currently adopted. The preliminary assessment outlined in this technical note indicates an estimated damage category of 'slight' for one of the selected buildings and nil for the other two selected buildings.

Table B6 Building / Structure Damage Risk Classification (Burland 1997)

Damage Category	Category of damage	Description of typical damage* (Ease of repair is underlined)	Approx. crack width* (mm)	Limiting tensile strain (%)
0	Negligible	Hairline cracks	< 0.1	< 0.05
1	Very Slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in buildings. Cracks in external brickwork visible on inspection.	< 1	0.05 - 0.075
2	Slight	Cracks easily filled. Redecorating probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weather tightness. Doors and windows may stick slightly.	< 5	0.075 - 0.15
3	Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weather tightness often impaired.	5 - 15 or a number of cracks > 3	0.15 – 0.3
4	Severe	Extensive repair work involving breaking out and replacing sections of walls, especially over doors and windows. Windows and door frames distorted, floor sloping noticeably. Walls leaning and bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15 - 25 but also depends on number of cracks	> 0.3
5	Very Severe	This requires a major repair job involving partial or complete rebuilding. Beams lose bearing, walls lean badly and require shoring. Windows broken due to distortion. Danger of instability.	Usually > 25 but depends on number of cracks.	-

5 Conclusion

The CRR 2016 alignment has a lower cover immediately north of Park Road Railway Station than the previous CRR 2011 project. However, on the basis that the estimated damage category has been assessed as ‘slight’ for a single worst case building using a conservative set of input parameters, the preliminary settlement analysis and building damage assessment indicates that the tunnel excavation is still sufficiently far away from the majority of affected buildings within the influence zone.

The estimated damage category for selected building no. 2 (i.e. ‘Slight’) is higher than the typically accepted damage category of ‘Very Slight’. However, it is important to note that the preliminary assessment assumptions around wall height (6m) and structure type (masonry) are likely to be conservative for building structures which appear, on the basis of an initial desk study, to be “Queenslanders” i.e. timber framed and weatherboard clad structures not more than 2 stories high. It is well accepted that this structure type is less sensitive to differential ground movement than the masonry structure type on which the preliminary assessment damage assessment is based.

Furthermore, as is typical for underground infrastructure projects of this type and magnitude, it is anticipated that some or all of the following mitigation measures will be adopted as part of the project’s detailed design and construction phase:

- Where predictive modelling indicates settlement may be likely, design and construction measures are to be implemented to manage and mitigate the identified impacts. Detailed design and construction planning is to incorporate measures to limit settlement generally to 25mm or to 50mm in a worst case event, measured at any location within 50 m of the route centreline or the outer walls of an underground station or excavated structure (excluding designated worksites and surface properties owned by the proponent);
- If necessary, carry out building specific underpinning, strengthening or other protective measures prior to commencement of tunnel construction; and
- Establish and implement a monitoring plan, including building monitoring points. This regime is to reference predicted settlements and provide a corresponding action plan.

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name			
Signature			

4 Technical Report: Land contamination

4.1 Introduction

Key aspects addressed in this technical report include contaminated sites, asbestos and unforeseen contaminants. Changes to the horizontal alignment and shortening of the tunnel will alter some of the land affected by CRR 2016. As a result, the amount of contaminated land and asbestos encountered will change.

Similar to CRR 2011, with a majority of the alignment within an urban environment, the risk of encountering known and unknown contaminants is high, especially for underground stations. For CRR 2016, works have been contained within the existing rail corridor where possible to minimise wider project impacts. However, contaminated material will likely be encountered within the existing rail corridor.

For this technical report, information has been obtained from previous studies[27] identifying potential site specific contamination risks. This includes sites listed on the Environmental Management Register (EMR) and Contaminated Land Register (CLR) as well as information from historic aerial images, land use mapping, Flammable/ Combustible Goods licenses and Area Management Advice records for unexploded ordnance. Prior to construction, an updated search would be completed for land contamination sites to identify any additional sites that may have become registered.

Additional sections of this report which also inform land contamination include Technical report 3 (Topography, geology, geomorphology and soils), Technical report 8 (Groundwater), and Technical report 9 (Surface water).

4.2 Changes to potential impacts

4.2.1 Potential contaminated sites

A list of locations at which contamination is known or may be encountered along the CRR 2016 alignment, relative to CRR 2011, is provided in Table 4.1. Activities that have been identified as likely to cause land contamination are defined as notifiable activities. Land that was historically, or is currently used for notifiable activities are recorded on the EMR. Notifiable activities considered to be of higher risk include those activities which present a greater risk of generating contaminants that are likely to be mobile in groundwater. Land parcels listed on the EMR for hazardous contaminants are also considered to be of higher risk. Land listed on the CLR are shown when an investigation has proven that contaminants are present at concentrations that represent a risk to human health. For such sites, action is required to remediate or manage the land to prevent adverse environmental and human health impacts.

Impacts may also occur as a result of contamination on adjacent sites which share a property boundary with CRR 2016 as presented in Table 4.2. Those sites considered to be of higher risk include sites where migration of contamination via groundwater and/or ground gas is considered more likely.

In relation to Mayne Yard, an estimated 36,000m^3 of material will be excavated for CRR 2016 for the construction of a trough structure (underpass). Given the historic land use of this site, any contaminated land would need to be remediated or disposed of to landfill.

[27] Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, and Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement.

Table 4.1 Potential contaminated locations directly impacted by CRR 2016

Location	CRR 2011 likely contamination/ potential for contamination presence	CRR 2016 change[28]
Salisbury	Notifiable activity for this land included scrap yard and land fill. These land parcels were identified as having previously contained a scrap yard or land fill.	CRR 2016 does not propose works at any of these locations.
Rocklea Station	The notifiable activity for this site included rail yards, engine reconditioning works, and service station.	
Moorooka Station	Notifiable activity for this site included hazardous contaminants.	
Clapham Yard	Notifiable activity listed included rail yards and petroleum product or oil storage.	
Yeerongpilly Station	Notifiable activity for this land included petroleum product or oil storage, foundry operations, petroleum product or oil storage.	
Southern portal	Located at Yeerongpilly, the notifiable activity for which this land parcel listed on the EMR indicated that contamination was present. The nature of the contamination was not established within the context of the CRR 2011 EIS.	The Southern portal for CRR 2016 is now located in rail corridor land north of Dutton Park Station. The notifiable activity for this land is hazardous contaminants. There is the potential for soil contamination to be intercepted at the southern construction worksites. The PA Hospital (adjacent the construction worksite) has also been listed on the EMR as notifiable activity of petroleum product and oil storage.
Boggo Road Station	None identified.	Boggo Road Station now located to the east of CRR 2011, largely within the rail corridor. The notifiable activity for this land is rail yards.
Woolloongabba Station	The site of the current GoPrint building was formerly a rail yard and remained on the EMR. The notifiable activity for which this land parcel was listed on the EMR indicated that contamination was present. The nature of the contamination was not established within the context of the CRR 2011 EIS. Further investigation and mitigation was proposed as part of the detailed design phase of works.	Woolloongabba Station is now located to the east of CRR 2011. The site is listed as a notifiable activity for rail yards and hazardous contaminants. There is the potential for soil contamination to be present in the vicinity of works at Woolloongabba. This may include residual soil and groundwater contamination due to the former use as a rail yard and potential to produce noxious or harmful gases. If encountered and left unmanaged, such ground gas has the potential to pose a risk to human health or result in explosive atmospheres.

[28] Extracts from Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement, Chapter 8. And Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Chapter 6.

Location	CRR 2011 likely contamination/ potential for contamination presence	CRR 2016 change[28]
Albert Street	Location of station within notifiable activity for petroleum product or oil storage. The site of the Royal on the Park was listed on the EMR for petroleum product or oil storage.	Albert Street Station is now located one block north from CRR 2011. Potential for contamination presence consistent with CRR 2011.
Roma Street Station	The Roma Street BTC was listed on the EMR for 'petroleum product or oil storage'. Lot 1 on SP207220 included a license for between 50,000 litres and 200,000 litres of on-site above ground flammable/combustible storage. The Roma Street Parkland occupies the site of the former Roma Street rail yards. The rail yard was remediated during redevelopment although the land parcels remain on the EMR. Further investigation was required to determine whether contamination remained on the site.	The CRR 2016 Roma Street Station is located further north-west of CRR 2011, beneath the existing Roma Street BTC site. The BTC tower is listed on the EMR for petroleum products/oil storage, consistent with CRR 2011. The nature of fuel storage at the site is not known. Hydrocarbon contamination is typically associated with soil, groundwater and ground gas (soil vapour) contamination. The notifiable activity for this land is rail yards.
Northern portal	The land parcels were identified as a former RAAF Store (Victoria Park).	The Northern portal for CRR 2016 is now located within the rail corridor. The notifiable activity for this site includes rail yards and hazardous contaminant. Potential for soil contaminants to be intercepted.
Exhibition Station	The notifiable activity for this site included petroleum products, oil storage, and hazardous contaminants. The notifiable activity for which these land parcels are listed on the EMR indicated contamination was present. For O'Connell Terrace, the notifiable activity included petroleum produce and oil storage.	Consistent with CRR 2011.
Mayne Yard	The notifiable activity for this site included rail yards, petroleum product or oil storage. Groundwater at Mayne Yard was known to be contaminated from a historic diesel release onsite and was undergoing remediation and monitoring. Flammable and combustible (F/C) liquids license records indicated the land parcel was a current license for the above ground storage of between 50,000 and 200,000 litres of F/C liquids.	Consistent with CRR 2011.

Table 4.2 Risk of potential contaminated properties adjacent to the construction footprint

Location	**CRR 2011 likely contamination / potential for contamination presence**	**CRR 2016 change[29]**
Adjacent to Salisbury Station	Notifiable activity for this site included landfill.	CRR 2016 does not propose works at any of these locations.
Adjacent to the Gold Coast and Beenleigh Lines on the east side of existing Rocklea Station	Notifiable activity for this site included paint manufacture or formulation.	
Adjacent to Rocklea Station	Potential notifiable activity at this site included- wood treatment or preservation.	
Adjacent to Clapham Rail Yard	Notifiable activity for this land included abrasive blasting; metal treatment or coating; petroleum product or oil storage. UST containing <50,000 litre flammable/combustible liquid.	
Part of Gold Coast and Beenleigh Lines immediately south of existing Yeerongpilly Station on west side of existing rail line	Notifiable activity at this site included rail yards.	
Adjacent to Southern portal	No contaminants identified.	The notifiable activity adjacent to this site is for petroleum product or oil storage.
Adjacent to Boggo Road Station	Notifiable activity for this site included rail yards.	Consistent with CRR 2011.
Adjacent to Woolloongabba Station	Notifiable activity for this site included rail yards.	Consistent with CRR 2011.
Adjacent to Albert Street Station	No contaminants identified.	The notifiable activity adjacent to this site is for petroleum product or oil storage.
Adjacent Roma Street Station	Notifiable activity for this site was for landfill. A review of the BCC landfill records indicated that this property was not a municipal landfill.	The notifiable activity adjacent this site is for petroleum product or oil storage. Roma Street Parklands is currently managed under a Site Management Plan. The area which has been remediated is located within 100m north of the proposed Roma Street Station and a containment cell housing contaminated material beneath the parkland is located within 200m north of the proposed Roma Street Station.
Adjacent to Exhibition Loop	The notifiable activity of hazardous contaminants for which this property was listed on	Consistent with CRR 2011.

[29] Extracts from Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement, Chapter 8 and Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Chapter 6.

Location	CRR 2011 likely contamination / potential for contamination presence	CRR 2016 change[29]
	the EMR indicated that contamination was present.	
Adjacent Mayne Yard	Notifiable activity for this site included petroleum product or oil storage/engine reconditioning works and rail yards as well as hazardous contaminants and scrap yards.	Consistent with CRR 2011.

(i) Contaminated groundwater

There is potential for a temporary increase in groundwater drawdown between Boggo Road Station and Woolloongabba Station for CRR 2016 given the changed tunnelling technique (mined) and alignment depth. This is a change from CRR 2011 with potential impacts during construction including an increased potential for discharge of potentially contaminated groundwater from worksites to surface water and restrictions on the utilisation and disposal of contaminated groundwater arising from dewatering of the below ground works.

(ii) Ground gas accumulation

Similar to CRR 2011, there is the potential for vapour or gas produced (soil gas) to be present where contamination or putrescible (decaying) material in soil and/or groundwater produces gas or is of a volatile nature. Soil gas has the potential to migrate into and accumulate in underground infrastructure (i.e. tunnels, stations and shafts) for CRR 2016. In general, the ground gas accumulation risk is consistent with CRR 2011.

4.2.2 Asbestos

The following sites (previously identified by CRR 2011) are known to contain asbestos material and are also relevant to CRR 2016:

- Woolloongabba Station - The GoPrint building is asbestos registered for the building and printery infrastructure; and
- Roma Street Station - The presence of asbestos containing materials was noted in the Asbestos Registers for QR facilities at Platform 10 and the BTC is likely to contain asbestos materials.

Additional sites now relevant to CRR 2016 which are known to contain asbestos material include:

- Dutton Park station/Southern portal - may contain asbestos materials identified on the Asbestos Registers for QR buildings or structures in this area; and
- Northern portal - asbestos containing material has been noted in the Asbestos Register for QR facilities in this location.

The demolition of buildings and construction of Boggo Road Station and Albert Street Station may also uncover asbestos material.

4.3 Changes to mitigation measures

4.3.1 Potential contaminated sites

Although there are changes to the location of contaminated sites intercepted by the CRR 2016 alignment, the mitigation measures are generally consistent with CRR 2011. These include undertaking further investigations to inform the risk posed from disturbance of contaminated soil and/or groundwater.

Mitigation measures no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to further site management strategies for Salisbury, Moorooka and Rocklea Station, Northern rail corridor and the Southern portal (Yeerongpilly).

Additional mitigation measures now relevant to CRR 2016, based on additional assessment work undertaken since CRR 2011[30] include:

- A Stage 1 and Stage 2 (as required) Detailed Site Investigation;
- Contaminated or unsuitable spoil material which cannot be used for spoil placement will be remediated or disposed of to landfill. Develop approaches to remediate contaminated or unsuitable material on site and minimise disposal to landfill, where possible;
- Construction activities relating to the disturbance, excavation, removal and/or disposal of contaminated soil and/or groundwater to be undertaken in accordance with the following:
  - Monitor the generation of contaminated dust during earthworks;
  - Implement appropriate erosion and sediment controls and staging of site activities to minimise the extent of disturbed areas and the potential run-off of contaminated soils;
  - Minimise the exposure of humans and the environment to potentially contaminated soils during excavation activities;
  - Implement controls for material haulage, such as covering loads or wetting material, to reduce airborne dust emissions;
  - Document all contaminated material during transport operations (including the descriptions of processes, personnel and organisations involved in the removal, transportation and placement of contaminated material);
  - Keep documented records of contaminated material movement and disposal;
  - Implement appropriate workplace health and safety procedures, including use of PPE and hygiene controls, and documentation of inspections and workplace health and safety compliance throughout construction and operation;
  - A disposal permit will be required for the removal and/or disposal of contaminated soil which are recorded on the EMR and CLR to an off-site location;
  - Updated EMR and CLR searches to be undertaken during detailed design; and
  - Off-site disposal of contaminated material will be to a licensed landfill facility.

(i) Contaminated groundwater

Mitigation measures which are consistent with CRR 2011 include the following:

- Groundwater monitoring to be undertaken to establish whether contamination is likely to be present in groundwater systems; and
- Where required, treat groundwater drawn into the Project infrastructure prior to discharge.

[30] Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Chapter 6.

Additional mitigation measures now relevant to CRR 2016 include:

- Undertaking a Stage 1 and Stage 2 (as required) Detailed Site Investigations to ascertain the risk posed from disturbance by the Project of potentially contaminated sites.

(ii) Ground gas accumulation

Additional mitigation measures now relevant to CRR 2016 include:

- Undertaking Stage 1 and Stage 2 (as required) Detailed Site Investigations to ascertain the risk posed from disturbance of potentially contaminated sites, including ground gas that may have accumulated from such sites;
- Where further investigations identify potential risks from ground gas, gas monitoring systems and alarms will be fitted in underground infrastructure to assess ambient gas concentrations, including oxygen, methane, carbon dioxide and carbon monoxide; and
- Where ground gas accumulation in underground work areas and/ or infrastructure is expected to occur, consider appropriate engineering controls to minimise the inflow of ground gas.

4.3.2 Asbestos

Additional mitigation measures now relevant to CRR 2016 include:

- Undertaking an Asbestos Management Plan prior to the commencement of demolition and construction works. This is based on additional assessment work undertaken since CRR 2011[31]. This is relevant for Dutton Park Station (Southern portal), Woolloongabba Station, Boggo Road Station, Albert Street Station, Roma Street Station and the Northern portal. Any asbestos contaminated soil is to be disposed of in accordance with the Asbestos Management Plan;
- An asbestos audit is to be undertaken by a licensed asbestos contractor, where buildings or structures are to be partially or fully demolished, including a review of applicable registers, prior to commencing demolition; and
- Analytical testing to be undertaken where asbestos is suspected in previously filled areas, to confirm the presence or absence of asbestos prior to intrusive works. If asbestos is present, manage asbestos containing materials in accordance with the relevant legislation and Codes of Practice.

4.3.3 Unforeseen contaminants

Mitigation measures consistent with CRR 2011 include the following:

- In the event of an incident, environmental health and safety management controls will be implemented, including regulator notifications as required, and the residual risk is expected to be low;
- In the event of encountering any unforeseen contamination, appropriate procedures and measures will be required for the notification, mitigation, investigation, remediation and validation of the contamination; and
- A Construction Occupational Health and Safety Plan will also be completed to manage exposure of construction workers to potential contaminants in soil and/or water. Contaminated land procedures to be completed for potentially contaminated sites includes:

---

[31] Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Chapter 6.

- Identification of the likely forms of contamination that could occur (e.g. fuels, oils, paints);
- Procedures for the appropriate storage of hazardous materials in compliance with relevant standards;
- The prevention of land contamination during construction;
- The identification, investigation and management of unforeseen contamination;
- Spill response and remediation;
- Listing properties on the EMR in accordance with the *Environment Protection Act 1994;*
- The management, remediation and disposal of contaminated soil and/or spoil generated from properties listed on the EMR/ CLR;
- Post construction management and/or monitoring requirements; and
- Approval and disposal permits for the removal of contaminated soil, as required.

4.4 Conclusion

Consistent with CRR 2011, there are a range of known registered contaminated sites at rail stations and tunnel portals and the possibility of encountering additional unforeseen contaminants during demolition and construction activities.

There is an increased potential for temporary groundwater drawdown between Boggo Road and Woolloongabba Station given the changed tunnel construction, alignment location and depth for CRR 2016. There are additional sites at the tunnel portals (QR buildings) which may contain asbestos material and require an Asbestos Management Plan. At Mayne Yard, the excavation work proposed for CRR 2016 will be undertaken generally in accordance with the QR Mayne Yard EMP. A Stage 1 and 2 Detailed Site Investigation will be required for CRR 2016 to manage all known and potential contaminated sites.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

5 Technical Report: Land use and tenure

5.1 Introduction

The key aspects addressed in the technical report include land use types, property requirements, land tenure, new and approved development, post-construction land use, and spoil movement. Overall, the potential impacts on land use and tenure for CRR 2016 have reduced due to the shortened alignment and surface works being predominantly contained within the existing rail corridor. While the extent of the alignment has changed, the type of land use impacts are generally consistent with CRR 2011.

5.2 Changes to potential impacts

5.2.1 Land use types

As with CRR 2011, land uses within and adjacent to the CRR 2016 reflect inner city and inner suburban land use types. These are a mix of commercial, light industrial, community and open space and residential uses. Key changes include the following:

- Overall there is a reduced impact on land uses, particularly for residential and light industrial properties, as the CRR 2016 alignment is shorter and does not include works south of Dutton Park Station;
- The CRR 2016 Northern portal and surface rail works are within the existing rail corridor north of Roma Street Station which significantly reduces the impact on Victoria Park; and
- In suburbs common to CRR 2011 and CRR 2016, most of the volumetric land use impacts[32] will be at slightly different locations due to the revised alignment.

Consistent with CRR 2011, construction of some of the below ground infrastructure (e.g. stations) may influence future development opportunities at some locations.

Key differences to land use impacts from CRR 2016 due to changes in alignment/station and construction worksites compared to CRR 2011 are summarised in Table 5.1.

Table 5.1 Key differences to land use – construction and operational impacts

Location	**Land use impacts**	
	CRR 2011	**CRR 2016**
Salisbury to Dutton Park Station	This section of the CRR 2011 project contained the most direct impacts on land use due to the surface works required for the Southern portal and Yeerongpilly Station, new surface tracks, station upgrades and ancillary infrastructure. The land uses impacted comprised a mix of industrial, commercial, residential and community uses.	CRR 2016 does not propose works at these locations and therefore there will be no impact on land use.

[32] Volumetric land use impacts relate to land below the surface of the property

Location	Land use impacts	
	CRR 2011	CRR 2016
Dutton Park Station to Boggo Road Station	Residential land was potentially impacted volumetrically. Land at Boggo Road Urban Village was directly impacted as it was required for construction and operation of the Boggo Road Station. Potential impact during construction on Boggo Road Gaol and the Ecosciences building (directly adjacent). There was construction impacts at Boggo Road Busway and Park Road Rail Station	The Boggo Road Station is located east of the CRR 2011 alignment. The existing land is currently vacant and zoned as Specialised Centre – major education and research. The construction of the rail station at this location will result in reduced land use impacts to the Ecosciences precinct (which contains sensitive equipment) and the Boggo Road Gaol, compared to CRR 2011. The ESA village (Leukaemia Foundation), located near to construction worksites will potentially be impacted by increased noise, vibration and dust impacts. During construction, there may also be temporary impacts on the Boggo Road Busway Station and Park Road Railway Station and impacts on residential land around Boggo Road Station, in particular, near Quarry Street. As part of the Boggo Road Station, there will be a dedicated pedestrian connection to the PA Hospital. Land at Joe Baker Street, and part of Boggo Road Urban Village, will be required for operational access of the Boggo Road Station. On completion of construction works, land around Boggo Road Station will be available for future development.
North of Boggo Road Station to Woolloongabba Station	Residential land and a block of commercial land along Reid Street, just south of the Woolloongabba Station would be impacted volumetrically. Land at Woolloongabba (the Queensland Government GoPrint site) would be impacted directly, as it was required temporarily for the Woolloongabba worksite. The Western portion of the GoPrint site was required permanently for the Woolloongabba Station and plaza, while the balance would be available for new development.	The location of Woolloongabba Station has moved to the east section of the GoPrint site. The GoPrint building, Landcentre and Dental Clinic will be demolished prior to construction. Residential land from Quarry Street residential and commercial land on Hubert Street, south of the Woolloongabba Station will be impacted volumetrically. Additionally, an area north of Vulture Street (at the St Nicholas Russian Orthodox Church) will be impacted volumetrically. The Woolloongabba Busway Station adjoins the Woolloongabba Station and will be volumetrically impacted above the station by a new pedestrian connection to the Woolloongabba Busway Station and Stanley Street. There are further opportunities for changes to pedestrian connections to Gabba Stadium, Vulture Street and the busway. It is considered that construction land use impacts at this location will be greater than CRR 2011 due to the increased area and scale of work activities proposed here. On completion of construction works, land adjacent to the Woolloongabba Station will be available for development. Opportunities for improved land use will be available due to its planning designation.
North of Woolloongabba Station to Albert Street Station	Volumetric impacts to medium and low rise multi-unit residential land, St Joseph's Primary School, open space at Kangaroo Point cliffs, the City Botanic Gardens,	The CRR 2016 alignment under Kangaroo Point would volumetrically impact the predominantly single unit and low rise multi-unit residential area just west of Main Street. The alignment avoids the

Location	Land use impacts	
	CRR 2011	CRR 2016
	the Brisbane River, and high and low-rise mixed use commercial and residential properties in the CBD. The development of Albert Street Station required permanent lane closure along part of Alice Street, the resumption of ten small commercial sites along Albert Street and the Royal on the Park hotel site. Increased pedestrian areas needed for the Albert Street station required reduced lane widths at Margaret and Mary Street intersections with Albert Street.	St Joseph's Primary School and the Brisbane Temple – Church of Latter-day Saints. The CRR 2016 alignment is the same as the CRR 2011 alignment from the Kangaroo Point cliffs to Albert Street Station, therefore CRR 2016 land use impacts are mostly consistent with CRR 2011 in these locations. The location of the Albert Street Station has moved one block north-west toward Elizabeth Street. Albert Street may be pedestrianised and permanently closed to vehicle traffic between Mary and Charlotte Street and may be pedestrianised between Charlotte Street and Elizabeth Street with some limited local traffic access for service vehicles only. This opportunity may also require closure or reconfiguration of the Myer Centre car park exit ramp located on Albert Street, which could be relocated to Charlotte Street. Albert Street Station requires the demolition of the same ten small commercial properties located on the north-west corner of the Albert Street intersection with Mary Street and one medium rise commercial building on the south-west corner of this intersection. Compared to CRR 2011, there are no requirements for a lane closure on Alice Street nor the resumption of the Royal on the Park site. The construction related impacts have generally increased due to the proposed construction techniques, road closure requirements and station entrance locations including pedestrianisation of part of Albert Street, however the period of disruption would be reduced compared to CRR 2011.
West of Albert Street Station to Roma Street Station	Low to high rise mixed use commercial and residential properties in the CBD would be impacted volumetrically. There were impacts on Roma Street Railway Station platforms, the Inner Northern Busway, Emma Miller Place and Roma Street Parkland Boulevard.	The CRR 2016 alignment and volumetric impact is the same as the CRR 2011 alignment between Albert Street Station and Turbot Street. The CRR 2016 alignment differs in the location of Roma Street Station, being located approximately 200m west of the CRR 2011 location. To cater for this new station location, the alignment has volumetric impacts on the State Law Courts (corner Roma Street and George Street) and mixed commercial and residential sites along George Street between Herschel Street and Makerston Street. The CRR 2016 Roma Street Station requires the demolition of the BTC West Tower and coach ramp. Compared to CRR 2011, there is reduced impacts on parkland, such as Emma Miller Place, but increased impacts to commercial and residential properties from construction of the station. On completion, land adjacent to Roma Street Station may offer opportunities for more entrances

Location	Land use impacts	
	CRR 2011	**CRR 2016**
		to the Roma Street Station area through integration with future development.
North of Roma Street Station to Exhibition Station	Roma Street Parklands, property at Gregory Terrace in Spring Hill and Brisbane Girls Grammar School (BGGS) at Gregory Terrace had potential volumetric land use impacts. A part of Victoria Park would be permanently volumetrically and directly impacted by tunnels, cut and cover and dive structures for the Northern portal, new surface rail lines / corridor, and a further part temporarily impacted by the worksite during construction. RNA Showgrounds would be temporarily and permanently directly impacted by the new additional rail lines and the new Exhibition Station. A portion of the west showgrounds land beside the existing rail corridor from O'Connell Terrace to the southern end of the existing station would be required permanently and a further narrow strip of land was required to the west and east showgrounds along the O'Connell Terrace frontage. Four vacant properties on the north side of O'Connell Terrace were directly impacted for construction of the new widened road bridge over the tracks.	Hardgrave Park, the Northern Busway and the Brisbane Grammar School (BGS) will have potential volumetric land use impacts. The CRR 2016 Northern portal will be located within the existing rail corridor, avoiding the CRR 2011 permanent direct requirements from Victoria Park. Small areas of the eastern ends of Victoria Park, north and south of the rail and ICB corridor, currently used as a worksite and a park maintenance depot, will be temporarily impacted as a CRR 2016 worksite. Near the southern worksite, there will also be temporary realignment to some existing cycle and pedestrian paths off Gregory Terrace, consistent with CRR 2011. Land use impacts at the RNA Showgrounds from the CRR 2016, Exhibition Loop rail lines and station will be slightly reduced compared to CRR 2011. The extent of permanent and temporary land requirements for CRR 2016 will be slightly less than CRR 2011.
North of Exhibition Station to Mayne Yard	Land was permanently required north of O'Connell Terrace for additional track and realignments, and a feeder station near Mayne Yard. In addition, a viaduct extended through the east side of Mayne Yard to the merge at the Breakfast/Enoggera Creek rail bridge.	Land use impacts in this section are generally consistent with CRR 2011, although there is a change in CRR 2016 to two individual tracks on different ground level alignments through Mayne Yard with a portion of one in a trough (underpass). One less private property would be impacted by acquisition for CRR 2016.
North of Mayne Yard	CRR 2011 works were not proposed north of Breakfast/Enoggera Creek.	The CRR 2016 alignment will follow the existing rail corridor and extends northwards connecting in with the existing northern lines just south of Albion Station.

5.2.2 New completed and approved development

Since 2011, a number of major developments have been constructed and approved within the vicinity of the CRR 2016 alignment, particularly around Albert Street Station, at Kangaroo Point and near the proposed Woolloongabba Station and Boggo Road Station. These are mostly a range of residential and mixed-use developments. Further information in relation to those developments which may potentially have a cumulative impact on CRR 2016 are discussed within Technical report 19 (Cumulative impacts). These developments have been considered and accommodated in the CRR 2016 design.

5.2.3 Property requirements

At the time of its EIS assessment, the CRR 2011 project identified a total of 412 properties that would have been impacted by a whole or partial acquisition. Of these, 108 properties were required for surface works and 304 were for volumetric acquisition for underground tunnels and stations.

Current land use for 2017 against the CRR 2011 project show a slight increase of the total properties requiring acquisition from 412 to 422. This increase is most likely due to subdivision of land on existing sites.

There is a substantial reduction of property acquisitions required for CRR 2016, with a total of 224 properties, comprising 29 properties required for surface works and 195 required for volumetric acquisition for underground tunnel and station works.

Surface acquisitions of commercial / industrial sites have reduced from 60 to 15, surface acquisition of residential sites have reduced from 39 to zero and volumetric acquisitions for residential sites have reduced by 94.

A breakdown of surface and volumetric property requirements by land use type is provided in Table 5.2. Overall, this indicates that there are less properties (both at surface and below) that require acquisition for CRR 2016 compared to CRR 2011, mainly due to the reduced tunnel length.

Table 5.2 Number of properties[33] required by land use type

Property Acquisition – Land Use Type	CRR 2011*	CRR 2011 (current land use)**	CRR 2016
Surface Acquisition – number of properties			
Residential	39	44	0
Commercial / Industrial	60	60	15
Other (park, showground, and so on)	9	12	14
Total properties requiring surface acquisition	108	116	29
Volumetric Acquisition – number of properties			
Residential	235	244	141
Commercial / Industrial	50	43	38
Other (park, showground, and so on)	19	19	16
Total properties requiring volumetric acquisition	304	306	195
Total properties requiring acquisition	**412**	**422**	**224**

* Property numbers based on ownership, development and uses of properties as at July 2011
** Property numbers based on ownership, development and uses of properties as at February 2017

[33] Property numbers exclude existing roads, busways and railway properties.

5.2.4 Land tenure

As with CRR 2011, properties directly affected and requiring standard or volumetric acquisition for CRR 2016 comprise of a mix of tenure types, including state land lease, freehold, reserves, roads, deeds of grant and tidal waterway. The way in which land tenures are to be dealt with for CRR 2016 will be consistent with CRR 2011 and normal practice for rail corridors and stations, and any surplus land.

5.2.5 Post-construction land use

The plan for post-construction land use from CRR 2016 remains consistent with CRR 2011. This includes:

- Following completion of construction, land that is not required for the rail infrastructure and operation may become available, where appropriate, for redevelopment, in accordance with the relevant planning framework;
- While redevelopment will be separate from the Project, investigations will be undertaken to integrate residual land with adjoining proposed rail stations; and
- Opportunities to integrate with other proposed developments and community facilities.

5.3 Changes to mitigation measures

Mitigation measures which are consistent with CRR 2011 include the following:

- Ongoing consultation to be undertaken with key stakeholders in relation to future development;
- Ongoing consultation to be undertaken with the RNA with regard to the design, access, heritage and construction schedules of CRR 2016;
- Access to adjoining properties and access for delivery vehicles to be maintained, where practicable. Where changes to access are required, alternative access arrangements to be identified in consultation with property owners and local businesses;
- Safe and efficient access to major land uses such as the RNA Showgrounds, Gabba Stadium, Suncorp Station, and Roma Street Parklands, particularly during major events;
- Implement appropriate environmental measures aimed at reducing potential construction impacts such as noise and vibration, dust, emissions and odours and construction traffic; and
- Access for emergency services vehicles to be maintained for the duration of construction works.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to consultation with property owners and developers around Yeerongpilly and minimising loss of pre-1946 character housing around Yeerongpilly.

Additional mitigation measures now relevant to CRR 2016 include:

- Minimise the size of CRR 2016 permanent and construction worksite footprints to reduce impacts on existing land uses through design refinement;
- Undertake ongoing consultation with QR regarding post construction use of QR land required for the construction worksites; and
- Undertake ongoing consultation with relevant parties where disruption to land uses and facilities are required.

5.4 Conclusion

In general, land use and tenure impacts have decreased given the shortened alignment of CRR 2016. In particular, there is a substantial reduction of property acquisitions required for the project, with a total of 225 properties requiring either surface or volumetric acquisition, compared to 412 for CRR 2011. The way in which land tenures are to be dealt with for CRR 2016 will be consistent with CRR 2011 and normal practice for rail corridors and stations, and any surplus land.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

6 Technical Report: Visual amenity and lighting

6.1 Introduction

The key aspects discussed in this technical report relate to the changes to visual amenity, lighting and the landscape. Visual amenity relates to the anticipated change to representative viewpoints that are expected to occur during construction and operation.

Representative viewpoint locations have been assessed with reference to previous studies[34] to assist with analysing potential changes. The visual assessment is accompanied by photographs and photomontages to illustrate how CRR 2016 may change the landscape. A review of lighting has been undertaken and the effect of project changes on the landscape has been assessed for the elements that contribute to the character of each precinct. A review of landscape and visual baseline conditions was completed as well as a site survey to record and confirm the landscape and visual impacts associated with CRR 2016.

The form and nature of landscape and visual impacts are considered to be generally consistent with the impacts identified for CRR 2011, however the location of impacts will differ as a result of the changes to the alignment and location of underground stations. Lighting impacts are also generally consistent with the impacts identified for CRR 2011. During operation the CRR 2016 proposed station architecture and public realm will result in a beneficial outcome, consistent with CRR 2011.

Key changes relate to an increase in potential adverse impacts at Roma Street Station during the demolition phase of works, reduced adverse impacts to Victoria Park as a result of the CRR 2016 Northern portal being relocated to within the existing rail corridor and a reduced impact at Mayne Yard with the removal of the previously proposed viaduct structure.

6.2 Landscape

6.2.1 Changes to potential impacts

Table 6.1 summarises the changes to landscape impacts during construction and operation of CRR 2016, compared to CRR 2011. For the purposes of providing a summary of changes, the following terms (from previous studies) have been interpreted to result in adverse impacts:

- Visual clutter;
- Removal/impact on mature trees;
- Loss of open space;
- Loss of properties;
- Loss of vegetation; and
- Decline in visual exposure.

Where the level of impacts is undefined in previous studies, the following terms have been interpreted to result in beneficial impacts:

- Enhance;

[34] Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement. And Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement.

- Improve;
- Positive;
- Catalyst for rejuvenation;
- More active street frontages;
- Increased variety of uses;
- Visually appealing; and
- Positive urban and architectural design quality.

Table 6.1 Changes to potential landscape impacts

Location	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
Salisbury to Dutton Park Station		
The CRR 2011 alignment commenced at Salisbury with localised widening and surface works within the existing rail corridor. Further north the alignment extended to the west of Moorooka on viaduct before moving in to tunnel at Yeerongpilly. The key components of the CRR 2011 alignment that had the potential to result in adverse landscape impacts included a new pedestrian overpass at Fairlee Terrace and Heaton Street, a rail over-bridge at Muriel Avenue, the realignment of the Ipswich Road on-ramp, a grade separated bridge at Moolabin Creek, a viaduct within Clapham Rail Yard, a Southern portal and dive structure and a new station at Yeerongpilly.	The CRR 2016 project commences at Dutton Park Station. There will be localised widening within the existing rail corridor just north of Dutton Park Station. A construction worksite (for the Southern portal) will extend to the south east of the rail alignment along Kent Street with space for light vehicle parking, worksheds, laydown and offices. The reduction in length of the alignment and removal of proposed infrastructure between Salisbury to Dutton Park Station results in a reduced level of potential impacts in these locations.	The reduction in the rail alignment length and associated infrastructure requirements will result in reduced potential landscape impacts during operation than CRR 2011 (resulting from the presence of infrastructure).
Boggo Road Station		
The CRR 2011 Boggo Road Station was situated along 'The Boulevard,' west of the Ecosciences building. The CRR 2016 station will be situated in close proximity to the Boggo Road Busway Station and Park Road Railway Station to establish a key multi-modal interchange. For CRR 2016, an existing QR building on the north-east side of the existing Park Road Railway Station will need to be demolished and Outlook Park will be required for station infrastructure.	During construction, a site compound will be situated along the southern extent of Joe Baker Street and will accommodate offices, generators, water treatment sites, ramps for partial tunnel excavation, temporary noise barrier, worksheds and laydown areas. The form and nature of construction phase impacts will be consistent with the impacts identified for CRR 2011, however the anticipated location of impacts will be different. The CRR 2016 works are also anticipated to result in a reduced level of impact to the Ecosciences building and the State Heritage listed Boggo Road Gaol.	The CRR 2016 project is considered to result in a beneficial impact on the landscape resource and the existing station precinct during operation, including a reduced level of impact to the Ecosciences building and the State Heritage listed Boggo Road Gaol. Opportunities to relocate facilities currently contained within Outlook Park will be explored in consultation with BCC. Overall, CRR 2016 is considered to result in a beneficial impact, which is consistent with CRR 2011.
Woolloongabba Station		

Location	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
The CRR 2016 Woolloongabba Station will be positioned on the eastern side of the GoPrint site, approximately 120m east of the previous CRR 2011 alignment. The revised horizontal alignment is positioned to respond to the future growth potential of the Woolloongabba precinct and to better integrate with the Woolloongabba Busway Station. The CRR 2016 works will require the demolition of the GoPrint building, Landcentre and Dental Clinic to facilitate the tunnelling and station construction phase.	The CRR 2016 construction worksite will be larger and will accommodate offices, car parking, water treatment, a substation, workshop, an acoustic shed, as well as spoil and TBM segment storage. The construction phase impacts for CRR 2016 will be consistent with CRR 2011 as much of the site was previously allocated for construction phase processes. Spoil volumes at Woolloongabba Station will be slightly greater than CRR 2011, however this is considered to result in a negligible increase in potential impact due to the site previously being allocated for construction phase processes.	During operation, the precinct benefit from improved access to multi-modal public transport. The Woolloongabba Station will be designed to respond to anticipated growth in this area, whilst also allowing direct access to the Gabba Stadium. On completion, CRR 2016 is considered to result in a beneficial impact, which is consistent with CRR 2011.
Albert Street Station		
The CRR 2016 Albert Street Station will be positioned one block further to the north of the CRR 2011 position. During the operational phase, an opportunity exists to permanently close to vehicle traffic and pedestrianise the section of Albert Street between Mary Street and Charlotte Street and between Charlotte and Elizabeth Street (local traffic access being retained in this latter section). As part of this, the existing Myer Centre car park exit on Albert Street may be closed or relocated to Charlotte Street (heading towards George Street). The CRR 2016 project requires the demolition of some properties located north of the intersection with Mary Street on either side of Albert Street.	The scale of the construction phase impacts for the landscape will be consistent with those identified for CRR 2011, although the location of impact will be different. In addition, CRR 2016 only requires one main construction worksite, compared to two for CRR 2011. Some temporary construction activities would take place for the relocation of the Myer Centre car park exit ramp, if required. The CRR 2016 station construction worksite will be utilised to provide space for laydown, offices, an acoustic shed, and water treatment.	The CRR 2016 project is considered to have a beneficial impact on the landscape resource and the existing precinct, which is consistent with CRR 2011. In particular, CRR 2016 has been designed to respond to the BCC Master Plan - Albert Street Vision by proposing to pedestrianise parts of Albert Street. The section of Albert Street between Mary Street and Charlotte Street would be fully pedestrianised with two escalators and a lift to provide access to the concourse and platform level. A third escalator would also be positioned in a newly pedestrianised section of Albert Street between Charlotte Street and Elizabeth Street (with some local traffic access retained). The newly created public realm would also provide a series of public spaces that expand on the BCC vision for Albert Street.

Location	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
Roma Street Station		
The CRR 2016 Roma Street Station is positioned to the west of the location proposed for CRR 2011. It is anticipated to act the city's primary multi-modal transport interchange. The CRR Roma Street Station requires the demolition of the BTC West Tower and coach ramps.	The CRR 2016 construction worksite is located to reflect the new station location and will provide room for laydown areas, parking, offices, an acoustic shed, water treatment, and truck access. It is anticipated that construction works will result in an increase in potential impacts in comparison to CRR 2011 as a result of the increased extent of demolition. However, impacts on Emma Miller Place will be reduced in line with the construction worksite being to the west of the Roma Street Parkland entrance. Overall, the CRR 2016 construction impacts on the landscape at Roma Street are greater than CRR 2011.	During operation, the CRR 2016 Roma Street Station will provide a catalyst for change, including opportunities to unlock the north-west of the city and improve views of the heritage listed Roma Street station building and its interface with the surrounding precinct. The CRR 2016 project is considered to have a beneficial impact on the landscape resource and the existing station precinct during operation. Therefore it will be consistent with CRR 2011.
Exhibition Station		
CRR 2016 Exhibition Station will be in a similar location to CRR 2011, although O'Connell Terrace bridge will no longer require widening and raising. Enhanced pedestrian access will be provided between Exhibition Station and both O'Connell Terrace and Bowen Bridge Road. A new track will be provided on structure at surface level. A number of properties situated on O'Connell Terrace will also require demolition.	The construction phase will result in the expansion of the existing rail corridor, extending into the RNA Showground. Impact on the mature fig trees will be slightly reduced compared to CRR 2011. It is anticipated that parts of the RNA Showground will be utilised as a construction compound for the extent of the works and comprise of a laydown area, office and workshop/storage. The CRR 2016 project occupies a slightly smaller construction worksite compared to CRR 2011 and will result in slightly reduced impacts.	The Exhibition Station will provide a new station in close proximity to the new mixed use development proposed as part of the RNA Showground master plan. The CRR 2016 project is considered to have a similar impact on the landscape resource and the existing station precinct compared to CRR 2011.
Mayne Yard		
At Mayne Yard, CRR 2016 includes two new tracks, one situated at-grade and traversing the western area of Mayne Yard and one traversing the eastern area of Mayne Yard. The latter track will be partly contained within a trough (underpass).	For CRR 2016, the southbound track will partially be contained within a trough structure. This will result in a more intrusive construction method, however, the works would remain within the existing rail corridor.	During operation, landscape impacts are considered to be reduced compared CRR 2011 due to the removal of the viaduct structure.

Location	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
This is different to CRR 2011, which included a viaduct structure accommodating both tracks. The new CRR 2016 tracks will connect to the existing network north of the Breakfast/Enoggera Creek rail bridge and just south of Albion Station (within the existing rail corridor).	The construction of the viaduct (9m above ground level) proposed for CRR 2011 would have more apparent within the landscape with the presence of cranes and elevated construction activities. Impacts during construction for CRR 2016 are generally consistent with CRR 2011, although likely to be less visually evident as a result of removal of the viaduct structure.	

6.3 Summary of potential landscape impacts during construction and operation

Potential adverse landscape impacts during construction will be consistent to those identified for CRR 2011 at Boggo Road Station, Woolloongabba Station and Albert Street Station. At Roma Street Station, there will be an increase in potential adverse impacts due to the increased demolition phase of works, however the impact on Emma Miller Place will be reduced. At Exhibition Station, construction impacts will be slightly reduced and at Mayne Yard, construction impacts will be consistent with CRR 2011, although less visually evident.

When operational, Woolloongabba Station, Boggo Road, Albert Street Station, Roma Street Station and Exhibition Station will all have a beneficial landscape impact, consistent with CRR 2011. At Mayne Yard, CRR 2016 will be less visually evident with the removal of the previously proposed rail viaduct structure.

6.4 Visual amenity and lighting

6.4.1 Changes to potential impacts

A comparative visual assessment has been undertaken with reference to the landscape and physical environment (refer to Table 6.2). Viewpoints have been selected with reference to CRR 2011 to comparatively document changes and are illustrated in Figures 6.1 to 6.5.

Viewpoint locations include:

- **Viewpoint 1** | *Boggo Road Station*: Joe Baker Street looking north east;
- **Viewpoint 2** | *Woolloongabba Station*: Stanley Street looking north towards the Queensland Government Landcentre;
- **Viewpoint 3** | *Albert Street Station*: Looking south-east down Albert Street at Charlotte Street intersection;
- **Viewpoint 4** | *Roma Street Station*: Corner of George Street and Roma Street looking north-west; and
- **Viewpoint 5** | *Exhibition Station*: Bowen Bridge Road looking north-east.

In addition to the representative viewpoints, a summary of the potential impacts on Victoria Park and Mayne Yard has been provided.

The CRR 2011 EIS[35] provides a description of the lighting sources anticipated during construction and operation. The CRR 2016 construction lighting is anticipated to be consistent with CRR 2011, although at slightly different construction worksite locations. The CRR 2016 operational lighting is also anticipated to be consistent with the operational lighting for CRR 2011, although it no longer includes lighting of the ventilation or emergency access building at Fairfield. The following sections describe lighting during construction and operation in further detail.

Construction lighting

During construction, night lighting will be required at a number of locations for any night time activities undertaken within the worksites and for personal and property safety. All of the worksites require appropriate security lighting to ensure the safety and security of personnel and property.

[35] Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement, Chapter 10.

While most night time activities will be undertaken underground or within the confines of the acoustic sheds, some works may require external lighting.

Lighting generated at external locations within the construction worksites may be visible from nearby sensitive receptors. Although lighting will be focussed over the particular points of interest, some light trespass will be likely. Depending on the activities undertaken and the worksites' proximity to sensitive receptors, some sites are likely to have a greater potential impact than others.

Construction lighting near active rail and road corridors will need to be considerate of operational signal lighting. The use of lighting that impedes the effective operation of these signal lights could result in implications to train or traffic movements.

Residential properties with limited visual barriers, such as high fences or vegetation, could be susceptible to light glare from passing construction vehicles.

Operational lighting

Once operational, the Project's lighting requirements will be similar to lighting requirements on Brisbane's existing rail network. Generally, light will be provided to improve amenity and safety and will be consistent within the urban environment.

Lighting along surface tracks will be minimal and in line with current QR lighting requirements. Due to the low lighting requirements, it is unlikely that the additional surface tracks provided (north of the Northern portal and south of the Southern portal) will generate light impacts on sensitive receptors. However, the increased frequency of trains operating on the network as a result of the Project may increase the frequency of light impacts associated with train operations in some areas.

Consistent with CRR 2011, surface rail stations will be lit as per the requirements of the *Disability Discrimination Act 1992* and QR standards. Lighting will be required to illuminate platform, mezzanine, concourse and entrance areas to ensure safe and equitable access from the station entrance to the train. In coordination with other security measures, lighting will also be used as a deterrent to crime. Some light trespass and glare may be experienced at sensitive receptors located near stations.

The external lighting for the underground stations will primarily be required to provide safe and equitable access into the stations. Due to the nature of the substantially illuminated environments where these stations will be located, it is unlikely that the entrance lighting will present any additional impacts.

Table 6.2 Changes to potential visual amenity impacts

Context	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
Boggo Road Station		
The CRR 2016 Boggo Road Station will be situated near the intersection of Boggo Road and Joe Baker Street and provide connections to Boggo Road Busway Station, PA Hospital and Park Road Rail Station. The initial public realm design seeks to retain and promote the panoramic views of Mt Coot-tha, the CBD and the inner city suburbs along the Brisbane River. The representative viewpoint is positioned on Boggo Road looking north-east towards the proposed station and is illustrated in Figure 6.1.	During construction, the worksite will be situated along the southern extent of Joe Baker Street and will be visible from the representative viewpoint location. The construction worksite may be enclosed with construction site hoarding. During construction, the existing elevated panoramic view will be restricted. The overall form and nature of potential construction phase impacts will be consistent with CRR 2011, although at a different location. As such, the construction phase impacts will be consistent with the level of impact identified in CRR 2011.	The CRR 2011 report identifies that replanting trees lost during construction and development of the site will reduce the prominence of permanent structures. The CRR 2016 station design will respond to the valued panoramic views experienced at this location with trees positioned to frame views on the approach to the station. The station architecture and public realm has the potential to have a positive impact on the area resulting in an enhanced site character and beneficial impact during operation. Figure 6.1 shows the visibility of the proposed station from the representative viewpoint. Overall, Boggo Road Station will have a positive influence on the visual amenity of the area.

Figure 6.1 Boggo Road Station (existing viewpoint and on completion)

Context	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
Woolloongabba Station		
The CRR 2016 Woolloongabba Station will be situated between the existing GoPrint building and Queensland Government Landcentre building with pedestrian access to the Woolloongabba Busway Station. The representative viewpoint is located on Stanley Street looking north to the proposed station location and is illustrated in Figure 6.2.	The construction phase impacts in relation to visual amenity will be similar to CRR 2011 with the construction worksite being clearly visible from the representative viewpoint location. Overall, the impacts are consistent with CRR 2011.	The station architecture and public realm will be directly visible from Stanley Street and any future development. Consistent with CRR 2011, the operational phase will have a positive impact on the area and result in an enhanced site character. Figure 6.2 shows a conceptual illustration of the visibility of the station looking north from Stanley Street.

Figure 6.2 Woolloongabba Station (existing viewpoint and on completion)

Context	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
Albert Street		
The CRR 2016 Albert Street Station will have entries situated between Mary Street and Elizabeth Street. Sections of Albert Street may be pedestrianised and permanently closed to traffic between Mary Street and Charlotte Street and pedestrianised and closed to through traffic between Charlotte Street and Elizabeth Street. The area currently contains an active streetscape that is enclosed by the adjacent character buildings and modern residential and commercial towers. The representative viewpoint is positioned on Albert Street looking south east at the Charlotte Street intersection and is illustrated in Figure 6.3.	The CRR 2016 Albert Street Station worksite will be enclosed by boundary hoarding that would be visible from the representative viewpoint location. Potential visual amenity impacts during construction are considered to be consistent with CRR 2011 although the location will be different.	Consistent with CRR 2011, the design is considered to have a positive influence on visual amenity with the potential to offer an improved streetscape and series of public spaces. Figure 6.3 shows a conceptual illustration of the visibility of the station.

Figure 6.3 Albert Street Station (existing viewpoint and on completion)

Context	**Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)**	**Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)**
Roma Street Station		
The CRR 2016 Roma Street Station is positioned beneath the existing BTC (West Tower) site. It is anticipated to act the city's primary multi-modal transport interchange. The representative viewpoint is located on the corner of George Street and Roma Street looking north-west towards the BTC and is illustrated in Figure 6.4.	Construction works will be visible from the adjacent buildings and the surrounding road network and result in an increase in potential visual impacts at this location compared to CRR 2011, which did not propose any works here. No visual impacts are anticipated at Emma Miller Place, which was required for construction activities in CRR 2011. Overall, the impact on visual amenity in the area of the Roma Street Station construction works will increase compared to CRR 2011 due to the changed station location and demolition phase of works.	The CRR 2016 project will have a positive influence on the visual amenity of the area. The outcome is consistent with CRR 2011 but at a different location. In its new location, the CRR 2016 Roma Street Station is considered to have greater potential to catalyse the redevelopment of the Roma Street Station precinct. Figure 6.4 shows a conceptual illustration of the visibility of the station

Figure 6.4 Roma Street Station (existing viewpoint and on completion)

Context	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
Exhibition Station		
The Exhibition Station will be in a similar location to CRR 2011. The viewpoint is located on the corner of Bowen Bridge Road and O'Connell Terrace north-east towards the proposed station location and is illustrated in Figure 6.5.	The construction phase will result in the expansion of the existing rail corridor. It is anticipated that the construction site will be enclosed by boundary hoarding reducing low level views to the construction works. The CRR 2016 project occupies a slightly reduced construction area and will result in slightly reduced visual impacts to CRR 2011.	Once operational, the CRR 2016 project is considered to have a similar impact on the visual amenity of the existing station precinct. Overall, it is considered to have a beneficial impact, consistent with CRR 2011. Figure 6.5 shows a conceptual illustration of the visibility of the station.

Figure 6.5 Exhibition Station (existing viewpoint and on completion)

Context	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
Mayne Yard		
At Mayne Yard, CRR 2016 includes two new tracks, one situated at-grade and traversing the western area of Mayne Yard and one traversing the eastern area of Mayne Yard. The latter track will be partly contained within a trough (underpass). This is different to CRR 2011, which included a viaduct structure accommodating both tracks. The new CRR 2016 tracks will connect to the existing network north of the Breakfast/Enoggera Creek rail bridge and just south of Albion Station (within the existing rail corridor).	The construction of the viaduct for CRR 2011 would have been visible in the surrounding landscape. The trough structure for CRR 2016 is anticipated to be less visible during construction, resulting in a reduced level of potential impacts at this location, however CRR 2016 also requires track works in a different part of Mayne Yard. Overall, impacts on visual amenity at Mayne Yard are generally consistent with CRR 2011.	The visual impact associated with CRR 2016 at Mayne Yard during operations is considered to be reduced compared to CRR 2011 due to the viaduct structure no longer being proposed.

Context	Changes to construction impacts (a comparison between CRR 2011 and CRR 2016)	Changes to operational impacts (a comparison between CRR 2011 and CRR 2016)
Victoria Park		
The CRR 2011 alignment positioned the Northern portal along the northern edge of Victoria Park between the ICB land bridge and Bowen Bridge Road. Additional land was required within Victoria Park for CRR 2011 for the cut and cover and dive structures. The CRR 2016 alignment positions the Northern portal structure within the existing rail corridor to minimise encroachment on Victoria Park.	The CRR 2016 design has been refined to reduce permanent impacts on Victoria Park associated with the Northern portal. There will also be no loss of mature trees. As part of construction works, there will be some localised relocation or temporary realigning of a bikeway (similar to CRR 2011) and worksite activities at the existing BCC temporary staging facility. The CRR 2016 construction phase will have a substantially reduced visual impact at Victoria Park compared to CRR 2011.	The CRR 2016 operational phase is considered to result in a substantially reduced visual impact compared to CRR 2011. The relocation of the Northern portal structure will ensure the existing visual amenity of Victoria Park is maintained.

6.4.2 Summary of potential visual impacts during construction and operation

Potential adverse visual impacts during construction will be consistent with those identified for CRR 2011 at Boggo Road Station, Woolloongabba Station and Albert Street Station, although at slightly different worksite locations. At Roma Street Station, there will be an increase in adverse visual impacts due to the increased demolition works, however the impact on Emma Miller Place will be reduced. At Exhibition Station, it will occupy a slightly reduced construction area and at Mayne Yard, construction impacts are consistent with CRR 2011, although slightly less visually evident. The relocation of the Northern portal structures will substantially reduce the adverse visual impacts at Victoria Park during construction.

When operational, Woolloongabba Station, Boggo Road Station, Albert Street Station, Roma Street Station and Exhibition Station will all have a beneficial visual impact, consistent with CRR 2011. CRR 2016 will maintain the existing visual amenity of Victoria Park with substantially reduced adverse visual impacts compared to CRR 2011. The operation of the Project at Mayne Yard will also have a reduced impact on visual amenity compared to CRR 2011.

6.5 Changes to mitigation measures

Mitigation is an integral part of the design process for CRR 2016 by informing station architecture and public realm design. The design approach has evolved since CRR 2011 although broadly the criteria are comparable. A key design change since 2011 is the reduction of the anticipated scale of architectural features at stations to allow the public realm to be a dominant part of the station experience. Further detail on the initial station architecture and public realm design response is provided within Appendix C1.

This section provides an outline of changes to mitigation measures. These are in addition to the urban design treatments, streetscape improvements and other measures included as part of the Reference Design Drawings (Volume 3).

Mitigation measures which are consistent with CRR 2011 include the following:

- Worksites should be designed and located to minimise potential impacts on the landscape amenity of open space and park areas;
- A visual mitigation plan should be prepared prior to construction to mitigate potential visual impacts of noise barriers and hoardings, where appropriate;
- Revegetate, rehabilitate and enhance open space areas disturbed or damaged by construction works as soon as practicable following construction;
- Where appropriate, compensatory plantings should be undertaken to replace vegetation removed for the Project;
- Implement directionally-controlled shielded lights that are mounted at a sufficient height to allow the light to be focussed appropriately on the target and to minimise light spill. Use lights that have a low wattage;
- Where possible, minimise external night time construction activities and traffic movement within the worksites. Use access routes that avoid local roads that are fronted by sensitive receptors;
- Lighting systems should be implemented through consultation with the relevant road or rail authorities;
- Implement light barriers between the Project and adjacent road corridors;

- Noise barriers should where possible be designed to reduce potential visual impacts from surrounding properties and roadways by:
  - incorporating high quality materials and urban design and landscape treatments, including where appropriate, landscape elements such as low, massed plantings;
  - allowing, where appropriate, more expansive views, including maintaining existing views beyond the rail corridor, through the use of clear or transparent materials panelling; and
  - maintaining existing breezes.
- Look at providing enhanced landscape and streetscape amenity on streets connecting to stations;
- Soften the visual impact of Project elements, such as the stations, though the use of landscaping, including where appropriate, landmark trees and massed low plantings;
- Investigate opportunities to provide appropriately designed property fencing and streetscape works to improve passive surveillance; and
- Ensure urban design treatments are consistent with and respect the character and amenity of the surrounding area, particularly near residential neighbourhoods.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to the following:

- Designing worksites to minimise potential impact on landscape amenity within Victoria Park and Fairfield;
- Minimising potential impacts on landscape values in the vicinity of Moolabin Creek and Rocky Waterholes Creek;
- Softening visual impacts around the rail viaduct at Clapham Rail Yard and ventilation shaft at Fairfield;
- Undertaking urban design treatments near residential neighbourhoods at Yeerongpilly; and
- Investigating appropriate screening for the viaduct at Mayne Yard.

6.6 Conclusion

The form and nature of landscape and visual impacts are generally considered to be consistent with the impacts identified for CRR 2011, however the location of impacts will differ as a result of the changed alignment and underground station locations.

Due to the reduction in the alignment length and removal of associated infrastructure, CRR 2016 will have a reduced level of impact south of Dutton Park Station compared to CRR 2011. At Boggo Road Station, Woolloongabba Station and Albert Street Station the potential impacts will be similar to those identified for CRR 2011. A potential increase in adverse impacts during construction is anticipated to occur at Roma Street Station due to the demolition phase of works. However, there will be a reduced adverse impact on Emma Miller Place.

At Victoria Park, there will be substantially reduced landscape and visual amenity impacts due to the CRR 2016 alignment and Northern portal structure now located within the existing rail corridor. There will no longer be a loss of mature trees at Victoria Park associated with construction works.

At Exhibition Station there will be no requirement to raise O'Connell Terrace Bridge. There will also be a reduced impact on mature fig trees and a smaller worksite area. Overall, landscape and visual amenity impacts will be slightly reduced compared to CRR 2011.

At Mayne Yard, CRR 2016 tracks will be at-grade and one track will be partially in a trough structure. As a result, infrastructure will be less visible than the viaduct structure proposed for CRR 2016.

