4. Project Description

Northern Link

Phase 2 – Detailed Feasibility Study

CHAPTER 4

PROJECT DESCRIPTION

- September 2008

Contents

4.	**Project Description**	**4-1**
4.1	**General Description of Northern Link**	**4-1**
4.2	**Project Design**	**4-5**
4.2.1	Design Standards and Criteria	4-5
4.2.2	Tunnel Configuration	4-6
4.2.3	Mainline Tunnel Alignment	4-7
4.2.4	Alignment of the Tunnel Ramps	4-9
4.2.5	Design of the Surface Connections	4-10
4.2.6	Ventilation Stations and Outlets	4-25
4.3	**Project Delivery Mode**	**4-28**
4.3.1	Program and Responsibilities	4-28
4.3.2	Establishment and Preliminary Works	4-28
4.3.3	Property Requirements	4-28
4.3.4	Tunnel Portal Cover Sheds (TPCSs)	4-33
4.3.5	Demolition and Utility Modifications	4-33
4.3.6	Tunnel Construction	4-34
4.3.7	Construction of Mainline Tunnels	4-34
4.3.8	Construction of Tunnel Connecting Ramps	4-35
4.3.9	Cross Passages	4-36
4.3.10	Construction of Cut and Cover Tunnels	4-36
4.3.11	Surface Road Connecting Works	4-37
4.3.12	New Surface Structures	4-38
4.3.13	Construction of Ventilation System	4-38
4.3.14	Modification to Existing Structures	4-38
4.3.15	Landscaping Works	4-38
4.3.16	Rehabilitation of Construction Sites	4-39
4.3.17	Traffic and Access During Construction	4-39
4.3.18	Construction Spoil	4-42
4.3.19	Demand on Resources	4-47
4.3.20	Commissioning of Works	4-50
4.4	**Project Operations Mode**	**4-50**
4.4.1	Facility Management	4-50
4.4.2	Tunnel Ventilation	4-51
4.4.3	Services	4-53
4.5	**Infrastructure Requirements**	**4-54**
4.5.1	Utility Modifications	4-54
4.5.2	Wastewater	4-56
4.6	**Permits, Licences and Approvals**	**4-56**
4.6.1	Approvals Pathway	4-57
4.6.2	Development Approvals	4-58
4.6.3	Other Approvals, Licences, Permits and Certifications	4-62
4.6.4	Local Laws	4-63

4. Project Description

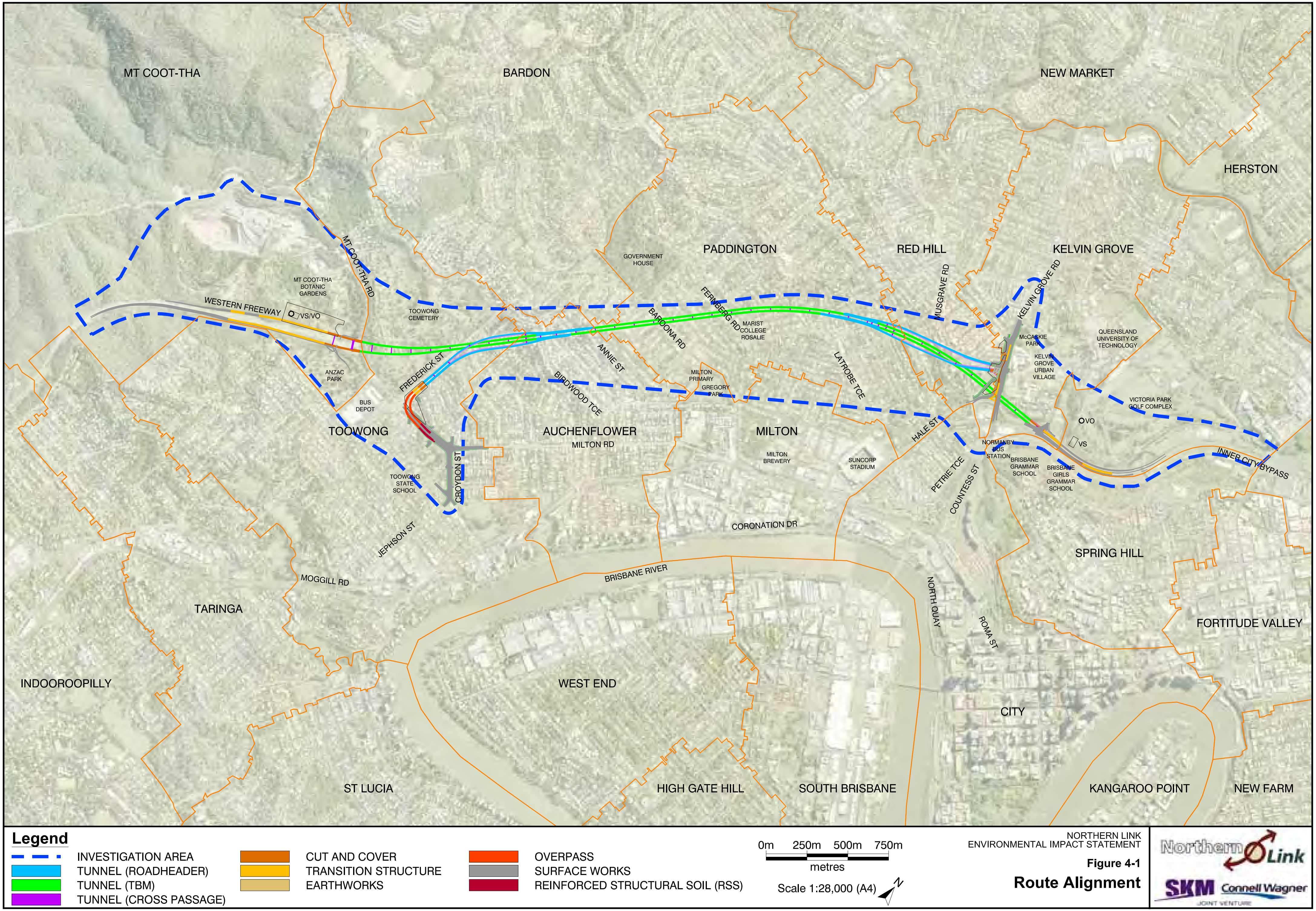
This chapter addresses elements of Section 3 of the Terms of Reference. It describes the Reference Project design and delivery through its lifetime, including design, construction, decommissioning of the construction sites and the operation of the road tunnel.

4.1 General Description of Northern Link

The Project is approximately 6.4km long, with approximately 4.3km of that constructed as tunnel, mainly in hard competent rock below residential areas of Toowong, Auchenflower, Paddington, Red Hill and Kelvin Grove. Surface works would extend into Mt Coot-tha and Herston. The road tunnels would link the Western Freeway at Toowong with the Inner City Bypass (ICB) at Kelvin Grove. A local connection to Milton Road with east facing access would be provided east of Frederick Street in Toowong. A further connection is proposed to Kelvin Grove Road at its intersection with Musk Avenue. Layout of the Project, within the study corridor identified in the Terms of Reference (ToR) for this EIS, is shown in **Figure 4-1** and the indicative longitudinal section of the alignment is shown in **Figure 4-2**. Typical tunnel cross sections are shown in **Figure 4-3**.

The Project would include:

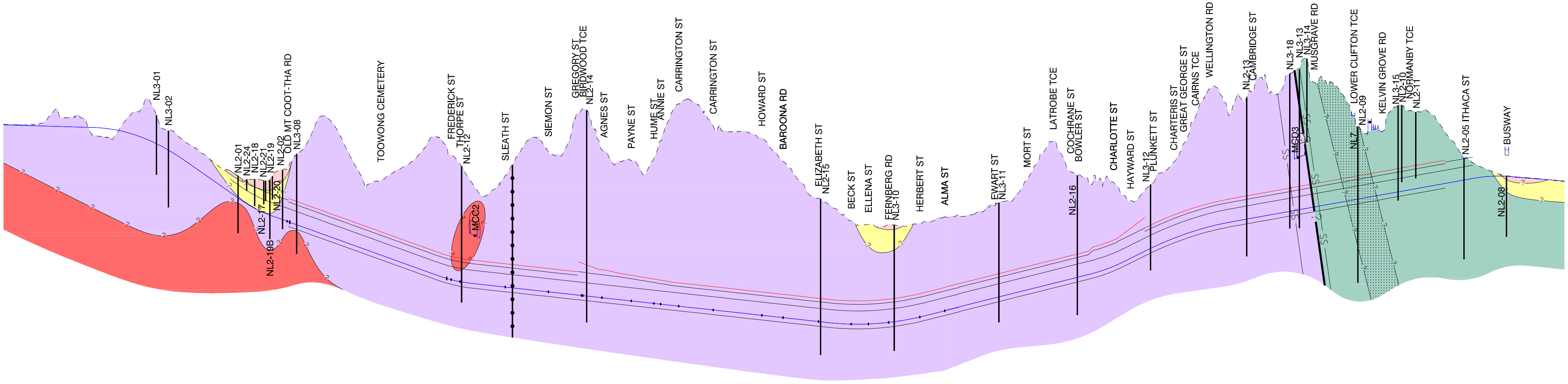
- two separate parallel road tunnels, one for eastbound traffic and one for westbound traffic;
- tunnel portals (openings to the surface) in four positions:
  - on the Western Freeway just west of the Mt Coot-tha Road roundabout at Toowong;
  - just east of Frederick Street and north of Milton Road in Toowong;
  - on the ICB at Kelvin Grove; and
  - just west of Kelvin Grove Road at its junction with Musk Avenue.
- One two or three lanes to/from each portal:
  - each mainline tunnel portal (Western Freeway and ICB) with 2 lane carriageways;
  - Toowong connection entry portal with two lanes merging into a single lane immediately inside the tunnel and exit portal with two lanes having diverged from the mainline as a single lane
  - Kelvin Grove Road portals each with three lanes, the exit ramp having diverged from the mainline as a single lane and the entry ramp tapering to one lane before joining the westbound mainline tunnel;
- fire and life safety mechanical and electrical systems including power supplies, fire response and protection facilities, communication and security systems and emergency egress;
- a ventilation system to manage air quality in the tunnel and near portals, including ventilation stations to house the extraction fans and elevated outlets near the portals adjacent to the Western Freeway and the ICB;
- surface road changes to connect the tunnels into the existing road network including temporary works to meet the needs of construction, the general public and road users;
- traffic management systems including signage, lighting, CCTV and radio/mobile re-broadcast capability; and
- electronic tolling, plant monitoring and control systems.



NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-1
Route Alignment

Northern Link
SKM Connell Wagner
JOINT VENTURE



Legend

- EXISTING SURFACE LEVELS
- INFERRED NORMANBY FAULT
- INFERRED FAULT SHEARING ZONE
- INFERRED GEOLOGICAL BOUNDARY
- RHYOLITE DYKE
- FILL
- QUATERNARY ALLUVIUM (sand, silt, mud, clay and gravel)
- BUNYA PHYLLITE (phyllite)
- NERANLEIGH FERNVALE BEDS (greywacke, siltstone, shale, chert, jasper and basic volcanics)
- APPROXIMATE OUTCROP ZONE OF SPILITE WITHIN NERANLEIGH FERNVALE BEDS
- METAMORPHIC AUREOLE (Hornfels)

0m 250m 500m
metres

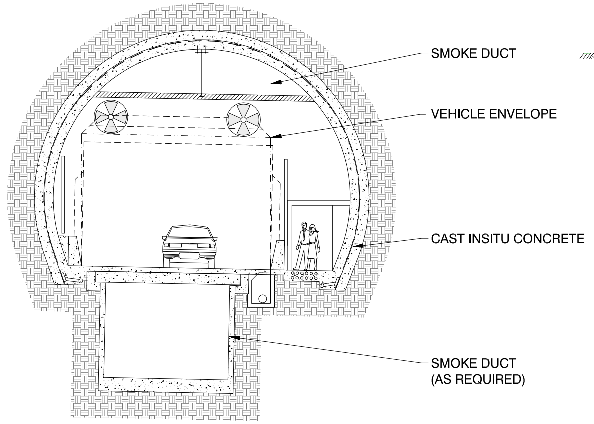
Scale 1:19,600 (A4)

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

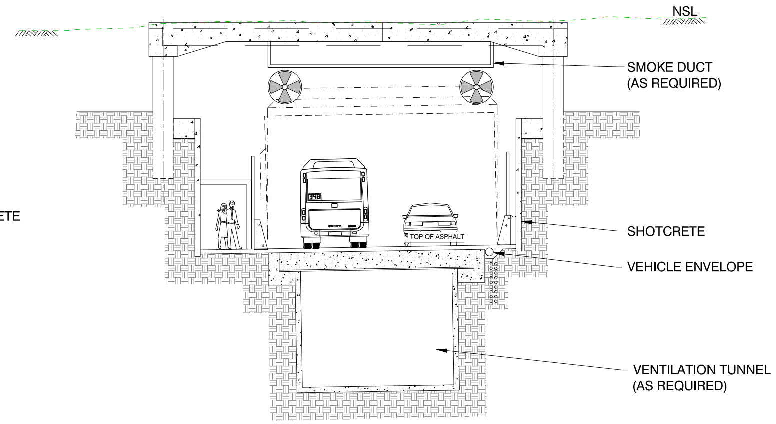
Figure 4-2

Indicative Geological Longitudinal Section

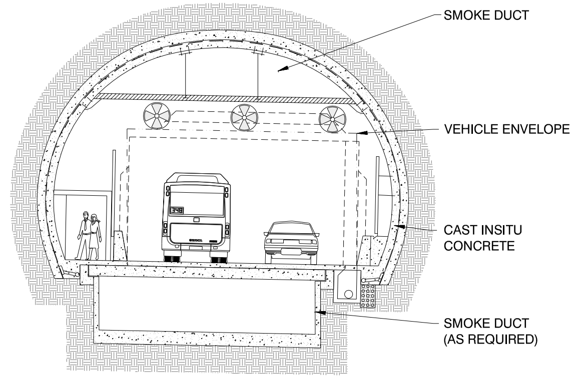
Northern Link
SKM Connell Wagner
JOINT VENTURE



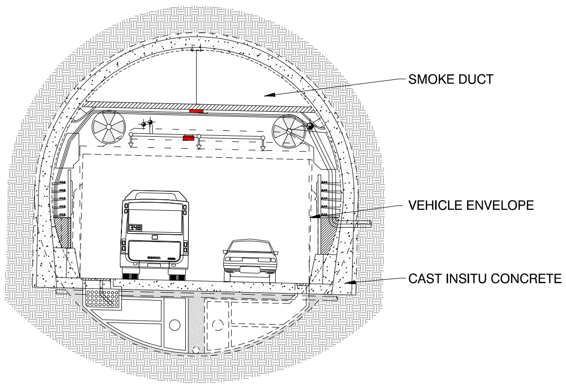
ONE LANE ROADHEADER TUNNEL SECTION



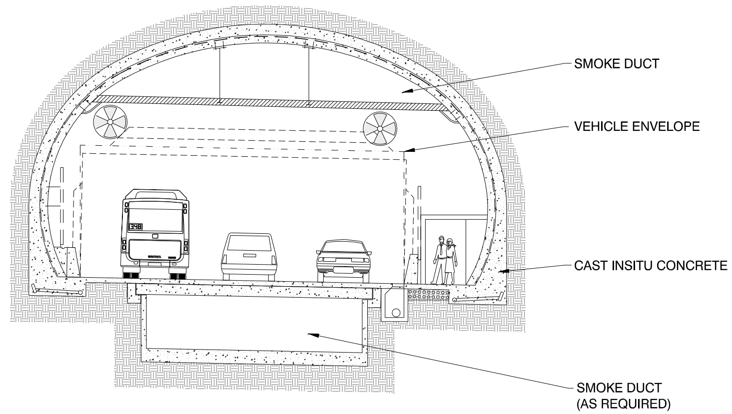
TYPICAL CUT AND COVER TUNNEL
LONGITUDINAL PASSAGE



TWO LANE ROADHEADER TUNNEL SECTION



TWO LANE TBM TUNNEL SECTION



THREE LANE ROADHEADER TUNNEL SECTION

0m 4m 8m
metres

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-3

Typical Sections

Northern Link
SKM Connell Wagner
JOINT VENTURE

4.2 Project Design

4.2.1 Design Standards and Criteria

There are no Australian design standards in use which are directly relevant to road tunnels, nor is there unified consistency amongst international standards (PIARC, 2001), with projects using a mix of performance and prescriptive approaches, international codes, international and national practice and benchmarking to achieve consensus on design issues. There have been significant developments in international codes of practice and standards since the occurrence of tunnel fires in Europe (Mont Blanc, Tauern, Saint Gotthard). Such codes and standards include a mixture of prescriptive design parameters and performance based parameters supported by appropriate quantitative risk analysis (PIARC 2001, 2004).

Fire and Life Safety (FLS) systems for the Project would be based on development in Australian practice and fire regulations cognisant of emerging international trends and guidelines in the area of fire and smoke control in tunnels (PIARC, 1999). The tunnels would provide the following in the event of a fire.

- reliable separation between the fire zone and nearby areas of comparative safety such as a cross passage, longitudinal passage or the adjacent tunnel;
- limiting structural damage in the direct area of the fire; and
- away from the fire, but in an area that may still be affected by hot smoke, making sure emergency equipment continues to operate and that objects do not fall and make conditions unsafe for people trying to escape or for emergency service response efforts to the incident.

The design objective for the mainline tunnels is to achieve a 90km/h design speed for a signposted speed of 80km/h. This would be consistent with the rest of the Brisbane urban road network and is a speed that is commonly adopted for urban road tunnels elsewhere in Australia and overseas. Slower design speeds have been adopted for connections to the local road network at each connection.

The vertical grade of a road has impacts upon vehicle speeds and the quantity of vehicle emissions, with steepening grades increasing the effects. Steep uphill grades result in slowing of heavy vehicles and potential traffic delays, and increased vehicle emissions, and the need for additional ventilation. Once the gradient relative to road length exceeds a certain value, an additional climbing lane is required to address such effects. High downgrades also can create delays, particularly in a speed-monitored environment, as ‘tailbacks’ can form due to breaking effects as vehicles strive to keep to the speed limit. Based upon these considerations, desirable maximum grades of 5% up and 5% down have been adopted for the mainline tunnels. The entry ramps desirable maximum grade is 5% up and 7% down and the exit ramps desirable maximum grade is 8% up and 5% down. A minimum grade in the tunnel of 0.5% was adopted to ensure adequate performance of the longitudinal drainage system. This minimum grade ensures that minor drainage inflows drain to ‘sag points’ within the tunnel from where water would be collected and transferred via a piped drainage system.

Design life is used to mean the time before the first major maintenance is required. Different components of the Project have different design lives and these are summarised in **Table 4-1** below.

Each of the tunnel portals at the four connections has been designed to provide flood immunity to a 10,000 year ARI storm event.

Table 4-1 Design Life for Project Components

Component	Design Life
Bridge and roadway support structures Tunnel structures, underpasses, supports and structural linings Retaining walls including reinforced soil walls Reinforced embankments; Inaccessible drainage elements New local road pavement support structures	100 years
Buildings	50 years
Sign support structures and other roadside furniture Noise barriers Tunnel rigid pavements Tunnel architectural panels	40 years
Reconstructed local road pavements (excluding wearing courses and resurfacing) Drainage elements that are accessible for refurbishment including building drainage Lighting Mechanical and electrical equipment including fire protection systems Traffic management and control systems	20 years
Fixed sign faces Local road wearing courses	10 years

4.2.2 Tunnel Configuration

The mainline tunnel configuration provides for two parallel tunnels, with the more northerly tunnel dedicated to eastbound traffic and the more southerly tunnel to westbound traffic. The two tunnels would be aligned next to each other, with minimum separation of at least 10m in the driven tunnel sections. As discussed below, cross-passages would connect the two tunnels at regular intervals along the route.

Lane widths, separations and shoulders are to accord with Queensland Department of Main Roads planning and design standards for road planning and construction. Each mainline tunnel would have two 3.5m wide running lanes, with a 1m wide shoulder on the left hand side and 0.5m on the right. Dedicated break down bays would not be provided within the tunnels, as there would be sufficient room to pass a stationary vehicle safely, at an appropriate speed, with the configuration proposed. The posted height clearance is 4.6m, providing a vehicle envelope of 4.9m, above which 0.7m of space would be allowed for ducts, lighting and signage. The widths of tunnel connecting ramps have been designed for the Reference Project to enable passing of stalled vehicles. A single lane ramp would have a 4m wide running lane with a 2m wide shoulder on the left hand side and 1m on the right. A two lane ramp would have two 3.5m wide running lanes with a 1.5m wide shoulder on the left hand side and 0.5m on the right.

