Northern Link

3. Project Development

Northern Link

Phase 2 – Detailed Feasibility Study

CHAPTER 3

PROJECT DEVELOPMENT

- September 2008

Contents

3. Project Development

This chapter addresses Part B, Section 3.1 of the Terms of Reference (ToR) requiring a description of the various design options that were assessed in the development of the reference project. These are to include alternative route alignments which address the project objectives stated in the ToR. Design options should be discussed in sufficient detail to enable an understanding of the criteria for the selection of the preferred option in terms of technical, commercial, social and/or environmental aspects. Relevant illustrations, maps, diagrams and drawings that show the location and context of the assessed options should be provided.

3.1 Initial Development of the Project

The key findings of the *TransApex* Prefeasibility Study in March 2005 concluded that TransApex was a technically feasible and financially viable opportunity to address the growing congestion problems of Brisbane on the arterial roads of the inner city and the CBD. It would also contribute to delivering a transport system that would achieve integrated land use and sustainable transport outcomes. Northern Link would provide a cross-city tunnel connection between the Western Freeway at Toowong in the west and the Inner City Bypass (ICB) and Kelvin Grove Road in the north. Options for Northern Link connections considered in conjunction with the basic requirement of connection to the Western freeway included:

- a local connection in the west at Toowong;
- a connection to the ICB with a Kelvin Grove connection; and
- a connection to the ICB via a Hale Street connection.

The *TransApex* Prefeasibility Study investigated and documented two possible alternatives for the Northern Link project that incorporated these options. The two alternatives considered were a bored option and a railway option and are discussed in the following sections.

Bored Option

The Bored Option would connect the Western Freeway, west of the Toowong Cemetery, directly to the ICB, east of Kelvin Grove Road. Local connections were included in the Bored Option, to the Frederick Street roundabout and to the southern end of Kelvin Grove Road. The Bored Option would provide a direct connection between the Western Freeway and the ICB. The Bored Option would be approximately 5.52km in twin tunnels with two lanes of traffic in each direction.

The bored tunnel would commence before the boundary of the Toowong Cemetery and drive east in a straight line towards the ICB. A local connection was included with Frederick Street via south facing ramps and to Kelvin Grove Road via north facing ramps. The mainline tunnels would continue east to connect to the surface at the ICB east of Victoria Park Road. The Pre-feasibility Bored Option is shown on **Figure 3-1**.

- **Figure 3-1 Prefeasibility Bored Option**

Railway Option

The Railway Option would connect the Western Freeway, west of Toowong Cemetery to Hale Street, Milton and generally runs east of the railway line. A local connection to Sylvan Road at Bennett Street, Toowong via west facing ramps was included in the Railway Option.

The Railway Option maximised the use of cut and cover construction on the expectation that it would be less expensive than a driven tunnel option. It was developed to address a Milton Road option and comprised predominately cut and cover construction, with some shallow driven sections. The Railway Option alignment generally followed the railway corridor, although it was not directly influenced or controlled by the railway.

The Prefeasibility Railway Option is shown on **Figure 3-2**.

3.2 Preliminary Assessment of Prefeasibility Options

Following the TransApex Prefeasibility Study the Brisbane City Council undertook a Preliminary Assessment of the Northern Link project to assess whether Northern Link should progress to a Detailed Feasibility Study. The Preliminary Assessment was conducted in accordance with the Queensland Government's Value for Money Framework (VfM Framework) and to ensure that the project's development is consistent with the National Guidelines for Transport System Management (NGTSM) Framework for AusLink initiatives.

The initial review of the Prefeasibility Study options concluded that the preferred technical solution for further development was the Bored Option outlined in Council's *TransApex* Prefeasibility Study in 2005. Reasons supporting the decision to eliminate the Railway Option during the assessment was that it did not sufficiently meet the traffic, engineering and environmental criteria. Specifically, this included:

- a high risk of capital cost increase due to the greater property and traffic impacts and the variable geotechnical conditions and tunnelling methods required;
- greater community impacts due to extensive cut and cover tunnel construction work which would create noise and dust impacts in established residential areas;
- disruption of sporting clubs during construction;
- more surface rehabilitation works than the Bored Option with cost implications;
- geological conditions which prevent construction of a double deck driven tunnel; and
- high groundwater impacts from construction.

Figure 3-2 Prefeasibility Railway Option

3.2.1 Strategic Options Development

Development of the strategic options presented by the Bored Option (Option 1) was undertaken in order to further consider the key constraints, and the regional and local opportunities for the development of the Reference Project.

Bored mainline corridor options were initially identified to cater for identified strategic needs by providing a motorway standard link between the Western Freeway and the Inner City Bypass. The mainline corridors identified were:

- Western Freeway to Inner City Bypass;
- Western Freeway to Hale Street; and
- Western Freeway to North Quay.

Precinct connection opportunities from the mainline corridors were identified and are shown in **Table 3-1**. These precinct connections via the local road network were considered in the development of the strategic layouts.

Table 3-1 Precinct Connections

Precinct	Description	Precinct Connection Opportunities
Toowong	Specialist Centre - University of Queensland Major Centre - Regionally significant commercial and community based services	Frederick St Croydon St Jephson St Benson St
Kelvin Grove	Specialist Centre – Queensland University of Technology Kelvin Grove Urban Village	Kelvin Grove Rd Hale St
CBD	Primary Centre – significant centre of employment and business; ▪ Concentration of commercial, retail, administrative, educational, recreational and cultural facilities; and ▪ Government administration for the State	Countess St North Quay

Strategic options, using the three mainline corridors and precinct connections, were developed with consideration of the key physical and non-physical constraints in combination with the design parameters for the project as identified in **Table 3-2**.

Table 3-2 Strategic Review Framework

Traffic Criteria	Measure
Functional role of Northern Link in road hierarchy	Northern Link traffic volume (2026 AWDT)
	Freight traffic on Northern Link that is regionally significant (2026)
	Total traffic on Northern Link related to CBD travel (2026)
Engineering Criteria	**Measure**
Complexity of construction	Geotechnical, impact on services, connections complexity and tunnelling risk
Construction method flexibility	Worksites required, traffic management and construction traffic impacts
Programme	Length of construction, delay risks

Cost effectiveness	Base option comparative (Corridor Option 1)
Impacts on existing infrastructure	Impact on major infrastructure items, eg: ICB
Property impacts	Impact on properties
Environmental Criteria	**Measure**
Liveability, connectivity and amenity	Minimises impact on environmental constraints
Likely community acceptance	Level of community acceptance

As a result of the review five strategic options were identified for further development.

- **Option 1 – Prefeasibility Option**

Option 1 is the 'Bored Option', from the *TransApex* Prefeasibility Study as shown in **Figure 3-3**. Option 1 would connect at the western end to the Western Freeway at the Mt Coot-tha Road / Western Freeway roundabout in Toowong, and proceed directly to join the ICB to the east of Kelvin Grove Road. Two local connections were included in this option, to the Frederick Street / Milton Road roundabout at the western end and to Kelvin Grove Road at the eastern end.

The Western Freeway layout as presented for Option 1 would be developed further to create road geometry with compliant grades, but the extent of works on the Western Freeway may be significantly increased.

There would be an opportunity to undertake a major reconfiguration of the Mt Coot-tha Road / Frederick Street intersection, by removing the existing overpass and roundabout and creating a signalised intersection with or without grade separation. This would potentially address the merge/weave and legibility issues which exist with the present layout and would be reviewed at later stages of the project.

- **Option 2 – Straight Through**

Option 2 is the 'Bored Option', excluding the precinct connection ramps to Toowong at Frederick Street and Kelvin Grove Road. as shown in **Figure 3-4**. Option 2 would connect at the western end to the Western Freeway at the Mt Coot-tha Road / Western Freeway roundabout in Toowong, and proceed directly to join the ICB to the east of Kelvin Grove Road.

The Western Freeway layout as presented could be enhanced further to create road geometry with compliant grades, but the extent of works on the Western Freeway would be significantly increased. Roadheader and drill and blast excavation would be reduced as this option would remove the need to construct the tunnel junctions, ramps, and other variable tunnel cross sections. The underground Y junctions would also not be required.

- **Option 5 – Toowong Connection from Croydon Street and Enhanced Kelvin Grove Road Connection**

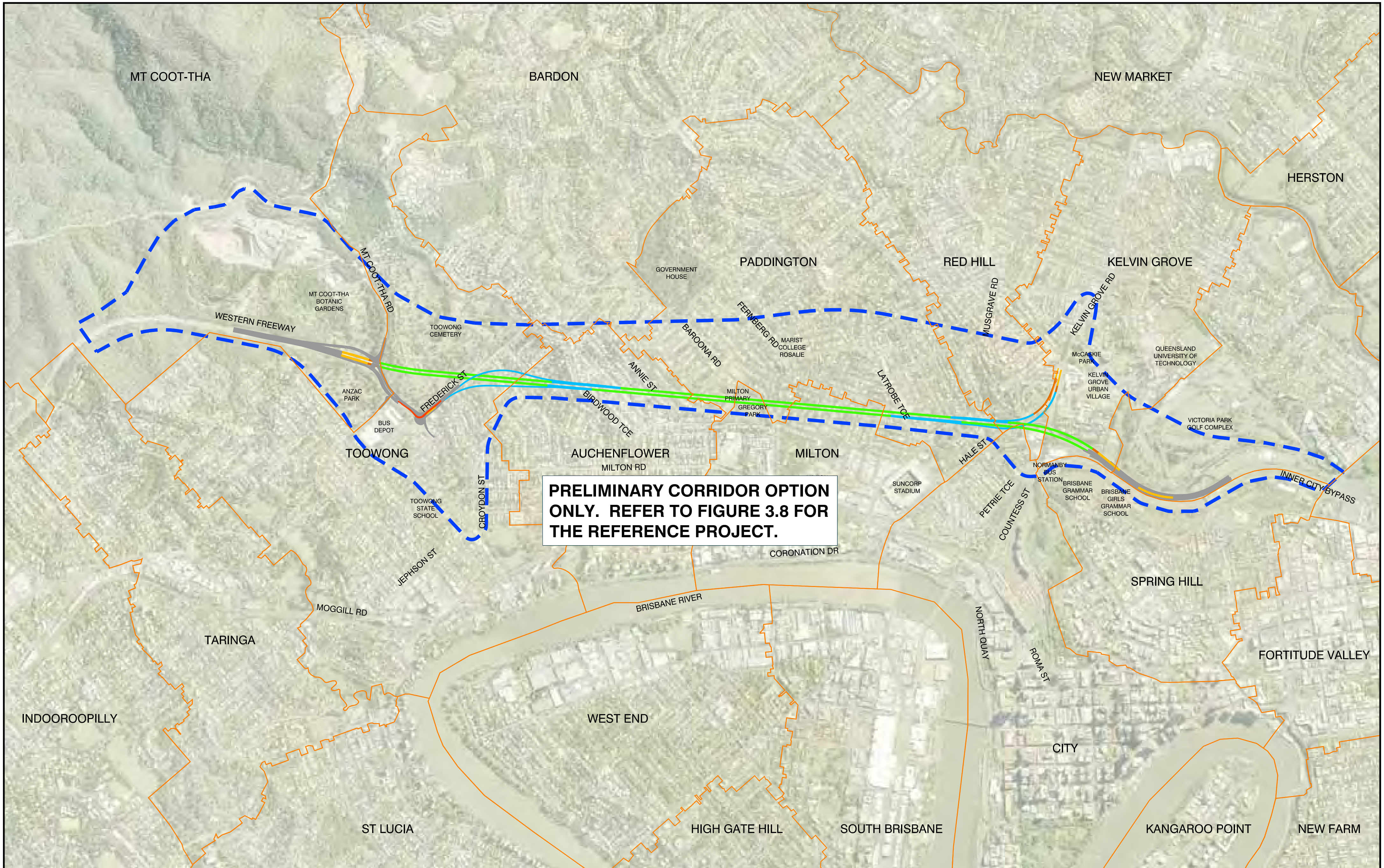
Option 5 would connect the Western Freeway in the west, at the roundabout intersection of Mt Cootha Rd and the Western Freeway, directly to the ICB north east of Kelvin Grove Rd, similar to Option 1. The Option included an alternative connection for the Toowong precinct from Croydon Street to provide a direct connection over Milton Rd and into the mainline tunnels. The Kelvin Grove Road ramps also provided an indirect connection for the City from Kelvin Grove Road South.