When operational, Woolloongabba Station, Boggo Road Station, Albert Street Station, Roma Street Station and Exhibition Station will all have a beneficial visual impact, consistent with CRR 2011.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

Appendix C

CRR 2016 Station architecture

C1 CRR 2016 station architecture and public realm design response

Station architecture

The station precinct, public space and architecture seek to create an experience that supports the beautiful subtropical City of Brisbane – a culturally vibrant, people-oriented landscape experience. For this reason the proposed architectural approach is deliberately low key, seeking to frame views of the sky with natural light and ventilation whilst having a small footprint that allows the public space and its landscape to be the dominant station experience.

The proposed station architecture is based on three key design elements as follows:

a) Facilitating daylight into stations

- Views of the sky are key in the design process to minimise the feeling of an enclosed space that is cut off from the outside. In the subtropics, access to natural light and sky views are key; and
- The station entrances and elements seek to maximise natural light and views of the sky into the stations below, whilst ensuring heat through solar gain is minimised.

b) Framing the green experience

- In a subtropical city, the presence of planting and vegetation is fundamental. The station entrances are framed by planting to enhance the subtropical experience as users move in and out of the stations; and
- The station entrances are also naturally ventilated through louvered structures at the entrances, allow views out of the station towards the planted entrances.

c) Shade and shelter

- The station entrances provide shade with filtered light, also providing shelter to the immediate vicinity outside the entrance; and
- The shade elements of the stations also provide TransLink signage and station identity.

To create a consistent identity and experience throughout CCR 2016, the station architecture comprises of a series of components which are adjusted to different station settings. The kit of parts comprises of the following elements:

- Glazed roof for weather protection;
- Self-adjusting louvres for sun control, shade and natural ventilation;
- Structural ribs that reflect the pattern of merging railway tracks;
- Overlapping glass side panels which facilitate weather protection and natural ventilation; and
- Green collar which supports planting, trellis vines, seats and signage.

Public realm

The public realm for the station precincts are to be responsive, well connected, functional, and robust spaces that satisfy the needs of the users and builds on the existing character of the local area. The design intends to deliver spaces that avail a sense of safety, are legible and easy to navigate, encourage use and activation and leaves a lasting impression on patrons. The design response will be accessible and cater for a multitude of activities, providing opportunity for social interaction, catering for both passive and active recreation, while also introducing commercial opportunities. The public realm focuses on the following design aspirations:

a) Responsive environment

A responsive public realm is permeable, caters for a multitude of movements through the space, allowing unobstructed views and movement, and enabling user choice. The design aims to satisfy this through high canopy trees with low understorey planting, uncluttered spaces, and reducing the number of large areas with solid obstacles. Another feature of the design is the strong connectivity achieved through linked spaces, this improves and encourages pedestrian movement, both within the site and between contextual areas. Clear signage and identifiable elements improve legibility and wayfinding, which further support spaces that are easy to navigate.

b) Outdoor dining rooms

The inclusion of 'outdoor dining' rooms will create an enlivened and activated public realm, while also providing an economic benefit to the precinct. Included in the design are areas specifically allocated as 'outdoor rooms' with unique pavement treatments used to define these areas. Trees are used to shape the vertical plane and frame these intimate spaces. Light weight structures will provide shade, amenity, and allow the flow of natural breezes.

c) Green infrastructure/ BCC Master Plan, Albert Street Vision

Trees, while important in providing shade and amenity, have been located to define movement lines / direction through the space, and contextually to connect city wide green spaces through a continuous link of green stretching between these spaces.

Softscape items will soften hardscape and built form, and introduce a natural element into a built environment.

d) Commercial opportunity

Like the outdoor dining areas, commercial premises within the public realm provide areas of activation and create an economic benefit to the station precinct, while also providing attractors to entice people into the space. In addition to fixed commercial premises the design incorporates areas that are open, without obstacles, which provide opportunity for temporary commercial installations such as mobile carts and the opportunity for market stalls.

e) User interaction

Designed elements which allow users to engage with the space provide activation generators, allowing opportunities for user interaction which delivers a positive user experience, such as performance space, open lawn areas and interactive play features. These elements support a sense of place and creates a unique identity.

f) Passive recreation

Opportunities have been provided for users to sit, relax, and enjoy these unique spaces, taking advantage of Brisbane's comfortable subtropical climate. Spaces include areas of informal seating, open lawn areas and shades areas beneath tree canopies. These spaces provide a place where workers can have lunch and enjoy a brief respite. The variety of shapes and scales, as well as their location avail opportunity for interaction and social gathering.

7 Technical Report: Nature conservation

7.1 Introduction

Nature conservation aspects addressed within this technical report relate to native flora and fauna, as well as pest and weed species. The CRR 2016 alignment traverses a highly urbanised area with limited ecological value for significant species or vegetation communities recognised at local, State or National level.

Areas considered to contain some minor habitat features for common, urban-adapted species include South Brisbane Cemetery, Dutton Park Station, Brisbane River, City Botanic Gardens, Wickham Park, Hardgrave Park, Roma Street Parklands, Victoria Park and Breakfast/Enoggera Creek. Direct impact to these areas has largely been avoided due to tunnelling or by containing the alignment within the existing rail corridor, where possible.

The main design changes associated with CRR 2016 that alter the nature conservation assessment relate to the alignment now avoiding direct impact on Victoria Park, Emma Miller Place and Moolabin Creek. Overall, there will be less vegetation removed for CRR 2016 compared to CRR 2011. The alignment also avoids the Red Imported Fire Ant (RIFA) biosecurity zone. As the CRR 2016 alignment is closer to Breakfast/Enoggera Creek adjacent to Mayne Yard, there is greater potential to indirectly impact a known flying-fox roost site located in the area.

7.2 Changes to potential impacts

7.2.1 Flora

Similar to the CRR 2011 design, the CRR 2016 alignment is in close proximity to two areas of mapped remnant vegetation that are classified as ‘Least Concern’ and ‘Endangered/Of Concern’ Regional Ecosystem located along Breakfast/Enoggera Creek adjacent to Mayne Yard. A ‘Not of Concern’ local Regional Ecosystem is also located along the edge of the Brisbane River near the City Botanic Gardens and around the Pacific Motorway. These areas will not be directly impacted by the CRR 2016 alignment through vegetation removal, but may be subject to indirect effects.

The majority of flora species within the study corridor are common and widespread. Vegetation of local significance is restricted to street tree plantings, parklands and cemetery areas, including ‘Council-controlled Vegetation’, which provide landscape character and social amenity value. Vegetation that will require removal for CRR 2016 is consistent with that already identified for CRR 2011. This is mainly found at surface work locations, construction worksites, on existing roadsides or within the existing rail corridor, which have already been disturbed. Vegetation loss includes:

- Loss of several planted trees near the Woolloongabba Station;
- Removal of some planted trees along Albert Street and Mary Street;
- Removal of the roadside vegetation adjacent to the BTC; and
- Removal of several fig trees at the RNA Showgrounds (although slightly reduced for CRR 2016).

Additional vegetation removal, not previously identified for CRR 2011, includes several planted trees around the Boggo Road Station worksite (including Outlook Park). These trees are part of the street and park landscaping and are considered ‘Council-controlled Vegetation’.

Vegetation that no longer requires removal as part of the project includes vegetation within Victoria Park (which is listed on the Queensland Heritage Register), Emma Miller Place (remnants of the original station garden of heritage value), and planted roadside vegetation along Alice Street (near the City Botanic Gardens).

Indirect effects which remain the same as CRR 2011, include the potential for surface water run-off, dust, light, erosion risk and/or pollution/contamination run-off to impact on areas of retained vegetation. There is also the potential for indirect impacts from groundwater drawdown along the tunnel, stations and beneath the City Botanic Gardens, although impacts on vegetation which potentially rely on shallow groundwater, is considered unlikely and relatively low as previously identified by CRR 2011. In addition, there are a small number of trees considered to access groundwater at Hardgrave Park (adjacent to Countess Street)[36]. However, the CRR 2016 alignment at this location will have undrained, bored tunnels and the potential for groundwater drawdown at this location is considered to be highly unlikely.

7.2.2 Fauna

CRR 2011 previously identified the potential for flying-foxes to feed within the study corridor, including potential foraging resources for the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed Grey-headed Flying-fox. For CRR 2016, the reach of Breakfast/Enoggera Creek, adjacent to Mayne Yard, was identified as a known flying-fox roost, with historic and current records of the ‘least concern’ State listed Black Flying-fox *Pteropus alecto* utilising the mangroves and riparian vegetation for roosting. The CRR 2016 alignment has a greater potential to indirectly impact Black Flying-foxes (if present) given the alignment is closer to the creek and the flying-fox roost than CRR 2011. It is noted that QR has an existing EMP specific to Mayne Yard.

Historic monitoring data collected by the Department of Environment and Heritage Protection (DEHP) since 2012 has records of the Black Flying-fox using this roost. From 2012-2014, Black Flying-fox numbers, exceeding 1,000 animals, were recorded at this roost site. Since May 2014, the roost site has been used sporadically, with greatly reduced numbers recorded and some surveys returning no observations of any flying-foxes. For the CRR 2016 project, a flying-fox roost assessment was completed in July 2016 and three Black Flying-fox were recorded. This species and all flying-foxes and their roosting sites are protected under the Queensland *Nature Conservation Act 1992*.

The July 2016 flying-fox roost assessment did not observe any Grey-headed Flying-fox. A referral to the Commonwealth Department of Environment would only be required for any action that has the potential to significantly impact on Matters of National Environment Significance. The trigger for a referral does not apply as the required numbers to meet the criteria for a nationally-important roost site have not been recorded.

North of Mayne Yard, CRR 2016 will tie in with the existing North Coast rail lines south of Albion Station, using the existing rail siding bridge, which crosses Breakfast/Enoggera Creek. The impact on aquatic fauna will be negligible provided surface-water run-off and potential risk from contaminants/pollution events is managed in accordance with the Draft Outline EMP.

Areas in close proximity to the CRR 2016 alignment that contain potential habitat for other native fauna include South Brisbane Cemetery, Dutton Park, City Botanic Gardens, Wickham Park, Roma Street Parklands, Hardgrave Park, Victoria Park and Breakfast/Enoggera Creek. Consistent with CRR 2011, widespread and least concern fauna species which commonly occur in urban environments may be temporarily disturbed during construction. These fauna species are

[36] Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Revised Reference Design Assessment Report.

considered to be urban specialists and are resilient to the direct and indirect impacts associated with the construction and operation of CRR 2016.

Impacts to native fauna likely to occur due to loss of habitat and reduced ecological connectivity will be negligible given their ability to disperse/persist elsewhere. Nearby parklands will continue to provide important habitat and food resources for native fauna. Given the scattered nature of the works, it is not considered that this will affect fauna movement or important bioregional corridors of State significance.

Indirect impacts on native fauna species will generally remain of the same order as previously identified for CRR 2011 relating to potential changes in their movement, behaviour and distribution from construction activities including noise/vibration, lighting, dust, potential contaminant and surface water runoff.

7.2.3 Pests and weeds

There are a number of invasive plants that are Category 3 restricted matters listed under the *Queensland Biosecurity Act 2014* which exist within the study corridor. A majority of these are located along the existing rail corridors, which are managed by QR. Other pest plants, such as Chinese Celtis (*Celtis sinensis*), Camphor Laurel (*Cinnamomum camphora*), Cat's Claw Creeper (*Macfadyena unguis-cati*) and Singapore Daisy (*Sphagneticola trilobata*) are located within parklands, including Dutton Park, Wickham Park, Roma Street Parklands, Victoria Park and the RNA Showgrounds.

Invasive fauna species, including the European Fox (*Vulpes vulpes*) (Category 3 invasive animal) and Cane toad[37] exist within the study corridor, however CRR 2016 will not result in actions that increase the distribution or occurrence of these species. The RIFA, which is a category 1 restricted pest under the *Biosecurity Act 2014,* is currently located outside the CRR 2016 study corridor, south of Dutton Park and around Brisbane Airport[38]. However, transport of a fire ant carrier (such as soil, gravel, turf, plants, mulch, straw, manure, asphalt, gravel or vehicles and equipment) from fire ant zones into the study corridor may increase the risk of spread.

During construction, potential impacts to pest/weed species will remain similar to CRR 2011 relating to construction plant movement having the potential to increase weed infestation through topsoil disturbance, although the impacts will vary slightly with changed construction worksite locations for CRR 2016. Deliberate distribution of Category 3 invasive biosecurity matters is not permitted under the *Biosecurity Act 2014.*

7.3 Changes to mitigation measures

Mitigation measures which are consistent with CRR 2011 include the following:

- Reducing the construction footprint and minimising vegetation loss (where possible);
- Developing and implementing a Rehabilitation Plan, Landscape Plan, Pest and Weed Management Plan;
- Adopting erosion and sediment control measures and soil hygiene procedures including completion of an ESCP;
- Reducing impacts from light dispersal on nearby sensitive receptors especially near Breakfast/Enoggera Creek and Victoria Park, whilst still providing lighting for public safety;

[37] Note: Cane Toads are not an invasive biosecurity matter under the *Biosecurity Act 2014*.
[38] www.daf.qld.gov.au/__data/assets/pdf_file/0007/167812/Fire_Ant_Biosecurity_Zone_Map_1_July_2016.pdf Accessed August 2016

- Consulting with an arborist in relation to fig tree relocation at the RNA Showgrounds;
- Obtaining necessary clearing permits and clearly marking 'no-go' areas;
- Capturing and relocating fauna (fauna spotter/catcher) as required during construction works;
- Undertaking environmental incident reporting as required;
- Employing a suitably qualified person for vegetation rehabilitation and on-going monitoring of fauna/flora and ESCP;
- Undertaking any operational works within designated areas to further reduce vegetation/fauna disturbance; and
- Development and implement a RIFA Risk Management Plan.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to:

- Additional tree assessment and management plan for Alice Street; and
- Completion of a tree planting strategy near for southern section ventilation shaft (Fairfield).

Additional mitigation measures now relevant to CRR 2016 include:

- Undertake a pre-construction fauna survey within and around worksites to identify any species for which a species management plan needs to be developed; and
- All project sites receiving fire ant carriers must ensure that a Biosecurity Instrument Permit is provided by the supplier, or a Biosecurity Queensland certified inspection certificate is supplied for fire ant carriers. The origin of all vehicles and equipment must be checked to see if they have come from declared biosecurity zones, and that the vehicle or machinery is visually clean and has maintained good vehicle hygiene.

7.4 Conclusion

The CRR 2016 alignment traverses a highly urbanised area with limited ecological value for significant species or vegetation communities. The majority of vegetation is located within already disturbed urban environments.

The alignment now avoids direct impact on Victoria Park, Emma Miller Place and Moolabin Creek and overall there will be less vegetation removed compared to CRR 2011. There is potential for indirect effects on flora habitat from surface water run-off, dust, erosion and pollution, consistent with CRR 2011.

In relation to fauna, the potential for indirect impacts on State protected Black Flying-fox species adjacent to Breakfast/Enoggera Creek at Mayne Yard will be greater than CRR 2011 given the closer proximity of the alignment to this creek. This risk will be managed with appropriate mitigation measures.

Other widespread and least concern fauna species will be less susceptible to impacts within the urbanised environment and potential for construction activities to influence their behaviour and distribution is considered to be consistent with CRR 2011. While pest and weed species are widespread throughout the study corridor, there is a reduced risk on RIFA as CRR 2016 does not extend to within any Fire Ant Biosecurity Zones.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project. The Draft Outline EMP reflects management requirements contained this technical report and as outlined in the QR EMP (Mayne Yard) for fauna and flora species.

8 Technical Report: Groundwater

8.1 Introduction

Key aspects discussed in this technical report include groundwater flow, inflow and drawdown as well as groundwater contaminants and groundwater dependent ecosystems. Groundwater resource in the study corridor is variable and influenced by the Brisbane River and the local drainage system, as much as it is by the geological conditions. In some locations, there is likely to be a hydraulic connection between the Brisbane River and the local streams and shallow aquifers. These connections may be through alluvial beds and fractured or jointed rock formations close to the surface. The unconformity between some rock formations, such as Brisbane Tuff and Neranleigh-Fernvale Beds adjacent to the Brisbane River, presents a complexity to the groundwater conditions.

The CRR 2016 alignment has a different length, depth, and changed portal and station locations, compared to CRR 2011. A review of hydrogeological conditions was undertaken for Woolloongabba and Boggo Road Stations given the construction of a mined tunnel at this location, which was previously a bored tunnel for CRR 2011. This may result in an increased risk of temporary groundwater drawdown compared to CRR 2011, and changed design and construction methodology has been proposed to mitigate these effects.

A high level review was also undertaken of the underground stations at Roma Street and Albert Street, however this identified no change to the impacts and mitigation measures previously identified for CRR 2011.

8.2 Changes to potential impacts

8.2.1 Groundwater flow, inflow and drawdown

There are two broad types of aquifers that influence groundwater within the study corridor including:

- Fractured rock (secondary porosity) aquifer systems. This comprises of Neranleigh-Fernvale Beds, Brisbane Tuff, Aspley and Tingalpa Formations and the Woogaroo Sub-Group; and
- Alluvial (primary porosity) aquifer systems overlying bedrock aquifers.

It is considered that for CRR 2016, there will be little change in groundwater flow over time, consistent with CRR 2011. In relation to groundwater inflow[39], leakage of groundwater into tunnels and cavern construction is anticipated to be minimal. In addition, groundwater inflow into tunnels, station caverns and cut and cover sections is expected to decrease over time, which is consistent with CRR 2011.

In relation to groundwater drawdown[40], consistent with CRR 2011, this may occur around the drained sections of each underground station. There is a possibility that connectivity between shallow alluvial aquifers and deeper fractured rock aquifers may exist and that groundwater drawdown in the underlying rock to drained portions of the project, such as stations, may impact upon groundwater in the shallow alluvial systems.

[39] Groundwater inflow – volume of water that enters the underground structures, caverns, stations and tunnels.
[40] Groundwater drawdown – the observed impact on the piezometric level, that is, the in-situ groundwater level in an aquifer.

8.2.2 Groundwater drainage – hydrogeological conditions

For CRR 2016, the construction of the mined tunnel between Boggo Road Station and Woolloongabba Station is different to the bored tunnel proposed for CRR 2011. As such, a review of hydrogeological conditions was undertaken at this location in order to inform further design and construction requirements.

The CRR 2016 Woolloongabba Station will be undrained in the alluvial layers to limit potential groundwater inflow and impact on the upper aquifer. There is relatively low rockhead cover and evidence of higher permeability/groundwater flow which occurs within the top 10-20m. The design will comprise:

- An undrained arch and drained base given the northern mined cavern may have high permeability; and
- A drained cavern and base for the southern mined cavern into the running tunnels.

The CRR 2016 cut and cover section of Boggo Road Station will also be undrained (above rock) and the base will be drained. The rock is typically fractured near the surface with evidence of groundwater flow through iron-staining of joints.

It is expected that these stations will encounter contact zones between Neranleigh-Fernvale Beds, Brisbane Tuff and Aspley Foundation (for Woolloongabba Station) and Brisbane Tuff and Apsley Formation (for Boggo Road Station). This carries the risk of increased permeability and inflows of groundwater at these contacts, but this is likely to be manageable with probing and grouting.

The mined tunnel component between Woolloongabba Station and Boggo Road Station is anticipated to intersect mixed ground, low rockhead and higher permeability soil/rock. There is a potential for major transmissive features such as the Normanby Fault to be encountered and potential for increased permeability and groundwater inflows. The recommendation for managing this therefore includes:

- Design of undrained mined tunnels; and
- Tunnel construction and temporary support structures to consider groundwater inflow potential and support of potentially problematic ground conditions.

A comparison between the CRR 2011 and CRR 2016 designs in relation to groundwater drainage is shown in Table 8.1.

Table 8.1 Summary of groundwater drainage comparison between CRR 2011 and CRR 2016

Location	2011 – Groundwater drainage[41]	2016 – Groundwater drainage
Boggo Road Station	Drained.	Cut and cover undrained above rock, base of cut and cover to be drained.
Boggo Road to Woolloongabba	Undrained – segmental linings with gaskets and undrained cross passages.	Undrained mined tunnels.
Woolloongabba Station	Undrained section for cut and cover elements protruding above rock (station sited in remnant inactive river). Base of box and cavern elements	Cut and cover to be undrained above rock with a drained base structure. Northern mined cavern to have undrained arch and drained base. Southern mined cavern to have a drained cavern and base.

[41] Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement, Chapter 12.

Location	2011 – Groundwater drainage[41]	2016 – Groundwater drainage
	drained (i.e. openings in rock drained).	
All other underground stations (i.e. Albert and Roma Street Station)	Station locations would be drained in the rock and undrained in the alluvium.	Same as CRR 2011 for Albert and Roma Street Station. The upper parts of the walls will be undrained through the more permeable ground (within the fill and alluvial deposits). All the base slabs for the underground stations will be drained.
Tunnels (TBM)	All tunnel sections would be constructed by TBM and would be undrained. Tunnels would be lined with pre-cast segmental concrete linings. Gaskets would be included wherever these linings were used to create a waterproof lining.	Consistent with CRR 2011.
Cross passages	Undrained.	Consistent with CRR 2011.

8.2.3 Groundwater contamination

Consistent with CRR 2011, contaminant transport in groundwater is influenced by the drawdown effects of tunnel construction and operation. As the extent of the groundwater drawdown cone extends, so does the area in which contaminants in the groundwater potentially may be impacted. The drawdown cone is indicative of a net groundwater movement towards the tunnel or station as a drain. Groundwater may be flowing towards the tunnel alignment through natural processes regardless of drawdown.

If the tunnel acts to drain this contaminated groundwater then it also will ultimately be captured by the tunnel. Mobile groundwater contaminants within the capture zone[42], will eventually discharge into the drained Northern and Southern portal sections of the tunnel for CRR 2016. Should there be dissolved contaminants in groundwater within the capture zone, then it will also be expected that the contamination will eventually appear as seepage into the tunnel.

8.2.4 Acid sulfate soils

The extent of groundwater drawdown associated with underground construction is unlikely to extend into areas of potential acid sulfate soils for CRR 2016. The potential to lower groundwater levels in these areas and expose potential acid sulfate soils is therefore considered negligible. This is based on additional assessment work undertaken since CRR 2011[43]. The risk of this potential impact has therefore reduced compared to CRR 2011.

8.2.5 Groundwater dependent ecosystems

The level of groundwater dependency for CRR 2016 is considered to be relatively low for terrestrial vegetation, river base flow systems and aquifer systems during drought conditions, where surface water flux is uncommon. This is consistent with CRR 2011.

[42] The capture zone is effectively that region of aquifer that is within the “cone of depression” of the water table that forms in response to groundwater discharge
[43] Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Chapter 9.

8.3 Changes to mitigation measures

Mitigation measures which are consistent with CRR 2011 include the following:

- Undertaking a water quality monitoring programme pre, during and post construction (refer to Element 7 of Draft Outline EMP (Volume 2);
- Preparing and implementing specific management plans for construction works that may disturb groundwater;
- Developing storage and handling procedures for fuels, chemicals and other hazardous materials, to avoid the release of contaminants to groundwater;
- Implementing appropriate practices and procedures for waste handling, storage and disposal and accidental spillages in order to avoid contamination of groundwater;
- Identifying water bores in the area potentially affected by groundwater drawdown; and
- Undertaking groundwater monitoring to be maintained during construction and operation to address issues pertaining to drawdown and quality. Groundwater quality monitoring will be undertaken 12 months prior to construction.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to groundwater monitoring at existing boreholes located south of Dutton Park Station, such as at Yeronga, Fairfield and Annerley.

Based on the additional review of hydrogeological conditions and updated information additional mitigation measures now relevant to CRR 2016 include:

- For CRR 2016, consideration will need to be given to the groundwater inflow rates so that pumps, holding tanks, pipes and water treatment facilities can be appropriately sized;
- For all underground rail stations and tunnels, further work is required to estimate inflow rates for both groundwater and grey water including station deluge water and station and tunnel cleaning water. It is likely that one system will be used to treat groundwater and deluge and another for surface water;
- The size and location for water treatment will need to be determined and may be economically or space constrained within the city station locations; and
- Additional discussions will need to be undertaken to determine suitable water quality and appropriate discharge location/s or determine suitable locations for water treatment either within the project boundaries or off-site.

As discussed previously, between Woolloongabba and Boggo Road Stations, there is an increased risk of temporary groundwater drawdown compared to CRR 2011, given the construction of a mined tunnel at this location (previously a bored tunnel). As such, further investigations required during detailed design and before construction of various sections include the following:

- A geological and hydrogeological model to determine:
  1. Hydraulic connectivity of the fill/alluvium and underlying rock mass; and
  2. Presence of any major transmissive structural feature within the rock mass. In particular, the nature and hydraulic conductivity of the contact zones between the Brisbane Tuff, Aspley Foundation, Neranleigh-Fernvale Beds and Normanby Fault Zone. This type of feature may result in inflows during construction.

- Further investigation is required in relation to groundwater cut off[44]. For the cut and cover structures, groundwater cut off must be achieved within the bedrock to prevent excessive drawdown and inflow during construction and operation. Toe grouting (within the higher permeability rock close to rockhead) may be considered to achieve this;
- Further investigation and testing to develop an understanding of the local hydraulic connectivity and rockhead condition is required to determine specific requirements for achieving cut off;
- Further investigation is required in relation to groundwater transmissive features. Minor transmissive features do not present a significant problem as these can be identified by probing ahead and pre-grouted during construction. Major transmissive feature (e.g. contact zones between the different bedrock formations and shear zones associated with the Normanby Fault - for Woolloongabba) may be of sufficiently high permeability that grouting is not feasible; and
- Further borehole investigations, groundwater monitoring and permeability testing at the station locations and along the tunnel alignment will be required to identify and characterise any major transmissive features and better constrain the local hydrogeological model for detailed design.

8.4 Conclusion

The main design changes relevant to groundwater assessment relate to CRR 2016 proposing mined tunnel construction between Woolloongabba Station and Boggo Road Station. While the effects relating to groundwater flow and inflow across the alignment are consistent with CRR 2011, there is potential for temporary additional groundwater drawdown between Woolloongabba Station and Boggo Road Station. Additional investigations have been proposed for the detailed design phase to determine ground conditions, local hydraulic connectivity, and groundwater transmissive features.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

[44] Use of structures (for example, sheet piles, grout barriers, etc.) to cut off groundwater from entering excavated areas (i.e. working area). This will minimise the requirement to undertake dewatering pumping.

9 Technical Report: Surface water

9.1 Introduction

The key aspects addressed in this technical report include surface water flow, sediment run-off, acid sulfate soil and contaminated soil, litter, toxicants and accidental spill and construction water use.

Consistent with CRR 2011, surface water has the potential to enter tributaries and creek systems which eventually flow into the Brisbane River. These waters subsequently enter Moreton Bay, which contains marine protected zones and the internationally-recognised Ramsar Wetlands. Risks to the Brisbane River from the Project are anticipated to be primarily from surface runoff and sediment may be discharged from tributaries that flow into the Brisbane River.

With the shorter tunnel length for CRR 2016, smaller construction footprint and reduced vegetation removal, impacts on surface water flow and sediment run-off are generally reduced compared to CRR 2011. At Mayne Yard, the CRR 2016 alignment is in closer proximity to Breakfast/Enoggera Creek than CRR 2011.

9.1.1 Surface water flow

For CRR 2016, there are no works within waterways, diversion of streams or works being undertaken south of Dutton Park Station, compared to CRR 2011. CRR 2011 had proposed new bridges across Moolabin Creek and Rocky Waterholes Creek at Yeerongpilly and Moorooka. The CRR 2016 alignment will connect new rail tracks to the existing tracks north of Breakfast/Enoggera Creek. No works associated with the bridge that crosses Breakfast/Enoggera Creek will be undertaken from within the waterway.

Consistent with CRR 2011, during operation there may be an increase in water flow velocities or frequencies as a result of increased stormwater runoff from hardened areas which can lead to creek erosion and subsequent decline in water quality and aquatic habitats. However, the increase in hardened areas is relatively small compared to the entire catchment size.

9.1.2 Sedimentation and run-off

Sedimentation has the potential to result from construction activities such as vegetation clearing, demolition of existing infrastructure, earthworks associated with track work, road/footpath realignment, tunnel activities and haulage roads as well as spoil removal, haulage and placement. The Brisbane River and Breakfast/Enoggera Creek are the closest receiving environments to the CRR 2016 alignment. The worksite areas of CRR 2016 are similar in size to the CRR 2011 worksites, however, with a reduced tunnel length, there is less spoil haulage movement and demolition of infrastructure. In addition, there will be less vegetation removal, with the changed alignment not impacting Victoria Park or Emma Miller Place.

During operation, activities have the potential to impact surface waters through sediment accumulation and runoff from rail infrastructure during and after heavy rainfall events. This is consistent with that reported for CRR 2011.

9.1.3 Acid sulfate soils and contaminated soil

Consistent with CRR 2011, acid sulfate soils can be disturbed through construction activities and around low lying areas. Further information regarding impacts associated with acid sulfate soils is detailed in Technical report 3 (Topography, geology, geomorphology and soils).

In relation to contaminated soils, there are numerous known contaminated sites throughout the study corridor. For CRR 2016, contaminated land within Mayne Yard has the potential to enter waterways (i.e. Breakfast/Enoggera Creek) if not managed properly. This risk has increased since CRR 2011, which did not have spoil removed for construction of an underpass. Further information regarding contaminated land is detailed in Technical report 4.

During operations, disturbance of acid sulfate soils and contaminated soil is not expected to occur. Any potential operational impacts are consistent with CRR 2011.

Compared to CRR 2011, there are no proposed works to the south of Dutton Park Station, hence no potential for construction activities to disturb contaminated land adjacent Moolabin Creek, Rocky Waterholes and Stable Swamp Creeks.

9.1.4 Litter, toxicants and accidental spillages

During construction and operation there is the potential for sources of pollutants to enter waterways from litter, nutrients, heavy metals, oils and hydrocarbons, bacteria and viruses and chemicals/hazardous substances. Potential impacts on receiving waterways are dependent on the source, nature and extent of pollutants, and may result in a reduction in aquatic ecosystem health, visual recreation and cultural/spiritual environmental values. Located directly adjacent Mayne Yard, Breakfast/Enoggera Creek is the site of most relevance for CRR 2016. Creeks south of Dutton Park Station are no longer impacted by the CRR 2016 alignment.

During operations, the main risk to surface water from the release of pollutants is from spills or the release of litter and toxicants such as heavy metals, petroleum hydrocarbons, surface run-off from tracks, stations and paved surfaces, and maintenance of rail vehicles. This risk is consistent with CRR 2011.

9.1.5 Environmental values

Environmental values relate to the health of ecosystems and the safe waterway use by humans. Potential impacts during construction and operation will include reduced aquatic ecosystem health, decreased visual and recreational amenity, changes to cultural and spiritual values of waterways, compromising human health. It is expected that the CRR 2016 project will have a reduced impact on environmental values given the alignment will no longer extend through Victoria Park or cross Moolabin Creek and Rocky Waterholes Creek (south of Dutton Park Station).

9.1.6 Construction water use

Water used during construction for dust suppression, compaction, wheel wash down, grout, firefighting supply and human consumption will be sourced from recycled water, where possible (i.e. wastewater from on-site treatment plants, rainwater harvesting, etc.). This is consistent with CRR 2011 and will reduce the demand on municipal potable water supplies. For CRR 2016, it is unlikely that recycled groundwater inflow treated at on-site water treatment plants could be used as a key source of water, given inflow is considered to be minimal and transient.

The use of recycled water may have potential impacts to the receiving environment should discharge occur, through uncontrolled releases and/ or contaminated runoff. The impact of this discharge is dependent on the type and extent of discharge, and may include impacts to aquatic health through the release of chemicals, hydrocarbons, sediment, and highly saline water.

9.2 Changes to mitigation measures

9.2.1 Surface water flow

Mitigation measures which are consistent with CRR 2011 relate to using Water Sensitive Urban Design (WSUD) measures for the Project.

Mitigation measures no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to temporary water treatment facilities at Yeerongpilly.

Based on additional assessment work[45], additional mitigation measures now relevant to CRR 2016 include:

- Treating drainage water at an onsite water treatment plant before being discharged as trade water to Queensland Urban Utilities' (QUU) sewer network or discharged QUU approval; and
- During construction, temporary treatment will also occur at both portal locations.

9.2.2 Sedimentation and run-off

Mitigation measures which are consistent with CRR 2011 include the following:

- Completion of an ESCP and associated monitoring; auditing and reporting; implementation of erosion control measures at surface worksites (such as check dams, drop structures and modifications to flow path);
- Chemical surface stabilisers, erosion control blankets, mulching, revegetation, stabilisation with geotextiles and surface roughening. Sediment control measures may include buffer zones, grass filter strips, configuration of construction exits and the use of sediment fences, traps, basins and weirs; and
- Stockpiles are to be located away from drainage areas and flood affected areas.

Mitigation measures no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to the progressive rehabilitation at Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek.

9.2.3 Acid sulfate soils and contaminated soils

Mitigation measures which are consistent with CRR 2011 include the following:

- Acid sulfate soils to be managed through further investigations and a management plan; and
- Where contaminated soils are to be disturbed, appropriate runoff controls are to be implemented ahead of works commencing to divert surface run-off around exposed soils. Mayne Yard is the main area of relevance for CRR 2016 given its location next to Breakfast/Enoggera Creek.

Further information relating to mitigation measures for both acid sulfate soils and land contamination is provided in Technical report 3 (Topography, geology, geomorphology and soils) and Technical report 4 (Land contamination).

[45] Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Chapter 9.

9.2.4 Litter, toxicants and accidental spill

Mitigation measures which are consistent with CRR 2011 include the following:

- Storage and handling procedures for chemicals, litter and other hazardous materials to be developed and implemented to avoid the release of contaminants to waterways, stormwater drains or roadside gutters, including procedures for both managing uncontrolled releases to waters; and
- A combination of one or more control measures is to be implemented including oil and grit separators, gross pollutant traps, trash racks, screens, detention basins, sand filters, filter strips, buffer zones, grassed swales and water quality ponds.

Additional mitigation measures now relevant to CRR 2016 include:

- Water at underground rail stations to be captured by a drainage system, treated and discharged as trade water to QUU sewer network.

9.2.5 Environmental values

Mitigation measures which are consistent with CRR 2011 include the following:

- Rehabilitation plans will be designed to ensure relevant environmental values are addressed. Surface water monitoring programmes will be conducted to audit, monitor and manage potential impacts to environmental values.

9.2.6 Construction water use

Mitigation measures which are consistent with CRR 2011 include the following:

- Construction water management measures to be developed and implemented, including: provision of bunded chemical storage areas; spill response kits; spill clean-up procedures; designated wash down areas for concrete deliveries; treatment of construction water and runoff controls; and progressive rehabilitation of sites.

Additional mitigation measures now relevant to CRR 2016 include:

- Collection, treatment, diversion and assessment of wastewater generated from construction activities via water treatment facilities.

Further groundwater treatment measures are detailed in Technical report 8 (Groundwater).

9.2.7 Water quality monitoring

Mitigation measures which are consistent with CRR 2011 include the following:

- A water quality monitoring programme to be implemented prior to, during and subsequent to construction to monitor discharges from construction worksites to all identified receiving waters;
- The monitoring programme to also assess water quality within receiving waters to evaluate compliance with the specified Water Quality Objectives (WQOs); and
- The monitoring programme will allow for the capture of adequate baseline data to establish seasonal WQOs for the Project with consideration for the receiving surface waters.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to baseline water quality samples for Stable Swamp Creek, Rocky Waterholes Creek, and Moolabin Creek.

9.3 Conclusion

Given the reduced length of tunnel, smaller construction footprint and reduced need for vegetation removal, impacts on surface water flow and sediment run-off are considered to be reduced compared to CRR 2011.

Potential impacts at Mayne Yard will need to be managed as the extent of works has changed and the CRR 2016 alignment is closer to Breakfast/Enoggera Creek. The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project. The Draft Outline EMP reflects management requirements contained this technical report and as outlined in the QR EMP for Mayne Yard.

10 Technical Report: Flood management

10.1 Introduction

Flooding is primarily a surface issue, and, as such, impacts on flooding from CRR 2016 may affect permanent infrastructure (e.g. underground stations and tunnel portals) and temporary infrastructure associated with construction activities (e.g. construction worksites).

In terms of flooding, a 1 in 100 year flood event can be described as a result of a storm or localised overland flow, whereas a 1 in 10,000 year flood event can be defined by wider river and creek flooding.

CRR 2016 is designed to achieve flood immunity in a 1 in 10,000 year flood event (i.e. Q10,000 design flood level) at all underground rail stations. For CRR 2011, Albert Street Station was designed to a 1 in 10,000 year flood event, however Woolloongabba, Boggo Road and Roma Street Stations were designed to a 1 in 100 year flood event. CRR 2016 has therefore improved flood immunity at underground stations and also provides greater flexibility with protection at Albert Street Station.

In line with the design principles for CRR 2011, there will be no increase in upstream flood levels nor reduction in floodplain storage as a result of CRR 2016 infrastructure.

10.2 Changes to potential impacts

10.2.1 Albert Street Station

Flood immunity is a critical design element for Albert Street Station. The CRR 2016 Albert Street Station has moved one block north and will have a similar flood risk to CRR 2011. At this new location, the station will be designed with an entrance level of approximately 4.3m AHD. The design flood level range will be between 9 to 10.5m to meet the Q10,000 design flood level (Refer to Table 10.1).

Table 10.1 Q10,000 Design Flood Levels

Location	Design entrance level (m)	Estimated Q10,000 design flood level range (m)	Flood protection requirements
Albert Street Station	4.3	9 – 10.5	Susceptible to flooding - mitigation measures required

Albert Street Station will be designed with smaller entrance structures to enable discrete flood protection measures that can be easily and quickly deployed. There are now three levels of flood protection proposed, depending on the flood event. These treatment options are designed to be deployed sequentially, to allow time to monitor their effectiveness during flood events and will offer a more flexible approach to flood mitigation.

Type A: 1 in 100 year flood event

As part of the urban design, station entrances will be locally raised whilst still being *Disability Discrimination Act 1992* compliant. This will reduce surface water runoff from entering the station and provide flood immunity from small flood events.

Type B: 1 in 800 year flood event

During a 1 in 800 year flood event, the Albert Street Station will be closed, but other CRR 2016 stations could remain operational. Each station entrance will have low height flood mitigation measures, such as an upstand wall (approximately 1m high) on three sides.

A vertical flood barrier (approximately 1m high) will be activated at each entrance location immediately in front of the escalators or lifts. This flood barrier adjoins the low height upstand walls to provide a barrier around the full perimeter of each entrance. These flood barriers can be activated remotely, such as by mobile phone, with the panels recessed below ground level. An alternative solution to this may include manually placed planks.

Type C: 1 in 10,000 year flood event

For more significant events, the next level of flood protection will be activated. Small structures will be placed horizontally above the low height upstand walls. These will have gaskets and other seals to provide water cut-off. This will be designed for the required hydrostatic water pressure from a Q10,000 flood event.

Alternative or additional measures for protection could be considered, such as having flood gates at concourse level or platform level to protect critical assets. These options are to be investigated further during detailed design.

This three-staged approach for flood events (discussed above) was not explored for Albert Street Station as part of CRR 2011. The CRR 2016 design therefore provides greater variation in mitigation measures during flood events.

10.2.2 Other underground stations and portals

For CRR 2016, Boggo Road, Woolloongabba and Roma Street Stations have been designed above the Q10,000 design flood level. For CRR 2011, these locations were designed to provide protection for a 1 in 100 year flood event and not a 1 in 10,000 year flood event.

Both the Northern and Southern portal for CRR 2016 are above the Q10,000 design flood level. The CRR 2011 Southern portal (Yeerongpilly) was below this flood level and had floodgates proposed as part of the design.

10.2.3 Surface works

In relation to Mayne Yard, it was noted that this site has a long history of flooding. Consistent with CRR 2011, the proposed surface works for the CRR 2016 alignment will not impinge on the current floodplain or flood behaviour of Breakfast/Enoggera Creek. However, detailed flood modelling will be required during detailed design to ensure proposed infrastructure avoids potential flood impacts.

10.2.4 Worksites

During construction, overland flow paths may convey water that is not part of a creek, river or waterway in and out of worksites. While a majority of worksites are outside of areas identified as having riverine, creek or storm surge flood risk, the Northern and Southern portal and possibly worksites between the Northern portal and Mayne Yard may be affected by overland flooding. This is consistent with the impacts identified for CRR 2011.

10.3 Changes to mitigation measures

Consistent with CRR 2011, to reduce overland flows into construction worksites, bunds will be constructed or the ground level raised to protect worksites from flooding, ensuring equipment, materials, bulk storage areas and hazardous substances are stored above the predicted flood levels. Construction of these bunds or raising of ground levels may cause temporary impacts on flooding, but will not impact on private property or community infrastructure.

Mitigation measures no longer relevant to CRR 2016, previously identified for CRR 2011, include flood mitigation near Moolabin Creek and Rocky Waterhole Creek.

Additional mitigation measures now relevant to CRR 2016 includes:

- Providing staged approach flood protection at Albert Street Station;
- Suitably designing on-site stormwater networks to ensure that the risks of overland flow entering the tunnel portal and stations are minimised to an appropriate level;
- Implementation of suitable mitigation measures, such as the construction of bunds or raising ground levels, to:
  - Prevent flooding of construction worksites in a 1 in 20 Annual Exceedance Probability (AEP) event;
  - Prevent flooding of bulk storage facilities for hazardous substances in 1 in 50 AEP event; and
  - Allow continued access to the local road network from construction worksites during flood events up to 1 in 50 AEP events.
- Suitably designing construction worksites to not cause or contribute to afflux for a 1 in 5 AEP flood event or greater on the floodplain of any waterways or in overland flow paths;
- Construction activities, including any temporary works and spoil placement are designed to prevent flood waters being re-directed over other private property;
- During operation, rainfall and rising water levels will be monitored. Flood preparation and emergency response procedures will be enacted when the potential for floods arise. This will include the restriction or diversion of services until the flood waters abate. Prior to recommissioning, inspections and tests will be undertaken to ensure that all systems and services are functioning correctly; and
- In relation to Mayne Yard further detailed flood modelling will be required during detailed design.

10.4 Conclusion

For CRR 2016, design changes have been made to station entrances to provide protection during 1 in 10,000 year flood events, with more flexible flood protection approaches specifically proposed for Albert Street Station. Other management measures and mitigations have been updated since CRR 2011 to reflect flood allowances for road access, hazardous substances, worksites and operational emergency procedures.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

11 Technical Report: Air quality

11.1 Introduction

This technical report addresses changes that alter the potential air emissions and associated off-site air quality impacts of CRR 2016 compared to CRR 2011. The key design changes that impact the air quality assessment include:

- CRR 2016 not providing an additional rail track between Yeerongpilly and Salisbury. This change removes all of the changes to local roads associated with the requirements for the additional track;
- CRR 2016 not including the section of tunnel and track between Yeerongpilly and Boggo Road Station. This removes the major construction impacts for this area as well as local road impacts associated with the construction and operation of the previously proposed Yeerongpilly station. This change also removes the ventilation shaft at Fairfield and increases the number of trains operating on the surface tracks in this section compared to CRR 2011;
- Relocation of the southern and Northern portals;
- Relocation of Albert Street Station with an associated closure of parts of Albert Street. This change affects local traffic movements in the CBD;
- Changes to the location of construction worksites with corresponding changes to construction traffic movements and local traffic impacts;
- Changes to the proposed tunnelling construction methodology, with the bulk of the spoil being removed via the Woolloongabba Station site. This will have some effect on overall construction traffic movements and local traffic impacts, and
- Changes to the proposed spoil placement sites resulting in changes in construction traffic movements and potential local traffic impacts. The reduced tunnel length will in turn reduce the overall spoil volumes to be removed and the number of associated truck movements.

The assessment of the changes resulting from the CRR 2016 Project has been based on:

- A CRR 2016 opening year of 2023 compared to a CRR 2011 opening year of 2020; and
- Assessment of construction related impacts reflecting the revised construction methodology.

A review of the air quality assessment criteria and existing ambient air quality data available for Brisbane was performed as part of this review, and is summarised below.

11.1.1 Assessment criteria

The air quality objectives used for CRR 2016 are presented in Table 11.1. These criteria are generally the same as those used in the CRR 2011 assessment, except for modelling of particulate matter less than 2.5 microns ($PM_{2.5}$) emissions. The CRR 2011 air quality impact assessment was limited to modelling of Total Suspended Particulate (TSP), particulate matter less than 10 microns (PM_{10}) and dust deposition rates.

The National Clean Air Agreement (NCAA) was endorsed by Commonwealth, state and territory Environment Ministers in December 2015, in which it was agreed to strengthen national ambient air quality reporting standards for airborne fine particles. All jurisdictions have agreed to implement strengthened standards for particles, as well as move to tighter standards for annual average and 24-hour $PM_{2.5}$ in 2025. In February 2016, a variation to the National Environment Protection Measure (Ambient Air Quality) was made that:

- Includes performance monitoring goals for $PM_{2.5}$ (rather than advisory goals);
- Includes an annual average goal for PM_{10}; and
- Reduces the number of allowable exceedances for all particles to “none”.

The assessment criteria used for CRR 2016 reflect these changes in the national standards and amendments to the Environmental Protection Policy (Air). The dust deposition criterion has also been revised to reflect the latest guidance from DEHP.

Table 11.1 Air quality objectives relevant to the project

Pollutant	Air quality objective	Averaging period	Source
Human health			
TSP	90 µg/m³	Annual	Environmental Protection Policy (Air) 2008
PM_{10}	50 µg/ m³	24 hours	Environmental Protection Policy (Air) 2008
	25 µg/ m³	Annual	National Environment Protection Measure (NEPM) (Ambient Air) 2016
$PM_{2.5}$	25 µg/ m³	24 hours	Environmental Protection Policy (Air) 2008
	8 µg/ m³	Annual	Environmental Protection Policy (Air) 2008
Nuisance			
TSP	80 µg/ m³	24 hours	Northern Link (Legacy Way) Project criterion
Dust Deposition	120 mg/m²/day	30 days	DEHP (2015)

11.1.2 Existing air quality

In order to be able to assess the potential cumulative impacts of emissions from the CRR 2016 construction activities, an estimate of the existing air quality is required.

As the ambient air quality data presented for CRR 2011 is approximately ten years old, a review of the most recent monitoring data available from the DEHP ambient air quality network in the Brisbane area has been performed (see Appendix D1). A comparison of the background air pollutant concentrations is shown in Table 11.2.

The background concentrations of pollutants assumed for CRR 2016, which are considered to be reflective of current air quality, are also shown in Table 11.2. In most cases these values are slightly lower than those used in CRR 2011, indicating a general improvement in air quality in the Brisbane area since the CRR 2011 assessment was performed.

Table 11.2 Background concentrations of air quality indicators

Air quality indicator	Averaging period	Units	Value used in CRR 2011 assessment	Revised value used in CRR 2016*	Air quality objective[46]
TSP	24-Hours	µg/m³	29	26	80
	Annual	µg/ m³	28	24	90
PM_{10}	24-Hours	µg/ m³	19	17	50
	Annual	µg/ m³	Not assessed	14.5	25

[46] As per Table 11.1

Air quality indicator	Averaging period	Units	Value used in CRR 2011 assessment	Revised value used in CRR 2016*	Air quality objective[46]
$PM_{2.5}$	24-Hours	µg/ m^3	Not assessed	8.3	25
	Annual	µg/ m^3	Not assessed	6.5	8
Dust deposition	30-Days	$mg/m^2/day$	60	60	120

* Based on monitoring data recorded at Rocklea, South Brisbane, Brisbane CBD and Cannon Hill ambient monitoring site in 2014-2015 calendar years

11.2 Changes to construction phase potential impacts

11.2.1 Changes to sources of air emissions

The construction worksite sizes for CRR 2016 are comparable to CRR 2011, reflecting the slight variation in station location and alignment. For CRR 2011, the following worksites were identified as having the greatest potential for off-site air quality impacts due to fugitive dust emissions and were subject to a quantitative impact assessment involving the estimation of dust emission rates and dispersion modelling studies:

- Clapham Rail Yard;
- Yeerongpilly Station and Southern portal;
- Boggo Road Station;
- Woolloongabba Station; and
- Northern portal.

With the changes to the project design, construction-phase impacts associated with Clapham Rail Yard and Yeerongpilly Station are no longer relevant as they are no longer part of the project. The construction worksites identified for detailed assessment for CRR 2016 are therefore:

- Southern portal and Boggo Road Station;
- Woolloongabba Station;
- Northern portal; and
- Mayne Yard.

In CRR 2011, construction phase impacts associated with Albert Street Station and Roma Street Station were not quantitatively assessed based on the fact that the works would occur in the shaft or purpose-built acoustic shed, hence there would be a low potential for adverse air quality impacts. This is unchanged for CRR 2016 and these construction worksites have again not been included in the modelling study. In CRR 2011, construction phase impacts associated with the Exhibition Station construction worksite were also not quantitatively assessed based on the fact that the scale of the works proposed would have a low potential for air quality impacts. The CRR 2016 worksite for the Exhibition Station has therefore not been included in the air dispersion modelling study.

There are changes to Mayne Yard for CRR 2016 and dust emissions associated with these construction works have been included in the air dispersion modelling study. It also noted that approximately 36,000 m^3 of spoil will be excavated at this construction worksite as part of constructing the trough (underpass).

Further details regarding the construction worksite locations that have been assessed for CRR 2016 are shown in Table 11.3.

Table 11.3 Worksites assessed for CRR 2016

Worksite	CRR 2016
Southern portal	The surface construction worksite will be located between PA Hospital and the rail corridor.
Boggo Road Station	The surface construction worksite for the station will be located between Joe Baker Street and the rail corridor.
Woolloongabba Station	The surface construction worksite will be located from Leopard Street to Main Street.
Northern portal	The worksite will be within the existing rail corridor with a smaller worksite at the existing BCC temporary staging facility (off Gregory Terrace).
Mayne Yard	The CRR 2016 alignment comprises two new CRR tracks through Mayne Yard replacing the flyover proposed for CRR 2011. The worksites for track works will be contained within Mayne Yard.

11.2.2 Changes to emission estimation

Particulate emission rates (TSP, PM_{10} and $PM_{2.5}$) have been estimated for the key construction worksites identified in Section 11.2.1 based on published emission factors for the following dust-generating activities (as relevant to each site):

- Drilling and blasting;
- Mobile machinery (excavators, front end loaders, bulldozers, rock breakers and piling rigs);
- Loading trucks with spoil;
- Wheel-generated dust from truck movements on unpaved areas; and
- Wind erosion of disturbed areas.

The emission factors used to estimate fugitive dust emissions for CRR 2016 are unchanged from those used in CRR 2011 except that $PM_{2.5}$ emission factors have been sourced from literature to enable an assessment of off-site $PM_{2.5}$ concentrations.

The emission factors used are summarised in Table 11.4. These emission factors have been used to estimate the dust emission rates from each construction worksite, which have then been entered into the dispersion model along with site-representative meteorological data, sensitive receptor locations, topography etc., to predict the downwind dust concentrations which can be compared to the ambient air quality criteria in Table 11.1.

Table 11.4 Emission factors used for the estimation of dust emissions from construction activities

Construction activity	Unit	Emission factors used in CRR 2016		
		TSP #	PM_{10} #	$PM_{2.5}$
Drilling	kg/hole	0.59	0.31	0.031
Blasting	kg/blast	11.7	6.09	0.35
Excavators/FELs	kg/tonne spoil	0.025	0.012	0.0005
Bulldozers on spoil	kg/hour	1.63	0.33	0.17
Loading trucks	kg/tonne spoil	0.0003	0.0001	0.00001

Construction activity	Unit	Emission factors used in CRR 2016		
		TSP #	PM_{10} #	$PM_{2.5}$
Wheel-generated dust	kg/VKT *	3.88	0.96	0.096
Rock breaker	kg/tonne	1.63	0.33	0.17
Piling rig	kg/tonne	1.63	0.33	0.17
Wind erosion	kg/ha hour	0.4	0.2	0.02

* VKT = Vehicle kilometres travelled

As per CRR 2011

The activity data used in estimating fugitive dust emissions from construction activities (number of truck movements, quantities of spoil and areas of disturbance, etc.) have been revised to reflect the changes in the construction works proposed for CRR 2016. The key changes in the activity data assumed for CRR 2016 are a reduction in the estimated quantities of spoil and associated haul truck movements at the Southern portal, Boggo Road Station, Woolloongabba Station and Northern portal construction worksites. The level of spoil generated by CRR 2016 is less than CRR 2011 (i.e. 0.97 million m^3 compared to 1.4 million m^3 in situ volumes) due to the shortened tunnel length.

The control factors assumed for the mitigation measures proposed to minimise dust emissions in the CRR 2011 air quality impact assessment have also been reviewed and updated as appropriate. The control factors used for both TSP and PM_{10} emissions in CRR 2011 were:

- Water sprays on drilling = 70% control;
- Hoardings around construction worksite to reduce emissions from blasting, bulldozers and truck loading = 30%;
- Hoardings and water sprays to reduce emissions from excavators and FELs = 65%; and
- Water sprays to control emissions from wheel-generated dust = 75%.

The control factors used in estimating fugitive dust emission rates for CRR 2016 are summarised in Table 11.5. They are identical to CRR 2011 except for:

- The additional containment provided by the acoustic enclosure at the Woolloongabba Station construction worksite has been accounted for; and
- The additional containment provided by the enclosure equipped with a fabric filter at the Southern portal and Boggo Road Station construction worksites has been accounted for.

The model predictions are considered very conservative as they are based on peak activity levels occurring continuously for the entire year. It is unlikely that all of the construction activities shown in Table 11.5 would occur at the same time and air quality emissions would be further managed through co-ordination of construction activities.

Table 11.5 Control factors used for the estimate of dust emissions from construction activities

Construction worksite	Construction activity	Control method	Control factor
Southern portal and Boggo Road Station	Drilling	Enclosure Equipped with fabric filter	99%
	Blasting		
	Excavators/FELs		
	Bulldozers on spoil		
	Loading trucks		
	Wheel-generated dust		
	Rock breaker		
	Piling rig		
	Wind erosion		
Northern portal Mayne Yard	Drilling	Water Spray	70%
	Blasting	Hoardings around construction worksite	30%
	Excavators/FELs	Hoardings and water spray	65%
	Bulldozers on spoil	Hoardings around construction worksite	30%
	Loading trucks	Hoardings around construction worksite	30%
	Wheel-generated dust	Sealed/hardstand roads	100%
	Rock breaker	Hoardings around construction worksite	30%
	Piling rig	Hoardings around construction worksite	30%
	Wind erosion	Water Spray	50%
Woolloongabba Station	Drilling	Acoustic enclosure, water spray	91%
	Blasting	Acoustic enclosure, hoardings	70%
	Excavators/FELs	Acoustic enclosure, hoardings, sprays	85%
	Bulldozers on spoil	Acoustic enclosure, hoardings	70%
	Loading trucks	Acoustic enclosure, hoardings	70%
	Wheel-generated dust	Sealed/hardstand roads	100%
	Rock breaker	Acoustic enclosure, hoardings	70%
	Piling rig	Acoustic enclosure, hoardings	70%
	Wind erosion	Acoustic enclosure, water spray	85%

The emission rates calculated for each of the construction worksites are presented in Table 11.6 (TSP), Table 11.7 (PM_{10}) and Table 11.8 ($PM_{2.5}$). These emission rates have been used in the CALPUFF air dispersion model to predict worst case off-site TSP, PM_{10} and $PM_{2.5}$ concentrations and dust deposition rates at the nearest sensitive receptors.

The total construction worksite TSP and PM_{10} emission estimates calculated in the CRR 2011 air quality impact assessment are also presented in Table 11.6 and Table 11.7 for comparison. Table 11.6 and Table 11.7 show that the estimated particulate emission rates in kg/hour for CRR 2016 for the key construction worksites are lower than the emission rates estimated for CRR 2011. At the Woolloongabba Station and Boggo Road Station construction worksites, this is mainly due to the additional dust control measures (i.e. mitigation measures) proposed for CRR 2016. For the other sites, this is predominantly due to the reduced tunnel length, smaller quantities of spoil being handled and the associated reduction in the number of haul truck movements. In relation to Table 11.8, the CRR 2011 air quality impact assessment did not include modelling of particulate matter less than 2.5 microns ($PM_{2.5}$) emissions, so no comparison can be made.

Table 11.6 Estimated TSP emissions from construction activities for CRR 2016 (kg/hour)

Construction Activity	Southern portal	Boggo Road Station	Woolloongabba Station	Northern portal	Mayne Yard
Drilling	<0.1	<0.1	0.3	1.0	-
Blasting	<0.1	<0.1	0.3	0.7	-
Excavators/FELs	<0.1	<0.1	0.8	0.4	0.2
Bulldozers on spoil	-	<0.1	0.2	0.6	3.4
Loading trucks	<0.1	<0.1	<0.1	<0.1	<0.1
Wheel-generated dust	-	-	-	-	-
Rock breaker	<0.1	<0.1	1.0	-	-
Piling rig	<0.1	<0.1	1.0	-	-
Wind erosion	-	-	0.2	1.3	0.7
TOTAL SITE (CRR 2016)	**0.06**	**0.1**	**3.7**	**3.3**	**4.3**
CRR 2011	**N/A**	**15.8**	**11.6**	**13.2**	**N/A**

Table 11.7 Estimated PM_{10} emissions from construction activities for CRR 2016 (kg/hour)

Construction Activity	Southern portal	Boggo Road Station	Woolloongabba Station	Northern portal	Mayne Yard
Drilling	<0.1	<0.1	0.2	0.5	-
Blasting	<0.1	<0.1	0.2	0.4	-
Excavators/FELs	<0.1	<0.1	0.4	0.2	<0.1
Bulldozers on spoil	-	<0.1	<0.1	0.1	0.7
Loading trucks	<0.1	<0.1	<0.1	<0.1	<0.1
Wheel-generated dust	-	-	-	-	-
Rock breaker	<0.1	<0.1	0.2	-	-
Piling rig	<0.1	<0.1	0.2	-	-
Wind erosion	-	-	<0.1	0.6	0.4
TOTAL SITE (CRR 2016)	**0.03**	**0.04**	**1.2**	**1.5**	**1.1**
CRR 2011	**N/A**	**5.2**	**5.5**	**4.5**	**N/A**

Table 11.8 Estimated $PM_{2.5}$ emissions from construction activities for CRR 2016 (kg/hour)

Construction Activity	Southern portal	Boggo Road Station	Woolloongabba Station	Northern portal	Mayne Yard
Drilling	<0.1	<0.1	<0.1	<0.1	-
Blasting	<0.1	<0.1	<0.1	<0.1	-
Excavators/FELs	<0.1	<0.1	<0.1	<0.1	<0.1
Bulldozers on spoil	-	<0.1	<0.1	<0.1	0.4
Loading trucks	<0.1	<0.1	<0.1	<0.1	<0.1
Wheel-generated dust	-	-	-	-	<0.1
Rock breaker	<0.1	<0.1	0.1	-	-
Piling rig	<0.1	<0.1	0.1	-	-
Wind erosion	-	-	<0.1	<0.1	<0.1
TOTAL SITE (CRR 2016)	**0.004**	**0.01**	**0.3**	**0.2**	**0.4**

11.2.3 Changes to meteorological and air dispersion modelling

The same modelling suite as used in the CRR 2011 air quality impact assessment was used for this assessment, however the meteorological data used for CRR 2016 has been updated based on observational data from 2012, whereas CRR 2011 used a 2008 meteorological dataset.

Meteorological modelling

Meteorological modelling was performed to compile a 1-year, 3-dimensional hourly dataset suitable for use in the CALPUFF dispersion model.