The tunnel configuration provides for the use of the tunnels by Class 1-10 vehicles, Class 10 being a B-double, or heavy truck and trailer up to 4.6m in height. B-doubles combinations 4.3m to 4.6m high may only be used in Queensland on an approved B-double route, which currently exclude the Western Freeway and there is no intention of designating the tunnel for B-double use. The largest unregulated freight vehicle likely to use the tunnel would include class 9, up to 6 axle articulated vehicles or 3 axle rigid vehicles with three axle trailer. These classes of vehicles provided for in the tunnel configuration include up to three axle articulated buses.

The use of the tunnel by bicycles and also placarded vehicles would be prohibited. Placarded vehicles include:

- any load of bulk dangerous goods;
- a load containing at least 250kg or 250 litres of dangerous goods;
- any of which are Class 2.1 (flammable gas), Class 2.3 (toxic gas);
- a load containing any quantity of Class 6.2 (infectious substances); and
- any other load of dangerous goods of at least 1000kg or 1000 litres.

Westbound Traffic

For westbound mainline traffic, entry to the tunnel would be provided directly from the ICB and from Kelvin Grove Road. The entry ramp at Kelvin Grove Road would facilitate access from both the northbound and southbound directions of Kelvin Grove Road and from the existing loop ramp that would provide a connection from Musgrave Road (northbound) to Kelvin Grove Road. All connections for westbound mainline traffic would be via free flow ramps. Westbound mainline traffic could exit directly to the Western Freeway or onto Milton Road for access to the Toowong precinct. The exit ramp to Milton Road would be directly to the signalised intersection of Milton Road and Croydon Street. All traffic from the exit ramp to Milton Road would be restricted to turn right to Croydon Street.

Eastbound Traffic

For eastbound mainline traffic, entry to the tunnel could be gained directly from the Western Freeway and from Milton Road, between Croydon Street and Frederick Street. The entry ramp at Milton Road would be accessed from Milton Road, Croydon Street and Morley Street. Eastbound mainline traffic could exit directly on to the ICB or onto Kelvin Grove Road. The exit ramp to Kelvin Grove Road has been designed to allow traffic to go northbound on Kelvin Grove Road via a free flow slip, or either straight ahead to Musk Avenue or southbound on Kelvin Grove Road via a signalised intersection at Musk Avenue/Kelvin Grove Road intersection. The southbound movement has been particularly designed to allow buses (generally Rocket bus services from the Western Freeway) to access the Inner Northern and Northern Busway systems at the Normanby bus station.

4.2.3 Mainline Tunnel Alignment

The mainline (eastbound and westbound) tunnel alignment would portal on either side of the Western Freeway approximately 200m west of the Mt Coot-tha roundabout. The alignment passes beneath the suburbs of Toowong, Auchenflower, Paddington, Red Hill and Kelvin Grove to join the ICB, east of Kelvin Grove Road.

The cut and cover alignments of the eastbound tunnel would be to the north of the Western Freeway and through Mt Coot-tha Road to the north of the Mt Coot-the roundabout. At the ICB connection the cut and cover section of the eastbound tunnel is relatively short and south of the southern side of the properties facing Normanby Terrace, through the pedestrian and cycle path, to the Victoria Park Road connection with the ICB. The cut and cover alignments of the westbound tunnel would be to the south of the Western Freeway, through the cycle and pedestrian path and through the southern side of the Mt Coot-tha roundabout. At the ICB connection the cut and cover alignment for the westbound tunnel is significantly longer than the eastbound cut and cover tunnel. The cut and cover would commence from the existing ICB road reserve south of Normanby Terrace, and continue along the ICB to portal some 150m east of an alignment with Kalinga Avenue and the Inner Northern Busway.

The eastbound driven tunnel would commence within the Mt Coot-tha Road reserve west of the boundary of the Toowong Cemetery to follow an alignment beneath the Toowong Cemetery, Frederick Street (near its intersection with Thorpe Street), Birdwood Terrace (east of its intersection with Fairseat Street), the intersection of Carrington and Daintree Streets, Baroona Road (between Howard and McNab Streets), Beck

Street (west of its intersection with Nash Street), and Fernberg Road (east of its intersection with Ellena Street). From Fernberg Road the alignment arcs slightly south under Latrobe Terrace (north of its intersection with Cochrane Street), Hayward Street (between Plunket and Charlotte Streets), Cairns Terrace at its intersection with Great George Street, St Brigid's Church on Musgrave Road, and Kelvin Grove Road (north of the ICB) to connect with the cut and cover tunnel at the ICB, identified above.

The westbound driven tunnel also commences to the west of the Toowong Cemetery boundary and some 40m south of, and parallel to, the eastbound tunnel alignment. The westbound tunnel alignment follows a curved alignment beneath the Toowong cemetery converging towards the eastbound tunnel to form an alignment approximately 10m south of, and parallel to, the eastbound tunnel between Fernberg Road and its eastern connection with the cut and cover tunnel, on the ICB, south of Normanby Terrace.

The vertical alignment involves a desirable grade from each portal to a low point approximately 30m beneath Beck Street, Paddington. The depth of the tunnel below the ground surface varies considerably due to the marked variation in height of the land surface over the numerous sharp ridges along the alignment. An indication of the approximate depth of the tunnels between their crown and the existing surface, is identified in **Table 4-2** below.

- **Table 4-2 Approximate Depth from Existing Surface to Crown of Mainline Tunnels**

Location	Eastbound Tunnel Depth (m)	Westbound Tunnel Depth (m)
Western Driven Tunnel Portal	11	9
Toowong Cemetery	15	16
Frederick Street (near its intersection with Thorpe Street),	36	33
Birdwoord Terrace (east of its intersection with Fairseat Street),	58	58
Carrington (intersection with Daintree Street)	60	66
Baroona Road (between Howard and McNab Streets),	50	48
Beck Street (west of its intersection with Nash Street),	30	30
Fernberg Road (east of its intersection with Ellena Street)	28	28
Latrobe Terrace, north of its intersection with Cochrane Street,	45	43
Hayward Street (between Plunket and Charlotte Streets),	10	13
Cairns Terrace at its intersection with Great George Street,	33	40
St Brigid's Church on Musgrave Road,	44	44
Kelvin Grove Road (north of the ICB)	16	15
Eastern Driven Portal	9	8

The alignment for the mainline tunnels has been based on a number of factors, including:

- road geometry based on design speed, sight distance, vertical alignments, including the need for entry or exit ramps to cross over and/or connect to the mainline tunnels and the need to connect into the existing levels at the surface connections; and
- geotechnical conditions, including groundwater conditions, particularly at the Western Freeway connection.

4.2.4 Alignment of the Tunnel Ramps

For the Toowong connection, entry and exit driven tunnel ramps are proposed to provide a connection between the mainline tunnels from beneath Birdwood Terrace to a new surface road connection located east of Frederick Street with elevated ramps to Milton Road and its intersection with Croyden Street. Short sections of cut and cover tunnels would be constructed south of Morley Street, just to the east of Frederick Street. Driven tunnelling for both ramps would commence from below Morley Street following an alignment east of Frederick Street. The east bound entry ramp would cross over the mainline tunnels in the vicinity of Thorpe Street with both ramps then aligning themselves either side of the mainline tunnels and forming an underground junction between Birdwood Terrace and the vicinity of Annie Street.

The vertical alignment of the Toowong connecting ramps includes a desirable grade for the eastbound entry ramp until it crosses over the mainline tunnels. This is followed by a maximum 7% grade in the vicinity of Sleath Street to Siemon Street prior to its merging with the mainline tunnel between Birdwood Terrace and Annie Street. The westbound exit ramp follows a more constant grade of some 6% as it is not constrained by the need to cross the mainline tunnels as is required for the eastbound entry ramp. An indication of the approximate depth of the driven ramps between their crown and the existing surface is identified in **Table 4-3** below.

- **Table 4-3 Approximate Depth from Existing Surface to Crown of Toowong Connecting Ramps**

Location	Eastbound Entry Ramp Depth (m)	Westbound Exit Ramp Depth (m)
Morley Street (connection to the cut and cover)	4	6
Musgrave Street	12	15
Victoria Crescent	14	15
Thorpe Street	14	13
Sleath Street	15	32
Siemon Street	47	39
Gregory Street	NA	46
Birdwood Terrace	58	58
Agnes Street	45	44
Payne Street	44	39
Annie Street	52	NA

For the Kelvin Grove connection, entry and exit driven tunnel ramps are proposed to provide a connection between the mainline tunnels from a location between Latrobe Terrace and Hayward Street, Red Hill to meet Kelvin Grove Road directly opposite Musk Avenue. The eastbound exit ramp follows an alignment to the north of the mainline tunnels below Musgrave Road between Woolcock Street and Scott Street and emerging to the west of Kelvin Grove Road through a short section of cut and cover tunnel through Upper Clifton Terrace. The entry ramp connects from both Kelvin Grove Road north and south to cut and cover entry tunnels. The alignment of the entry ramp would extend from cut and cover tunnel at Upper Clifton Terrace westward over the mainline tunnel (under St Brigid's Church carpark) until Cambridge Street where it swings parallel to the mainline tunnels to join with the mainline tunnel in the vicinity of Charlotte Street.

The vertical alignment of the eastbound exit ramp would rise uniformly whereas the westbound entry ramp would be almost level until it had crossed over the mainline tunnels and would then change gradient to descend to merge with the mainline westbound tunnel. An indication of the approximate depth of the driven ramps between their crown and the existing surface is identified in **Table 4-4** below.

- **Table 4-4 Depth from Existing Surface to Crown of Kelvin Grove Road Connecting Ramps**

Location	Eastbound Exit Ramp Depth (m)	Westbound Entry Ramp Depth (m)
Connection to the cut and cover	6	13
Upper Clifton Terrace	10	22
Musgrave Road	22	20
St Brigid's carpark	NA	25
Cambridge Street	30	17
Cairns Terrace	21	39
Plunkett Street	14	19
Charlotte Street	22	16
Bowler Street	31	28

4.2.5 Design of the Surface Connections

Western Freeway Connection

The proposed surface road connections to the Western Freeway are shown on **Figure 4-4A** and **Figure 4-4B**. As discussed in Chapter 3, Project Development, the Western Freeway connection takes into account the future planning requirements of DMR for the Western Freeway to include three lanes each way to the existing Mt Coot-tha Road roundabout, including two general purpose lanes and a transit lane (T2). The design of the Western Freeway connection includes:

- Northern Link ramps and portals would be provided on the outside of the existing Western Freeway allowing capacity for the future road widening of the Western Freeway (with the transit lanes (T2) on the inside);
- a single lane diverge from the Western Freeway would be provided to a two lane entry ramp to Northern Link;
- a two lane exit ramp, with the ramp merging to one lane would be provided from Northern Link, prior to merging with the Western Freeway;
- there would be no permanent road works west of the Frederick Street/Milton Road roundabout and the Mt Coot-tha Road roundabout would be retained in its present configuration; and
- the existing cycle and pedestrian path along the southern side of the Western Freeway would be relocated along the southern side of the Northern Link exit ramp, including works to the overpass across the Western freeway and relocation of the path on the northern side in order to maintain the connectivity and functionality planned by DMR for the Cycle and Pedestrian Bridge.

The proposed final landscape and urban design features for the Western Freeway Connection, as discussed in Chapter 14, are indicated on **Figure 4-5**.

Legend

- INVESTIGATION AREA
- TRANSITION STRUCTURE
- SURFACE WORKS
- EARTHWORKS

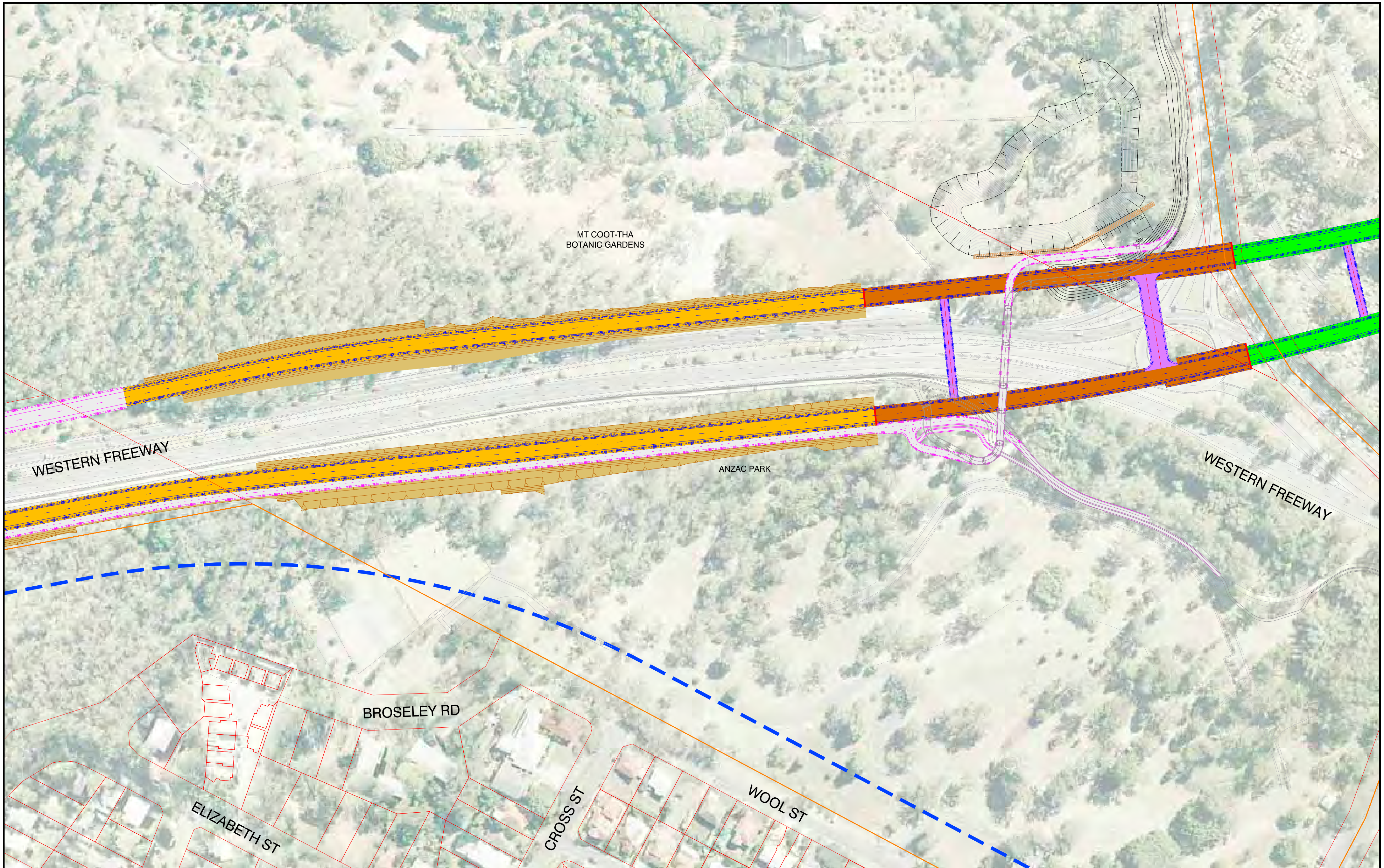
0m 50m 100m
metres
Scale 1:3,360 (A4)
N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-4A

Western Freeway Surface Connection

Northern Link
SKM Connell Wagner
JOINT VENTURE



Legend

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

0m 50m 100m
metres
Scale 1:3,360 (A4)
N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-4B

Western Freeway Surface Connection

Northern Link
SKM Connell Wagner
JOINT VENTURE

0m 60m 120m
metres
Scale 1:4,200 (A4)
N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-5

**Master Plan
Western Freeway**

Northern Link
SKM Connell Wagner
JOINT VENTURE

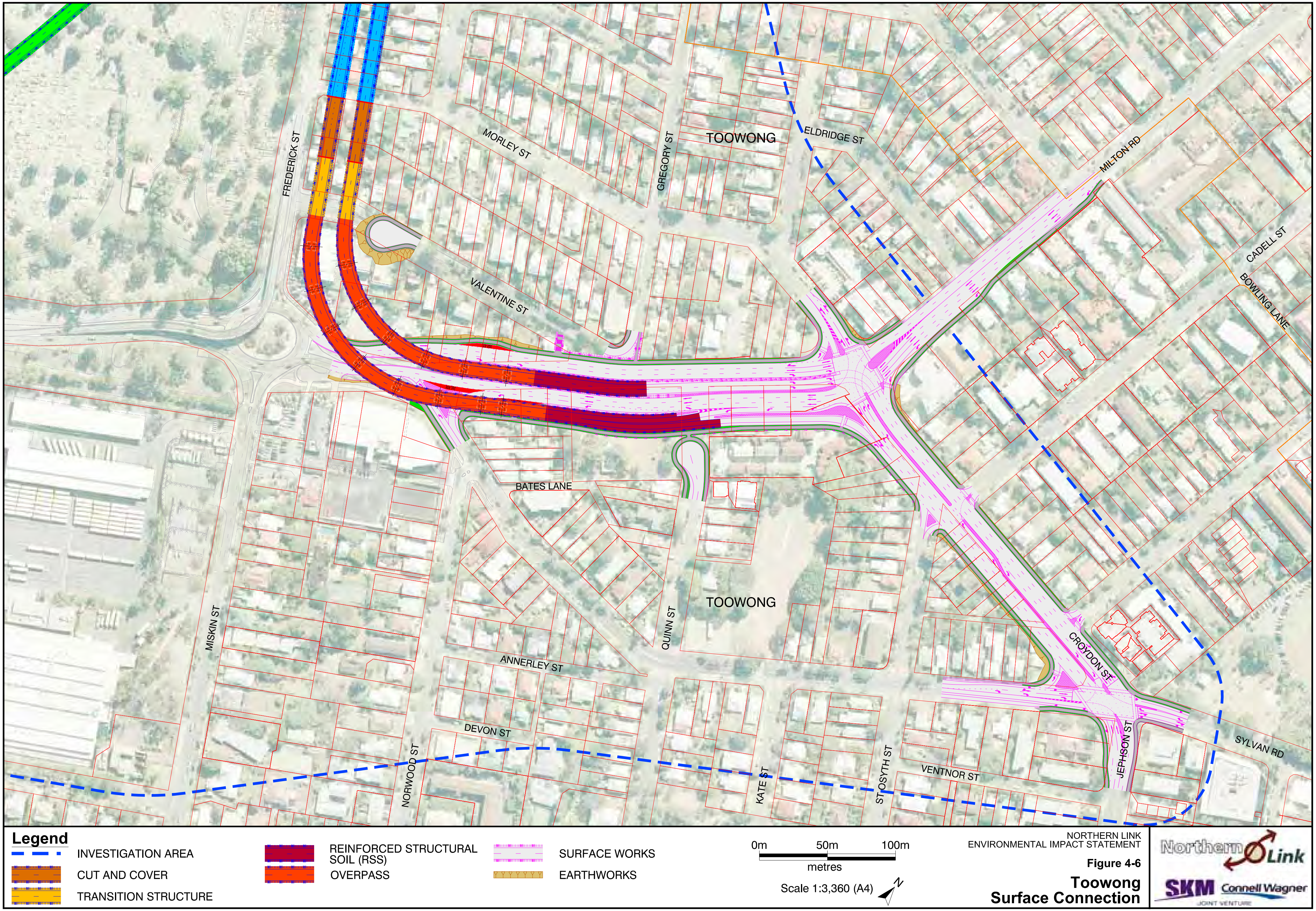
Toowong Connection

The proposed surface roads at the Toowong connection are shown in **Figure 4-6**. The Toowong connection would be via grade separated dual-lane east facing ramps that would connect with Milton Road and Croydon Street. Frederick Street, including the existing elevated ramp from Frederick Street to Mt Coot-tha Road and the existing Toowong Roundabout, would not be affected by the Reference Project design. The design of the Toowong connection includes:

- the entry to the mainline tunnel would be via a dual-lane east facing elevated ramp positioned on the outside of the Milton Road westbound carriageway. Access would be provided from Croydon Street via a dedicated left lane free flow slip lane at the intersection of Milton Road. Access would also be provided from Milton Road (east) via a left hand diverge that could also be accessed by vehicles that turn right from Morley Street;
- the exit from the mainline tunnel would be via a dual-lane east facing elevated ramp connecting to the inside of the Milton Road eastbound carriageway. Both lanes would be directed into Croydon Street through the signalised intersection. No direct access would be provided to Milton Road or Morley Street;
- the existing city bound right turn pocket from Milton Road to Sylvan Road would be removed and replaced by a dedicated right turn lane at the Croydon Street signalised intersection; and
- the existing signalised intersection of Milton Road, Croydon Street and Morley Street would be upgraded to allow for:
  - Milton Road (east) – widened to three traffic lanes approximately 200m upstream of the intersection to facilitate three west bound traffic lanes at the stop line and a left turn pocket and slip to Croydon Street;
  - Croydon Street (south) – three traffic lanes at the stop line with two lanes for the right turn to Milton Road (east) and one lane to Milton Road (west) and Morley Street. A free flow left turn slip would be provided to the Northern Link entry ramp;
  - Milton Road (west) – five lanes at the stop line of which two inside lanes are directly from the Northern Link exit ramp and would provide for right turn only to Croydon Street (south). The other three lanes would be from the Toowong Roundabout. The inside third lane would be for the right turn to Croydon Street and the remaining two outside lanes would be for the straight ahead movement to Milton Road (east). A left turn slip would be provided to Morley Street;
  - Morley Street (north) – little change from the existing configuration with two lanes at the stop line. The outside lane would be for the left and straight ahead movement and the inside lane would be for the right turn and straight ahead movements; and
  - the pedestrian crossing on the Milton Road western approach would be removed. The ability for pedestrians to cross at the signalised intersection of Milton Road/Croydon Street/Morley Street would be maintained through the provision of pedestrian crossings on three of the four approaches. Due to the width of Milton Road, a staged crossing of the eastern approach with a wide median island would be provided.
- Croydon Street would be widened from two lanes to three lanes in each direction between Milton Road and the signalised intersection of Sylvan Road. The Sylvan Road and Jephson Street approaches to this intersection would be amended to suit;
- the intersection of Croydon Street with Cadell and St Osyth Streets would be modified to make St Osyth Street a left in and left out access only. Cadell Street would have the left turn in and left turn out access as well as a right turn in from Croydon Street northbound;

- Bayliss Street would become left in and left out access only with Croydon Street;
- the section of Milton Road between Sylvan Road and Croydon Street would be widened to accommodate 10 traffic lanes made up of three inbound and three outbound for Milton Road through-traffic plus two entry and two exit lanes connecting the Northern Link tunnels;
- Sylvan Road would become left in and left out access only with Milton Road;
- the existing accesses of Valentine Street at Frederick Street and Quinn Street at Milton Road would be severed so creating cul-de-sacs;
- the intersection of Gregory Street with Milton Road would be closed off;
- pedestrian crossings of all approaches would be maintained at the Croydon Street/Jephson Street/Sylvan Road signalised intersection. Full pedestrian footpaths would be kept on both Croydon Street and Milton Road; and
- the on-road bike paths on Sylvan Road and its connectivity with the Western Freeway and the Bicentennial bikeway would be maintained. The on-road bike paths would be kept on the Sylvan Road approaches to the Croydon Street/Jephson Street/Sylvan Road signalised intersection.

The proposed final landscape and urban design features for the Toowong Connection, as discussed in Chapter 14, are indicated on **Figure 4-7.**



NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-6
Toowong
Surface Connection

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-7

Master Plan
Toowong Connection

Northern Link

SKM Connell Wagner JOINT VENTURE

Kelvin Grove Connection

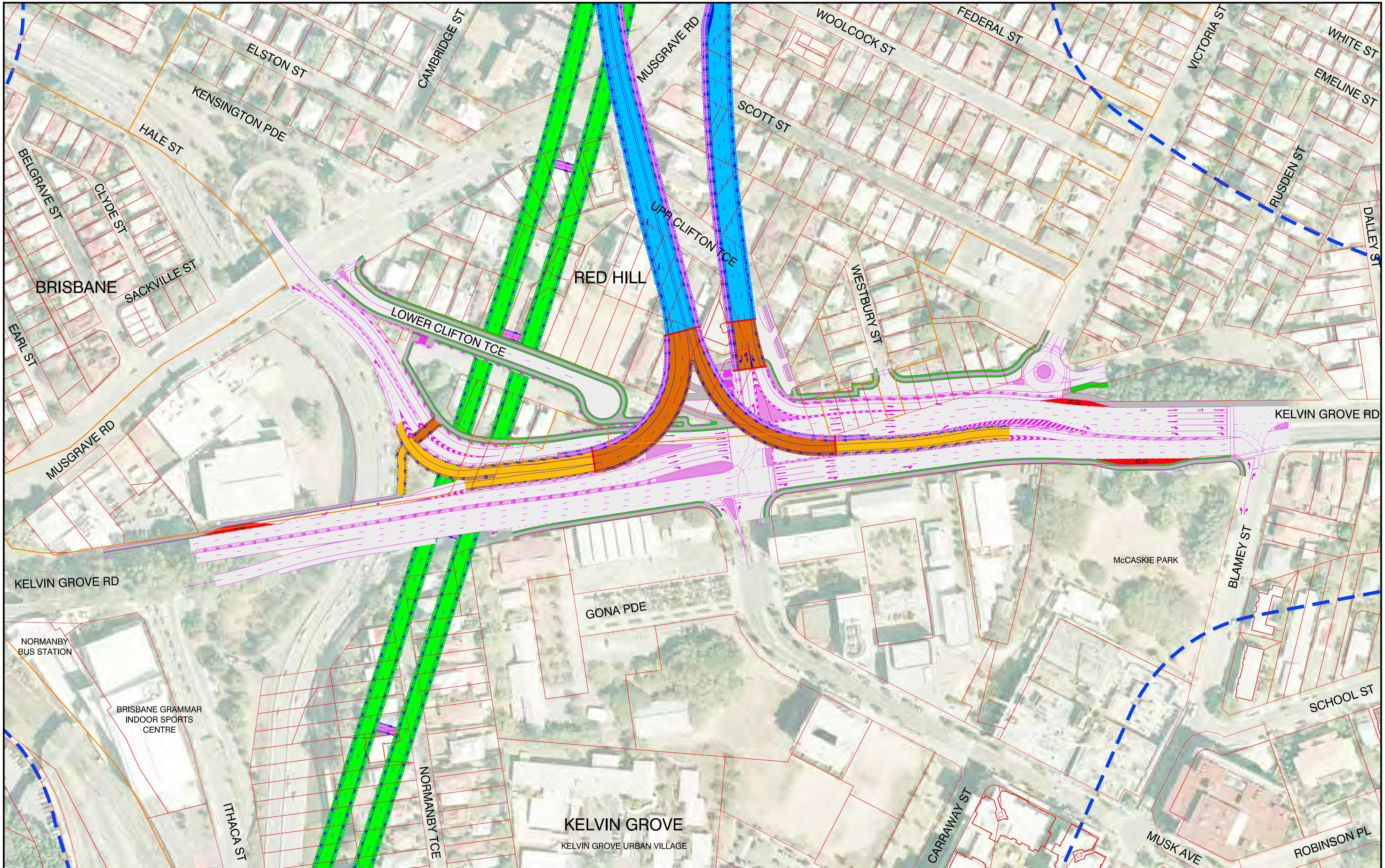
The Reference Project design includes direct connections to Kelvin Grove Road and from the existing loop ramp that connects Musgrave Road (northbound) to Kelvin Grove Road (northbound). The proposed layout of the Kelvin Grove connection is shown in **Figure 4-8**. The design of the Kelvin Grove surface connection includes:

- two separate entry and exit ramps would provide a connection with Kelvin Grove Road, emerging on the western side of Kelvin Grove Road, opposite Musk Avenue;
- the exit ramp from the Northern Link tunnel includes a widening of the two lane exit ramp to three lanes within the exit ramp approximately 220m from the signalised intersection with Kelvin Grove Road, providing:
  - a dedicated single left lane to access Kelvin Grove Road (northbound) through a free flow slip connection and merge with Kelvin Grove Road northbound; and
  - two lanes providing for the right turn to Kelvin Grove Road (southbound) at the stop line of the intersection with Kelvin Grove Road. The inside lane would also provide for the straight ahead movement to Musk Avenue.
- the entry ramp would be accessed from Kelvin Grove Road north and south as well as from the existing loop ramp that connects Musgrave Road with Kelvin Grove Road (northbound) and includes:
  - an access to the entry ramp from Kelvin Grove Road (southbound) would be provided through a diverge adjacent to the median of Kelvin Grove Road south of Blamey Street. The diverge would lead directly into the tunnel via a cut and cover portal avoiding the signalised intersection of Kelvin Grove Road with Musk Avenue and the Northern Link exit ramp; and
  - the Kelvin Grove Road (northbound) entry ramp to Northern Link would be provided through a single left hand lane diverge from Kelvin Grove Road, north of its crossing under the ICB. This would lead to a cut and cover tunnel at a merge with the Musgrave Road loop ramp so creating a two lane entry ramp that would taper to one lane prior to merging with the entry ramp from Kelvin Grove Road (southbound). This entry ramp would also avoid the intersection of Kelvin Grove Road with Musk Avenue and Northern Link exit ramp.
- Surface works on Kelvin Grove Road would extend from Ithaca Street to Blamey Street. The existing Kelvin Grove Road through lane capacity would be maintained. Some modifications of the Kelvin Grove Road/Blamey Street intersection would also be required;
- lower Clifton Terrace would become a cul-de-sac with left in and left out access only with Musgrave Road;
- upper Clifton Terrace would remain as a cul-de-sac, with a developed turn around facility, with access to Musgrave Road only;
- Westbury Street would not connect directly to Kelvin Grove Road but would have access via a new service road to Victoria Street;
- Victoria Street would no longer have direct access to Kelvin Grove Road but would have a roundabout at its eastern end retaining access to Rusden Street; and
- connectivity at the Musk Avenue and Blamey Street intersections with Kelvin Grove Road would remain as at present with all turns available.

The connection of Northern Link with Kelvin Grove Road has been designed such that all pedestrian connections would be maintained with appropriate accessibility for mobility impaired users. The pedestrian facilities would maintain the linkages between the Kelvin Grove Urban Village and the community and bus stops to the west of Kelvin Grove Road. Key features of the pedestrian facilities include the following.

- The existing pedestrian footpaths on both sides of Kelvin Grove Road between College Road and Musk Avenue would be maintained. The footpath on the eastern side of Kelvin Grove Road between Musk Avenue and the entry ramp to the ICB would be widened. The footpath on the western side between the connecting loop from Hale Street and Musgrave Road would be re-aligned to suit proposed road surface works.
- The existing pedestrian underpass below the connecting loop from Hale Street and Musgrave Road to Kelvin Grove Road would be maintained and lengthened to suit the additional traffic lanes that would be required to access Northern Link.
- New pedestrian footpaths would be provided on both sides of Lower Clifton Terrace.
- Existing pedestrian crossing facilities of the signalised intersection of Kelvin Grove Road/Musk Avenue and Northern Link would be maintained. A pedestrian crossing would also be provided across Northern Link approach to this intersection. Access from this intersection to Upper Clifton Terrace and the continuation of the footpath northwards on Kelvin Grove Road would be via steps or a switchback ramp that provide access to a pedestrian route over the tunnel portal. A pedestrian crossing would not be provided across the Northern Link north facing exit ramp to Kelvin Grove Road.
- Pedestrian footpaths would continue to be provided on both sides of Kelvin Grove Road between Musk Avenue and Blamey Street.
- At the signalised intersection of Kelvin Grove Road and Blamey Street pedestrian crossings would be provided on Blamey Street and the southern approach of Kelvin Grove Road. The existing crossing of Kelvin Grove Road is currently on the northern approach and it is proposed to relocate this crossing to the southern approach.

The proposed final landscape and urban design features for the Kelvin Grove surface connection, as discussed in Chapter 14, are indicated on **Figure 4-9**.



Legend

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

0m 40m 80m
metres
Scale 1:2,800 (A4)

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-8

Kelvin Grove Road Surface Connection

Northern Link
SKM Connell Wagner JOINT VENTURE

0m 40m 80m
metres
Scale 1:2,800 (A4)

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-9

**Master Plan
Kelvin Grove Road**

Northern Link
SKM Connell Wagner
JOINT VENTURE

Inner City Bypass Connection

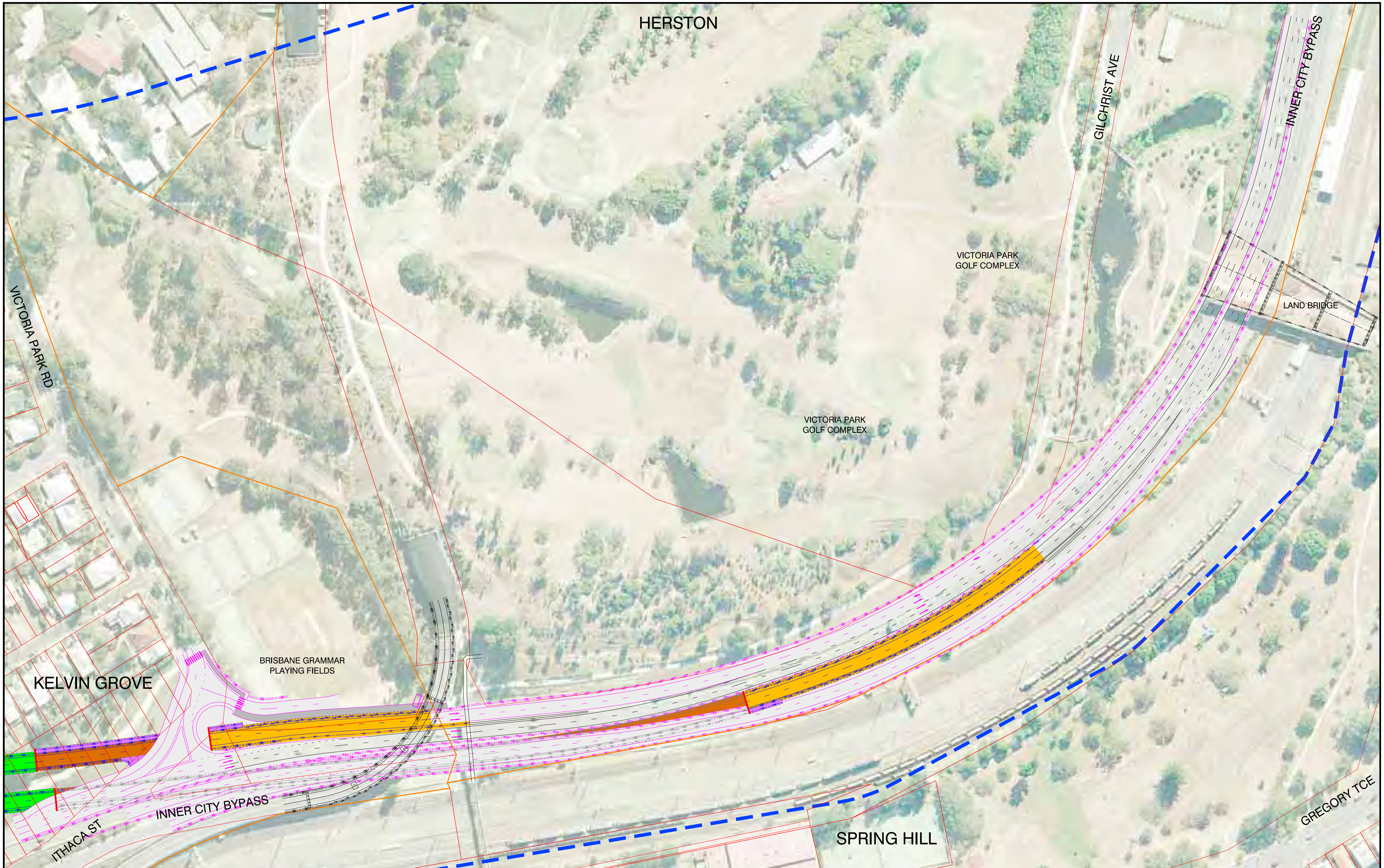
The proposed layout of the ICB connection is shown in **Figure 4-10**.

The existing ICB is three lanes in each direction. The lane configuration at the eastern connection at the Northern Link portals would be two lanes each way for Northern Link and two lanes each way for the ICB. The design of the ICB surface connection includes:

- the outside lane of the Northern Link eastbound exit ramp would merge into three lanes for the ICB prior to the ICB landbridge;
- the entry ramp from Kelvin Grove Road to the ICB currently becomes the third outside lane of the ICB. The entry ramp would merge with the ICB to the east of Victoria Park Road, with two eastbound ICB lanes continuing past the tunnel transition structure;
- the eastbound tunnel cut and cover structure would allow for the left-in and left-out connection of the ICB and Victoria Park Road to be maintained;
- the westbound movement from the ICB to Hale Street would be facilitated through a lane drop and a divergence at the Land Bridge to create two lanes that would continue to Hale Street. The divergence to Ithaca Street would be maintained; and
- two westbound lanes of the ICB would continue to the Northern Link entry ramp.

The surface works associated with connecting Northern Link to the ICB would not impact on the off-road bikeway adjacent to the southern side of the ICB or on the bikeway and pedestrian paths on the ICB landbridge. The off-road bikeway on the northern side of the ICB between Kelvin Grove Road and the ICB landbridge would be re-aligned.

The proposed final landscape and urban design features for the ICB surface connection, as discussed in Chapter 14, are indicated on **Figure 4-11**.



Legend

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

0m 40m 80m
metres
Scale 1:2,800 (A4)
N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-10

ICB Surface Connection

Northern Link
SKM Connell Wagner
JOINT VENTURE

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-11

Master Plan
Inner City Bypass

Northern Link
SKM Connell Wagner
JOINT VENTURE

4.2.6 Ventilation Stations and Outlets

A ventilation station and associated ventilation outlet would be required near the exit from each of the mainline tunnels. No ventilation stations or ventilation outlets are required in association with either the Toowong or Kelvin Grove connections. There are two preferred sites for the ventilation stations and the ventilation outlets.

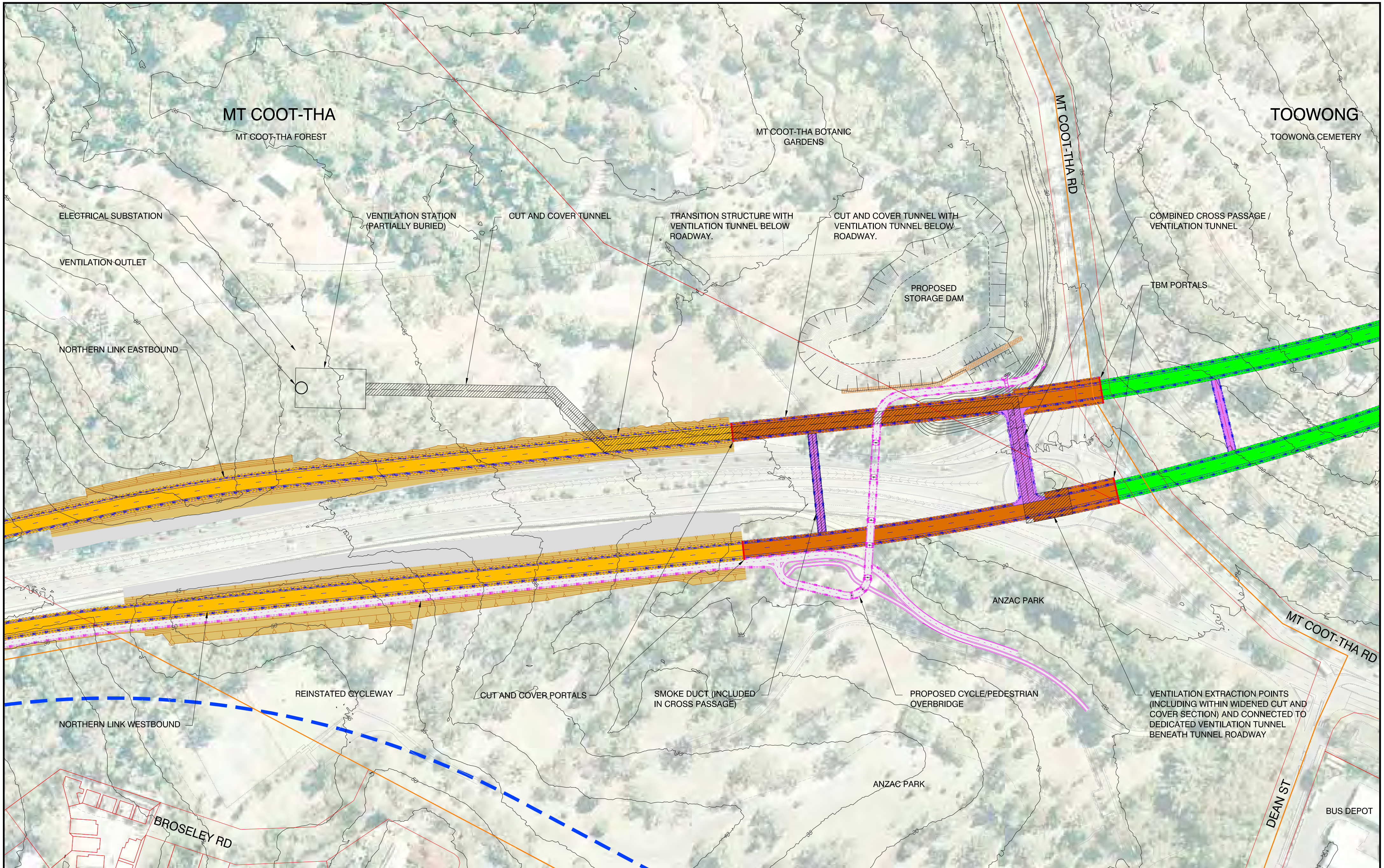
- The western ventilation station and outlet – on Council owned land on the Mt Coot-tha side of the Western Freeway, approximately 400m west of Mt Coot-tha Road.
- The eastern ventilation station and outlet – both on Council owned land within the Victoria Park Golf Course, east of the Inner Northern Busway and north of the ICB with the ventilation outlet being a separate structure further north on a topographic rise.