- **Option 8 – Hale Street Connection**

Option 8 would connect the Western Freeway in the west with Hale Street in the east, with the Toowong local connections at Croydon Street. The Caxton Street bridge over Hale Street would need to be reconstructed with tunnel and road corridor modifications constrained to avoid Suncorp Stadium and the associated plaza adjacent to Caxton St. Tunnel portals would need to be moved north on Hale Street to improve the tunnel flood immunity. This would be likely to reduce the number of surface lane connections due to the reduce length of road corridor available for weaving movements. Fewer surface lanes would reduce the overall worksite and reduce the impact on the local community.

- **Option 16 – Countess Street Connection**

Option 16 would connect the Western Freeway in the west, at the intersection with Mt Cootha Rd, to the ICB in the east with local connections to Croydon Street and Countess Street / Roma Street. Significant traffic management constraints would need to be addressed for Roma Street / Countess Street works.



Legend

- INVESTIGATION AREA
- TUNNEL ROADHEADER
- TUNNEL (TBM)
- CUT AND COVER
- TRANSITION STRUCTURE
- OVERPASS
- SURFACE WORKS

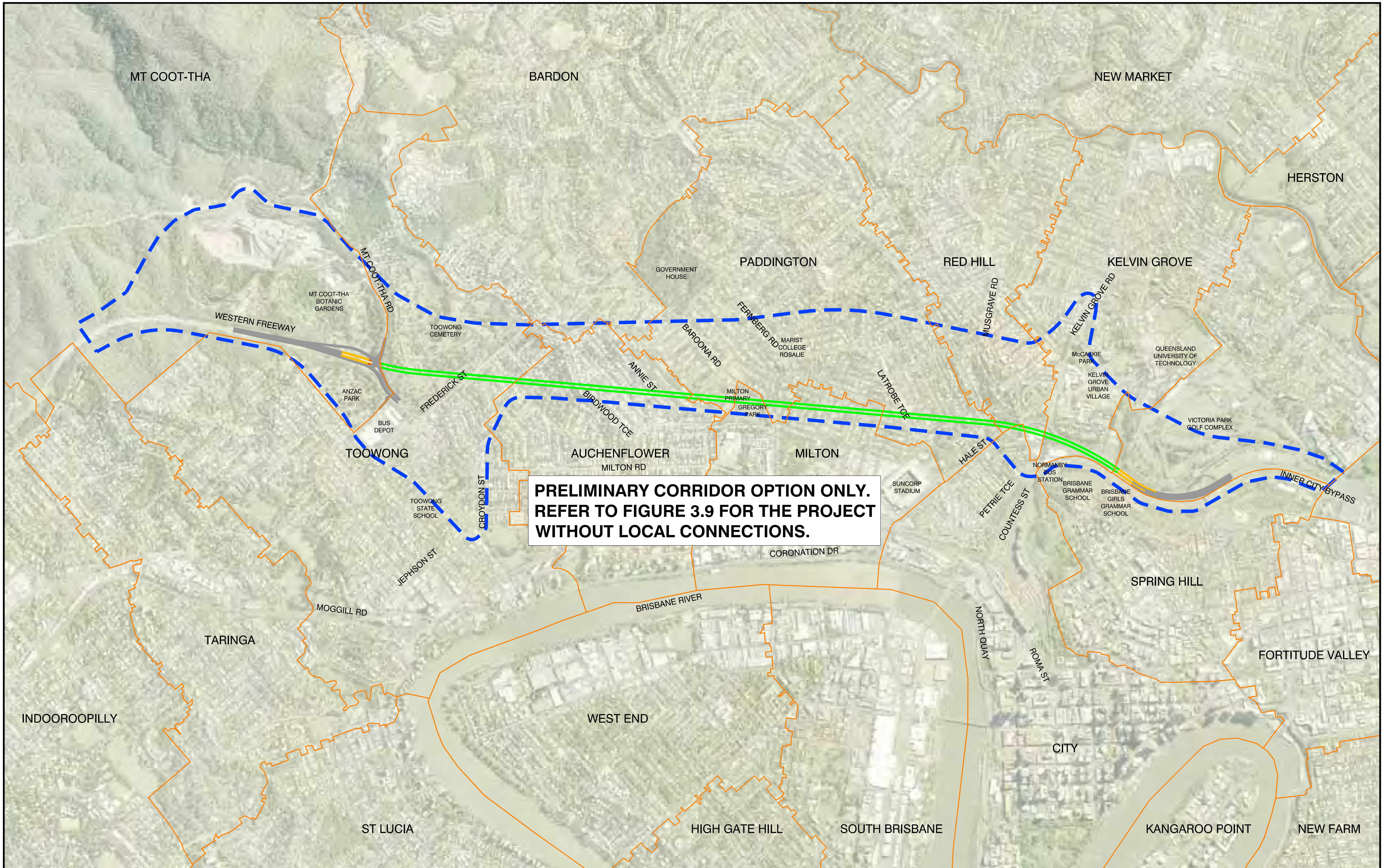
0m 250m 500m 750m
metres
Scale 1:28,000 (A4)

NORTHERN LINK
ENVIRONMENTAL IMPACT STUDY

Figure 3-3

Corridor Option 1

Northern Link
SKM Connell Wagner JOINT VENTURE



Legend

SURFACE WORKS

TUNNEL (TBM)

CUT AND COVER

TRANSITION STRUCTURE

INVESTIGATION AREA

0m 250m 500m 750m

metres

Scale 1:28,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-4

Corridor Option 2

Northern Link

SKM Connell Wagner JOINT VENTURE

3.2.2 Summary Review and Options Assessment

A summary review of these options is presented in **Table 3-3**.

Table 3-3 – Summary Review of Options

Option No	Mainline Connection	Precinct Connection	Review Summary
1 (Pre-feasibility Bored Option)	WF to ICB	Kelvin Grove Rd/Frederick St	▪ Prefeasibility Option ▪ Acceptable mainline traffic function ▪ Medium construction risk ▪ Low infrastructure impacts ▪ Low property impacts ▪ Base line cost (100%)
2	WF to ICB	No precinct connections	▪ Lower mainline traffic function ▪ Lowest construction risk ▪ Lowest infrastructure impacts ▪ Lowest property impacts ▪ 80% comparative project cost ▪ No precinct connections
5	WF to ICB	Kelvin Grove Rd/Croydon St	▪ Mid range mainline traffic function ▪ High construction risk ▪ Medium infrastructure impacts ▪ Medium property impacts ▪ 115% comparative project cost ▪ More direct connection to Toowong precinct
8	WF to Hale St	Kelvin Grove Rd/Croydon St	▪ Mid range mainline traffic function ▪ High construction risk ▪ High infrastructure impacts ▪ High property impacts ▪ 80% comparative costs ▪ More direct connection to Toowong precinct ▪ Provides all movements surface connection at Hale St ▪ Indirect CBD connection
16	WF to ICB	Croydon St/ Countess St	▪ Mid range mainline traffic function ▪ Medium construction risk ▪ Medium infrastructure impacts ▪ Low property impacts ▪ 130% comparative costs ▪ More direct connection to Toowong precinct ▪ Direct CBD connection

The options were assessed against the Strategic Review Framework outlined in **Table 3-2**.

A summary of the comparative assessment and the criteria that would differentiate between the strategic options is shown in **Table 3-4**.

Table 3-4 Strategic Option Review

Option	Traffic Criteria	Design and Construction Criteria	Environmental Criteria
1	Acceptable mainline traffic function. Regionally significant freight traffic and CBD traffic similar in all options.	Mid range construction risk. Low infrastructure impacts. Medium property impacts. Base option cost.	Low to medium likelihood of community acceptance. Medium impact on environmental constraints.
2	Lower range mainline traffic function. Regionally significant freight traffic and CBD traffic similar in all options.	Lower construction risk. Lower infrastructure impacts. Lower property impacts. Lowest cost.	Higher likelihood of community acceptance. Low impact on environmental constraints.
5	Mid range mainline traffic function. Regionally significant freight traffic and CBD traffic similar in all options.	Higher construction risk. Medium infrastructure impacts. Medium property impacts. Higher cost.	Lower likelihood of community acceptance. Medium impact on environmental constraints.
8	Mid range mainline traffic function. Regionally significant freight traffic and CBD traffic similar in all options.	Higher construction risk. Higher infrastructure impacts. Higher property impacts. Higher cost.	Lower likelihood of community acceptance. Medium impact on environmental constraints.
16	Mid range mainline traffic function. Regionally significant freight traffic and CBD traffic similar in all options.	Medium construction risk. Medium infrastructure impacts. Higher property impacts. Highest cost.	Lower likelihood of community acceptance. Medium impact on environmental constraints.

3.3 Design Development

The Preliminary Assessment concluded that the Northern Link project should proceed to the Detailed Feasibility Study with further detailed investigations to be undertaken for Option 1 (Pre-feasibility Bored Option) and Option 2 (Straight Through – no local connections). The following sections describe the design development of the mainline alignment and the connections that were taken forward into the Reference Project (Chapter 4).

3.3.1 Mainline Alignment

Further design development was undertaken for the mainline alignment and the surface connections. The design grades for the connection ramps developed in the Prefeasibility Study for the Bored Option were required to be reduced to meet current design standards. To meet these standards the mainline alignment was moved further to the north to higher topography and raised which allowed the reduction in the connection ramp grades associated with Option 1. It also moved the mainline alignment further away from the alluvial channels associated with drainage lines to the Brisbane River. Refer to Chapter 4, Project Description and detailed drawings of the Reference Project in Volume 2 of the EIS.