A review of meteorological data recorded by the Bureau of Meteorology (BOM) Automatic Weather Stations at Brisbane Airport and Archerfield Airport over the period 2011-2015 was performed to identify the most appropriate year for use in the meteorological and dispersion modelling studies. The analysis showed that data collected during the 2012 calendar year are in reasonably good agreement with long term averages compared to other years and was therefore selected for use for CRR 2016.

A summary of the annual wind behaviour at each construction worksite predicted by CALMET for 2012 is presented in Figure 11.1. Presented in a circular format, wind roses show the frequency of winds blowing from particular directions over a specified period. The length of each "spoke" around the circle is related to the frequency that the wind blows from a particular direction per unit time. Each spoke is also broken down into color-coded bands to show the frequency of specific wind speed ranges.

Figure 11.1 indicates that the predominant wind directions at all construction worksites were from the south-west quadrants. The Southern portal/Boggo Road Station, Woolloongabba and Mayne Yard construction worksites experienced predominantly light to moderate winds (between 1.5 m/s and 5.5 m/s). Winds at the Northern portal construction worksite are predicted by the meteorological model to be lighter than at the other three construction worksites. The frequency of calm wind conditions (wind speeds less than 0.5 m/s) is predicted to vary from 1.5% to 2% of the year across the four construction worksites.

Further details of the meteorological modelling methodology and meteorological dataset are provided in Appendix D2.

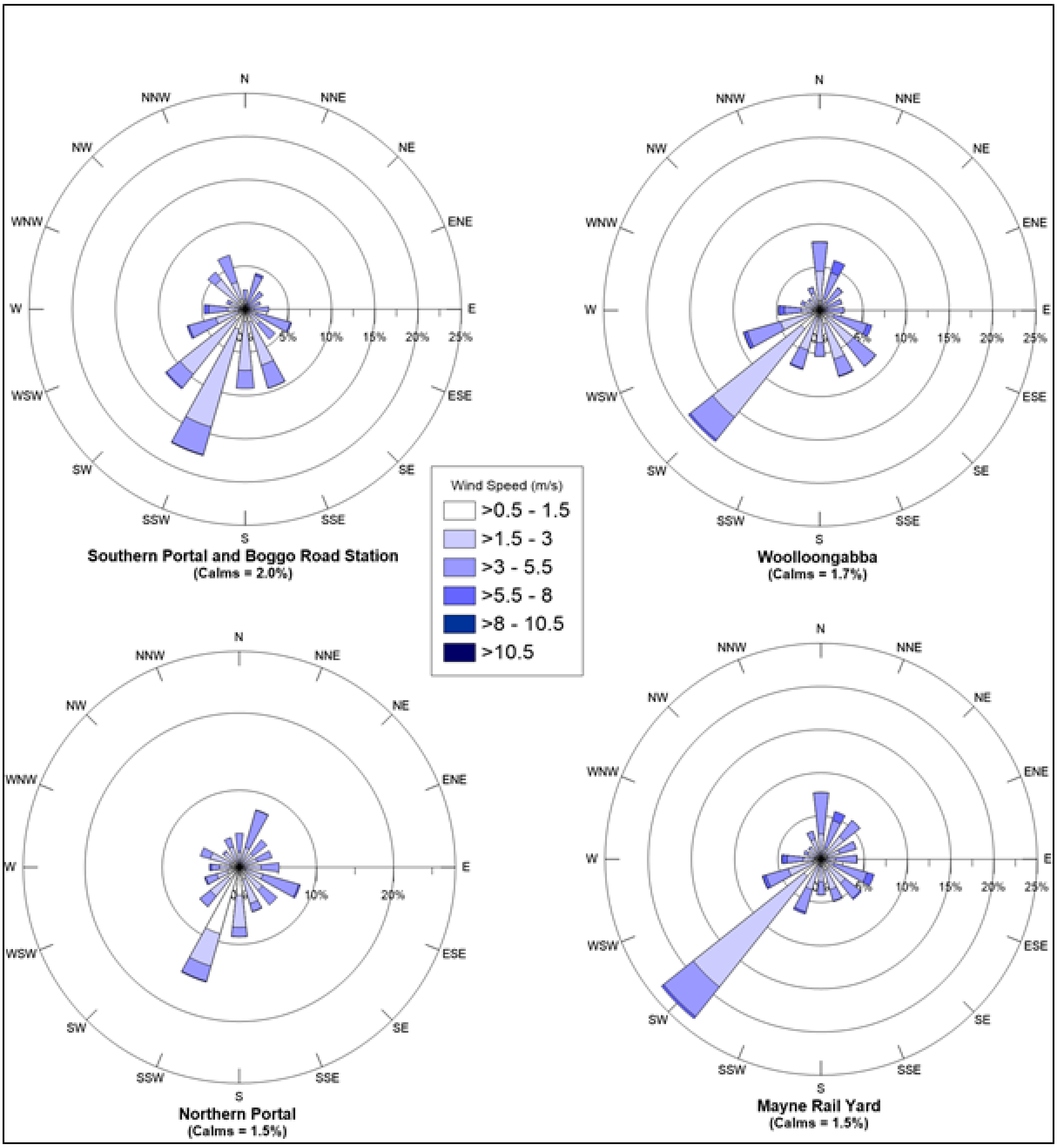


Figure 11.1 Wind Roses Predicted by CALMET for Southern portal, Woolloongabba, Northern portal and Mayne Yard

11.2.4 Changes to predicted off-site impacts

The results of the modelling are presented as contour plots in Appendix D3 to Appendix D6, with the predicted impacts at surrounding sensitive receptors for each site summarised in Table 11.9 to Table 11.12. The locations of these receptors are shown in the contour plots presented in Appendix D3 to Appendix D6.

A discussion of the results predicted for each construction worksite, compared to the impacts predicted for CRR 2011, is provided below. As discussed within Section 11.2.1, Albert Street Station and Roma Street Station have not been discussed below, as these sites would have low potential for adverse air quality impacts given the construction works will occur in the shaft or purpose-built acoustic shed. This is consistent with CRR 2011. In addition, Exhibition Station construction worksite was also not quantitatively assessed due to the low potential for air quality impacts. This is also consistent with CRR 2011.

Southern portal and Boggo Road

The results presented in Table 11.9 show no health or nuisance-based exceedances for the modelled pollutants at any surrounding sensitive receptor locations.

The Boggo Road construction worksite has been relocated to the eastern side of the Ecosciences building and the Southern portal construction worksite has been relocated to the north-west of the PA Hospital. The predicted concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition presented in this report for the cumulative impacts from the Boggo Road and Southern portal construction worksites however, are lower than those predicted for Boggo Road in CRR 2011. The predicted concentrations are also lower than those predicted for the Yeerongpilly Station and Southern portal construction worksite in CRR 2011. This is due to the addition of an enclosure equipped with a fabric filter to control dust emissions from both the Southern portal and Boggo Road construction worksites in CRR 2016.

The actual construction sequencing for the Southern portal will be influenced by the number and frequency of rail possessions. It is likely that construction activities will need to be staged such that the extent of predicted concentrations will be lower than this conservative analysis. Therefore, the residual impact may not require an enclosure or fabric filter for all or part of the construction activities. This is consistent with the Draft Outline EMP (Volume 2) and will need to be further assessed during detailed design.

Woolloongabba

The results presented in Table 11.10 show no exceedances of health-based ambient air quality criteria for the modelled pollutants at any surrounding residential receptor locations. Slight health-based exceedances of the 24-hour and annual average PM_{10} and annual average $PM_{2.5}$ criteria are predicted at the commercial receptor W5 (i.e. Main Street). However, CRR 2016 proposes demolition of this building, therefore there will be no impact at this receptor.

The nuisance-based criterion for 24-hour average TSP concentrations is predicted to be exceeded at receptors W1 (Vulture Street - residential) and W4 (St Nicholas Russian Orthodox Cathedral). In addition, exceedances of the annual average dust deposition rate nuisance criterion are predicted at all receptors with the exception of W7 (St Joseph's Primary School). These model predictions are very conservative as they are based on peak activity levels occurring continuously for the entire year. Therefore the peak 24-hour and maximum monthly predictions shown in Table 11.10 reflect the peak activities occurring under the worst case meteorological conditions. In addition, receptors W1 and W4 are located very close to the emission sources (within 30m) and it is likely that the model is over-predicting actual impacts this close to the sources given that the model grid is 30m.

The predicted impacts at surrounding sensitive receptors are lower than those of CRR 2011. This is due to the inclusion of additional mitigation measures (paving/sealing of haul roads) to minimise wheel-generated dust emissions compared to CRR 2011.

Northern portal

The results presented in Table 11.11 show no exceedances for the modelled pollutants at any surrounding sensitive residential receptor locations. Exceedances of the nuisance-based dust deposition criterion are predicted along the BGGS northern site boundary, however no health-based criteria are predicted to be exceeded in this area[47].

---

[47] The dust deposition plots in Appendix D5 show that the contour lines go over the northern border of the BGGS site. This does not however extend as far as receptor site N7, where the dust deposition rate is below the criterion.

The predicted concentrations are lower than for CRR 2011 due to the inclusion of additional mitigation measures (paving/sealing of haul roads) to minimise wheel-generated dust emissions. In addition, the proposed footprint of the construction worksite is smaller compared to CRR 2011.

Mayne Yard

The results presented in Table 11.12 show no health or nuisance-based exceedances for the modelled pollutants at any surrounding residential receptor locations.

The nuisance-based criterion for 24-hour average TSP concentrations is predicted to be exceeded at receptor M3 (Burrows Street - commercial) and exceedances of the annual average dust deposition rate nuisance criterion are predicted at receptors M3 and M4 (Burrows Street - both commercial).

In CRR 2011, the Mayne Yard worksite was not identified as having potential for off-site air quality impacts and no quantitative impact assessment was undertaken. As such, no comparison can be made to CRR 2016. Similar to other worksites, control methods for CRR 2016, including hoarding, water spray and sealed/hardstand roads, will be used to reduce dust emissions.

Table 11.9 Predicted cumulative impact at surrounding sensitive receptors during construction – Southern portal and Boggo Road

ID	Description	TSP (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		Maximum monthly dust deposition rate (mg/m²/day) (nuisance-based)
		24-Hour (nuisance-based)[48]	Annual (health-based)	24-Hour (health-based)	Annual (health-based)	24-Hour (health-based)	Annual (health-based)	
S1	Ecosciences Building - Commercial	26.9	24.2	17.5	14.6	8.4	6.5	60.6
S2	PA Hospital (General support services building)	29.7	24.8	18.6	14.9	8.6	6.6	65.0
S3	Rawnsley Street - residential	27.4	24.4	17.7	14.7	8.4	6.5	61.9
S4	Annerley Road - residential	26.3	24.1	17.2	14.5	8.3	6.5	60.1
S5	Dutton Park Primary School	26.5	24.1	17.3	14.5	8.3	6.5	60.0
S6	Leukaemia Foundation ESA	28.0	24.5	18.0	14.7	8.5	6.5	62.9
Guideline		80	90	50	25	25	8	120

[48] Refer to the Air quality objectives within Table 14.1

Table 11.10 Predicted cumulative impact at surrounding sensitive receptors during construction – Woolloongabba

ID	Description	TSP (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		Maximum monthly dust deposition rate (mg/m²/day) (nuisance-based)
		24-Hour (nuisance-based)	Annual (health-based)	24-Hour (health-based)	Annual (health-based)	24-Hour (health-based)	Annual (health-based)	
W1	Vulture Street - residential	96.2	44.3	40.1	21.5	13.9	8.0	220.2
W2	Vulture Street - commercial	74.9	34.4	32.4	18.2	12.6	7.3	145.7
W3	Main Street - residential	67.3	34.9	30.9	18.4	11.7	7.3	141.4
W4	St Nicholas Russian Orthodox Cathedral	88.9	43.4	37.4	21.1	13.4	8.0	216.6
W5	Main Street - commercial	135.5	57.8	52.1	25.8	17.3	9.1	329.3
W6	Stanley Street - commercial	78.2	31.7	34.5	17.2	12.4	7.1	170.8
W7	St Joseph's Primary School	47.7	28.5	24.1	16.2	10.2	6.8	92.4
Guideline		80	90	50	25	25	8	120

Table 11.11 Predicted cumulative impact at surrounding sensitive receptors during construction – Northern portal

ID	Description	TSP (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		Maximum monthly dust deposition rate (mg/m²/day) (nuisance-based)
		24-Hour (nuisance-based)	Annual (health-based)	24-Hour (health-based)	Annual (health-based)	24-Hour (health-based)	Annual (health-based)	
N1	Gregory Terrace - residential	36.7	26	22.6	15	9.0	7	67.9
N2	St Joseph's College	38.1	26	23.3	16	9.1	7	70.0
N3	Centenary Aquatic Centre	40.1	26	25.2	16	9.4	7	75.5
N4	Gregory Terrace - residential	35.0	26	21.7	15	8.9	7	66.9
N5	Gregory Terrace - commercial	56.1	32	32.2	19	10.2	7	108.2
N6	Bowen Bridge Road - Commercial	32.8	26	21.0	15	8.8	7	67.2
N7	Brisbane Girls Grammar School	38.8	27	23.8	16	9.1	7	95.3
N8	Royal Brisbane Hospital	40.4	26	24.6	15	9.2	7	76.2
N9	Mental Illness Fellowship	41.1	26	25.0	16	9.2	7	80.1
Guideline		80	90	50	25	25	8	120

Table 11.12 Predicted cumulative impact at surrounding sensitive receptors during construction – Mayne Yard

ID	Description	TSP (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		Maximum monthly dust deposition rate (mg/m²/day) (nuisance-based)
		24-Hour (nuisance-based)	Annual (health-based)	24-Hour (health-based)	Annual (health-based)	24-Hour (health-based)	Annual (health-based)	
M1	Le Geyt Street - residential	44.7	27.2	6.4	15.7	11.2	7.0	104.8
M2	Bowen Street - commercial	76.1	30.8	14.9	16.9	15.3	7.5	105.7
M3	Burrows Street - commercial	83.8	37.0	20.1	18.9	14.4	7.9	238.5
M4	Burrows Street - commercial	64.5	33.9	14.8	17.9	13.2	7.5	182.8
M5	Burrows Street - commercial	55.3	27.8	7.1	15.7	11.7	7.0	115.1
M6	Grantson Street - residential	32.6	25.1	2.7	15.0	9.4	6.7	77.4
Guideline		80	90	50	25	25	8	120

11.3 Changes to operational phase potential impacts

11.3.1 Changes to sources of air emissions

No changes to the key sources of operational-phase air emissions would occur as a result of CRR 2016. They would remain:

- Emissions from trains and railways - As in CRR 2011, CRR 2016 will influence train movements in the Brisbane area, including suburban and interurban passenger trains and diesel powered freight and coal trains; and
- Emissions from motor vehicles - As in CRR 2011, CRR 2016 will impact on motor vehicle use and emissions at both local (near train stations) and regional scales as a result of changes in the availability and access to rail services.

11.3.2 Effects of train movements

CRR 2016 allows for an increase in passenger train capacity to and through the CBD. Not associated with the CRR 2016 project, there is a reduction in forecast freight movements due to a wider network freight reduction, in particular intermodal movements to and from the North Coast Line.

For CRR 2011, passenger trains between Yeerongpilly Station and Boggo Road Station were in-tunnel while freight trains remained at surface. For CRR 2016, freight movements will still occur at surface, however the number of forecast freight trains will be reduced compared to the numbers for CRR 2011. Therefore air emissions predicted for this section will also be reduced relative to that predicted for CRR 2011.

There are no direct emissions to air associated with electric trains aside from minor particulate matter emissions related to brake pad wear, vaporisation of metals, the friction between the wheels and rail. As outlined in the CRR 2011 air quality impact assessment, railway emissions are a small contributor to total emissions in SEQ. Therefore, the predicted changes to train movements described above for CRR 2016 are unlikely to affect regional air quality. GHG emissions from railway operations are presented in Section 11.4.

11.3.3 Effects of motor vehicles

Changes to motor vehicle use as a result of CRR 2016 have the potential to affect air quality on both a regional and local scale.

Regional operational effects

The estimated daily vehicle kilometres travelled (VKT) with and without CRR 2016 for private vehicles using the urban and highway modes of travel, have been reviewed. This data indicates that CRR 2016 would result in a 0.3% decrease in VKT on opening (compared to 0.4% for CRR 2011) and a 0.6% decrease 10 years after opening (compared to 0.9% for CRR 2011). Overall, CRR 2016 is predicted to result in a reduction of 1.8 million VKT per day in urban traffic by 2036. This is slightly lower than that predicted for CRR 2011.

The CRR 2011 air quality impact assessment concluded that the predicted change in air emissions from road traffic with and without the Project would be negligible and would have little effect on ambient air quality in the region. This outcome remains unchanged for CRR 2016 and the measured air pollutants concentrations from road vehicles in the Brisbane region are not anticipated to change as a result of the Project.

Localised operational effects

An assessment of the likely impact (during operation of CRR 2016) on local air quality due to traffic changes in the vicinity of each station is provided below:

- **Boggo Road Station**: The location of the Boggo Road Station proposed as part of the CRR 2016 project is generally in a similar location to CRR 2011 and there will be no substantial change to the local road network. As such, there will be no changes in local air quality anticipated compared to CRR 2011;
- **Woolloongabba Station**: The location of the station requires no substantial change to the local road network and no changes in local air quality associated with localised traffic changes would be anticipated;
- **Albert Street Station**: The greatest change associated with the relocation of the Albert Street station as part of CRR 2016 compared to CRR 2011 is the proposed pedestrianisation of Albert Street between Mary Street and Charlotte Street and between Charlotte Street and Elizabeth Street. This will result in an overall improvement in local air quality in this area due to a redistribution of traffic to other parts of the CBD network;
- **Roma Street Station**: The location of the Roma Street Station proposed as part of the CRR 2016 project is generally in a similar location to CRR 2011. The location of the station requires no substantial change to the local road network and no changes in local air quality would be anticipated; and
- **Exhibition Station**: The CRR 2016 road changes proposed for the Exhibition Station are similar to CRR 2011 and no changes in local air quality would be anticipated.

11.3.4 Underground rail stations

No changes in air quality within the underground stations are anticipated for CRR 2016 compared to CRR 2011. Platform screen doors are still proposed to be utilised at all underground platforms, which would physically separate air in the rail corridor from air in the railway stations. Combined with effective station ventilation systems, this barrier will assist in reducing exposure to rail users from dusts and other contaminants

11.3.5 Station ventilation and portal emissions

As in CRR 2011, air within the tunnel and stations would be exhausted to the surface by ventilation systems at the underground stations and via the portal entrances. However, CRR 2016 does not require a ventilation shaft at Fairfield as was proposed in CRR 2011 (due to tunnel extending to Yeerongpilly).

No changes in the nature or composition of the air emissions discharged from the underground station ventilation systems or portals are anticipated for CRR 2016 compared to CRR 2011.

11.3.6 Thermal impacts

No changes in thermal impacts from the underground station ventilation systems are anticipated for CRR 2016 compared to CRR 2011.

11.4 Changes to greenhouse gas emissions

The GHG calculation methodology and activity data assumptions from CRR 2011 have been reviewed, and the calculations have been updated based on CRR 2016 project information.

Details of the calculations are provided in Appendix D7. The key changes in the calculations compared to CRR 2011 are:

- Updated GHG emission factors for petrol and diesel combustion and for electricity use in Queensland, taken from the latest National Greenhouse Accounts Factors Workbook published by the Australian Department of the Environment in August 2015;
- Revised estimates of electricity and diesel consumption for the construction phase, which have been scaled from the CRR 2011 estimates based on the reduction in spoil quantities;
- Revised estimates of electricity consumption by the stations (lighting, ventilation etc.) during the operational phase, taking into account the reduction in the number of above ground stations (dropping from two to one);
- Revised information on the anticipated changes in road traffic (i.e. total daily travel distances) for the Brisbane road network due to the Project, sourced from the CRR 2016 modelling;
- Updated information on the Queensland vehicle fleet composition and fuel types based on the Australian Bureau of Statistics Motor Vehicle Census 31 Jan 2015, released 23 July 2015; and
- Updated information on fuel efficiency values for articulated trucks and motorcycles taken from the Australian Bureau of Statistics Survey of Motor Vehicle Use for Year Ending 31 October 2014, released 15 October 2015.

Data is not currently available to enable the projected changes in the electricity demand for passenger train operations associated with CRR 2016 to be quantified and will be addressed through future sustainability initiatives as detailed in the Draft Outline EMP (Volume 2). The forecast increase in the number of passenger trains from current levels for CRR 2016 is less than that predicted for CRR 2011. As a result, the operational phase electricity demand associated with train operations for CRR 2016 will also be lower than that estimated for CRR 2011. On this basis, the increase in electricity demand estimated for passenger train operations for CRR 2011 has been used as a conservative estimate for calculating the associated GHG emissions for CRR 2016. This will result in a conservative assessment of the changes in GHG emissions from CRR 2011 to CRR 2016.

The resulting scope 1 and scope 2 GHG emissions estimated for CRR 2016, compared to the estimates reported in the CRR 2011 GHG assessment, are presented in Table 11.13 (construction phase) and Table 11.14 (operational phase). The GHG emission estimates for the operational phase have been calculated based on 2026 and 2036 forecast years. The proposed change to the opening year for CRR 2016 has necessitated a change to the years at which potential impacts are assessed. Construction impacts are assessed on a construction programme to achieve a 2023 year of opening and the operational impacts are based on a 2026 transport model representing opening year.

The total Scope 1 and Scope 2 GHG emission estimates for the CRR 2016 construction phase are 34% lower than CRR 2011. The CRR 2016 operational-phase GHG emission estimates are 18% lower than CRR 2011 for activities associated with station operations.

The operational-phase GHG emission estimates for train movements (i.e. increased electricity use) are 13 - 14% lower than the emissions estimated for CRR 2011. This is associated with a 13% decrease in the GHG emission factor for electricity consumption in Queensland. As noted above, these calculations are based on the electricity demand for train operations estimated for CRR 2011 and due to a smaller increase in train numbers for CRR 2016 compared to CRR 2011, this is anticipated to overestimate actual emissions for CRR 2016.

The estimated changes in GHG emissions due to changes in the Brisbane road network performance over a ten year period resulting from CRR 2016 are presented in Table 11.15. This shows a reduction in GHG emissions from road traffic as a result of the project.

Table 11.13 Changes in GHG emission estimated for construction phase

Source	**CRR 2011**	**CRR 2016**	**Change**
	t CO_2-e	**t CO_2-e**	**t CO_2-e (%)**
Excavation of tunnels, shafts and caverns			
Electricity consumption	174,663	110,741	-63,921 (-37%)
Diesel fuel consumption	21,938	15,792	-6,146 (-28%)
Site preparation, surface works and station construction			
Electricity consumption	244,773	155,193	-89.580 (-37%)
Diesel fuel consumption	211,235	152,055	-59,179 (-28%)
TOTAL	652,608	433,781	-218,826 (-34%)

Table 11.14 Changes in GHG emissions estimated for the operational phase

SOURCE	**CRR 2011**	**CRR 2016**	**Change**
	t CO_2-e/year	**t CO_2-e/year**	**t CO_2-e/year (%)**
Train Stations			
Above ground stations	4,035	1,194	
Underground stations	29,811	26,462	
Stations sub total	**33,846**	**27,655**	**-6,191 (-18%)**
Train Movements			
Trains - 2026	62,610	55,575	
Trains - 2036	109,222	96,950	
TOTAL (2026)	**96,457**	**83,231**	**-13,226 (-14%)**
TOTAL (2036)	**143,069**	**124,606**	**-18,463 (-13%)**

Table 11.15 Changes in GHG emissions estimated due to changes in the road network performance

Year	**GHG emissions without project**		**GHG emissions with project**		**Difference in annual GHG emissions (t CO_2-e/year)**
	AWDT (t CO_2-e/day)	**Annual (t CO_2-e/year)**	**AWDT (t CO_2-e/day)**	**Annual (t CO_2-e/year)**	
2026	20,958	6,916,112	20,897	6,895,946	-20,166
2036	25,536	8,426,803	25,251	8,332,965	-93,838

AWDT = average weekday travelled, Annual = AWDT x 330

11.5 Changes to mitigation and monitoring

Mitigation measures which are consistent with CRR 2011 include the following:

- *Odour*: The same management measures identified for the control of potential off-site nuisance impacts due to the excavation and handling of contaminated soils in CRR 2011 are also valid for CRR 2016 and have been adopted in the Draft Outline EMP (Volume 2). Contaminated soils are anticipated to be present at various locations throughout the entire study corridor (especially Mayne Yard), which means there is a risk of odour impacts associated with the extraction and handling of these material;
- *Diesel Exhaust*: The same mitigation measures identified in the CRR 2011 air quality impact assessment for diesel exhaust emissions will be adopted for CRR 2016 as detailed in the Draft Outline EMP (Volume 2). Total diesel fuel consumption for the construction phase is estimated to be lower for CRR 2016 compared to CRR 2011 due to smaller quantities of spoil being handled and the associated reduction in the number of haul truck movements. However, peak short-term fuel consumption rates are unlikely to be substantially lower, hence the incremental impacts on peak 1-hour and 24-hour concentrations of pollutants contained in exhaust fumes emitted at each construction worksite (such as oxides of nitrogen and sulfur dioxide) are likely to be unchanged;
- *GHG Emissions*: No changes to the construction phase GHG mitigation measures proposed for CRR 2011 are proposed or are considered to be required for CRR 2016.

Additional mitigation measures now relevant to CRR 2016 include:

- *Nuisance Dust*: As discussed in Section 11.2.4, the maximum off-site suspended and deposited particulate levels predicted at the key construction worksites are lower than the levels predicted for CRR 2011. This is due to smaller quantities of spoil being handled and the associated reduction in the number of haul truck movements and the inclusion of the additional dust mitigation measures, specifically:
  - Paving/sealing of haul roads at the Woolloongabba and the Northern portal construction worksites; and
  - Where predictive modelling indicates exceedances of the air quality goals for human health at nearby sensitive receptor locations, measures such as work sheds or enclosures equipped with a fabric filter for the removal of airborne particulate matter may be required at Boggo Road and the Southern portal.
- *$PM_{2.5}$:* $PM_{2.5}$ is an issue for urban environments due to vehicle emissions and it is not unusual for major cities in Australia like Brisbane to record exceedances of the 24 hour criterion in the inner city. Construction-related dust emissions are mostly mechanically generated by earthworks and wind erosion and tend to be dominated by larger particles, whereas $PM_{2.5}$ is very fine and is mainly generated by combustion sources. It is proposed to manage $PM_{2.5}$ emissions through maintenance of the construction fleet and construction equipment. A Construction Vehicle Management Plan is proposed which will address this matter.

These additional controls have been added to the dust mitigation measures identified in the CRR 2011 air quality impact assessment for adoption in CRR 2016, as detailed in the Draft Outline EMP (Volume 2).

If monitoring shows exceedances during construction, additional mitigation measures may be implemented, such as stopping dust generating activities during dry, windy conditions, undertaking additional audits of dust controls, increasing watering rates during dry periods, and undertaking targeted consultations with affected parties.

Construction phase air quality monitoring

A total of 17 indicative dust monitoring locations were identified for CRR 2011 across the main construction worksites. These monitoring sites have been revised based on the results of the findings presented in Section 11.2.4 and new indicative locations are now proposed where relevant. The total number of proposed monitoring sites is now 14 for CRR 2016, as shown in Table 11.16, which also notes the type of monitoring proposed (dust deposition or PM_{10}). The reduction in the number of locations for dust monitoring is generally a result of the reduced alignment length.

Table 11.16 Indicative dust monitoring locations

Worksite	CRR 2016
Southern portal and Boggo Road Station	1. Dutton Park State School, south eastern corner of site (PM_{10}) 2. Ecosciences Precinct, roof level at location indicative of AC intakes (PM_{10}) 3. PA Hospital grounds, ground level (DD) 4. PA Hospital, roof level at location indicative of AC intakes (PM_{10}) 5. Joe Baker Street, near ESA Village (DD) 6. Dutton Street, at selected residence (DD)
Woolloongabba Station	7. TMR/DEHP monitoring station at South Brisbane (PM_{10}) 8. Russian Orthodox Cathedral (DD) 9. Reid Street, adjacent Chalk Hotel car park (DD)
Albert Street Station	10. Courtyard area, Level 3, The Sebel (DD, PM_{10})
	11. Albert Street, south-west corner with Mary Street (DD, PM_{10})
Roma Street Station	12. Adjacent to residential complex, Roma Street Parkland (DD)
Northern portal	13. Victoria Park, adjacent to Brisbane Girls Grammar School (DD) 14. Gregory Terrace, adjacent to Centenary Aquatic Centre (DD)

Note: DD = Dust deposition

11.6 Conclusion

The air quality impact assessment for CRR 2016 has identified that during the construction phase, estimated emission rates for construction activities and predicted cumulative off-site air quality impacts are lower compared to that predicted for CRR 2011. The assessment included additional construction mitigation measures that have been identified at the Southern portal, Boggo Road Station, Woolloongabba Station and the Northern portal construction worksites. These are in addition to the dust mitigation measures identified in the CRR 2011 air quality impact assessment.

Consistent with CRR 2011, contaminated soils are anticipated to be present at various locations throughout the entire study corridor (especially Mayne Yard), which means there is a risk of odour impacts associated with the extraction and handling of these materials. Total diesel fuel consumption for the construction phase is estimated to be lower for CRR 2016 compared to CRR 2011.

During operations, no changes in thermal impacts or air emissions discharged from the underground station ventilation systems and air quality within the underground stations are anticipated for CRR 2016 compared to CRR 2011. A ventilation shaft is no longer proposed at

Fairfield. Regional air pollutant concentrations associated with emissions from trains and railways and motor vehicles are not anticipated to change as a result of CRR 2016, compared to CRR 2011.

The total GHG emission estimates for the CRR 2016 are reduced for both the construction and operational phases compared to CRR 2011.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

Appendix D

Review of Existing Air Quality

D1 Review of existing Air quality

In the CRR 2011 AQGHG Assessment, a review of ambient air quality data reported by DERM for their Rocklea, South Brisbane and Brisbane CBD air quality monitoring stations (AQMSs) from 2005 to 2009 and data recorded by Airport Link at Bowen Hills from 2004 and 2005 was performed. Based on this review, the background air pollutant concentrations shown in Table D-1 were used in the CRR 2011 air quality impact assessment.

These values were assumed based on data that are now 10 years old in some cases, hence a review of the most recent monitoring data (2014-2015) available from the DERM ambient air quality network has been performed and the assumed background concentrations have been revised as required to ensure they are reflective of current air quality.

The background concentrations of pollutants assumed in for CRR 2016 are also shown in Table D-1 based on a review of the most recent air quality monitoring data, including:

- **Cannon Hill monitoring station**: Located in a residential and industrial area south east of the northern section of the study corridor. The site was commissioned in January 2014 and measures concentrations of PM_{10} and $PM_{2.5.}$ This site is likely to be heavily influenced by particulate emissions from coal trains;
- **Brisbane CBD monitoring station**: Located in an elevated position at the QUT campus. The site measures concentrations of PM_{10}. This site is likely to be heavily influenced by surrounding traffic emissions;
- **South Brisbane monitoring station**: Located near the Riverside Expressway. The site measures concentrations of PM_{10} and $PM_{2.5}$ and is also likely to be heavily influenced by surrounding traffic emissions; and
- **Rocklea monitoring station**: Located in an open area surrounded by industrial and residential uses. The site measures concentrations of PM_{10} and $PM_{2.5}$.

A summary of the ambient concentrations of PM_{10}, $PM_{2.5}$ and TSP reported by these stations is provided in Table D-2. Plots of the 24-hour average TSP, PM_{10} and $PM_{2.5}$ concentrations recorded are presented in Figure D-1 to Figure D-3. Based on a review of these data, the background concentrations assumed for CRR 2016 are as shown in Table D-1. These values were selected as follows:

- The annual average background TSP concentration is the average of the annual average TSP concentrations measured by the Cannon Hill monitoring station in 2014 and 2015;
- The 24-hour average background TSP concentration is the 70th percentile of the 24-hour average TSP concentrations measured by the Cannon Hill monitoring station over 2014 and 2015;
- The annual average background PM_{10} concentration is the average of the annual average PM_{10} concentrations measured by the Rocklea monitoring station in 2014 and 2015;
- The 24-hour average background PM_{10} concentration is the 70th percentile of the 24-hour average PM_{10} concentrations measured by the Cannon Hill, Brisbane CBD, South Brisbane and Rocklea monitoring stations over 2014 and 2015;
- The annual average background $PM_{2.5}$ concentration is the average of the annual average $PM_{2.5}$ concentrations measured by the Rocklea monitoring stations in 2014 and 2015;

- The 24-hour average background $PM_{2.5}$ concentration is the 70th percentile of the 24-hour average concentrations measured by the Cannon Hill, South Brisbane and Rocklea monitoring stations over 2014 and 2015; and
- The annual average background dust deposition rate is an assumed value (in the absence of any local monitoring data) that would be expected to be conservative estimate for an urban environment. It is identical to that used in the CRR 2011 assessment.

Table D-1 Background concentrations of Air quality indicators

Air quality indicator	Averaging period	Units	Value assumed for CRR 2011	Value use for CRR 2016	Air quality objective
TSP	24 hours	$\mu g/m^3$	29	26	80
	Annual	$\mu g/m^3$	28	24	90
PM_{10}	24 hours	$\mu g/m^3$	19	17	50
	Annual	$\mu g/m^3$	Not assessed	14.5	25
$PM_{2.5}$	24 hours	$\mu g/m^3$	Not assessed	8.3	25
	Annual	$\mu g/m^3$	Not assessed	6.5	8
Dust deposition	30 days	$mg/m^2/day$	60	60	120

Table D-2 Summary of TSP, PM_{10} and $PM_{2.5}$ monitoring data for Brisbane (2014 and 2015)

Parameter	**Cannon Hill**		**Brisbane CBD**		**South Brisbane**		**Rocklea**	
	2014	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
24 hour average PM_{10} concentration								
Average	16.9	14.6	14.2	14.2	16.3	15.5	14.0	14.9
70th Percentile	19.3	16.6	15.9	16.0	17.7	17.4	15.6	16.8
95th Percentile	27.3	22.5	27.2	23.5	29.5	24.8	24.3	24.1
99th Percentile	33.9	33.1	35.4	32.1	36.0	31.4	30.4	31.0
Maximum	43.4	62.4	38.6	49.9	46.5	43.2	31.6	44.0
Exceedances	0	1	0	0	0	0	0	0
24 hour average $PM_{2.5}$ concentration								
Average	9.0	6.9	-	-	7.0	7.5	5.7	7.3
70th Percentile	10.6	8.0	-	-	7.6	8.3	6.6	8.8
95th Percentile	16.3	11.7	-	-	13.6	14.8	13.0	13.4
99th Percentile	22.7	14.3	-	-	18.5	18.8	18.7	16.5
Maximum	26.1	16.1	-	-	29.4	25.5	21.9	20.3
Exceedances	1	0	-	-	1	1	0	0
24 hour average TSP concentration								
Average	24.4	23.2	-	-	-	-	-	-
70th Percentile	26.6	25.1	-	-	-	-	-	-
95th Percentile	41.3	37.3	-	-	-	-	-	-
99th Percentile	49.6	56.2	-	-	-	-	-	-
Maximum	138.0	145.9	-	-	-	-	-	-
Exceedances	1	1	-	-	-	-	-	-

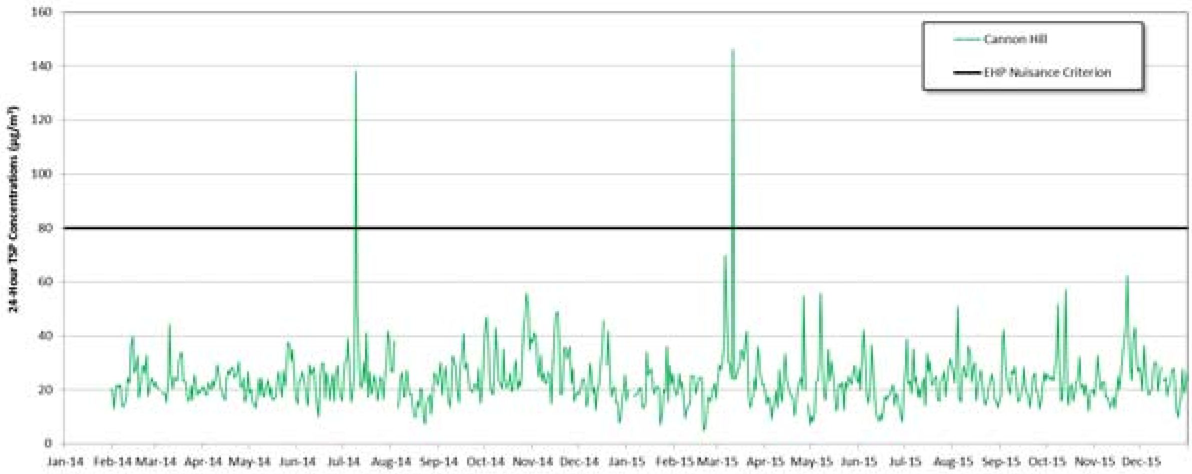


Figure D-1 TSP monitoring data for Brisbane (2014 and 2015)

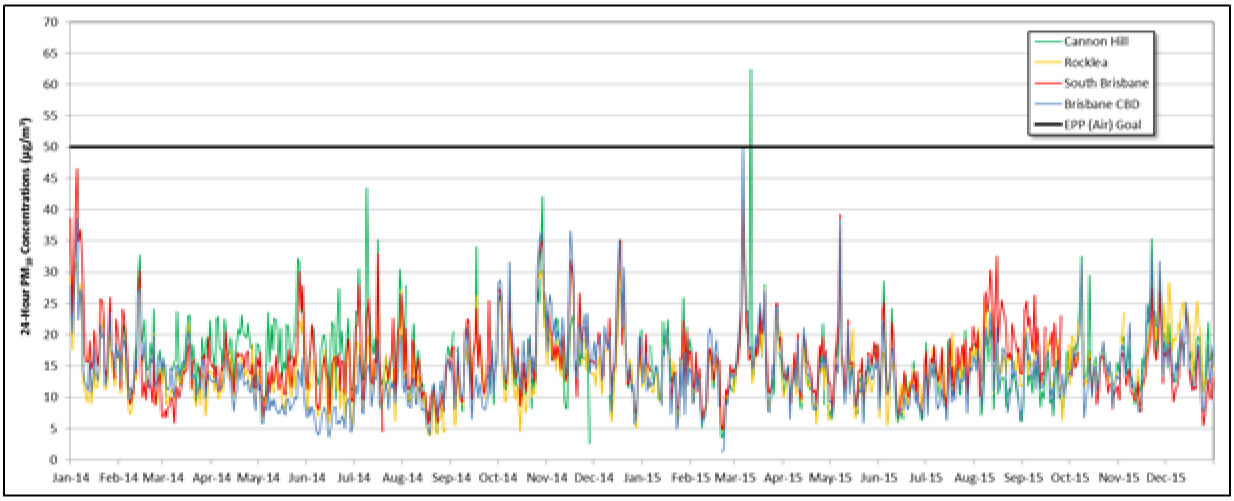


Figure D-2 PM_{10} monitoring data for Brisbane (2014 and 2015)

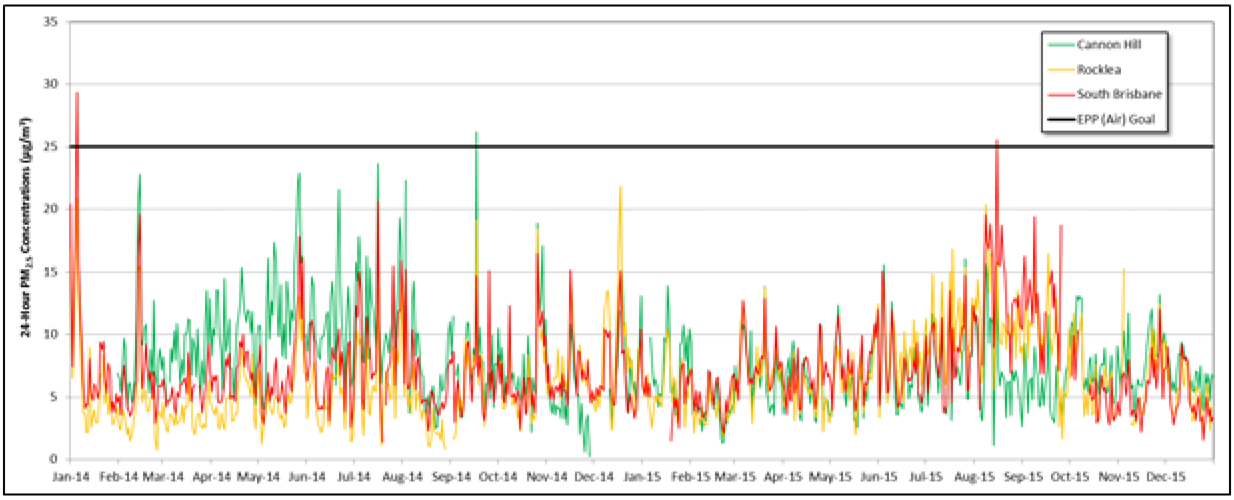


Figure D-3 $PM_{2.5}$ monitoring data for Brisbane (2014 and 2015)

D2 Meteorological modellings

Emissions from the CRR 2016 construction worksites have been modelled using a combination of the TAPM, CALMET and CALPUFF models. CALPUFF is a transport and dispersion model that ejects “puffs” of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so it typically uses the fields generated by a meteorological pre-processor CALMET, discussed further below.

Selection of meteorological year

Meteorological data collected over the period 2011-2015 by the nearest BOM automatic weather stations (Brisbane and Archerfield Airports) were analysed to select a representative year for dispersion modelling. The analysis showed that data collected during the 2012 calendar year are in reasonably good agreement with long term averages compared to other years and was therefore selected for use in modelling particulate emissions from the proposed CRR 2016 construction activities.

TAPM

The TAPM prognostic model, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to generate the upper air data required for CALMET modelling. The TAPM model predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The programme allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate one full year of hourly meteorological observations at user-defined levels within the atmosphere.

Additionally, the TAPM model may assimilate actual local wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values. Available data from nearby BOM stations (Brisbane Airport and Archerfield Airport) were used to nudge (i.e. influence) the TAPM predictions.

Table D-3 details the parameters used in the TAPM meteorological modelling for CRR 2016.

Table D-3 Meteorological parameters used for this study – TAPM

TAPM (v 4.0)	
Number of grids (spacing)	4 (30km, 10km, 3km and 1km)
Number of grid points	25 x 25 x 35
Year of analysis	2012
Centre of analysis	502,394m E 6,965,567m S
Data assimilation	Brisbane Airport and Archerfield Airport BOM Stations

CALMET

In the simplest terms, CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain that are required as inputs to the CALPUFF dispersion model. Associated two-dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, sea breeze, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly varying wind field thus reflects the influences of local topography and land uses.

CALMET modelling was conducted using the nested CALMET approach, where the final results from a coarse-grid run were used as the initial guess of a fine-grid run. This approach differs from that used in the CRR 2011 air quality impact assessment and has the advantage that off-domain terrain features, including slope flows, blocking effects etc., can be allowed to take effect and the larger-scale wind flow provides a better start in the fine-grid run.

The outer domain (25km × 25km) was modelled with a resolution of 0.5km. TAPM-generated three dimensional meteorological data were used as the initial guess wind field and the local topography and available surface weather observations in the area (Archerfield Airport and Brisbane Airport) were used to refine the wind field predetermined by TAPM data.

A number of nested CALMET runs were then conducted to refine the meteorology to a 30 m resolution for each construction worksite, which has then been used in the CALPUFF dispersion modelling study. This fine grid resolution has been used due to the close proximity of the construction activities to nearby sensitive receptors at some of the sites. A larger grid resolution would not be as accurate in resolving the localised dispersion effects over these small distances. Fine scale local topography and land use information were used for the inner domains to refine the wind field parameters predetermined by the coarse CALMET run.

The model domain and grid resolution for each of these runs are presented in Table D-4.

Table D-4 Meteorological parameters used for this study – CALMET (v 6.1)

Domain 1	
Meteorological grid area	25km × 25km
Meteorological grid resolution (spacing)	0.5km
Initial guess field	3D Output from TAPM model run
Domain 2	
Meteorological grid area	5km × 5km
Meteorological grid resolution (spacing)	0.1km
Initial guess field	3D output from CALMET run for Domain 1
Inner Domain – Southern portal and Boggo Road Station	
Meteorological grid area	3km ×3km
Meteorological grid resolution (spacing)	0.03km
Initial guess field	3D output from CALMET run for Domain 2
Inner Domain - Woolloongabba	
Meteorological grid area	2km × 2km
Meteorological grid resolution (spacing)	0.03km
Initial guess field	3D output from CALMET run for Domain 2
Inner Domain – Northern portal	
Meteorological grid area	3km × 3km
Meteorological grid resolution (spacing)	0.03km
Initial guess field	3D output from CALMET run for Domain 2
Inner Domain – Mayne Yard	

Meteorological grid area	2km × 2km
Meteorological grid resolution (spacing)	0.03km
Initial guess field	3D output from CALMET run for Domain 2

Meteorological Data Used in the Modelling Study

The following summary of the meteorological data used in the modelling study has been compiled based on data extracted for the Southern portal/Boggo Road site and for Mayne Yard. These sites were estimated to have the greatest particulate emission rates and are also located at the two ends of the study area.

Wind Speed and Direction

A summary of the annual wind behaviour predicted by CALMET for the four sites modelled is presented in Figure D-4 and Figure D-5.

Presented in a circular format, the wind roses in Figure D-5 show the frequency of winds blowing from particular directions over a specified period. The length of each "spoke" around the circle is related to the frequency that the wind blows from a particular direction per unit time. Each spoke is also broken down into color-coded bands to show the frequency of specific wind speed ranges.

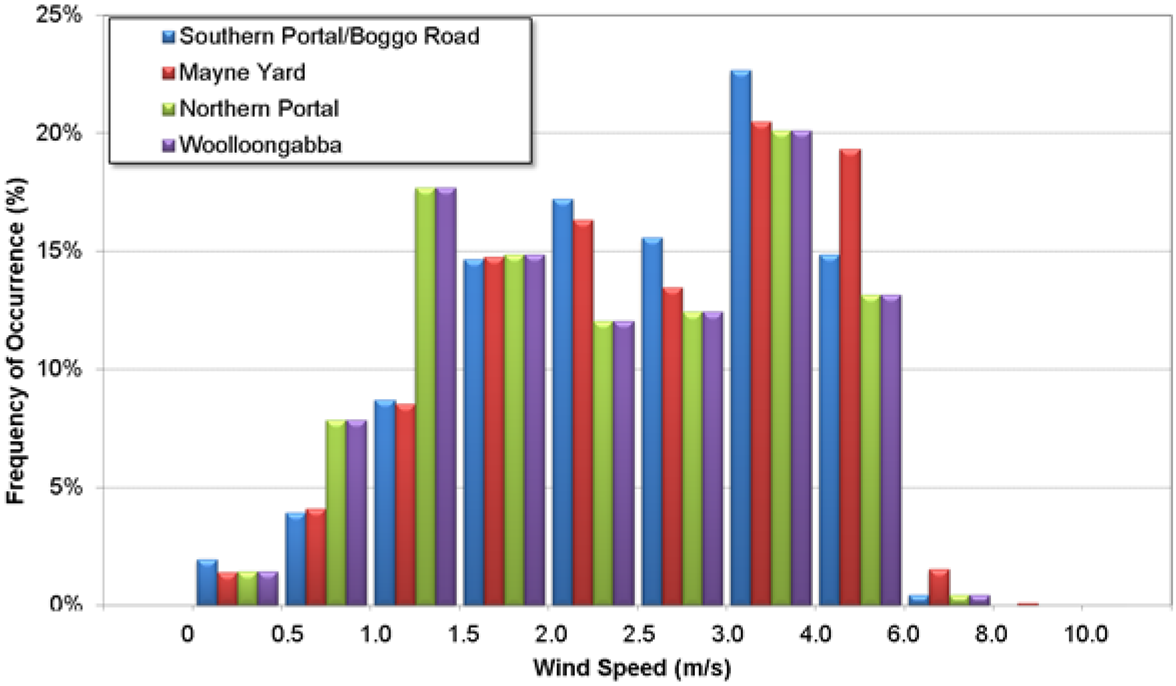


Figure D-4 Wind speed frequency chart as predicted by CALMET (2012)

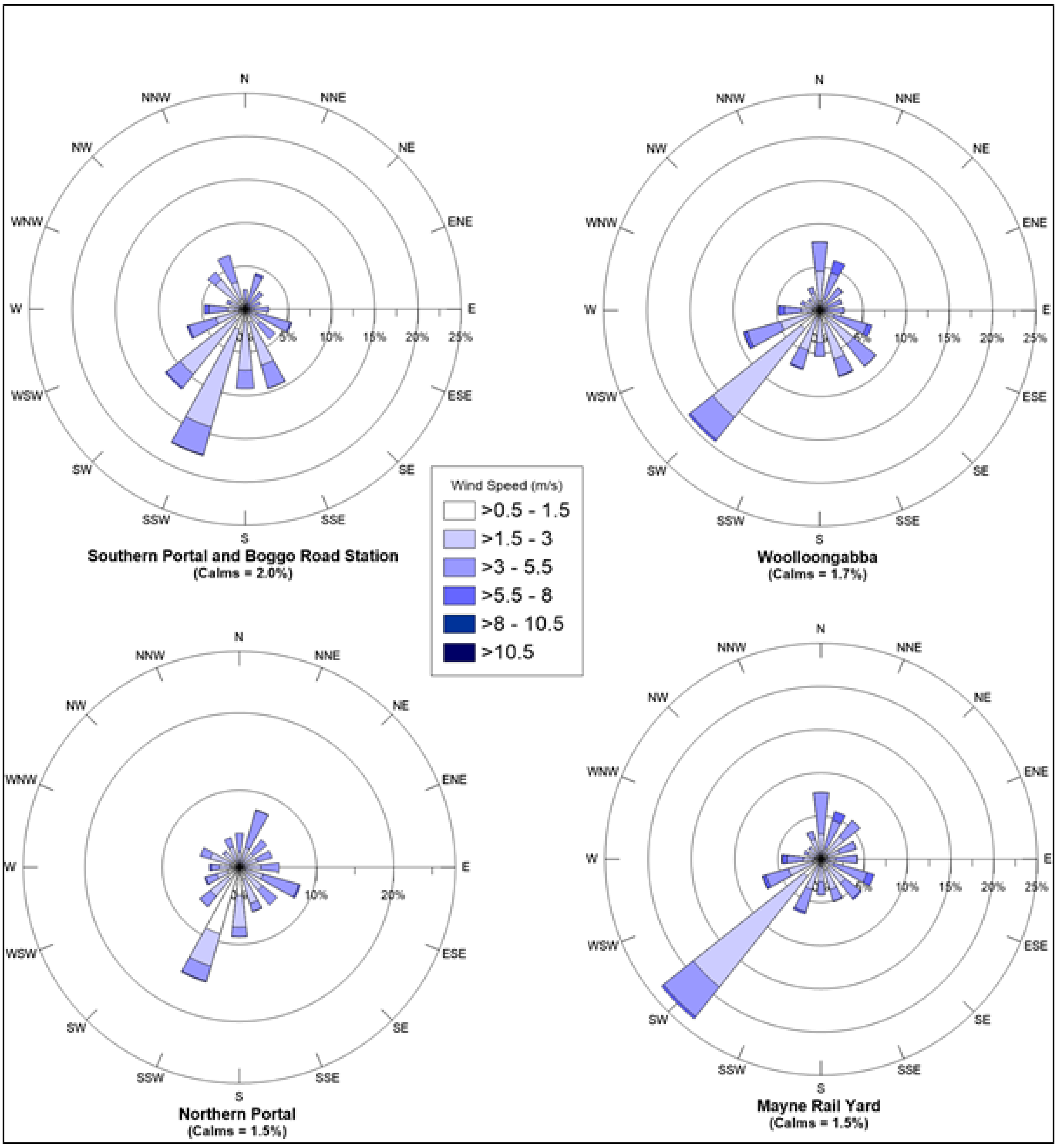


Figure D-5 Wind roses as predicted by CALMET (2012)

Atmospheric stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Turner assignment scheme identifies six Stability Classes, A to F, to categorize the degree of atmospheric stability as follows:

A = Extremely unstable conditions

B = Moderately unstable conditions

C = Slightly unstable conditions

D = Neutral conditions

E = Slightly stable conditions

F = Moderately stable conditions

The meteorological conditions defining each Pasquill stability class are shown in Table D-5.

Table D-5 Meteorological conditions defining Pasquill stability classes

Surface wind speed (m/s)	Daytime insolation			Night time conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 cloud	<= 4/8 cloudiness
<2	A	A – B	B	E	F
2 – 3	A – B	B	C	E	F
3 – 5	B	B – C	C	D	E
5 – 6	C	C – D	D	D	D
>6	C	D	D	D	D

Notes

Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.

Night refers to the period from 1 hour before sunset to 1 hour after sunrise.

The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

Source: Pasquill, (1961).

The frequency of each stability class predicted by CALMET for the construction worksites is presented in Figure D-6.

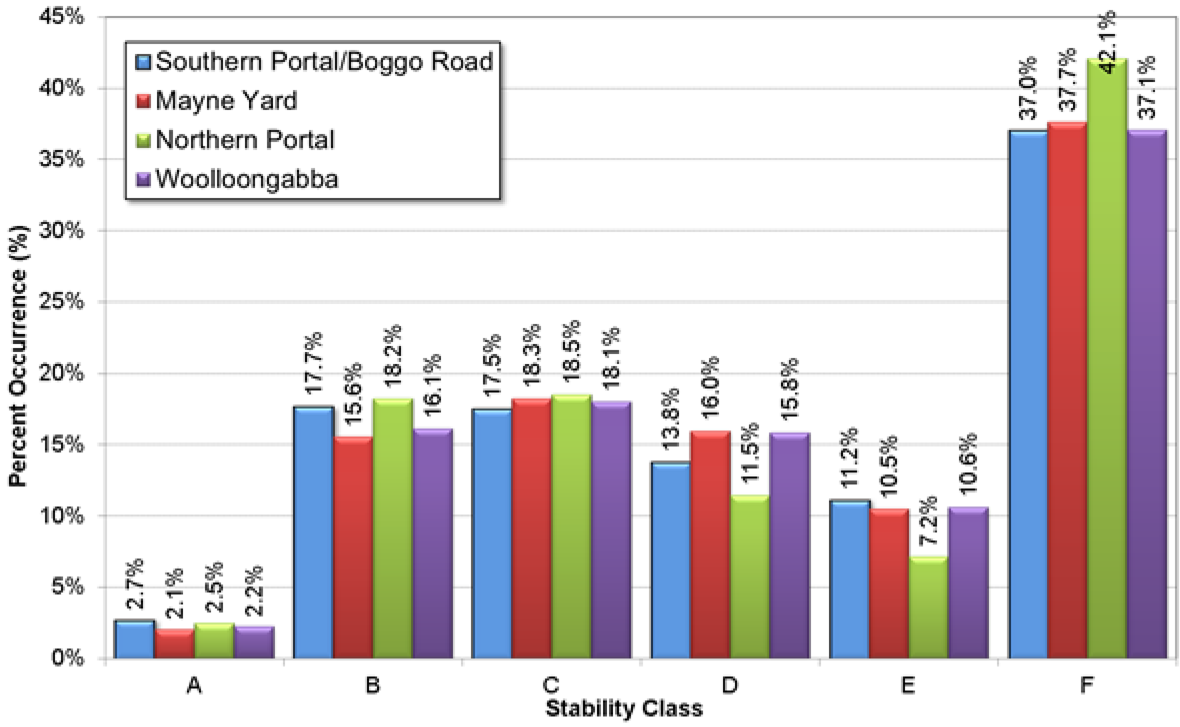


Figure D-6 Stability class distribution predicted by CALMET (2012)

Mixing heights

Diurnal variations in maximum and average mixing depths predicted by CALMET for the four construction worksites during 2012 are illustrated in Figure D-7 to Figure D-10. As would be expected, an increase in the mixing depth during the morning is apparent for all sites, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground based temperature inversions and the growth of the convective mixing layer.

