Northern Link

6. Geology and Soils

Northern Link

Phase 2 – Detailed Feasibility Study

CHAPTER 6

GEOLOGY AND SOILS

- September 2008

Contents

6. Geology, Geomorphology and Soils

This chapter addresses Part B, Section 5.1 of the Terms of Reference (ToR). The topography, geomorphology, soils and geology of the study corridor and adjacent areas are described to provide a general understanding of the geological history of the region. Potentially economic minerals, energy resources, extractive resources, slope stability, soil types and geological features such as faults, joints and other lineations are described and potential impacts associated with the project are identified. The potential for Acid Sulphate Soils (ASS) or other contaminated soils and appropriate management measures should there be a risk of disturbance during construction or operation, are identified. Settlement risk and *erosion risk, particularly during construction is identified and management measures in accordance with those set out in 'Soil Erosion and Sediment Control – Engineering Guidelines for Queensland Construction Sites, 1996' are provided together with other management measures such as monitoring and rehabilitation measures.*

6.1 Description of Existing Environment

6.1.1 Topography

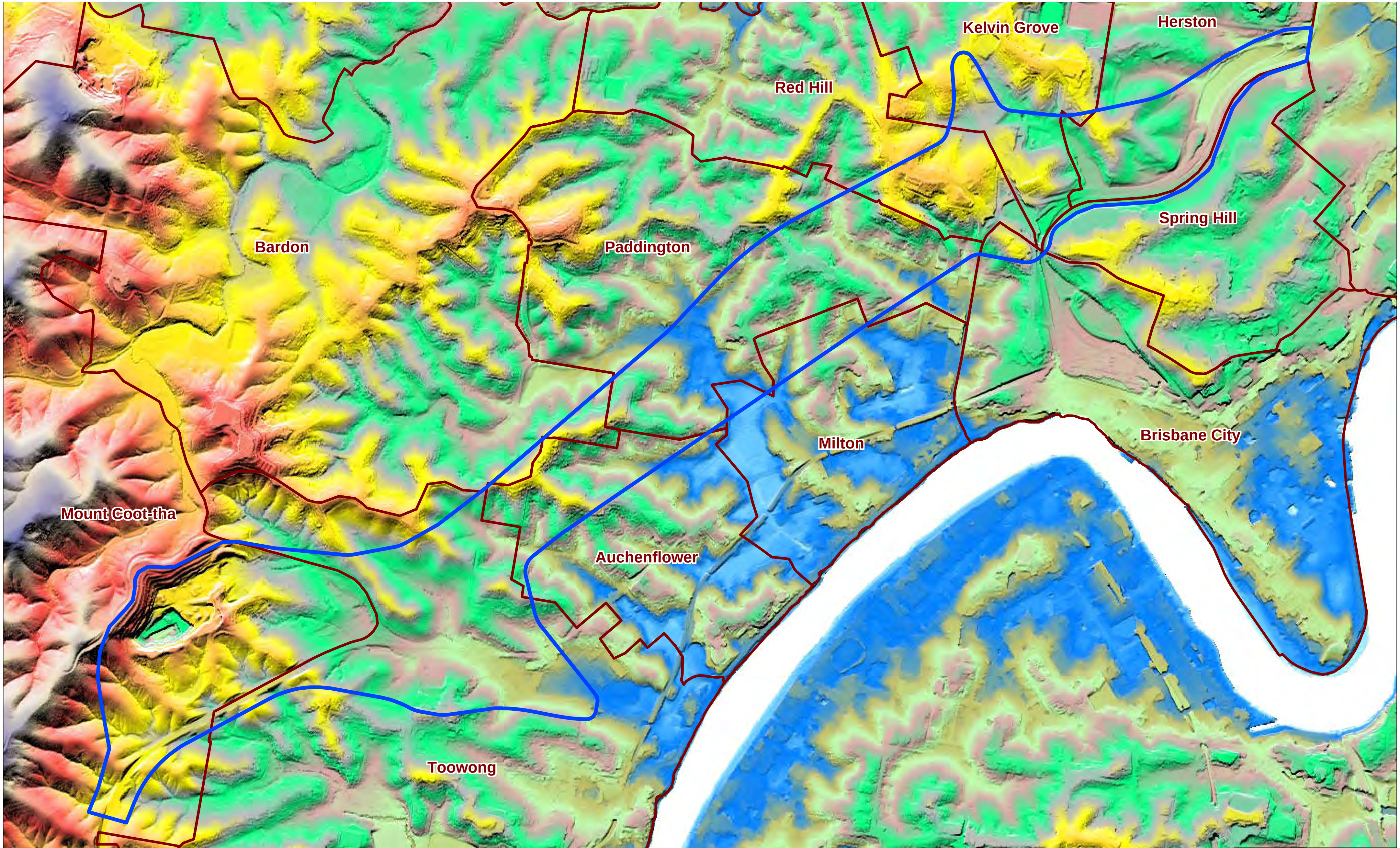
Elevations within the study corridor are up to 70m above the Australian Height Datum (AHD) on Musgrave Road and 50m above on other ridge lines such as the Frederick Street – Birdwood Terrace intersection. In general, the topography is undulating with several steep ridges radiating from Mt Coot-tha. The proposed portals are at elevations of approximately 25m at the Western Freeway and Frederick Street, 50m at Kelvin Grove Road and 35m at the Inner City Bypass (ICB) (**Figure 6-1)** and (**Figure 6-2**)**.**