The preferred locations for each of the ventilation stations and outlets are indicated on **Figure 4-12** and **Figure 4-13** for the western and eastern sites, respectively.

The western ventilation station is proposed to be located on the western end of the Western Freeway worksite, and to be cut into or partially buried within the forested slope of the hillside in this location. Burial would allow for stacking of the fans onto two levels and possible dimensions for the ventilation station of 41m long, 23m wide and 13.5m high. The Reference Project base height for the ventilation outlet location is at RL 46.4m with the opening at RL 66.4m providing for the outlet opening to be 20m above the ground level at this location. Its height above the ventilation station would depend on the extent of burial able to be obtained for the ventilation station. The ventilation duct from the extraction point within the westbound cut and cover tunnel exit ramp, on the southern side of the Western Freeway, would be constructed under the widened cross passage and connect under the eastbound cut and cover tunnel entry ramp to access the ventilation station on the northern side of the Western Freeway (refer **Figure 4-3** - Typical Section - typical cut and cover tunnel longitudinal passage).

The eastern ventilation station is proposed to be partially buried into the elevated ridgeline immediately east of the Inner Northern Busway tunnel portal that cuts through this ridgeline. The location is approximately 50m north of the ICB to avoid interference with the drainage capacity in this location. The partial burial would provide for a building of the same configuration and proportions as the western ventilation station (ie: 41m long, 23m wide and 13.5m high). The ventilation outlet would be built approximately 150m further north on elevated ground in order to minimise the height of the outlet structure. The Reference Project base height for the ventilation outlet location is at RL 42.1m with the opening at RL 57.1m providing for the outlet opening to be 15m above the ground at this location. The height of the ventilation outlet would be 15m. The ventilation duct from the extraction point on the eastbound tunnel would be cut below the cut and cover of the tunnel entry ramp and then connect to the southern side of the ventilation station. A similar cut and cover ventilation duct would be constructed from the northern side of the ventilation station to the ventilation outlet.

Provision would be made at each of the sites for the possible future installation of filtration equipment. Filtration equipment is large and would require a large building or structure to house it and link it within the ventilation station.



Legend

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

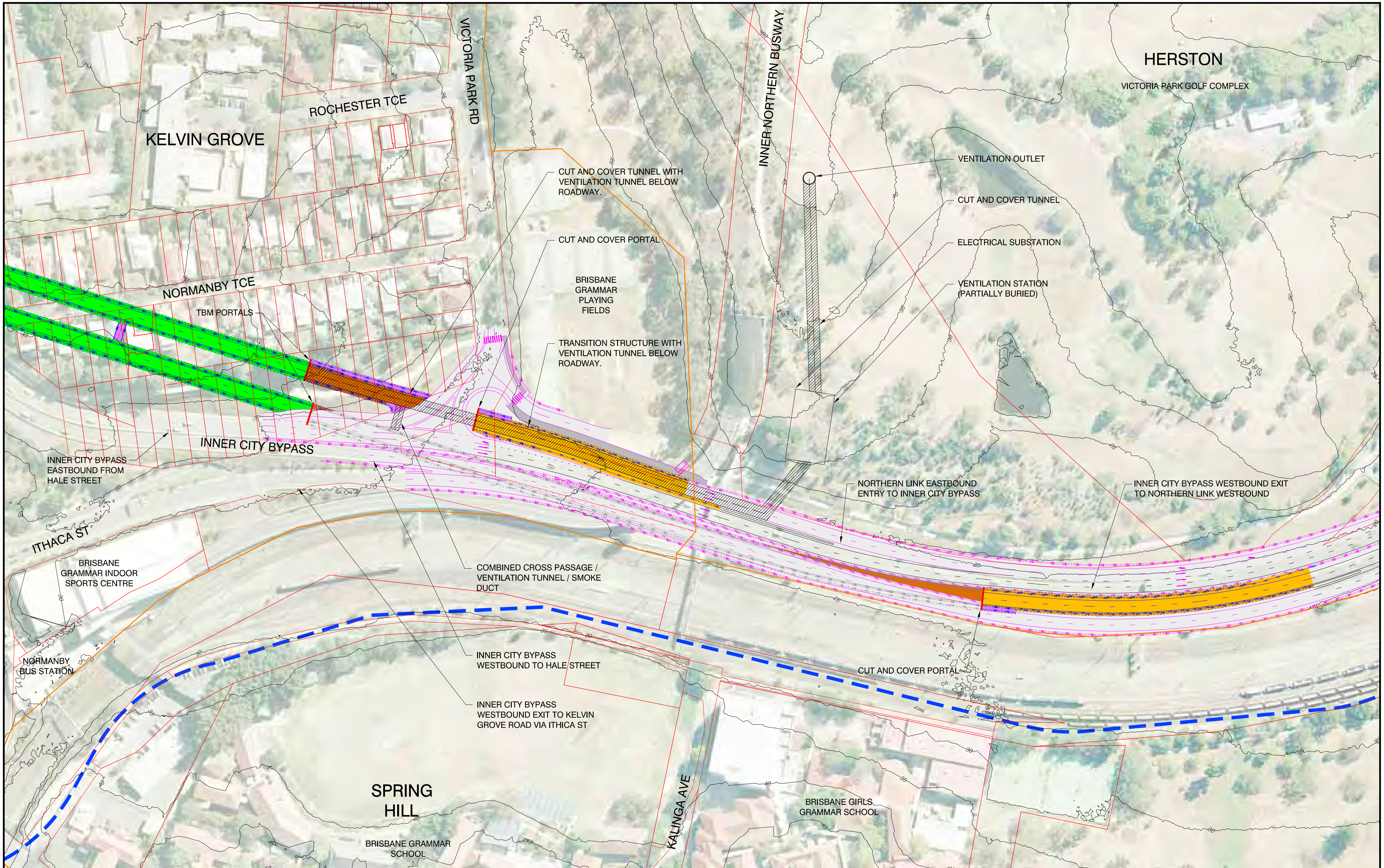
0m 40m 80m
metres
Scale 1:2,800 (A4)
N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-12

Western Ventilation Station And Outlet

Northern Link
SKM Connell Wagner JOINT VENTURE



Legend

INVESTIGATION AREA
TUNNEL (TBM)
TUNNEL (CROSS PASSAGE)
CUT AND COVER
TRANSITION STRUCTURE
SURFACE WORKS
PROPOSED WORKSITE
PROPOSED VENTILATION STATION
PROPOSED VENTILATION OUTLET
VENTILATION

0m 40m 80m
metres
Scale 1:2,800 (A4)
N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-13

Eastern Ventilation Station And Outlet

Northern Link
SKM Connell Wagner
JOINT VENTURE

4.3 Project Delivery Mode

4.3.1 Program and Responsibilities

A preliminary, generalised works program for the Project is shown in **Figure 4-14**. Construction has been assumed to commence in November 2009, subject to the Coordinator-General's evaluation of the EIS and subsequent evaluation of the Changed Project (if necessary) from the preferred tenderer, in accordance with the *State Development and Public Works Organisation Act 1971*. The overall design and construction would take approximately 3.5 years, with the tollroad open to traffic by mid 2013.

The construction of the Project would involve three key phases, namely:

- pre-construction activities such as design, approvals and site establishment;
- construction of project works; and
- commissioning.

The major components of work for the Project are discussed below.

4.3.2 Establishment and Preliminary Works

Worksites would be located on the northern side of the Western Freeway (**Figure 4-15**), on the northern side of Milton Road at Toowong (**Figure 4-16**), and on the western side of Kelvin Grove Road at Red Hill (**Figure 4-17)**. These worksites would provide a base for adjacent surface works. All worksites would be fenced and appropriate security measures provided.

The three tunnel portal worksites would be provided with equipment to manage waste water from the tunnel, power supply and associated transformers, offices, workshop, labour facilities, first aid facilities, equipment storage, primary support materials storage, air-conditioning for certain construction materials, material loading station, smoke duct segment delivery, water supply for machinery and temporary ventilation equipment. A shotcrete batching plant would be established at the Western Freeway worksite to service each of the worksites. This batching plant could be serviced with materials from the Mt Coot-tha Quarry.

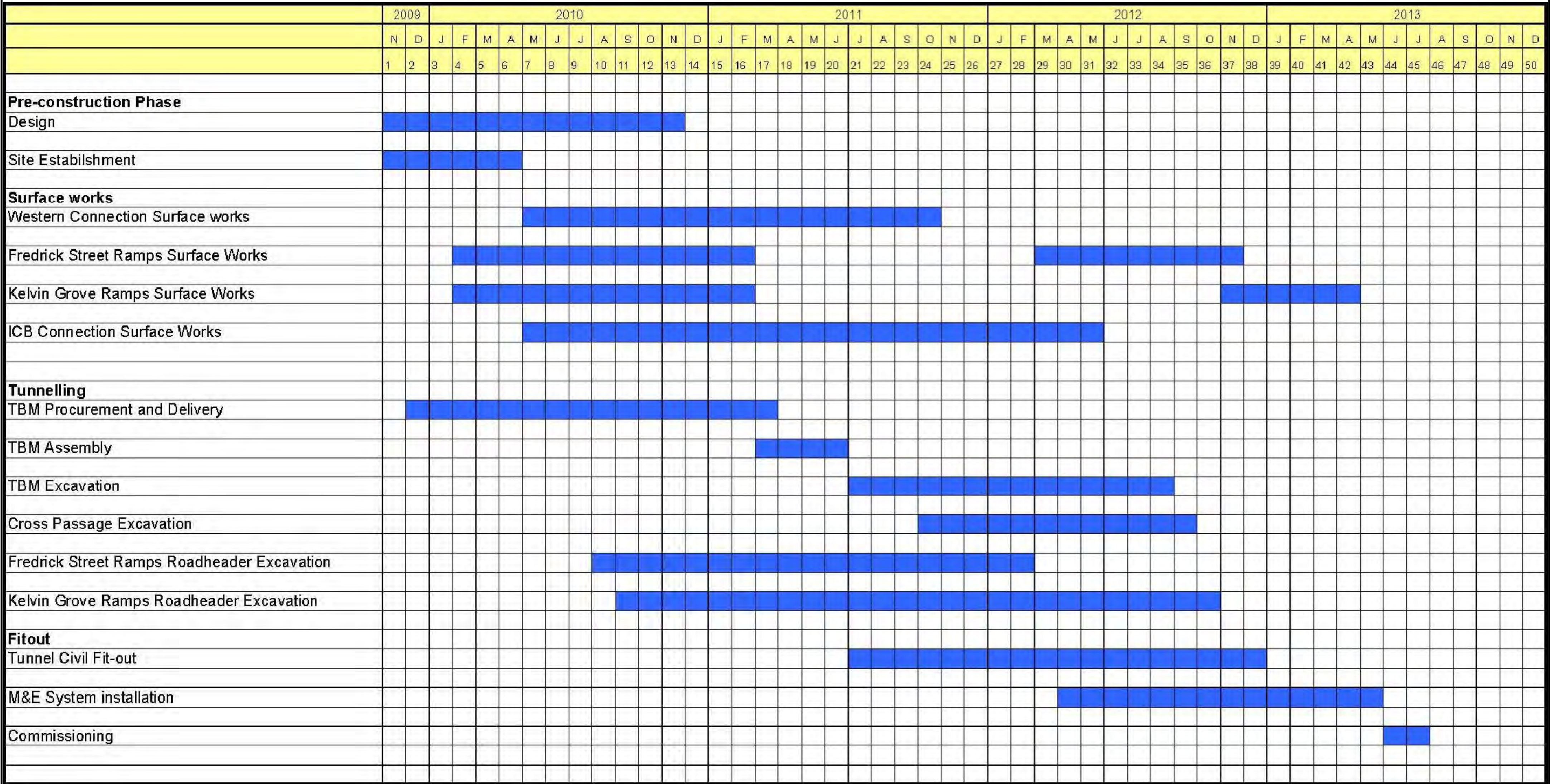
4.3.3 Property Requirements

The anticipated number and type of properties required for the Reference Project is identified in **Table 4-5** below.

- **Table 4-5 Anticipated Property Requirements**

Location	State-owned	Council-owned	Privately-owned	Total
Red Hill/Kelvin Grove	4	8	30	42
Mt Coot-tha/Toowong	1	7	66	74
TOTAL	**5**	**15**	**96**	**116**

Of the total 116 properties required for the Project, 94 lots would be required as whole lots and 22 lots would be affected by a partial land take. The Reference Project also anticipates 614 parcels of land would be affected by volumetric title reconfiguration (subdivision) and acquisition to provide separate tenure for the underground tunnels while retaining the surface title rights by the existing owners. Compensation would be provided to the owners, including for the loss of the volumetric lot.



Duration 45 months

Northern Link

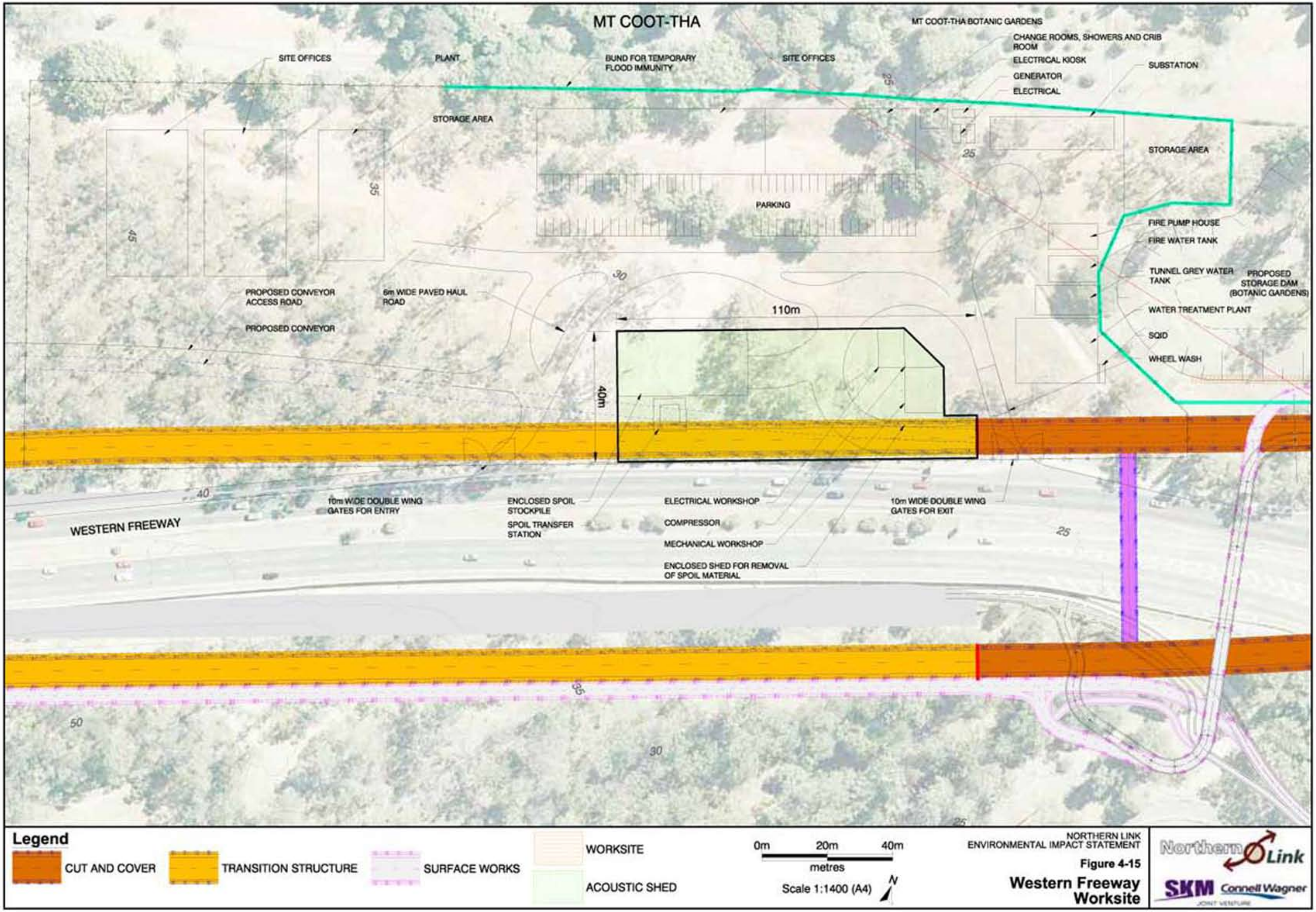
Summary Construction Programme

Based on Concept Design May 2008

NORTHERN LINK
ENVIRONMENTAL IMPACT STUDY

FIGURE 4-14

PROGRAM OF WORKS



NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-15

Western Freeway Worksite

Northern Link
SKM Connell Wagner JOINT VENTURE

Legend

ROADHEADER

WORKSITE

ACOUSTIC SHED

0m 20m 40m

metres

Scale 1:1400 (A4)

N

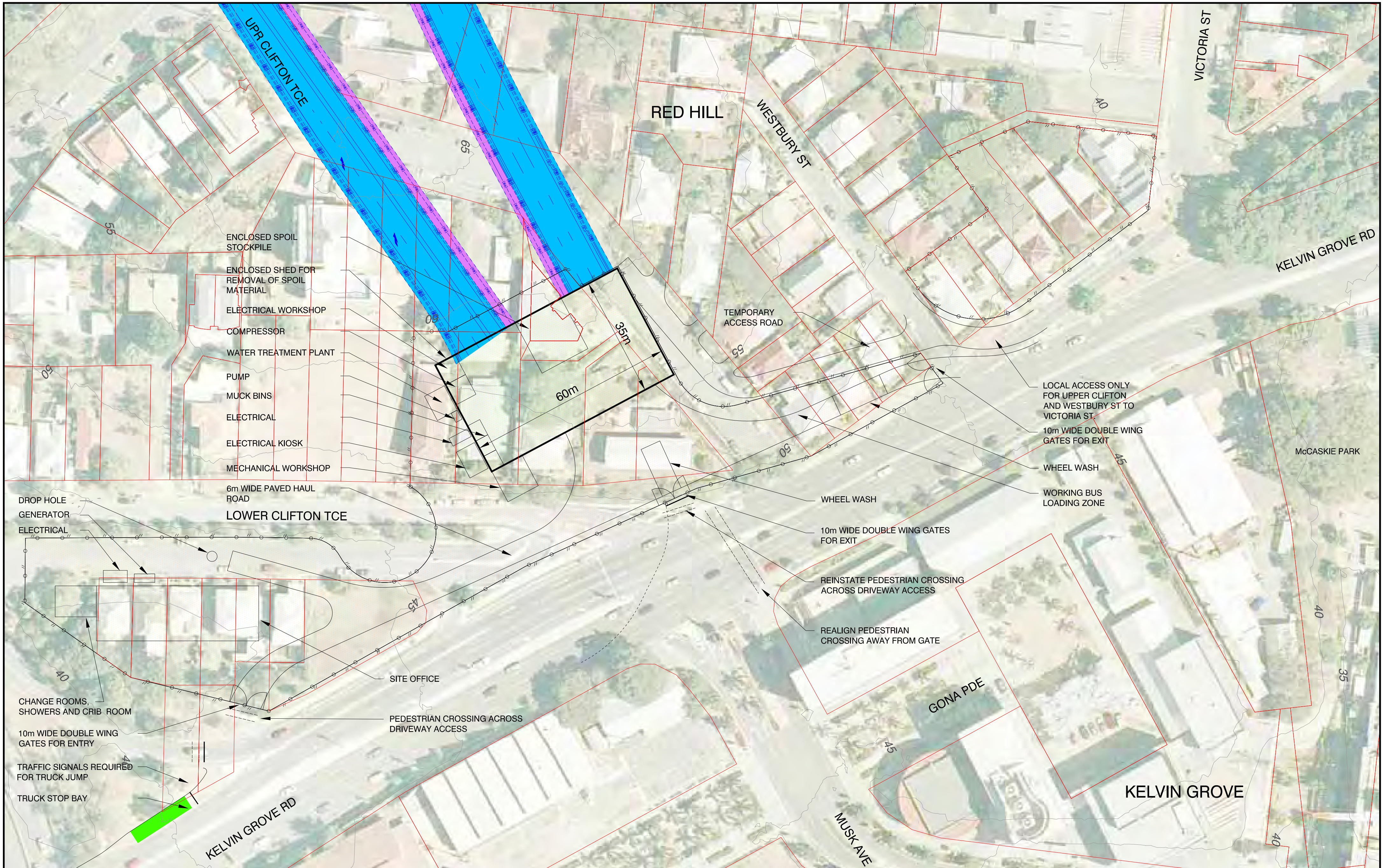
NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-16

Toowong Worksite

Northern Link

SKM Connell Wagner JOINT VENTURE



Legend

ROADHEADER
LONGITUDINAL PASSAGE
WORKSITE
ACOUSTIC SHED

0m 20m 40m
metres
Scale 1:1400 (A4)
N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-17

Kelvin Grove Worksite

Northern Link
SKM Connell Wagner JOINT VENTURE

4.3.4 Tunnel Portal Cover Sheds (TPCSs)

The Western Freeway, Toowong and Kelvin Grove tunnel portals would each be enclosed in an acoustically lined TPCS over the portal to control dust and noise emission from the tunnelling operations. At the Western Freeway worksite, the acoustic shed would cover the eastbound tunnel portal while the westbound tunnel portal, on the southern side of the Western Freeway, would be fitted with dust-proof acoustic doors.