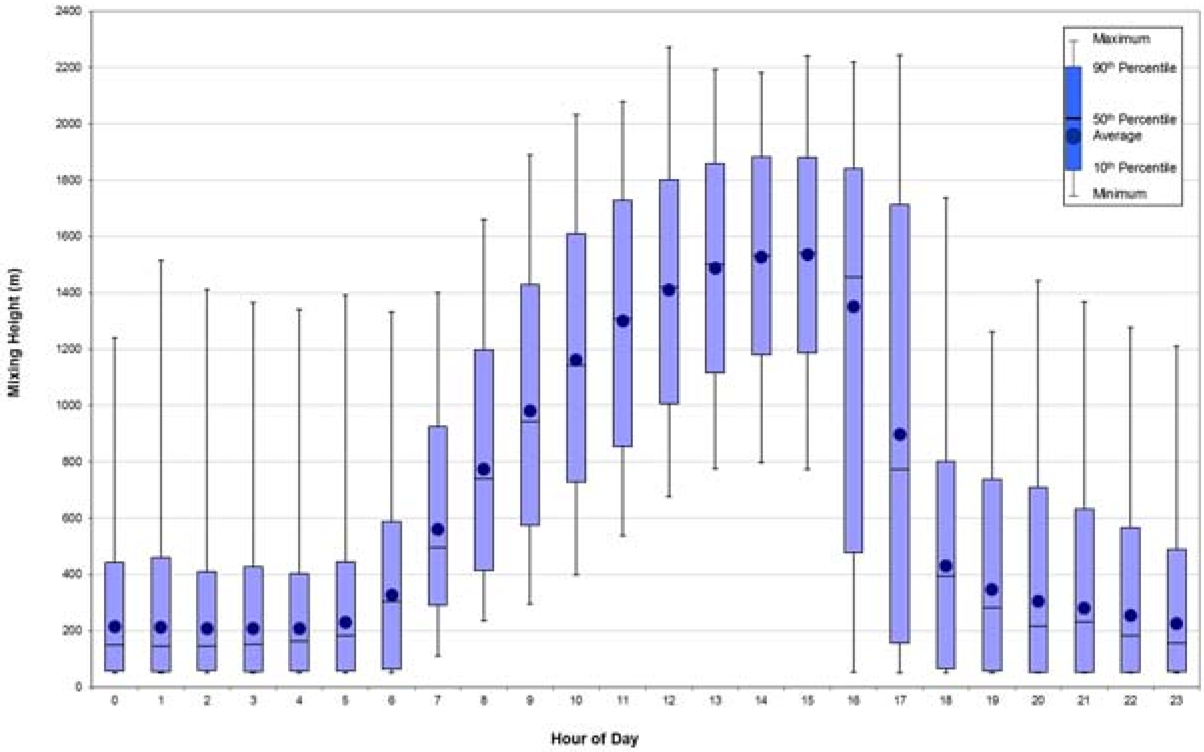


Figure D-7 Mixing heights predicted by CALMET – Southern portal/Boggo Road (2012)

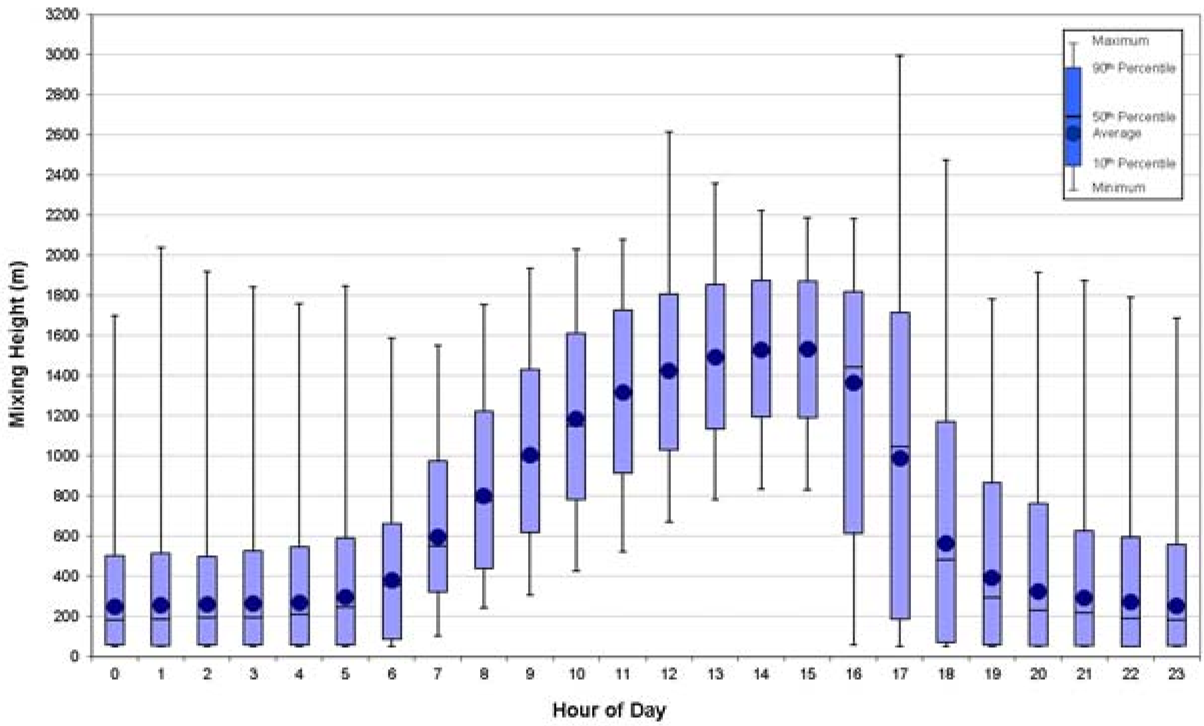


Figure D-8 Mixing heights predicated by CALMET – Woolloongabba Station (2012)

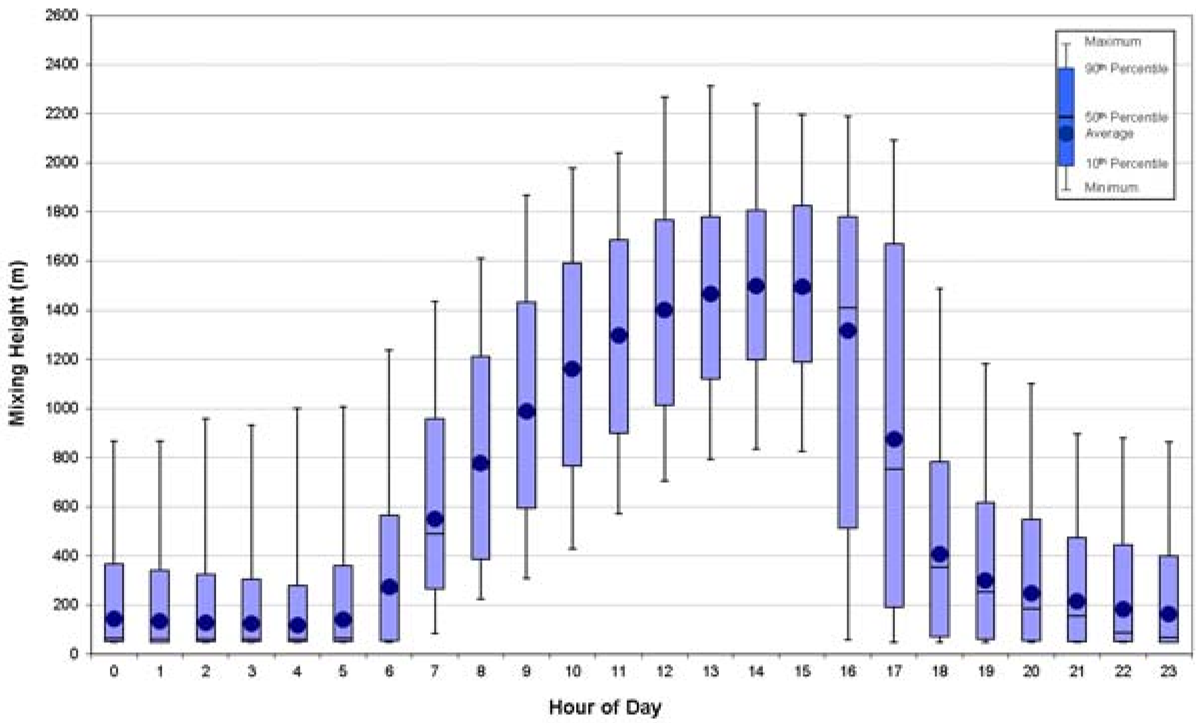


Figure D-9 Mixing heights predicted by CALMET – Northern portal (2012)

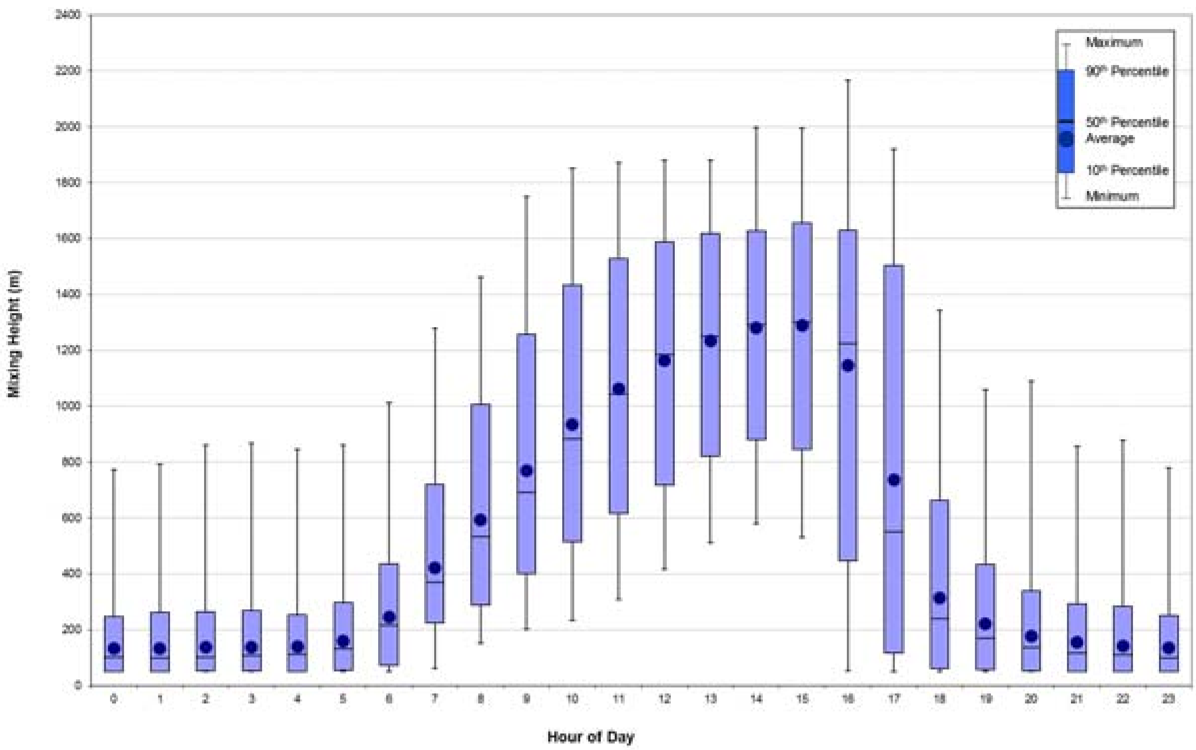


Figure D-10 Mixing heights predicted by CALMET – Mayne Yard (2012)

D3 Modelling results – contour plots for Southern portal and Boggo Road Station

CONTOUR PLOTS –BOGGO ROAD AND SOUTHERN PORTAL

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup
Cross River Rail 2016
Air Quality Impact Assessment
Cumulative Impact - Construction

Pollutant	$PM_{2.5}$	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS –BOGGO ROAD AND SOUTHERN PORTAL

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	$PM_{2.5}$	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS –BOGGO ROAD AND SOUTHERN PORTAL

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	PM_{10}	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS –BOGGO ROAD AND SOUTHERN PORTAL

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup
Cross River Rail 2016
Air Quality Impact Assessment
Cumulative Impact - Construction

Pollutant	PM_{10}	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS –BOGGO ROAD AND SOUTHERN PORTAL

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	TSP	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS –BOGGO ROAD AND SOUTHERN PORTAL

Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	TSP	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS –BOGGO ROAD AND SOUTHERN PORTAL

Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	Dust Deposition	Averaging Period	1-Month	Unit	$mg/m^2/day$

D4 Modelling results – contour plots for Woolloongabba

CONTOUR PLOTS – WOOLLOONGABBA

Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	$PM_{2.5}$	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS – WOOLLOONGABBA

Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	$PM_{2.5}$	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS – WOOLLOONGABBA

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

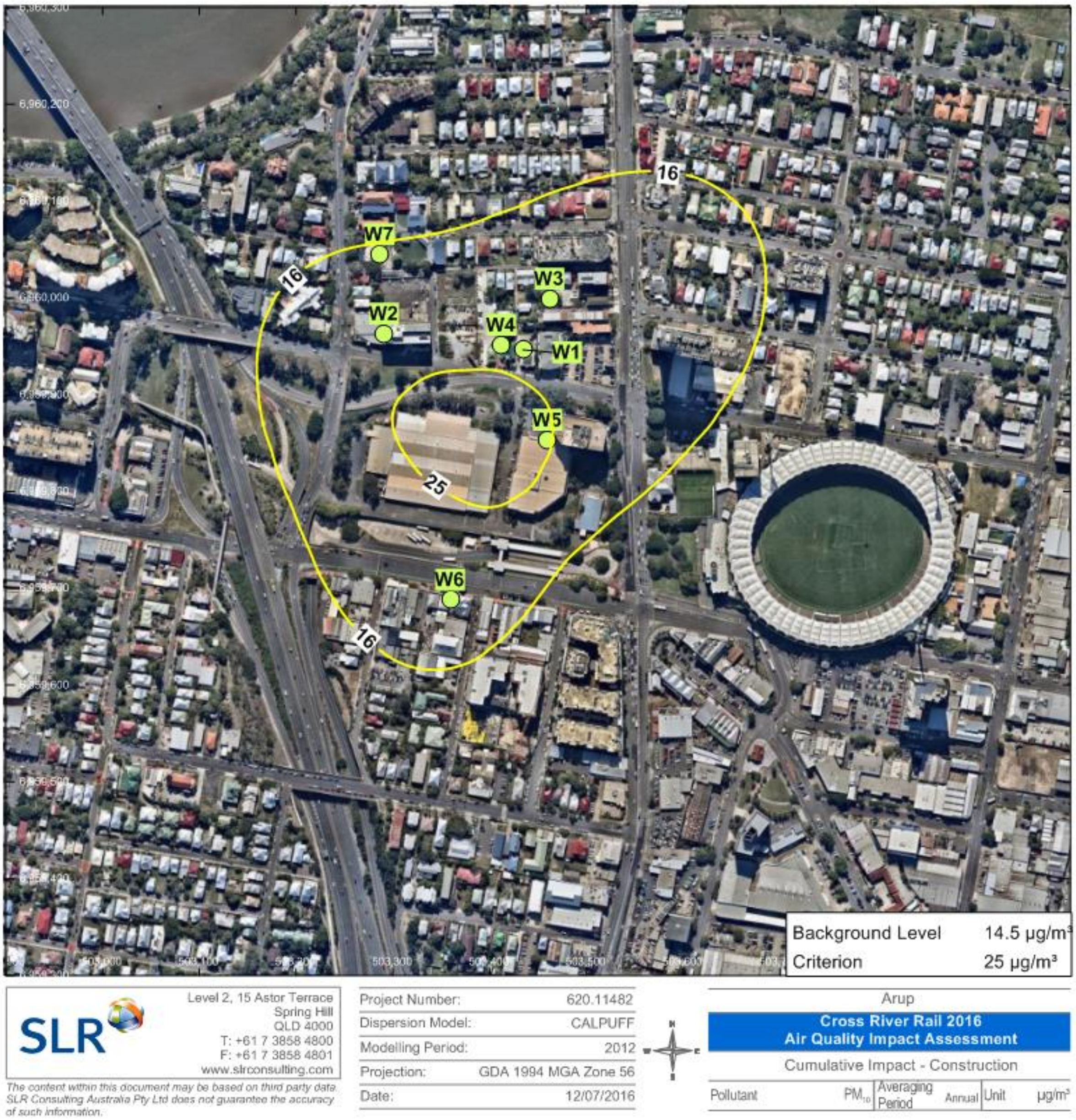
Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	PM_{10}	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS – WOOLLOONGABBA



CONTOUR PLOTS – WOOLLOONGABBA

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	TSP	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS – WOOLLOONGABBA

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	TSP	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS – WOOLLOONGABBA

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	13/06/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	Dust Deposition	Averaging Period	1-Month	Unit	mg/m²/day

D5 Modelling results – contour plots for Northern portal

CONTOUR PLOTS – NORTHERN PORTAL

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup
Cross River Rail 2016
Air Quality Impact Assessment
Cumulative Impact - Construction

Pollutant	$PM_{2.5}$	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS – NORTHERN PORTAL

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

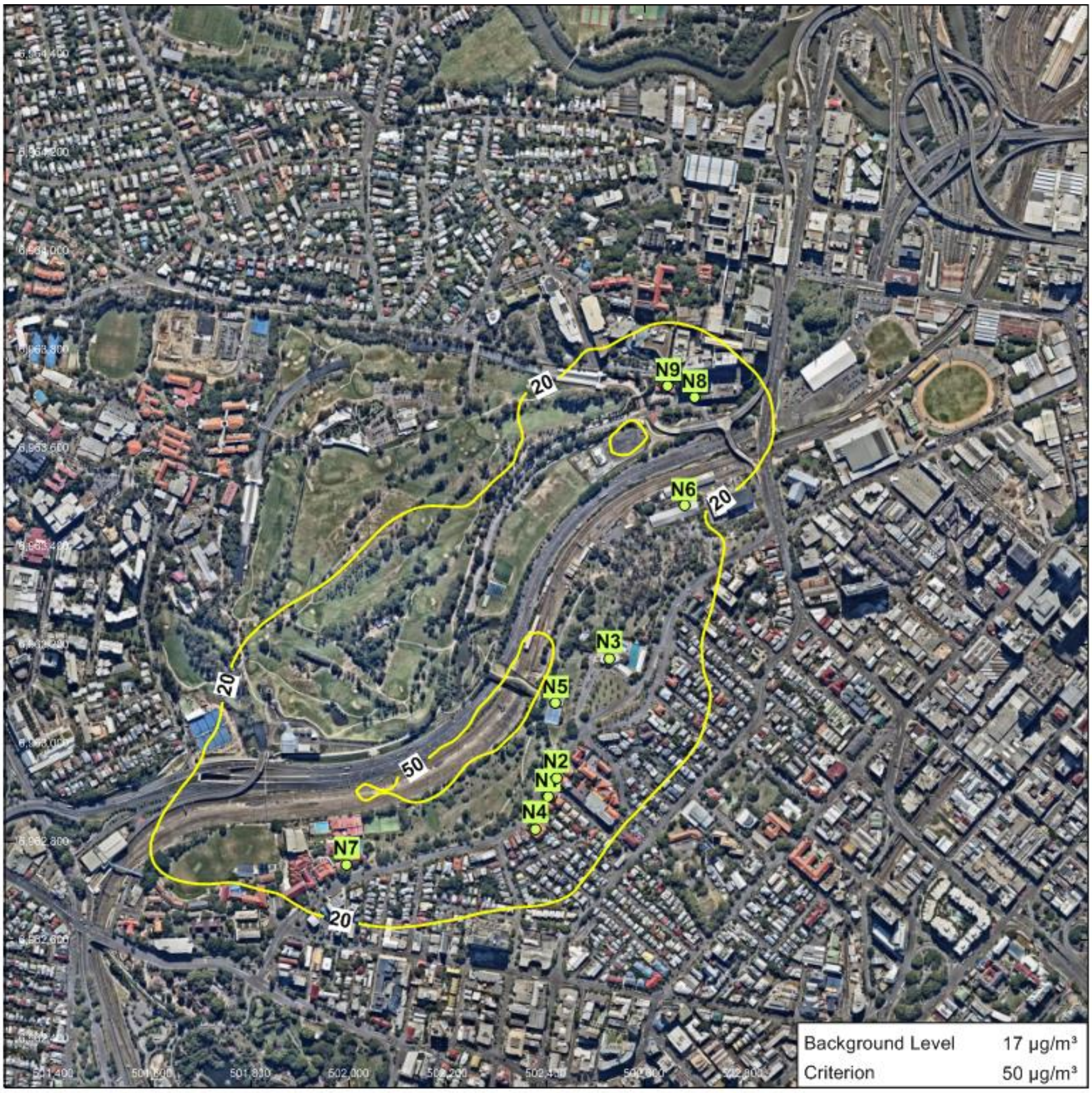
Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	$PM_{2.5}$	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS – NORTHERN PORTAL



SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	PM_{10}	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS – NORTHERN PORTAL

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	PM_{10}	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS – NORTHERN PORTAL

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	TSP	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS – NORTHERN PORTAL

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	TSP	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS – NORTHERN PORTAL

Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	13/06/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	Dust Deposition	Averaging Period	1-Month	Unit	mg/m²/day

D6 Modelling results – contour plots for Mayne Yard

CONTOUR PLOTS – MAYNE YARD

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

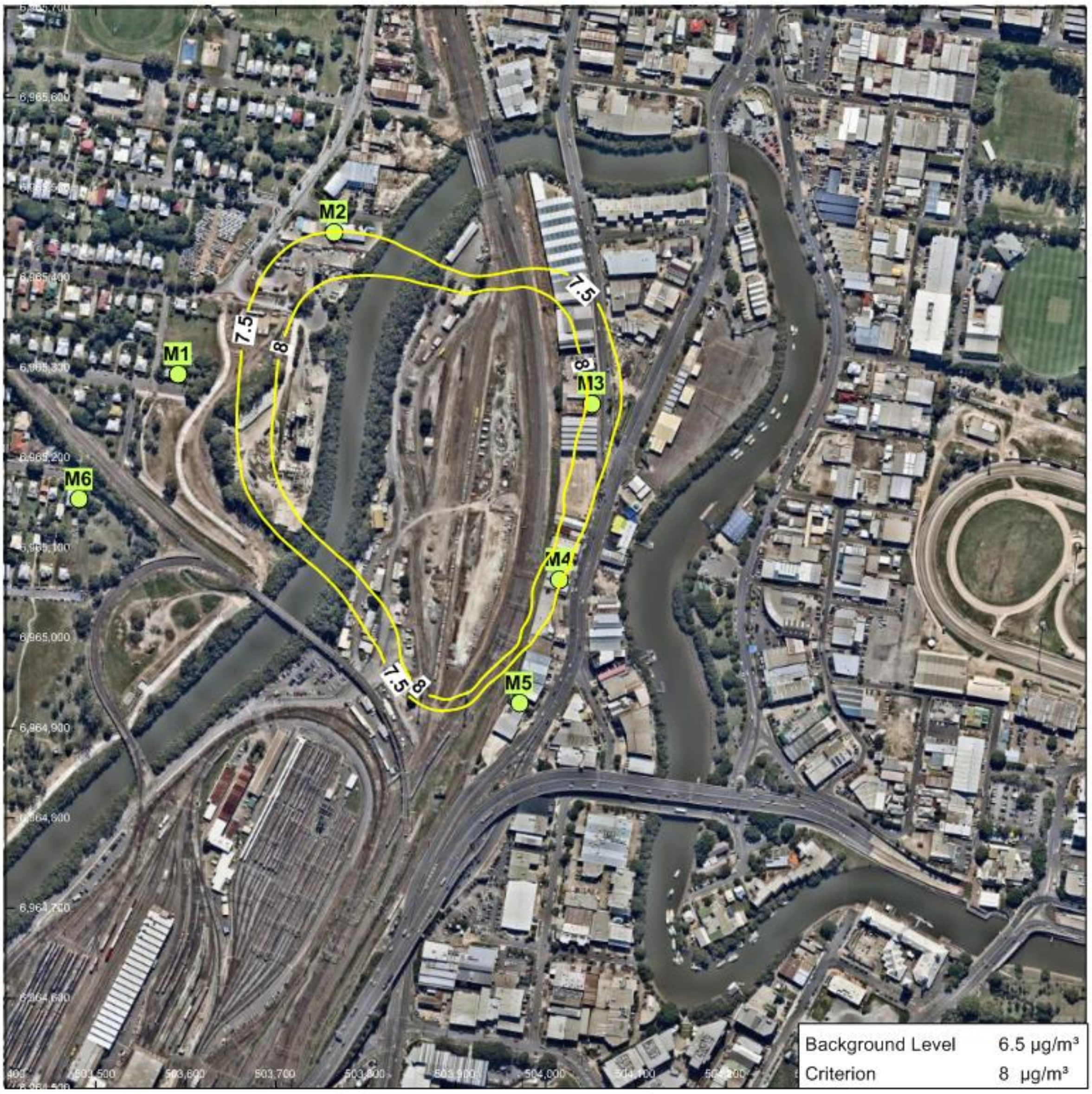
Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	$PM_{2.5}$	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS – MAYNE YARD



SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	$PM_{2.5}$	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS – MAYNE YARD

Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	PM_{10}	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS – MAYNE YARD

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	PM_{10}	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS – MAYNE YARD

Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	TSP	Averaging Period	24-Hour	Unit	µg/m³

CONTOUR PLOTS – MAYNE YARD

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	12/07/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	TSP	Averaging Period	Annual	Unit	µg/m³

CONTOUR PLOTS – MAYNE YARD

SLR
Level 2, 15 Astor Terrace
Spring Hill
QLD 4000
T: +61 7 3858 4800
F: +61 7 3858 4801
www.slrconsulting.com

Project Number:	620.11482
Dispersion Model:	CALPUFF
Modelling Period:	2012
Projection:	GDA 1994 MGA Zone 56
Date:	13/06/2016

Arup

Cross River Rail 2016
Air Quality Impact Assessment

Cumulative Impact - Construction

Pollutant	Dust Deposition	Averaging Period	1-Month	Unit	mg/m²/day

D7 Estimation of GHG emissions

A comparison of the emission factors and activity data used in the estimation of GHG emissions for CRR 2016 are presented in Tables D-6 and D-7, compared to the values used in the GHG assessment prepared for CRR 2011. The key changes in the calculations compared to CRR 2011 are as detailed below.

Emission factors

Updated GHG emission factors for petrol and diesel combustion and for electricity use in Queensland, taken from the latest National Greenhouse Accounts Factors Workbook published by the Australian Department of the Environment in August 2015. The key difference is the emission factor for Scope 2 emissions (consumption of electricity) which has reduced from 0.89 kg CO_2-e/kWh to 0.79 kg CO_2-e/kWh.

Construction phase diesel and electricity consumption

The estimated electricity and diesel consumption for the construction phase have been scaled from the CRR 2011 estimates based on the reduction in spoil quantities (a factor of 1.4, or 71% of the CRR 2011 values).

Electricity consumption by the stations during the operational phase

The estimated electricity consumption by per station (station ventilation, tunnel ventilation, air conditioning, lighting, fire services, hydraulics, vertical transport) has been assumed to be the same as CRR 2011, however the number of above ground stations has been reduced (dropping from two to one).

Electricity consumption by the trains during the operational phase

Data are not currently available to enable the projected changes in the electricity demand for passenger train operations associated with CRR 2016 to be quantified. The forecasted increase in the number of passenger trains from current levels associated with CRR 2016 is less than that predicted for CRR 2011 however, and the CRR 2016 alignment is shorter. As a result, the operational phase electricity demand associated with train operations for CRR 2016 will also be lower than that estimated for CRR 2011. On this basis, the increase in electricity demand estimated for passenger train operations for CRR 2011 has been used as a conservative estimate for calculating the associated GHG emissions for CRR 2016. This will result in a conservative assessment of the changes in GHG emissions from CRR 2011 to CRR 2016.

Change in fuel use by road vehicles due to CRR 2016

The calculation of future changes in GHG emissions from road vehicles due to CRR 2016 were revised as flows:

- Data obtained from the CRR 2016 traffic modelling study (refer Technical report 1) on the anticipated changes in travel distance (weekday Vehicle Kilometres Travelled (VKT)) for the Brisbane road network due to the Project was used in the calculations;
- Updated data on the Queensland vehicle fleet composition and fuel types for each vehicle category was used based on the Australian Bureau of Statics Motor Vehicle Census 31 Jan 2015, released 23 July 2015; and
- Updated information on fuel efficiency values for articulated trucks and motorcycles taken from the Australian Bureau of Statics Survey of Motor Vehicle Use for Year Ending 31 October 2014, released 15 October 2015.

Table D-6 GHG emission factors

Emission source	Units	CRR 2011	CRR 2016
Diesel Fuel	t CO_2-e/kL	2.70	2.721
Unleaded Petrol	t CO_2-e/kL	2.38	2.383
Electricity from grid (QLD)	kg CO_2-e/kWh	0.89	0.79

* SOURCE: Table 4 and Table 5, NGA Factors Workbook, Australian Department of the Environment, August 2015

Table D-7 Activity data – scope 1 and scope 2 emissions

Emission source	Units	CRR 2011	CRR 2016
Construction phase			
Excavation of tunnels, shafts and caverns			
Electricity consumption	kWh	196,250,000	140,180,000
Diesel fuel consumption	kL	8,125	5,800
Site preparation, surface works and station construction			
Electricity consumption	kWh	275,026,000	196,447,000
Diesel fuel consumption	kL	78,235	55,880
Operational phase			
Electricity consumption for above ground station*	kWh/year	1,511,379	1,511,379
Electricity consumption for below ground station*	kWh/year	8,373,893	8,373,893
Average electricity consumption for train operation	kWh/trip	304	304
Additional trains due to project – 10 year horizon	trains/day	634	634
Additional trains due to project – 20 year horizon	trains/day	1,106	1,106

* Per Station: includes station ventilation, tunnel ventilation, air conditioning, lighting, fire services, hydraulics, vertical transport.

Table D-8 Estimated impact of the project on vehicle kilometres travelled by Brisbane vehicle fleet

Speed Limit	Units*	CRR 2011		CRR 2016	
10 Year Horizon		Without Project	With Project	Without Project	With Project
40km/hour	VKT/day	170,482	166,460	9,710,091	9,696,043
50km/hour	VKT/day	1,496,338	1,480,441	20,964,456	20,924,925
60km/hour	VKT/day	27,484,565	27,342,410	13,491,443	13,458,778
70km/hour	VKT/day	6,798,433	6,758,493	6,656,323	6,644,171
80km/hour	VKT/day	11,282,017	11,250,552	7,640,265	7,625,684
90km/hour	VKT/day	1,459,540	1,460,702	1,715,983	1,714,533
100km/hour	VKT/day	22,096,790	22,032,619	26,788,806	26,703,058

Speed Limit	**Units***	**CRR 2011**		**CRR 2016**	
10 Year Horizon		**Without Project**	**With Project**	**Without Project**	**With Project**
TOTAL	VKT/day	70,788,165	70,491,677	86,967,367	86,767,192
CHANGE		-296,488		-200,175	
20 Year Horizon		**Without Project**	**With Project**	**Without Project**	**With Project**
40km/hour	VKT/day	214,876	207,860	10,887,386	10,846,869
50km/hour	VKT/day	1,702,984	1,654,556	24,715,908	24,591,554
60km/hour	VKT/day	32,933,220	32,551,831	15,541,305	15,476,881
70km/hour	VKT/day	7,877,904	7,756,129	8,012,013	7,981,792
80km/hour	VKT/day	14,954,745	14,673,710	9,747,746	9,709,483
90km/hour	VKT/day	1,788,637	1,787,879	2,069,946	2,066,168
100km/hour	VKT/day	29,167,999	29,233,459	33,113,200	32,867,473
TOTAL	VKT/day	88,640,365	87,865,424	104,087,504	103,540,220
CHANGE		-774,941		-547,284	

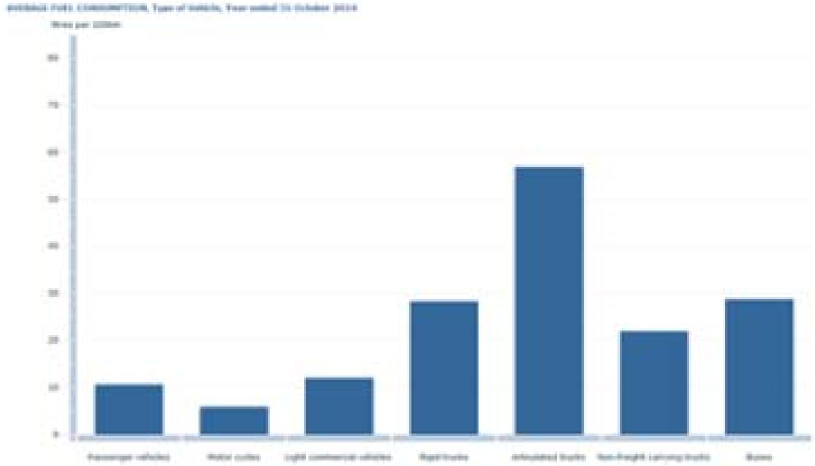
Copies of the spreadsheet calculations using the emission factors and activity data outlined above are attached.

Emission Source	Emission Factor	
Diesel Fuel	2.721	t CO_2-e/kL
Unleaded Petrol	2.383	t CO_2-e/kL
Electricity from grid (QLD)	0.79	kg CO2-e/kWh

Vehicle Type	Proportion of Fleet	% Using Petrol
Passenger cars	70%	90%
Light commercial vehicles	20%	44%
Light rigid trucks	1%	6%
Heavy rigid trucks	2%	4%
Articulated trucks	1%	1%
Motorcycles	5%	100%

Vehicle Type	Urban (L/100 km)	Highway (L/100km)
Passenger Cars - Petrol	11.10	6.31
Passenger Cars - Diesel	7.17	4.75
Light commercial vehicles - Petrol	16.16	9.28
Light commercial vehicles - Diesel	11.33	7.93
Light rigid trucks - Diesel	13.1	
Heavy rigid trucks - Diesel	28.5	
Articulated trucks - Diesel	56.9	
Motorcycles	5.9	

Emission Source	Units	CRR 2016
Construction Phase		
Excavation of tunnels, shafts and caverns		
Electricity consumption	kWh	140,178,571
Diesel fuel consumption	kL	5,804
Site preparation, surface works and station construction		
Electricity consumption	kWh	196,447,143
Diesel fuel consumption	kL	55,882
Operational Phase		
Electricity consumption for above ground station*	kWh/year	1,511,379
Electricity consumption for below ground station*	kWh/year	8,373,893
Average electricity consumption for train operation	kWh/trip	304
Additional trains due to project – 10 year horizon	trains/day	634
Additional trains due to project – 20 year horizon	trains/day	1106



Source(s): Survey of Motor Vehicle Use Data Cubes, Australia

http://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0

Speed Limit Zone	Units*	CRR 2016			
10 Year Horizon		**Without Project**	**% Urban**	**With Project**	**% Urban**
40 km/hr	VKT/day	9,710,091	100%	9,696,043	100%
50 km/hr	VKT/day	20,964,456	100%	20,924,925	100%
60 km/hr	VKT/day	13,491,443	100%	13,458,778	100%
70 km/hr	VKT/day	6,656,323	4%	6,644,171	3%
80 km/hr	VKT/day	7,640,265	4%	7,625,684	3%
90 km/hr	VKT/day	1,715,983	0%	1,714,533	0%
100 km/hr	VKT/day	26,788,806	0%	26,703,058	0%
TOTAL	VKT/day	**86,967,367**		**86,767,192**	
20 Year Horizon		**Without Project**	**% Urban**	**With Project**	**% Urban**
40 km/hr	VKT/day	10,887,386	100%	10,846,869	100%
50 km/hr	VKT/day	24,715,908	100%	24,591,554	100%
60 km/hr	VKT/day	15,541,305	100%	15,476,881	100%
70 km/hr	VKT/day	8,012,013	6%	7,981,792	5%
80 km/hr	VKT/day	9,747,746	9%	9,709,483	8%
90 km/hr	VKT/day	2,069,946	10%	2,066,168	9%
100 km/hr	VKT/day	33,113,200	16%	32,867,473	12%
TOTAL	VKT/day	**104,087,504**		**103,540,220**	

Construction GHG Emissions

SOURCE	**t CO2-e**
Excavation of tunnels, shafts and caverns	
Electricity consumption	110,741
Diesel fuel consumption	15,792
Site preparation, surface works and station construction	
Electricity consumption	155,193
Diesel fuel consumption	152,055
TOTAL	**433,781**

Operational GHG Emissions

SOURCE	**Number of stations**	**t CO2-e**
Train Stations		
Above ground stations	1	1,194
Underground stations	4	26,462
Stations sub total		**27,655**
Train Movements	**kWh/year**	
Trains - 10 year horizon	70,348,640	55,575
Trains - 20 year horizon	122,721,760	96,950
TOTAL (Year 10)		**83,231**
TOTAL (Year 20)		**124,606**

Road Network GHG Emissions

	10 Year Horizon Without Project								
Vehicle Type	100 VKT/day Petrol Urban	100 VKT/day Petrol Highway	100 VKT/day Diesel Urban	100 VKT/day Diesel Highway	kL Petrol/day Urban	kL Petrol/day Highway	kL Diesel/day Urban	kL Diesel/day Highway	GHG Emissions (t CO2-e/yr)
Passenger cars	281,848	266,046	31,316	29,561	3,129	1,679	225	140	4,108,089
Light commercial vehicles	39,369	37,162	50,106	47,297	636	345	568	375	1,618,047
Light rigid trucks	268	253	4,205	3,970	4	3	55	52	101,536
Heavy rigid trucks	358	338	8,590	8,108	10	10	245	231	442,905
Articulated trucks	45	42	4,429	4,181	3	2	252	238	443,784
Motorcycles	22,369	21,115	0	0	132	125	0	0	201,751
TOTAL					**3,913**	**2,164**	**1,344**	**1,036**	**6,916,112**

	10 Year Horizon With Project								
Vehicle Type	100 VKT/day Petrol Urban	100 VKT/day Petrol Highway	100 VKT/day Diesel Urban	100 VKT/day Diesel Highway	kL Petrol/day Urban	kL Petrol/day Highway	kL Diesel/day Urban	kL Diesel/day Highway	GHG Emissions (t CO2-e/yr)
Passenger cars	280,399	266,234	31,155	29,582	3,112	1,680	223	141	4,095,426
Light commercial vehicles	39,167	37,188	49,849	47,330	633	345	565	375	1,613,283
Light rigid trucks	267	254	4,184	3,972	3	3	55	52	101,303
Heavy rigid trucks	356	338	8,546	8,114	10	10	244	231	441,885
Articulated trucks	45	42	4,406	4,184	3	2	251	238	442,762
Motorcycles	22,254	21,130	0	0	131	125	0	0	201,287
TOTAL					**3,893**	**2,165**	**1,337**	**1,037**	**6,895,946**

	20 Year Horizon Without Project								
Vehicle Type	100 VKT/day Petrol Urban	100 VKT/day Petrol Highway	100 VKT/day Diesel Urban	100 VKT/day Diesel Highway	kL Petrol/day Urban	kL Petrol/day Highway	kL Diesel/day Urban	kL Diesel/day Highway	GHG Emissions (t CO2-e/yr)
Passenger cars	365,449	290,303	40,605	32,256	4,056	1,832	291	153	5,029,493
Light commercial vehicles	51,047	40,550	64,969	51,609	825	376	736	409	1,973,079
Light rigid trucks	348	276	5,453	4,331	5	4	71	57	121,524
Heavy rigid trucks	464	369	11,137	8,847	13	11	317	252	530,094
Articulated trucks	58	46	5,743	4,562	3	3	327	260	531,146
Motorcycles	29,004	23,040	0	0	171	136	0	0	241,467
TOTAL					**5,074**	**2,361**	**1,743**	**1,131**	**8,426,803**

	20 Year Horizon With Project								
Vehicle Type	100 VKT/day Petrol Urban	100 VKT/day Petrol Highway	100 VKT/day Diesel Urban	100 VKT/day Diesel Highway	kL Petrol/day Urban	kL Petrol/day Highway	kL Diesel/day Urban	kL Diesel/day Highway	GHG Emissions (t CO2-e/yr)
Passenger cars	354,194	298,110	39,355	33,123	3,932	1,881	282	157	4,965,637
Light commercial vehicles	49,475	41,641	62,968	52,997	800	386	713	420	1,950,586
Light rigid trucks	337	284	5,285	4,448	4	4	69	58	120,885
Heavy rigid trucks	450	379	10,794	9,085	13	11	308	259	527,307
Articulated trucks	56	47	5,566	4,685	3	3	317	267	528,353
Motorcycles	28,111	23,660	0	0	166	140	0	0	240,198
TOTAL					**4,917**	**2,424**	**1,689**	**1,161**	**8,332,965**

12 Technical Report: Noise and vibration

12.1 Introduction

This Technical report discusses changes to the Project which will alter the potential noise and vibration impacts for CRR 2016 compared to CRR 2011. Key design changes having potential to result in changes to noise and vibration impacts and mitigation measures include:

- CRR 2016 not providing an additional track between Yeerongpilly and Salisbury. This change will remove all of the changes to local roads and impacts associated with the additional track;
- A reduction in bored and mined tunnel length from approximately 10km to 5.9km resulting in less receptors potentially being exposed to construction and operational noise and vibration between Boggo Road and Yeerongpilly for CRR 2016. This change also increases the number of trains on the surface tracks in this section compared to CRR 2011;
- A change in tunnel alignment, particularly south of Woolloongabba Station and north of Roma Street Station, potentially exposing new receptors to construction and operational noise and vibration impacts with required mitigation measures. Similarly, the change in tunnel alignment may also reduce potential construction and operational noise and vibration impacts to receptors that were previously identified for CRR 2011;
- New locations of tunnel portals, underground stations including Boggo Road, Woolloongabba, Albert Street and Roma Street Stations and associated worksites, potentially exposing new receptors to construction and operational noise and vibration impacts with required mitigation measures. Similarly, these changes may also result in a reduction of impacts to other receptors that were previously identified for CRR 2011;
- Potentially new operational surface rail noise impacts at some locations due to the requirement of new tracks, upgrades to the existing rail network, changes in surface rail train movements and fleet composition at the portals;
- Relocation of Albert Street Station with an associated pedestrianisation of Albert Street and permanent closure to through-traffic between Mary Street and Charlotte Street and between Charlotte Street and Elizabeth Street. This affects local traffic movements in the CBD;
- Changes to the location of construction worksites resulting in potential changes to construction traffic movements and local traffic impacts;
- Changes to the proposed tunnelling construction methodology, with the bulk of the spoil being removed via the Woolloongabba Station site. This will have some effect on overall construction traffic movements and local traffic impacts;
- Changes to the proposed construction methodology at station locations including increased use of acoustic sheds to mitigate noise impacts, and
- Changes to the proposed spoil placement sites resulting in changes to construction traffic movements and potential local traffic impacts. The reduced tunnel length will also reduce the overall spoil volumes to be removed and associated truck movements.

12.1.1 Basis of the assessment

This assessment has utilised the following noise prediction models and calculation spreadsheets developed for the CRR 2011 noise and vibration impact assessment. The noise models and calculation were updated for the CRR 2016 design and the associated proposed rail operations and construction activities.

- SoundPLAN v7.4 noise prediction model for airborne noise emissions from above ground construction activities;
- SoundPLAN v7.4 noise prediction model for airborne noise emissions from surface railway operations at the Northern and Southern tunnel portals;
- Spread-sheet calculation of change in operational noise from train movements on existing surface tracks and infrastructure (in areas where there is no new infrastructure); and
- Modelling for the core calculation of ground-borne noise and vibration from station shaft, station cavern and tunnel excavation and train operations (in tunnel).

The assessment methodology is detailed in the noise and vibration impact assessment reports,[49] prepared for CRR 2011.

12.1.2 Assessment criteria

The noise, vibration and ground-borne noise assessment criteria adopted are generally consistent between the CRR 2011 and CRR 2016 assessments. The following regulatory guideline for noise and vibration has been updated since CRR 2011:

- The Planning Levels for airborne noise from railway activities (train movements) are retained as LA_{eq} (24hour) 65 dB and Single Event Maximum 87 dB and are now within QR's Safety and *Environmental Management Systems*. In 2011, the Planning Levels were detailed in QR's Code of Practice for Railway Noise.

12.2 Construction

12.2.1 Construction noise and vibration for worksites

For CRR 2011, a detailed assessment of potential construction noise and vibration impacts was carried out for all construction worksites. As a result of the project design changes for CRR 2016, the construction worksites identified for detailed modelling and assessment include:

- Southern portal and Boggo Road Station; and
- Roma Street Station.

Table 12.1 presents a summary of the changes in construction noise and vibration impacts between CRR 2011 and CRR 2016 for the construction worksites above. These are presented with some mitigation measures in place. Typical construction noise levels with either 3m acoustic hoarding surrounding the worksite or existing railway noise barriers have been adopted at the nearest noise sensitive receptors.

Table 12.1 also includes an assessment of anticipated changes to potential construction noise and vibration impacts for CRR 2016 construction worksites that have not undergone detailed noise and vibration modelling. For these sites, which include Woolloongabba Station, Albert Street Station, the

[49] SLR Consulting Australia, 2011. *Cross River Rail Environmental Impact Statement Construction Noise and Vibration PART A*, document 20-2654-R2, dated 14 July 2011.
SLR Consulting Australia, 2011. *Cross River Rail Environmental Impact Statement Operational Noise and Vibration PART A*, document 20-2524-R3, dated 6 June 2011.
SLR Consulting Australia 2011. *Cross River Rail Environmental Impact Statement Operational Noise and Vibration PART B*, document 20-2524-R3, dated 6 June 2011

Northern portal, Exhibition Station and Mayne Yard, the detailed modelling and assessment carried out for CRR 2011 and the BaT project is considered representative of the impacts and mitigation anticipated for CRR 2016.

Note that the predicted worksite construction noise impacts referred to in Table 12.1 is a worst case assessment, based on conservative assumptions, and will change over the course of construction due to a number of factors such as depth of construction, and construction techniques.

Table 12.1 Worksite construction noise and vibration change assessment summary (with mitigation)

Construction worksite	CRR 2011	CRR 2016	Change in construction noise and / or vibration impacts (with mitigation)
Salisbury Station	Laydown areas, new footbridge, surface tracks and road realignment.	No works proposed for CRR 2016.	No noise and vibration impacts as no works proposed for CRR 2016.
Rocklea Station	Construction of Muriel Avenue bridge and road works.		
Moorooka Station	Worksite and stockpiling of materials for construction of viaduct.		
Clapham Rail Yard	New Clapham Yard provided train stabling facilities.	No works proposed for CRR 2016.	No noise and vibration impacts as no works proposed for CRR 2016.
Yeerongpilly Station	Southern tunnel portal at Yeerongpilly with substantial surface works including cut and cover tunnel and dive structure, and new station constructed at Yeerongpilly. Realignment of Wilkie Street and large construction yard.	No works proposed for CRR 2016.	No noise and vibration impacts as no works proposed for CRR 2016.
Southern Portal & Boggo Road Station (refer to Appendix E1 for detailed assessment results)	Southern portal located north of Yeerongpilly Station with portal west of Crichton Street. Boggo Road Station worksite located between Boggo Road Gaol and Ecosciences building.	Southern portal located north of Dutton Park Station with twin portals within the rail corridor. The surface construction worksite will be located between PA Hospital and the rail corridor. Boggo Road Station located east of Joe Baker Street on the Lot 2 site and extending below the Eastern Busway. The surface construction worksite will be located between Joe Baker Street and the rail corridor.	Overall a similar level of airborne construction noise impacts have been predicted for the Southern portal and Boggo Road Station worksite for CRR 2016 compared with CRR 2011. Predicted impacts are similar for Ecosciences and ESA Village (Leukaemia Centre) and new airborne construction noise impacts have been identified for the PA Hospital, Railway Terrace and Merton Road (to Elliott Street) residential receptors. The Southern portal worksite location for CRR 2016 has the potential to result in predicted exceedance of the daytime construction noise goals for: • Railway Terrace residential receptors (up to 19 dBA); • ESA Village Leukaemia Centre (up to 12 dBA);

Construction worksite	CRR 2011	CRR 2016	Change in construction noise and / or vibration impacts (with mitigation)
			• PA Hospital (up to 9 dBA). The night-time construction noise goals would also be exceeded at these receptor locations if works were to be undertaken during these time periods. Potential exceedance (up to 13 dBA) of the daytime construction noise goal has been identified for residential receptors north of Park Road Rail Station. An increase in ground-borne noise impacts during construction of Boggo Road Station have been predicted for CRR 2016 compared with CRR 2011. Exceedance of the internal ground-borne noise goals are predicted during tunnel portal and/or station shaft/cavern excavation for: • ESA Village Leukaemia Centre (up to 4 dBA); • Residential receptors north of Park Road Railway Station (up to 17 dBA).
Woolloongabba Station	On western side of GoPrint site.	Surface worksite in the same general location as CRR 2011 however the station shaft and cavern is further east adjacent to the location of the existing Queensland Government Landcentre building.	Based on the proposed CRR 2016 worksite and construction activities, it is anticipated that airborne noise impacts from surface construction works would be consistent with those identified in the detailed assessment of CRR 2011.
Albert Street Station	Below Albert Street, between Alice Street and Charlotte Street. Station entrances at Mary Street and Alice Street.	Station below Albert Street, between Mary Street and Elizabeth Street. One main worksite required at Albert Street for CRR 2016.	Overall airborne construction noise impacts for Albert Street Station will be similar to CRR 2011. As a consequence of having one worksite (CRR 2016) instead of two (CRR 2011), residential receptors located along Alice Street would now be anticipated to comply with the construction noise and vibration goals. For the CRR 2016 Albert Street construction worksite, the proposed demolition of commercial buildings together with the location of the proposed station shaft

Construction worksite	CRR 2011	CRR 2016	Change in construction noise and / or vibration impacts (with mitigation)
			is anticipated to result in an increase in airborne construction noise (until the acoustic shed is constructed) and potentially ground-borne noise and vibration for the residential apartment buildings at 70 Mary Street (Mantra on Mary) and 108 Albert Street (Oaks Festival Towers) and associated ground floor commercial occupancies.
Roma Street Station (refer to Appendix E2 for detailed assessment results)	North of BTC, traversing below existing Roma Street Station.	Construction worksite now located on the site of the existing BTC West Tower and coach terminal.	For CRR 2016, new properties predicted to be affected by exceedances of the daytime construction noise goals are: • Roma Street (Abbey Apartments) residential receptors (up to 7 dBA); • Queensland Police Headquarters and Watch House (up to 7 dBA). The night-time construction noise goals would also be exceeded at these receptor locations if works were undertaken during these times. Due to the location of the CRR 2016 Roma Street Station worksite, the Roma Street Station Hotel (i.e. Hotel Jen) is now predicted to comply with the airborne noise criteria, which is a reduced impact from CRR 2011. Due to the removal of the CRR 2011 worksite adjacent to Parkland Boulevard, residential receptors in the Parkland Boulevard apartment building are now predicted to comply with the daytime airborne noise goals, which is a reduced impact from CRR 2011. Exceedance of the internal ground-borne noise goals is predicted for CRR 2016 during station shaft/cavern excavation for: • Roma Street Station building (up to 2 dBA);

Construction worksite	CRR 2011	CRR 2016	Change in construction noise and / or vibration impacts (with mitigation)
			• Roma Street commercial buildings (including BTC East Tower) (by 1 dBA); • The Abbey Apartments on Roma Street (up to 10 dBA). Overall, the detailed assessment for CRR 2016 has identified an increase in ground-borne noise impacts compared with CRR 2011. The increase in predicted impacts is due to the new location of the station cavern and shaft.
Northern portal	Located within Victoria Park with portal near Land Bridge.	Construction worksite generally located within Exhibition Loop rail corridor.	It is anticipated that by moving the Northern portal and the large majority of the associated worksite into the rail corridor, the predicted Gregory Terrace residential receptor exceedances from CRR 2011 would be avoided. This results in a reduced impact from CRR 2011. Detailed assessment of the BaT project in the vicinity of BGGS showed that construction airborne noise goal exceedances (i.e. up to approximately 7 dBA) would likely occur when construction plant is working in close proximity to BGGS. Given the closer proximity, an increased impact is predicted for BGGS compared to CRR 2011.
Exhibition Station	South-west of O'Connell Terrace road-over-rail bridge.	Location of construction worksite similar to CRR 2011 i.e. within existing rail corridor within RNA Showgrounds.	Based on the detailed assessment of CRR 2011 and the proposed CRR 2016 worksite and construction activities, it is anticipated that there would be no change in predicted noise and vibration impacts at this worksite. Therefore airborne noise, ground-borne noise and vibration will be consistent to that of CRR 2011.
Mayne Yard	Two new CRR tracks through Mayne Yard require a flyover over southbound	Revised alignment for two new CRR tracks through Mayne Yard replacing the flyover. The northbound CRR track is at surface	There is potential for an increase in construction noise levels for CRR 2016 (compared with CRR 2011) due to the more intensive nature (i.e. mobility of plant) of construction of the underpass. However, compliance

Construction worksite	CRR 2011	CRR 2016	Change in construction noise and / or vibration impacts (with mitigation)
	suburban track, northbound suburban and northbound main tracks	level, on the western side of the site, and the southbound CRR has an underpass to provide grade separation with the existing main track.	with the construction noise goals for works occurring within the rail corridor would be anticipated due to the setback distance to the nearest sensitive receptors (i.e. at least 200 m from the worksite.

12.2.2 Ground-borne noise and vibration from mechanical tunnel excavation

The two single track tunnels for the CRR 2016 are proposed to be constructed by TBMs from Woolloongabba Station to the Northern portal. For the tunnel section between Boggo Road Station to Woolloongabba Station, the CRR 2016 construction methodology has changed to mined tunnelling excavation involving roadheader and potentially drill and blast tunnelling. This construction methodology takes longer, but generates significantly lower ground-borne noise and vibration to receptors above the tunnels.

Predicted ground-borne noise and vibration levels from TBM and mined tunnelling works at the nearest receptors along the CRR tunnel alignment are presented in Appendix E3. The predicted levels were calculated with reference to previous measurement of noise and vibration levels from the operation of TBM's and roadheaders during the construction of the CLEM7 tunnel in Brisbane in similar rock conditions.

The assessment of vibration levels determined there are no exceedances of the cosmetic damage vibration goals for residential property or the stricter cosmetic damage goal for heritage buildings. Comparing the CRR 2011 and CRR 2016 alignments, the change in indicative maximum vibration levels and ground-borne noise levels are summarised as follows:

- Between Boggo Road Station and Woolloongabba Station, indicative maximum vibration levels and ground-borne noise levels are generally lower for CRR 2016 due to roadheader excavation instead of TBM (used for CRR 2011). Ground-borne noise impacts are predicted during roadheading for residential receptors located in Quarry Street, Park Road, Elliott Street, Lockhart Street, Abingdon Street, Longwood Street, Ross Street, Fleurs Street, Peterson Street, Wilton Street and Hubert Street. Drill and blast may be used as an alternative construction method for mining sections of tunnel between Boggo Road Station and Woolloongabba Station. To a greater degree than mechanical excavation methods (i.e. roadheader and TBM), the design of a blast can be controlled to ensure that vibration levels remain within specified bounds;
- Between Woolloongabba Station and Albert Street Station, indicative maximum vibration levels and ground-borne noise levels are generally higher for CRR 2016 due to tunnel alignment, although the tunnel depths are similar to CRR 2011;
- Between Albert Street Station and Roma Street Station, indicative maximum vibration levels and ground-borne noise levels are generally similar between CRR 2011 and CRR 2016. Due to the change in horizontal and vertical alignment between CRR 2011 and CRR 2016, new exceedances of the night-time sleep disturbance criterion of 35 dBA LA_{eq} have been predicted for 450 George Street, 454 George Street and 160 Roma Street (The Abbey Apartments). Where the alignment passes underneath the State Law Courts, the internal noise goal of 40dBA will not be exceeded. In addition, this site will be within the ground–borne noise and vibration goals and predicted ground-borne noise levels (refer to Appendix E2); and
- Between Roma Street Station and the Northern portal, indicative maximum vibration levels and ground-borne noise levels are generally similar between CRR 2011 and CRR 2016, although predicted at different locations due to the change in tunnel alignment. A marginal 0.2mm/s increase in vibration level and a 4 dBA ('noticeable') increase in ground-borne noise level have been predicted for the BGGS, but it remains compliant with the human comfort vibration goal for educational facilities. Compliance with the heritage building vibration criterion (i.e. 2mm/s) is predicted for Victoria Barracks based on a minimum slant distance of 37m (i.e. between tunnel crown and building foundation). The indicative maximum vibration level for Victoria Barracks is between 0.1 to 0.3mm/s ('barely noticeable') and no further mitigation is proposed (refer to Appendix E3).

Goal exceedances resulting from TBM passbys will only occur during a relatively short period (less than 1 week for each TBM passby) and potential levels may not result in a disturbance impact to building occupants.

12.2.3 Low frequency noise assessment

For CRR 2011, the assessment of low frequency noise during construction was based on the Ecoaccess Assessment of Low Frequency Noise Guideline and includes an assessment of annoyance due to infrasound (dBG) and low frequency noise (LpA,LF). The assessment indicated that annoyance goals will likely be exceeded during driven tunnelling works for offset distances of within approximately 100m from the TBM.

For the tunnelling works for CRR 2016, there remains potential for low frequency noise impacts to result at receptors within a 100m offset from the TBM, as was predicted for CRR 2011.

12.2.4 Construction traffic

A comparison of peak hourly and daily spoil and material delivery trucks for CRR 2011 and CRR 2016 is presented in Technical report 1 (Transport). This shows that all construction worksites will have less daily spoil truck movements for CRR 2016. The daily peak spoil movements at Woolloongabba Station are marginally lower due to the revised sequencing of construction activities, which will involve extraction of spoil from the mined tunnel followed by the bored tunnel. Overall this means that the peak spoil movements are less as these activities do not overlap.

Noting that CRR 2011 truck movements complied with the assessment criteria at all worksites, the CRR 2016 road traffic movement would also comply with the criteria. Consequently further detailed assessment of changes in road traffic noise level between CRR 2011 and CRR 2016 is not required.

12.3 Operation

12.3.1 Overview

In addition to the CRR 2016 tunnels, passenger and freight trains will operate on existing sections of the rail network where there is no requirement for upgraded or new rail infrastructure as part of this project. QR's Planning Levels for managing railway noise do not apply where there is no change in infrastructure, and therefore these existing track sections are not assessed against QR's $LA_{eq(24hour)}$ and Single Event Maximum Planning Levels.

An assessment has been undertaken to calculate the potential change in noise levels resulting from the difference in the daily rail movements between CRR 2011 and CRR 2016 (refer Table 12.2).

The exceptions are the Northern and Southern portal areas for CRR 2016, which require new tracks and upgrades to the existing rail network. Furthermore, the Northern and Southern portals for CRR 2016 are in different locations to CRR 2011. The new portal locations are assessed in Section 12.3.3.

Table 12.2 CRR 2011 and CRR 2016 daily train numbers on existing surface tracks

Section	Number of trains			
	Freight [1,2]	Passenger[3]	Freight [1,2]	Passenger [3]
CRR 2011	**Year 2021**		**Year 2031**	
Salisbury - Yeerongpilly	25	452	30	723
Yeerongpilly - Park Road	39	160	47	171
Roma Street - Bowen Hills	0	724	0	742
Victoria Park – Bowen Hills (Exhibition Loop via Normanby) - south of CRR 2016 portal	38	0	46	0
Victoria Park – Bowen Hills (Exhibition Loop via Normanby) - between CRR 2011 / 2016 portals	38	0	46	0
Victoria Park – Bowen Hills (Exhibition Loop via Normanby) - north of CRR 2011 portal	38	342	46	552
CRR 2016	**Year 2026**		**Year 2036**	
Salisbury - Yeerongpilly	8	407	12	470
Yeerongpilly - Park Road	34	407 [4]	42	470 4
Roma Street - Bowen Hills	0	882	0	913
Victoria Park – Bowen Hills (Exhibition Loop via Normanby) - south of CRR 2016 portal	18	0	26	0
Victoria Park – Bowen Hills (Exhibition Loop via Normanby) - between CRR 2011 / 2016 portals	18	273	26	337
Victoria Park – Bowen Hills (Exhibition Loop via Normanby) - north of CRR 2011 portal	18	273	26	337

Notes

1. Freight trains between Salisbury and Park Road were assumed to be 620 m long for the Year 2021 in CRR 2011. All other CRR 2011 freight trains were assumed to be 1,500 m long (including Salisbury to Park Road in Year 2031).
2. All freight trains assumed to be 620 m long for CRR 2016.
3. Tunnel traffic in CRR 2011 Year 2031 assumed to be 9-car SMU and 6-car SMU assumed for Year 2021 tunnel traffic and all surface passenger traffic. All passenger traffic in CRR 2016 assumed to be 6-car SMU
4. Large difference in number of passenger trains due to CRR 2011 previously in-tunnel and CRR 2016 now on surface tracks

12.3.2 Airborne noise assessment – surface rail works

The predicted difference in railway noise emission levels between the CRR 2011 and CRR 2016 rail traffic movements are presented in Table 12.3, along with a qualitative assessment of the noise impact. The qualitative assessment of the predicted change in noise level has referenced guidance on perceptible changes in transport noise[50].

Based on the change in daily train movements and fleet composition, it has been determined that total rail noise levels would vary by -6 to +1 dBA between CRR 2011 and CRR 2016. It is noted that a 1 dBA increase in daily $LA_{eq(24hour)}$ noise levels would not be a perceptible change.

With regards to the increase in passenger trains between Yeerongpilly and Park Road, the 4 dBA change in passenger train $LA_{eq(24hour)}$ noise level would be offset to a degree by the reduction in

[50] Department of Transport and Main Roads, 2013. Transport Noise Management Code of Practice Volume 1 – Road Traffic Noise, Table 2.4 page 9, November 2013.

freight train noise with the net effect being a negligible change in $LA_{eq(24hour)}$ rail noise between Yeerongpilly and Park Road.

Between Roma Street to BGGS and between Centenary Pool to Bowen Hills there may be a potentially noticeable improvement in the daily LA_{eq} noise levels with CRR 2016 compared to CRR 2011.

It is noted that the portion of the Victoria Park to Bowen Hills line between BGGS and the Centenary Pool will include passenger trains in CRR 2016 whereas with CRR 2011 there were no passenger movements proposed since the Northern portal was located further north within Victoria Park. This change introduces new passenger rail noise, however, the net effect is still a reduction in noise due to a decrease in forecast daily freight movements (which dominates the total rail noise levels) by almost half for CRR 2016 compared to CRR 2011.

There are no predicted changes in the Single Event Maximum noise level, for any segment of the project, as a result of the change in train numbers and fleet composition. Therefore the Single Event Maximum noise level has not been included in the assessment in Table 12.3.