6.1.2 Geomorphology

The Northern Link study corridor is situated between Toowong and Herston traversing undulating ground dissected by three relatively short drainage systems emptying into the Milton reach of the Brisbane River along its left bank. The geomorphology of the area is dominated by the Mt Coot-tha massif in the west. Mt Coot-tha owes its elevation to the intrusion of Enoggera Granite during the late Triassic. This intrusion has been uncovered by erosion at the northern end of Mt Coot-tha where the granite has been quarried at The Gap and Keperra. Although granite is not evident at the surface in the southern part of Mt Coot-tha, it is very close to the surface. This is evidenced by the hornfels of the Mt Coot-tha Quarry which formed as a thermally metamorphosed aureole when the rock was heated up and welded by the great heat of the molten granite cauldron before it cooled and crystallised. This hardening of the rock above the granite intrusion made the Mt Coot-tha massif resistant to weathering resulting in retention of its elevation. Over eons of weathering Mt Coot-tha has become the centre of a generally radial drainage system as the less resistant rocks further from the granite intrusion weathered more readily and their detritus was transported down streams and the river to the ocean.

The ridges of the inner western suburbs are watersheds between streams draining the eastern side of Mt Coot-tha. These ridges may be traced by the following roads on their crestlines which are from west to east:

- Swann Road, Stanley Terrace;
- Kensington Terrace, Sherwood Road, Dean Street and Elizabeth Street;
- Birdwood Terrace; and
- Given Terrace, Latrobe Terrace.



LEGEND

Study Area Corridor

Suburbs Boundary

00 20 30 50 75 100 150 200

Meters

0 500 1000

metres

Scale 1: 25,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 6 - 1

Topography

Northern Link

SKM Connell Wagner
JOINT VENTURE

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LEGEND

- Study Area Corridor
- Suburbs Boundary
- 10m Contours

0 500 1000

metres

Scale 1: 25,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 6 - 2

Contours Information

Northern Link

SKM Connell Wagner

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The underlying Bunya Phyllite generally forms poor soils and in many places, road cuttings or other exposed excavations show the very thin soil cover characteristic of the study corridor. This generally thin soil cover accentuates the steepness of the relatively low ridges between drainages as significant rain events over geological time have removed much of the soil from the higher ground.

Sediment has accumulated along the lower sections of the drainage lines with most of the significant deposits of alluvium close to the Brisbane River. In the study corridor the only appreciable accumulation of alluvium is in the vicinity of the Mt Coot-tha Botanic Gardens near the Toowong portal. This is likely to be less than 10m deep.

Lowered sea levels during the Pleistocene ice ages rejuvenated erosional down-cutting by the Brisbane River and its tributaries. With subsequent rising sea levels, these channels were inundated to deposit the alluvium now filling the bottoms of drainages. The history of the Brisbane River is likely to have begun before the Quarternary period. The drainage pattern seems to have occurred in the Tertiary (about 20 million years ago) period with some changes to the pattern being influenced by block faulting tectonic events of the Permian and/or Triassic periods.