3.3.2 Western Freeway Connection

Both Options 1 and 2 provided for the mainline connection to the Western Freeway in proximity to the Botanical Gardens. The preliminary design for the Western Freeway Connection included provision of a signalised intersection at Mt Coot-tha Road and the layout is shown in **Figure 3-5**.

Ongoing consultation was undertaken with the Queensland Department of Main Roads (QDMR) in relation to the future lane requirements for the Western Freeway. To advance the connection design to the Western

Freeway a number of design assumptions were required. An initial assumption was agreed with QDMR that the Western Freeway would ultimately provide three traffic lanes in each direction to the existing Mt Coot-tha Road roundabout. This would include two general-purpose lanes and a High Occupancy Vehicle (HOV) lane.

Further concept development was undertaken on the location of the portal connections with the agreed lane configurations. The design options investigated were:

Northern Link portals between the Western Freeway carriageways with:

- the HOV inside (ie: right hand lane); and
- the HOV outside (ie: left hand lane).

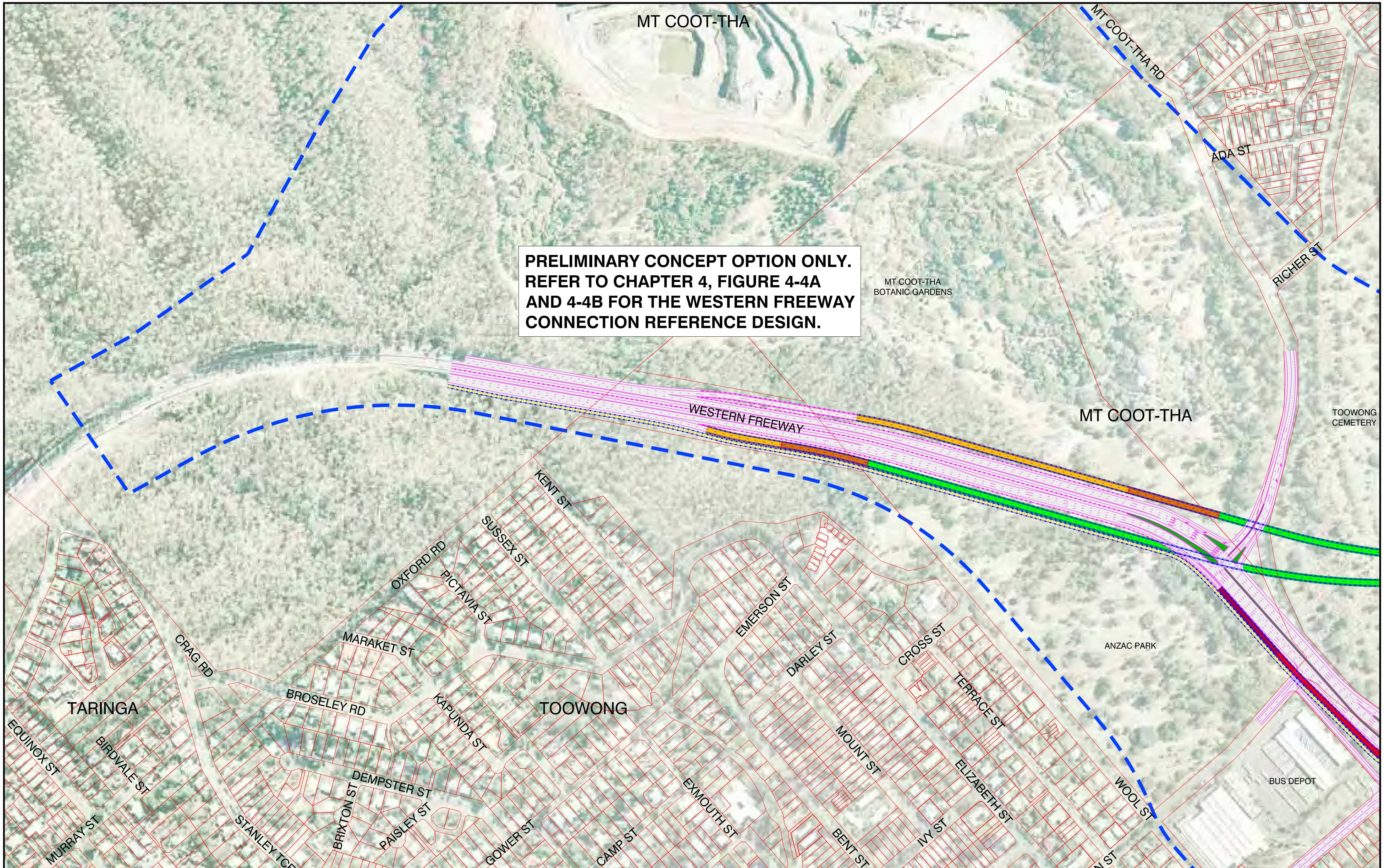
Northern Link portals outside the Western Freeway carriageways with:

- HOV inside (ie: right hand lane); and
- HOV outside (ie: left hand lane).

The combination of Northern Link portals on the outside with HOV lanes on the inside (median) was preferred, in consultation with QDMR, because:

- it provided good quality access to Northern Link for toll road users;
- potential compatibility with the East West Link; (TransApex project);
- maximises the length of HOV lanes to Mt Coot-tha Road roundabout;
- no trapped lanes are involved; and
- no right hand diverges.

As a result of further development of the Toowong Connection no permanent works were required west of the Frederick Street/Milton Road roundabout. This would result in the Mount Coot-tha roundabout being retained in its present configuration. The Northern Link portals would be located on the outside with provision for future three lanes each way (HOV on the inside) for the Western Freeway. It was concluded that this layout be further developed as the preferred concept layout for the Western Freeway Connection. Refer to Chapter 4, Project Description, Figures 4-4A and 4-4B for details of the preferred Western Freeway Connection.



Legend

- INVESTIGATION AREA
- TUNNEL (TBM)
- TUNNEL (CROSS PASSAGE)
- CUT AND COVER
- TRANSITION STRUCTURE
- SURFACE WORKS
- REINFORCED STRUCTURAL SOIL (RSS)
- OVERPASS
- CYCLEWAY

0m 100m 200m
metres
Scale 1:7,000 (A4)

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-5

Preliminary Western Freeway Connection

Northern Link
SKM Connell Wagner
JOINT VENTURE

3.3.3 Toowong Connection

Option 1 provided for a connection to the Toowong precinct via south-facing ramps in Frederick Street. This connection option maintained the existing elevated ramp bridge and the Frederick St/Milton Road roundabout.

The preliminary concept, shown in **Figure 3-6** was developed with the objective of retaining the existing movements at the Frederick Street/Milton Road roundabout and all movements provided to/from the tunnel ramps.

The key features of this option included:

- the Frederick Street/Milton Road roundabout would be replaced with traffic signals and all existing movements would be retained;
- the grade separated ramp from Frederick Street to Western Freeway would be maintained on a revised alignment;
- all movements to and from the tunnel ramps would be provided;
- the westbound Milton Road movement into the tunnel would be via a grade separated ramp over the intersection. All other tunnel entry/exit movements would be at Frederick Street; and
- surface work would be required on Croydon Street to increase capacity for the expected increase of traffic for the Frederick Street connection.

Further analysis was undertaken on this concept with the Strategic Review Framework and it was concluded that this option did not meet a number of criteria including high complexity of construction, limited construction method flexibility, low cost effectiveness, high impacts on existing infrastructure, high property impacts and high environmental impacts. The following issues were identified:

- additional construction widths were required for the construction of the structures in Frederick Street increasing the impact on property;
- increased complexity in the design of structures to maintain traffic clearances and required clear spans;
- complex traffic management under construction with the risk of traffic ‘rat running’ during construction;
- high property impacts in Frederick Street; and
- potentially substantial increase in construction cost.

An alternative option was developed with the main objective to reduce the impacts identified from the initial concept. The main feature of the alternative option was the provision of east facing ramps only to Milton Road.

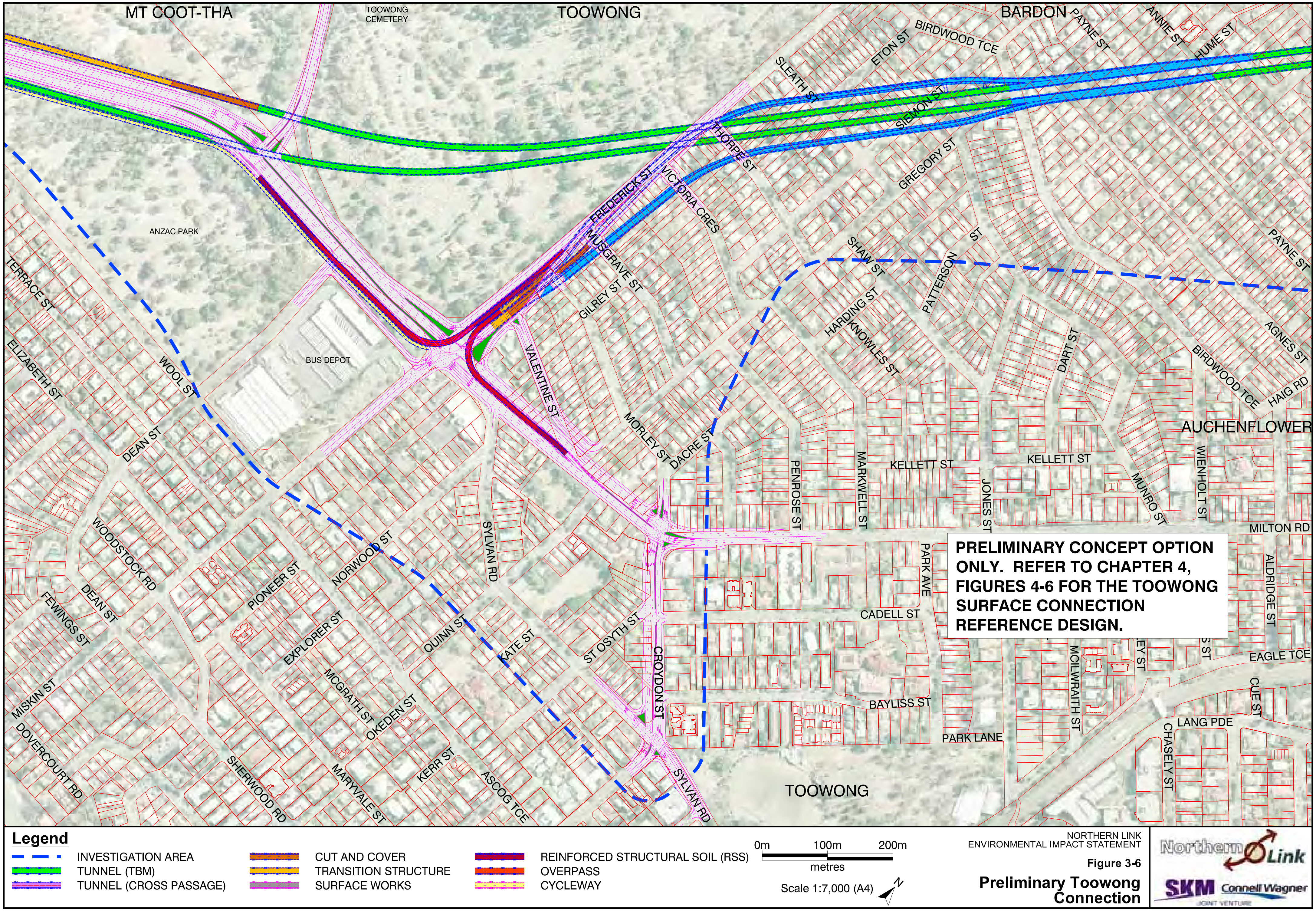


Figure 3-6
Preliminary Toowong Connection

The main features include:

- grade separated east facing ramps connecting into Milton Road;
- tunnel entry/exit ramps clear of Frederick Street;
- tunnel ramp exit traffic directed into Croydon Street;
- right turn into Sylvan Road from Milton Road eastbound would be removed. An alternative right turn lane is provided into Croydon Street;
- dedicated left turn lane from Croydon Street into Milton Road and into the tunnel entry ramps;
- no physical impacts on Frederick Street;
- maintains the existing grade separated ramp at Frederick Street;
- no upgrade works required west of Frederick Street/Milton Road roundabout; and
- No tunnel access via Toowong connection from the west (ie from the Western Freeway, Mt Coot-tha Road, Frederick Street or Miskin Street).

It was concluded that this alternative should be developed further as the preferred concept layout. The primary reasons for the selection of this layout over its alternatives are:

- It allows the Project to provide the most efficient connections, via existing designated arterial traffic routes, with the designated activity centres at the University of Queensland, Toowong and Indooroopilly under City Shape and Brisbane City Plan 2000 (see Chapter 11);
- It is consistent with the designated arterial road function of both Milton Road and Croydon Street, while recognising that some further capacity of each of those roads would be required in a 'without Northern Link' scenario;
- It allows the connection to be constructed close to the mainline tunnel, without compromising imperatives of flood immunity (see Chapter 7);
- It was considered to be the most efficient, cost-effective option that fulfils the required traffic function, with least disruption and property impact.

Refer to Chapter 4, Project Description, Figure 4-6 for details of the preferred Toowong Connection.

Impacts on the existing pedestrian and cycle network were investigated for the design layout. The main impact was the removal of the signalised pedestrian crossing across the western leg of Milton Road at the Milton Road/Croydon Street intersection as a result of the additional traffic lanes required. Options were investigated to maintain the pedestrian connection across Milton Road and these are described below.

Pedestrian Underpass

This option would provide a pedestrian underpass of Milton Road from the vicinity of Valentine Street and Gregory Street on the northern side connecting to Quinn Park on the southern side. This option would provide a connection between the northern side of Milton Road to the residential areas south of Milton Road, Toowong Primary School, Quinn Park and bus stops.

The pedestrian underpass would require a high capital cost, maintenance costs such as cleaning, lighting and surveillance costs, be subject to vandalism and a risk to personal security.

At Grade Signalised Crossing

This option would provide an at-grade signalised pedestrian crossing of Milton Road between Croydon Street and Frederick Street connecting to Quinn Park on the southern side. This option would provide a connection between the northern side of Milton Road to the residential areas south of Milton Road, Toowong Primary School, Quinn Park and bus stops.

The signalised pedestrian crossing would require the lowest capital cost to implement. However, the crossing could have a negative impact on the road network performance, including the DMR network, and would have sight distance constraints for the westbound crossing of Milton Road due to the walled structures connecting to the elevated tunnel ramps.

Pedestrian Overpass

An option was investigated for a pedestrian overpass in the same location as the pedestrian underpass described above. This option would provide a connection between the northern side of Milton Road to the residential areas south of Milton Road, Toowong Primary School, Quinn Park and bus stops.

The pedestrian overpass would require high capital cost, maintenance costs and safety concerns particularly at night. The overpass would have visual impacts and depending on the design of the southern ramp approach require more land in Quinn Park.

An additional overpass option was investigated at the western leg of Milton Road to replace the removed pedestrian crossing. In addition to the impacts described above this option would impact residential accesses to Morley Street resulting from the northern approach ramps.

An assessment was undertaken on the four options with the conclusion that whilst the options provided a benefit of connectivity to and from the northern side of Milton Road, these options would not be feasible based on a variety of factors:

- high capital and maintenance costs with the exception of the signalised crossing option;
- impacts on the existing road network for the signalised crossing option;
- safety and security;
- visual and property impacts;
- low pedestrian volumes using the existing pedestrian crossing at Milton Road (west) with the probable low utilisation of an alternative mid block crossing; and
- proposed crossing options within 200 metres of the existing crossing.

3.3.4 Inner City Bypass Connection

Both Options 1 and 2 provided for a connection to the ICB in proximity to the Inner Northern Busway overbridge. The eastbound portal was located at Victoria Park Road, with the transition structure extending east of the Inner Northern Busway elevated ramp. The westbound portal and transition structure would be east of the Inner Northern Busway overbridge.

Project design development for the Inner City Bypass Connection has generally maintained the layout from the Prefeasibility Study, however, the cut and cover was initially located west of Victoria Park Road which removed the left in/left out at Victoria Park Road. As a result of the community consultation for the design, the cut and cover portal was moved further east and reinstated the left in/left out at Victoria Park Road. Refer to Chapter 4, Project Description, Figure 4-10 for details of the preferred Inner City Bypass Connection.

Strategic investigations were also undertaken for a north-south pedestrian linkage from the Kelvin Grove Precinct through to the Normanby Five- Ways. Three options were considered and are described below:

- pedestrian overpass from Lower Clifton terrace, over the Kelvin Grove northbound entry lane, connecting into the ICB overbridge, with a separate connection to the western side of Kelvin Grove Road leading to the Normanby 5 Ways;
- pedestrian overpass over the ICB between Kelvin Grove Road and Victoria Park Road connecting into the Normanby Bus Station and the existing pedestrian network; and
- pedestrian overpass over the ICB east of the Inner Northern Busway bridge connection into the existing pedestrian/cycle network on the southern side of the ICB.

These options were developed at a strategic level and are subject to further investigations.

3.3.5 Kelvin Grove Connection

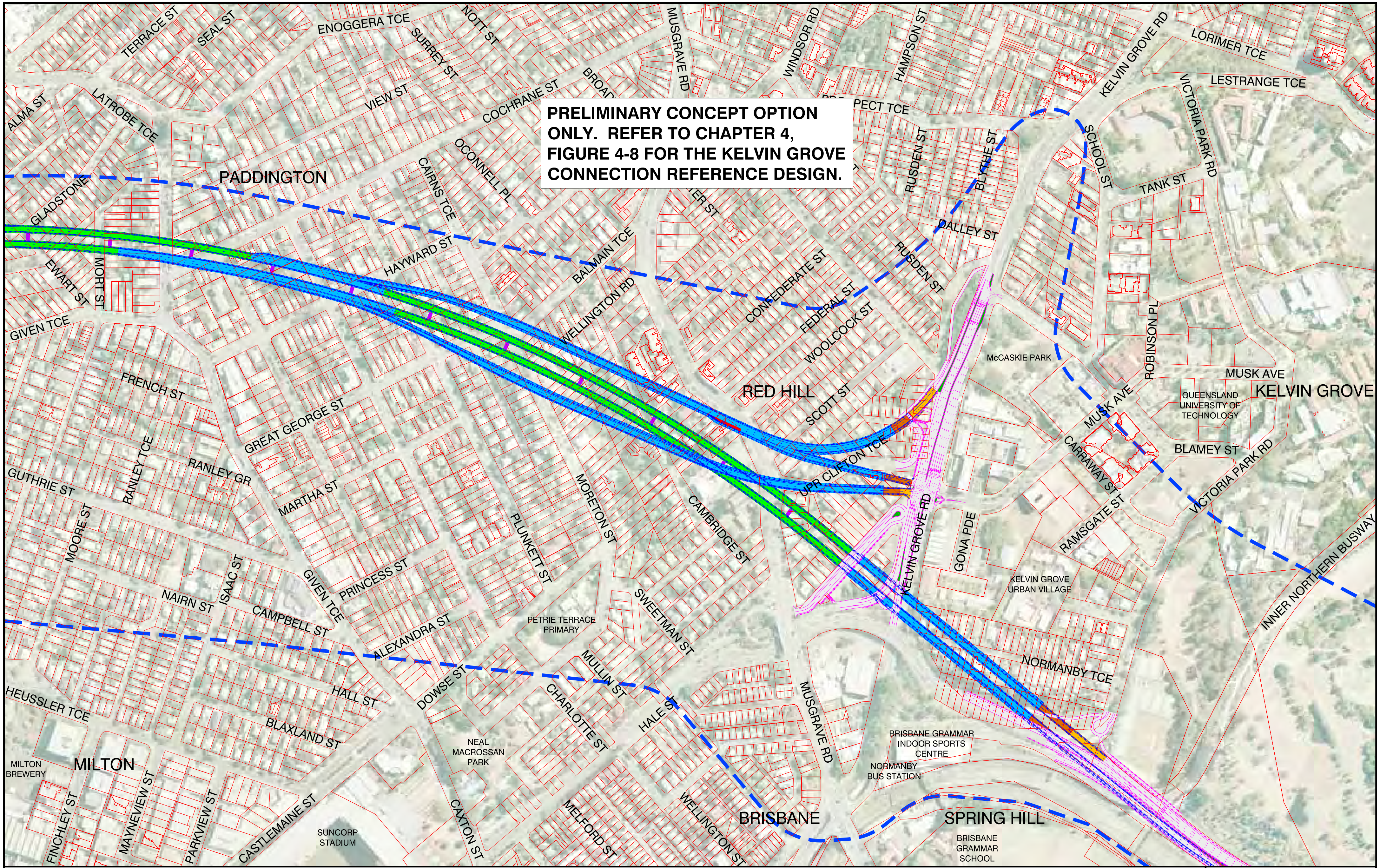
Option 1 provided for a connection to Kelvin Grove Road via north-facing ramps. Option 1 has been further developed to provide a Public Transport (PT) surface connection at Kelvin Grove Road. As a result, the tunnel entry ramp from Kelvin Grove Road north was relocated south to connect at Musk Avenue. This provided an outbound bus connection to the tunnel from Kelvin Grove Road south. A PT ramp was also provided from the tunnel exit ramp to connect to Kelvin Grove Road at Musk Avenue to allow an inbound bus connection to Kelvin Grove Road south. This modification reduced the surface impacts on Kelvin Grove Road as shown in **Figure 3-7**.