Table 12.3 Predicted incremental change in rail noise emission for surface rail works during operation

Section	Change in noise level (dBA $LA_{eq(24hour)}$) CRR 2016 compared to CRR 2011[51]							
	Year of opening				Ten years after opening			
	Freight	Passenger	Total [1]	Change in impact	Freight	Passenger	Total [1]	Change in impact
Salisbury - Yeerongpilly	-4.9	0.5	1.2	no change	-4.0	-3.5	-3.5	no change
Yeerongpilly - Park Road	-2.3	4.1	0.8	no change	-3.0	4.4	0.3	no change
Park Road - Roma Street	-48.4	1.9	1.0	no change	-11.0	2.0	1.2	no change
Roma Street - Bowen Hills (existing at-surface track via Central Station)	0.0	0.9	0.9	no change	0.0	0.9	0.9	no change
Roma Street – BGGS	-5.8	0.0	-5.8	noticeable improvement	-5.0	0.0	-5.0	noticeable improvement
BGGS – Centenary Pool	-5.8	57.0	-0.3	no change	-5.0	57.9	0.0	no change
Centenary Pool – Bowen Hills	-5.8	-1.0	-2.9	noticeable improvement	-5.0	-4.1	-4.4	noticeable improvement

Note
1. The total change in noise level is the change in the logarithmic sum of the combined freight and passenger noise levels, not the linear sum of the individual changes for freight and passenger noise levels.

[51] For example at Salisbury to Yeerongpilly, at year of opening, freight generated noise is forecast to be 4.9dBA lower for CRR 2016 compared to the forecast noise level for CRR 2011

12.3.3 Airborne noise assessment – portal areas

The Northern and Southern portals for CRR 2016 are in revised locations compared to CRR 2011. The change in location of the two portals and associated reconfiguration of some of the existing rail tracks is detailed in Table 12.4.

Table 12.4 Design changes for northern and southern portal

Portal	CRR 2011 design	CRR 2016 design	Influence on airborne noise
South	9.5km tunnel with Southern portal near Yeerongpilly Station.	5.9km tunnel with Southern portal located between Dutton Park and Park Road Railway Station.	The relocation of the portal with CRR 2016 will remove CRR portal noise from the Yeerongpilly site but introduce a new/ additional source of rail noise to the local environment at the new Southern portal.
North	Northern portal adjacent Victoria Park between ICB land bridge and Bowen Bridge Road.	Northern portal located near ICB and BGGS	The relocation of the portal with CRR 2016 will remove CRR portal noise from near the Centenary Pool but introduce a new/ additional source of rail noise to the local environment at the new Northern portal.

Assumptions

The assumptions made when undertaking SoundPLAN noise modelling of the portal areas are summarised in Table 12.5.

Table 12.5 SoundPLAN noise modelling assumptions

Modelling component	CRR 2011 assumption	CRR 2016 assumption
Passenger traffic speed	no speed profiles available – 80km/h throughout model	no speed profiles available – 80km/h throughout model
Freight traffic speed	no speed profiles available – 60km/h throughout model	no speed profiles available – 60km/h throughout model
Locomotive	Double-header current generation	Double-header current generation
Locomotive notch setting	Notch 6 throughout model [*]	Notch 6 throughout model [1]
Division of total daily traffic	50/50 split in each direction	50/50 split in each direction
Cleveland Line traffic volume	N/A	200 trains per day total
Passenger fleet composition	2021 – 6-car SMU throughout 2031 – 9-car SMU for CRR traffic, all other traffic 6-car SMU	6-car SMU throughout in all years
Freight consist length	2021 – 620 m consist for Salisbury and Park Road and 1,500m elsewhere 2031 – all consist 1,500m	All consist 620 m.
Portal SWL noise emission	Based on in-tunnel reverberant level of 105 dBA, open portal area and train numbers: LA_{eq} – 94-99 dBA LA_{max} – 121 dBA	Based on in-tunnel reverberant level of 105 dBA, open portal area and train numbers: LA_{eq} – 93 dBA LA_{max} – 118 dBA
Freight traffic direction of travel	N/A	To/from Port of Brisbane

Modelling component	CRR 2011 assumption	CRR 2016 assumption
Noise modelling software	SoundPLAN V6.5	SoundPLAN V7.4

* Train throttle control with 1 being the slowest and 8 the fastest speed.

Southern portal

Noise modelling was completed of the new Southern portal area between Annerley Road, Burke Street and Ipswich Road for CRR 2016. The predicted noise levels include contributions from all surface rail traffic in the vicinity of the portal, including noise emissions from the portal itself. These predicted operational rail noise levels have been assessed against QR's $LA_{eq(24hour)}$ 65 dBA and Single Event Maximum 87 dBA planning levels.

The predicted noise levels for CRR 2016 are displayed in both tabular format and as noise contours in Appendix E5.

In 2026, operational rail traffic noise levels of up to 69 dBA $LA_{eq(24hour)}$ and 92 dBA LA_{max} are predicted at receptors within the modelled area. Noise levels of up to 70 dBA $LA_{eq(24hour)}$ and 92 dBA LA_{max} are predicted for 2036. The increase in rail traffic between 2026 and 2036 results in a negligible 1 dB increase in railway noise. Twelve residences, including the ESA Village (Leukaemia Foundation) and residences on Rawnsley Street and Railway Terrace are predicted to exceed one or more of the planning levels in both years by up to 5 dBA.

A comparison (between CRR 2011 and CRR 2016) of the highest predicted railway noise levels and the number of residences predicted to exceed the Planning Levels is provided in Table 12.6. This comparison is for the unmitigated design i.e. there is no consideration of the noise reduction performance achieved from the construction of new and/or upgraded railway noise barriers. Changing the location of the Southern portal for CRR 2016 reduces the number of potential noise sensitive receptors in proximity to the portal location and this, along with the rail noise levels, accounts for the change in the number of affected residences.

Table 12.6 Comparison – Southern portal rail noise levels (without mitigation)

Southern portal design	Rail noise levels		Number of residences above planning levels	Difference
	$LA_{eq(24hour)}$	SEM *		
CRR 2011 (2031)	75	92	37	The daily rail noise levels are up to 5 dB lower with the CRR 2016 design. An approximate 67% reduction in the number of residences above the Planning Levels has been achieved with CRR 2016.
CRR 2016 (2036)	70	92	12	

* SEM = Single Event Maximum

Northern portal

Noise modelling was completed for the new Northern portal area between BGGS and Bowen Bridge Road for CRR 2016. As with the Southern portal, the predicted noise levels include contributions from all surface rail traffic in the vicinity of the portal, including noise emissions from the portal itself.

Without mitigation, in 2026, operational rail traffic noise levels of up to 60 dBA $LA_{eq(24hour)}$ and 86 dBA LA_{max} are predicted at receptors within the modelled area. Predicted noise levels of up to 62 dBA $LA_{eq(24hour)}$ and 86 dBA LA_{max} are predicted for 2036. No noise sensitive receptors are predicted to exceed either of the planning levels in either year. As such, no noise mitigation is required in this area.

In CRR 2016, the Northern portal design complies with the Planning Levels and this is consistent with the CRR 2011 Northern portal design for which full compliance with the Planning Levels was also predicted.

With regards to BGGS, the new location of the Northern portal will introduce a new/ additional source of rail noise for the school. Modelling of CRR 2016 rail noise levels for the BGGS Sports Centre building (i.e. closest to the Northern portal) has confirmed that freight trains would dominate both the $LA_{eq(24hour)}$ and LA_{max} assessment parameters. It is important to note that BGGS is currently exposed to freight train noise and, as noted in Table 12.2, the forecast daily freight train numbers would decrease from 38 in 2021 as forecast for CRR 2011 to 18 in 2026 as forecast for CRR 2016.

The predicted noise levels are displayed in tabular format and as noise contours in Appendix E5.

12.3.4 Ground-borne noise assessment – train operations

Railway vibration is generated by dynamic forces at the wheel-rail interface and this vibration propagates via the rail mounts into the ground or track support structures. It then travels through the ground or structures and in some circumstances may potentially be heard as ground-borne noise or felt as tactile vibration by the occupants of buildings.

In order to reduce the potential for ground-borne noise impacts at sensitive receptors without impacting operations via speed reductions, mitigation measures tend to focus on improving the vibration isolation characteristics of the track.

In order to reduce ground-borne noise and vibration levels within buildings located close to railway lines, a range of alternative track designs are available. These generally include the insertion of a resilient layer between the rail and tunnel foundation, either in the form of a resilient rail fastener, booted sleeper, floating slab track or a combination of approaches.

The predicted ground-borne noise levels with the compliance trackform for both the CRR 2011 and CRR 2016 designs are detailed in Appendix E6, noting the same ground-borne noise goals has been applied to both CRR 2011 and CRR 2016. It can be seen that in general there is minimal difference in predicted ground-borne noise levels and with a slight change in mitigation trackform, CRR 2016 complies with the project criteria at all receptors with the proposed resilient and highly resilient rail fasteners in place.

The alignment and determined minimum required mitigation for the CRR 2011 and CRR 2016 design is shown in Figure 12.1. It can be seen that the extent of the Highly Resilient Rail Fasteners north of Boggo Road Station is slightly extended in the CRR 2016 design. The CRR 2016 also requires a short section of Highly Resilient Rail Fasteners just south of Roma Street Station to mitigate the ground-borne noise levels at two hotels. The CRR 2016 design will require a significantly shorter distance with Resilient Rail Fasteners north of Roma Street Station because it follows within the existing rail corridor.

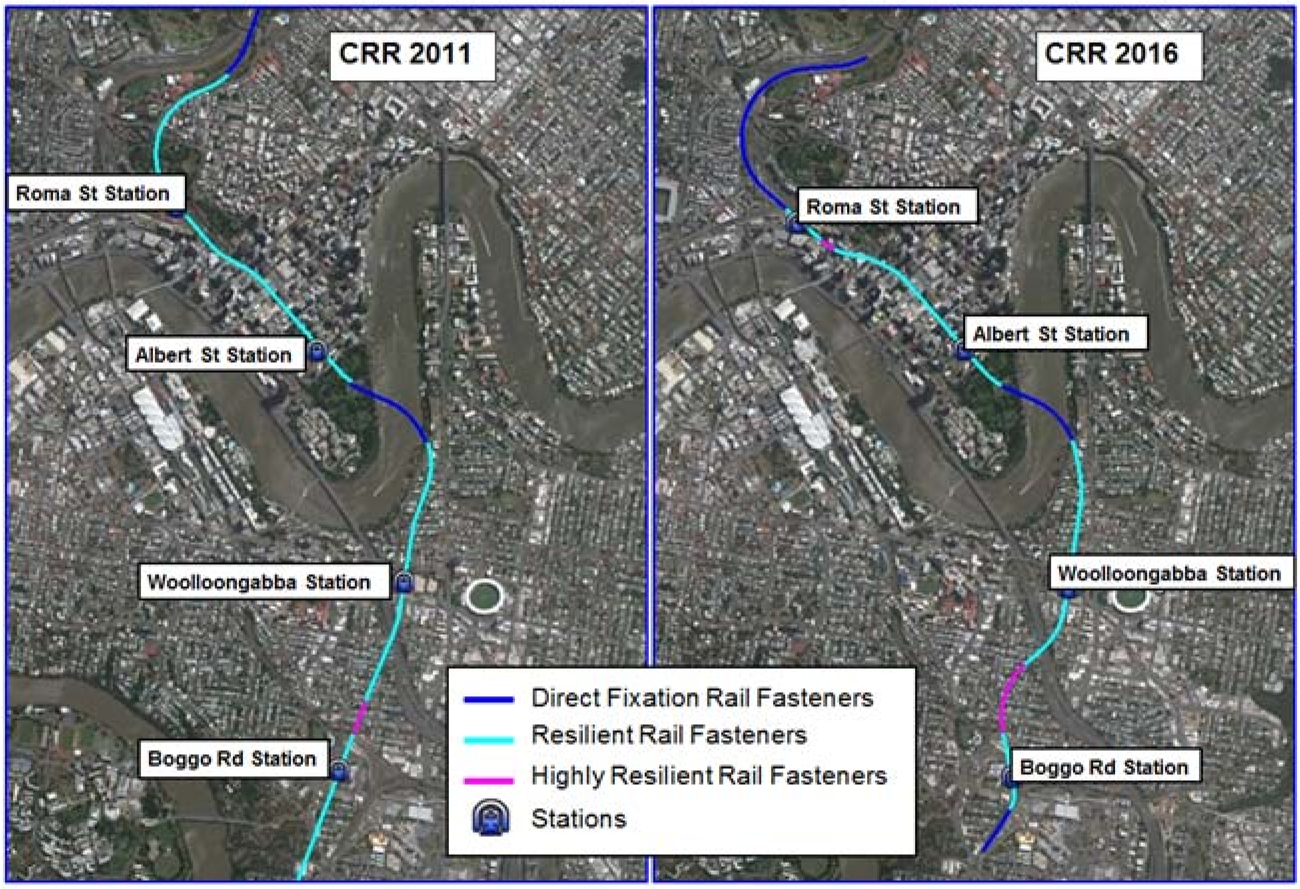


Figure 12.1 Compliance trackform for CRR 2011 and CRR 2016

12.3.5 Ground-borne vibration assessment – train operations

As discussed in Section 12.3.4, railway vibration is generated by dynamic forces at the wheel-rail interface that propagates via the rail mounts into the ground and into adjacent buildings.

The alignment and determined minimum required mitigation for the CRR 2011 and CRR 2016 design is shown in Figure 12.1. The compliance trackform is determined by the ground-borne noise which throughout the alignment has been more stringent than any vibration goal (consistent with CRR 2011).

The exception to this is where there are special receptors that may contain highly vibration sensitive equipment. Facilities close to the alignment identified to contain highly vibration sensitive equipment include the Eco-science precinct, the PA Hospital and Queensland University of Technology (QUT). However, all of these receptors are predicted to achieve the appropriate "sensitive equipment" vibration criteria with the compliance trackform set by achieving the ground-borne noise goals.

The predicted ground-borne vibration levels with the compliance trackform for both the CRR 2011 and CRR 2016 designs are detailed in Appendix E6. In general, there is minimal difference in predicted ground-borne vibration levels and with a slight change in mitigation trackform, CRR 2016 complies with the project criteria at all receptors with the proposed resilient and highly resilient rail fasteners in place.

12.3.6 Airborne noise assessment – ancillary facilities

Feeder stations

For the purpose of the noise assessment, the Southern and Exhibition feeder station are assumed to be the same design as assessed for CRR 2011 where all components will be enclosed in buildings, with the transformer building open in the direction of the tracks (where possible). A noise reduction through the feeder station building facades of approximately 20 dBA can be expected. It is noted that the Southern feeder station for CRR 2016 will be a small scale electrical substation and therefore the assessment provided here represents a worst-case scenario.

The only notable change between the CRR 2011 and CRR 2016 design is the change in proximity of the nearest sensitive receptors at the Southern feeder station. The potential change in airborne noise impacts is provided in Table 12.7. All predicted noise levels comply with the 40 dBA LA_{90} noise criterion determined for CRR 2011.

Table 12.7 Assessment of noise emissions from feeder stations

Feeder station	Distance to nearest sensitive receptor (m)		Predicted noise level, LA_{90} (dBA)		Change in impact
	CRR 2011	CRR 2016	CRR 2011	CRR 2016	
Southern feeder station	160	70	<30	<35	No change
Exhibition feeder station	200	180	<30	<30	No change

Station ancillary facilities

The maximum allowable sound power levels emitted by station mechanical plant and ventilation noise sources was predicted for each CRR 2011 station. Due to the geographical change in station locations for Boggo Road Station and Roma Street Station, the predictions for these two stations have been revisited in Table 12.8 for the nearest noise sensitive residential receptors to CRR 2016.

There will be no change in impacts (maximum acceptable noise emissions) for Woolloongabba Station and Albert Street Station.

The locations and design of the mechanical plant and ventilation systems for CRR 2016 will need to be assessed in more detail during the detailed design phase to verify the noise emission from the facilities.

Table 12.8 Assessment of noise emissions from station ancillary facilities

Station	Distance to nearest sensitive receptor (m)		Noise goal for CRR 2011 and CRR 2016, LA_{90} (dBA)	Maximum SWL* noise emission level from facility (dBA)		Change in impact
	CRR 2011	CRR 2016		CRR 2011	CRR 2016	
Boggo Road Station	90	100	37	84	85	Consistent outcome between CRR 2011 and CRR 2016, being no predicted impact and similar design requirement.

Station	Distance to nearest sensitive receptor (m)		Noise goal for CRR 2011 and CRR 2016, LA_{90} (dBA)	Maximum SWL* noise emission level from facility (dBA)		Change in impact
	CRR 2011	CRR 2016		CRR 2011	CRR 2016	
Roma Street Station	80	45	47	97	88	A lower allowable noise emission level is more rigorous for CRR 2016 (due to the closer receptor) to ensure compliance with the noise goal.

* SWL sound power level (source noise emission level).

12.4 Management and mitigation measures

12.4.1 Construction phase mitigation and management measures

The majority of the CRR 2011 management measures are still applicable to the CRR 2016 project. These construction and operation noise and vibration mitigation measures are detailed in the CRR 2016 Draft Outline EMP (Volume 2).

Mitigation measures which are consistent with CRR 2011 include the following:

Woolloongabba Station

- The acoustic shed being constructed as early in the programme as practicable and management of spoil truck movements in accordance with the requirements set out in Technical report 1 (Transport).

Albert Street Station

- The acoustic shed being constructed as early in the programme as practicable, rockbreaking ground-borne noise and vibration trials to accurately determine extent of the predicted impact and preference given to drill and blast of station shaft.

Roma Street

- The acoustic shed being constructed as early in the programme as practicable. Undertake a detailed investigation of all alternative mining techniques with the aim of avoiding or minimising potential ground-borne noise impacts. For example, drill and blast could be more efficient than use of heavy rockbreakers.

Low frequency noise

- Implement a comprehensive notification and education programme to assist in allaying community concerns in localities where low frequency noise would likely be exceeded during tunnelling works;
- Provide local communities with tunnelling progress and subsequent likely (temporary) exposure periods;

Construction traffic noise and vibration

- Restrict heavy goods vehicle movements to operating only on designated haulage routes for construction materials and spoil.

Additional mitigation measures now relevant to CRR 2016 include:

Southern portal & Boggo Road Station

- The new location of the Southern portal will require, as a minimum, 3m high acoustic hoarding (minimum surface density of 15kg/m^2) around the worksite perimeter. Further to this, temporary noise barriers may be required adjacent to noise intensive plant such as rockbreakers, in order to mitigate potential exceedances of the noise goals. The actual construction sequencing for the Southern portal will be influenced by the number and frequency of rail possessions. It is likely that construction activities will need to be staged such that the extent of predicted noise will be lower than this conservative analysis;
- During excavation of the tunnel portals and Boggo Road Station cavern, removal of spoil from the Southern portal and Boggo Road Station worksites should be restricted to the daytime period, where possible. A 3m high acoustic hoarding will also be required around the worksite; and
- It is anticipated that the initial stages of shaft excavation would be carried out by rockbreaker due to the closeness of sensitive receptor buildings. The point at which drill and blast excavation could be safely and efficiently carried out within the shaft would be determined as part of detailed investigations for the site. Acoustically, exposure to a short-term blast event would be preferred to long term rockbreaking (where ground-borne noise impacts have been identified). Also, ground-borne noise levels from drilling of blast holes are typically lower than rockbreaking noise levels.

Northern portal

- Further assessment of potential impacts to BGGS during the construction phase of CRR 2016 is recommended during detailed design. In addition to regular liaison with BGGS, it is recommended that noise monitoring be carried out at BGGS during construction of the project.

12.4.2 Operation phase mitigation and management measures

Additional mitigation measures now relevant to CRR 2016 include:

Railway Terrace and Rawnsley Street

- During operation, twelve noise sensitive receptors in the vicinity of the Southern portal are predicted to exceed QR's 65 dBA $LA_{eq(24hour)}$ and 87 dBA Single Event Maximum planning levels. Eleven (11) of the predicted exceedances occur along Railway Terrace and Rawnsley Street and the final exceedance predicted for the ESA Village – Leukaemia Foundation;
- There is an existing noise barrier along Railway Terrace, adjacent to the existing rail corridor which varies in height between 4.25m and 5.5m. Increasing the height of this existing noise barrier to 6m (the typically accepted maximum noise barrier height in Queensland) along the full length eliminates four of these predicted exceedances at the southern end of Railway Terrace, by reducing noise levels by up to 8 dBA;
- Although the increase in height does reduce rail noise levels at some of the other residences by up to 3 dBA, it is not able to reduce the noise levels to below the planning levels, leaving seven residences along Railway Terrace and Rawnsley Street predicted to exceed the planning levels with the designed noise barrier upgrade. This is due to the elevated track structure near Railway Terrace carrying freight traffic and the topography of the area; and
- In order to achieve the planning noise levels at all Railway Terrace and Rawnsley Street residences, a 5m noise barrier would be required on the edge of the elevated track structure. This would not be a feasible solution particularly from a civil engineering standpoint due to wind loading design constraints. Further investigation and consultation with affected parties will be required to manage operational rail noise at this location during detailed design.

ESA Village – Leukaemia Foundation

- An exceedance is predicted at the Leukaemia Foundation Building (41 Peter Doherty Street). Due to the size of the building, a noise barrier is not a practical solution for mitigating rail noise as it is not possible to break line-of-sight to the tracks with a noise barrier of no more than 6 m in height. Given the recent construction of the building, it is highly likely that the building has been designed and constructed with noise attenuation measures in the building facade. Determining whether or not this is the case would be the first step in further investigating how to manage operation rail noise at this location.

Where operational noise goals cannot be achieved through the provision of noise barriers, the Proponent will negotiate with affected parties to determine a suitable form of mitigation. Further detail regarding these mitigation measures is provided in the CRR 2016 Draft Outline EMP (Volume 2).

12.5 Conclusion

The noise and vibration impact assessment for CRR 2016 has identified that during the construction phase there will generally be a similar extent of airborne construction noise impacts compared to that predicted for CRR 2011, albeit in some cases in relation to different sensitive receptors.

Construction noise and / or vibration impacts will be avoided or reduced most notably at Yeerongpilly, Albert Street Station and the Northern portal worksite, with new impacts predicted at the Southern portal and Boggo Road worksites. At the Roma Street worksite, noise and vibration impacts will relate to different sensitive receptors. Construction noise exceedances are anticipated at some locations at particular phases of construction, which will be short-term and managed through the measures documented in the Draft Outline EMP (Volume 2).

Compared to CRR 2011, impacts resulting from the mechanical tunnel excavation for CRR 2016 are predicted to be generally lower between Boggo Road Station and Woolloongabba Station, higher between Woolloongabba Station and Albert Street Station and similar between Albert Street Station and the Northern portal.

During operations, some residences near the Southern portal are predicted to exceed one or more of the Planning Levels and further noise attenuation will be required. Further investigation and consultation with affected parties during detailed design will be required to manage operational rail noise at this location.

Elsewhere, there is minimal difference in predicted operational air-borne noise and ground-borne noise and vibration levels from train operations for CRR 2016 compared to CRR 2011. There are slight changes in mitigation trackform, with Resilient Rail Fasteners and Highly Resilient Rail Fasteners being used by both projects.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

Appendix E

Construction - Southern Portal and Boggo Road Station Noise and Vibration Modelling Results

E1 Construction – Southern portal and Boggo Road Station noise and vibration modelling results

Southern portal & Boggo Road Station construction noise and vibration modelling results

Detailed modelling of construction noise and vibration impacts for the Southern portal and Boggo Road Station, at Dutton Park, is presented below.

The nearest noise and/or vibration sensitive receptors to the Southern portal site are identified in Table E-1 with the receptor areas illustrated in Figure E-1. The site specific construction noise goals are presented in Table E-2.

The following colour codes have been used: Pink = Residential, Blue = Commercial, Yellow = Hospital, Orange = Educational and Yellow with red boundary = Church or Place of Worship.

Figure E-1 Southern portal and Boggo Road Station receptor areas

Table E-1 Nearest sensitive receptors – Southern portal and Boggo Road Station

Worksite	Receptor area	Distance to worksite boundary
Southern portal and Boggo Road Station	A - Railway Terrace Commercial	10m
	B - Railway Terrace (Pound Street to Rawnsley Street)	14m
	C - ESA Village (Leukaemia Centre)	< 10m
	D - Ecosciences Building	20m
	E - Police Station & Gaol	145m
	F - Dutton Park Primary School	150m
	G - Merton Road to Elliott Street Residential	20m
	H - Burke Street Commercial	12m

Worksite	Receptor area	Distance to worksite boundary
	I – Metropolitan line service (MLS) commercial	10m
	J - PA Hospital	20m
	K - Rusk Street & Cornwall Street Residential	75m
	L – PA Early Education Centre	55m

Table E-2 Southern portal and Boggo Road Station external construction noise goals

Receiver location/type	Monday to Saturday 6:30 am to 6:30 pm		Monday to Saturday 6:30 pm to 6:30 am, Sundays and public holidays	
	Steady state (dBA $LA_{eq,adj,15min}$)[1]	Non-steady state (dBA $LA_{10,adj,15min}$)[1]	Continuous (dBA $LA_{eq,adj(15min)}$)[1]	Intermittent (dBA LA_{max})[1]
A - Railway Terrace Commercial	67	77	-	-
B - Railway Terrace Residential	47	57	42	49
C - ESA Village (Leukaemia Centre) Residential	62	72	57	64
D - Ecosciences Building Commercial	67	77	-	-
E - Police Station & Gaol Commercial	62[2]	72[2]	-	-
F - Dutton Park Primary School	52	62	-	-
G - Merton Road to Elliott Street Residential	47	57	42	49
H - Burke Street Commercial	67	77	-	-
I - MLS	67	77	-	-
J - PA Hospital	62[3]	72[3]	57	64
K - Rusk Street & Cornwall Street Residential	47	57	42	49
L – PA Early Education Centre	52	62	-	-

Notes

1. Noise goal has been adjusted to represent external free-field levels.
2. Noise goal relevant at all times.
3. Based on AS2107 category “wards” for medical buildings.

Scenarios were developed for Southern portal and Boggo Road Station construction works being representative of activities having potentially the greatest (i.e. worst case) noise impact on the surrounding receptors. Worst case scenarios have been developed based on all plant items, as confirmed by the Project team including on-site spoil trucks where applicable, operating simultaneously. These scenarios are:

- Scenario 1 – Site Establishment and removal of existing railway infrastructure;
- Scenario 2 – Pile installation along cut and cover sections of Boggo Road Station and tunnel portals;

- Scenario 3 – Initial excavation of the cut and cover structures outside of the rail corridor;
- Scenario 4 – Pile installation within the rail corridor (likely during weekend rail possessions); and
- Scenario 5 – Mining of the portals and Boggo Road Station shaft/cavern below the cut and cover structure.

For the above construction scenarios, typical construction noise levels with either 3 m acoustic hoarding surrounding the worksite or existing railway noise barriers have been predicted at the nearest noise sensitive receptors and are presented in Table E-3. Airborne construction noise levels have been predicted over the respective receptor catchment area as reflected by the range in noise levels in Table E-3.

Airborne construction noise level contours for the five scenarios are presented at the end of Appendix E1.

Table E-3 Southern portal and Boggo Road Station predicted airborne construction noise levels

Receptor	Predicted external construction noise levels $LA_{10,adj,15min}$				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
A - Railway Terrace Commercial	61 - 64	55 - 58	64 - 67	53 - 61	46 - 49
B - Railway Terrace Residential	63 - 71	58 - 66	66 - 74	61 - 76	49 - 56
C - ESA Village Residential	64 - 75	62 - 75	67 - 76	72 - 84	58 - 69
D - Ecosciences Building Commercial	55 - 80	61 - 81	62 - 82	45 - 70	38 - 65
E - Police Station & Gaol Commercial	45 - 59	54 - 61	53 - 61	40 - 62	31 - 47
F - Dutton Park Primary School 1	45 - 51	52 - 57	50 - 56	39 - 40	29 - 32
G - Merton Road to Elliott Street Residential	48 - 65	53 - 69	52 - 70	43 - 61	35 - 51
H - Burke Street Commercial	58 - 65	56 - 71	61 - 71	57 - 63	47 - 53
I - Metropolitan Line Service	59 - 70	61 - 69	63 - 72	58 - 73	52 - 62
J - PA Hospital	46 - 80	45 - 73	48 - 81	43 - 73	36 - 65
K - Rusk Street & Cornwall Street Residential	46 - 51	45 - 55	48 - 56	42 - 51	32 - 36
L – PA Early Education Centre 1	58 - 61	60 - 63	61 - 64	57 - 60	51 - 54

Predicted ground-borne noise and vibration impacts for the Southern portal and Boggo Road Station are presented in Table E-4.

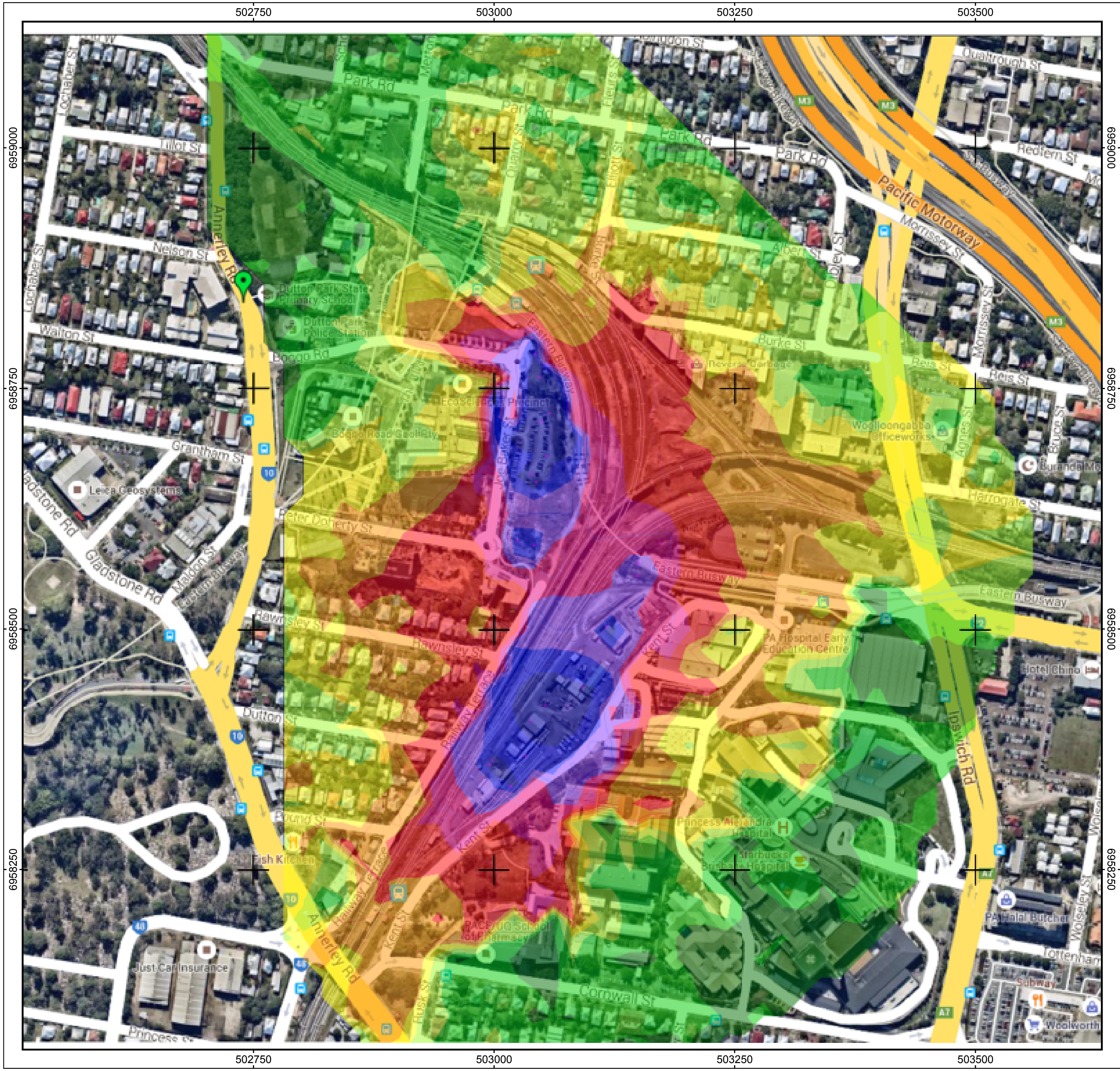
Table E-4 Southern portal and Boggo Road Station ground borne noise and vibration predicted levels

Receptor area	Period	Ground-borne noise and vibration goals			Predicted ground-borne vibration level PPV (mm/s)	Predicted ground-borne noise level (dBA) [1]	
		Vibration PPV (mm /s)	Internal ground-borne noise (dBA)			Rock-breaker	Road-header
			Continuous	Intermittent			
B - Railway Terrace (Pound Street to Rawnsley Street)	Day	10	40 $LA_{eq,adj}$	50 $LA_{10,adj}$	0.12	33 LA_{10}	35 LA_{eq}
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.12	37 LA_{max}	35 LA_{eq}
C - ESA Village	Day	25	40 $LA_{eq,adj}$	50 $LA_{10,adj}$	0.19	39 LA_{10}	39 LA_{eq}
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.19	**43** LA_{max}	**39** LA_{eq}
D - Ecosciences Building	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.44	53 LA_{10}	26 LA_{eq}
D - Ecosciences Building (TEM)	24/7	0.013 RMS mm/s [2]	N/A	N/A	0.01 RMS mm/s [2]	N/A	N/A
F - Dutton Park Primary School	Day	10	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.03	33 LA_{10}	19 LA_{eq}
G - Merton Road to Elliott Street Residential	Day	10	40 $LA_{eq,adj}$	50 $LA_{10,adj}$	2.0	47 LA_{10}	**52** LA_{eq}
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	2.0	**51** LA_{max}	**52** LA_{eq}
H - Burke Street Commercial	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.04	35 LA_{10}	18 LA_{eq}
I – Metropolitan line service	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.02	28 LA_{10}	17 LA_{eq}
J - PA Hospital	Day	25	40 $LA_{eq,adj}$	50 $LA_{10,adj}$	0.03	26 LA_{10}	20 LA_{eq}
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.03	30 LA_{max}	20 LA_{eq}

Notes

1. Exceedances shown in **bold**
2. The TEM criterion is specified in root mean square (RMS) vibration velocity. The vibration predictions assume a crest factor (i.e. difference between Peak Particle Velocity (PPV) and RMS) of 4.

All predicted ground-borne noise and vibration levels have been based on the shortest distance between the excavation source and the receptor building. For some receptors, the predicted ground-borne noise level from roadheading is equivalent to or higher than that predicted for rockbreaking. This occurs when the receptor building is located closer to the roadheader work area (i.e. station cavern) than the rockbreaker work area (i.e. station shaft).



Customer:
Arup
Project: Cross River Rail 2016
Project-No. 620.11482

Map
1

CRR 2016 - Southern Portal - Scenario 1
Site Establishment & Demolition
Airborne Construction Noise Levels
Calculation 1.8 m above ground

Project engineer: SH
Created: 07-Oct-2016
Processed with SoundPLAN 7.4, Update 13-Mar-2015

Signs and symbols
Noise calculation area
Point source

Levels LA10,15min
in dB(A)

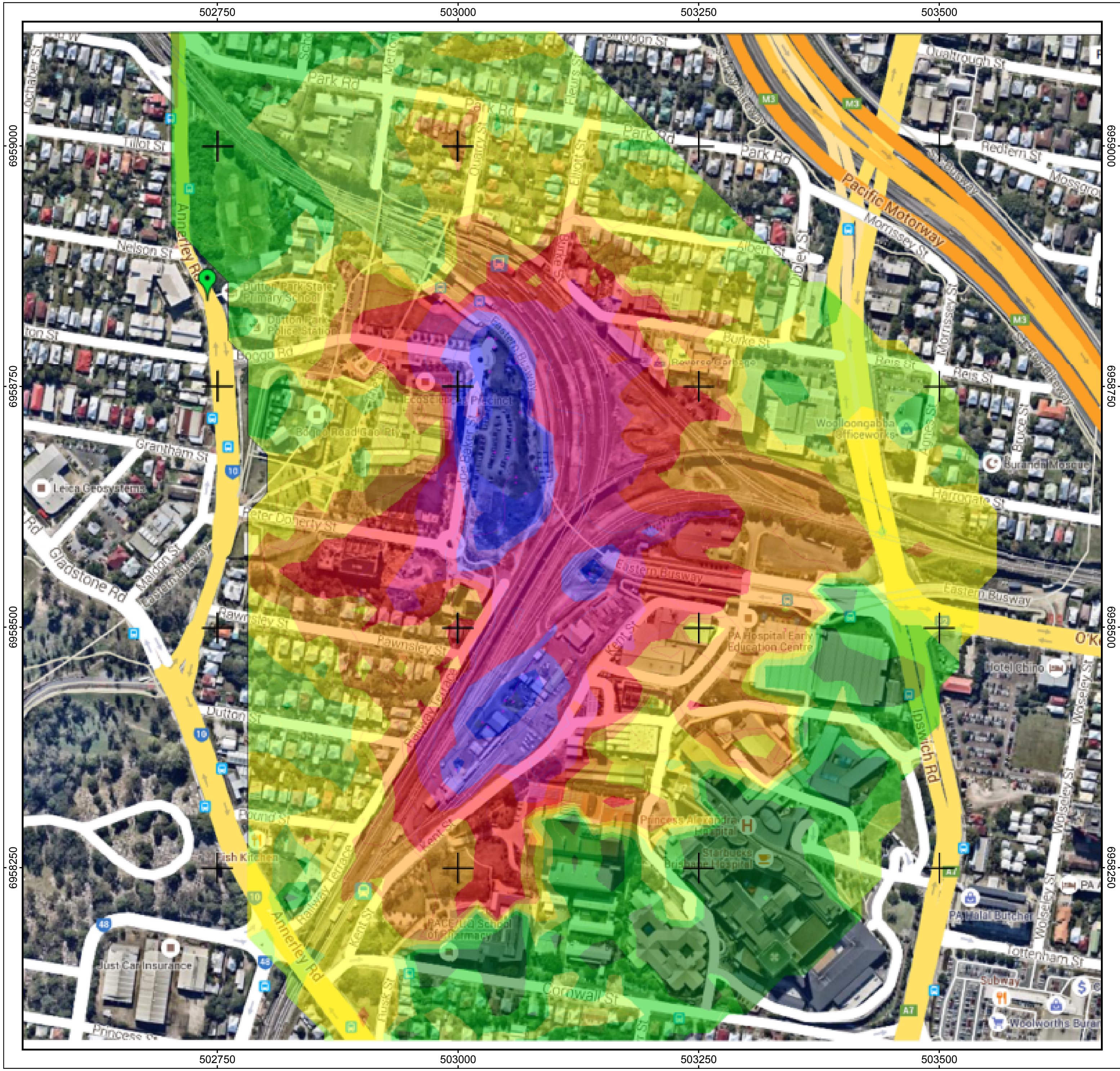
<= 45
45 < <= 50
50 < <= 55
55 < <= 60
60 < <= 65
65 < <= 70
70 < <= 75
75 < <= 80
80 < <= 85
85 <

N

Length scale 1:4000
0 25 50 100 150 200 m

SLR

C:\1 - Data\1 - SLR Projects\620.11482 CRR v2\620.11482 CRR 2016 Construction Noise\CRR 2016 SP Scenario 1 LA10.sgs



Customer:
Arup
Project: Cross River Rail 2016
Project-No. 620.11482

Map
2

CRR 2016 - Southern Portal - Scenario 2
Piling Around Portals and Cut & Cover
Airborne Construction Noise Levels
Calculation 1.8 m above ground

Project engineer: SH
Created: 07-Oct-2016
Processed with SoundPLAN 7.4, Update 13-Mar-2015

Signs and symbols

- Noise calculation area
- Point source
- Line source

Levels LA10,15min
in dB(A)

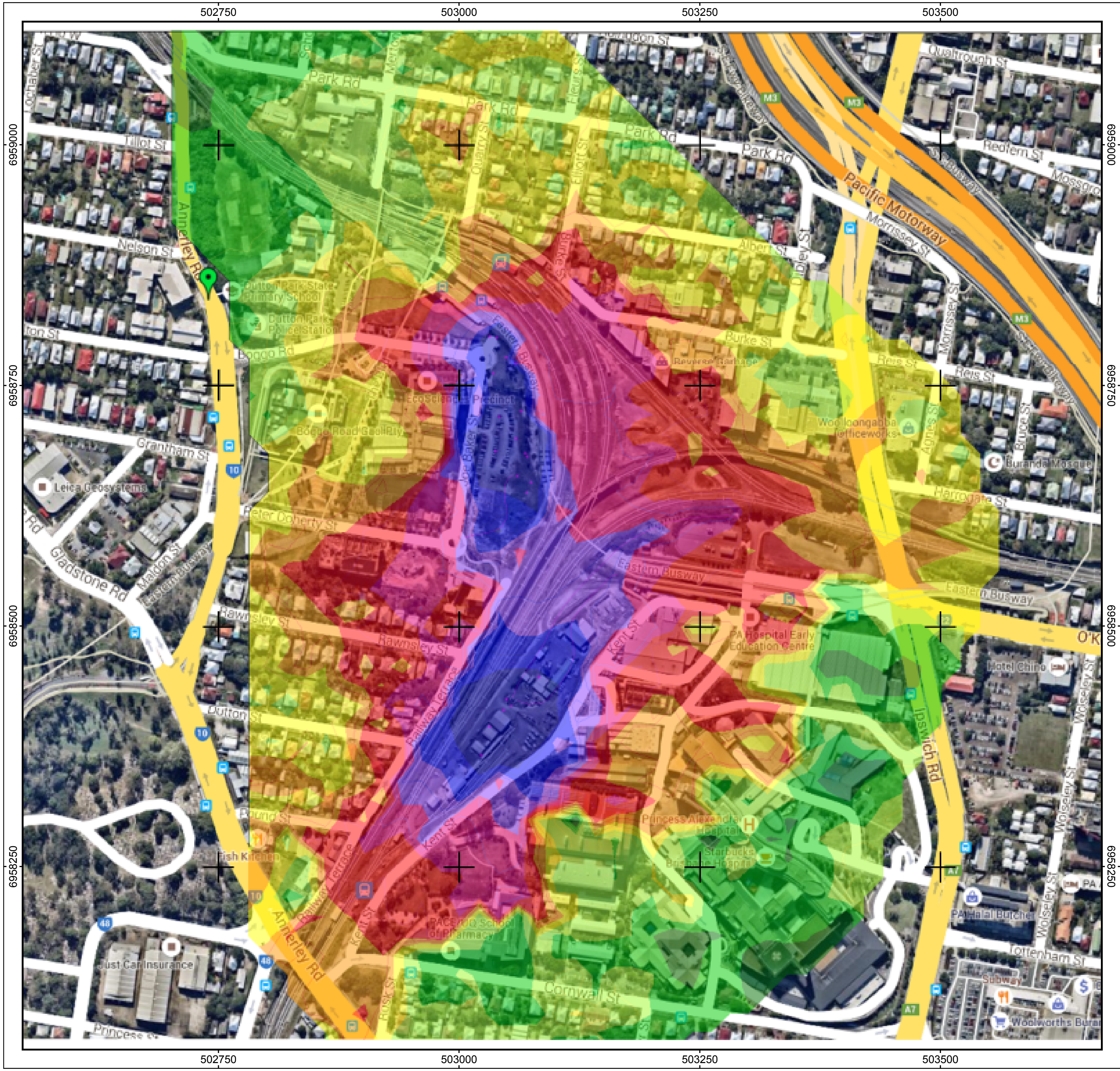
	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	<= 70
70 <	<= 75
75 <	<= 80
80 <	<= 85
85 <	

Length scale 1:4000

0 25 50 100 150 200 m

N

SLR



Customer:
Arup
Project: Cross River Rail 2016
Project-No. 620.11482

Map
3

CRR 2016 - Southern Portal - Scenario 3
Initial Portal, Cut & Cover Excavation
Airborne Construction Noise Levels
Calculation 1.8 m above ground

Project engineer: SH
Created: 07-Oct-2016
Processed with SoundPLAN 7.4, Update 13-Mar-2015

Signs and symbols

Noise calculation area
Point source
Line source

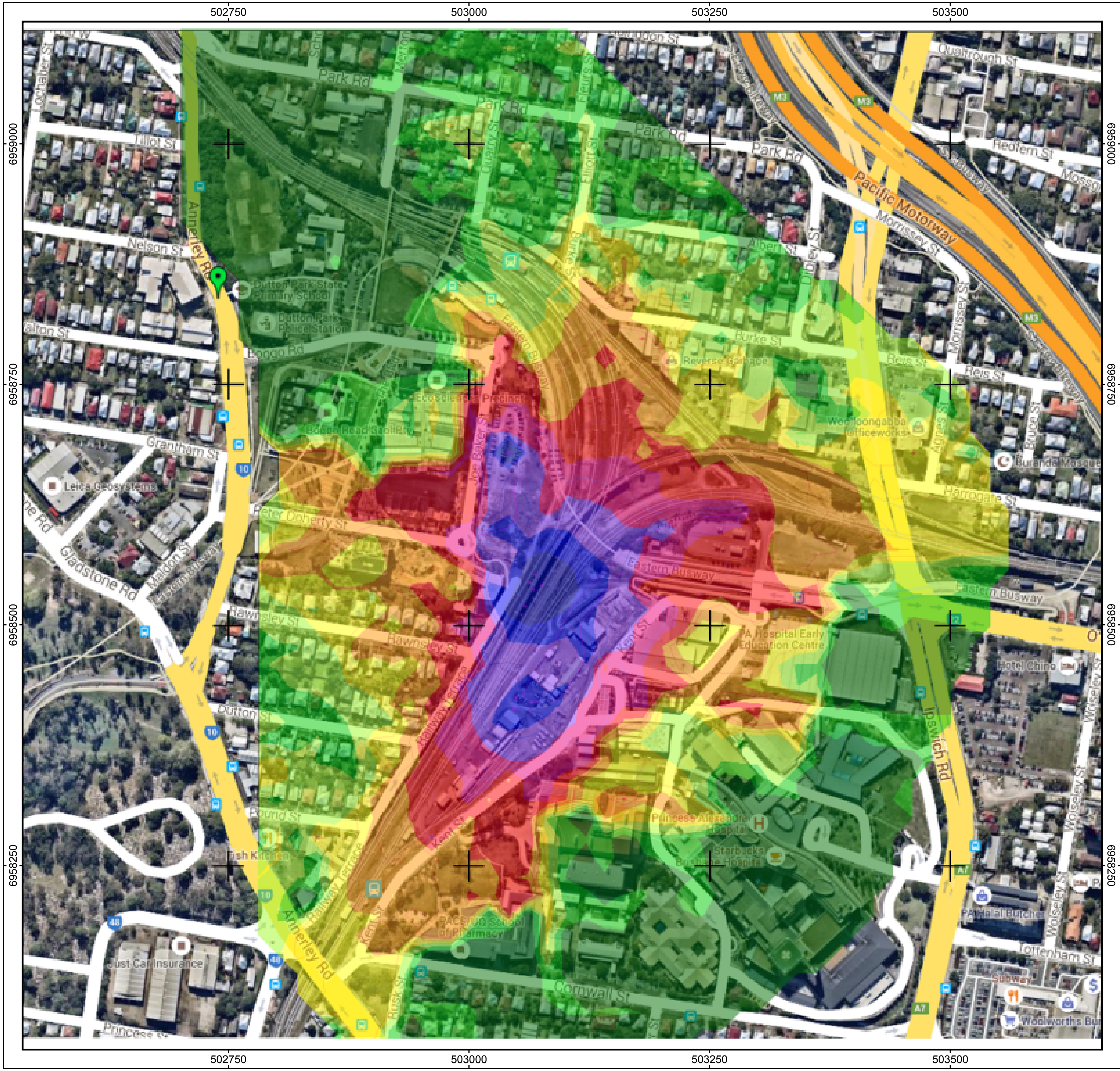
Levels LA10,15min
in dB(A)

	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	<= 70
70 <	<= 75
75 <	<= 80
80 <	<= 85
85 <	

Length scale 1:4000
0 25 50 100 150 200 m

SLR

C:\1 - Data\1 - SLR Projects\620.11482 CRR v2\620.11482 CRR 2016 Construction Noise\CRR 2016 SP Scenario 3 LA10.sgs



Customer:
Arup
Project: Cross River Rail 2016
Project-No. 620.11482

Map

4

CRR 2016 - Southern Portal - Scenario 4
Piling within the Rail Reserve
Airborne Construction Noise Levels

Calculation 1.8 m above ground

Project engineer: SH
Created: 07-Oct-2016
Processed with SoundPLAN 7.4, Update 13-Mar-2015

Signs and symbols

- Noise calculation area
- Point source
- Line source

Levels LA10,15min
in dB(A)

	<=	45
45 <	<=	50
50 <	<=	55
55 <	<=	60
60 <	<=	65
65 <	<=	70
70 <	<=	75
75 <	<=	80
80 <	<=	85
85 <		

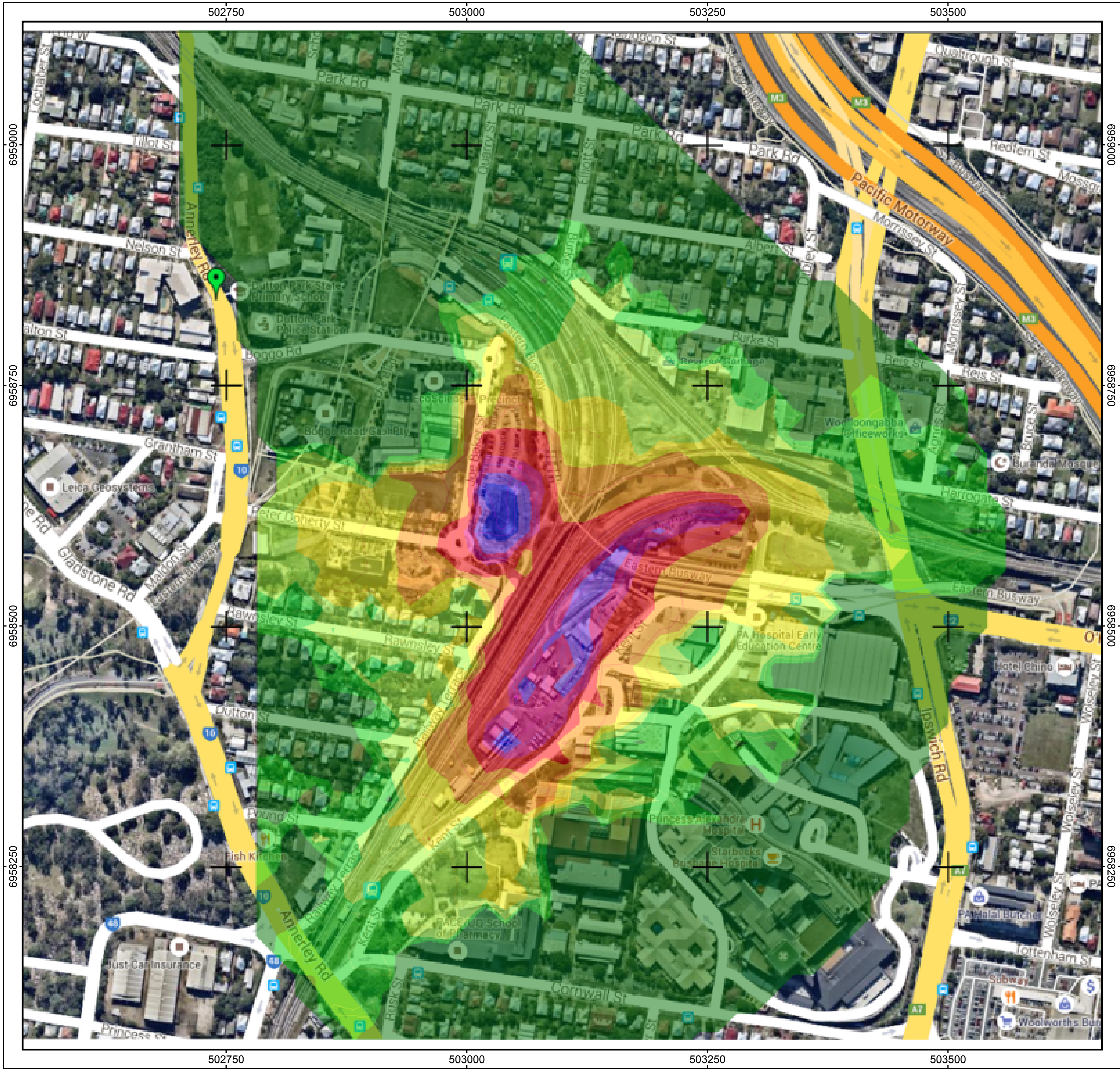
N

Length scale 1:4000

0 25 50 100 150 200 m

SLR

C:\1 - Data\1 - SLR Projects\620.11482 CRR v2\620.11482 CRR 2016 Construction Noise\CRR 2016 SP Scenario 4 LA10.sgs



Customer:
Arup
Project: Cross River Rail 2016
Project-No. 620.11482

Map
5

CRR 2016 - Southern Portal - Scenario 5
Mining of Station Shaft and Portals
Airborne Construction Noise Levels
Calculation 1.8 m above ground

Project engineer: SH
Created: 07-Oct-2016
Processed with SoundPLAN 7.4, Update 13-Mar-2015

Signs and symbols

- Noise calculation area
- Point source
- Line source

Levels LA10,15min
in dB(A)

	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	<= 70
70 <	<= 75
75 <	<= 80
80 <	<= 85
85 <	

N

Length scale 1:4000
0 25 50 100 150 200 m

SLR

C:\1 - Data\1 - SLR Projects\620.11482 CRR v2\620.11482 CRR 2016 Construction Noise\CRR 2016 SP Scenario 5 LA10.sgs

E2 Construction – Roma Street Station noise and vibration modelling results

Roma Street Station construction noise and vibration modelling results

Detailed modelling of construction noise and vibration impacts for Roma Street Station is presented below.

The nearest noise and/or vibration sensitive receptors to the Roma Street Station site are identified in Table E-5 with the receptor areas illustrated in Figure E-2. The site specific construction noise goals are presented in Table E-6.

The following colour codes have been used: Pink = Residential, Blue = Commercial, Yellow = Hospital, Orange = Educational and Yellow with red boundary = Church or Place of Worship.

Figure E-2 Roma Street Station receptor areas

Table E-5 Nearest sensitive receptors – Roma Street Station

Worksite	Receptor area	Distance to worksite boundary
Roma Street Station	A - Parkland Boulevard Residential	130
	B - Parkland Boulevard Commercial	150
	C - Wickham Terrace Commercial	220
	D - St Alban Catholic Church	235
	E - Wickham Terrace Residential	220
	F - Brisbane Private Hospital	250
	G - Dentist School	300
	H - Magistrates Court	220

Worksite	Receptor area	Distance to worksite boundary
	I - Supreme & District Courts	95
	J - Roma Street Station Hotel (Hotel Jen)	55
	K - Roma Street Station Commercial Building	0
	L - George Street Commercial	30
	M - Roma Street Commercial	30
	N - George Street Residential (backpackers)	60
	O - Roma Street Residential (Abbey)	35
	P - Police Headquarters & Watch House	30
	Q - Roma Street Station (heritage listed)	20
	R - Ambulance & Fire Station	115

Table E-6 Roma Street external construction noise goals

Receiver location/type	Monday to Saturday 6:30 am to 6:30 pm		Monday to Saturday 6:30 pm to 6:30 am, Sundays and Public Holidays	
	Steady state (dBA $L_{Aeq,adj,15min}$)[1]	Non-steady state (dBA $L_{A10,adj,15min}$)[1]	Continuous (dBA $L_{Aeq,adj,15min}$)[1]	Intermittent (dBA L_{Amax})[1]
A - Parkland Boulevard Residential	67	77	57	64
B - Parkland Boulevard Commercial	67	77	-	-
C - Wickham Terrace Commercial	67	77	-	-
D - St Alban Catholic Church	47[2]	57[2]	-	-
E - Wickham Terrace Residential	52	62	42	49
F - Brisbane Private Hospital	62[3]	72[3]	57	64
G - Dentist School	52	62	-	-
H – Magistrates Court	57	67	-	-
I - Supreme & District Courts	57	67	-	-
J - Roma Street Station Hotel (Hotel Jen)	67	77	57	64
K - Roma Street Station Commercial Building	67	77	-	-
L - George Street Commercial	67	77	-	-
M - Roma Street Commercial	67	77	-	-
N - George Street Residential (backpackers)	67	77	57	64
O - Roma Street Residential (Abbey)	67	77		

Receiver location/type	Monday to Saturday 6:30 am to 6:30 pm		Monday to Saturday 6:30 pm to 6:30 am, Sundays and Public Holidays	
	Steady state (dBA $LA_{eq,adj,15min}$)[1]	Non-steady state (dBA $LA_{10,adj,15min}$)[1]	Continuous (dBA $LA_{eq,adj,15min}$)[1]	Intermittent (dBA LA_{max})[1]
P - Police Headquarters & Watch House	67	77	57	64
R - Ambulance & Fire Station	67	77	57	64

Notes

1. Noise goal has been adjusted to represent external free-field levels.
2. Monday to Saturday 6:30am to 6:30pm goals relevant at all times.
3. Based on AS2107 category “wards” for medical buildings.

Scenarios were developed for Roma Street Station construction works being representative of activities having potentially the greatest (i.e. worst case) noise impact on the surrounding receptors. Worst case scenarios have been developed based on all plant items, as confirmed by the Project team including on-site spoil trucks where applicable, operating simultaneously. These scenarios are:

- Scenario 1 – Site establishment and removal of existing buildings;
- Scenario 2 – Pile installation around station shaft perimeter; and
- Scenario 3 – Initial excavation of the station shaft.

For the above construction scenarios, typical construction noise levels with 3m acoustic hoarding surrounding the worksite have been predicted at the nearest noise sensitive receptors and are presented in Table E-7. Airborne construction noise levels have been predicted over the respective receptor catchment area as reflected by the range in noise levels in Table E-7.

Airborne construction noise level contours for the three scenarios are presented at the end of Appendix E2.

Table E-7 Roma Street Station predicted airborne construction noise levels

Receptor	Predicted external construction noise levels $LA_{10,adj,15min}$		
	Scenario 1	Scenario 2	Scenario 3
A - Parkland Boulevard Residential	61 - 77	56 - 67	59 - 72
B - Parkland Boulevard Commercial	58 - 61	52 - 55	57 - 60
C - Wickham Terrace Commercial	55 - 64	50 - 53	52 - 61
D - St Alban Catholic Church	59 - 62	50 - 53	54 - 57
E - Wickham Terrace Residential	61 - 65	51 - 55	56 - 60
F - Brisbane Private Hospital	62 - 64	51 - 54	59 - 61
G - Dentist School	42 - 46	38 - 42	41 - 45
H - Magistrates Court	45 - 62	37 - 56	45 - 61
I - Supreme & District Courts	63 - 70	54 - 64	61 - 72
J - Roma Street Station Hotel (Hotel Jen)	52 - 58	48 - 51	52 - 56
K - Roma Street Station Commercial Building (including BTC East Tower).	59 - 85	56 - 74	58 - 82
L - George Street Commercial	57 - 65	56 - 62	55 - 64

Receptor	Predicted external construction noise levels $LA_{10,adj,15min}$		
	Scenario 1	Scenario 2	Scenario 3
M - Roma Street Commercial	68 - 75	61 - 70	64 - 76
N - George Street Residential (backpackers)	58 - 60	59 - 62	60 - 63
O - Roma Street Residential (Abbey)	78 - 80	72 - 76	79 - 84
P - Police Headquarters & Watch House	73 - 84	66 - 76	72 - 84
R - Ambulance & Fire Station	64 - 69	58 - 62	63 - 67

Predicted ground-borne noise and vibration impacts for Roma Street Station are presented in Table E-8. All predicted ground-borne noise and vibration levels have been based on the shortest distance between the excavation source and the receptor building. For some receptors, the predicted ground-borne noise level from roadheading is equivalent to or higher than that predicted for rockbreaking. This occurs when the receptor building is located closer to the roadheader work area (i.e. station cavern) than the rockbreaker work area (i.e. station shaft).