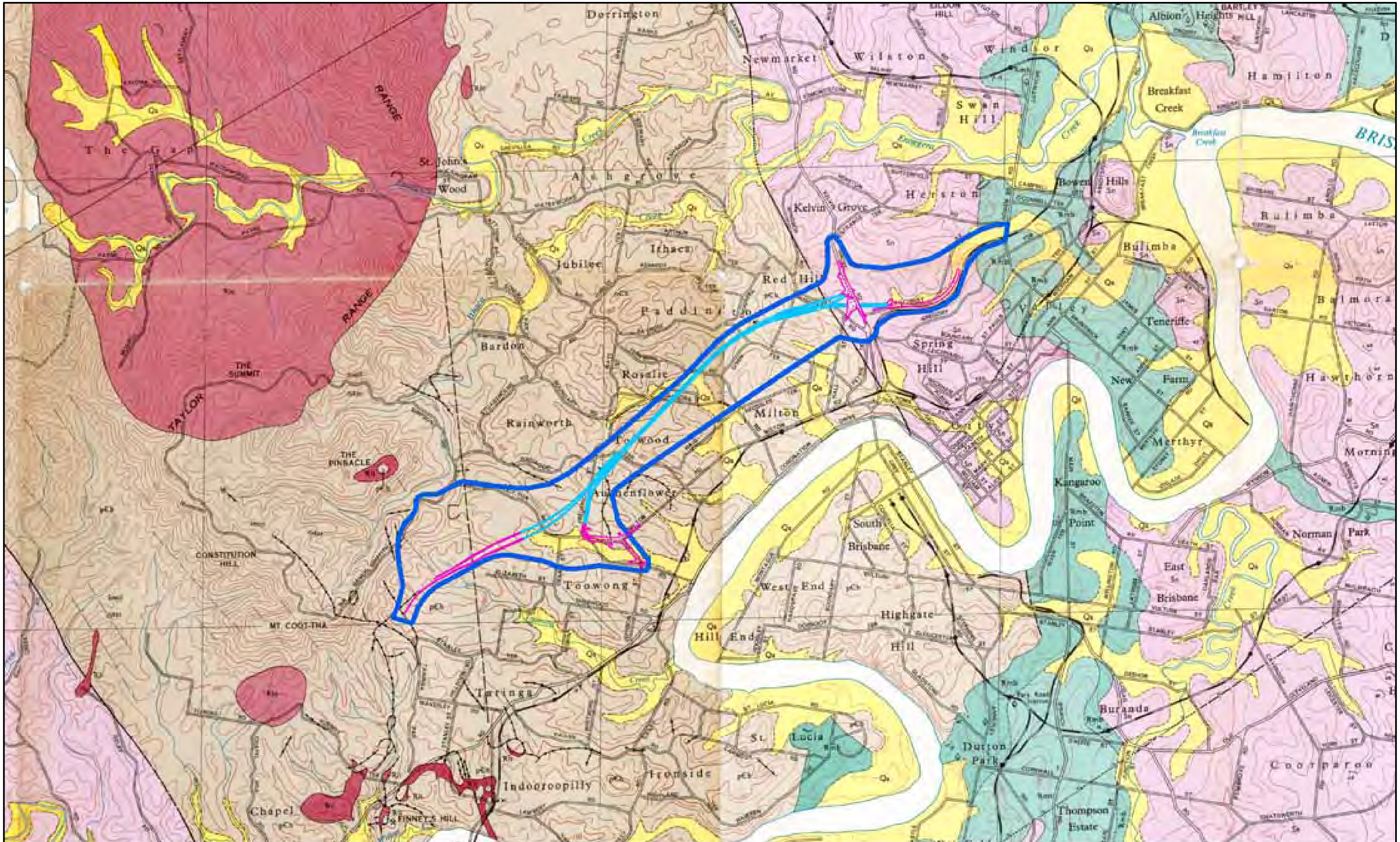
From extensive geomorphological research along the south-eastern Queensland coastline, Cranfield *et al.* (1976) considered the present sea level to be within 3m of the highest known sea level of the area. The extent of marine influence in depositing sediments in Brisbane River tributaries is uncertain. Marine sediments are known in the Bulimba area whereas sediments in the Moggill Creek valley (Brookfield) or Cedar Creek valley, (Ferny Grove and Upper Kedron) are deposited well above any marine influence.

Consequently geological maps of the Brisbane area show most alluvial deposits as undifferentiated gravel, sand, silt, mud and clay. The *Brisbane 1:100,000 Geological Sheet 1986* shows the Quarternary Alluvium from the Brisbane River near Cribb Street north through Castlemaine Street and Suncorp Stadium across Given Terrace as land fill by man.

6.1.3 Geology

Figure 6-3 shows the surface geology of the study corridor and adjacent areas. Surface geological mapping of the study corridor identifies two low grade metamorphic rock units, namely the Bunya Phyllite and the Neranleigh-Fernvale Beds. The Bunya Phyllite occupies the area from the western end of the study corridor to approximately Musgrave Road at the Normanby Fiveways. Further east, the study corridor has been mapped as including the Neranleigh-Fernvale Beds.