Further refinement to this option relocated the tunnel exit ramp to enter directly into the Kelvin Grove Road/Musk Avenue intersection on the western side. This allowed all traffic movements at the Kelvin Grove Road / Musk Avenue intersection. It was concluded that this surface connection should be developed as the preferred concept layout for the Kelvin Grove Road connection. Refer to Chapter 4, Project Description, Figure 4-8 for details of the preferred Kelvin Grove Connection.

3.4 The Developed Project

The Preliminary Assessment concluded that the Northern Link project should proceed to the Detailed Feasibility Study. Further detailed investigations have been undertaken since the Preliminary Assessment of both the mainline tunnels and the precinct connections.

The developed design of the mainline tunnel alignment, with the local connections, has been taken forward as the Reference Project for the EIS, and is shown in **Figure 3-8**.



Legend

- INVESTIGATION AREA
- TUNNEL (ROADHEADER)
- TUNNEL (TBM)
- TUNNEL (CROSS PASSAGE)
- CUT AND COVER
- TRANSITION STRUCTURE
- SURFACE WORKS
- FOOTPATH / MEDIAN

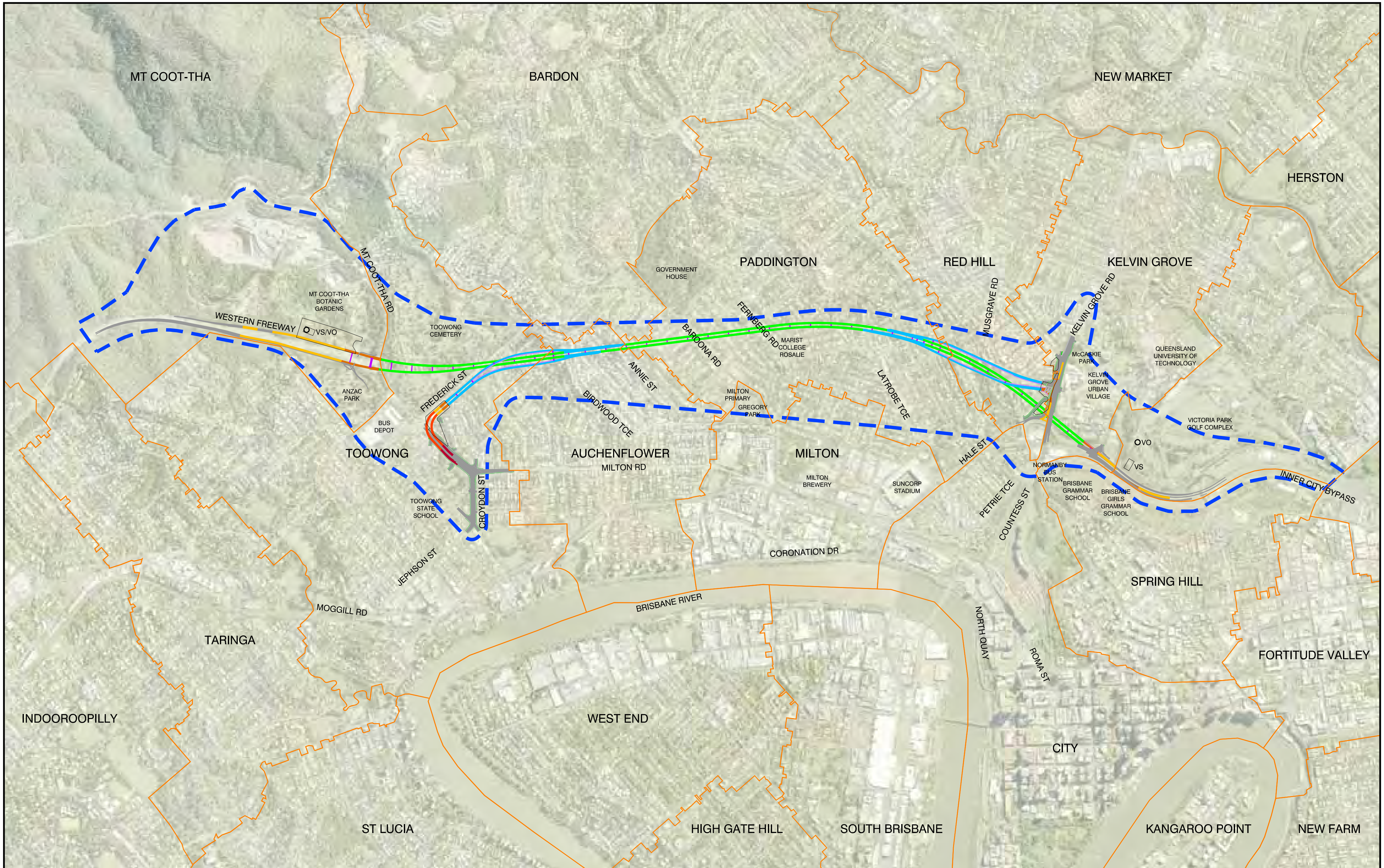
0m 250m 500m 750m
metres
Scale 1:28,000 (A4)

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-7

Preliminary Kelvin Grove Road Connection

SKM Connell Wagner JOINT VENTURE



Legend

- INVESTIGATION AREA
- TUNNEL (ROADHEADER)
- TUNNEL (TBM)
- TUNNEL (CROSS PASSAGE)
- CUT AND COVER
- TRANSITION STRUCTURE
- OVERPASS
- SURFACE WORKS
- EARTHWORKS
- REINFORCED STRUCTURAL SOIL (RSS)
- PROPOSED WORKSITE
- PROPOSED VENTILATION STATION (VS)
- PROPOSED VENTILATION OUTLET (VO)

0m 250m 500m 750m

metres

Scale 1:28,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-8

The Reference Project

Northern Link

SKM Connell Wagner
JOINT VENTURE

3.4.1 Consideration of the Project Without Connections

During the development of the project, a design without connections at Toowong and Kelvin Grove has been developed (the 'straight through' option). See **Figure 3-9**.

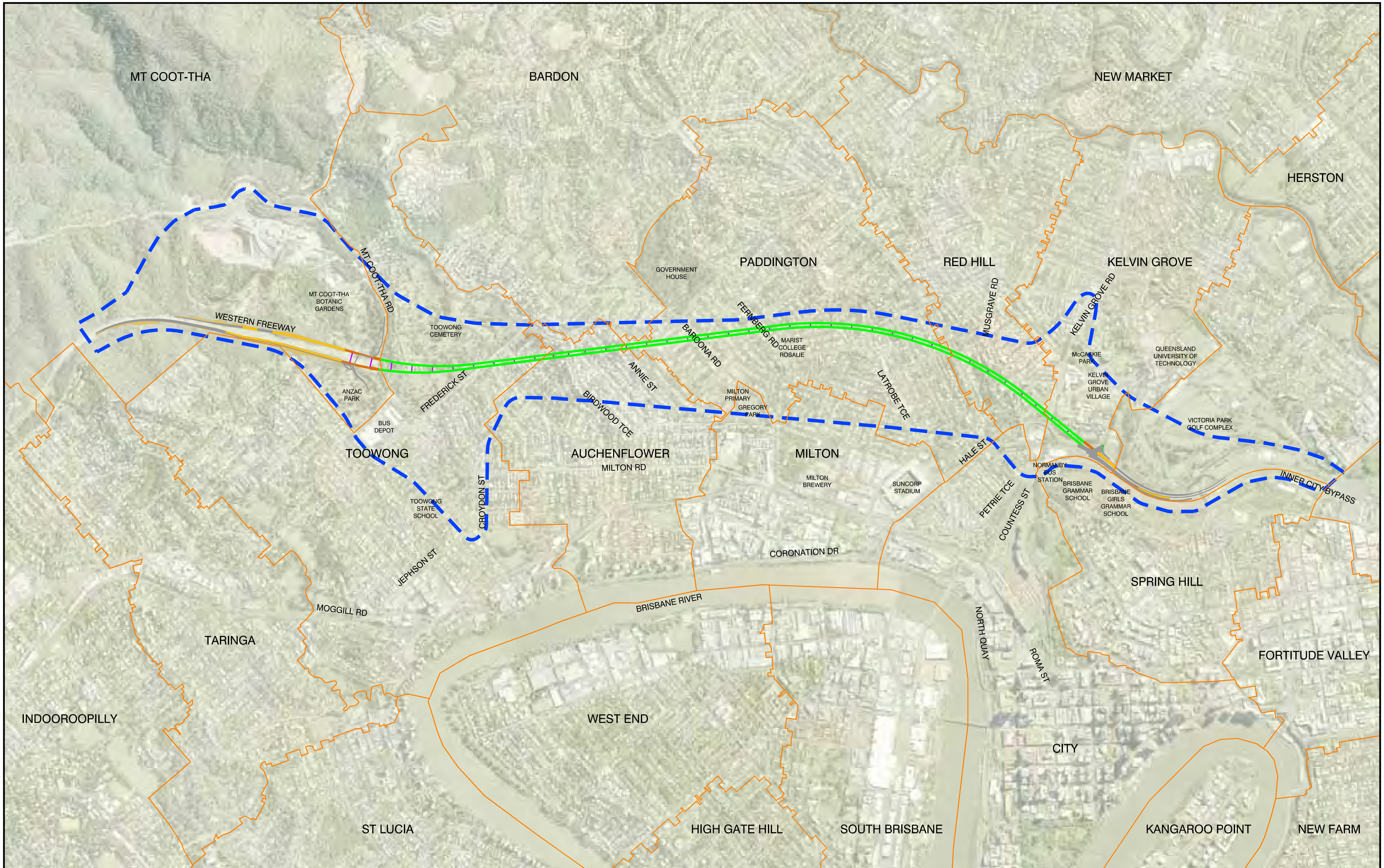
This option is capable of meeting the strategic needs of the project and work to date indicates that it could produce an acceptable outcome for Council while maintaining significant local community support.

In exploring the opportunities for the project, it needs to be recognized that despite the popularity and acceptability of the straight through option with Council and the local community, by seeking innovation through the tendering process these localised connections may provide presently unrecognised benefits for Council and the community. To this end, the Reference Design submitted for consideration includes connections at Toowong and Kelvin Grove. The reasons for this include:

- It would involve a more comprehensive assessment of the project's benefits and impacts than omitting them - and in the interests of the community these impacts and benefits need to be fully understood.
- It would give the community a complete assessment of the project with connections and a good understanding of the project without connections

It is important to note delivery of the project would proceed as a Public Private Partnership and will allow for bidding consortiums to innovate and propose solutions that lead to design improvements over the EIS Reference Design. Public submissions to the EIS will help the consortiums understand local concerns and aid in the potential development of alternative solutions. While there is some initial preference by Council and the local community for the final design not to contain connections at Kelvin Grove and Toowong (as currently detailed in the reference design), it is possible that through the innovative PPP process, proponents may develop solutions that address the concerns of Council and the local community while still providing some form of localised access to the tunnel.