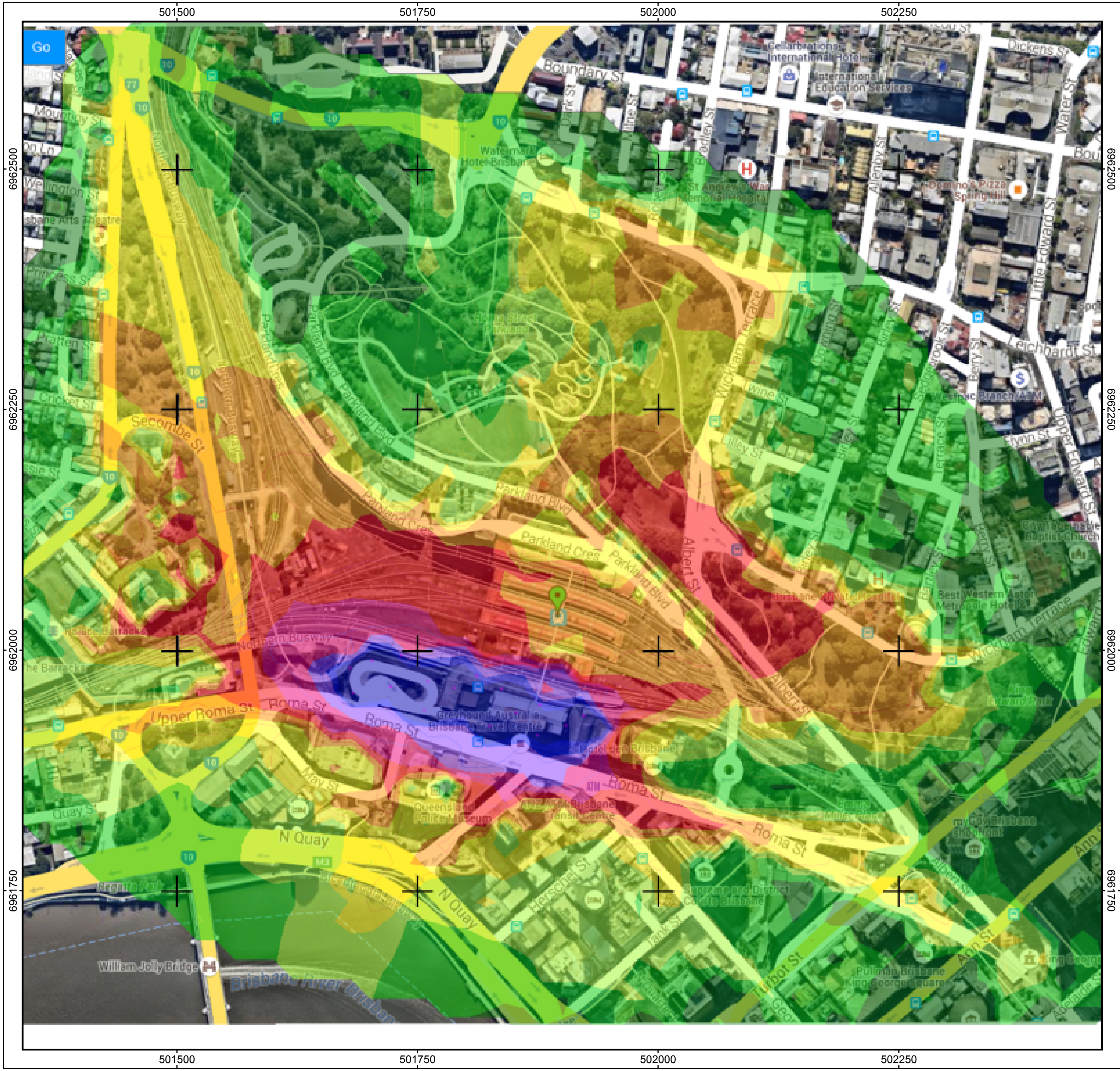
Table E-8 Roma Street Station ground-borne noise and vibration predicted levels

Receptor area	Period	Ground-borne noise and vibration goals			Predicted ground-borne vibration Level PPV (mm/s)	Predicted ground-borne noise level (dBA) [1]	
		Vibration PPV (mm/s)	Internal ground-borne noise (dBA)			Rockbreaker	Roadheader
			Continuous	Intermittent			
A - Parkland Boulevard Residential	Day	25	40 $LA_{eq,adj}$	50 $LA_{10,adj}$	0.04	32 $LA_{10,adj}$	24 $LA_{eq,adj}$
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.04	36 LA_{max}	24 $LA_{eq,adj}$
B - Parkland Boulevard Commercial	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.03	27 $LA_{10,adj}$	20 $LA_{eq,adj}$
C - Wickham Terrace Commercial	Day	10	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.01	23 $LA_{10,adj}$	8 $LA_{eq,adj}$
D – St Alban Church	24/7	10	40 $LA_{eq,adj}$	50 $LA_{10,adj}$	0.01	23 $LA_{10,adj}$	8 $LA_{eq,adj}$
E - Wickham Terrace Residential	Day	10	40 $LA_{eq,adj}$	50 $LA_{10,adj}$	0.01	23 $LA_{10,adj}$	8 $LA_{eq,adj}$
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.01	27 LA_{max}	8 $LA_{eq,adj}$
F - Brisbane Private Hospital	Day	25	40 $LA_{eq,adj}$	50 $LA_{10,adj}$	0.01	21 $LA_{10,adj}$	7 $LA_{eq,adj}$
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.01	25 LA_{max}	7 $LA_{eq,adj}$
G - Dentist School	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.01	19 $LA_{10,adj}$	7 $LA_{eq,adj}$
H – Magistrates Court	Day	25	35 $LA_{eq,adj}$	45 $LA_{10,adj}$	0.01	24 $LA_{10,adj}$	13 $LA_{eq,adj}$
I - Supreme & District Courts	Day	25	35 $LA_{eq,adj}$	45 $LA_{10,adj}$	0.04	31 $LA_{10,adj}$	25 $LA_{eq,adj}$
J – Roma Street Station Hotel (Hotel Jen)	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.09	35 $LA_{10,adj}$	33 $LA_{eq,adj}$
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.09	39 LA_{max}	33 $LA_{eq,adj}$
K - Roma Street Station Commercial Building	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.36	45 $LA_{10,adj}$	**47** $LA_{eq,adj}$
L - George Street Commercial (Transcontinental Hotel)	Day	2	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.44	39 $LA_{10,adj}$	45 $LA_{eq,adj}$

Receptor area	Period	Ground-borne noise and vibration goals			Predicted ground-borne vibration Level PPV (mm/s)	Predicted ground-borne noise level (dBA) [1]	
		Vibration PPV (mm/s)	Internal ground-borne noise (dBA)			Rockbreaker	Roadheader
			Continuous	Intermittent			
M - Roma Street Commercial (King George Chambers)	Day	2	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.58	45 $LA_{10,adj}$	**46** $LA_{eq,adj}$
N - George Street Residential (backpackers)	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.11	35 $LA_{10,adj}$	34 $LA_{eq,adj}$
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.11	39 LA_{max}	34 $LA_{eq,adj}$
O - Roma Street Residential (Abbey)	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.25	48 $LA_{10,adj}$	41 $LA_{eq,adj}$
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.25	**52** LA_{max}	**41** $LA_{eq,adj}$
P - Police Headquarters & Watch House	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.34	51 $LA_{10,adj}$	36 $LA_{eq,adj}$
Q - Roma Street Station (heritage)	24/7	2	N/A	N/A	0.22	N/A	N/A
R - Ambulance & Fire Station	Day	25	45 $LA_{eq,adj}$	55 $LA_{10,adj}$	0.02	31 $LA_{10,adj}$	12 $LA_{eq,adj}$
	Night	0.5	35 $LA_{eq,adj}$	42 LA_{max}	0.02	35 LA_{max}	12 $LA_{eq,adj}$

Notes

1. Exceedances shown in **bold.**



Customer:
Arup
Project: Cross River Rail 2016
Project-No. 620.11482

Map

1

CRR 2016 - Roma St Station - Scenario 1
Site Establishment & Demolition
Airborne Construction Noise Levels
Calculation 1.8 m above ground

Project engineer: SH
Created: 07-Oct-2016
Processed with SoundPLAN 7.4, Update 13-Mar-2015

Signs and symbols

Noise calculation area

Point source

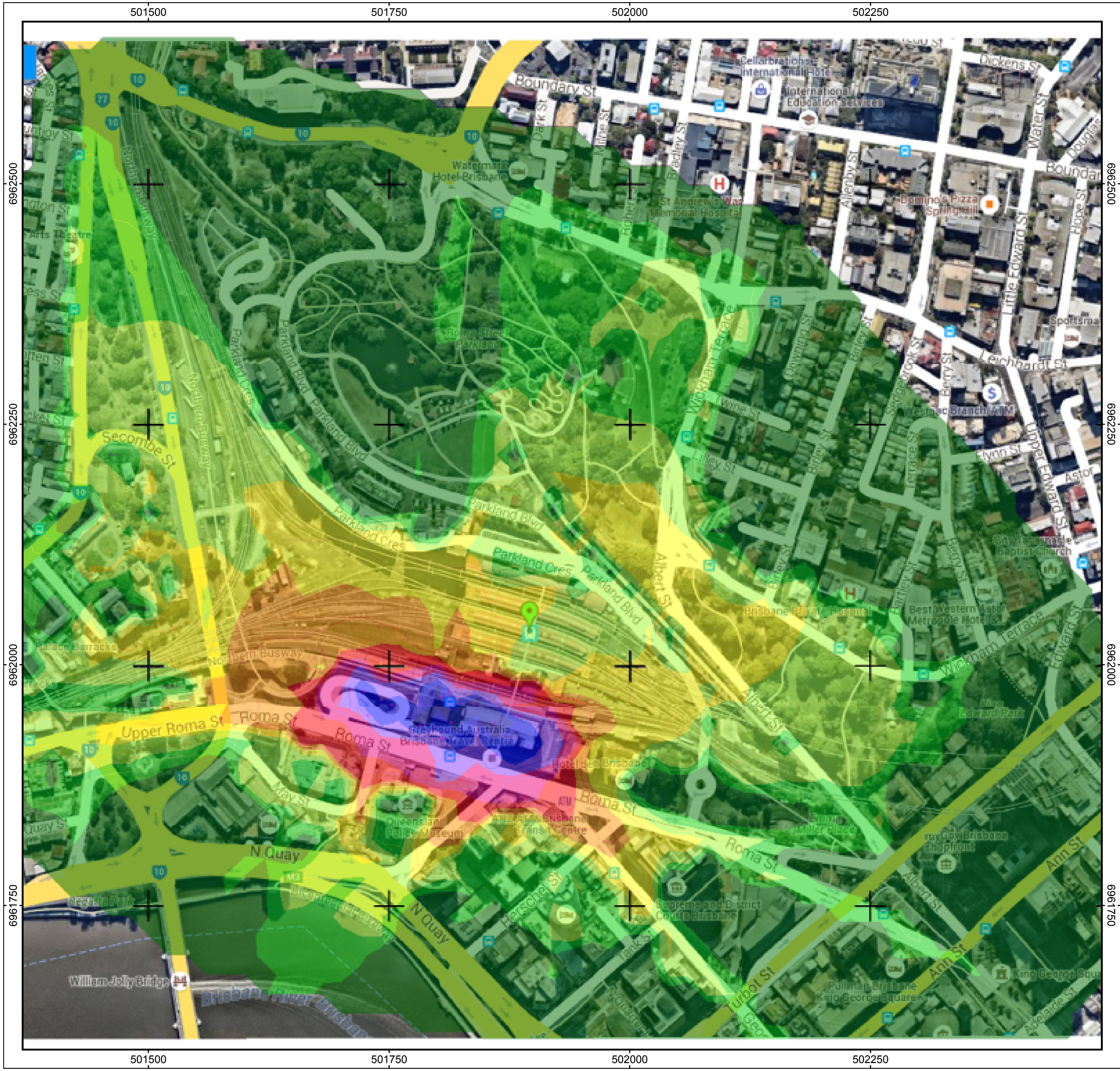
Levels LA10,15min
in dB(A)

	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	<= 70
70 <	<= 75
75 <	<= 80
80 <	<= 85
85 <	

N

Length scale 1:4000
0 25 50 100 150 200
m

C:\1 - Data\1 - SLR Projects\620.11482 CRR v2\620.11482 CRR 2016 Construction Noise\CRR 2016 Roma Scenario 1 LA10.sgs



Customer:
Arup
Project: Cross River Rail 2016
Project-No. 620.11482

Map
2

CRR 2016 - Roma St Station - Scenario 2
Piling Station Shaft Perimeter
Airborne Construction Noise Levels
Calculation 1.8 m above ground

Project engineer: SH
Created: 07-Oct-2016
Processed with SoundPLAN 7.4, Update 13-Mar-2015

Signs and symbols
Noise calculation area
Point source

Levels LA10,15min
in dB(A)

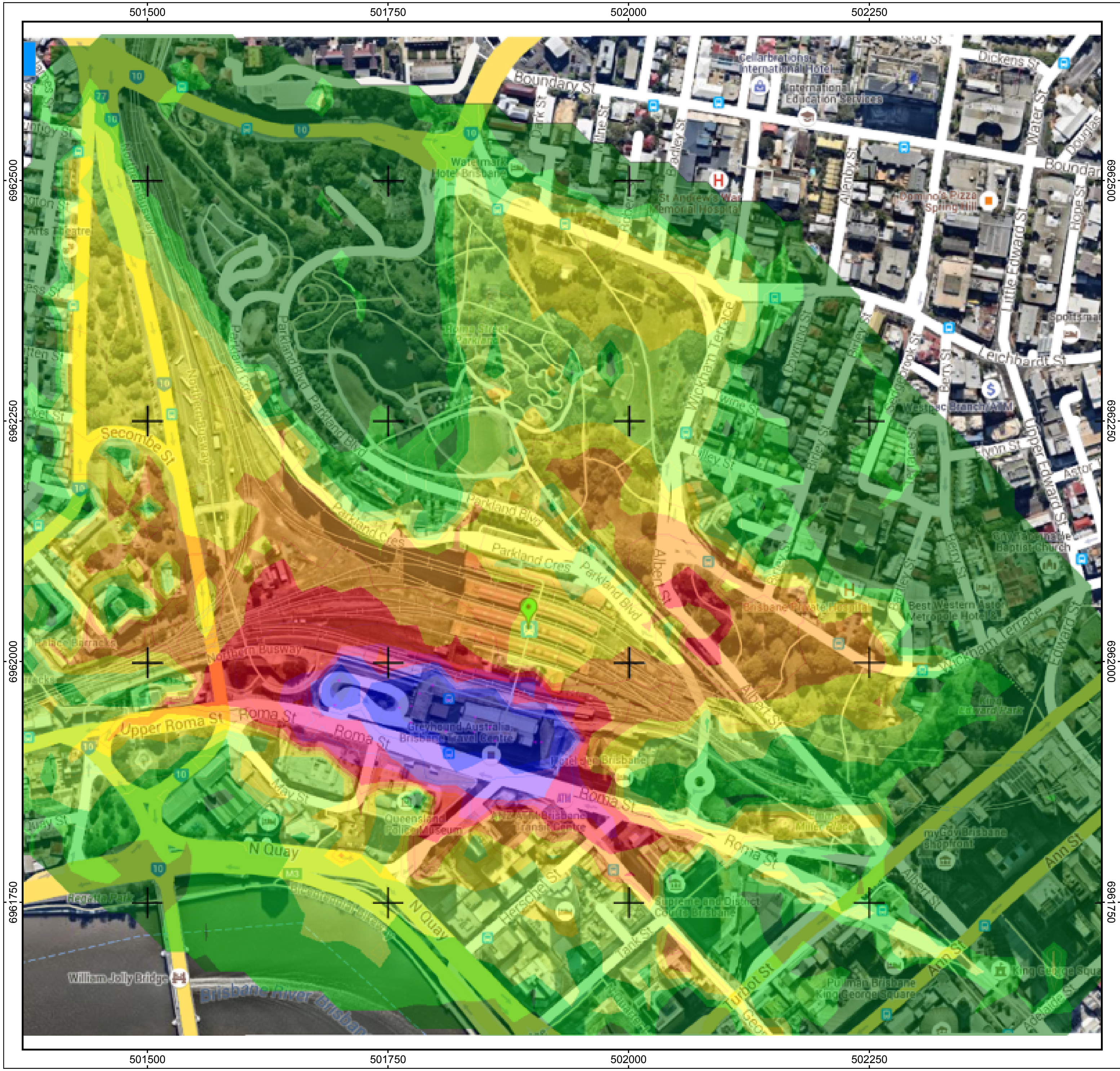
	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	<= 70
70 <	<= 75
75 <	<= 80
80 <	<= 85
85 <	

N

Length scale 1:4000
0 25 50 100 150 200 m

SLR

C:\1 - Data\1 - SLR Projects\620.11482 CRR v2\620.11482 CRR 2016 Construction Noise\CRR 2016 Roma Scenario 2 LA10.sgs



Customer:
Arup
Project: Cross River Rail 2016
Project-No. 620.11482

Map
3

CRR 2016 - Roma St Station - Scenario 3
Initial Station Shaft Excavation
Airborne Construction Noise Levels
Calculation 1.8 m above ground

Project engineer: SH
Created: 07-Oct-2016
Processed with SoundPLAN 7.4, Update 13-Mar-2015

Signs and symbols
Noise calculation area
Point source

Levels LA10,15min
in dB(A)

	<= 45
45 <	<= 50
50 <	<= 55
55 <	<= 60
60 <	<= 65
65 <	<= 70
70 <	<= 75
75 <	<= 80
80 <	<= 85
85 <	

Length scale 1:4000
0 25 50 100 150 200 m

SLR

C:\1 - Data\1 - SLR Projects\620.11482 CRR v2\620.11482 CRR 2016 Construction Noise\CRR 2016 Roma Scenario 3 LA10.sgs

E3 Construction – predicted ground-borne noise and vibration from mined tunnelling

Table E-9 Summary of mechanical tunnel excavation ground-borne vibration levels

Tunnel section	**Type of building**	**Min slant distance to tunnel crown (m)**		**Indicative maximum vibration Level (mm/s)**		**Possible impact** NF - Not felt TP - Threshold of perception BN - Barely noticeable N - Noticeable EN - Easily noticeable SN - Strongly noticeable VSN - Very strongly noticeable		**Mitigation options** P = pre notification BCS = building condition survey BSS = building sensitive study M = monitoring	
		CRR 2011	**CRR 2016**	**CRR 2011**	**CRR 2016**	**CRR 2011**	**CRR 2016**	**CRR 2011**	**CRR 2016**
Boggo Road Station to Woolloongabba Station **CRR 2011 TBM** **CRR 2016 Mined**	Residential Commercial Educational Heritage Hotel	10 – 92 26 – 123 82 – 110 56 – 95 48	9 – 119 24 – 145 81 – 134 109 – 143 81	0.1 to 1.4 0.1 to 0.5 0.11 to 0.14 0.1 to 0.2 0.3	0.1 to 0.5 0.1 to 0.13 0.1 0.1 to 0.2 0.1	EN BN TP TP BN	BN TP TP TP TP	P, BSS, M	P, BSS, M
Woolloongabba Station to Albert Street Station **TBM**	Residential Commercial Educational Worship Medical Hotel	34 – 200 26 – 167 35 – 233 36 – 190 200 24 – 153	24 – 198 27 – 323 35 – 234 22 – 189 197 28 – 140	0.1 to 0.4 0.1 to 0.5 0.1 to 0.4 0.1 to 0.3 0.1 0.1 to 1.0	0.1 to 0.5 0.1 to 0.8 0.1 to 0.6 0.1 to 0.6 0.1 0.1 to 0.8	BN BN BN BN TP N	BN N N N TP N	P, M	P, M
Albert Street Station to Roma Street Station **TBM**	Residential Commercial Educational Worship Heritage Medical Hotel	 12 – 177 50 – 153 49 – 80 28 – 65 27 – 96 18 – 141	28 – 208 13 – 182 49 50 – 80 31 – 66 30 – 100 18 – 127	 0.1 to 2.0 0.1 to 0.4 0.3 to 0.4 0.3 to 0.8 0.2 to 0.8 0.1 to 1.3	0.1 to 0.8 0.1 to 1.8 0.4 0.3 to 0.4 0.3 to 0.7 0.2 to 0.7 0.2 to 1.3	 EN BN BN N N EN	N EN BN BN N N EN	P, M	P, M

Tunnel section	**Type of building**	**Min slant distance to tunnel crown (m)**		**Indicative maximum vibration Level (mm/s)**		**Possible impact** NF - Not felt TP - Threshold of perception BN - Barely noticeable N - Noticeable EN - Easily noticeable SN - Strongly noticeable VSN - Very strongly noticeable		**Mitigation options** P = pre notification BCS = building condition survey BSS = building sensitive study M = monitoring	
		CRR 2011	**CRR 2016**	**CRR 2011**	**CRR 2016**	**CRR 2011**	**CRR 2016**	**CRR 2011**	**CRR 2016**
Roma Street Station to Northern portal **TBM**	Residential	33 – 120	34 – 133	0.1 to 0.4	0.1 to 0.4	BN	BN	P	P
	Commercial	45 – 281	33 – 158	0.1 to 0.3	0.1 to 0.4	BN	BN		
	Educational	38 – 135	41 – 259	0.1 to 0.3	0.1 to 0.5	BN	BN		
	Worship		85		0.1		TP		
	Heritage		37 - 158		0.1 to 0.3		BN		
	Medical	136		0.1		TP			
	Hotel	46 – 107	104 – 107	0.1 to 0.3	0.1	BN	TP		

Notes

1. Ground-borne vibration goals: Cosmetic damage of 5 mm/s (2 mm/s for Heritage listed sites), Residential (hotel) sleep disturbance of 0.5 mm/s.

Table E-10 Summary of mechanical tunnel excavation ground-borne noise level

Tunnel section	Type of building	Min slant distance to tunnel crown (m)		Indicative maximum ground-borne noise level (dBA)		Possible impact Very Low: <35 dBA Low: 35 – 40 dBA Moderate (Mod): 40 to 45 dBA High: > 45 dBA		Mitigation options P = pre notification M = monitoring R = temporary relocation	
		CRR 2011	**CRR 2016**	**CRR 2011**	**CRR 2016**	**CRR 2011**	**CRR 2016**	**CRR 2011**	**CRR 2016**
Boggo Road Station to Woolloongabba Station **CRR 2011 TBM** **CRR 2016 Mined**	Residential	10 – 92	9 – 119	27 to 57	16 to 50	Very Low to High	Very Low to High	P, M, R	P, M, R
	Commercial	26 – 123	24 – 145	28 to 44	13 to 37	Very Low to Mod	Very Low to Low		
	Educational	82 – 110	81 – 134	25 to 29	14 to 21	Very Low	Very Low		
	Hotel	48	81	36	21	Low	Very Low		
Woolloongabba Station to Albert Street Station **TBM**	Residential	34 – 200	24 – 198	17 to 40	17 to 45	Very Low to Low	Very Low to Mod	P, M, R	P, M, R
	Commercial	26 – 167	27 – 323	19 to 44	11 to 48	Very Low to Mod	Very Low to High		
	Educational	35 – 233	35 – 234	20 to 40	15 to 45	Very Low to Low	Very Low to Mod		
	Worship	36 – 190	22 – 189	18 to 39	18 to 46	Very Low to Low	Very Low to High		
	Medical	200	197	17	17	Very Low	Very Low		
	Hotel	24 – 153	28 – 140	21 to 50	22 to 48	Very Low to High	Very Low to High		
Albert Street Station to Roma Street Station **TBM**	Residential		28 – 208		22 to 48		Very Low to High	P, M, R	P, M, R
	Commercial	12 – 177	13 – 182	24 to 59	23 to 58	Very Low to High	Very Low to High		
	Educational	50 – 153	49	26 to 40	41	Very Low to Low	Mod		
	Worship	49 – 80	50 – 80	34 to 40	34 to 40	Very Low to Low	Very Low to Low		
	Heritage	28 – 65	31 – 66	37 to 48	37 to 47	Low to High	Low to High		
	Medical	27 – 96	30 – 100	32 to 49	31 to 47	Very Low to High	Very Low to High		
	Hotel	18 – 141	18 – 127	27 to 54	28 to 54	Very Low to High	Very Low to High		
Roma Street Station to Northern portal **TBM**	Residential	33 – 120	34 – 133	24 to 41	25 to 40	Very Low to Mod	Very Low to Low	P, M, R	P, M R
	Commercial	45 – 281	33 – 158	13 to 37	20 to 41	Very Low to Low	Very Low to Mod		
	Educational	38 – 135	41 – 259	22 to 39	14 to 43	Very Low to Low	Very Low to Mod		
	Worship		85		28		Very Low		

Tunnel section	Type of building	Min slant distance to tunnel crown (m)		Indicative maximum ground-borne noise level (dBA)		Possible impact Very Low: <35 dBA Low: 35 – 40 dBA Moderate (Mod): 40 to 45 dBA High: > 45 dBA		Mitigation options P = pre notification M = monitoring R = temporary relocation	
		CRR 2011	CRR 2016	CRR 2011	CRR 2016	CRR 2011	CRR 2016	CRR 2011	CRR 2016
	Medical	136		22		Very Low			
	Hotel	46 – 107	104 – 107	25 to 36	25 to 26	Very Low to Low	Very Low		

Notes

1. Ground-borne noise goals: Commercial 40 to 50dBA, Residential standard hours 40dBA and non-standard hours 35 dBA

E4 Construction – comparison of CRR 2011 and CRR 2016 peak daily truck movement

Table E-11 Comparison of peak hourly trip generation from each worksite

Construction worksite	Peak spoil movement (trucks/hour)	
	CRR 2011	CRR 2016
Southern portal	15	3
Boggo Road Station	9	6
Woolloongabba Station	14	11
Albert Street Station	8	5
Roma Street Station	10	6
Northern portal	8	5
O’Connell Terrace	4	4
Mayne Yard	9	8

E5 Operation – predicted airborne noise for the Northern and Southern portals

Table E-12 Operation – Predicted airborne noise for the Southern and Northern portal

Receptor	Existing mitigation				Designed mitigation				Change			
	Year 2026		Year 2036		Year 2026		Year 2036		Year 2026		Year 2036	
	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}
Southern Section												
35 Dutton Street	60	85	60	85	58	82	59	82	-2	-3	-1	-3
44 Dutton Street												
34 Railway Terrace	64	**92**	65	**92**	61	86	62	86	-3	-6	-3	-6
38 Railway Terrace	63	**91**	64	**91**	60	84	61	84	-3	-7	-3	-7
38A Railway Terrace	60	**89**	61	**89**	58	82	59	82	-2	-7	-2	-7
42 Railway Terrace	63	**91**	64	**91**	60	83	61	83	-3	-8	-3	-8
46 Railway Terrace	**66**	**92**	**67**	**92**	64	**90**	65	**90**	-2	-2	-2	-2
48 Railway Terrace	65	**90**	65	**90**	62	**88**	63	**88**	-3	-2	-2	-2
50 Railway Terrace	65	**91**	**66**	**91**	63	**90**	64	**90**	-2	-1	-2	-1
66 Railway Terrace	63	**91**	64	**91**	62	**90**	63	**90**	-1	-1	-1	-1

Receptor	Existing mitigation				Designed mitigation				Change			
	Year 2026		Year 2036		Year 2026		Year 2036		Year 2026		Year 2036	
	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}
68 Railway Terrace	64	**91**	65	**91**	64	**91**	65	**91**	0	0	0	0
44 Rawnsley Street	58	80	59	80	58	80	59	80	0	0	0	0
47 Rawnsley Street	62	85	63	85	61	85	62	85	-1	0	-1	0
48 Rawnsley Street	58	83	59	83	58	83	59	83	0	0	0	0
49 Rawnsley Street	65	**90**	**66**	**90**	63	**90**	64	**90**	-2	0	-2	0
52 Rawnsley Street	59	85	60	85	59	85	60	85	0	0	0	0
56 Rawnsley Street	62	**88**	63	**88**	62	**88**	62	**88**	0	0	-1	0
2 Rusk Street	61	81	62	81	61	81	62	81	0	0	0	0
4 Rusk Street	61	81	62	81	61	81	62	81	0	0	0	0
6 Rusk Street	61	80	62	80	61	80	62	80	0	0	0	0
8 Rusk Street	61	80	61	80	61	80	61	80	0	0	0	0
10 Rusk Street	60	80	61	80	60	80	61	80	0	0	0	0
Leukaemia Building	**69**	**91**	**70**	**91**	**69**	**91**	**70**	**91**	0	0	0	0
PA Hospital Childcare	61	80	62	80	61	80	62	80	0	0	0	0
Northern Section – Note all predicted noise levels for the Northern portal achieve the Planning Levels and there is no requirement for the design of rail noise mitigation in this section of CRR 2016												

Receptor	Existing mitigation				Designed mitigation				Change			
	Year 2026		Year 2036		Year 2026		Year 2036		Year 2026		Year 2036	
	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}
1 Brunswick Street	52	74	53	74								
111 Gregory Terrace	53	74	54	74								
115 Gregory Terrace	53	75	54	75								
117-119 Gregory Terrace	54	77	55	77								
129 Gregory Terrace	54	77	55	77								
133 Gregory Terrace	55	76	56	76								
159 Gregory Terrace	56	76	57	76								
173 Gregory Terrace	56	76	57	76								
183 Gregory Terrace	56	76	57	76								
189 Gregory Terrace	55	74	56	74								
195 Gregory Terrace	56	74	57	74								
207 Gregory Terrace	56	74	57	74								

Receptor	Existing mitigation				Designed mitigation				Change			
	Year 2026		Year 2036		Year 2026		Year 2036		Year 2026		Year 2036	
	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}
209 Gregory Terrace	56	74	57	74								
211 Gregory Terrace	56	74	57	74								
217 Gregory Terrace	56	74	57	74								
221 Gregory Terrace	56	74	57	74								
227 Gregory Terrace	56	74	57	74								
235 Gregory Terrace	56	74	57	74								
251 Gregory Terrace	57	75	58	75								
255 Gregory Terrace	56	73	57	73								
257 Gregory Terrace	56	73	57	73								
259 Gregory Terrace	58	75	59	75								
263 Gregory Terrace	57	75	58	75								
285 Gregory Terrace - St Joseph's College A	58	75	59	75								

Receptor	Existing mitigation				Designed mitigation				Change			
	Year 2026		Year 2036		Year 2026		Year 2036		Year 2026		Year 2036	
	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}
285 Gregory Terrace - St Joseph's College B	57	74	58	74								
285 Gregory Terrace - St Joseph's College C	58	75	59	75								
285 Gregory Terrace - St Joseph's College D	51	72	53	72								
331 Gregory Terrace	57	75	58	75								
333 Gregory Terrace	55	73	56	73								
339 Gregory Terrace	52	72	53	72								
369 Gregory Terrace	54	72	55	72								
383 Gregory Terrace	51	71	52	71								
391 Gregory Terrace	55	73	56	73								
397 Gregory Terrace - Motel	55	72	56	72								

Receptor	**Existing mitigation**				**Designed mitigation**				**Change**			
	Year 2026		**Year 2036**		**Year 2026**		**Year 2036**		**Year 2026**		**Year 2036**	
	$LA_{eq(24hour)}$	**LA_{max}**	**$LA_{eq(24hour)}$**	**LA_{max}**	**$LA_{eq(24hour)}$**	**LA_{max}**	**$LA_{eq(24hour)}$**	**LA_{max}**	**$LA_{eq(24hour)}$**	**LA_{max}**	**$LA_{eq(24hour)}$**	**LA_{max}**
417 Gregory Terrace	55	72	56	72								
429 Gregory Terrace	56	73	57	73								
441 Gregory Terrace	56	73	57	73								
445 Gregory Terrace	56	73	57	73								
449 Gregory Terrace	55	75	56	75								
451 Gregory Terrace A	56	76	57	76								
451 Gregory Terrace B	55	75	56	75								
453 Gregory Terrace	51	74	52	74								
184 Kennigo Street	47	66	48	66								
9 Reading Street	56	74	57	74								
56 Torrington Street	55	76	57	76								
BGGS - Building A	59	84	60	84								

Receptor	Existing mitigation				Designed mitigation				Change			
	Year 2026		Year 2036		Year 2026		Year 2036		Year 2026		Year 2036	
	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}	$LA_{eq(24hour)}$	LA_{max}
BGGS - Building E2 (Science)	56	77	57	77								
BGGS - Building G	55	78	56	78								
BGGS - Building MC (Sports Centre)	60	86	62	86								

Notes

1. Numbers in **bold** indicate an exceedance of the relevant planning level.

E6 Operation – predicted ground-borne noise and vibration levels with compliance trackform

Table E-13 Summary of predicted operational ground-borne noise levels (with compliance trackform)

Rail selection chainage (km)	Type of building	Ground-borne noise goal (dBA)	Min slant distance to track level (m)		Predicted ground-borne noise Level (dBA)		Mitigation measures
			CRR 2011	CRR 2016	CRR 2011	CRR 2016	
Boggo Road Station to Woolloongabba Station CRR 2011: 3.95 – 5.1 CRR 2016: 1.3 – 2.8	Residential	35 (night-time)	15 – 94	14 – 120	<10 to 34	<10 to 34	**CRR 2011:** Resilient Rail Fasteners Chainage 4.15 – 4.35km Highly Resilient Rail Fasteners **CRR 2016:** Resilient Rail Fasteners Chainage 1.77 – 2.2km Highly Resilient Rail Fasteners
	Commercial	40	22 – 89	29 – 147	<10 to 29	<10 to 28	
	Educational	40	76 – 111	82 – 135	<10	<10	
	Worship	40	60 – 97	111 – 145	<10 to 15	<10	
	Medical	40		87		13	
	Hotel	35 (night-time)	43	83	20	<10	
Woolloongabba Station to Albert Street Station CRR 2011: 5.1 – 6.85 CRR 2016: 2.8 – 4.65	Residential	35 (night-time)	39 – 202	27 – 199	<10 to 26	<10 to 27	**CRR 2011**: Resilient Rail Fasteners Rail section under the Brisbane River with Direct Fixation Rail Fasteners Chainage 5.95 – 6.55km **CRR 2016**: Resilient Rail Fasteners Rail section under the Brisbane River with Direct Fixation Rail Fasteners Chainage 3.65 – 4.2km
	Commercial	40	26 – 168	32 – 324	<10 to 25	<10 to 27	
	Educational	40	37 – 234	37 – 235	<10 to 23	<10 to 23	
	Worship	40	42 – 192	26 – 309	<10	<10 to 25	
	Medical	40	201	199	<10	<10	
	Hotel	35 (night-time)	19 – 146	33 – 142	<10 to 27	<10 to 27	
Albert Street Station to Roma Street Station CRR 2011: 6.85 – 7.9 CRR 2016: 4.65 – 5.75	Residential	35 (night-time)	N/A	32 – 209	N/A	<10 to 27	**CRR 2011**: Resilient Rail Fasteners **CRR 2016**: Resilient Rail Fasteners Chainage 5.52 – 5.61km
	Commercial	40	17 – 91	19 – 208	<10 to 36	<10 to 35	
	Educational	40	52 – 58	52 – 139	13 to 23	<10 to 18	
	Worship	40	52 – 82	54 – 82	16 to 30	13 to 21	
	Heritage	40	33 – 67	36 – 69	21 to 34	18 to 29	
	Medical	40	32 – 98	36 – 102	13 to 35	<10 to 27	

Rail selection chainage (km)	Type of building	Ground-borne noise goal (dBA)	Min slant distance to track level (m)		Predicted ground-borne noise Level (dBA)		Mitigation measures
			CRR 2011	CRR 2016	CRR 2011	CRR 2016	
	Hotel	35 (night-time)	23 – 82	23 – 128	<10 to 33	<10 to 31	
Roma Street Station to Northern portal CRR 2011: 7.9 – 9.55 CRR 2016: 5.75 – 7.1	Residential Commercial Educational Worship Medical Hotel	35 (night-time) 40 40 40 40 35 (night-time)	38 – 121 50 – 113 43 – 122 138 51 – 108	39 – 146 38 – 160 44 – 259 88 105 – 109	<10 to 25 <10 to 21 <10 to 24 <10 <10 to 20	<10 to 34 <10 to 34 <10 to 301 11 <10	**CRR 2011**: Resilient Rail Fasteners Direct Fixation Rail Fasteners from Chainage 9.05km **CRR 2016**: Resilient Rail Fasteners Direct Fixation Rail Fasteners from Chainage 5.9km

Notes

1. 36 dBA at BGGS Centre, not as sensitive as normal educational

Extent of Project compliance trackform is detailed in Section 12.3.5. Also the LA_{max},slow noise level refers to the 95th percentile train pass by event.

Table E-14 Summary of predicted operational ground-borne vibration levels (with compliance trackform)

Rail section chainage (km)	Type of building	Residential night-time vibration goal (mm/s)[1,2]	Min. slant distance to track level (m)		Predicted ground-borne vibration level (mm/s)1		Mitigation measure
			CRR 2011	CRR 2016	CRR 2011	CRR 2016	
Boggo Road Station to Woolloongabba Station CRR 2011: 3.95 – 5.1 CRR 2016: 1.3 – 2.8	Residential Commercial Educational Worship Medical Hotel	0.2	15 – 94 22 – 89 76 – 111 60 – 97 43	14 – 120 29 – 147 82 – 135 111 – 145 87 83	0.002 to 0.032 0.003 to 0.031 0.003 to 0.005 0.005 to 0.010 0.014	0.002 to 0.043 0.001 to 0.024 0.002 to 0.003 0.002 to 0.003 0.008 0.004	**CRR 2011:** Resilient Rail Fasteners Chainage 4.15 – 4.35km Highly Resilient Rail Fasteners **CRR 2016:** Resilient Rail Fasteners Chainage 1.77 – 2.21km Highly Resilient Rail Fasteners
Woolloongabba Station to Albert Street Station CRR 2011: 5.1 – 6.85 CRR 2016: 2.8 – 4.65	Residential Commercial Educational Worship Medical Hotel	0.2	39 – 202 26 – 168 37 – 234 42 – 192 201 19 – 146	27 – 199 32 – 324 37 – 235 26 – 309 199 33 – 142	0.001 to 0.025 0.002 to 0.023 0.002 to 0.016 0.001 to 0.008 0.002 0.001 to 0.023	0.001 to 0.027 0.001 to 0.028 0.001 to 0.018 0.002 to 0.005 0.001 0.001 to 0.026	**CRR 2011**: Resilient Rail Fasteners Rail section under the Brisbane River with Direct Fixation Rail Fasteners Chainage 5.95 – 6.55km **CRR 2016**: Resilient Rail Fasteners Rail section under the Brisbane River with Direct Fixation Rail Fasteners Chainage 3.65 – 4.2km
Albert Street Station to Roma Street Station CRR 2011: 6.85 – 7.9 CRR 2016: 4.65 – 5.75	Residential Commercial Educational Worship Heritage Medical Hotel	0.2	N/A 17 – 91 52 – 58 52 – 82 33 – 67 32 – 98 23 – 82	32 – 209 19 – 208 52 – 139 54 – 82 36 – 69 36 – 102 23 – 128	N/A 0.004 to 0.059 0.009 to 0.025 0.015 to 0.029 0.023 to 0.056 0.012 to 0.058 0.006 to 0.044	0.001 to 0.034 0.001 to 0.048 0.001 to 0.015 0.011 to 0.019 0.016 to 0.036 0.006 to 0.027 0.004 to 0.040	**CRR 2011:** Resilient Rail Fasteners **CRR 2016:** Resilient Rail Fasteners Chainage 5.52 – 5.61km Highly Resilient Rail Fasteners
Roma Street Station to Northern portal CRR 2011: 7.9 – 9.55 CRR 2016: 5.75 – 7.1	Residential Commercial Educational Worship	0.2	38 – 121 50 – 113 43 – 122	39 – 146 38 – 160 44 – 259 88	0.002 to 0.023 0.003 to 0.018 0.003 to 0.021	0.002 to 0.017 0.001 to 0.017 0.001 to 0.027 0.005	**CRR 2011**: Resilient Rail Fasteners Direct Fixation Rail Fasteners from Chainage 9.05km **CRR 2016:** Resilient Rail Fasteners

	Medical Hotel		138 51 – 108	105 – 109	0.003 0.005 to 0.017	0.003 to 0.004	Direct Fixation Rail Fasteners from Chainage 5.9km

Notes

1. The predicted vibration levels and vibration goal are based on the maximum 1 second rms vibration level, not to be exceeded by more than 5% of train passbys
2 The residential night-time vibration goal is the most stringent operational vibration goal.

13 Technical Report: Waste management

13.1 Introduction

This technical report discusses elements of the CRR 2016 design that have resulted in changes to waste that will be generated including spoil material, demolition, construction and operational waste and the waste management measures. Changes are generally a result of the shorter tunnel, which reduces the volume of spoil produced as well as changes the construction and demolition waste disposal management.

The design for CRR 2016 will adopt the same waste management hierarchy as CRR 2011, which includes (in order of priority):

- To avoid and reduce;
- Re-use;
- Recycle;
- Recover energy; and
- Treat and dispose of waste.

For Queensland, the overarching waste strategy is set by the Queensland Governments *Waste-Everyone's Responsibility Queensland Waste Avoidance and Resource Productivity Strategy (2014-2024)*. Published in 2014, this recent strategy sets a recovery rate of 80% for construction and demolition waste and 55% for commercial and industrial waste by 2024, with an overall reduction of 15% of waste going to landfill based on 2014 figures.

Additional information relevant to waste is also discussed under Technical report 1 (Transport), Technical report 3 (Topography, geology, geomorphology and soils), Technical report 4 (Land contamination), Technical report 8 (Groundwater) and Technical report 9 (Surface water).

13.2 Changes to waste generation

13.2.1 Waste generating activities

Consistent with CRR 2011, there will be four main activities that will generate waste material during construction of CRR 2016. These include:

- Spoil material from tunnel and dive excavation;
- Demolition and construction waste associated with the construction of tunnels and stations;
- General solid waste generated by site staff, visitors and other personnel; and
- Liquid waste from the treatment of groundwater and wash-down activities.

Waste will also be generated throughout the operational phase, but to a lesser extent than the construction phase.

13.2.2 Spoil Material

The quantities of spoil material produced in comparison to CRR 2011 are illustrated in Table 13.1.

Table 13.1 Estimated spoil quantity comparison

Location	CRR 2011 spoil quantity (volume m^3)	CRR 2016 Spoil quantity (volume m^3)[52]
Southern portal	Yeerongpilly 375,000 + Ventilation shaft/building 11,500	Near Dutton Park Station – 39,000
Boggo Road Station	155,000	119,000
Woolloongabba Station	437,000	470,000
Albert Street Station	190,000	135,000
Roma Street Station	161,000	112,000
Northern portal	96,000	65,000 (dive + C&C)
Mayne Yard	-	36,000
TOTAL	**1,400,000**	**976,000**

There will be notably less total spoil produced (approximately 30% less) due to the shorter length of tunnel and revised station designs for CRR 2016 compared to CRR 2011. The main spoil removal location for CRR 2016 will be at Woolloongabba. TBMs will be launched from Woolloongabba and head northwards and material will also be extracted from here for the mined tunnel between Woolloongabba Station and Boggo Road Station.

Concentrating the majority of the tunnel works at the Woolloongabba site will create materials handling and logistical support efficiencies. The changes to spoil handling movements and material deliveries at Woolloongabba are expected to result in some temporary traffic movement changes. Further assessment regarding traffic impacts is contained in Technical report 1 (Transport).

With the exception of the tunnel portal dive structures and the upper portions of the cut and cover station structures, CRR 2016 is anticipated to be constructed predominantly in rock. Subject to offsite handling and processing, a proportion of the spoil material could potentially be reused as aggregate and/or other construction material.

Residual spoil material will be transported to spoil placement sites. Five potential sites have been identified for CRR 2016:

- *Brisbane Airport* - landside development site identified in the Brisbane Airport Masterplan for general industry uses;
- *Swanbank, Swanbank Road* - an area of long-term land reclamation of exhausted open cut coal mines;
- *Pine Mountain, Pine Mountain Road* - former quarry intended to be rehabilitated;
- *Larapinta, Paradise Road* - sites previously used for sand extraction from the floodplain for Oxley Creek which feeds into the Brisbane River. The sand pits are currently open and if used, could be rehabilitated; and
- *Port of Brisbane, Port Drive* - site identified for future expansion and currently subject to ongoing reclamation works under an approved management plan.

[52] The same assumptions identified in the CRR 2011 EIS have been adopted here with reference to a 1.5 bulk factor.

These sites have been selected based on general availability, size of the land, environmental values, haul route length and proximity to sensitive receptors. In comparison, CRR 2011 identified Swanbank as a single preferred spoil placement site. Although these five sites are now proposed for CRR 2016, not all sites will be used for spoil placement, with contingency provided to cater for commercial or environmental drivers at the relevant time. Following detailed design, the contractor will have firmer details as to the quantity of spoil, its rate of excavation or production, and how it will be placed at any of the nominated spoil placement sites.

The approval to use spoil sites, including any Commonwealth approvals for placement of spoil, will not be sought as part of the current State environmental assessment. If required, approvals would be sought by the relevant entity prior to placement.

Contaminated or unsuitable spoil material which cannot be used for spoil placement will be disposed to an appropriate licenced landfill, which may be different to the sites identified above.

13.2.3 Demolition and construction waste

The key changes for waste generated during construction and demolition relate to the changed worksite locations for CRR 2016. Key demolition activities are summarised in Table 13.2.

Table 13.2 Demolition activities

Location (CRR 2016)	Description
Southern portal	Demolition and relocation of rail corridor infrastructure. Demolition of existing buildings on QR land (adjacent Kent Street).
Boggo Road Station	Demolition of existing QR building on north-east side of the existing Park Road Rail Station.
Woolloongabba Station	Demolition of GoPrint building (867 Main Street), Landcentre (849 Main Street) and Dental Clinic (873 Main Street).
Albert Street Station	Demolition of properties located north of the intersection with Mary Street on either side of Albert Street. These include commercial buildings at 83 - 109 Albert Street (north side of Albert Street) and 100 - 104 Mary Street (south side of Albert Street).
Roma Street Station	Demolition of the BTC (West Tower) and coach ramps.
Northern portal	Demolition and relocation of rail corridor infrastructure. Demolition of some existing buildings on QR land between Victoria Park and Bowen Bridge Road.
Exhibition Station	Demolition/removal of buildings at 11 O'Connell Terrace as a construction laydown area. Demolition of some showgrounds amenities and associated small buildings currently situated in and adjacent to the rail corridor.
Mayne Yard	Demolition of existing buildings on QR land.

The quantity and type of waste will depend on the construction methodology, location, land uses and design features. Hazardous material, such as asbestos and contaminants may be encountered during demolition and construction phases. This is further discussed in Technical report 4 (Land contamination) and Technical report 18 (Hazard and risk).

Waste streams generated from demolition and construction activities will be consistent with those already identified from CRR 2011, such as the following:

- Inert waste – top soil, green waste, rock, uncontaminated soils, concrete, bricks, timber (untreated), metals, plaster board, electrical and plumbing fittings, furnishings, bitumen, road base aggregates, scrap metal and steel, timber framework (untreated), plasterboard, geotextiles, cable, pipework offcuts, conduit;

- General solid waste – timber (treated), carpets, food waste, packaging material, timber framework(treated), medical and first aid, office waste, silt and sediment;
- Regulated waste – contaminated soil, asbestos sheeting, hazardous waste, potentially contaminated soil, tyres, batteries, cleaning agents, fuels, lubricants, waste oil, waterborne sludge or residue, absorbent material and spent spill kit material; and
- Liquid waste – treated water from groundwater and equipment wash down.

Following recent changes relating to waste management principles[53], a number of the above waste streams are now classified as priority wastes, including:

- Green waste;
- Food waste;
- Treated timbers;
- Plasterboard;
- Concrete; and
- Used tyres and used oils.

These waste streams will be subject to individual waste strategies in order to promote more beneficial re-use opportunities.

Estimated quantities of construction and demolition waste generated during construction, such as concrete, steel, formwork, hazardous excavation, paints, chemicals, soils, lubricants, fire retardants, cabling, packaging, waste water, sludge and tyres vary from location to location, however the overall magnitude will be similar (and no greater) than CRR 2011 estimates.

The Draft Outline EMP for the Project includes a Waste and Resource Recovery Management Plan (WRRMP). This plan will detail and quantify the sources and types of waste during demolition and construction and will establish the recovery rates for each waste type. It is envisaged that there will be limited opportunity for material storage and reuse onsite and therefore, consistent with CRR 2011, it is expected that a majority of waste material will be removed offsite for recovery or disposal. The WRRMP will detail individual strategies for the handling and treatment of priority waste streams.

General Solid Waste:

Estimates of general and recycled waste material generated during construction and removed from site will also be consistent with CRR 2011 with respect to general waste (food scraps, non-recyclable) at 690kg/week, paper and cardboard waste (office staff) at 160kg/week and other recyclable wastes (office and construction staff) at 345kg/week on the assumption that staffing numbers will be similar.

13.2.4 Operational waste

Operational waste volumes will be substantially less than construction waste and dependent on operation frequencies of trains and maintenance regimes. Operational waste is not anticipated to be greater than that of CRR 2011. Waste types will generally be consistent with those already mentioned, including:

[53] Queensland Waste Strategy (2014)

- Liquid waste – groundwater inflow, pavement and tunnel wash down water, and surface water runoff;
- Regulated waste – tunnel wastewater, sludge/residue, waste paints, solvents, tyres, batteries, waste oils, fuels, chemical containers, electrical insulation;
- General solid waste – electrical cable, conduit offcuts, general waste, packaging material, glass, aluminium cans, plastic bottles, paper/cardboard, office waste, silt and sediment; and
- Green waste – vegetation, trimmings.

13.3 Changes to potential impacts

The potential impacts for CRR 2016 are consistent with those already identified for CRR 2011 including:

- Dust resulting from the inappropriate storage, handling and disposal of excavated material;
- Soil and water including surface water and groundwater, due to contamination from material spills during handling and haulage;
- Soil and water overflows from sediment control structures and sediment ponds during extreme rainfall events;
- Soil and water including surface water and groundwater, due to contamination from inappropriate storage, handling and disposal of solid and liquid waste and materials separated for recycling, reuse or recovery;
- An increase in the incidence of vermin, insects and pests resulting from the inappropriate storage and handling of putrescible waste; and
- An impact on social amenity during construction as a result of poor housekeeping in construction areas.

13.4 Changes to mitigation measures

Mitigation measures which are consistent with CRR 2011 include the following:

- Implementing measures to avoid, reuse, recycle, recover, treat and dispose of waste through completion of a project WRRMP;
- Sourcing material from sustainable resources, where possible and implementing alternative technology and procurement processes;
- Adequately designing of waste disposal areas for public and commercial areas;
- Managing surface water runoff and silt from erosion and sediment control devices;
- Adequate handling of sulphur hexafluoride (from high-voltage switchgear and control gear);
- Appropriate handling and disposal of asbestos material during the demolition stage and implementing measures for the management of asbestos;
- Further testing and management of potential contaminants at the GoPrint site, rail corridor and Roma Street Station; and
- Management of acid sulfate soils through avoidance, minimisation of disturbance, neutralisation and hydraulic separation (as appropriate), subject to further investigation.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011 are limited to:

- Management of asbestos for dwellings at Yeerongpilly and Royal on the Park;
- Management of contaminated soils south of Dutton Park Station and Royal on the Park; and
- Marketability of the potential recyclable items generated during the construction of the Project given changed policies and approval processes since 2011.

Additional mitigation measures now relevant to CRR 2016 as a result of legislative changes include:

- Management of hazardous material and dangerous goods through use of a Hazardous Goods Management Plan;
- Water will be captured by a drainage system at each of the stations and portals, and either transferred to a local treatment plant, treated and discharged to an approved point or discharged straight to sewer dependent upon QUU approval;
- Implementing measures in accordance with the requirements of the Energy Networks Association (ENA) Industry Guideline; and
- The recovery targets established in the *Queensland Government 2014 Waste Strategy – Waste-Everyone's Responsibility* will be set out in the WRRMP.

13.5 Conclusion

The changes to the design result in a considerable reduction in the total spoil generated and as a result waste impacts.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project. This includes a WRRMP that will establish measures to meet the recovery targets set in the *Queensland Government 2014 Waste Strategy – Waste-Everyone's Responsibility*. The WRRMP will establish individual strategies for the management of priority waste streams as identified by the Queensland Government. In addition, for the CRR 2016, 'just-in-time' delivery will be used so far as is reasonably practicable to minimise material wastage.

14 Technical Report: Indigenous cultural heritage

14.1 Introduction

This technical report discuss changes to impacts associated with CRR 2016 in relation to Indigenous cultural heritage.

A search of the Department of Aboriginal and Torres Strait Islander Partnerships (DATSIP) Aboriginal cultural heritage Database and Register was carried out for the CRR 2016 alignment and surrounding area in June 2016. While this is not definitive as to the existence of Indigenous cultural heritage in the study corridor, it is noted that the search revealed that no new Indigenous Cultural Heritage sites or places have been recorded on the register since CRR 2011.

14.2 Changes to potential impacts

The potential impacts due to the activities associated with CRR 2016 in relation to Indigenous cultural heritage are reduced given that the Project will not directly impact Victoria Park or York's Hollow, with the exception of a temporary realignment of a bikeway in Victoria Park during the construction phase of the project.

Victoria Park and York's Hollow (Heritage Register No: LB:N62 and LB:N69) are of significance to the Aboriginal people of the Brisbane region with York's Hollow being noted in CRR 2011 EIS as being '*the most important Aboriginal cultural heritage site known within the study area*[54]'. Given the importance of this site, it is likely to be viewed positively by the Aboriginal community that this place will not be directly impacted by CRR 2016.

The cultural heritage parties for the area, represented by Jagera Daran Pty Ltd. and Turrbal Association Inc. will be consulted with on these changes, in particular the potential impact of the activities associated with the temporary realignment of the bikeway during the construction phase.

14.2.1 Corridor-wide considerations

There are a number of cultural heritage issues to consider in the delivery of CRR 2016 which will need to comply with the *Aboriginal Cultural Heritage 2003* (ACH Act). These considerations relate to cultural heritage management procedures as well as the legislative requirements of the ACH Act.

In compliance with the cultural heritage duty of care prescribed by the *ACH Act* all reasonable and practicable measures will be taken to avoid harm to Indigenous cultural heritage. Penalties may apply to any failure to comply with this duty as well as to any commission of the offences of unlawfully harming, excavating, relocating, taking away or possessing Aboriginal cultural heritage. The provisions of the *ACH Act* prescribing these offences are known as the "*cultural heritage protection provisions*".

All reasonable and practicable measures will be taken to avoid harm to Indigenous cultural heritage.

All work will also comply with the principles of the Burra Charter including Article 2.4 which states that 'places of cultural significance should be safeguarded and not put at risk or left in a vulnerable state' (Australian ICOMOS 2013). These requirements are unchanged from CRR 2011.

During CRR 2011, the Yugara/Yugarapul People and Turrbal People (QCD2015/001) Native Title claim covered a great deal of the study corridor. Since then this case has been heard in the Federal

[54] Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement, Chapter 18.

Court (QUD586/2011 16/03/2015) where it was found that Native Title does not exist within the claim area (the Determination).

While the Determination remains in effect, there will be no possibility for new Native Title Claims to be brought or registered in relation to the study corridor. Nevertheless, it is advised that the native title register be checked for new registrations prior to commencement of the project. Two parties, Jagera Daran Pty Ltd and the Turrbal Association Inc. have been identified by DATSIP as representing the parties in relation to CRR 2016. Both Jagera Daran Pty Ltd and Turrbal Association Inc. will be contacted to inform them of the project and to seek their advice in relation to the management of Indigenous cultural heritage within the study corridor. On-going contact will be maintained with the cultural heritage parties throughout the duration of the Project.

14.2.2 Cultural heritage management plan

A Cultural Heritage Management Plan (CHMP) is mandatory under Part 7 of the *ACH Act* whenever an EIS is required. A formal CHMP under Part 7 of the *ACH Act* establishes a statutory process for addressing cultural heritage with certainty. A CHMP is a State-approved agreement between the land user and the Aboriginal party(ies) of the area about how project activities may be managed to avoid harm to Indigenous cultural heritage or to minimise harm where avoidance is not reasonably practicable.

The CHMP process involves a statutory one-month notification period in which the land user notifies the State, affected landowners and occupiers and the Aboriginal party(ies) for the area of their intention to develop a CHMP, which is followed by a maximum 84 day negotiation and consultation period with those Aboriginal parties who respond to the notice and are endorsed by the land user to participate in the negotiations.

As a land user will have a defence against prosecution for a contravention of any of the cultural heritage protection provisions where its activities are carried out under an approved CHMP, a CHMP will provide certainty in relation to compliance with the Act. As an added benefit, a CHMP will ensure that the process is completed in a timely and cost effective manner.

A CHMP will be negotiated between the cultural heritage parties for the area and the CRR Proponent. This approach is consistent with CRR 2011.

14.3 Changes to mitigation measures

Mitigation measures will need to be reviewed and agreed through the CHMP by the cultural heritage parties for CRR 2016. Mitigation measures which are consistent with CRR 2011.

14.3.1 Corridor-wide considerations

Cultural heritage awareness training will be undertaken by all personnel prior to the commencement of any on-site construction activities. Cultural heritage awareness training will be conducted by a representative of the cultural heritage parties and/or an appropriately qualified consultant.

14.3.2 Jagera

During CRR 2011, Jagera Daran Pty Ltd were commissioned to undertake a cultural heritage report within the study corridor. Jagera Daran Pty Ltd forwarded several recommendations based on their report including:

- Development of specific construction-related monitoring activities for the Project (including test pits) to facilitate the safe removal of any Indigenous cultural heritage finds;

- Consideration of opportunities for Aboriginal people to be involved in the construction and development of the Project, including opportunities for traineeships and employment on the Project;
- The use of interpretive signage at key places within the new rail corridor, acknowledging the history and culture of Aboriginal people within Brisbane;
- Consideration of the planting of native vegetation, including food plants, as part of the revegetation strategy for the Project;
- Inclusion of art work painted by Aboriginal Parties in the public art for the Project; and
- Maintenance of gardens and lawns around the stations to sustain native vegetation.

In addition, Jagera Daran requested the consideration of the following items in the detailed design process:

- Consideration of the use of properties acquired for the Project to provide services and affordable housing for Aboriginal people; and
- Consideration of the return of remnant land acquired for the Project to Aboriginal Parties.

These recommendations will be reviewed as part of the CHMP consultation and negotiation process.

14.3.3 Turrbal

During CRR 2011, Turrbal Association Inc. were commissioned to undertake a cultural heritage report within the Project area. The Turrbal Association Inc. forwarded several recommendations based on their report including:

- Discussions and negotiations with Turrbal representatives regarding native title matters, cultural heritage and land use strategy, prior to commencement of construction of the Project;
- All Project related activities that may potentially impact on waterways be monitored by Turrbal personnel;
- All ground-breaking activities related to the Project that may potentially impact on Turrbal cultural heritage values be monitored by Turrbal personnel;
- The removal or clearing of vegetation for the Project within the native title claim area be monitored by Turrbal personnel upon commencement of work;
- Activities (including ground disturbance) that may potentially impact on any natural features of the landscape be monitored by Turrbal personnel; and
- Turrbal representatives to develop and deliver cultural awareness training to the Project's Proponent prior to construction, at the cost of the Project.