At the Western Freeway connection the eastbound cut and cover tunnel entrance would be covered with a TPCS (indicatively about 50m long, 30m wide and 15-20m tall), and all tunnelling operations would be contained within this dust-proof acoustically lined shed to control dust and noise emission. The transfer facility for moving spoil from the two conveyors exiting the tunnels onto a single conveyor would be done within the shed or in a similarly acoustically designed structure. The ventilation fans for the tunnel during construction would be located inside the tunnel, and the ventilation from the tunnelling works would leave the shed, having passed through dust extraction equipment.

At the Toowong worksite a TPCS (indicatively 92m long, 42m wide and 15m high) would cover the portals immediately south of Morley Street and extend to just south of Valentine Street, parallel to Frederick Street. Tunnelling operations would be contained within this shed. The loading of trucks with tunnel spoil would be undertaken within the covered spoil shed. Ventilation fans for the tunnel during construction would be located inside the tunnel, and the ventilation from the tunnelling works would leave the shed having passed through dust extraction equipment. Haul trucks would be able to enter from Milton Road just east of the Toowong Roundabout, pass through the tunnel portal cover shed for loading spoil and exit onto Frederick Street to travel west to the Swanbank spoil placement site or U-turn at the Moggill Road intersection and return to the Western Freeway worksite for transfer to the Mt Coot-tha quarry by conveyor. The transfer of this spoil from the trucks onto the conveyor to the quarry would occur within the shed in order to mitigate dust and noise emissions.

At the Kelvin Grove Road worksite, a TPCS (indicatively 60m long, 35m wide and 15m high) would enclose the entry and exit ramp portals immediately west of Kelvin Grove Road. Tunnelling and spoil handling activities would be contained with the shed to mitigate noise and dust produced during construction of the tunnels. Spoil haul trucks would access the site from a truck stopping bay on Kelvin Grove Road just south of the Hale Street connection to Kelvin Grove Road. A set of temporary traffic lights would allow trucks to cross this through traffic into the southern end of the worksite. After being loaded in the tunnel portal cover shed haul trucks would enter the Kelvin Grove Road/Musk Avenue intersection via a set of temporary traffic lights for a right turn onto Kelvin Grove Road that would allow the left turn onto the ICB for the trip to spoil placement to the Port of Brisbane spoil placement land.

4.3.5 Demolition and Utility Modifications

Site preparation works which would include removal of existing buildings, kerbs, roadways and fencing, clearing of vegetation and erection of temporary barriers and fences would be undertaken as required. Any necessary, development approvals would need to be sought and obtained prior to the commencement of demolition works.

A significant number of utilities would need to be replaced, modified or relocated in the areas where construction requires excavations, particularly where existing roads and footpaths are to be altered. Among a wider range of utilities in the proposed construction areas, particular attention would need to be paid to:

- the 1530mm water supply main connecting the Enoggera Reservoir to Taringa traverses the Western Freeway transition structures;
- a high pressure gas main and fibre-optic cables are located on the southern side of Milton Road in line with the Toowong connection ramps;
- a local gas main along the western side of Kelvin Grove Road and electricity cable conduits under Kelvin Grove Road near Victoria Street would be intercepted by the tunnel on ramp; and
- water mains, sewerage lines and stormwater drains along the northern side of the ICB near the busway bridge.

These diversion works would be undertaken as part of the traffic management for construction.

In general, all utility diversion would commence as early as possible once the detailed design has reached a stage where the new route can be determined. Most diversions would be carried out with new trenches and access points located in footpaths, wherever possible. A number of utilities along the Western Freeway and ICB may need diversions during construction and reinstatement.

4.3.6 Tunnel Construction

Tunnel construction would occur either as driven tunnel or as cut and cover tunnel. There are a number of methods for constructing driven tunnels, whereas cut and cover tunnel construction is more conventional. The mainline tunnels would be constructed as driven tunnels, with cut and cover techniques adopted for the sections where the tunnels are close to the surface and/or in poor ground conditions, usually as they approach or leave the surface.

Mainline tunnel construction methods are defined by the cross-section requirements for predicted traffic flows and subterranean conditions that vary along the alignment. Options for tunnel construction methods were considered and a methodology identified, for the purpose of impact assessment in this EIS. The methodology adopted for this EIS is expected to allow construction impacts to be managed to meet both technical requirements and community expectations as reflected in the environmental objectives expressed in the draft outline environmental management plans provided in Chapter 20, Urban Regeneration. However it is possible that the construction methods may change when the Project is subject to detailed design and construction planning, supported by more detailed field survey data and investigations. It is also possible that a construction contractor might propose different construction methods for either technical or commercial reasons, or a combination of both technical and commercial reasons.

For the purpose of developing the Reference Project and conducting this impact assessment, the construction methods proposed were separated into:

- the mainline driven tunnels;
- entry and exit ramps to the Toowong and Kelvin Grove connections; and
- cut and cover tunnels connecting driven tunnels to transition structures to reach the surface.

4.3.7 Construction of Mainline Tunnels

The mainline tunnels would be constructed for two traffic lanes in each tunnel. They would be constructed by Tunnel Boring Machines (TBMs), except for the Y-junctions where an enlarged tunnel cross section would be required and roadheaders or drill and blast would be used to achieve these variations. They would be constructed predominantly within high strength rock.

A TBM is an efficient and reliable machine used to excavate tunnels through a variety of rock strata. A TBM typically consists of one or two shields (large metal cylinders) and trailing support mechanisms. At the front end of the shield is a rotating cutting wheel. Behind the cutting wheel is a chamber where the excavated spoil is deposited and removed. Behind the chamber there is a set of hydraulic jacks supported by the finished part of the tunnel that push the TBM forward. The rear section of the TBM is braced against the tunnel walls and used to push the TBM head forward. At maximum extension the TBM head is then braced against the tunnel walls and the TBM rear is dragged forward.

A two-staged construction sequence for tunnel support is proposed. The primary support would consist of temporary rockbolts and sprayed concrete (shotcrete) and would provide appropriate temporary stability, safety and settlement control. With the primary support in place a waterproof membrane would be installed followed by the secondary support to withstand the permanent loads. Permanent support would generally consist of cast in-situ unreinforced concrete linings. Some reinforcement would be required at tunnel/cross passage intersections and/or where any asymmetric loading conditions on the tunnels may require reinforcement.

Typically within a TBM tunnel the permanent concrete lining would be constructed with an invert arch (at the bottom) and a crown arch (at the top), providing a complete circular permanent lining. The Reference Project relies only on a Crown arch to pavement level with footings supported on an exposed rock ledge cut into the side walls of the tunnel post TBM excavation of the tunnel. Below pavement level, no arch lining would be installed, with the backfill material beneath the pavement level compacted against the excavated (exposed) rock surface.

The two mainline tunnels would be approximately 10m apart with connecting cross passages located typically every 120m along these tunnels. Cross passages provide a form of egress from one tunnel to the other in the event of an incident in one of the tunnels.

For the Reference Project, this EIS has assumed that the TBM for each of the mainline tunnels would be launched from the Western Freeway worksite. The TBM cutting heads would be disassembled and removed at the ICB connection where facilities would be provided for its recovery and removal. The trailing mechanisms would also be disassembled and removed from the eastern ICB connection, or alternatively it could be disassembled within the tunnel and removed from the Western Freeway worksite.

The tunnels are proposed to be ‘drained’, due to the low risk of impacts associated with lowering the ground water levels. Drained tunnels would permit some inflow of groundwater, with such inflows to be collected in specially designed sumps at the low point and transferred by an internal drainage system to an approved point of discharge after water quality testing is completed and the water is found suitable for discharge.

With the use of TBMs for construction of the mainline tunnels working from the Western Freeway, spoil from the work face would be taken by in-tunnel conveyors within each tunnel back to the Western Freeway worksite where they would be transferred onto a single external conveyor that would take spoil to the Mt Coot-tha Quarry.

4.3.8 Construction of Tunnel Connecting Ramps

The entry and exit ramps between the mainline tunnels and the Toowong and Kelvin Grove Connections would be constructed either one or two lanes wide with sections near the driven portals at Kelvin Grove three lanes wide.

The ramps would be constructed by roadheaders and/or drill and blast predominantly in competent rock. A roadheader is a track mounted machine with a cutting head mounted on a boom. The cutting head uses tungsten carbide picks to cut the rock, however, these have limitations in terms of the rock strength and abrasivity. Electrically powered, a typical modern machine has an installed power of the order of 300kW. By controlling the boom, the operator can cut any profile, consistent with the reach of the machine and the requirements for ground support.

Roadheader and/or drill and blast excavation offers considerable versatility and flexibility as a tunnelling technique in suitable conditions, and is used to excavate tunnels of various shapes and sizes. Northern Link would require these methods to construct the ramps, large span Y-Junctions (3 lanes and greater), cross passages and other varying or non-standard tunnel cross sections as opposed to a TBM, which is limited to a single size circular tunnel profile.

The ramps would also be designed as ‘drained’, due to the low risk of impacts associated with lowering the ground water levels and with inflows to be collected and transferred by an internal drainage system to an approved point of discharge.

With the operation of roadheaders, construction spoil would report to the Toowong and Kelvin Grove worksites. Spoil handling and loading facilities would be provided at each worksite to facilitate removal and transportation to one of the identified spoil placement site(s).

4.3.9 Cross Passages

Cross passages would be constructed every 120m along the mainline tunnels and tunnel connecting ramps where possible for emergency egress, equipment and potentially sump storage requirements. Where cross passages are not possible between adjoining tunnels, longitudinal passages would be required.

The cross passages would be approximately 5m by 5m in section, and approximately 10m in length. Apart from the evacuation function, the cross passages would contain much of the mechanical and electrical equipment for the fire systems and lighting. In the cut and cover areas where a single sliding door arrangement is used, mechanical and electrical equipment would be located in dedicated equipment rooms adjacent to the tunnels.

Due to the different vertical alignments of adjacent entry and exit ramps, egress via cross passages may not be practical in which case longitudinal pedestrian egress passages are proposed along the entry and exit ramps leading to the portals at Kelvin Grove and between the location of the cross passages and the mainline tunnel for the entry and exit ramps to the Toowong connection.

Construction of cross passages would be undertaken with a mechanical excavator or roadheader, and possibly with the aid of drilling and blasting in hard rock conditions. Construction spoil from the cross passages would be removed through the driven tunnels or the cut and cover tunnels as required.

4.3.10 Construction of Cut and Cover Tunnels

Cut and cover tunnels that are required for transition to the surface would have a roof of constructed elements, as opposed to a natural rock arch. The roof would consist of prestressed concrete (PSC) deck units and/or cast in-situ reinforced concrete slabs similar to the conventional bridges found in the region. Cut and cover tunnels at each portal would connect the driven tunnels to the surface or to surface ramps.

The first step would be to install the walls which would include a number of structure;

- bored pile retaining wall. The specific type of bored pile would vary depending on geotechnical conditions at the section, but may include:
  - secant pile wall where softer ground with high watertable is encountered:
  - contiguous pile wall where better ground conditions with low water table is encountered;
  - pile and panel wall where 'soft' rock conditions are encountered;
  - walls would require some permanent anchors, depending on location; and
  - shotcrete infill panels, with drainage, would be required for all walls.
- diaphragm walls where softer ground with high watertable is encountered and a certain degree of water tightness within the cut and cover structure is required;
- rock bolted wall. Where the competent rock is above the alignment grade line and too strong for piling, a rock bolted face, with permanent rock bolts and shotcrete face, would be incorporated; and
- combination walls of bored piles and rock bolted face.

The cut and cover tunnel roof is anticipated to be precast concrete deck units with in situ concrete deck slab, complete with waterproof membrane. Cast in-situ reinforced concrete slabs may also be used where access to the existing surface can be achieved for a lengthy duration (ie: not beneath an existing operational roadway). The cut and cover section of tunnel through the alluvial channel from the Mt Coot-tha Botanical Gardens would need to be constructed as undrained tunnel to exclude groundwater from entering the tunnel. Cut and cover tunnels at the other connections could be constructed as drained tunnels because the potential to impact groundwater environments in those areas is very low.

Spoil from the cut and cover tunnels would generally be removed from site by truck and transported to the approved spoil placement site(s).

The structural deck units or reinforced concrete slab may be required to support roads or other equipment required for tunnel management and maintenance and to support a depth of cover soil and foundation material necessary for sustainable plantings of selected tree species. Cut and cover construction may also be used for more than one tier of functional structure. For example, it is anticipated that at the ICB connection, the ventilation duct between the tunnel extraction point and the ventilation station would be located directly beneath the eastbound cut and cover road tunnel and transition structure due to the narrow space available between the Inner Northern Busway abutment and the central piers.

4.3.11 Surface Road Connecting Works

New surface road connecting works would be required at each connection, with most being at grade. At the Toowong connection they would form predominantly open elevated structures with a small section of reinforced earth embankments prior to their joining with a widened Milton Road. Any suitable fill for the reinforced earth structures would be obtained from the ongoing tunnel excavations.

Conventional methods of road construction would be used for the new roads and for the modification to existing surface roads. This process would involve excavators, graders, compaction equipment and pavement placing equipment. Drainage, new utility ducting and kerbing would be installed and connected to existing systems during this stage. Following completion of the paving works the road furniture would be installed, consisting of safety barriers, noise barriers, line marking, lighting, signage and landscaping of surrounding areas.

4.3.12 New Surface Structures

Two new ramp structures would be built above ground to convey the entry and exit ramps at the Toowong connection. These elevated ramps travel approximately 160-180m southbound from the Frederick Street cut and cover tunnel portals towards Milton Road before turning directly eastbound for approximately 150m before passing onto reinforced earth embankments to descend onto Milton Road. These new ramps would be constructed with precast concrete units that would be lifted into place by large cranes.

4.3.13 Construction of Ventilation System

Two ventilation stations, ventilation outlets and associated buildings are to be constructed. Both ventilation stations are proposed on sloping ground, allowing potential for partial burial into the existing slope in order to minimise visual impact and provide for some degree of stacking of the large extraction fans to reduce building footprint. The ventilation outlets would be erected using large mobile cranes. Space would be allowed in or adjacent to the ventilation station for possible installation of filtration equipment if a decision is made to provide filtration in the future.

4.3.14 Modification to Existing Structures

The Queensland Department of Main Roads has begun construction of a crossing for cyclists and pedestrians over the Western Freeway directly west of the existing Mt Coot-tha roundabout. This crossing would link the Western Freeway Bikeway at Toowong with Mt Coot-tha Road. The proposed overpass comprises a 210m structure with a 125m ramp from Anzac Park, a 66.5m structure over the Western Freeway and an 85m ramp to Mt Coot-tha Road. The overbridge design spans the existing Western Freeway with a pier in the central median and piers clear of the existing formation. The proposed overbridge is programmed for completion in 2008/09.

The function of this shared pedestrian and cycle path, including the yet to be constructed crossing of the Western Freeway would need to be maintained during construction and operation of the Project. This would require a modification to the alignment of the shared path to new locations south of the tunnel exit ramp and north of the entry ramp cut and cover construction prior to the construction of the tunnel ramps. The crossing bridge would need to be lengthened and the intersection with the southern path modified to provide access to the bridge.

The drainage line from the botanic gardens through the 1650mm reinforced concrete pipe culvert beneath the Western Freeway, through Anzac Park into the pipework system to the Brisbane River would remain functional throughout construction. This would be achieved by firstly constructing the bored pile walls for the cut and cover tunnel troughs. This would be followed by extending the 1650mm pipe across the top of the bored pile walls as an aquaduct followed by excavation of the trough between the walls. The aquaduct would function over the cut and cover section until the roof was put in place and the terrane reinstated to restore the drainage to its present configuration.

4.3.15 Landscaping Works

Extensive landscaping works would be carried out at all of the connections and other key locations throughout the Project, in accordance with landscape plans developed during detailed design. Concepts of these are described in Chapter 14. This work would be undertaken towards the end of the construction period and to suit appropriate planting seasons. Some landscape works may continue after the tunnel has opened, as the resultant reduction in traffic in this area would permit these works to be carried out with less disruption to traffic.

4.3.16 Rehabilitation of Construction Sites

The construction worksites at the three connections would be rehabilitated following the completion of their use for construction works. Options for their future redevelopment are provided in Chapter 20 of the EIS. Sedimentation and erosion control devices developed during construction, if no longer required would be decommissioned and surface contours and appropriate drainage lines reinstated. Sedimentation and erosion control devices may be retained in locations where surface drainage from the completed works would continue to risk on-going soil erosion. Such devices would be maintained and incorporated in any future use or development of the worksites. The rehabilitation of the worksite at the Western Freeway would be undertaken in consultation with the Mt Coot-tha Botanic Gardens and their Masterplan for the future development of the site.

4.3.17 Traffic and Access During Construction

Changes and potential disruptions to traffic and access arrangements during the construction phase are always of concern to residents, local businesses and community facilities. Also, the maintenance of efficient traffic flows along major arterial roads, such as the Western Freeway, Mt Coot-tha Road, Milton Road, Frederick Street, Kelvin Grove Road and the ICB during construction is essential. At the same time, it is also important for construction traffic to have safe and efficient access to the construction worksites.