The preferred tenderer is likely to be announced in mid 2009. In order to achieve the best outcome for Council and the community, tenderers need scope to submit proposals that differ from the EIS Reference Design. Consequently, a Request for Project Change may be lodged with the Coordinator General for public comment at that time.



Legend

- INVESTIGATION AREA
- TUNNEL (TBM)
- TUNNEL (CROSS PASSAGE)
- CUT AND COVER
- TRANSITION STRUCTURE
- SURFACE WORKS
- EARTHWORKS

0m 250m 500m 750m
metres

Scale 1:28,000 (A4)

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-9

The Project without local connections

Northern Link

SKM Connell Wagner
JOINT VENTURE

3.5 Ventilation Systems and Outlets

Ventilation systems are necessary design elements to allow management of air quality within the tunnel by dilution of the pollutants exhausted from the petrol, diesel and any other types of engines that power the vehicles using the tunnels. Vehicle pollutants are a function of traffic volumes, vehicle mix (age and type), speed and the effect of gradients within the tunnel. For effective ventilation of unidirectional road tunnels the longitudinal system, taking advantage of the 'piston effect' of the travelling vehicles, is considered world's best practice and most appropriate for the Northern Link tunnels. For longitudinal ventilation of a tunnel, under normal operations, ambient air would enter the tunnel from all portals and would be moved along the tunnel by a combination of vehicle-induced airflow and mechanical ventilation through the use of jet fans located throughout the main tunnel and associated ramps. The air would then be extracted at a point within the main line tunnel towards the exit portal and from there vented to the atmosphere by means of a ventilation outlet.

A longitudinal ventilation system is expected to deliver the best outcome for both in-tunnel air quality and for ambient air quality (Chapter 8, Air Quality and Greenhouse Gases) for an analysis of the ambient air quality impacts). For the Northern Link project such a ventilation system would require a ventilation station and ventilation outlet located near each end of the mainline tunnels. It is recognized that choice of a site for each ventilation outlet is a matter of community interest and concern. For that reason a range of potential sites has been presented during public consultation for the Project and new sites introduced as candidates in response to public concerns. The locations proposed in the reference design (one of which was not among the list of candidates initially considered) were determined having regard to a range of community, environmental and construction and operational criteria discussed later in this section.

All air is extracted from the tunnel at a point approximately 100m from the exit portal which places some constraint on the area within which a ventilation outlet may be placed to achieve cost-effective construction and operational conditions. Feasible options for ventilation outlet sites were selected within a distance of 500m from each extraction point.

3.5.1 Ventilation Stations and Outlets – Site Options

To identify possible locations for the two ventilation stations and outlets, general investigation areas were established, within, but not limited to, 500m of the likely location of the extraction points.

At the Western Freeway connection two potential sites shown in **Figure 3-10** were considered for further analysis.

- W1 – on Brisbane City Council land beside the Western Freeway.
- W2 – on Brisbane City Council land near the boundary between the Botanic Gardens and the Mt Coot-tha Quarry.

Three potential sites shown in **Figure 3-11** were considered at the ICB connection.

- N1 – on Lower Clifton Terrace.
- N2 –on the high point of land east of Musk Avenue and Gona Parade within the Kelvin Grove Urban Village.
- N3 – the small triangular block of land on the western side of the Inner Northern Busway immediately south of QUT Kelvin Grove campus and in the Victoria Park golf course.

Two other sites were considered but discarded very early in the study.

- Brisbane City Council land on Musgrave Road between Belgrave Street and Hale Street.
- South of the ICB in the triangular block between Musgrave Road and Kelvin Grove Road.

During public consultation it became apparent that each of these three sites had some drawbacks and further search for potential sites was undertaken that yielded two further candidate sites shown in **Figure 3-11**.

- N4 – within the Victoria Park Golf Course, on high ground immediately east of the inner Northern Busway.
- N5 – further east in Victoria Park Golf Course within a copse of mature trees adjacent to the maintenance facilities.

Legend

INVESTIGATION AREA	TRANSITION STRUCTURE
TUNNEL (TBM)	SURFACE WORKS
TUNNEL (CROSS PASSAGE)	EARTHWORKS
CUT AND COVER	WORKSITE

W1 PROPOSED VENTILLATION SITE

W2 ALTERNATE VENTILLATION SITE

0m 100m 200m

metres

Scale 1:7,000 (A4)

N

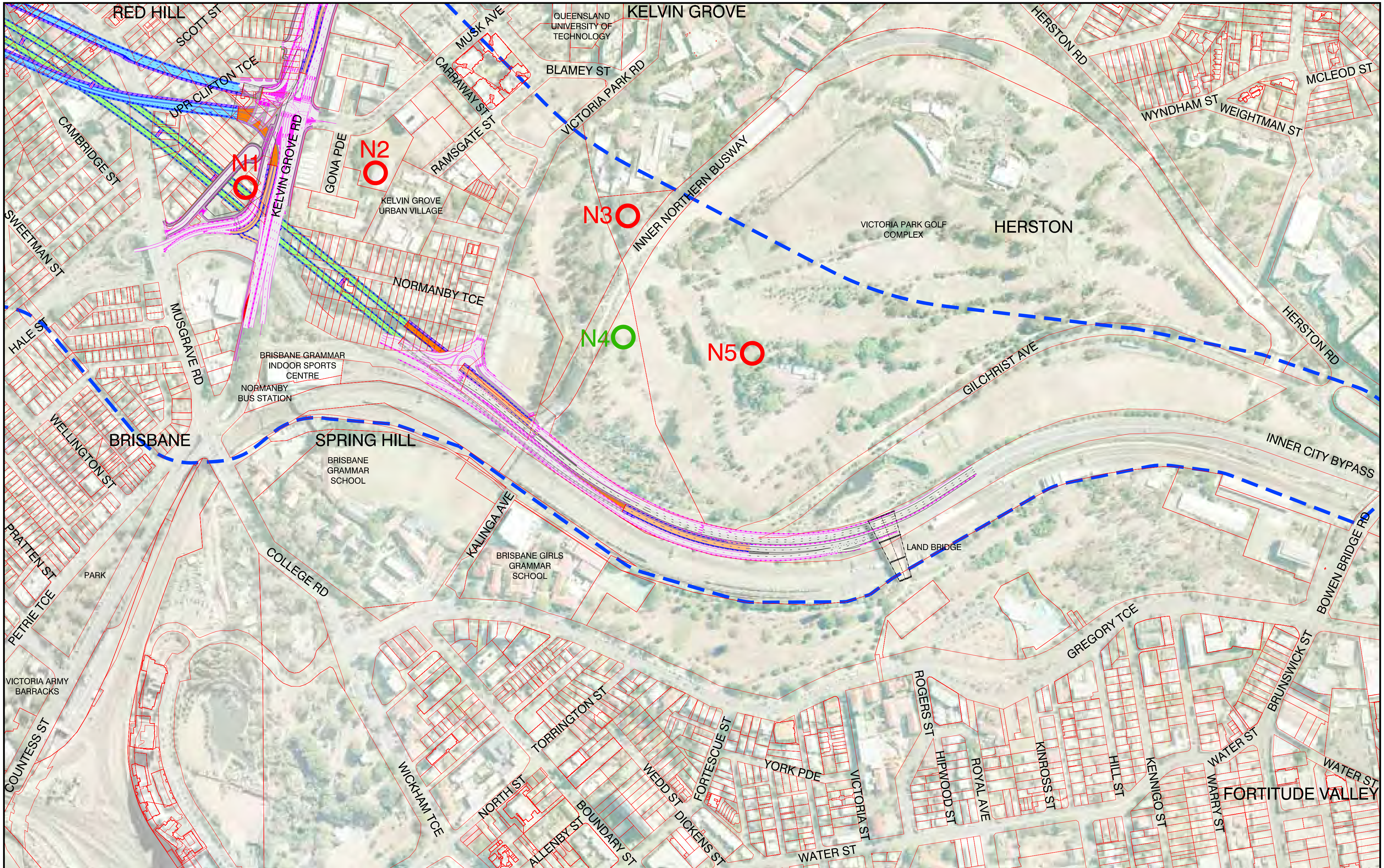
NORTHERN LINK
ENVIRONMENTAL IMPACT STUDY

Figure 3-10

Western Ventilation Sites

Northern Link

SKM Connell Wagner
JOINT VENTURE



Legend

- INVESTIGATION AREA
- TUNNEL (ROADHEADER)
- TUNNEL (TBM)
- TUNNEL (CROSS PASSAGE)
- CUT AND COVER
- TRANSITION STRUCTURE
- SURFACE WORKS
- LINEMARKING WORKS
- N4 PROPOSED VENTILATION SITE
- N5 ALTERNATE VENTILATION SITE

0m 100m 200m
metres
Scale 1:7,000 (A4)
N

NORTHERN LINK
ENVIRONMENTAL IMPACT STUDY

Figure 3-11

Eastern Ventilation Sites

Northern Link

SKM Connell Wagner
JOINT VENTURE

3.5.2 Selection of Ventilation Stations and Outlet Sites

During the preparation of this EIS, the various site options for each of the ventilation outlets were presented to the community at information sessions, through information extension activities such as the newsletter and website, and discussed with the community reference groups. The main issue of concern for people who engaged in this process was understanding the potential impact that operation of the ventilation outlets would have on the surrounding air quality, and consequently, upon community health.

Input sought from the community during the preliminary consultation process indicated that for many people, visual impact and changes to amenity were the next most important issues after impacts on air quality and associated concerns with impacts on community health. Sites which would not lead to an exceedance of the air quality goals and which would have little visual impact would be of less concern to many people than sites requiring high to very high ventilation outlets.

The site selection process, including the criteria for site selection, was explained during this preliminary consultation process. Preliminary indications of site responses to some criteria were also presented at community information sessions.

Each option was assessed against a range of criteria including ventilation function, air quality, land use, physical constraints, access, visual impact and relative indicative costs of construction of the ventilation shaft connecting the ventilation station with the outlet.

The key objective for site selection was to ensure that the goals for ambient air quality would not be exceeded as a consequence of operating the ventilation outlets for Northern Link. The site selection process determined that the goals would be achieved for each site with varying heights of the ventilation outlets. For some sites, the outlet height would be in excess of 50 metres to achieve the goals, raising concerns consequently about visual impact and amenity, while for other sites, outlet heights would be as low as 15 to 20 metres.

Availability of land, and access to land, were also important considerations in site selection, as was the use of land comprising a candidate site and land adjacent to each site. In several instances, development applications or development proposals would be impacted either by the construction of a ventilation outlet, or would impact upon the height of the ventilation outlet to achieve the goals.