These recommendations will be reviewed by as part of the CHMP consultation and negotiation process.

14.4 Conclusion

The potential impacts on Indigenous cultural heritage associated with CRR 2016 are generally reduced given the changed alignment no longer directly impacts Victoria Park and York's Hollow. These are two registered heritage places that are known to be of significance to the Aboriginal people of the Brisbane region. Given the importance of these sites, this change is likely to be viewed in a positive light by the Aboriginal and broader community.

The cultural heritage parties will be contacted to inform them of the modified project and to seek their advice in relation to the management of Indigenous cultural heritage within the Project area.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

15 Technical Report: Non-Indigenous cultural heritage

15.1 Introduction

This technical report addresses non-Indigenous heritage by comparing CRR 2011 and CRR 2016, focusing on changes that result in either better heritage outcomes or raise previously unidentified potential adverse heritage impacts.

The technical report is informed by searches of the following:

- The National Heritage List and Commonwealth Heritage List (places of National and Commonwealth significance);
- Queensland Heritage Register (places of State significance);
- BCC Heritage Register (places of Local significance); and
- QR heritage places.

No fieldwork was undertaken, but a synthesis of previous studies[55] was completed.

The CRR 2016 project is generally similar in alignment to CRR 2011 with modifications to station locations, tunnel length and depth. In some cases, these modifications result in the elimination of adverse heritage impacts identified for CRR 2011, or an improvement of others. There are also a number of previously unidentified potential adverse heritage impacts that arise as a result of the new alignment. However, overall the CRR 2016 alignment will result in improved heritage outcomes relative to CRR 2011, particularly with the elimination of impacts to the Queensland heritage listed Victoria Park.

A preliminary analysis has been undertaken for CRR 2016 to assess potential building damage in relation to settlement at locations including north of Boggo Road Station and north of Roma Street Station (near the Victoria Barracks). As detailed in Appendix B1 and B2, this concluded that there was a 'negligible' damage potential at the Victoria Barracks. In relation to potential damage to heritage buildings from vibration, this is generally consistent with CRR 2011, with a reduced potential between Boggo Road Station and Woolloongabba Station and an increased potential between Woolloongabba Station to Albert Street Station and around Albert Street Station. Further details are summarised below and provided in Technical report 3 (Topography, geology, geomorphology and soils) and Technical report 12 (Noise and vibration).

A number of historic shipwrecks are reported to be in the Brisbane River that are included on the Australian National Shipwreck Database. The Project would pass deep beneath the Brisbane River and would not impact on these shipwrecks. Consequently, they are not considered further in this assessment.

15.2 Changes to potential impacts

Potential adverse heritage impacts may be due to one or both of the following:

[55] Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement. Chapter 19 (report prepared by SKM-Aurecon, July 2011). 'Proposed Cross River Rail Project - Cultural Heritage Report' (Parts A and B) (report prepared by UQ Culture & Heritage Unit for SKM-Aurecon, November 2010); Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement (Chapter 12).

- A potential impact on the visual setting of a known heritage place due to the introduction of unsympathetic built form in its proximity on completion of construction and during operation; and/or
- A potential adverse impact on the physical fabric of a known heritage place as a result of vibration and/or settlement caused by the construction works.

15.2.1 Southern portal (excluding Boggo Road Station)

For CRR 2016, the Southern portal will now be located north of Dutton Park Station within the existing rail corridor. A list of heritage places relevant to the Southern portal is shown in Table 15.1 and illustrated in Figure 15.1.

The changes to potential heritage impacts in relation to the CRR 2016 Southern portal include the following:

- On the approach to the Southern portal, the CRR 2016 alignment follows the existing surface tracks within the rail corridor. In this new location for the portal structure and surface works, the potential for impacts (i.e. visual impacts on heritage places in the vicinity) is low given the existing and historic rail uses of this area;
- The elimination of the tunnelling works proposed by CRR 2011 adjacent to the State heritage listed Boggo Road Gaol reduces the potential for adverse impacts to nearby heritage buildings and places as a result of vibration and/ or settlement; and
- The CRR 2011 alignment passed beneath the south-east corner of the South Brisbane Cemetery. CRR 2016 does not include works in this location and this is a beneficial heritage outcome.

Overall, CRR 2016 eliminates a number of potential adverse heritage impacts identified for CRR 2011 and will provide better overall heritage outcomes in this section.

Table 15.1 Heritage places at the Southern portal (excluding Boggo Road Station)

Name of heritage place	Heritage register (or other)
Boggo Road Gaol	State
South Brisbane Cemetery	State
Dutton Park parklands	Local
Dutton Park Station platform shelter	QR heritage place

15.2.2 Boggo Road Station

CRR 2011 proposed that Boggo Road Station would be situated underground between the Boggo Road Gaol and the Ecosciences Building. The CRR 2016 Boggo Road Station will also be an underground station but located between the rail corridor and the Ecosciences Building.

The State heritage listed Boggo Road Gaol (refer Figure 15.1) is the heritage place relevant to the Boggo Road Station. The changes to potential heritage impacts in relation to Boggo Road Station include the following:

- The proposed station will be in the vicinity of Boggo Road Gaol, but further from the gaol complex than CRR 2011. This is a beneficial heritage outcome; and
- There remains the potential for adverse visual impacts on the setting of the Boggo Road Gaol related to the construction of station entrances, but this is reduced compared to CRR 2011.

Overall, the level of impact for CRR 2016 will be reduced compared to CRR 2011 in this location.

15.2.3 Boggo Road Station to Woolloongabba Station (excluding Woolloongabba Station)

The CRR 2016 alignment between Boggo Road Station and Woolloongabba Station has been modified from CRR 2011, but remains underground. The CRR 2016 tunnel between the two stations will be a mined tunnel rather than the bored tunnel proposed for CRR 2011. A list of heritage places relevant to this section is shown in Table 15.2.

The changes to potential heritage impacts in relation to the tunnel between Boggo Road Station and Woolloongabba Station include the following:

- In general, there will be minimal difference in predicted ground-borne vibration levels during operation with a minor change in mitigation trackform for CRR 2016 to comply with the project criteria at all receivers;
- The predicted ground-borne vibration levels for construction have reduced between Boggo Road Station to Woolloongabba Station due to the change to mined tunnelling excavation instead of using TBMs as proposed for CRR 2011; and

CRR 2016 will generally be consistent with the heritage impacts previously identified for CRR 2011 but will have the beneficial outcome of moving the tunnel further from a number of identified heritage places in this section, namely The Chalk Hotel and St Seraphim Russian Orthodox Church.

Table 15.2 Heritage places between Boggo Road Station and Woolloongabba Station (excluding Woolloongabba Station)

Name of heritage place	Heritage register
The Chalk Hotel (735 Stanley Street, Woolloongabba).	Local
The Nazareth Lutheran Church (listed on the BCC Heritage Register) at 12 Hawthorne Street	Local
Holy Trinity Anglican Church at 68 Hawthorne Street.	State
St Seraphim Russian Orthodox Church at 60 Hawthorne Street	Local

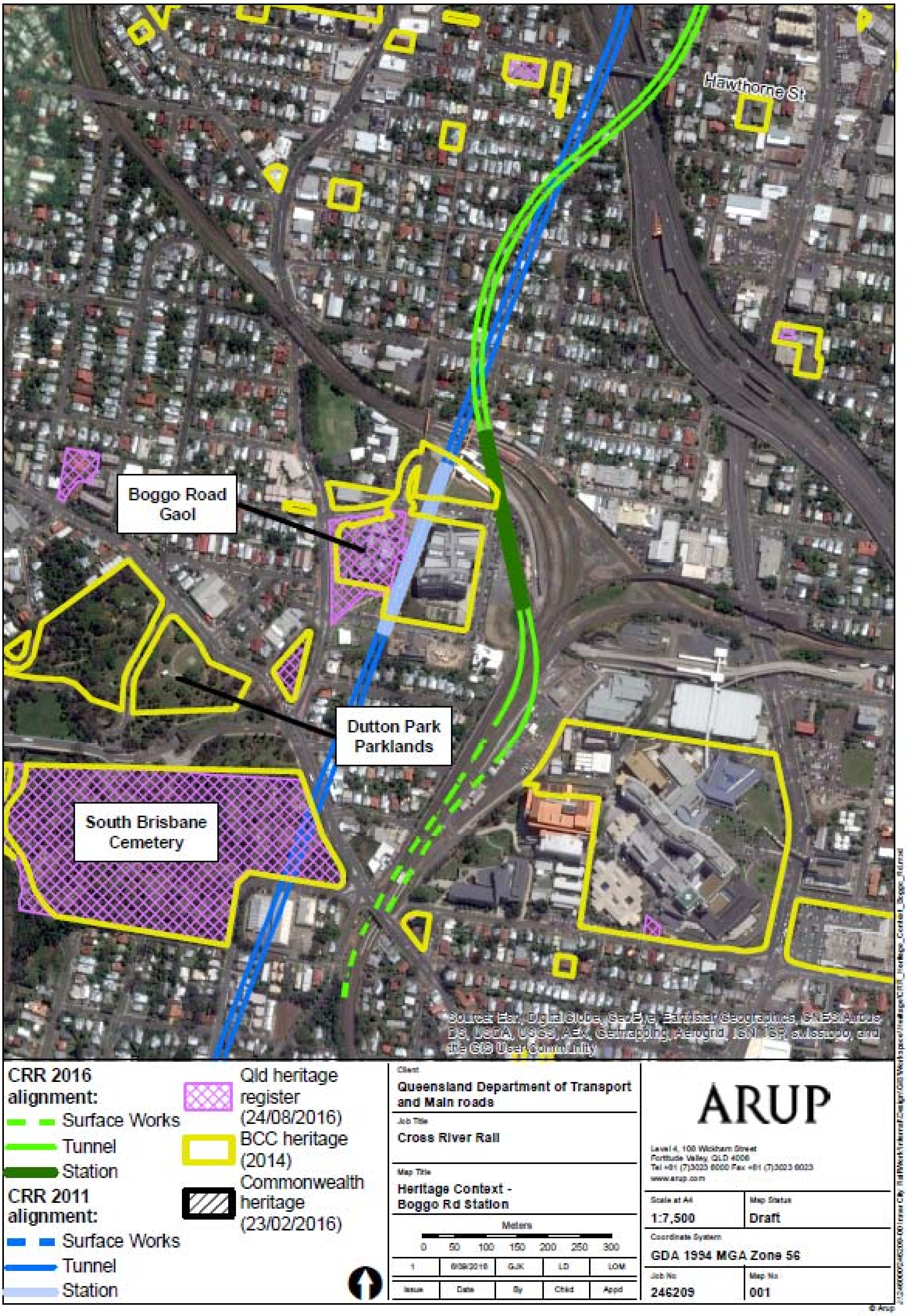


Figure 15.1 Heritage places in the vicinity of Boggo Road Station and Southern portal

15.2.4 Woolloongabba Station

CRR 2011 located Woolloongabba Station on the western side of the GoPrint site. CRR 2016 places Woolloongabba Station on the eastern side of the GoPrint building. A list of heritage places relevant to the Woolloongabba Station area is shown in Table 15.3 and Figure 15.2.

It is anticipated that there will be no change in predicted vibration impacts at the Woolloongabba Station worksite. CRR 2016 is also unlikely to create adverse heritage impacts related to settlement additional to those identified for CRR 2011.

Although the CRR 2016 alignment will be located closer to a number of identified heritage places, the potential for adverse heritage impacts caused by vibration and settlement has been assessed as being nil to low.

Overall, CRR 2016 will be generally consistent with impacts previously identified for CRR 2011 at this location.

Table 15.3 Heritage places at Woolloongabba Station

Name of heritage place	Heritage register or other
The former RAOB Hall at 1 Hubert Street, Woolloongabba	Local
The former Woolloongabba Post & Telegraph Office (QHR 600357) at 765 Stanley Street on the corner with Hubert Street, Woolloongabba	State
The former Woolloongabba Police Station (QHR 601382) at 842-848 Main Street, Woolloongabba	State
Semi Detached Residences at 38 Mark Lane, Kangaroo Point	Local

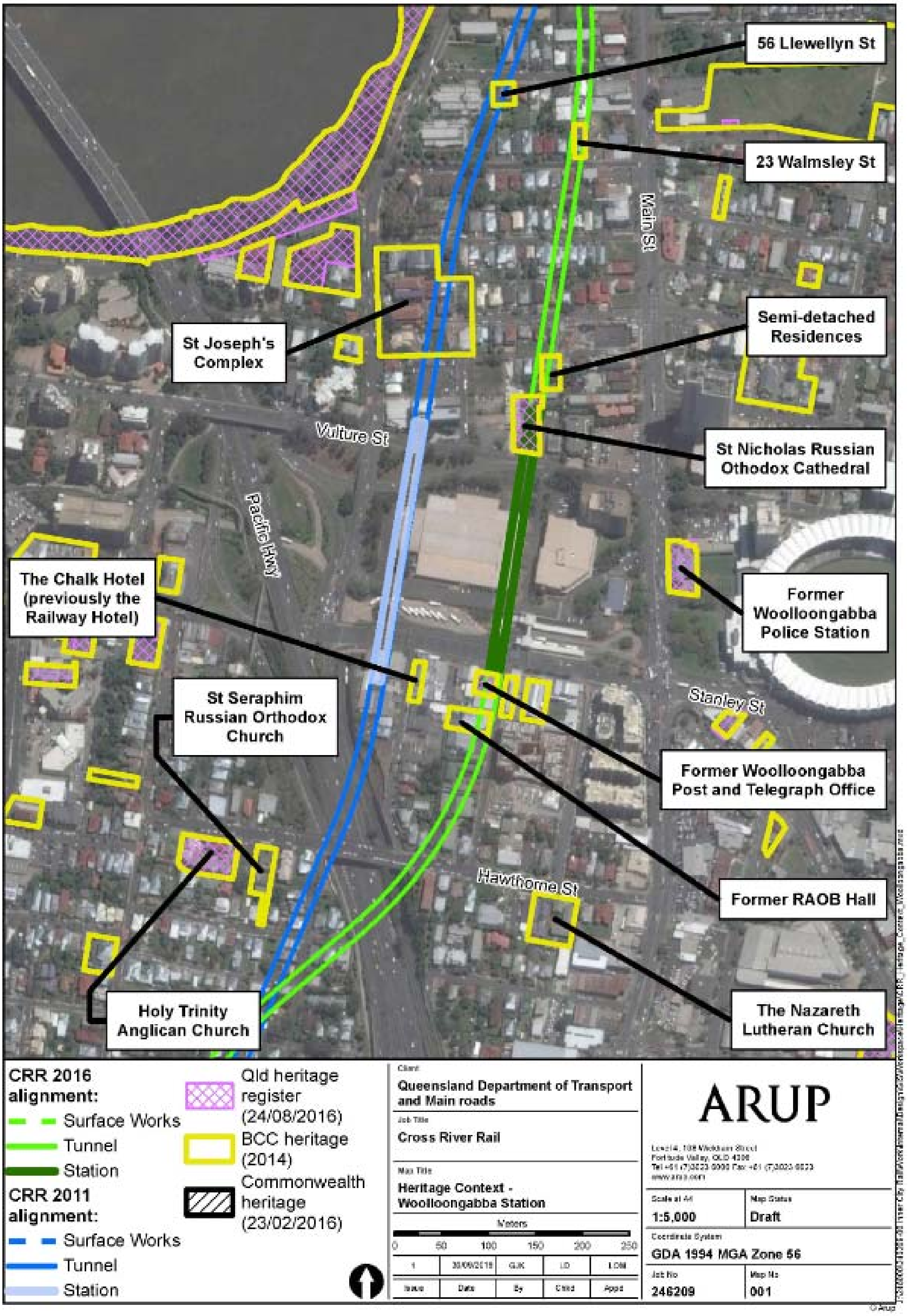


Figure 15.2 Heritage places in the vicinity of Woolloongabba Station

15.2.5 Woolloongabba Station to Albert Street Station (South of the Brisbane River)

CRR 2016 will be on a slightly more easterly alignment compared to CRR 2011 as it extends towards the Kangaroo Point cliffs. A list of heritage places relevant to this section is shown in Table 15.4.

CRR 2016 will bring the tunnel in closer proximity to St Nicholas Russian Orthodox Cathedral and the houses along 32 Mark Lane, 23 Walmsley Street and 56 Llewellyn. However, the alignment is located further from the St Joseph's complex than CRR 2011, which passed directly beneath this site.

CRR 2011 identified some potential for impacts on heritage buildings due to settlement including the St Nicholas Russian Orthodox Cathedral. For CRR 2016, preliminary settlement analysis has indicated that although the alignment and station configuration are different to CRR 2011, the settlement is anticipated to be of a similar magnitude to CRR 2011.

The potential heritage impacts identified for CRR 2016 will generally be similar to those identified for CRR 2011 in this section.

Table 15.4 Heritage places between Woolloongabba Station and Albert Street Station (south of the Brisbane River)

Name of heritage place	Heritage register or other
St Joseph's complex, Leopard Street (church, school and presbytery)	Local
St Nicholas Russian Orthodox Cathedral (Queensland Heritage Register) at 330-334B Vulture Street, Kangaroo Point.	State
32 Mark Lane (to the rear/north of St Nicholas).	Local
23 Walmsley Street.	Local
56 Llewellyn Street.	Local

15.2.6 Woolloongabba Station to Albert Street Station (north of the Brisbane River)

The CRR 2016 tunnel follows the same alignment as CRR 2011 from the Brisbane River toward and along Albert Street (although at different depth in places). The CRR 2016 alignment will still pass directly under the Brisbane Botanic Gardens. The State heritage listed Brisbane Botanic Gardens (gardens' fence and historic fig trees) is the heritage place relevant to this section.

The changes to potential heritage impacts in relation to the section of tunnel between Woolloongabba Station and Albert Street Station north of the Brisbane River include the following:

- The CRR 2016 Albert Street Station is located further north compared to CRR 2011 and this removes the proposed Alice Street entrance, which is a beneficial heritage outcome for the gardens i.e. it will eliminate the impacts on the gardens' fence and nearby historic fig trees;
- Indicative maximum vibration levels and ground-borne noise levels are generally higher for CRR 2016 in this location. However, proposed mitigation measures will reduce vibration impacts to negligible and are generally consistent with CRR 2011; and
- The potential for settlement is consistent with CRR 2011.

15.2.7 Albert Street Station

Albert Street Station for CRR 2016 will be located one block further north of the CRR 2011 proposed. During operation, there is a proposal for Albert Street to be pedestrianised and permanently closed to through-traffic between Mary Street and Charlotte Street and between Charlotte Street and Elizabeth Street.

A list of heritage places relevant to Albert Street Station is shown in Table 15.5 and are illustrated in Figure 15.3. Figure 15.4 illustrates the potential archaeological resources in its vicinity, identifying Albert Street from Charlotte Street to King George Square as having no archaeological potential.

The changes to potential heritage impacts in relation to Albert Street Station include the following:

- The CRR 2016 alignment reduces potential heritage impacts at the southern end (from Alice Street to Margaret Street) compared to CRR 2011. The station's construction will no longer be in close proximity to the entrance to the Old Botanical Gardens, a site of exceptional archaeological potential and a heritage-listed place;
- The opportunity to pedestrianise parts of Albert Street will introduce a new use to this historic road alignment. However, the alignment itself will be retained and pedestrianisation will enhance the streetscape and may facilitate better appreciation of the historic facades. This represents a beneficial heritage outcome; and
- The issues relating to settlement for CRR 2016 will be similar to CRR 2011.

Overall, the potential heritage impacts in this location for CRR 2016 are generally a beneficial heritage outcome compared to CRR 2011.

Table 15.5 Heritage places at Albert Street Station

Name of heritage place	Heritage register or other
Brisbane Botanic Gardens - gardens' fence and historic fig trees	State
Royal Albert Apartments/Hotel (167 Albert Street, corner Elizabeth Street)	State
The road corridor on Albert Street between Margaret and Alice Streets (registered Archaeological place)	Brisbane CBD Archaeological Plan
Road corridor on Charlotte Street, between George and Albert Streets (registered Archaeological place)	Brisbane CBD Archaeological Plan
William Cairncross Building	Local

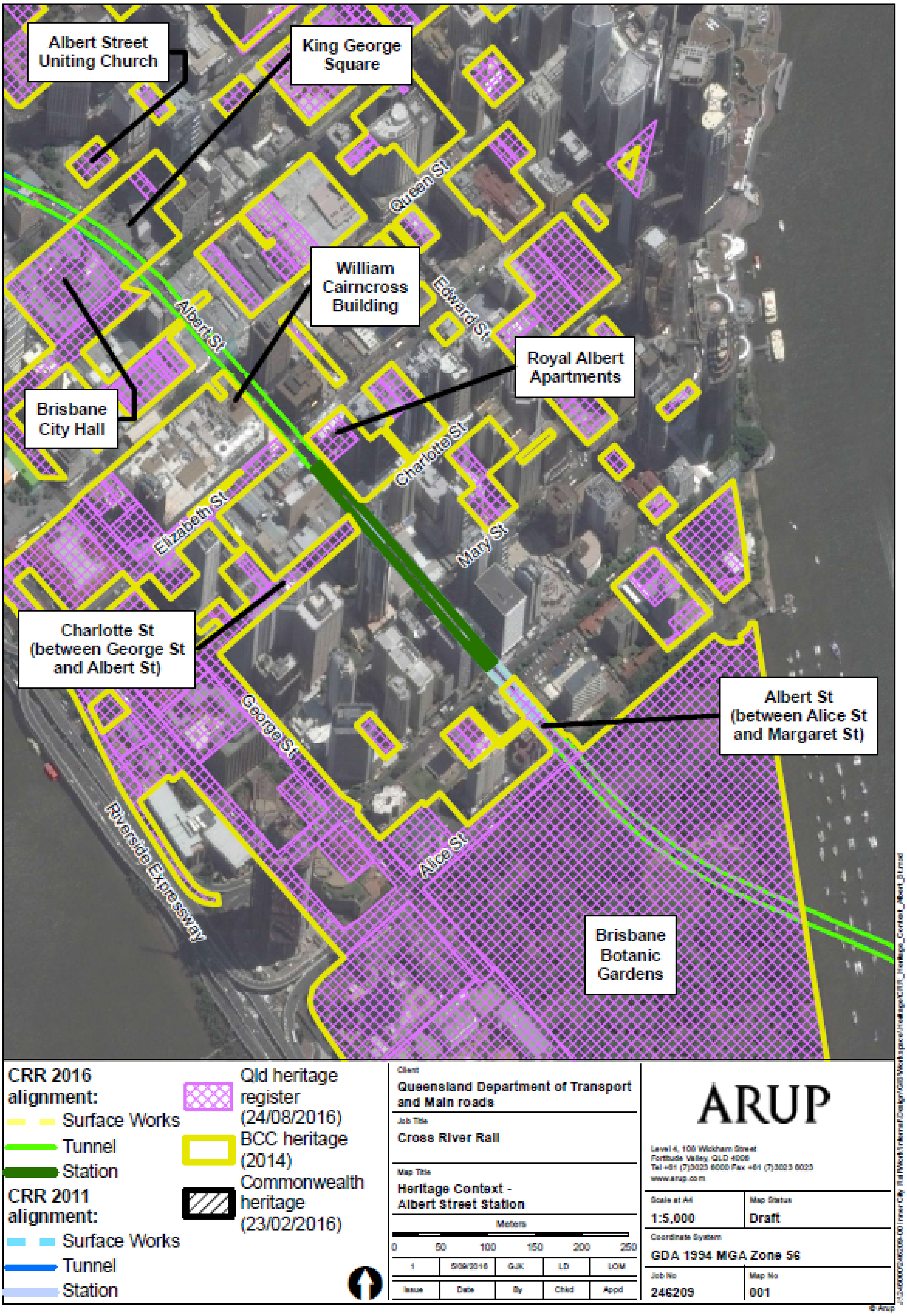


Figure 15.3 Heritage places in and around Albert Street Station

Figure 15.4 Extract from the Brisbane CBD Archaeological Plan

15.2.8 Albert Street Station to Roma Street Station (excluding Roma Street Station)

Between Albert Street Station and Roma Street Station, the CRR 2016 alignment will cross from Albert Street to George Street under the State Law Courts to a realignment west of the existing Roma Street Station. A list of heritage places relevant to this section is shown in Table 15.6.

Between Albert Street Station and Roma Street Station the indicative maximum vibration levels are generally consistent with CRR 2011. The potential vibration and settlement impacts of the CRR 2016 tunnel will be similar to those identified for CRR 2011 but will affect different structures from the corner of Roma Street and Ann Street northwards. The following heritage places will be in close proximity to CRR 2016:

- The McDonnell and East & Co Building, (414 George Street);
- Transcontinental Hotel (462-468 George Street);
- Former Bank of Queensland at 458-460 George Street;
- The former baby clinic at 51 Herschel Street; and
- The city block of historic buildings created by George Street, Turbot Street, Roma Street and Ann Street. This city block includes 327 George Street (the Jenyns Patent Corset Building), 65

and 65A Turbot Street (Turbot House), 71-97 Turbot Street (Brisbane Fruit and Produce Market), and the former BAFS Dispensary Building at 331/333 George Street.

The CRR 2016 tunnel will pass under a number of locations identified by the Brisbane CBD Archaeological Plan as having outstanding archaeological potential. However, as the CRR 2016 tunnel is at a similar depth to the CRR 2011 tunnel the potential for adverse impacts is the same as CRR 2011. The potential impacts of CRR 2016 on the historical archaeological resource will be the same as for CRR 2011.

The CRR 2016 alignment is under or adjacent to a number of State and Local heritage buildings that had no potential to be impacted by CRR 2011. However, the risk of impacting these structures for CRR 2016 is generally consistent with CRR 2011.

Table 15.6 Heritage places between Albert Street Station and Roma Street Station (excluding Roma Street Station)

Name of heritage place	Heritage register or other
Brisbane City Hall	State
King George Square	Local
Former Queensland Deposit Bank	Local
William Cairncross Building	Local
Albert Street Uniting Church	State
The McDonnell and East & Co Building, (414 George Street)	State
Transcontinental Hotel (462-468 George Street)	State
Former Bank of Queensland at 458-460 George Street	Local
The former baby clinic at 51 Herschel Street	Local
City block of historic buildings including: 327 George Street (the Jenyns Patent Corset Building), 65 and 65A Turbot Street (Turbot House), 71-97 Turbot Street (Brisbane Fruit and Produce Market)	Local
Former BAFS Dispensary Building at 331/333 George Street	State
A cluster of buildings on George Street (on the corner with Herschel Street) including the Former Bank of Queensland at 458-460 George Street; and the former baby clinic at 51 Herschel Street	Local

15.2.9 Roma Street Station

The CRR 2016 Roma Street Station will be located directly under the existing BTC requiring the demolition of the BTC (West Tower) and coach ramps. This building is not heritage listed and might be regarded as intrusive on the compromised but historic streetscape. A list of heritage places relevant to this area is shown in Table 15.7 and Figure 15.5.

In addition to the state heritage listing for Roma Street Railway Station building, the Queensland Heritage Register lists the following places:

- Roma Street Platform Shelter;
- Countess Street Rail Bridges; and
- Petrie Terrace Road Bridge.

Of these places, only the latter two remain relevant for CRR 2016 as there is no potential adverse heritage impact on the Roma Street Platform Shelter. By relocating the station further to the north-west, CRR 2016 moves the structure and works further away from the heritage-listed Roma Street Railway Station and associated heritage infrastructure (Roma Street Platform Shelter). This is considered a beneficial heritage outcome in terms of potential vibration damage and physical intervention to fabric.

The potential heritage impacts of the CRR 2011 Roma Street Station and CRR 2016 station are generally considered to be the same (low to nil) on the heritage places at this location given their distance from the respective stations. CRR 2016 may trigger some better heritage outcomes when compared with CRR 2011 at this location due to the potential redevelopment of the area.

Table 15.7 Heritage places at Roma Street Station

Name of heritage place	Heritage register
Roma Street Railway Station	State
Roma Street Platform Shelter	State
Countess Street Rail Bridge abutments	Local
Petrie Terrace Road Bridge	State

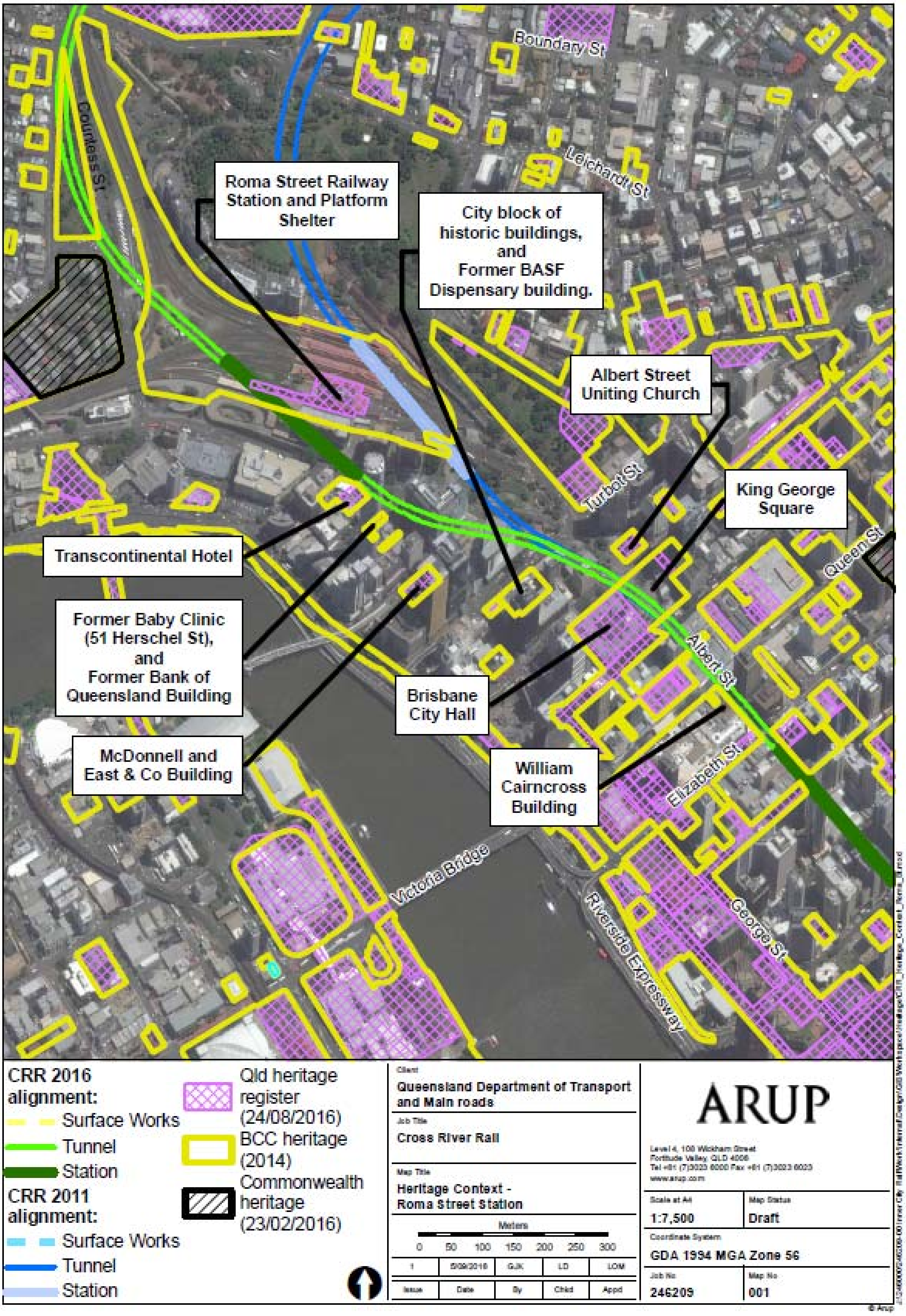


Figure 15.5 Heritage places in the vicinity of Roma Street Station

15.2.10 Roma Street Station to Exhibition Station

North of Roma Street Station, CRR 2016 will take a more westerly route than the CRR 2011 alignment, running in close proximity to Victoria Barracks on Petrie Terrace. It will then pass the north-western side of the State heritage listed Brisbane Grammar School (BGS) and then follow the existing Exhibition Rail Loop. A list of heritage places relevant to this section is shown in Table 15.8 and Figure 15.6 illustrates the alignment north of Roma Street Station.

The Northern portal is located within the existing rail corridor near the Local heritage listed BGGS and ICB. All the cut and cover and dive structure will be within the rail corridor reducing construction impacts on Victoria Park (Queensland Heritage Register) compared to CRR 2011.

Changes to the potential heritage impacts associated with CRR 2016 for the alignment between Roma Street Station and Exhibition Station include the following:

- The CRR 2016 tunnel will pass in closer proximity to Victoria Barracks than CRR 2011. Settlement analysis indicates the potential for settlement near the Victoria Barracks to have 'negligible' damage potential. Further detail is provided in Technical report 12 (Noise and vibration) and Appendix B1;
- Potential heritage impacts (settlement) for places on Petrie Terrace, Countess Street and Kelvin Grove Road arise as a result of the CRR 2016 alignment that were not relevant to CRR 2011;
- The CRR 2016 alignment is located further from BGS and is therefore unlikely to impact it.
- The CRR 2016 tunnel and Northern portal are in close proximity to BGGS. A marginal 0.2 mm/s increase in vibration level have been predicted for the BGGS, but it remains compliant with the human comfort for educational facilities;
- CRR 2016 will locate the tunnels further from Cliveden Mansions (17 Gregory Terrace) and 'Lokarlton' (173 Gregory Terrace) than CRR 2011, although no impacts on these sites were identified for CRR 2011;
- From the Northern portal, surface works will be within the existing rail alignment. This will eliminate a number of potentially significant heritage impacts for Victoria Park (454 Gregory Terrace) identified for CRR 2011; and
- Between Roma Street Station and the Northern portal, indicative maximum vibration levels are generally similar between CRR 2011 and CRR 2016.

Table 15.8 Heritage places between Roma Street Station and Exhibition Station

Name of heritage place	Heritage register
Victoria Barracks, Petrie Terrace (Commonwealth Heritage List and BCC Heritage Register).	Commonwealth, Local
Petrie Terrace Road Bridge	State
Brisbane Grammar School	State
Brisbane Girls Grammar School	Local
Victoria Park	State
Countess Street Rail Bridge	Local
Kelvin Grove Road - fig trees and air raid shelter (landscape precinct) at 140A Kelvin Grove Road	State
Cliveden Mansions (17 Gregory Terrace)	Local
'Lokarlton' (173 Gregory Terrace)	Local

Name of heritage place	Heritage register
Petrie Terrace Police Barracks (Paddington Barracks), Petrie Terrace	State
Hardgrave Park, 155 Petrie Terrace	Local
The western side of Petrie Terrace, from its intersection with Milton Road to its intersection with College Road, contains several places of heritage significance. These comprise a mixture of brick and timber buildings, including: • Jackson’s Granary (8 Petrie Terrace); • Substation (4 Petrie Terrace); • Lord Alfred Hotel (68 Petrie Terrace); • ‘Shawn’ Apartments (172 Petrie Terrace); • ‘Paslewyyd’ (176 Petrie Terrace); • ‘Princes Row’ (190-198 Petrie Terrace); • ‘O’Keeffe’s Buildings (226, 228 230 Petrie Terrace); • ‘Illawarra Mansions’ (242-246 Petrie Terrace); and • ‘Florence House’ (256 Petrie Terrace).	Local
The Normanby Hotel	State
‘Warriston’ at 6-8 Musgrave Road	Local

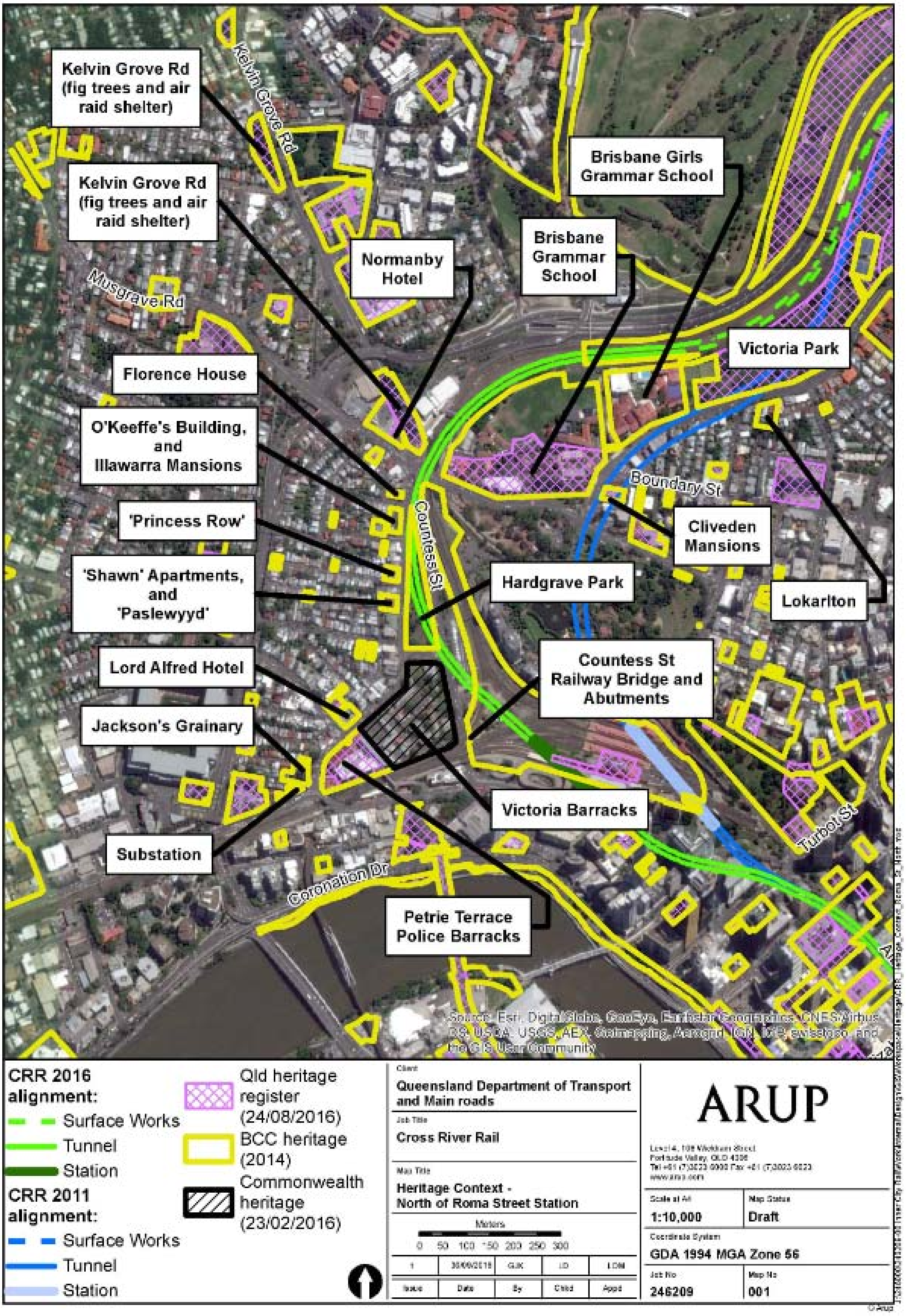


Figure 15.6 Heritage places north of Roma Street Station

15.2.11 Exhibition Station

The CRR 2016 Exhibition Station will be similar in form and location to the CRR 2011 proposed station. A list of relevant heritage places is shown in Table 15.9 and Figure 15.7.

The station proposed for CRR 2016 will involve the demolition of heritage listed buildings and fig trees as identified for CRR 2011. The heritage impacts identified for CRR 2016 are the same as for CRR 2011 due to the similarity of design.

Table 15.9 Heritage places at Exhibition Station

Name of heritage place	Heritage register or other
Heritage structures of RNA Showgrounds include: • Brick rail viaduct; • Dairy Cattle, Dairy Goat, Pig and Deer and Beef Cattle Pavilions; • Show ring No 2; • four mature trees around Show ring No 2; • Sideshow Alley; • Subways; • toilet block adjacent to the rail embankment; • Pedestrian bridge near O'Connell Terrace; and • Bowen Park across the RNA towards the John Macdonald Stand.	State
Exhibition Station, RNA Showgrounds	QR heritage place

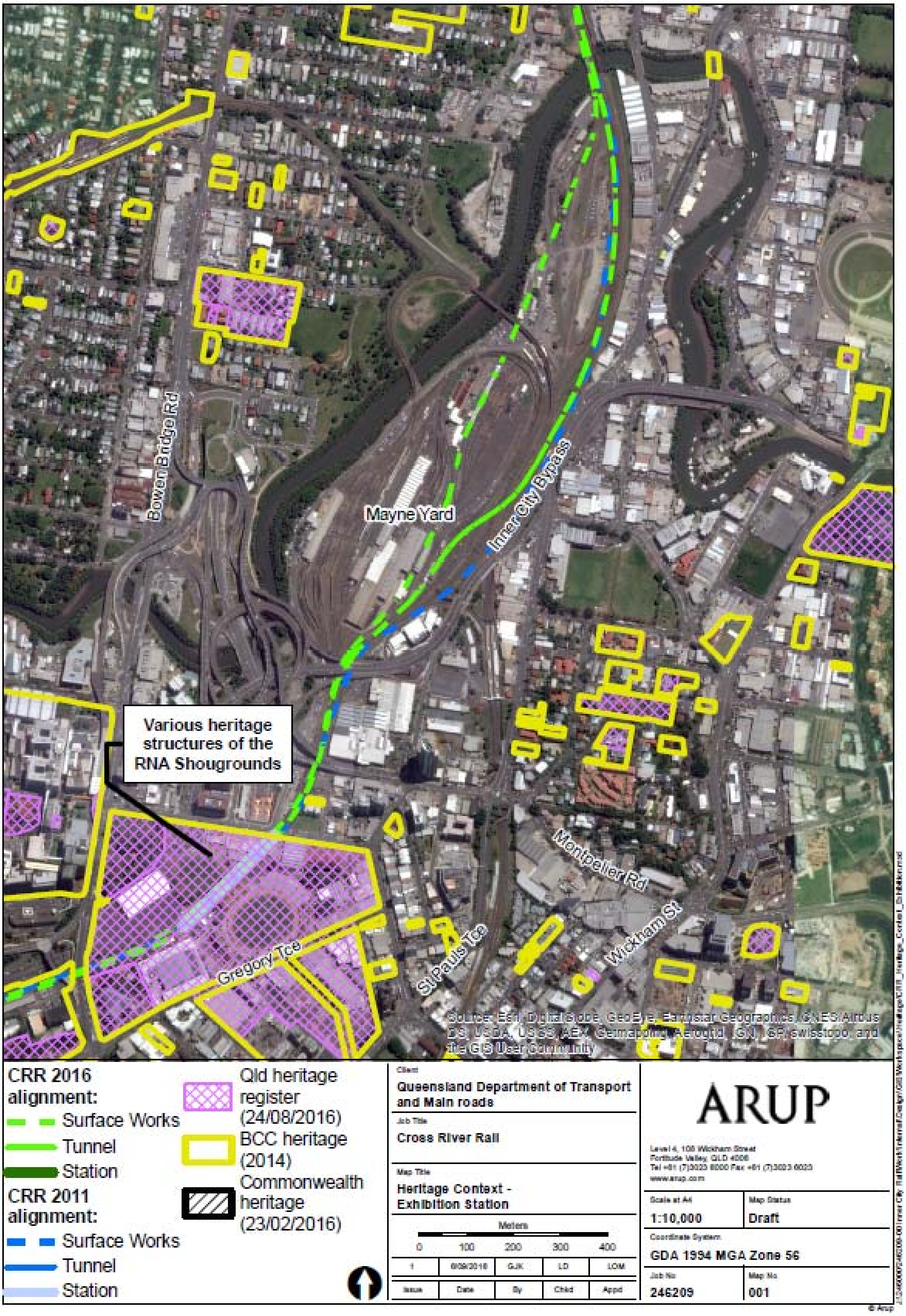


Figure 15.7 Heritage places in and around Exhibition Station

15.2.12 Alignment through Mayne Yard to south of Albion Station

CRR 2016 will include two new tracks through Mayne Yard. The northbound track will be at surface level (to the west), while the southbound (eastern track) will partially be within an underpass to provide grade separation with the existing main track. The CRR 2011 tracks would have been on viaduct, 9m above ground. The CRR 2016 alignment will connect to existing tracks north of Breakfast/Enoggera Creek using the existing sidings bridge.

CRR 2016 will not impact heritage places in this part of the alignment.

15.3 Changes to mitigation measures

Potential adverse heritage impacts on the visual setting of heritage buildings is usually an impact that can be avoided or mitigated through sympathetic design at the detailed design stage. Similarly, potential adverse heritage impacts to the physical fabric of heritage buildings can usually be avoided or mitigated through adoption of appropriate construction methodologies and other on-site mitigation measures combined with monitoring of the works in progress.

Where there is development on a Queensland heritage place as part of the Project, this will be managed through the assessment processes in the *Queensland Heritage Act 1992*.

For settlement, a summary of mitigation measures, further detailed in Technical report 3 (Topography, geology, geomorphology and soils), includes the following:

- Comprehensive geotechnical and groundwater investigations to be undertaken to confirm subsurface conditions and verify locations of potential settlement impacts;
- The locations identified for settlement monitoring will be subject to further refinement and a risk assessment during detailed design. Monitoring will be conducted from the commencement of underground construction works and dewatering;
- Where predictive modelling indicates settlement may be likely, detailed design and construction planning is to incorporate measures to limit settlement generally to 25mm or to 50mm in a worst case event, measured at any location within 50m of the route centreline or the outer walls of an underground station or excavated structure;
- If there is a concern that any subsequent ground settlement was caused by the Project, an independent consultant may be engaged to prepare a new building condition survey report;
- If necessary, carry out building specific underpinning, strengthening or other protective measures prior to commencement of tunnel construction; and
- Establish and implement a monitoring plan, including building monitoring points. This regime is to reference predicted settlements and provide a corresponding action plan.

15.3.1 Southern portal and Boggo Road Station

Mitigation measures which are consistent with CRR 2011 include the following:

- Boggo Road Station entrances to be designed sympathetically to ensure no adverse impacts on the visual setting of the gaol complex.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, include the following:

- South Brisbane Cemetery - the potential for adverse impacts as a result of vibration and settlement was assessed as being very low. It specified monitoring and management requirements and photographic record and structural audits before construction; and
- CRR 2011 required vibration monitoring through the construction process, especially around the Boggo Road Gaol.

The mitigation measures required for CRR 2016 are summarised in Table 15.10.

Table 15.10 Mitigation measures for the Southern portal and Boggo Road Station

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
Boggo Road Gaol	State	This site is located more than 100m from CRR 2016. If during detailed design further modelling indicates that this site requires settlement monitoring, then it will be undertaken. Design station sympathetically to visual setting of gaol complex

15.3.2 Boggo Road Station to Woolloongabba Station

Mitigation measures which are consistent with CRR 2011 include the following:

- Settlement monitoring will be required for some heritage places in the vicinity of the alignment.

The mitigation measures required for CRR 2016 are summarised in Table 15.11.

Table 15.11 Mitigation measures - Boggo Road Station to Woolloongabba Station

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
The Chalk Hotel (735 Stanley Street, Woolloongabba)	Local	Settlement monitoring (consistent with CRR 2011)
The Nazareth Lutheran Church (listed on the BCC Heritage Register) at 12 Hawthorne Street	Local	These sites are located more than 100m from CRR 2016. If during detailed design further modelling indicates that these sites require settlement monitoring, then it will be undertaken.
Holy Trinity Anglican Church at 68 Hawthorne Street.	State	
St Seraphim Russian Orthodox Church at 60 Hawthorne Street	Local	Settlement monitoring (consistent with CRR 2011)

15.3.3 Woolloongabba Station

Mitigation measures which are consistent with CRR 2011 include the following:

- The design of the station entrances be responsive to heritage places in the vicinity; and
- Settlement monitoring for tunnel construction and underground station construction at heritage places.

The mitigation measures required for CRR 2016 are summarised in Table 15.12.

Table 15.12 Mitigation measures at Woolloongabba Station

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
The former RAOB Hall at 1 Hubert Street, Woolloongabba	Local	Settlement monitoring. Detailed design of the station entrances be responsive to heritage places in the vicinity. (measures are consistent with CRR 2011)
The former Woolloongabba Post & Telegraph Office (QHR 600357) at 765 Stanley Street on the corner with Hubert Street, Woolloongabba	State	
The former Woolloongabba Police Station (QHR 601382) at 842-848 Main Street, Woolloongabba	State	This site is located more than 100m from CRR 2016. If during detailed design further modelling indicates that this site requires settlement monitoring, then it will be undertaken.
Semi Detached Residences at 38 Mark Lane, Kangaroo Point	Local	Settlement monitoring. Detailed design of the station entrances be responsive to heritage places in the vicinity. (measures consistent with CRR 2011)

15.3.4 Woolloongabba Station to Albert Street Station (excluding Albert Street Station)

Mitigation measures which are consistent with CRR 2011 include the following:

- Monitoring of settlement will be required for St Nicholas Russian Orthodox Cathedral; and
- Settlement implications near the Brisbane Botanic Gardens to be closely managed.

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, include the following:

- Management of fig trees and the fence near the Brisbane Botanic Gardens.

Additional mitigation measures now relevant to CRR 2016 include settlement monitoring of local heritage places located at 32 Mark Lane, 23 Walmsley Street and 56 Llewellyn Street. The mitigation measures required for CRR 2016 are summarised in Table 15.13.

Table 15.13 Mitigation measures - Woolloongabba Station to Albert Street Station

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
St Nicholas Russian Orthodox Cathedral	State	Settlement monitoring (consistent with CRR 2011)
32 Mark Lane (to the rear/north of St Nicholas Russian Orthodox Cathedral)	Local	Settlement monitoring
23 Walmsley Street.	Local	Settlement monitoring
56 Llewellyn Street.	Local	Settlement monitoring
Brisbane Botanic Gardens	State	Settlement monitoring (consistent with CRR 2011)

15.3.5 Albert Street Station

Mitigation measures which are consistent with CRR 2011 include the following:

- Potential settlement issues in relation to the Royal Albert building to be closely managed;
- Any surface ground disturbance to involve participation of archaeologists; and
- Settlement to be managed for the William Cairncross Building at 188-196 Albert Street;

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to vibration monitoring of the William Cairncross Building at 188-196 Albert Street.

Additional mitigation measures now relevant to CRR 2016 include Albert Street Station to undertake rockbreaking ground-borne noise and vibration trials to accurately determine extent of the predicted impact and preference given to drill and blast of station shaft. The mitigation measures required for CRR 2016 are summarised in Table 15.14.

Table 15.14 Mitigation measures at Albert Street Station

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
Royal Albert Apartments/Hotel (167 Albert Street, corner Elizabeth Street)	State	Settlement monitoring. Surface ground disturbance to involve archaeologist. (measures are consistent with CRR 2011)
William Cairncross Building	Local	Settlement monitoring (consistent with CRR 2011)
Around Albert Street Station	various	To undertake rockbreaking ground-borne noise and vibration trials to accurately determine extent of the predicted impact and preference given to drill and blast of station shaft

15.3.6 Albert Street Station to Roma Street Station (excluding Roma Street Station)

Mitigation measures which are consistent with CRR 2011 include the following:

- Settlement monitoring at Brisbane City Hall, King George Square, Former Queensland Deposit Bank, and Albert Street Uniting Church.

Additional mitigation measures now relevant to CRR 2016 include:

- Settlement monitoring is now required at the following locations:
  - The McDonnell and East & Co Building (414 George Street);
  - Transcontinental Hotel (462-468 George Street);
  - Former Bank of Queensland at 458-460 George Street;
  - The former baby clinic at 51 Herschel Street; and
  - Former BAFS Dispensary Building.
- Subject to further assessment, settlement monitoring may be required at the city block of historic buildings created by George Street, Turbot Street, Roma Street and Ann Street; and

- Particular care to be taken in relation to the Tank Street area (where a convict era reservoir existed in the location of a small creek/pond).

The mitigation measures required for CRR 2016 are summarised in Table 15.15.

Table 15.15 Mitigation measures between Albert Street Station and Roma Street Station

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
Brisbane City Hall	State	Settlement monitoring (consistent with CRR 2011)
King George Square	Local	
Former Queensland Deposit Bank	Local	
Albert Street Uniting Church	State	
The McDonnell and East & Co Building, (414 George Street)	State	Settlement monitoring
Transcontinental Hotel (462-468 George Street)	State	Settlement monitoring
Former Bank of Queensland at 458-460 George Street	Local	Settlement monitoring
The former baby clinic at 51 Herschel Street	Local	Settlement monitoring
City block of historic buildings including: 327 George Street (the Jenyns Patent Corset Building), 65 and 65A Turbot Street (Turbot House), 71-97 Turbot Street (Brisbane Fruit and Produce Market)	Local	Settlement monitoring
Former BAFS Dispensary Building at 331/333 George Street	State	Settlement monitoring
A cluster of buildings on George Street (on the corner with Herschel Street) including the Former Bank of Queensland at 458-460 George Street; and the former baby clinic at 51 Herschel Street.	Local	Settlement monitoring

15.3.7 Roma Street Station

Mitigation measures which are consistent with CRR 2011 include the following:

- Undertake settlement monitoring in relation to heritage buildings at the existing Roma Street Station; and
- Undertake settlement monitoring at heritage places.

The mitigation measures required for CRR 2016 are summarised in Table 15.16.

Table 15.16 Mitigation measures at Roma Street Station

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
Roma Street Railway Station	State	Settlement monitoring (consistent with CRR 2011)
Countess Street Rail Bridge abutments	Local	Settlement monitoring

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
		(consistent with CRR 2011)
Petrie Terrace Road Bridge	State	Settlement monitoring (consistent with CRR 2011)

15.3.8 Roma Street Station to Exhibition Station

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to the close management of impacts on Victoria Park.

Additional mitigation measures now relevant to CRR 2016 includes:

- Undertake settlement monitoring at heritage places as summarised in Table 15.17.
- Further assessment of potential impacts to BGGS during the construction phase of CRR 2016 is recommended during detailed design;
- Avoid damage to mature trees and established vegetation in the narrow strip affected by the temporary realignment of the bicycle path on the edge of Victoria Park.

The mitigation measures required for CRR 2016 are summarised in Table 15.17.

Table 15.17 Mitigation measures - Roma Street Station to Exhibition Station

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
Victoria Barracks, Petrie Terrace	Commonwealth, Local	Settlement monitoring
Petrie Terrace Road Bridge	State	Settlement monitoring
Brisbane Grammar School	State	Settlement monitoring Further assessment during detailed design of potential vibration impacts during construction.
Brisbane Girls Grammar School	Local	Settlement monitoring
Victoria Park	State	Avoid damage to mature trees with temporary realignment of bicycle path
Countess Street Rail Bridge	Local	Settlement monitoring
Kelvin Grove Road - fig trees and air raid shelter (landscape precinct) at 140A Kelvin Grove Road	State	Settlement monitoring
Cliveden Mansions (17 Gregory Terrace)	Local	These sites are located more than 100m from CRR 2016. If during detailed design further modelling indicates that these sites require settlement monitoring, then it will be undertaken.
‘Lokarlton’ (173 Gregory Terrace)	Local	
Petrie Terrace Police Barracks (Paddington Barracks), Petrie Terrace	State	
Hardgrave Park, 155 Petrie Terrace	Local	Settlement monitoring
Places of heritage significance on the western side of Petrie Terrace including:	Local	Settlement monitoring

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
• 'Shawn' Apartments (172 Petrie Terrace); • 'Paslewyyd' (176 Petrie Terrace); • 'Princes Row' (190-198 Petrie Terrace); • 'O'Keeffe's Buildings (226, 228 230 Petrie Terrace); • 'Illawarra Mansions' (242-246 Petrie Terrace); and • 'Florence House' (256 Petrie Terrace).		
Jackson's Granary (8 Petrie Terrace).	Local	These sites are located more than 100m from CRR 2016. If during detailed design further modelling indicates that these sites require settlement monitoring, then it will be undertaken.
Substation (4 Petrie Terrace).	Local	
Lord Alfred Hotel (68 Petrie Terrace).	Local	
The Normanby Hotel.	State	Settlement monitoring
'Warriston' at 6-8 Musgrave Road.	Local	Settlement monitoring

15.3.9 Exhibition Station

Mitigation measures which are consistent with CRR 2011 include the following:

- Continue to consult with the RNA in relation to potential impacts and mitigation measures;
- Address heritage impacts through detailed design stage. Look to retain or adapt heritage, character and cultural features and the history of the site and surrounding area; and
- Consult arborist in relation to fig tree relocation.

The mitigation measures required for CRR 2016 are summarised in Table 15.18.

Table 15.18 Mitigation measures at Exhibition Station

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
Heritage structures of RNA Showgrounds include: • Brick rail viaduct; • Dairy Cattle, Dairy Goat, Pig and Deer and Beef Cattle Pavilions; • Show ring No 2; • four mature trees around Show ring No 2; • Sideshow Alley; • Subways; • toilet block adjacent to the rail embankment;	State	Consult with the RNA regarding mitigation measures. Address heritage impacts during detailed design. Consult an arborist in relation to fig tree relocation. (measures are consistent with CRR 2011)

Name of heritage place	Heritage register	Mitigation measures for CRR 2016
• Pedestrian bridge near O'Connell Terrace; and • Bowen Park across the RNA towards the John Macdonald Stand.		

15.3.10 Mayne Yard

No mitigation is identified as there are no potential impacts on heritage places identified.

15.4 Conclusion

CRR 2016 will have a number of beneficial heritage outcomes compared to CRR 2011, which include:

- No impacts to Yeerongpilly, Rocklea and Salisbury Stations;
- Reduced tunnelling at the Southern portal reduces the risk of damage to heritage buildings and places due to vibration and settlement;
- No impacts on South Brisbane Cemetery or Dutton Park parklands;
- Boggo Road Station will be further from the Boggo Road Gaol complex;
- The more easterly alignment between Boggo Road Station and Woolloongabba Station will take the tunnels further from the Holy Trinity Anglican Church and St Seraphim Russian Orthodox Church reducing the risk of damage through settlement;
- The more easterly alignment between Woolloongabba Station and the Brisbane River takes the tunnels further from St Joseph's Convent, School and Church reducing the risk of impacts due to settlement;
- Albert Street Station will be further removed from the Brisbane Botanic Gardens eliminating potential adverse impacts to the fence, mature fig trees and Beatrice Lane. The rail station's location one block further north places the bulk of the potential surface ground disturbance in an area identified by the Brisbane CBD Archaeological Plan as having no archaeological potential. The opportunity to pedestrianise parts of Albert Street provides an opportunity for enhanced appreciation of the heritage facades in this street;
- Adverse impacts on the historic Roma Street Station and associated infrastructure will be reduced. The demolition of the BTC (West Tower) provides an opportunity to enhance the appreciation of heritage facades in the vicinity;
- Removal of adverse heritage impacts on Victoria Park;
- Tunnel alignments will be further from BGS reducing potential adverse impacts through vibration and settlement; and
- Tunnel alignments will be further from Cliveden Mansions and 'Lokarlton', further reducing potential adverse impacts through settlement.

Notwithstanding these beneficial heritage outcomes, CRR 2016 raises some potential adverse heritage impacts that did not arise in relation to CRR 2011. This is particularly the case on the section of tunnel alignment north of Roma Street Station, which will be located in closer proximity to a number of heritage places concentrated on Petrie Terrace and Countess Street and their environs. Potential impacts on these heritage places will need to be managed through such measures as settlement monitoring and designing stations that are sympathetic to their visual settings.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

16 Technical Report: Social environment

16.1 Introduction

This technical report addresses the changes to the impacts and benefits associated with the social environment as a result of CRR 2016. This includes changes to property impacts, equity, social infrastructure, community values, local area impacts and project workforce.