- Access to the Western Freeway worksite, adjacent to the northern or eastbound tunnel, would be via a left in and left out diverge and merge lane with the Western Freeway. A cross passage tunnel would be constructed between the worksite and the southern or westbound tunnel construction area to provide access for loaded vehicles to travel west from the worksite in order to avoid using the Mt Coot-tha Roundabout or the Toowong Roundabout.
- The existing arrangements from the eastern end of the Western Freeway at the Mt Coot-tha Roundabout to the Toowong Roundabout are proposed to remain. The existing access to the Mt Coot-tha Botanic Gardens, Anzac Park and the Toowong Cemetery through connections with Mt Coot-tha Road, Dean Street, Miskin Street and Frederick Street would not alter with the Project.
- The Toowong worksite access would be via a left in only entrance on the northern side of Milton Road heading east, and immediately east of the Toowong Roundabout. The exit from the worksite would be via a left out only movement to Frederick Street near the existing intersection of Valentine Street. A separate exit for site office vehicles only would be provided directly on to Milton Road opposite the Sylvan Road intersection.
- The existing operation and local access from Frederick Street is proposed to remain unchanged with the exception of the left-in and left-out access from Valentine Street that would be closed. Gregory Street would also no longer have direct access with Milton Road. Convenient access to both Valentine Street and Gregory Street would be available via Morley Street. Access to Miskin Street from the Toowong roundabout would also not be altered with the Project.
- Local access to the residential precinct to the south of Milton Road and east of Miskin Street, which includes the Toowong State School, would alter during construction of the Project. The structures associated with the Toowong connecting ramps would require the removal of the existing priority right turn from Milton Road to Sylvan Road and the closure of the current access to Quinn Street from Milton Road. A right turn movement at the signalised intersection of Milton Road and Croydon Road would provide access to Sylvan Road. Access to Sylvan Road, west of Croydon Street, and Quinn Street would be completed through the right turn from Croydon Street to Sylvan Road. Sylvan Road and Quinn Street would also be accessible from Ascog Terrace via Miskin Street.

- The proposed surface works on Croydon Street include a central median and the removal of the existing properties on the western kerb between Milton Road and Jephson Street. The central median would include a break at Cadell Street to facilitate right turn movements from Croydon Street. The right turn out of Cadell Street to Croydon Street would be prevented on safety grounds. Access to properties on the eastern kerb of Croydon Street and to Bayliss Street would be left in and left out only. Convenient access would remain to Bayliss Street via Park Avenue for trips from the north and south and from Cadell Street for trips from the west.
- The proposed surface works maintain the existing unnamed laneway between Croydon Street and St. Osyth Street for vehicular access to the rear of properties on Sylvan Road.
- The signalised intersection of Croydon Street, Jephson Street and Sylvan Road would include the removal of the right turn from Jephson Street to Sylvan Road. Appropriate local access would be available for this movement via Lissner Street and Bennett Street.
- Access to the Kelvin Grove Road worksite would be provided at the southern end of the worksite next to the one lane connection from Hale Street to Kelvin Grove Road. A truck stop bay with an appropriate length deceleration taper would be provided on Kelvin Grove Road in order to access this entry from Kelvin Grove Road heading north. Vehicle actuated traffic signals would be installed to provide a truck jump to allow trucks to enter the worksite across the Hale Street and Musgrave Road merge to Kelvin Grove Road. The main exit out from the Kelvin Grove Road worksite would be a right turn onto Kelvin Grove Road through modification of the signalised intersection at Musk Avenue. An auxiliary exit would be provided at the north of the worksite.
- On the western side of Kelvin Grove Road between the ICB and Victoria Street the proposed local access changes that would be required to facilitate the Northern Link connection with Kelvin Grove Road are summarised in **Table 4-6**.

Table 4-6 Proposed local access changes in the Kelvin Grove precinct

Street	Current access	Proposed access	Alternative Route
Lower Clifton Terrace	One way north bound - left in from Musgrave Road and left out to Kelvin Grove Road	Two way street and closed at Kelvin Grove Road. Left in and left out with Musgrave Road	Trips to Kelvin Grove Road via left out to Musgrave Road and left turn at signalised intersection from Musgrave Road to Kelvin Grove Road.
Upper Clifton Terrace	All movements with Musgrave Road. No access to Kelvin Grove Road	No change	No change
Westbury Street	Left in from Kelvin Grove Road and left and right to Victoria Street for access to Kelvin Grove Road (left out) and Windsor Road and Musgrave Road	Access with Kelvin Grove Road closed	Access to Kelvin Grove Road via Victoria Street and Windsor Road or Prospect Terrace.
Victoria Street	Left in and left out with Kelvin Grove Road and all movements with Windsor Road and other local streets in the network for access to Musgrave Road and Prospect Terrace.	Access with Kelvin Grove Road closed	Access to Kelvin Grove Road via Victoria Street and Windsor Road or Prospect Terrace.

Prospect Terrace	All movements at Kelvin Grove Road (signalised intersection)	Currently it is not possible to access Musgrave Road from the ICB (westbound). The route of ICB – Ithaca Street, Kelvin Grove Road, Victoria Street is currently used as an alternative.	Musgrave Road accessed from ICB (westbound) via Ithaca Street, Kelvin Grove Road, Prospect Terrace.

There may need to be some minor traffic diversions for the excavation works associated with the establishment of the Kelvin Grove Worksite, due to the close proximity of the existing hillside to the pedestrian footpath along the western side of Kelvin Grove Road. There would also be traffic diversions required to construct the surface connections as described below and shown in the *Traffic Management and Staging Drawings (01-14)* in *Volume 2 of the EIS*.

At the Western Freeway connection traffic diversions would include:

- Diversion of traffic lanes on the Western Freeway in a number of stages to construct the cut and cover tunnels (and associated cross passages) beneath the Western Freeway. Two lanes each way would be maintained on the Western Freeway.
- Diversion of traffic lanes on Mt Coot-tha Road to construct the cut and cover tunnels beneath Mt Coot-tha Road. Access to Mt Coot-tha Road from the Western Freeway would be maintained during construction.
- Diversion of traffic lanes on both the Western Freeway and Mt Coot-tha Road to install the TBMs through the cut and cover tunnels in the vicinity of the driven tunnel portals. This may require some lane closures and/or diversions, however it would occur outside of peak times, such as over a weekend. To mitigate this impact, the TBMs could be assembled within the transition structures outside of the cut and cover tunnel portals and then 'walked' down to the driven tunnel portal.

At the Toowong connection traffic diversions would include:

- Construction of the necessary surface works and bridge works clear of Milton Road and Croydon Street prior to diversion of traffic onto these new works.
- Construction of the surface works and bridge works on the existing Milton Road and Croydon Street following diversion of traffic onto the new works.

At the Kelvin Grove Road connection traffic diversions would include:

- Construction of the necessary surface works and cut and cover tunnels clear of Kelvin Grove Road prior to diversion of traffic onto these new works.
- Construction of the surface works on the existing Kelvin Grove Road following diversion of traffic onto the new works. The current lane configurations of Kelvin Grove Road, including access to Musk Avenue and Blamey Street, would be maintained during construction staging.

At the ICB connection traffic diversions would include:

- In the eastbound direction of the ICB, three traffic lanes would be maintained, as would the left-in and left-out access to Victoria Park Road.

- In the westbound direction of the ICB, three traffic lanes would be maintained and as with the existing layout the outside lane would diverge to Ithaca Street. The capacity of Ithaca Street would not be affected by construction works.

Construction would need to proceed in accordance with a Construction Environmental Management Plan (EMP) and a Construction Traffic Management Plan (CTMP). The CTMP would be prepared in consultation with Queensland Transport, Department of Main Roads and Brisbane City Council to address and manage construction traffic issues, including, but not limited to the following issues:

- use of established truck routes and arterial roads for the haulage of construction materials and spoil;
- access from worksites to arterial roads to minimise truck traffic in local streets;
- management of haulage tasks during peak traffic periods, where necessary;
- management heavy vehicle movements on the ICB to avoid interference with major events, such as events at RNA Exhibition Ground or Suncorp Stadium;
- the capacity of intersections on haulage routes;
- the management of truck movements on the road network in consultation with the local community;
- exceptional circumstances for specific construction tasks (eg: delivery and removal of tunnelling machinery).

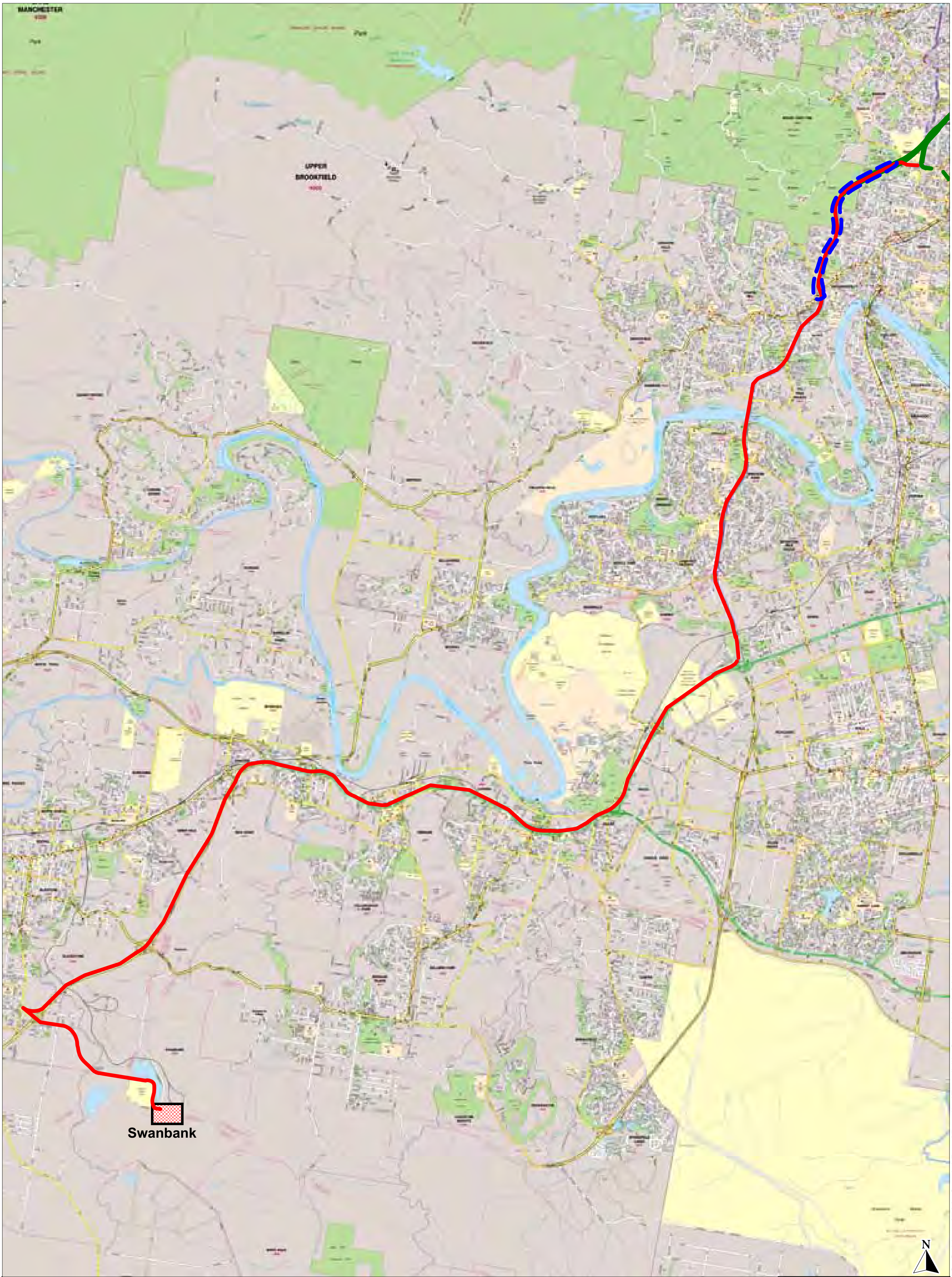
4.3.18 Construction Spoil

The Project would generate approximately 1.7 million m^3 of bank material[1], with the TBM driven tunnel producing approximately 1.1 million m^3 at the Western Freeway worksite as shown in **Table 4-7**. Three general options have been considered for the disposal of the excavated material, namely the Mt Coot-tha Quarry, Swanbank (Swanbank land fill site) and the Port of Brisbane (Fisherman Islands and the Port West Estate). The proposed Swanbank placement site and associated haulage route (Western Freeway, Centenary Highway, Ipswich Motorway and Swanbank Road accessed from the Cunningham Highway), is shown in **Figure 4-18**. The Port of Brisbane sites (Fisherman Islands and Port West Estate), and their associated haulage route (Kelvin Grove Road to access the ICB and then Kingsford Smith Drive, the Gateway Motorway, the Port of Brisbane Motorway and Lytton Road) are shown in **Figure 4-19**.

- **Table 4-7 Total Spoil Quantity Estimates and Placement Locations**

Worksites and Construction areas	Mt Coot-tha Quarry (Bank m^3)	Swanbank (Bank m^3)	Port of Brisbane (Bank m^3)	Spoil Quantity Estimate (Bank m^3)
Western Freeway	840,000	265,000		1,105,000
Toowong	240,000	20,000		260,000
Kelvin Grove			300,000	300,000
ICB construction area			25,000	25,000
Total	**1,080,000**	**285,000**	**325,000**	**1,690,000**

[1] Bank material is *in situ* material and does not include a 'bulking' factor for post-excavation calculations



LEGEND

- Indicative Haulage Route
- Potential Spoil Placement Site
- Northern Link Western Connection
- Moggill Road U-Turn to Western Freeway Worksite

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-18

Potential Spoil Placement Site at Swanbank and Truck Route

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LEGEND

- Indicative Haulage Route
- Northern Link Eastern Connection
- Potential Spoil Placement Site

Northern Link
Environmental Impact Statement

Figure 4-19

Potential Spoil Placement site at the Port of Brisbane and Truck Route

Northern Link
SKM Connell Wagner
JOINT VENTURE

Conveyor

The majority of the spoil is proposed be taken to the Mt Coot-tha quarry via an external conveyor from the Western Freeway worksite. The conveyor would be enclosed to mitigate potential impacts from noise or dust. The conveyor would follow a route west out of the worksite from the spoil handling facility within the enclosed work shed, through the Mt Coot-tha Botanic Gardens, including a small section of the Gardens within the Brisbane Forest Park, to the Mt Coot-tha Quarry. The conveyor would require a corridor of land up to 8m wide to provide for the elevated conveyor and an adjacent access road for construction and maintenance. The proposed route for the conveyor is shown in **Figure 4-20**. The conveyor would operate 24 hours a day provided that its operation does not exceed the goals for noise and dust generation.

Of the approximately 1,080,000 bank cubic metres taken to the quarry via the conveyor, approximately 840,000m^3 would come directly from the in-tunnel conveyors servicing the TBMs, effectively negating the need for nearly 65,000 loaded truck trips during the construction period. This is approximately half of the total loaded truck trips that would be required if a conveyor to the quarry was not used for the Project.

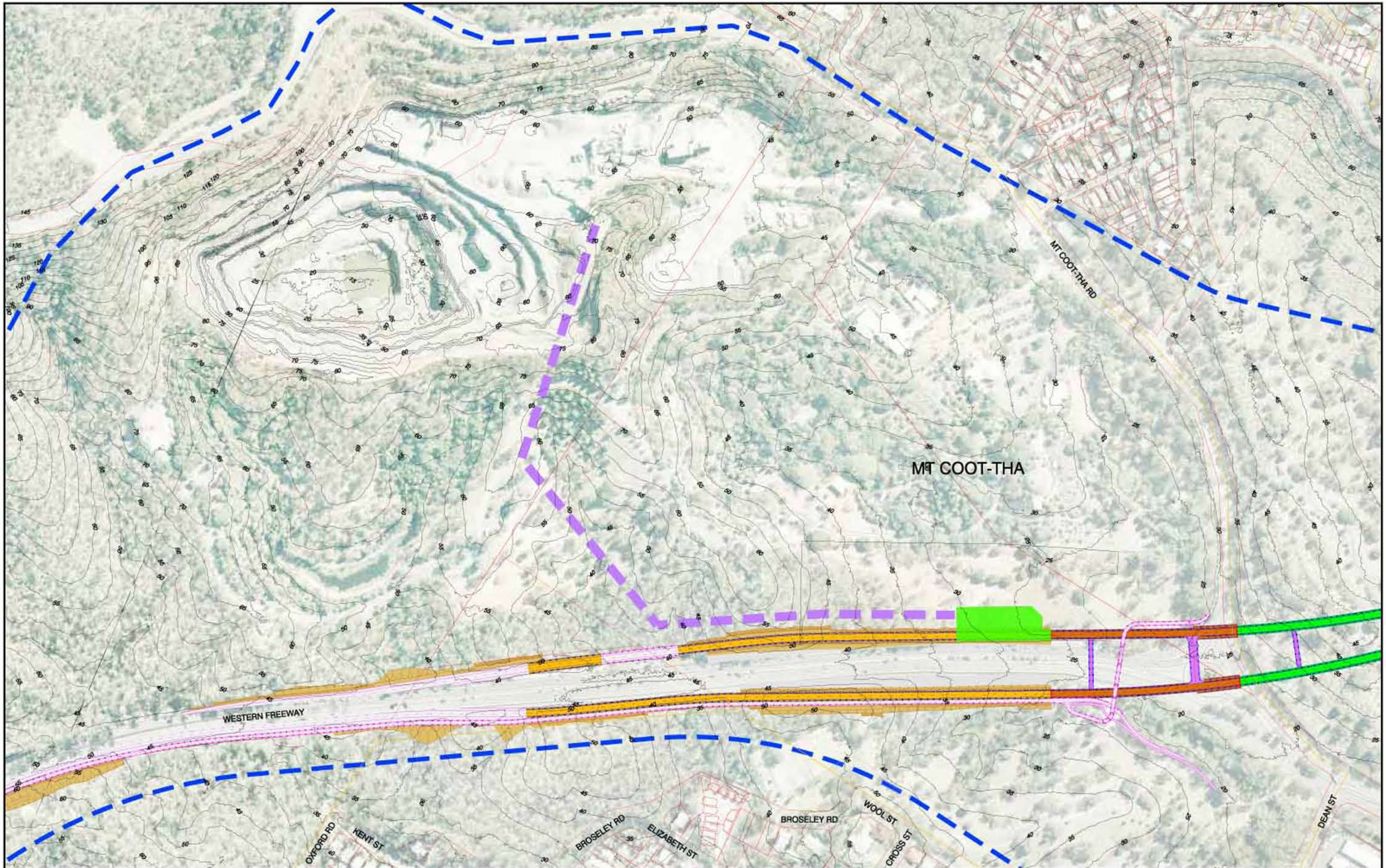
The other 240,000m^3 would be transported from the Toowong worksite by truck following a haulage route west along the Western Freeway from Frederick Street to the Moggill Road intersection, where the trucks would return east along the Western Freeway and unload the spoil for transfer to the conveyor within the worksite spoil handling enclosure.

Truck Haulage

The remainder of the spoil would be removed by truck. The spoil haulage scenario is based upon road haulage to the Port of Brisbane, Swanbank and to the Western Worksite from Toowong using trucks. These would most likely be tip truck and quad dog combinations with an approximate capacity of 13 bank cubic metres (or 33 loose tonnes). **Table 4-8** shows the estimated average daily truck movements and the anticipated duration of haulage from the work areas to the proposed spoil placement sites and also for transfer from Toowong to the Western Freeway worksite. **Table 4-8** is based on the estimated spoil volumes identified above with trucks able to carry approximately 33 tonnes of loose material.

- **Table 4-8 Spoil Removal by Trucks (approximate numbers)**

Worksites and Construction areas	Western Freeway Worksite	Swanbank	Port of Brisbane	Estimated Loaded Truck Movements from each work area	Duration of Operation (months)	Average Number of Truck Loads Per Day
Western Freeway		20,500		20,500	14	58
Toowong	18,500	1,500		20,000	19	43
Kelvin Grove			23,000	23,000	18	49
ICB construction area			2,000	2000	23	3
Total	**18,500**	**22,000**	**25,000**	**65,500**		



Legend

- INVESTIGATION AREA
- TUNNEL (TBM)
- TUNNEL (CROSS PASSAGE)
- CUT AND COVER
- TRANSITION STRUCTURE
- SURFACE WORKS
- EARTHWORKS
- WORKSITE
- ACOUSTIC SHED
- CONVEYOR ROUTE

0m 80m 160m

metres

Scale 1:5,700 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-20

Spoil Haulage Conveyor Route

Spoil from the Kelvin Grove worksite and ICB connection would travel east on the ICB, Kingsford Smith Drive, Gateway Motorway and Lytton Road to the Port of Brisbane (Fisherman Islands). Trucked spoil from the Western Freeway and Toowong worksites would travel west via Western Freeway, Centenary Highway, Ipswich Motorway, Cunningham Highway and Swanbank Road to the Swanbank placement site. It is proposed that most of the spoil from the Toowong worksite would be transported to the Western Freeway worksite and loaded on the conveyor to be transported to the Mt Coot-tha Quarry for recycling.