The ease and potential impact of construction of the ventilation outlet, ventilation station and the ventilation tunnel connecting the two facilities influenced site selection. For site W2, construction of the ventilation tunnel would have an adverse impact on the Brisbane Botanic Garden in terms of clearing vegetation and potential drawdown of groundwater. The ventilation tunnel for this site would be in the order of 600meters in length, adding significant to construction costs and construction impacts. Similarly, the ventilation tunnel for site N3 would have an adverse impact on the residential area to the west of Victoria Park Road and Victoria Park, while also having the potential to drawdown groundwater in the shallow alluviums of Victoria Park. The length of the ventilation tunnel connecting the ventilation station and site N5 would be in excess of 600metres. In addition to the environmental impacts and construction costs of the ventilation tunnels, increased tunnel length would also lead to increased energy demand during the operational phase. There would be consequential increases in greenhouse impacts with increased energy demands and associated operating costs.

For each of the potential ventilation outlet sites, there would be different locations and arrangements for the ventilation stations. For example, site N1 would have the ventilation station buried below Lower Clifton Terrace but above the mainline tunnels, whereas site N2 would have a ventilation station situated to the south of

Normanby Terrace adjacent to the mainline (north-bound) tunnel. Site N3 would require a ventilation station in a similar location to N2, whereas sites N4 and N5 would require a ventilation station situated between the extraction point and the outlet. Sites W1 and W2 would share a ventilation station site in approximately the same location.

An assessment of the cumulative impact of the Northern Link ventilation outlets with those from the North South Bypass Tunnel (CLEM7) at Bowen Hills and Airport Link at Windsor was undertaken and is presented in Chapter 8 – Air Quality.

Discussion of the comparison of options against the criteria is outlined in **Table 3-5**. These options were available for public comment in May 2008 as part of material presented and discussed in preliminary consultation activities. Responses from the public on the candidates at the Northern or Kelvin Grove end necessitated further search for suitable sites resulting in the presentation at the June 2008 consultation round of two further candidate site (N4 and N5) one of which has become the preferred site for that ventilation station and outlet. The preferred options are outlined in Chapter 4, Project Description in the EIS.

Table 3-5 Option Selection Criteria Discussion - Ventilation Outlets

Category	Option Selection Criteria	
Air Quality	Must achieve adequate dispersion to meet air quality goals	Preliminary dispersion modelling was undertaken for the emission of oxides of nitrogen (NO_x) from the outlets. NO_x is a critical air pollutant in the air shed with air quality criteria specified by the EPA and is only approx. 20% of the modelled emissions. All site locations have similar concentrations of NO_x in terms of both maximum ground level concentrations (1 hour and annual average), and the overall pattern of dispersion. Based on background concentrations at these sites the maximum 1hr NO_2 level would not reach half the air quality goal at ground level.
Ventilation function	Proximity of vent. outlet to: ▪ extraction point ▪ vent station	Approximate distances from respective extraction points on mainline tunnels (about 150m from exit to daylight) are: W1 = 480m; W2 = 720m; N1= 430m; N2 = 330m; N3 = 360m; N4 = 320m; N5 = 500m.
Land Use	Separation from tall buildings >100m	W1 and W2 are remote from any buildings above 2 stories with W1 at least 300m from any buildings; N4 and N5 are at least 300m from any tall buildings; N2 and N3 are situated within 100m of sites where multi-storey buildings are planned; N1 is less than 200m from several tall buildings on more elevated sites.
	Proximity to particular activities: ▪ child care, aged care, health care, schools ▪ residential	Most sites have been chosen to avoid proximity to sensitive locations. W1 and W2 are 250m from the nearest residences from which W1 is separated by the Western Freeway and heavily vegetated high ground and W2 by mature vegetation; N1 is relatively close to residences; N2 is adjacent to an aged care facility and residences; N3 is adjacent to the QUT campus; N4 is about 300m from the nearest school building and 150m from school playing fields; N5 is about 400m from the nearest school building.
Availability of land	Ownership, tenure and acquisition	W1, W2, N3, N4 and N5 are situated on Brisbane City Council owned land. N1 is being acquired for the project as a worksite.
Physical constraints	Flood-free land Drainage Clear of tall vegetation	W1 and W2 are both elevated sites without flood or drainage concerns. Some vegetation would be necessary (principally for the duct from the extraction point) to utilise either site but would be less for W1 where the clearing would be necessary to make it an effective worksite. N2, N3, N4 and N5 are elevated sites free of flood or drainage issues. N1 is situated within a flood retention basin and would thus have issues in respect of the structure not adversely impacting the drainage performance of the catchment that would need to be addressed in detailed design. W1, W2 and N5 are adjacent to tall trees but the ventilation outlet would be

Category	Option Selection Criteria	
		designed to provide dispersion above these.
Access	For maintenance and Emergency Services	Access could be made available to all sites; W1 and W2 would require arrangements to traverse parts of the Botanic Gardens and N3, N4 and N5 would need to be accessed through the Victoria Park Golf Course.
Visual Impact	Visual context relating to adjacent land and distant vantage points	Both W1 and W2 are well embedded within natural bush land and would have minor impact on visual amenity of the area; W1 would be apparent to motorists heading southwest on the Western freeway as they passed the Mt Coot-tha Road roundabout. At N1 a ventilation outlet would have significant visual impact, particularly for residences on the rising ground to Musgrave Road. N2 would have little visual impact as it would be surrounded by relatively high multi-storey buildings of the Kelvin Grove Urban Village development; N3, N4 and N5 are well embedded in green space where they could be designed to have low impacts on visual amenity.
Cost	Construction and operation	Cost differentials between candidate sites depend principally upon the length of the necessary duct length and cross section from the extraction point to the ventilation station and then to the ventilation outlet as well as height of the outlet. Costs for the ventilation station are assumed to be similar wherever it is situated.

From this comparative assessment process, and having regard to comments made during the preliminary consultation processes, the preferred sites for the ventilation stations and ventilation outlets were site W1 at the western end and site N4 at the northern end of Northern Link. Each of these sites is described in Chapter 4, Project Description.

3.6 Spoil Management Options

Construction of the Northern Link tunnel would require excavation of 1.7 million cubic metres of material, to be removed and transported to suitable placement or reuse sites. This volume of material is estimated to weigh approximately 4.2 million tonnes, assuming 1 cubic metre weighs 2.55 tonnes. Options have been identified and assessed for the handling, possible re-use, optimal transport and potential placement sites to manage spoil.

3.6.1 Spoil Production and Removal

Decisions on the tunnel alignment and grades, the layout of the ramps to any additional surface connections and the type of machinery to be used in the tunnel construction are critical to the determination of the volume and rate of spoil production. A number of different layouts have been considered for the Project with different connections and lengths of surface connection ramps. The proposed construction method and design for the project are assessed herein. This involves:

- all tunnels for two traffic lanes;
- the mainline tunnels (except for the Y-junction sections) being constructed with two tunnel boring machines launched from the Western Freeway worksite;
- Y-junction sections and the Toowong and Kelvin Grove surface connection ramps constructed using roadheader machines and drill and blast; and
- surface works at the Western and ICB connections achieved with rippers.

It is possible that a tenderer may develop an alternative construction methodology for the purposes of the reference design. However, the proposal that has been developed based on a likely methodology for this Project, which is achievable.

3.6.2 Selection of Placement Sites

Spoil placement options were identified by contacting potential recipients to determine their potential to receive spoil through the planned period of construction and in what quantities. Three potential sites are identified in **Table 3-6** and shown in Figure 4-18 and Figure 4-19. The risks and constraints associated with each of these potential sites have been assessed leading to the proposal in Chapter 4, Project Description which is considered the most likely plan for spoil management during construction.

- **Table 3-6 Spoil Placement Site Options**

Location	Ownership	Potential fill requirements and timing	Environmental and Planning Issues
Future Port expansion area at Fisherman Islands	Port of Brisbane Corporation	230ha being filled behind the extended seawall. Filling to take 10-15 years.	Approved reclamation project. Necessary approvals already in place via Port corporation. Could accept all Northern Link spoil if necessary
Mt Coot-tha Quarry	Brisbane City Council	Could accommodate all fill from the Project which would involve stockpiling material for reuse over a number of years post construction.	Quarry would need to advise EPA of changed mode of extracting product.
Swanbank	Thiess Services Pty Ltd	Site of over 250 ha has a projected receiving life in excess of 50 years. Could accommodate all spoil from this project if necessary.	Approved landfill project area. Appropriate generic approvals for receipt of spoil already in place.

3.6.3 Spoil Transport Options

Several different transport modes have been considered for the movement of spoil from the tunnels to the potential placement site(s). The options that have been considered include:

- road transport, via the arterial road network servicing each of the four portal sites;
- rail transport via the urban rail network, from the vicinity of the ICB to the Port of Brisbane precinct;
- river transport by barge from the vicinity of Toowong to the Fisherman Islands site; and
- conveyor transport from the western portal to the Mt Coot-tha Quarry.

Conveyor

Due to the proximity of the Mt Coot-tha Quarry the option to recycle the tunnel spoil at the quarry has been investigated and found to be feasible. The spoil would report to the Western Freeway work site via two in-tunnel conveyors from each TBM. A transfer facility would be constructed within the dust proof, acoustic lined shed to allow the spoil to exit the worksite on a single external conveyor that would run parallel to the Western Freeway and turn uphill towards the quarry as shown in Figure 4-20. The conveyor could be constructed on elevated stands and enclosed to minimise its temporary impact on the botanic gardens.

Once in the quarry the conveyor would be constructed to allow direct deposit on the secondary stockpile area or other site areas planned for materials stockpiling. Analyses of the rock material from boreholes in the alignment of the tunnels indicate that the spoil can be expected to be of a quality similar to that of the material now being blasted out of the quarry floor and walls. The spoil would be suitable for the same uses as the material quarried at present, that is, principally as aggregate for asphalt and concrete among a range of other uses. The spoil would be processed under the existing authority (Quarry Licence No. SR41) for crushing and screening. The processed spoil would be trucked out of the quarry without changing the numbers of truck movements from the quarry along Mt Coot-tha Road. The conveyor to the quarry would effectively enable the spoil material from the TBMs to be used as a valuable resource, off-setting the need for blasting and extracting rock from the quarry, and eliminating the need for approximately 65,000 return truck trips from the western connection and Toowong worksites, combined.

Road Transport

Spoil haulage by truck would be confined to the arterial road network. The hours for spoil haulage would be up to 24 hours per day from 6.30am Monday to 6.30pm Saturday, with no haulage at any time on Sundays or public holidays. This approach would require adequate capacity for secure on-site storage of spoil at each of the major worksites. Indicative worksite layouts as shown in Chapter 4 show site access points for trucks engaged in the spoil haulage task, and the likely position of sheds to contain spoil handling and its effects.