Overall, the environmental impacts relating to visual amenity, dust, noise/vibration and traffic disturbance, are generally consistent with CRR 2011. However, due to the shortened tunnel length, there will be an overall reduction in property and social infrastructure impacts.

Upon completion, there will be improved accessibility and connectivity, providing social benefits to the Brisbane inner city and wider community. The Project will enhance access to infrastructure, open spaces, parklands and areas of employment.

16.2 Changes to potential impacts

16.2.1 Property impacts

The Project will require the whole or partial acquisition of a number of properties for surface works (e.g. new stations, surface tracks, construction worksites etc.), as well as volumetric acquisitions.

CRR 2016 requires less property acquisition (surface and volumetric) than CRR 2011, mainly due to the reduced tunnel length, changes to alignment and relocation of the southern tunnel. The Southern portal will be constructed on land wholly within the existing rail corridor with no residential property acquisition requirements. A breakdown of surface and volumetric property requirements by land use type for both CRR 2011 and CRR 2016 is provided in Table 16.1.

Table 16.1 Summary of properties[56] required by land use type

Property Acquisition – Land Use Type	CRR 2011	CRR 2016	Change (+ / -)
Surface Acquisition – number of properties			
Residential	39	0	-39
Commercial / Industrial	60	15	-45
Other (i.e. park, showground, commercial facilities)	9	14	+5[57]
Total properties requiring surface acquisition	***108***	***29***	***-79***
Volumetric Acquisition – number of properties			
Residential	235	141	-94
Commercial / Industrial	50	38	-12
Other (e.g. park, showground)	19	16	-3
Total properties requiring volumetric acquisition	***304***	***195***	***-109***

[56] Property numbers exclude existing roads, busways and railway properties
[57] Additional properties are a result of subdivision of new uses on existing sites since 2011 and the required demolition of additional community facilities at Woolloongabba (e.g. Dental Clinic, Landcentre building) and at Roma Street (BTC).

Property Acquisition – Land Use Type	CRR 2011	CRR 2016	Change (+ / -)
Total properties requiring acquisition	**412**	**224**	**-188**

In relation to property impacts, key issues raised by the community as outlined in the CRR 2011 EIS, which are also relevant to CRR 2016, include:

- Uncertainty about the volumetric acquisition process;
- Potential impact on future development of properties above the tunnel or stations;
- Changes in property values due to changes to amenity during construction works;
- Uncertainty around property decisions, including decisions to buy or sell properties near to the Project;
- Potential risk of damage to and impacts on buildings from construction of the tunnel and stations; and
- The need for property condition surveys to be conducted to ensure any damage from construction can be measured and repaired, if necessary.

16.2.2 Equity

As with CRR 2011, the CRR 2016 project provides the opportunity for equitable transport access for local and regional communities and commuters and improves connections to where people live, work and play. While CRR 2016 no longer extends south of Dutton Park Station, communities along this section of the railway will benefit from transport access improvements across the network brought about by CRR 2016, once it is operational.

16.2.3 Social infrastructure

Consistent with CRR 2011, the CRR 2016 project will help improve access to a range of important district and regional level social infrastructure assets for communities in the study corridor as well as the wider South East Queensland (SEQ) region. These include:

- Major medical and health care facilities such as the RBWH, PA Hospital and Mater Hospital;
- Sport and entertainment facilities such as the Gabba Stadium, Suncorp Stadium and the RNA Showgrounds;
- Education facilities such as QUT and the University of Queensland;
- Major open spaces such as the City Botanic Gardens, Roma Street Parkland and Victoria Park; and
- Improved accessibility to a wide range of community service organisations (such as community and traditional services clubs, pensioner or senior citizen associations).

16.2.4 Community values

Community values are important to people for quality of life and sense of well-being. These may include physical elements, such as local amenities and intangible qualities, such as community cohesion. For CRR 2011, a group of residential properties were proposed to be acquired for construction of the Southern portal at Yeerongpilly. The resumption of this group of properties and the change in land use in this area may have impacted community cohesion and values in this area. The Southern portal for CRR 2016 is located north of Dutton Park Station within the existing rail corridor. While there are residential properties in the vicinity of the new portal location, none of these properties will be required for construction.

16.2.5 Local area impacts

Construction activities may lead to changes in local amenity and liveability for communities near construction worksites due to temporary impacts including increased construction noise, vibration, dust, construction traffic and visual impacts. Impacts on residential amenity and community health and safety for CRR 2016 are considered to be similar to CRR 2011 in terms of the types of impacts, however the locations impacted and number of people affected has reduced due to the shortened alignment and tunnel length. The construction impacts will be temporary and of a limited duration, compared with the long-term operational benefits.

During operation, communities near rail stations will benefit from enhanced transport services and accessibility to metropolitan and regional facilities, services and employment. Areas directly adjacent to new stations may experience improved amenity though the provision of station plazas, streetscape improvements and enhanced pedestrian access. However, as with CRR 2011, some neighbourhoods close to new stations may experience changes in local amenity due to: changes to the visual environment and views from new surface infrastructure; changes to local road access and through routes and changed traffic and parking in local streets around station precincts.

The differences between CRR 2011 and CRR 2016 local area impacts and benefits are summarised in Table 16.2. Information has been summarised from Technical report 1 (Transport), Technical report 3 (Topography, geology, geomorphology and soils), Technical report 6 (Visual amenity and lighting), Technical report 11 (Air quality, Technical report 12 (Noise and vibration) and Technical report 14 and 15 Cultural heritage.

Table 16.2 A summary of local area impacts – a comparison of CRR 2011 and CRR 2016

<table>
<tr><th rowspan="2">Location</th><th colspan="2">Local area impacts and benefits</th></tr>
<tr><th>CRR 2011</th><th>CRR 2016 change</th></tr>
<tr><td>Salisbury to Dutton Park Station</td><td>Impacts
• Southern tunnel portal construction – property resumptions, construction worksite, spoil removal (truck movements), change to local cohesion and amenity in Yeerongpilly;
• Potential for visual/noise/dust amenity impacts;
• Impacted on social infrastructure;
• Traffic, cyclist and pedestrian movement impacted; and
• Construction and operation of ventilation and emergency access building at Fairfield.
Benefits
• New station at Yeerongpilly – provided access to Queensland Tennis Centre and future TOD;
• Upgrade of Rocklea and Moorooka stations to meet Disability Discrimination Act 1992 requirements;
• Local road upgrades proposed – including signalisation of intersections; and
• New and upgraded pedestrian facilities in the vicinity of the railway.</td><td>Impacts
• Passenger trains now operating at surface instead of in tunnel between Park Road Station and Yeerongpilly may change the visual amenity; and
• The increase in passenger trains between Yeerongpilly and Dutton Road Station (now at surface) would be offset by the reduction in freight train movements with the effect being a negligible change in forecast rail noise.
Benefits
• There will be reduced construction related activities and impacts (i.e. noise, vibration, dust, traffic disruptions) in the rail corridor and at stations south of Dutton Park Station;
• Reduced potential damage to heritage buildings due to vibration and settlement; and
• No impacts on South Brisbane Cemetery or Dutton Park parklands.
Overall summary
There will be an overall reduction of local area impacts during construction and operation south of Dutton Park Station for CRR 2016.</td></tr>
<tr><td>Boggo Road Station (north of Dutton Park Station and including Boggo Road Station)</td><td>Impacts
• Change in local amenity and access around Boggo Road Urban Village, Ecosciences precinct, Boggo Road Gaol, Boggo Road Busway Station, Dutton Park State Primary School, residents along Peter Doherty Street, and Rawnsley Street during construction;
• Potential for construction related impacts relating to visual/noise/dust amenity issues; and
• Changes to traffic movement and access.
Benefits</td><td>Impacts
• Similar to CRR 2011 in relation to local amenity and access, although reduced impact on Boggo Road Gaol and Dutton Park State Primary School;
• Potential construction impacts relating to visual/noise/vibration amenity are consistent with CRR 2011, although at different sensitive receptors including PA Hospital, ESA Village Leukaemia Foundation, residents along Railway Terrace and Merton Road (to Elliott Street);
• During operation, noise attenuation (barriers and/or insulation) will be required for some residential receptors along Railway Terrace and Rawnsley Street and at ESA Village Leukaemia Foundation;</td></tr>
</table>

<table>
<tr><th rowspan="2">Location</th><th colspan="2">Local area impacts and benefits</th></tr>
<tr><th>CRR 2011</th><th>CRR 2016 change</th></tr>
<tr><td></td><td>Improved access for pedestrians and visual amenity and increased economic opportunities at Boggo Road Urban Village, PA Hospital and interchange opportunities with Boggo Road Busway Station.</td><td>Air quality impacts at Boggo Road are lower than predicted for CRR 2011. If predictive modelling indicates exceedances of air quality, measures such as work sheds or enclosures with fabric filters may be required;
Outlook Park (near Boggo Road Station) will be required for station infrastructure, however opportunities to relocate park facilities will be explored in consultation with BCC;
Potential for settlement is slightly greater than CRR 2011 at Quarry Street; and
Consistent with CRR 2011, potential for temporary, short-term closure of the Boggo Road Busway Station during construction.
Benefits
The tunnel portal will be located within the existing rail corridor and does not require any residential property acquisitions;
Alignment on the eastern side of Boggo Road Urban Village reduces amenity impacts for local residents during construction;
CRR 2016 will provide improved connectivity directly from the underground station to the PA Hospital through a pedestrian underpass;
Heavy vehicle movements to and from the Southern portal worksite and Boggo Road Station will be less than CRR 2011; and
Construction traffic will travel via O'Keefe Street to minimise impact on the PA Hospital and into Peter Doherty Street and out via Boggo Road to reduce impacts on residents along Rawnsley Street and the ESA Village Leukaemia Foundation. This provides a more controlled management of truck movements than CRR 2011.
Overall summary
The overall impacts at the Southern portal are similar to CRR 2011. Impacts associated with the CRR 2016 Boggo Road Station construction are generally reduced with a majority of work now occurring within/adjacent to the existing rail corridor.</td></tr>
<tr><td>Woolloongabba Station (north of</td><td>Impacts</td><td>Impacts</td></tr>
</table>

Location	Local area impacts and benefits	
	CRR 2011	**CRR 2016 change**
Boggo Road Station and including Woolloongabba Station)	• Change to local amenity from potential impacts including noise, dust, visual on local residents and visitors to the area around the proposed Woolloongabba Station; • Change to traffic movement and access; and • Potential impact on the amenity of nearby community uses, such as the St Nicholas Russian Orthodox Cathedral at Vulture Street. ***Benefits*** • Improved access and local pedestrian and visual amenity; • Increased economic opportunities to the Woolloongabba area; and • New Woolloongabba Station would improve transport access for communities in Woolloongabba and support future residential and commercial development within the Woolloongabba PDA.	• Potential dust to receptors surrounding the Woolloongabba Station, including Vulture Street and the St Nicholas Russian Orthodox Cathedral. These impacts will be temporary and will not exceed health-based ambient air quality goals. The impacts are lower than CRR 2011; • Potential vibration and settlement impacts around Woolloongabba Station will be consistent with CRR 2011; • Based on a preliminary settlement analysis for CRR 2016, settlement is anticipated to be of a similar magnitude to CRR 2011 for the St Nicholas Russian Orthodox Cathedral; • Noise impacts from surface construction works will be consistent with CRR 2011 with the inclusion of an acoustic shed; • Potential for short-term, temporary closure of the Woolloongabba Busway Station during construction; and • For CRR 2016, the South Brisbane Dental Hospital, an important element of wider health services which provides general and specialist oral health services, will be demolished. ***Benefits*** • Improved access and economic opportunities around Woolloongabba Station and integration with future development is consistent with CRR 2011; • The tunnel alignment is located further from the Holy Trinity Anglican Church and St Seraphim Russian Orthodox Church reducing the risk of potential damage on heritage buildings; • Between Boggo Road Station and Woolloongabba Station, noise and vibration levels will be generally lower than CRR 2011 due to the proposed roadheader excavation (instead of TBMs); and • Heavy vehicle movements to and from the Woolloongabba Station worksite will be less than the peak haulage movements forecast in CRR 2011, despite the greater total spoil volume at this location for CRR 2016. ***Overall summary*** The overall construction impacts at Woolloongabba Station for CRR 2016 are consistent to those identified for CRR 2011.

<table>
<tr><th rowspan="2">Location</th><th colspan="2">Local area impacts and benefits</th></tr>
<tr><th>CRR 2011</th><th>CRR 2016 change</th></tr>
<tr><td>Albert Street Station (north of Woolloongabba Station and including Albert Street Station)</td><td>Impacts
Change to local amenity and access along Albert Street and Alice Street which may have impacted on amenity at the Botanic Gardens;
Resumption of the Royal on the Park site;
Residents in residential apartments and local business near worksites may have experienced impacts on amenity from noise, dust and vibration;
Pedestrian access and amenity in the vicinity of the Albert Street construction worksite may have been impacted;
Changes to local road access may have also occurred in the vicinity of worksites, resulting in potential disruptions and delays for motorists; and
Permanent removal of the left lane at Alice Street on the corner of Alice Street and Albert Street, which reduced road capacity.
Benefits
Development of a new civic plaza at the northern entrance to the Albert Street Station on the corner of Albert Street and Mary Street;
New Albert Street Station would provide a ‘green link’ to the southern end of the city and improve public transport access to QUT, the City Botanic Gardens and the southern part of the CBD; and
No direct impacts on social infrastructure.</td><td>Impacts
Increase in noise and vibration may occur for the residential apartments at 70 Mary Street and 108 Albert Street. An acoustic shed will be constructed during works.
Benefits
The CRR 2016 alignment takes the tunnel further from heritage buildings including St Joseph’s Convent, School and Church and will not impact on the Brisbane Botanic Gardens eliminating potential impacts to the fence, mature fig trees and Beatrice Lane;
The proposal to pedestrianise Albert Street (between Mary Street and Charlotte Street) and between Charlotte Street and Elizabeth Street, with local vehicle access, will result in an overall improvement in pedestrian access to the city centre and community infrastructure, such as QUT Gardens Point campus and the Brisbane Botanic Gardens . This may also provide an enhanced appreciation of the heritage facades in this street;
There is a low potential for adverse air quality impacts given the construction works will occur in the shaft or purpose-built acoustic shed (consistent with CRR 2011); and
Heavy vehicle movements to and from the Albert Street Station worksite are less than the peak haulage movements forecast in CRR 2011.
Overall summary
The overall construction impacts at Albert Street Station for CRR 2016 are consistent to those identified for CRR 2011.</td></tr>
<tr><td>Roma Street Station (north-west of Albert Street Station, including Roma Street Station)</td><td>Impacts
Potential for noise, visual and traffic impacts around the worksites at Roma Street Station;
Potential impact on amenity for users of Roma Street Parklands;</td><td>Impacts
Potential for noise impacts (increased from CRR 2011) at Abbey Apartments (Roma Street), Roma Street Station building and commercial buildings;
Between Albert Street and Roma Street the vibration levels are generally consistent with CRR 2011; and</td></tr>
</table>

<table>
<tr><th rowspan="2">Location</th><th colspan="2">Local area impacts and benefits</th></tr>
<tr><th>CRR 2011</th><th>CRR 2016 change</th></tr>
<tr><td></td><td>• Potential for disturbance for residents who live close to Roma Street Parklands and Roma Street Station;
• Impact on the western portion of Emma Miller Place on Roma Street;
• Residential amenity for occupants of the Roma Street Parkland Apartments may have been impacted as a result of increased noise, dust, lighting and traffic from construction activities; and
• Access to construction worksites for the station would use Parkland Boulevard, which is a key access to the Roma Street Parkland. The parkland car park would also be used to support construction works for the station.
Benefits
• Improved public transport access and consolidation of Roma Street's role as a key hub for transport services.</td><td>• Consistent with CRR 2011, potential adverse air quality and noise impacts will be mitigated through using a purpose-built acoustic shed.
Benefits
• Reduction in impacts to Parkland Boulevard residents from noise/visual impacts;
• Removal of the permanent impacts on Roma Street Parklands and Emma Miller Place;
• Reduction of adverse impacts on the heritage-listed Roma Street Railway Station and associated infrastructure (Roma Street Platform Shelter); and
• Heavy vehicle movements to and from this worksite are less than the peak haulage movements forecast in CRR 2011.
Overall summary
The overall construction impacts at Roma Street Station for CRR 2016 are generally consistent to CRR 2011.</td></tr>
<tr><td>Northern portal (from Roma Street Station to the Northern portal)</td><td>Impacts
• The cut and cover tunnel works at Victoria Park would result in loss of open space in Victoria Park and reduction in local amenity during construction;
• The worksite would occupy an area of land within Victoria Park. There would be a permanent loss of a portion of the park adjacent to the existing rail corridor, diversion of a bicycle path and changes to amenity for park users; and
• Change to amenity for users of tennis courts owned by St Joseph's Gregory Terrace and Centenary Aquatic Centre.</td><td>Impacts
• Between Roma Street Station and the Northern portal noise and vibration levels are generally similar between CRR 2011 and CRR 2016;
• North of Roma Street, CRR 2016 will be located in proximity to a number of heritage places concentrated on Petrie Terrace and Countess Street and their environs including the Victoria Barracks. Preliminary settlement analysis has indicated the potential for settlement near the Victoria Barracks to have 'negligible' damage potential;
• There is a potential for an increase in noise, vibration and dust for CRR 2016 at the BGGS, although works will be compliant with the human comfort for educational facilities; and
• Temporary diversion of a bikeway will be required within Victoria Park during construction (similar to CRR 2011).
Benefits</td></tr>
</table>

<table>
<tr><th rowspan="2">Location</th><th colspan="2">Local area impacts and benefits</th></tr>
<tr><th>CRR 2011</th><th>CRR 2016 change</th></tr>
<tr><td></td><td></td><td>Removal of adverse heritage impacts on Victoria Park and York's Hollow. Connectivity through and beyond Victoria Park to key social infrastructure would be maintained;
Construction worksite particulate air emissions are lower than the emission rates estimated for CRR 2011; and
Heavy vehicle movements to and from this worksite are less than the peak haulage movements forecast in CRR 2011.
Overall summary
The overall impacts at the Northern portal are reduced compared to CRR 2011.</td></tr>
<tr><td>Exhibition Station
(Northern portal to Exhibition, including Exhibition Station)</td><td>Impacts
Potential for increased construction noise, dust and construction traffic. This may have impacted on amenity for local residents, workers and visitors;
Works associated with the modification of O'Connell Terrace would also have temporarily changed access for motorists, pedestrians and cyclists in the vicinity of construction works;
Potential disruption (access and facilities) at the RNA Showgrounds;
Potential disruption to emergency vehicles accessing RBWH via O'Connell Terrace during construction, although at least one lane would have been maintained at all times; and
The project works would have required the removal of some heritage buildings and structures adjacent to O'Connell Terrace and would have directly impacted on the heritage listed show ring adjacent to the existing Exhibition Station.
Benefits
Provided year round access to Exhibition Station to support growing residential and other uses in the Bowen Hills area. Also supported access to RBWH and the RNA Showgrounds; and</td><td>Impacts
Potential disruption by increased noise, dust, traffic to local residents consistent with CRR 2011. As CRR 2016 will not be raising the O'Connell Terrace bridge, there is reduced potential for disruption to access along O'Connell Terrace;
Impact on heritage buildings and structures will be similar to CRR 2011.
Benefits
The Project will maintain year round access to Exhibition Station, RBWH and the RNA Showgrounds and supports growing residential and other uses in Bowen Hills, consistent with CRR 2011;
Exhibition Station will have a low potential for air quality impacts and there will be no change in predicted noise and vibration impacts at this worksite, consistent with CRR 2011;
Enhanced pedestrian access will be provided between Exhibition Station and both O'Connell Terrace and Bowen Bridge Road; and
Impacts on fig trees at the RNA Showgrounds will be slightly reduced compared to CRR 2011;
Heavy vehicle movements to and from CRR 2016 worksite are consistent with CRR 2011.
Overall summary</td></tr>
</table>

Location	Local area impacts and benefits	
	CRR 2011	**CRR 2016 change**
	• Improved public transport services to support future developments at the Bowen Hills PDA and RNA Showgrounds.	The overall impacts at Exhibition Station are considered to be slightly reduced compared to CRR 2011.
Mayne Yard (north of Exhibition Station and including Mayne Yard)	***Impacts*** • Rail tracks to be constructed on viaduct would have resulted in potential visual impacts.	***Impacts*** • There is potential for an increase in construction noise for CRR 2016 (compared with CRR 2011) due to the more intensive nature of construction activity of the proposed trough (underpass) compared to the viaduct; • Removal of contaminated spoil from the Mayne Yard trough including the risk of odour impacts from contaminated soils associated with the extraction and handling of these materials; and • Increase of dust is predicted at two receptors at Burrows Street (both commercial buildings) and standard dust management practices will apply. ***Benefits*** • There will be less visual impacts for CRR 2016 due to removal of the viaduct and construction of a trough (underpass); • Construction worksite particulate air emissions for CRR 2016 will be lower than CRR 2011; and • Heavy vehicle movements to and from this worksite for CRR 2016 are forecast to be less than the peak haulage movement forecast in CRR 2011. ***Overall summary*** The overall impacts at Mayne Yard will be consistent with those identified for CRR 2016.

16.2.6 Project workforce

Consistent with CRR 2011, the CRR 2016 Project will generate a large demand for skilled workers as well as general civil construction labour during the construction phase. The project workforce for CRR 2016 is expected to be similar to that identified for CRR 2011 as shown in Table 16.3. In addition, the Project will generate a range of indirect jobs, such as in the construction, financial and business services, Government services and road transport sectors.

As with CRR 2011, parking for workers and visitors will be provided at each major construction worksite and limited visitor parking at Albert Street and Roma Street Station.

When operational, in addition to the workers to operate train services and staff stations, maintenance workers will be required to maintain project infrastructure.

Table 16.3 Comparison of the number of workers between CRR 2011 and CRR 2016

Numbers of workers per annum	CRR 2011 number of workers	CRR 2016 number of workers
Workers during construction (construction workers, Project Managers, design staff etc.)	1,600	1,547
Workers during peak construction period	2,200	2,932
Workers during operation	230[58]	576

16.3 Changes to mitigation measures

Mitigation measures which are consistent with CRR 2011 include the following:

- Providing on-going communication of construction activities and timeframes to impacted people, prior to the commencement of activities;
- A comprehensive suite of integrated mitigation measures relating to noise, vibration, dust and traffic management, within the Draft Outline EMP for both the construction and operational phases of the Project;
- Investigating the sequencing of construction works to minimise impacts;
- Investigating new initiatives, such as public art programs at the new stations and the involvement of bushland and park regeneration management groups in revegetation projects;
- Consultation between the Project and other developments to manage cumulative impacts during construction relating to such matters as traffic (including pedestrian, cycling), haulage routes and activities, noise/vibration, dust, visual amenity, etc;
- On-going consultation and coordination with the RNA to manage potential cumulative impacts, with respect to construction timeframes, construction sites, demolition, spoil removal and construction material haulage in order to minimise potential cumulative impacts on parking, access, traffic, noise, dust and the effective management of operations at the RNA Showgrounds; and
- Management of construction activities to minimise impacts during events e.g. Ekka (Exhibition Station), Gabba Stadium (Woolloongabba Station) and Suncorp Stadium (Roma Street Station).

[58] Excludes indirect jobs

Mitigation measures which are no longer relevant to CRR 2016, previously identified for CRR 2011, are limited to consultation and coordination with the Yeerongpilly TOD and discussions with key community groups such as the Dutton Park Primary State School regarding noise barriers along the school boundary.

Additional mitigation measures now relevant to CRR 2016 include:

- Involvement of the Traditional Owners, local communities and other relevant stakeholders, in rehabilitation of open space areas affected by construction activities; and
- Opportunities to relocate Outlook Park facilities prior to construction will be explored in consultation with BCC.

16.4 Conclusion

The Project will provide long-term benefits to communities in the study corridor, Brisbane and SEQ through improved transport access to major centres and employment areas.

The Project also supports important growth areas in inner Brisbane, helping to achieve the objectives of the SEQ Regional Plan 2009-2031 related to compact urban form and connecting communities. Long-term beneficial social and community effects will be realised through increased accessibility and connectivity to a range of district and regional level social infrastructure.

A range of impacts are reduced in CRR 2016 due to the smaller footprint and shorter tunnel length. There will be an overall reduction in the number of people exposed to potential social impacts during construction and operation of the Project. Social impacts relating to noise/vibration, dust, traffic and visual amenity will generally remain consistent to those previously identified for CRR 2011 although in some areas occur in different locations.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

17 Technical Report: Economics

17.1 Introduction

This technical report discuss changes to the economic assessment resulting from CRR 2016. A Cost Benefit Analysis summary of the CRR 2016 Business Case was published in June 2016 and provides an assessment of the project based on the following major capital elements:

- Twin 5.9km tunnels, entering a Southern portal north of Dutton Park Station, travelling under the Brisbane River and Brisbane CBD before exiting the Northern portal south of the Exhibition Station;
- Four new underground stations at Boggo Road, Woolloongabba, Albert Street and Roma Street;
- One upgraded station at Dutton Park and a new surface station at Exhibition;
- Northern surface works consisting of a new track from the portal around the Exhibition Loop and through to Mayne Yard;
- Provision for additional stabling at Mayne North Yard; and
- European Train Control System Level 2 (ETCS L2) installed inside the tunnels.

The key strategic benefits identified in the CRR 2016 Business Case are consistent with those of CRR 2011, and include:

- An additional rail crossing under the Brisbane River near the Brisbane CBD;
- Additional rail capacity to significantly improve and increase rail services across the SEQ network;
- Less-congested roadways; and
- City-building opportunities, for example at Woolloongabba, the Brisbane CBD and Bowen Hills.

The primary economic opportunity that has changed for CRR 2016 is the overall construction task being smaller due to the exclusion of works south of Dutton Park Station, affecting the cost, resources and labour required.

Refer to Technical report 16 (Social environment) for a comparison of the projected labour force and jobs created for CRR 2011 and CRR 2016.

17.2 Changes to potential impacts

17.2.1 Changes to Cost Benefit Analysis

A detailed CBA was undertaken as part of the CRR 2016 Business Case to test the project's economic viability. CBA is universally applied to investment decision making for infrastructure in Australia. Its principles are accepted as the most appropriate tool to measure the direct contribution to economic and social objectives. It measures the direct impacts of public sector investment relative to whole-of-life costs.

The key assumptions used for the CRR 2011 and CRR 2016 economic appraisals are shown in Table 17.1. A comparison of the CBA results for CRR 2011 and CRR 2016 is provided in Table 17.2.

Table 17.1 Economic appraisal assumptions

	CRR 2011	CRR 2016
Discount rate (based on Infrastructure Australia)	A central rate of 7% (real). Sensitivities at 4% & 10 %	A central rate of 7% (real). Sensitivities at 4% & 10 %
Price year	2010	December 2015
Evaluation period	30 years of benefits post construction	30 years of benefits post construction

Table 17.2 Comparison of CRR 2011 and CRR 2016 CBA

	CRR 2011	CRR 2016
Estimated Cost of Delivery	$8.9b (2010)	$5.4b (2015)
Benefit Cost Ratio (BCR)	1.42	1.41
Net Present Value (NPV)	$2,345m	$1,877m
Estimated No. of Jobs Per Annum	Construction - 1,600 FTEs Post-construction - 230 FTEs[59]	Construction - 1,547 FTEs Post-construction - 576 FTEs
Wider Economic Benefits	$1,176m	$1,209m

17.3 Conclusion

CRR 2016 continues to provide positive project economic benefits, supports construction and operational employment and provides wider economic benefits including productivity gains.

[59] Excludes indirect jobs

18 Technical Report: Hazard and risk

18.1 Introduction

This technical report discusses changes to the hazard and risk assessment. CRR 2011 described the potential hazards and risks to which people and property could be exposed by the Project, including natural events and the implications of climate change. The CRR 2011 EIS[60] contains a hazard and risk register which assessed hazards in terms of impacts, likelihood, consequence and the resulting risk. This was done for the unmitigated and then the mitigated scenarios.

The CRR 2016 project results in changes to the design and the construction methodology. The CRR 2011 hazard and risk register was reviewed to identify where changes will occur to the hazards and where new hazards arise. These hazards were then assessed to identify where changes occurred to the risk which resulted in additional or different mitigation measures being required.

18.2 Design changes related to hazard and risk

The changes to design are summarised below:

- The tunnel length has been reduced from approximately 10km to 5.9km;
- All previously proposed works south of Dutton Park Station are excluded from CRR 2016. This includes station works, access roads and the ventilation shaft at Fairfield;
- The Southern portal has been relocated from Yeerongpilly to north of Dutton Park Station;
- Boggo Road Station is no longer located under Boggo Road Gaol but further east between the Ecoscience Precinct building and existing rail corridor. As a result, the construction methodology for the station also changes;
- Woolloongabba Station has moved from the western to the eastern side of the GoPrint building;
- Albert Street Station has moved from between Alice Street and Mary Street to between Mary Street and Charlotte Street;
- Opportunity to pedestrianise and permanently close to through-traffic Albert Street between Mary Street and Charlotte Street and between Charlotte Street and Elizabeth Street;
- The Myer Centre car park exit on Albert Street may be closed or, if required, relocated to Charlotte Street to facilitate a northern station entrance;
- Re-aligned tunnels running under the Queensland Law Court buildings between Albert Street and George Street;
- Roma Street Station has been rotated and moved to the west requiring the demolition of the BTC (West Tower) and coach ramps;
- Realigned tunnel section from Roma Street Station to the Northern portal generally following the existing rail corridor;
- Relocation of the Northern portal in the existing rail corridor near the ICB and the BGGS;
- The fourth rail track is no longer proposed between the Northern portal and Mayne Yard, instead one rail track will be provided;

[60] Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement, Appendix J.

- Exhibition Station will be similar to CRR 2011 with the exception of no works to O'Connell Terrace bridge;
- Through Mayne Yard, the rail alignment is at surface and partially in trough (underpass), instead of on viaduct;
- The project now ties in to existing tracks north of Breakfast/Enoggera Creek (instead of south of the creek); and
- The horizontal and vertical alignment differs in places compared to CRR 2011.

18.3 Construction method changes related to hazard and risk

The changes relating to construction that are different for CRR 2016 include:

- From Boggo Road Station to Woolloongabba Station will be constructed by mined tunnel;
- Two TBMs are proposed for tunnelling rather than four;
- Tunnelling operations are predominately commenced from the Woolloongabba site including access for spoil and materials; and
- The worksite sizes for CRR 2016 are comparable to CRR 2011, however their locations have changed to reflect changes to alignment and station locations.

18.4 Changes to the commissioning phase for CRR 2016

As part of the completion of the CRR 2016 Project, a programme of testing will be undertaken over the commissioning phase. The commissioning phase will test all of the elements of the project individually, as coordinated systems and as an overall project wide system. Requirements will be consistent with CRR 2011. The key change will be the integration of the new ETCS and associated systems and signalling.

18.5 Hazardous activities and receptors

Receptors that could potentially be exposed to hazards include the following:

- Residential communities;
- Heritage places, health and community facilities;
- Sensitive receptors adjacent to the stations;
- Commuters who would use the train networks associated with the Project;
- Motorists, pedestrians and cyclists who use the existing pedestrian, road, bus and train networks surrounding the Project;
- Groundwater and surface water catchments and ecological communities; and
- The workforce constructing and operating the Project.

For CRR 2016, construction activities which have the potential to result in hazards include the following, which are broadly consistent with CRR 2011:

- Operation of vehicles and construction equipment in the confined tunnel and station areas, leading to the potential for spillages, fire, poor air quality and collisions;

- Storage of hazardous substances, use of oils, fuels and other hazardous chemicals including explosives, and their transport to construction areas;
- Construction failures and accidents including tunnel and station collapse or subsidence, flooding and worker injuries and death;
- Possible underground inflow of pollutants such as hydrocarbons and toxic chemicals;
- The transport of excavated materials to disposal areas;
- Working within an operating rail corridor, in close proximity to electricity in the operations rail corridors and facilities; and
- Tunnelling, including mined and bored may generate vibration causing property damage within the study corridor. This activity in particular will be different to CRR 2011, which did not include mined tunnelling.

In addition, similar to CRR 2011, operational activities which have the potential to result in hazard including: passenger safety incidents, staff and vehicle accidents and incidents in the tunnel, major train incidents including derailment, collision and fire, acts of terrorism leading to major fires and explosions, maintenance in a live rail corridor and flooding and inundation from both surface and groundwater sources.

18.6 Changes to potential impacts - risk assessment and management

The previous CRR 2011 Hazard and Risk Register was reviewed to consider the changes to impact, risk and mitigation as a result of the changes identified in Sections 18.2 to 18.4 above. This was done for each of the construction and operation hazards and risks previously identified.

It was determined that although the location or specifics of the impact may change for CRR 2016, the residual risk remains unchanged and the mitigation measures proposed as part of CRR 2011 remain relevant.

The CRR 2016 Draft Outline EMP (Volume 2) identifies the mitigation measures proposed to prevent and manage environmental impacts associated with the Project.

19 Technical Report: Cumulative impacts

19.1 Introduction

This technical report discuss changes to cumulative impacts resulting from CRR 2016. Cumulative impacts on environmental values/receptors is one or both of the following:

- The combination of individual environmental effects, such as, traffic impacts with noise and vibration impacts and dust impacts on a single receptor (e.g. human beings). The interaction of various environmental effects may occur during construction and/or operation; and
- The environmental impacts which result from CRR 2016 combined with the environmental impacts of one or more other projects on a single receptor, which occur at or around the same time. For example, the cumulative impacts of construction traffic from another development constructed at the same time as CRR 2016.

There is the potential for several infrastructure and urban development projects to be constructed at the same time as CRR 2016. These projects have potential to increase cumulative impacts resulting in disruption, nuisance and loss of amenity.

19.2 Changes to cumulative impacts with other projects

Cumulative effects from other projects combined with the CRR 2016 Project may be influenced by the spatial extent or geographical boundaries, the nature of the project and its impacts, the sensitivity of the receptors, receptor interactions, natural boundaries, and potential source-pathway-receptor interactions.

Since CRR 2011, a number of projects previously assessed to have potential cumulative impacts are no longer relevant to this assessment, including:

- Legacy Way;
- Eastern Busway (Main Avenue, Capalaba);
- Yeerongpilly TOD; and
- Sunland, Mary Street.

These projects are either already completed, will be completed prior to construction of CRR 2016, fall outside the CRR 2016 study corridor or are no longer considered to be proceeding in a relevant timeframe.

The projects which are consistent with those assessed for CRR 2011 and are also assessed against the CRR 2016 project include:

- Kingsford Smith Drive upgrade;
- Bowen Hills PDA - RNA Showground redevelopment;
- Woolloongabba PDA; and
- Boggo Road urban village.

Additional projects now relevant to CRR 2016, which were not previously assessed for CRR 2011, include:

- Albert Street redevelopment;

- Queen's Wharf Brisbane;
- Roma Street redevelopment;
- Brisbane Metro Subway System; and
- Inland Rail.

The ICB upgrade, which has connections to Lutwyche Road, Airport Link Tunnel, Clem Jones Tunnel, Legacy Way tunnel and Kingsford Smith Drive will commence construction in late 2016 and be completed by 2018. For this reason, it has not been included in the cumulative assessment.

A summary of the infrastructure and urban development projects that are planned or are being constructed that could interact with CRR 2016 is shown in Table 19.1

Table 19.1 Description of projects that may have cumulative impacts with CRR 2016

Name	Description
Boggo Road Urban village development	As part of this ongoing development, the Boggo Road Gaol buildings and courtyards will open up to a range of historical, educational and cultural opportunities. This will incorporate a mix of residential apartments, commercial office space and a new cultural and retail marketplace, all clustered around the adaptive reuse of the Gaol. The Boggo Road urban precinct will create a vibrant inner-city urban village that respects the historic significance of the Boggo Road Gaol, supports innovative knowledge-based research and businesses (Ecosciences Precinct), and creates a liveable, connected and sustainable urban community[61].
Woolloongabba PDA	The Woolloongabba PDA is a 10 hectare site bounded by Vulture Street to the north, Stanley Street to the south, Allen Street to the west and Main Street to the east. This proposed development will be located in areas with accessibility in the station precinct and will incorporate the CRR 2016 Woolloongabba Station and bus interchange. The current PDA envisages a central core of parkland and urban plaza areas that will provide gathering places and accommodate a range of community and recreational activities[62].
Albert Street redevelopment	The Brisbane City Centre Master Plan 2014 identifies the revitalisation of Albert Street to establish the street as a pedestrian boulevard, creating an active transport connection ('green spine') between the City Botanic Gardens and Roma Street Parklands and an open business and outdoor lifestyle[63].
Queen's Wharf Brisbane	This major development comprises: 26.8 hectares of redeveloped and public realm; a new pedestrian bridge to South Bank; a signature "Arc" building, including a feature Sky Deck, with restaurants and bars fully accessible to the public; five new premium hotels; three residential towers; a new department store; around 50 food and beverage outlets; a riverfront cinema; a Queensland Hotel and Hospitality School in partnership with TAFE Queensland[64].
Roma Street redevelopment	Roma Street Station is the city's premier transport hub, providing a gateway for long distance tourists and everyday workers. The

[61] www.boggoroadcommunity.com.au/. Accessed 5 July 2016.
[62] www.dilgp.qld.gov.au/resources/plan/pda/woolloongabba-development-scheme.pdf Accessed 1 June 2016.
[63] www.brisbane.qld.gov.au/planning-building/planning-guidelines-tools/city-centre-master-plan/priority-projects/priority-project-albert-street. Accessed 6 July 2016.
[64] www.statedevelopment.qld.gov.au/major-projects/queens-wharf-brisbane.html. Accessed 30 May 2016.

Name	Description
	station area will be enhanced as a subtropical city boulevard, celebrating the arrival experience. The area around the BTC will be redeveloped and revitalised to provide grand architecture and civic entrances. Underground transport facilities will unlock the capacity of the station and provide a new transit portal to the city centre.[65]
Bowen Hills PDA (RNA Showgrounds redevelopment)	The Bowen Hills PDA covers a total area of 108 hectares. The PDA contains a number of landmarks including: the RNA Showgrounds, Old Queensland Museum, Perry Park and Bowen Hills Railway Station[66]. Of particular relevance to the CRR 2016 is the RNA redevelopment. The project includes 340,000m^2 of new residential, commercial and retail buildings, together with an additional 76,000m^2 of new development on RNA retained land. The project includes the upgrade of the Brisbane Showgrounds including the completed Royal International Convention Centre, Plaza and Porte-Cochere together with 5.5 hectares of new development comprising of The Green and The Yards residential apartments, Kingsgate commercial precinct and the creation of King Street[67].
Kingsford Smith Drive upgrade	This project includes widening the existing road from four to six lanes between Theodore Street at Eagle Farm and Cooksley Street at Hamilton. It will also include improvement works between Cooksley Street and Breakfast/Enoggera Creek Road at Albion. It will improve the link between the CBD and Brisbane Airport, Port of Brisbane, Northshore Hamilton and the Australia Trade Coast area. It provides a strategic link between major urban, trade and tourism centres[68].
Brisbane Metro Subway System	The Brisbane Metro Subway System is a proposal by the BCC. If constructed, the project would consist of a mixture of new underground tunnels and transformation of the existing South East and Inner Northern Busways from Woolloongabba to Herston and into the CBD. It would cover a distance of approximately 7km and have three new stations with upgrades made to existing busway stations. The metro line would travel along the South East Busway into a new underground tunnel and station at the Cultural Centre before traversing the Victoria Bridge and into a new underground section beneath Adelaide Street. The metro would then connect to King George Square Station and use the existing route of the Inner Northern Busway stopping at all stations to Herston[69].
Inland Rail	Inland Rail is a 1,700km freight line that will extend between Melbourne (Tottenham) and Brisbane (Acacia Ridge), travelling via regional Victoria, New South Wales and Queensland. It will deliver enhancements to 700km of existing interstate track, major upgrades to a further 400km of track and construct 600km of new track. The track will enable the use of double-stacked, 1,800me and 21 tonne axle load trains, allowing for the transit of greater freight volumes and travel at speeds of up to 110km/hr.

A comparison of indicative construction timeframes for the above mentioned projects relative to CRR 2016 is shown in Table 19.2. Potential cumulative impacts from these projects may have either

65 www.brisbane.qld.gov.au/sites/default/files/transformative_area_poster_roma_street.pdfAccessed July 2016.
66 www.dilgp.qld.gov.au/resources/plan/pda/bowen-hills-development-scheme.pdf. Accessed 5 July 2016
67 www.rna.org.au/redevelopment.aspx. Accessed 1 June 2016
68 http://ksdupgrade.com.au/. Accessed 1st June 2016
69 https://brisbanedevelopment.com/brisbane-city-council-propose-brisbane-metro/. Accessed 1 June 2016

a direct interaction with CRR 2016 or an indirect interaction due to proximity and overlapping construction periods.

Table 19.2 Indicative construction timeframes for other proposed projects

Location	2017	2018	2019	2020	2021	2022	2023
The CRR 2016 project							
Boggo Road Urban village development							
Woolloongabba PDA							
Albert Street redevelopment							
Queen’s Wharf Brisbane							
Roma Street redevelopment							
Bowen Hills PDA (RNA Showgrounds redevelopment)							
Kingsford Smith Drive upgrade							
Brisbane Metro Subway System							
Inland Rail							

Direct effect	
Indirect effect	

19.2.1 Transport infrastructure projects

Kingsford Smith Drive upgrade

The Kingsford Smith Drive upgrade project has commenced and was initially identified as a possible haulage route to remove spoil for the northern worksites. However, based on the spoil haul route options identified for CRR 2016, using Kingsford Smith Drive to transport spoil has not considered viable based on the road upgrade occurring at the same time as CRR 2016. An alternative route, along Airport Link has therefore been proposed for CRR 2016. CRR 2011 had proposed to send spoil to Swanbank and did not propose Kingsford Smith Drive as a transport route. CRR 2016 is consistent with CRR 2011 in that there will be no cumulative impact.

Brisbane Metro Subway System

In 2016, BCC proposed the Brisbane Metro Subway System (BMSS) to address inner city bus network constraints. The project proposes a 7km link connecting Woolloongabba, through the CBD, to Herston and would predominantly use existing northern and south east busway infrastructure. Commencement of the metro project is subject to funding and the outcomes of a Business Case process. The BMSS project is not considered incompatible with CRR 2016 with both project serving particular future public transport needs.

As the BMSS project proposes upgrades to existing stations (in particular at Roma Street) and new stations (at Woolloongabba), there is the potential for direct cumulative impacts to result alongside CRR 2016 construction works. Cumulative impacts may include additional traffic congestion due to movement of construction materials in and around these locations, noise and vibration from construction activities, dust/air quality changes and construction work and visual impacts. Commercial businesses and residents in close proximity to Woolloongabba Station may be particularly sensitive to these activities along Vulture Street, Stanley Street and Main Street. Similarly, receptors located along Roma Street, George Street, Makerston Street, and other nearby streets to Roma Street Station may be affected.

The potential cumulative impacts of the BMSS project in combination with the CRR 2016 project were not previously identified for CRR 2011. These cumulative impacts would need to be assessed in further detail should the BMSS project proceed to delivery.

During operation, the increase in capacity on both bus and rail systems would help meet future needs of Brisbane's growing city. The cumulative impacts during operation are therefore considered to potentially provide beneficial effects.

Inland Rail

The Inland Rail project will extend between Melbourne and Brisbane and provide a freight line from Melbourne to Acacia Ridge. It is unlikely that this will have any cumulative impact if constructed at the same time as CRR 2016, however it may affect the wider network once Inland Rail and CRR 2016 become operational, with increased freight rail trains utilising the existing dual gauge track south of Dutton Park Station in conjunction with CRR trains. Freight rail is further discussed in Technical report 1 (Transport).

19.2.2 Urban development projects

Boggo Road urban village development

The ongoing Boggo Road urban village development may occur either during or closely after completion of CRR 2016. Direct cumulative impact may include additional construction traffic movement along Boggo Road, Joe Baker Street and Peter Doherty Street, increased access and amenity issues to nearby residents, potential noise, vibration, dust and visual impacts experienced by nearby sensitive receptors at Rawnsley Street, the Ecoscience Precinct, Leukaemia Foundation, PA Hospital, and Boggo Road Gaol. These potential cumulative impacts are consistent with CRR 2011. Further consultation will be required to explore opportunities to ensure appropriate integration of development and design components during construction and operation.

Once operational, the cumulative impact of Boggo Road Urban Village and CRR 2016 will have a long-term beneficial effect on the local and broader community, through provision of accessible public transport that is integrated with the surrounding urban development. CRR 2016 will help to deliver integrated transport – land use outcomes in this area, consistent with CRR 2011.

Woolloongabba PDA

There is the potential for development within the Woolloongabba PDA to occur during or shortly after the completion of CRR 2016, although the timing of future development is still to be determined. Direct cumulative impacts, consistent with those identified for CRR 2011, may include increased construction traffic and spoil/demolition haulage along Stanley and Vulture Street, temporary increases during construction from noise, vibration, dust and visual impacts. The Proponent will continue to work with relevant parties to coordinate design and development activities in this precinct to determine an efficient delivery and staging strategy. This may include the consideration of the orientation and siting of tall buildings within the development and the integration of development within the site to maximise connectivity to the surrounding health, entertainment and sporting precincts.

CRR 2011 identified that the Woolloongabba PDA proposed a number of pedestrian and cycle connectivity changes within the precinct which would adequately support the relocation of the Woolloongabba Station at the GoPrint site. It identified a key vehicular and pedestrian street between Main Street and the PDA that would facilitate connectivity to the public transport interchange and Gabba Stadium during major events. This planning is still current and relevant to CRR 2016, however requires revision to reflect the new station location. The Woolloongabba Station will provide a high quality public transport service and interchange opportunity for the area including the employment centre at the Mater Hospital and the Gabba Stadium. The Woolloongabba PDA, hospital campus and sporting venue will become more accessible to the population of SEQ.

Albert Street redevelopment

The Albert Street precinct was not previously identified for redevelopment during CRR 2011. The proposed works at Albert Street Station for CRR 2016 will be undertaken either prior to or in conjunction with redevelopment along Albert Street as part of the BCC City Centre Master Plan 2014 (Albert Street Vision). This will provide improved public amenity space and pedestrian outcomes, along with enhanced transport integration and connectivity. As part of CRR 2016, it is proposed to permanently close and pedestrianise Albert Street between Mary Street and Charlotte Street and pedestrianise between Charlotte Street and Elizabeth Street with some local traffic access. The CRR 2016 would in effect be the catalyst for the BCC vision for Albert Street.

Should the construction works be undertaken simultaneously, there is potential for direct cumulative impacts to traffic movement including pedestrians and cyclists and an increase of impacts associated with noise, vibration, dust and visual amenity on nearby residents and businesses. Further planning with BCC would manage the potential for this cumulative impact.

Queen’s Wharf Brisbane

With the Queen’s Wharf Brisbane development approximately 300m from the CRR 2016 Albert Street Station, potential direct cumulative impacts relate to construction traffic congestion, changes to pedestrian and cycle movement, noise and vibration, dust, and visual impacts. These potential cumulative impacts were not previously identified for CRR 2011.

Of these potential cumulative impacts, construction traffic is considered to be of particular note for CRR 2016. Construction traffic for both projects may utilise similar haulage routes resulting in potential impacts on traffic flow in and around the CBD. Intersections potentially common to both projects include George Street/Alice Street and William Street/Alice Street.

Prior to construction, a Traffic Management Plan will be completed for the CRR 2016 Albert Street Station and will need to be co-ordinated with the Queen’s Wharf Brisbane project, should these projects be constructed at the same time.

During operation, the cumulative impacts experienced by CRR 2016 along with the Queen’s Wharf Brisbane is likely to result in increased pedestrian activity in the local area, which may require further planning of the CBD street movement system. The proposed permanent closure of Albert Street (Mary Street to Elizabeth Street) to through-traffic for CRR 2016 will also result in mitigation works at the intersection of George Street and Elizabeth Street, as discussed in Technical report 1 (Transport). Further investigations may be required of cumulative impacts of traffic at key intersections.

Roma Street Redevelopment

CRR 2016 provides the opportunity for the redevelopment of the Roma Street precinct as identified in the BCC City Centre Master Plan 2014. Although unlikely, should redevelopment coincide with the construction of the CRR 2016 Roma Street Station, there would be potential for direct cumulative impacts to occur that were not previously identified for CRR 2011.

If constructed simultaneously, impacts may include increased construction traffic and demolition haulage along Roma Street and adjoining roads, temporary increases during construction from noise, vibration, dust and visual impacts, especially for nearby residents (Parkland Boulevard) and commercial business opposite Roma Street Station.

During operation, there will be significant opportunities to integrate the new public transport facilities with future urban development opportunities.

Bowen Hills PDA (RNA Showgrounds redevelopment)

Redevelopment of the RNA Showgrounds as part of Bowen Hills PDA will be located either side of the CRR 2016 Exhibition Station. There is the potential for direct cumulative impacts to arise due to its proximity and overlapping construction timeframes which may result in increased pressures on local on-street car parking; changes to vehicle, pedestrian and cycle access to key facilities, including the BGGS, St Joseph's College, Gregory Terrace, Victoria Park, RBWH and the RNA Showgrounds. There is also potential for reduced amenity from construction noise, vibration and dust impacts.

Both the CRR 2016 Exhibition Station and RNA redevelopment could potentially affect existing cultural heritage on the RNA Showgrounds, heritage listed places and buildings. The CRR 2016 potential heritage impacts are discussed in Technical report 15 (Non-Indigenous cultural heritage). However, development will seek to retain or adapt heritage, character and cultural features and history of the site and surrounding area. On completion of construction works, CRR 2016 will provide increased accessibility to the RNA site.

The potential cumulative impacts associated with the Bowen Hills PDA are consistent with those identified by CRR 2011.

19.3 Changes to management of cumulative impacts

Mitigation measures which are consistent with CRR 2011 include the following:

- Provide timely and clear information on the project and support to local residents;
- To undertake further investigation on the staging of construction works to minimise impacts;
- To undertake investigation of new initiatives, such as public art programs at the new stations and the involvement of bushland and park regeneration management groups in revegetation projects;
- Implement a variety of control measures as outlined in the Draft Outline EMP including traffic management;
- Undertake consultation and coordination with other nearby developments to ensure impacts are minimised on nearby sensitive receptors; and
- On-going coordination during planning and construction with the RNA to minimise impacts to heritage where possible.

Additional mitigation measures now relevant to CRR 2016 include:

- Integrate environmental design requirements (as detailed in the Draft Outline EMP) into the detailed design phase to further avoid or reduce construction impacts;
- Undertake regular reviews during construction to identify other developments with the potential to result in cumulative impacts;
- During construction of CRR 2016, engage in early and ongoing consultation with entities responsible for other projects with overlapping construction periods. This consultation will

coordinate construction activities as far as practicable through an integrated approach to reduce cumulative impacts;

- The Proponent is to consult with the BCC and the various entities responsible for other developments in order to better integrate connectivity and functionality between these developments so as to fully realise their significant economic and social benefits;
- Undertake a pedestrian and cycle assessment (relating to construction and operation) to determine suitable mitigation measures around Albert Street. Also undertake further investigations of the CBD street movement system to respond to the operational cumulative impacts of CRR 2016 and Queen's Wharf Brisbane on increased pedestrian activity in the local area; and
- Undertake further investigations to assess potential cumulative impacts of traffic at key intersections along Alice Street, George Street and Roma Street.

19.4 Conclusion

There is potential for direct and indirect cumulative impacts (such as traffic congestion, changes to pedestrian/cycling movement, noise/vibration, dust and visual amenity) to arise should other planned future projects be constructed at the same time as CRR 2016. The majority of these potential cumulative impacts were previously identified for CRR 2011 including those associated with the Bowen Hills PDA (RNA Showgrounds redevelopment), Woolloongabba PDA and Boggo Road urban village.

Potential cumulative impacts now also relevant to CRR 2016 include those associated with the Albert Street and Roma Street redevelopments, Queen's Wharf Brisbane and Brisbane Metro Subway System. Ongoing consultation and coordination with key stakeholders will be essential to coordinate developments with a view to reducing cumulative impacts and explore opportunities to integrate functionality and community benefits.

Refer to Volume 2 for the Draft Outline EMP which identifies the mitigation measures proposed to prevent and manage environmental impacts associated with this Project.

Appendix F

References

F1 Technical References

Australian Bureau of Statistics Survey of Motor Vehicle Use for Year Ending 31 October 2014 (9208.0), Australian Bureau of Statistics, released 15 October 2015 http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/9309.031%20Jan%202015?OpenDocument

Department of Environment and Heritage Protection, 2008. Environmental Protection (Air) Policy 2008, downloaded from https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProtAirPo08.pdf.

Department of Environment and Heritage Protection, 2015. Guideline: Environmental Protection Act 1994 - Application requirements for activities with impacts to air, Version 3.01, Effective 15 October 2015.

https://brisbanedevelopment.com/brisbane-city-council-propose-brisbane-metro/. Accessed 1 June 2016.

https://ksdupgrade.com.au/. Accessed 1st June 2016.

Motor Vehicle Census Australia 31 January 2015 (9309.0), Australian Bureau of Statistics, released 23 July 2015 http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/9309.031%20Jan%202015?OpenDocument

National Environment Protection Measure (Ambient Air Quality), as amended 3 February 2016, National Environment Protection Council, downloaded from https://www.legislation.gov.au/Details/F2016C00215

Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement.

Queensland Department of Transport and Main Roads, 2014, Bus and Train Project Environmental Impact Statement, Revised Reference Design Assessment Report

Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement.

Queensland Department of Transport and Main Roads, 2011. Cross River Rail Environmental Impact Statement Technical Report No.7 – Air quality and greenhouse gas assessment, SKM Aurecon.

Queensland Department of Transport and Main Roads, 2011, Cross River Rail Environmental Impact Statement. Chapter 19 (report prepared by SKM-Aurecon, July 2011). '*Proposed Cross River Rail Project - Cultural Heritage Report' (Parts A and B) (report prepared by UQ Culture & Heritage Unit for SKM-Aurecon, November 2010)*.

Queensland Department of Transport and Main Roads, 2016, Cross River Rail 2016 -Transport Model.

Queensland Department of Transport and Main Roads, 2013. Transport Noise Management Code of Practice Volume 1 – Road Traffic Noise, Table 2.4 page 9, November 2013.

SLR Consulting Australia, 2011. Cross River Rail Environmental Impact Statement Operational Noise and Vibration PART A, document 20-2524-R3, dated 6 June 2011.

SLR Consulting Australia 2011. Cross River Rail Environmental Impact Statement Operational Noise and Vibration PART B, document 20-2524-R3, dated 6 June 2011.

SLR Consulting Australia, 2011. Cross River Rail Environmental Impact Statement Construction Noise and Vibration PART A, document 20-2654-R2, dated 14 July 2011.

www.boggoroadcommunity.com.au/. Accessed 5 July 2016.

www.brisbane.qld.gov.au/planning-building/planning-guidelines-tools/city-centre-master-plan/priority-projects/priority-project-albert-street. Accessed 6 July 2016.

www.brisbane.qld.gov.au/sites/default/files/transformative_area_poster_roma_street.pdf. Accessed July 2016.

www.dilgp.qld.gov.au/resources/plan/pda/woolloongabba-development-scheme.pdf Accessed 1 June 2016.

www.dilgp.qld.gov.au/resources/plan/pda/bowen-hills-development-scheme.pdf. Accessed 5 July 2016.

www.rna.org.au/redevelopment.aspx. Accessed 1 June 2016.

www.statedevelopment.qld.gov.au/major-projects/queens-wharf-brisbane.html. Accessed 30 May 2016.

Appendix G

Glossary of terms

G1 Glossary of terms

Abbreviation	Term
ACH	Aboriginal Cultural Heritage Act 2003
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AQMS	Air Quality Monitoring Station
ARTC	Australian Rail Track Corporation
ASS	Acid Sulfate Soils
BaT	Bus and Train
BGS	Brisbane Grammar School
BCC	Brisbane City Council
BCR	Benefit Cost Ratio
BGGS	Brisbane Girls Grammar School
BMSS	Brisbane Metro Subway System
BOM	Bureau of Meteorology
BTC	Brisbane Transit Centre
CBD	Central Business District
CHMP	Cultural Heritage Management Plan
CLR	Contaminated Land Register
CPTED	Crime Prevention through Environmental Design
CRR	Cross River Rail
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTMP	Construction Traffic Management Plan
Cut and cover	A method of tunnel construction involving 'top-down' excavation preceding the installation of a cover structure and possible back-filling above the cover
DATSIP	Department of Aboriginal and Torres Strait Islander Partnerships
dBA	A-weighted sound pressure measured in decibels
DD	Dust Deposition
DEHP	Department of Environment and Heritage Protection
DOS	Degree of Saturation
Drained tunnel	A 'drained tunnel' requires drainage layer to force the drawdown of the water table
Dual gauge line	A railway line capable of accommodating trains with two different wheel gauges. In Queensland dual gauge tracks are capable of accommodating standard gauge trains (1435mm wheel spacing) and narrow gauge trains (1067 mm wheel spacing)
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMR	Environmental Management Register

Abbreviation	Term
ENA	Energy Networks Association
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESCP	Erosion and Sediment Control Plan
ETCS	European Train Control System
F/C	Flammable and combustible
GHG	Greenhouse Gas
Groundwater drawdown	Groundwater drawdown – the observed impact on the piezometric level, that is, the in-situ groundwater level in an aquifer
Groundwater inflow	Groundwater inflow – volume of water that enters the underground structures, caverns, stations and tunnels
ICB	Inner City Bypass
ISCA	Infrastructure Sustainability Council of Australia
KM	Kilometre
LA_{eq}	The A-weighted average noise level. It is defined as the steady noise level that contains the same amount of acoustical energy as a given time-varying noise over the same measurement period
LA_{max}	The maximum A-weighted noise level associated with a sampling period
LF	Low Frequency Noise
LOS	Level of Service
M	metres
MLS	Metropolitan Line Service
NCAA	National Clean Air Agreement
NEPM	National Environment Protection Measure
NPV	Net Present Value
PA	Princess Alexandra
PDA	Priority Development Area
PM_{10}	Particulate matter less than 10 microns
$PM_{2.5}$	Particulate matter less than 2.5 microns
PPV	Peak Particle Velocity
QR	Queensland Rail
QUT	Queensland University of Technology
QUU	Queensland Urban Utilities
RBWH	Royal Brisbane Women's Hospital
RfPC	Request for Project Change Report
RIFA	Red Imported Fire Ant
RMS	Root Mean Square
RNA	Royal National Agriculture and Industrial Association
SDPWO	*State Development and Public Works Organisation Act 1974*
SEQ	South East Queensland

Abbreviation	Term
SIDRA	Signalised and un-signalised Intersection Design and Research Aid
TBM	Tunnel Boring Machine
TMR	Department of Transport and Main Roads
Track slewing	The realignment of rail tracks, usually involving a curve to change direction
TSP	Total Suspended Particulate
Undrained tunnel	An ‘undrained tunnel’ has no long-term drawdown of the water table. Typically bored tunnels are undrained
VKT	Vehicle Kilometres Travelled
WQO	Water Quality Objectives
WRRMP	Waste and Resource Recovery Management Plan
WSUD	Water Sensitive Urban Design
$\mu g/m^3$	microgram per cubic metre

CROSS RIVER RAIL

CROSSRIVERRAIL