At the Western Freeway worksite spoil activity would commence at April 2010 (Year 1, Month 6) and last for approximately 14 months. The indicative construction program for the Reference Project indicates that the intensity of spoil haulage by truck would be constant at approximately 58 loaded trucks leaving the site each day during this period. This is equivalent to around 4 loaded truck movements per hour based on an 18 hour working day.

The main spoil activity at the Toowong worksite is scheduled to commence in July 2010 (Year 1, Month 9) and would last for 19 months. The total number of trucks loads required is approximately 20,000 over the 19 month period (approximately 1,500 truck loads to Swanbank and 18,500 truck loads to the Western Freeway worksite). The intensity of spoil movement from the Toowong worksite would be constant at approximately 43 loaded trucks leaving the site each day. This is equivalent to 2.5 loaded truck movements per hour based on an 18 hour working day.

Approximately 23,000 loaded truck movements would be handled from the Kelvin Grove worksite. In addition, approximately 2,000 loaded truck movements would be generated from the ICB construction area directly onto the road network. All of the spoil would be taken to the Port of Brisbane placement site at Fisherman Islands and/or the Port West Estate. The Kelvin Grove Road worksite would produce the main tunnel spoil from July 2010 (Year 1, Month 9) at a continuous rate of approximately 49 loaded trucks a day until January 2012 (Year 3, Month 3). Spoil movements from the ICB connection is forecast to commence in April 2010 (Year 1, Month 6) and continue at an approximate intensity of 3 loaded truck movements per day until February 2012 (Year 3, Month 7).

Other modes to transport spoil, such as rail or barge, would not be possible. Although the Kelvin Grove worksite is close to the Queensland Rail Exhibition Railway Line that is used by freight service, the lack of infrastructure to allow loading close to the worksites and unloading close to the spoil placement sites, the need for double handling of spoil material, the long indirect route for trains to the Port of Brisbane sites via the City, and the potential for disruption of existing rail services ruled out this option. Access to waterways and infrastructure to facilitate loading do not allow transport of spoil by barge.

Opportunities exist for reuse of spoil in the construction of embankments/reinforced earth at the Milton Road ramps. Also, suitable construction spoil could be used as invert fill in sections of the TBM driven tunnels.

4.3.19 Demand on Resources

Energy

At the Western Freeway worksite, the estimated electrical demand during construction would be approximately 21,400kVA, allowing for construction with two TBMs (one per tunnel) operating concurrently, for work area ventilation, for dewatering and surface office, workshop etc. This demand capacity would require specific power supply arrangements prior to commencement.

At the Toowong and Kelvin Grove worksites, the estimated electrical demand during construction would be approximately 6870kVA for each worksite. This would allow for construction with four roadheaders (two in each tunnel) operating concurrently, for work area ventilation, for dewatering and surface office, workshops etc. It would also allow for an additional two roadheaders which could be employed at either worksite, to create the cross passages between tunnels.

Water

The tunnelling methods used require the use of water for dust suppression and cooling of equipment. Water for construction purposes could be obtained from a number of possible sources. Water for human usage (showers, wash basins etc) would need to be of potable quality and would be obtained from metered standpipes connected to the existing mains supply system in the vicinity of the Western Freeway, Toowong and Kelvin Grove worksites. Where possible, water conservation techniques would be used, including aerated taps, waste efficient appliances, trigger action hoses, low/dual flushing or composting toilets and prompt repair of leaking taps and pipes.

Other water requirements could be satisfied by water of lesser quality. Total water usage for construction of the Project is estimated to be of the order of 110ML. Major water consumption would be in the manufacture of concrete and for concrete lining of the tunnels (secondary lining). The TBMs, roadheaders and other underground equipment require water supply during operation, including for dust suppression in the tunnels. Considerable volumes would also be required during surface works for laying road bed, dust control, wheel washes etc. Ground water encountered during excavation would be collected in a sump and pumped to the surface to be treated before either recycling for use in construction (machinery operation, dust suppression, landscaping and rehabilitation) or disposal to the existing stormwater system. It would be possible also that water used in the construction works could be used, after treatment, for dust control and wheel washes. **Table 4-9** shows the estimated volumes of water required at the respective worksites during tunnelling activities. Post tunnel excavation and concrete lining, the water supply requirements per day are likely to be considerably lower.

- **Table 4-9 Water Requirement Estimates by Worksite per day**

Worksite	Non-Potable (L/day)	Potable (L/day)	Total (L/day)
Western Freeway	110,000	30,000	140,000
Toowong	50,000	20,000	70,000
Kelvin Grove	50,000	20,000	70,000
TOTAL	**210,000**	**70,000**	**280,000**

The choices for obtaining the majority of the water supply have been outlined in Chapter 3, with the recommended source being the groundwater from the production borehole in the Mt Coot-tha Botanic Gardens, supplemented if necessary by drawing on the water storage in the Mt Coot-tha Quarry pit. Should the quality of water obtained from the borehole need to be improved to meet the construction purpose it is recommended that treatment facilities be incorporated into the Western freeway worksite.

Materials

The materials used during the construction of the Project would include concrete, reinforcing steel, shotcrete (sprayed concrete), precast concrete smoke duct segments, rockbolts, rockbolt resin, waterproofing membrane, gaskets and asphalt. Other materials include ducting, pipework and cables for the mechanical and electrical systems. The only materials to be used in significant quantities would be concrete, in the order of 180,000 m^3 and asphalt, in the order of 57,000 tonnes

Concrete for surface works and for the cast in situ tunnel lining would be sourced from local concrete batching plants. A batching plant is proposed on the site of the Western Freeway worksite for production of shotcrete to be sprayed on the tunnel walls as the primary (temporary) support. This batching plant would be supplied with aggregates from the Mt Coot-tha Quarry processing plant and water from the onsite bore (possibly treated to meet the specification requirements of the shotcrete). Asphalt for the road surfacing would be sought from local asphalt suppliers. Recycled material would be used wherever possible (eg: spoil from the tunnels being turned into aggregate for the shotcrete) and active procedures developed to minimise waste.

Workforce

Due to the specialist environment of the tunnel construction, the labour force would consist mainly of skilled technicians with a small portion of general skilled construction workers. The surface works associated with the connections for the tunnel would require general skilled construction workers. The possibility for job training and skills development would be investigated as a measure to increase the local component of the labour force for both tunnel construction and surface works.

At the commencement of the construction phase, the emphasis would be on the design and approval requirement, involving a significant team of designers and considerable co-ordination between the various disciplines.

Typical labour requirements for the construction phase of the Project are likely to be:

- tunnelling works – 200 full time equivalents;
- surface works and bridges at the connections – 230 full time equivalents;
- mechanical and electrical fit-out – 120 full time equivalents; and
- project management staff, including site management, head office, etc – 65 full time equivalents.

Hours of work for the construction phase would be:

- surface/above ground – 6.30am-6.30pm, Monday to Saturday with no work on Sundays or public holidays, although some out-of-hours work may be required on roads where high traffic volumes during the day preclude normal working hours;
- tunnel works – 7 days per week, 24 hours per day, with all activities underground or within the acoustic sheds; and
- spoil haulage by conveyor – 7 days per week, 24 hours per day; and
- spoil haulage by truck – at any time of the day or night between 6.30am Monday to 6.30pm Saturday, with no haulage on Sundays or public holidays. In practice this is likely to convert to 20 hours actual haulage, owing to shift changes and the need to avoid haulage in peak traffic periods, usually being 7.00am–8.30am and 5.00pm–6.30pm.

Dedicated workforce parking facilities would be provided at the eastern end of Victoria Park between Gilchrist Avenue and the ICB. At the western end dedicated workforce parking areas would be established either in the overflow carpark across Mt Coot-tha Road from the entrance to the Mt Coot-tha Botanic Gardens or in areas along Sir Samuel Griffith Drive between Mt Coot-tha Road and Simpsons Road, or any combination of more than one of these sites where required to avoid workforce parking on local streets. Shuttle buses would be provided to transport workers between the parking areas and the worksites.

4.3.20 Commissioning of Works

The majority of commissioning would be associated with the mechanical and electrical systems in the tunnels. These systems would be tested locally during the installation period. Once all installation and testing is complete a period of system testing and system integration would be required.

A period of testing the operation of the tunnel and its associated road network would occur once the system integration is complete. This would involve traffic running on the new roadways and interacting with the tunnel control systems including the toll system.

4.4 Project Operations Mode

4.4.1 Facility Management

Tunnel Control Centre

In the operational phase, a number of services are required for the safe and effective operation of the tunnel. These services would be monitored and controlled from the Tunnel Control Centre, a dedicated building proposed to be located adjacent to the Western Freeway within the rehabilitated worksite area.

Within the Tunnel Control Centre building would be the support workshops, incident control room, traffic control room and office space for administration. All data collected by the in-tunnel monitoring systems would be processed and all the services controlled from this location. It is also from here that water tankers would obtain water for the tunnel wash down operations, and here that the pressure booster for use by the fire brigade would be installed.

The Tunnel Control Centre site would also provide parking, maintenance and marshalling areas for emergency vehicles. This site would need ready and direct access to the mainline tunnels in each direction, as well as access to the connection tunnels and ramps. Fire protection, traffic management and control, communications and emergency procedures to provide for safety management would be provided and managed from the Tunnel Control Centre.

Traffic Management and Control System (TMCS)

A TMCS to control traffic movements in the tunnel and approaches would allow the operators to identify and respond to all reasonably foreseeable incidents to meet the requirements for public and staff safety. It would include:

- surveillance of the tunnel, approaches and ancillary structures;
- incident detection and alarm management;
- interfacing with the Brisbane City Council/DMR road management system; and
- emergency operation of the TMCS by Tunnel Control Centre staff.

The traffic management system would also be linked to the tunnel ventilation system to assist with the management of in-tunnel air quality by controlling the inflow of traffic in circumstances of extreme traffic congestion or traffic incidents in the tunnel system. In such circumstances, the ventilation system would need to operate at an appropriate level to maintain in-tunnel air quality within the goals.

Electronic Tolling System

The proposed tolling system is electronic with transponder scanners mounted on overhead gantries at the entry portals, thereby eliminating the need for toll plazas and tollbooths for cash payment. The tolling system would be inter-operable with all Australian toll roads. Payment of the toll is likely to be by E-Toll, and motor vehicles using the tunnel would need to be fitted with transponders or 'e-tags'. Transmitters and receivers on overhead gantries inside the tunnel would detect the transponders. Vehicles would be detected at high speed and at any lateral position across the carriageway. Classifiers on gantries would identify the size of vehicle and charge the appropriate toll. A process would be put in place to enable casual users of the tunnel to pay without the need for a transponder.

4.4.2 Tunnel Ventilation

A longitudinal ventilation system is proposed for the Project, as shown diagrammatically in **Figure 4-21**. Each of the mainline tunnels would be equipped with its own ventilation system, which draws air in at each of the portals (entry and exit) to achieve acceptable in-tunnel air quality as well as to minimise the potential for vitiated air escaping from the exit portals.

The tunnel ventilation system performs three functions:

- the maintenance of an acceptable air quality in the tunnel under normal operation;
- the maintenance of acceptable air quality around the portals; and
- the extraction of smoke in the event of a fire in the tunnel.

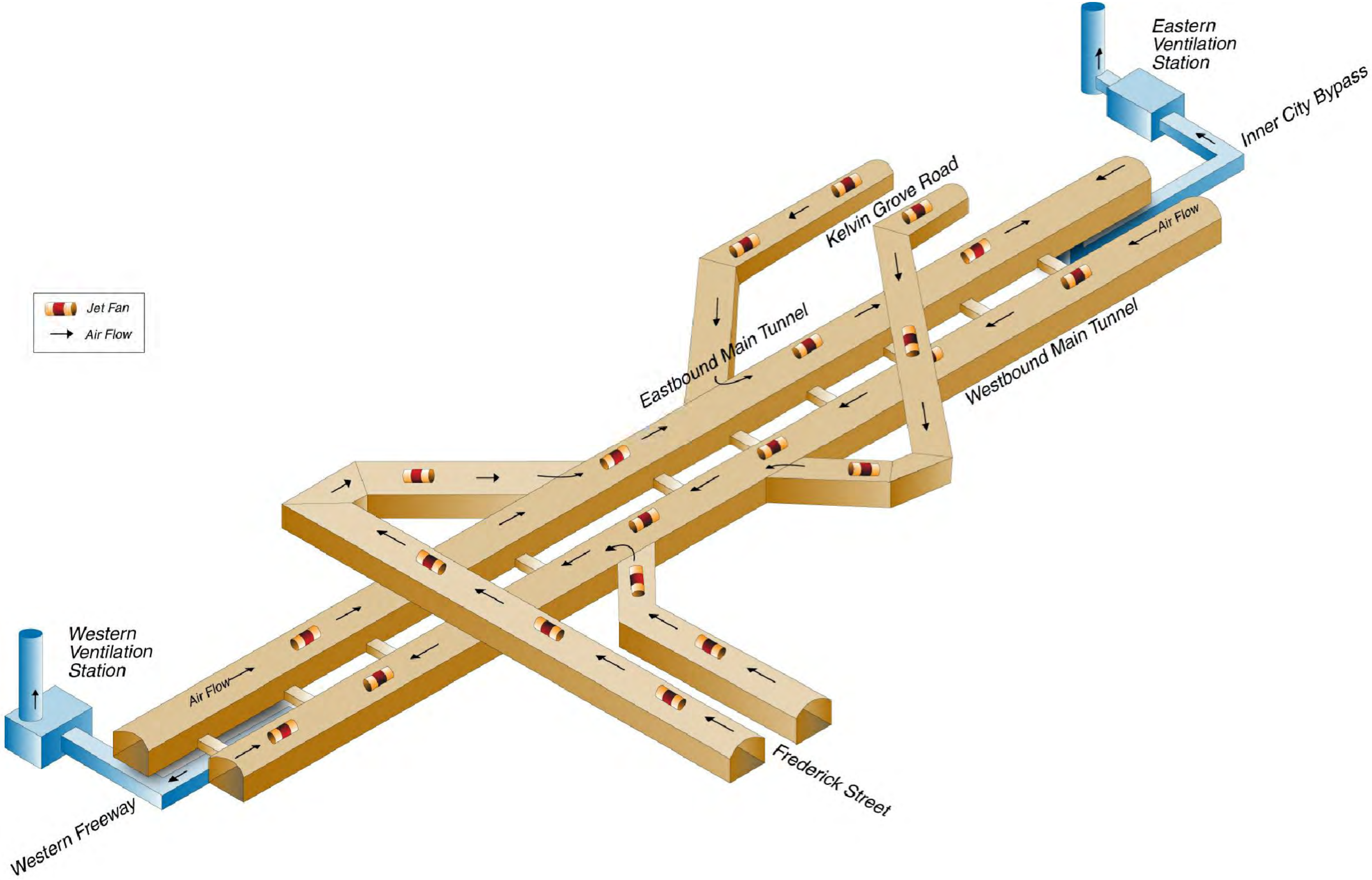
The air emissions generated by motor vehicles which are considered in ventilation design for tunnels are CO (carbon monoxide), particulates and various oxides of nitrogen, termed NO_x. The Permanent International Association of Road Congresses (PIARC) has recommended limits on the concentrations of these emissions within a tunnel. These limits have been adopted for the ventilation design of this tunnel, and are:

- a peak of 70ppm (parts per million) of CO, with a peak of up to 90ppm during extreme congestion;
- an average of 1ppm of NO_2; and
- a visibility limit[2] of $0.005m^{-1}$ for free flowing traffic and $0.007m^{-1}$ for congested traffic[3].

For design of the ventilation system, 'exceptional congestion' would be achieved in the tunnels with heavy traffic travelling at 10kph, whereas 'congestion' in the tunnels would be achieved with heavy traffic travelling at 20kph. On going and continuous monitoring of in-tunnel air quality would be linked to a system of traffic management to maintain appropriate traffic flows and consequent emission levels within the nominated air quality goals.

[2] the limit values are applied to ventilation sizing and refer to an "extinction or visibility coefficient based on the decay of a light beam as it passes through smoky air - K = $0.003m^{-1}$ describes clear tunnel (visibility several hundred meters) and K = $0.007m^{-1}$ describes a foggy atmosphere

[3] Peak traffic congestion occurs when traffic flows are less than 10 km/h



NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-21

Ventilation System

SKM Connell Wagner JOINT VENTURE

In order to achieve air quality within the nominated limits, the air in the tunnels is diluted with large quantities of fresh air drawn from the surface through each of the tunnel portals using jet fans installed along the roof of each tunnel (**Figure 4-3**). The mixed air would be extracted at a point about 100-200m back from the exit portal and ducted to the ventilation station from which it is forced to the ventilation outlet for expulsion to the atmosphere. The ventilation stations are designed to contain large axial fans which draw the air out of the tunnel and propel it to the ventilation outlets for dispersion.

Predominant airflow in the tunnels would be in the same direction as the traffic flow until the extraction point near the exit portal. At this location, the airflow would be reversed between the portal and the extraction point, to avoid the discharge of air at the portals. Visibility, air speed and gas monitors for CO and NO/NO_2 would be installed in each of the tunnels. Automated control systems respond to data collected by these air quality monitors, switching individual jet fans and axial fans on and off to regulate the overall airflow. The exit velocities for air flow from each of the ventilation outlets would range from approximately 7m/sec to 20m/sec, or approximately 25kph to 70kph in response to traffic flows, in-tunnel air quality and weather conditions.

In the event of a fire in the tunnel, the extraction of air is automatically switched over to operate through the smoke duct, which is housed in the roof of the tunnel. In the Kelvin Grove entry and exit ramps, the smoke duct in the ceiling would be augmented by a second smoke duct beneath the road surface that would be connected to the smoke ducts in the mainline tunnels for extraction of smoke in the event of an accident. In the Frederick Street entry and exit ramps, the smoke duct in the ceiling would also be augmented by a second smoke duct beneath the road surface that would be connected to the smoke ducts in the mainline tunnels for extraction of smoke in the event of an accident. Enlarging the smoke ducts within the ramps would negate the need for dedicated smoke extraction stations located at the ramp portals. By providing the additional smoke duct area within the lengths of the entry and exit ramps described above, the existing ventilation system would be capable of extracting the required air to maintain the required air quality within the tunnel. It would also not require linking the ramps and utilizing the smoke duct contained within the ramp unaffected by the incident.

The estimated annual average electricity usage for ventilation in the tunnels over a 41 year operation period is approximately 14.8 GWh (Gigawatt hours).

Provision would be made in the ventilation chambers or at the ventilation outlet site for each tunnel for filtration systems to be installed, should they prove to be effective and efficient in terms of energy consumption, and environmental benefits and impacts. A review of the technology and requirements for filtration is outlined in Chapter 9, Air Quality and Greenhouse Gases, of the EIS.

4.4.3 Services

Electrical Supply

All electrical equipment, including substations, transformers and an Uninterruptible Power Supply (UPS) would be located so that removal and/or replacement could be achieved in a maximum tunnel shutdown period of 4 hours. Design of the electrical system ensures that equipment failure would not result in total loss of power to any section of the tunnel, nor any essential services equipment. The tunnel electrical systems would be fully automated and controlled through a Plant Monitoring and Control System (PMCS) to enable their normal operation without manual operation at the tunnel.

Operational demand forecasts have been based on a combination of specific high level designs and extrapolations of observed demands in operating traffic tunnels in Australia. The dominant operating load is associated with the tunnel ventilation and it is this load group that would generally determine the peak load. Two ventilation stations are envisaged, one at each end of the mainline tunnel. At the western end, the ventilation station is expected to be located north of the Western Freeway in the proposed worksite. At the eastern end, the ventilation station is expected to be located east of the Inner Northern Busway.

There would be two points of operation supply, one at the Western Freeway connection and the second at the Inner City Bypass connection. Each of the two points of supply would be provided with two dedicated 11kV feeders, each capable of carrying approximately 6MVA of load. Under this arrangement, the forecast tunnel peak load can be carried by any two of the four feeders. The points of supply would be adjacent to the western and eastern ventilation stations. The external power supply would provide a double contingency 11kV feeder outage, without the need to shed loads. A dedicated UPS, independent of the mains supply, would ensure operation of the tunnels' emergency services systems in any circumstance.