At the ICB connection, construction of the transition structure and cut and cover tunnel would produce approximately 23,000 bank cubic metres (the measured volume prior to excavation) of spoil for removal. At the Kelvin Grove connection the construction of the on and off ramps would produce approximately 162,000 bank cubic metres of spoil. The only feasible method for removal of this spoil is considered to be truck haulage, because the relatively small volume of material would not justify the capital outlay involved in bulk handling facilities for an alternative haulage method. Haul trucks from the Kelvin Grove work site would be able to cross Kelvin Grove Road at a set of traffic lights installed at the Musk Avenue intersection, travel south along Kelvin Grove Road, turn left onto the ICB, to Kingsford Smith Drive, the Gateway Bridge and Port of Brisbane. The return trip would follow a similar route via the ICB and Ithaca Street, turning right onto Kelvin Grove Road and directly to the worksite.

Removal of all spoil by truck remains an option for the Western Freeway and Toowong worksites. This option would require stockpiling of spoil from the TBM in the acoustic lined shed, for loading onto trucks. The haul trucks would need to cross beneath the Western Freeway (using a cross passage for access as described in Chapter 4) then turn right to join the Western Freeway travelling west. The identified spoil placement site is at the Swanbank Landfill site just south of the Swanbank Power Station, and the haul route would therefore be along the Western Freeway, Centenary Highway, Ipswich Motorway, Cunningham Highway and Swanbank Road as shown on Figure 4-18. On the return journey a simple diverge from the Western Freeway would provide direct access to the work site. Truck access to and from the Toowong worksite would be directly via Milton Road or Frederick Street as shown on the worksite layout in Figure 4-16. The options for spoil from the Toowong worksite would be road haulage to Swanbank as discussed above, or a short haul to the spoil handling facility at the Western Freeway worksite, for transfer to the external conveyor to the Mt Coot-tha Quarry.

Rail Transport

Investigations were undertaken to determine the physical and commercial feasibility of transporting tunnel spoil by rail. Based on the Reference Project approach to construction, approximately three quarters of the spoil would report to the Western worksite with approximately one eighth reporting to the Toowong worksite and a further one eighth to the Kelvin Grove worksite. All three worksites are distant from railway facilities to the extent that the only practical means of transporting spoil to the rail would be by truck. As a result extra handling of the material from worksites to rail facilities to depot adjacent to placement site and finally placement would be required. The possibility of loading spoil onto rail for transport through the urban rail system to the Port of Brisbane was investigated as part of the Clem Jones Tunnel (CLEM7)[1] project and a suitable site for loading railway cars was identified adjacent to Victoria Park, not far from the proposed Northern Link ICB connection. However, the Reference Design has the bulk of spoil reporting to the Western worksite because there is not sufficient space in the ICB/QR corridor to accommodate a worksite within which the TBMs could be launched. There is no practical option for spoil haulage by rail from the Western worksite as the closest rail corridor is situated well to the east with the nearest point with any space being in Toowong Memorial Park. Double handling at both the dispatch and receiving depots would be required, as well as the construction of a dispatch siding in close proximity to residential areas.

For any rail haulage option, double handling at the receiving depot is likely, to transport construction spoil from the rail head by road to spoil placement sites. Accordingly, rail transport is not recommended for Northern Link spoil haulage.

Water-Based Transport

An assessment of possible loading facilities on the northern side of the river from Toowong west failed to identify any candidate sites downstream of the Centenary Bridge at Jindalee that would be free of impacts in terms of visual amenity, noise or river bank stability, among others. Added to this difficulty in finding a suitable loading site is the distance from the worksites to the river, which would necessitate double handling procedures similar to those required for rail. These constraints render spoil transport by barge along the river an unattractive option that has not been investigated further.

Preferred options are described in Chapter 4.

3.7 Construction Water Supply Options

As detailed in Chapter 4, Project Description, construction for Northern Link would require approximately 270,000 litres of water per day. The water is required for a variety of different purposes. Most of the requirement is not for human consumption or contact. This means that a variety of sources may be considered for the construction water, and that all of the water for the project need not necessarily be obtained from the same source. The undesirably low water levels in the SEQ catchment dams during the period 2006-2008 and the potential for levels to remain low during the Project's construction period, place an obligation on the Project to minimise its reliance on the city's general supply. The several different options investigated for water supply to the project are outlined below and assessed in **Table 3-7**.

[1] Formerly known as the North-South Bypass Tunnel (NSBT).

Table 3-7 Water supply options considered with qualitative relative assessment

Option	Reliability to supply requirements (300-350KL/day)	Reliability of water supply at commencement of construction	Provides potable water supply	Post construction opportunities	Construction impacts	Community Acceptance	Cost
Stormwater Harvesting – Permanent water storage tanks	M	M	N	H	H	L	H
Sewer Mining – Brisbane water sewer network	M	H	N	L	M	L	M
Groundwater – Botanical Gardens production well	H	H	N	H	L	H	M
Desalination – From Brisbane River	H	H	Y	L	M	M	H
Surface Water Storage – Dam sites on East Ithaca Creek	M	M	N	H	M	L	M
Surface Water Storage – Botanical Gardens	M	M	N	H	L	H	L
Quarry – Mt Coot-tha Quarry	M	M	N	M	L	H	L

Table Notes:

H=high; M=medium; L=low.

Y=yes; N=no.

Stormwater Harvesting

The local catchment draining the Mount Coot-tha Botanic Gardens, as detailed in Chapter 7, encompasses 40 hectares and has a discharge rate of 25m^3/second. After passing under the Western Freeway in two culverts the drainage line passes through Anzac Park into a stormwater system of concrete pipes that discharges to the Brisbane River adjacent to the Wesley Hospital. At least six suitable sites were identified where large concrete water storage tanks could be sunk into the ground along this drainage line, to be recharged from the stormwater system during any rain event. The storage tanks would be roofed over so that current amenity and function could be maintained. Based on the assessment this scheme would have the capacity to store up to 100 megalitres of stormwater runoff for project use. A pumping system would be required to take this captured water to the worksite for use. The proposed storage tanks would be permanent structures able to continue to provide a water source well beyond construction of Northern Link. Community facilities such as the Mt Coot-tha Botanic Gardens, Anzac Park, Toowong Memorial Park, Wesley Hospital and other local parklands could draw on this supply and relieve pressure on the main City water supply. The cost of installing these concrete tanks however would be high (in the order of $20-30 million), which makes this option less attractive.

Sewer Mining – Brisbane Water Sewer Network

Consideration was given to recycling sewer water for use in the Project. This would involve:

- a diversion manhole on an existing sewer;
- a sewer pumping station adjacent to the manhole;
- a rising main (underground pipe in trench) to transfer flow to the Western Freeway worksite;

- a raw water balancing tank and treatment plant at the worksite; and
- a treated effluent storage tank.

Several existing sewer take off points were identified with the most appropriate being just off Miskin Street on the bank of Toowong Creek. An in ground rising main from the pump station could follow one of three or four possible routes through suburban streets to Anzac Park and ultimately to the Western Freeway worksite, which would accommodate the treatment plant and holding basin to provide Class A water for the project. The cost of the treatment plant would be about $2 million to which would be added the pumping station, pipeline and its laying and other construction. The treatment plant and basins would require 500m^2 of the worksite. This option may raise issues of community acceptance, as odour issues could be significant.

Groundwater – Botanical Gardens Production Well

During the drought of 2005-2008 the Mt Coot-tha Botanic Gardens faced the expensive necessity of trucking water from the Darra aquifer to keep alive a large number of trees in the gardens. As part of the Brisbane Aquifer Project, drilling for groundwater was undertaken in January 2007 within the eastern part of the Brisbane Botanic Gardens. One drill hole encountered a section of fractured schist 61-67m below ground level, from which flowed brackish to salty water (indicated by an electrical conductivity measure of 3400-4600 micro Siemens per centimetre (µScm)) at a rate of up to 44 litres per second. Flow tests indicated a significant effect on groundwater levels from extracting water at such a rate continuously such that the recommended continuous pump rate to maintain the groundwater level is 3.3 litres per second (=280,000 litres/day or 100 megalitres per year). The bore has been cased as a production well. It is understood the Botanic Gardens management proposes to install a desalination plant to make water extracted from the borehole suitable for watering the Gardens. The capacity of this processing plant is 10 megalitres per year leaving a significant volume (80+ megalitres per year) of underground water available to Northern Link construction. This bore water would be suitable for many of the purposes of the construction phase and if water of better quality is required a treatment plant could be installed adjacent to the well head to provide the appropriate quality.

Desalination – From Brisbane River

At its nearest point the Brisbane River is approximately 2km from the Western Freeway worksite. Potentially a desalination station could be established adjacent to the river or on one of the worksites (probably the Western Freeway worksite). If placed adjacent to the river (eg: in the old quarry site just west of the Wesley Hospital), it would be necessary to truck water to the construction sites. If placed on the worksite a pipe system would be required to draw water from the river and to return the unwanted brine to the river.

Surface Water Storage – East Ithaca Creek

The high bushland of the Mt Coot-tha forest is drained by two large branches of Ithaca Creek, East and West Ithaca Creeks. East Ithaca Creek flows very close to the top of the catchment of the drainage line through the Botanic Gardens and is elevated well above the gardens and Northern Link worksite. A dam on East Ithaca Creek would hold up to 50 megalitres of water that could be piped under gravity to the worksite. A potential dam site was identified in the vicinity of Slaughter Falls where an existing small dam is the remnant of a much larger dam that was used for recreation in the late 19th century, which was washed away in the 1916 flood[2].

[2] University of Queensland Archaeological Services Unit (2007), *Existing Cultural Heritage Environment Report for the Proposed Northern Link Project*. UQASU Report No. 423. School of Social Science, University of Queensland, St Lucia.

The supply would depend on rainfall as the flow in this stream is only maintained from that source. It would provide a long term asset in taking pressure off the main city water supply and could become a recreational venue.

Surface Water Storage – Botanical Gardens

As part of its strategy to become self sufficient with respect to water supply, the Mt Coot-tha Botanic Gardens, through City Design, investigated and developed plans for a water storage dam just upstream from the Western Freeway. In the Northern Link concept design process the timing of construction of this structure has been carefully considered. If it was constructed ahead of the road tunnels it may have been an onsite source of construction water. However, it is considered that construction of the storage dam in this location before completion of the tunnels presents unacceptable risk. A large body of water situated just above the cut and cover tunnel construction is a potential major hazard in the event of a significant rain event during construction. Accordingly this option has no potential to supply construction water.

Mt Coot-tha Quarry

The deep pit towards the southern end of the Mt Coot-tha Quarry contains a substantial volume, up to 30 megalitres, of water derived from rainfall in catchment C3 on Figure 7-4 as well as groundwater from the higher ground of Mt Coot-tha. This storage provides all the water usage for the quarry and could be called upon to supplement other sources if required. Access to the water would most likely be by pumping to tankers for haul by road to the point where the water is required.

The preferred options for construction water supply are described in Chapter 4.