Electricity consumption for operations has been estimated for 41years. Over this time period annual average electricity consumption would be approximately 23GWh.

Up to twelve substations would be required along the length of the tunnels. Distribution from these substations would be fully interleaved, so that if one fails the adjoining substation would be able to supply both zones. Further duplication with backup units is designed into each substation.

In the event of a wider power systems failure, the entire tunnel would need to be closed down. The system would then initiate orderly cessation of all tunnel plant and services under the direction of tunnel operators using motorist advisory signs. Essential loads such as emergency lighting, signs, communications and central control would be maintained by the no-break UPS systems until the tunnel is cleared.

Lighting

Roadway lighting in the tunnel would be provided in zones. Lighting is brightest in the portal regions, with the intensity reducing progressively along the tunnel to a set minimum level. This gradation allows the driver's eyes to adjust to the dimmer environment. The intensity of the lighting in the portal region is set automatically, based on the ambient light conditions on the surface.

The base lighting would be fluorescent, with high-pressure sodium lamps in the portal areas. The lighting zones are interleaved, so that a failure in the distribution network would cause only a proportional loss of lighting in the affected zone.

Other lighting elements provided in the tunnel include:

- directional signage to guide pedestrians towards the cross passages in the event of an incident; and
- exit signage and emergency lighting in cross passages and egress tunnels.

4.5 Infrastructure Requirements

4.5.1 Utility Modifications

Relocation and disruption to utility services would occur at all four connections. Construction of the mainline tunnel would not impact on services due to the depth of the tunnels under the ground.

The services likely to be affected include:

- electricity distribution cables;
- natural gas distribution network;
- Brisbane City Council Stormwater and Sewer drains and Water mains; and
- Telstra, Optus and other communication providers.

Service authorities may be interested in the incorporation of future services routes in conjunction with the Project infrastructure and this would be considered in the preliminary design phase.

Preliminary investigations indicate that the major public utility plant relevant to the Project design and construction, including construction programming, would include:

- electricity:
  - an 11kV overhead line on the eastern side of Mt Coot-tha Road adjacent to the eastbound portal;
  - low voltage street lighting adjacent to the Mt Coot-tha Road intersection;
  - high voltage cables (33kV or higher) along both sides of Frederick Street; and
  - banks of conduits containing lower voltage cables (less than 11kV) across Kelvin Grove Road near Victoria Street.
- Gas:
  - a high-pressure main on the southern side of Milton Road;
  - local mains in construction areas;
  - a local main along the western side of Kelvin Grove Road between Musgrave Road north and Upper Clifton Terrace;
  - a small gas line in Ithaca Street; and
  - a medium sized gas main in proximity to the landbridge on the ICB.
- Telecommunications:
  - multiple conduits along the western side of Mt Coot-tha Road;
  - fibre optic cables and coaxial cables in Milton Road; and
  - fibre optic supplies located in conduits along Kelvin Grove Road.
- Stormwater:
  - 1650mm culvert beneath the Western Freeway;
  - 450mm drain along Frederick Street between Valentine Street and Milton Road;
  - various stormwater mains up to 650mm diameter along Kelvin Grove Road; and
  - large stormwater mains up to 1650mm diameter, plus large culverts and a drainage channel adjacent to the ICB and INB overbridge.
- Sewerage:
  - 1200mm pipes adjacent to the Frederick Street roundabout and ramp;
  - local sewers along Frederick Street and across the Frederick Street / Milton Road roundabout;
  - a vacuum sewer located within Kelvin Grove Road; and

  - sewer mains on the northern side of the ICB near the INB overbridge with associated branch connections transversely under the ICB.
- Water Supply:
  - major Taringa to Enoggera 1530mm water main crossing the Western Freeway transition structures;
  - local water main along Frederick Street and side street water connections;
  - mains in Lower Clifton Terrace and Kelvin Grove Road including a 600mm trunk main and various supply mains;
  - a supply main along the northern side of the ICB; and
  - a water main in Ithaca Street.

4.5.2 Wastewater

As described above, large volumes of water are required for construction over the life of the construction program. Opportunities would be investigated to reuse water collected on the site or from tunnel inflow, especially for dust control, wheel-wash facilities and similar purposes.

Wastewater generated at the site compounds would include water from showers, toilets and kitchen facilities. It would either be discharged to the sewer via standard connections or collected in holding tanks and removed to a licensed waste disposal facility.

4.6 Permits, Licences and Approvals

The Coordinator-General of Queensland declared Northern Link to be a significant project for which an EIS is required, on 31 October 2007, under Section 26(1)(a) of the *State Development and Public Works Organisation Act 1971* (SDPWO Act). Consequently, an EIS is required to be prepared for consideration by the Coordinator-General to ensure that the environmental values of the study corridor are recognised and any project-related impacts are identified and managed adequately.

The Project needs to be considered under both Commonwealth and State legislation to determine the approvals required. Relevant Commonwealth legislation includes:

- *Environment Protection and Biodiversity Conservation Act 1999*;
- *Native Title Act 1993; and*
- *National Greenhouse and Energy Reporting Act 2007*

A referral was made to the Commonwealth Minister for the Environment and Heritage under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) to determine whether the Project and its associated works are a ‘controlled action’ under the Act. The Delegate of the Commonwealth Minister for the Environment and Heritage determined on 6 December 2007 that the Project does not constitute a controlled action pursuant to s75 of the *EPBC Act*.

There are two registered native title claims under the Commonwealth’s *Native Title Act 1993*. These claims have been made by the Jagera People and the Turrbal People. To the extent that Native Title exists in relation to any land affected by construction or long term operations of the Project, native title will either be suppressed (for the construction period) or extinguished (by resumption of any native title in relation to the area of the operational tollway). An alternative to resumption could be the negotiation of an Indigenous Land Use

Agreement pursuant to which the native title rights are surrendered. These processes require compliance with the *Native Title Act 1993*. The Jagera and Turrbal People will need to be consulted and/or negotiations carried out to ensure clearance is obtained.

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) establishes a national framework for Australian corporations to report GHG emissions, reductions, removals and offsets, and energy consumption and production. The purpose of the NGER Act is to provide for a single, national system for the reporting of greenhouse gas emissions, abatements and energy consumption and production activities by corporations. The NGER Act applies to corporation activities from 1 July 2008, with the first reporting period ending on 30 June 2009. A corporation will trigger the reporting threshold if a facility(s) under its control emits greenhouse gases, produces energy or consumes energy at, or above, the level specified by the NGER Act. Defined reporting thresholds are provided in **Table 4-10**.

- **Table 4-10: NGER Corporation Reporting Thresholds**

Variable	Reporting Year		
	2008-9	2009-10	2010-11 (onwards)
CO_2-e emission (kt)	125	87.5	50
Energy production /consumption (TJ)	500	350	200

A facility based reporting threshold will also apply from July 2008. Under the NGER Act, the annual reporting thresholds for an individual facility is set at 25 kt $CO_{2\text{-}e}$ emitted or 100 TJ energy produced or consumed. The data collected through the reporting system will be used to help formulate and evaluate the Australian Emissions Trading Scheme (the Scheme). The Scheme is projected to be a 'cap and trade' system and should be operational no later than 2010. The detailed design of the Scheme is due to be finalised by the end of 2008.

4.6.1 Approvals Pathway

There is a wide array of Queensland legislation relevant to the statutory approval for the Project. The 'approvals pathway' for the Project primarily includes a combination of the SDPWO Act and the *Integrated Planning Act, 1997* (IPA). The SDPWO Act sets out the process to be followed for a significant project for which development approvals are required under the IPA. The IPA establishes an "integrated development assessment system" (IDAS) that recognises the roles and responsibilities of development control under local government planning schemes and also the statutory approval requirements of other areas of State legislation that may be relevant to the Project, including:

- *Aboriginal Cultural Heritage Act 2003;*
- *Acquisition of Land Act 1967;*
- *Animal Care and Protection Act 2001;*
- *Brisbane Forest Park Act 1977;*
- *Building (Flammable and Combustible Liquids) Regulation;*
- *Coastal Protection and Management Act 1995;*
- *Dangerous Goods Safety Management Act 2001;*
- *Environmental Protection Act 1994*
- *Land Protection (Pest and Stock Route Management) Act 2002 ;*
- *Nature Conservation Act 1992;*
- *Plant Protection (Red Imported Fire Ant) Quarantine Notice 2001;*
- *Queensland Heritage Act 1992;*
- *Soil Conservation Act 1986;*
- *Transport Infrastructure Act 1994;*
- *Vegetation Management Act 1999;*

- *Fisheries Act 1994;*
- *Health Regulations under the Health Act;*
- *Integrated Planning Act 1997;*
- *Land Act 1994;*
- *Water Act 2000; and*
- *Workplace Health and Safety Act 1995.*

As previously stated, the declaration by the Coordinator-General of the Project as a significant project under the SDPWO Act sets the statutory framework for the EIS to be prepared for the Project. The EIS is required to be prepared for consideration by the Coordinator-General to ensure that the environmental values of the study corridor are recognised and any project-related impacts adequately managed. In particular, the Coordinator-General's report may:

- state conditions that must apply to a development approval under the IPA;
- recommend requirements for inclusion in a community infrastructure designation under the IPA;
- make recommendations for other approvals; and
- impose conditions.

Further, a submission made in relation to this EIS is taken to be a submission for a later impact-assessable development application under the IPA.

4.6.2 Development Approvals

Development approvals required upon completion and approval of the EIS are likely to include:

- development approvals required under the provisions of the Planning Scheme (City Plan 2000), (eg: operational works for excavation or filling for spoil placement);
- development approvals required for development defined as "assessable" under Schedule 8 of the IPA eg:
  - building work that is not self-assessable or declared under the *Building Act 1975* to be exempt;
  - making a material change of use for an Environmentally Relevant Activity (ERA) under the *Environmental Protection Act, 1994*;
  - making a material change of use of premises if all or part of the land forming part of the premises is on the environmental management register or contaminated land register under the *Environmental Protection Act 1994*;
  - operational work for the clearing of native vegetation under the *Vegetation Management Act 1999*;
  - operational work of any kind that allows the taking, or interfering with, water under the *Water Act 2000*;
  - all aspects of development on a Queensland heritage place registered under the *Queensland Heritage Act 1992*; and
  - all aspects of development on a local heritage place

City Plan 2000

City Plan makes exempt from assessment under the City Plan 2000, development involving the construction, maintenance or operation of roads and things associated with roads including:

- activities undertaken for road construction;
- traffic signs and controls;
- depots;
- road access works;
- road construction site buildings;
- ventilation facilities, including exhaust fans and outlets;
- drainage works;
- rest area facilities and landscaping;
- parking areas;
- public transport infrastructure;
- control building; and
- toll plazas.

Development approval under City Plan for material change of use for filling and excavation for spoil placement would be required only if that is assessable under the City Plan designation for spoil placement locations, and not subject to a Community Infrastructure Designation (CID). Applications for development approvals for operational works need approval prior to the commencement of any works where such development is assessable. These may include operational works for filling and excavation for spoil placement that materially affects premises or their use.

A development approval for material change of use on Strategic Port land is required where the development proposed (spoil placement) is inconsistent with the Land Use Plan for the Port. While it is not expected that the spoil placement would be inconsistent with the Port Strategic Land Use Plan, the Fisherman Islands land is designated for port related activities under the Port Strategic Land Use Plan.

Development under a CID is exempt to the extent that approvals for assessable development involving material change of use and approvals for reconfiguration of a lot are required under the planning scheme, City Plan 2000.

Where it is proposed to proceed with a CID of all or part of the Project any designation process would be informed by the preparation, consultation and assessment processes undertaken for this EIS. A designation can be for a volumetric parcel of land. The CID could be undertaken either by a Minister of the Queensland Government or by the Brisbane City Council, following the processes established by the IPA.

Assessable Development Under Schedule 8 of the IPA

Reconfiguration of Land (Subdivision)

Reconfiguration to create a lot for the tunnel is exempt development under the IPA where either the land is not under the *Land Act 1994* or where acquired pursuant to the *Acquisition of Land Act. 1967*.

Building Works

The Project would require the construction of a number of buildings including:

- the erection of sheds over the worksites at each of the tunnel portals;
- tunnel control building which includes operational and management functions;
- the ventilation stations and outlets adjacent to each end of the mainline tunnel; and
- general maintenance buildings.

Depending on the mode of project delivery, development approval requirements may be triggered under the IPA. Where required, buildings would comply with the Building Code of Australia.

Material Change of Use for an ERA

Where the Project involves development for a material change of use of premises for an environmentally relevant activity (ERA), defined in Schedule 1 of the *Environmental Protection Regulation 1998*, that development is assessable development under the IPA.

The Project works may include a number of ERAs, including:

- **ERA 7 – Chemical and Dangerous Goods Storage**

  ERA 7 is the storage of more than 10 m^3 but less than 1,000m^3 of chemicals or dangerous goods. If dangerous goods, including explosives, are stored on worksites in excess of these quantities, approval for a material change of use for an environmentally relevant activity is required. Considering the proximity of sensitive land uses to the Toowong and Kelvin Grove worksites in particular, storage of explosives is not desirable.

- **ERA 15 - Sewage Treatment**

  ERA 15 may apply should the Project involve operating sewage treatment works with a peak design capacity of 21 or more equivalent persons for the purpose of treating sewage and producing recycled water (sewer mining) for use during the construction phase of the Northern Link project.

- **ERA 16 - Water Treatment**

  ERA 16 may apply should the Project involve the treatment of bore water within the western freeway worksite for use during the construction phase of the Northern Link project.

- **ERA 20c – Extracting Rock**

  This may apply where project works are considered to constitute an environmentally relevant activity (ERA 20c) for extracting rock or other material from a pit or quarry where the design capacity or equipment being used would exceed 100,000 tonnes per year. Construction of a road, including a tunnel, as described in this chapter is considered not to trigger an environmentally relevant activity for extracting rock.

- **ERA 22 – Crushing and Screening**

  This may apply should the spoil taken to the Mt Coot-tha Quarry during the excavation of the tunnels create a material change in the intensity or scale of the existing deemed development approval for the Quarry (Licence no. SR41). The proposed conveyor would generate material for stockpiling on the site over a 24 hour period, 7 days a week. The processing of the material would occur in accordance with the existing ERA 22 licence.

- **ERA 62 – Concrete Batching**

  For the proposed batching of concrete at the worksite during construction, a development approval for a temporary or mobile environmentally relevant activity is required where the planned production volume exceeds 100,000 tonnes per year.

The conventional practice is for asphalt to be transported to the construction site rather than produced on-site. Should manufacture of asphalt be required at the worksite during construction, a development approval for a temporary or mobile environmentally relevant activity (ERA 59) would be required.

The EP Regulation, including the Schedule of identified ERAs is currently under review. The Environmental Protection Agency has advised its intention to add Ventilation Outlets from road tunnels to Schedule 1 of the EP Regulations as an ERA from 1 January 2009. Accordingly, development approval would also be required for this element of the Project.

Material Change of Use of land on the EMR or CLR.

A development approval for a material change of use for land on the Environmental Management Register (EMR) or Contaminated Land Register (CLR) is required under the IPA, where the land does not have an approved site management plan.

A strategic-level investigation of the study corridor has identified a number of sites which contain potentially contaminated soils as a consequence of previous activities (eg: service stations, car repair stations) and which could be intercepted by construction of the Project. A number of these sites are covered by site management plans prepared in accordance with the *Environmental Protection Act 1994*.

The construction of the Project would need to comply with the conditions applying to the existing site management plans for each of the contaminated sites under which it passes.

Operational Works

Development approvals for operational works are required prior to the commencement of any works where such development is assessable development under the IPA (Sch 8, Part 1). These may include operational works for filling and excavation for spoil placement that materially affects premises or their use.

Assessable development for operational works includes clearing of native vegetation on freehold land and development approval would be required for the clearing of remnant native vegetation in accordance with the provisions of the *Vegetation Management Act 1999* to be lodged with the Department of Natural Resources and Water as the assessment manager.

Assessable development for operational works also include any kind of work that allows the taking, or interfering with, water under the *Water Act 2000.* Such work may include excavation and or the placement of fill affecting a watercourse, diverting the flow of a watercourse, and the removal of vegetation within a watercourse. A Riverine Protection Permit may also be required.

Assessable development for operational work also includes work that is the constructing or raising of a waterway barrier under the *Fisheries Act 1994*.

Queensland Heritage Place

Development carried out on a registered place under the *Queensland Heritage Act 1992* is assessable development under the *Integrated Planning Act 1997*. Brisbane Forest Park, Toowong Cemetery, Victoria Park are all places listed under the State Heritage Register. A development application, for code assessment, would be required to be assessed by the Chief Executive of the EPA. A cultural heritage management plan may be required to be approved prior to the construction of any works which adversely affect a place of cultural heritage significance included in the Queensland Heritage Register.

Local Heritage

Development on a local heritage place is also assessable and would require a development application to be lodged, for code assessment by the Brisbane City Council, unless Schedule 9 of the IPA applies to the development.

4.6.3 Other Approvals, Licences, Permits and Certifications

Under the *Environmental Protection Act 1994* a registration certificate is required for any identified environmentally relevant activities (ERAs).

Contaminated Land

A disposal permit would be required under the *Environmental Protection Act 1994* for removal of contaminated soil during construction for land on the Environmental Management Register or Contaminated Land Register.

Acid Sulphate Soils

Although the potential for construction works to intercept potential acid sulphate soils is considered extremely low, unexpected interception of ASS would mean that the Department of Natural Resources and Water would require the preparation of an environmental management plan. The plan must be prepared in accordance with the Guidelines and approved by the Department of Natural Resources and Water.

Water

A licence would be required if taking, or interfering with water, under the *Water Act 2000*.

Wildlife

A permit would be required if taking protected plants and animals under the *Nature Conservation Act 1992*

Cultural Heritage

Under the *Aboriginal Cultural Heritage Act 2003* a cultural heritage management plan is needed where an EIS is required. A cultural heritage survey is included in the EIS to identify the locality of places of cultural heritage significance.

Any works affecting a place of indigenous cultural heritage significance may require a permit to remove or relocate artefacts or other evidence of indigenous cultural heritage.

Works on a State Controlled Road

The approval of the Chief Executive Department of Main Roads is required under the *Transport Infrastructure Act 1994* if works are to be undertaken on a State Controlled Road or otherwise have a significant impact on a State Controlled Road.[4]

Works that Interfere with a Railway

The approval of Queensland Rail as the railway manager is required under the *Transport Infrastructure Act, 1994* if works are to be undertaken that would interfere with a railway.

Brisbane Forest Park

Land within the Brisbane Forest Park is regulated by the *Brisbane Forest Park Act, 1977* (the BFP Act) and controlled and managed by the Brisbane Forest Park By-Law 1999. The By-law regulates activities within the Brisbane Forest Park and allows for the granting of permits for various activities within the Brisbane Forest Park.

Future Approvals

Prior to construction, other development approvals may be required with the coming into force of further amendments to the IPA, as other State legislation is rolled into the IPA.

Greenhouse Gas Emission Reporting

The body with operational control over the tunnel would be required to report greenhouse gas emissions should these emissions exceed the relevant NGER thresholds. It is expected that the Project would be considered a "facility" under the NGER with just under 20kt of CO_{2-e} produced in 2014. This does not trigger the reporting threshold for a facility (25kt of CO_{2-e}). Over time energy consumption and associated greenhouse gas emissions for tunnel operation are expected to increase, and in 2040 greenhouse gas emissions would exceed the facility reporting level and the body with operational control of the tunnel would be required to report these emissions.

Reporting may be required at an earlier stage if the body with operational control of the facility also has operational control over other facility(s) whose aggregate emissions exceed the criteria set out for corporations by the NGER ie: 50kt of CO_{2-e} from 2010-11 onwards

4.6.4 Local Laws

Local laws govern activities such as blasting, temporary road closures and local traffic management measures during construction. Approvals from the Brisbane City Council under relevant local laws or provisions of the *Local Government Act, 1993* would be required prior to the commencement of such activities. Permanent road closures would be required and applied for under the *Land Act 1994*.

[4] Amendments to the *Transport Planning and Coordination Act 1994* provide for codes under IDAS for works on a local government road that limit access or remove public passenger transport infrastructure. These provisions are not yet operative.