There is some contention as to the occurrence or otherwise of a fault line in the area. Bryan and Jones (1954) identified a major thrust, the Normanby Fault, along the line of separation of these two units. A succession of other thrust faults further to the east towards and beyond Hamilton accounted for the recurrence of the Bunya Phyllite within the area mapped as Neranleigh-Fernvale Beds. Holcombe (1978) accepted a line of lithological distinction in the vicinity of the so-called Normanby Fault, but could not substantiate a tectonic fault zone. He inferred that the Bunya Phyllite and Neranleigh-Fernvale Beds comprised a single continuous succession of terrigenous rocks with the repetition of the Bunya Phyllite through the Neranleigh-Fernvale Beds due to facies differences and not due to structural dislocation. Holcombe (1978) identified the steepening of the foliation and structure in the area of the so-called Normanby Fault and provided possible structural cross sections that would explain such variation in attitude in a structural sense without necessarily invoking a major fault zone. Nevertheless two different lithological units can be recognised in the study corridor.



LEGEND

- Study Area Corridor

Proposed Alignment

- Surface Work
- Tunnel Underground

Geological Seetings

- Alluvium
- Brisbane Tuff
- Enoggera Granite
- Neranleigh Fernvale
- Bunya phyllite

0 1,000 2,000
metres

Scale 1:50,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 6 - 3

Geology

Northern Link

SKM Connell Wagner
JOINT VENTURE

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Bunya Phyllite

The formation consists of phyllite, minor arenites and basic volcanics regionally metamorphosed to greenschist grade. The phyllites are usually dark blue to black and consist principally of quartz, albite, muscovite and chlorite. Alternating micaceous and quartzose layers are present as are pervasive quartz veins. Layers of fine-grained basic metavolcanic and what may be altered dolerite sills are present, particularly in the north-east. These consist of generally strongly foliated actinolite schist with albite, actinolite and epidote as well as minor chlorite, sphene and stilpnomelane.

Mobilisation of silica is widespread throughout the unit. The phyllite is transacted by quartz veins which were subsequently contorted. The phyllite may be unveined but differentially altered to a fine-grained grey-black quartzite.

Neranleigh-Fernvale Beds

This unit includes shale, chert, jasper, feldspathic and lithic arenite, conglomerate and basic volcanics. Typical arenites consist of sericite, chlorite, quartz and epidote with accessory zircon. The unit may be up to 7000m thick and overlies the Bunya Phyllite, probably in a conformable relationship, however this is not clearly seen anywhere. The much quoted thrust fault concealment of this boundary is discussed below.

6.1.4 Faults and Folds

Normanby Fault

The Normanby Fault was described by Bryan and Jones (1954) as "The most conspicuous and probably the most important of the other normal faults is the Normanby Fault which approximately follows the regional north-westerly strike for at least 12 miles from a point in Bracken Street, Moorooka, where it is strongly developed and where an arresting fault breccia may be seen, to the city boundary near Bunyaville."

A second normal fault, to the west, the Kenmore Fault, was also introduced by Bryan and Jones (1954) to separate Bunya Phyllites from the Neranleigh-Fernvale Beds on the western side of the Indooroopilly Antiform. Cranfield *et al*. (1976) identified fieldwork in the D'Aguilar Range and extensive drilling of the area by the Department of Main Roads in 1971 as being unable to produce evidence for the existence of either of these faults. However, they showed on their figures (Cranfield *et al.* 1976, plates 4 and 5) shear zones or thrust faults, respectively, along the boundaries between the Bunya Phyllite and Neranleigh-Fernvale Beds in much the same position as the normal faults introduced by Bryan and Jones (1954). Cranfield *et al.* (1976) considered the north-east to south-west cross-sectional structure through central Brisbane to have resulted from a single nappe structure over thrust from the north-east with subsequent erosion producing the present surface distribution of rock units.

Holcombe's (1978) detailed structural analysis of the Bunya Phyllite, across the same cross-section investigated by Bryan and Jones (1954), lead him to conclude that the structural and lithological boundaries between the Bunya Phyllite and Neranleigh-Fernvale Beds only coincided in one area studied, Red Hill. He found no evidence for the thrust faults postulated by Bryan and Jones (1954) and Tucker (1967) and illustrated by Cranfield *et al.* (1976, plate 5). Thus although a surface lineament is discernable along the lithologically defined boundary between the Bunya Phyllite and Neranleigh-Fernvale sequences in the vicinity of the line previously mapped as the Normanby Fault, there is growing evidence to refute the existence of a major fault zone.

6.1.5 Rock Defects

A pervasive foliation is present throughout the Bunya Phyllite and the Neranleigh-Fernvale Beds and occurs to a lesser extent in the hornfels formed from the thermal metamorphism of the Bunya Phyllite. Foliation partings occur throughout these rocks and become more widely spaced with depth. Within the Neranleigh-Fernvale Beds, the foliation is fairly planar and generally dips at low to moderate angles in a mostly north-east direction. The Bunya Phyllite appears to have been subjected to more than one phase of deformation and consequently the foliation is wavy to contorted and varies frequently in dip and dip direction.

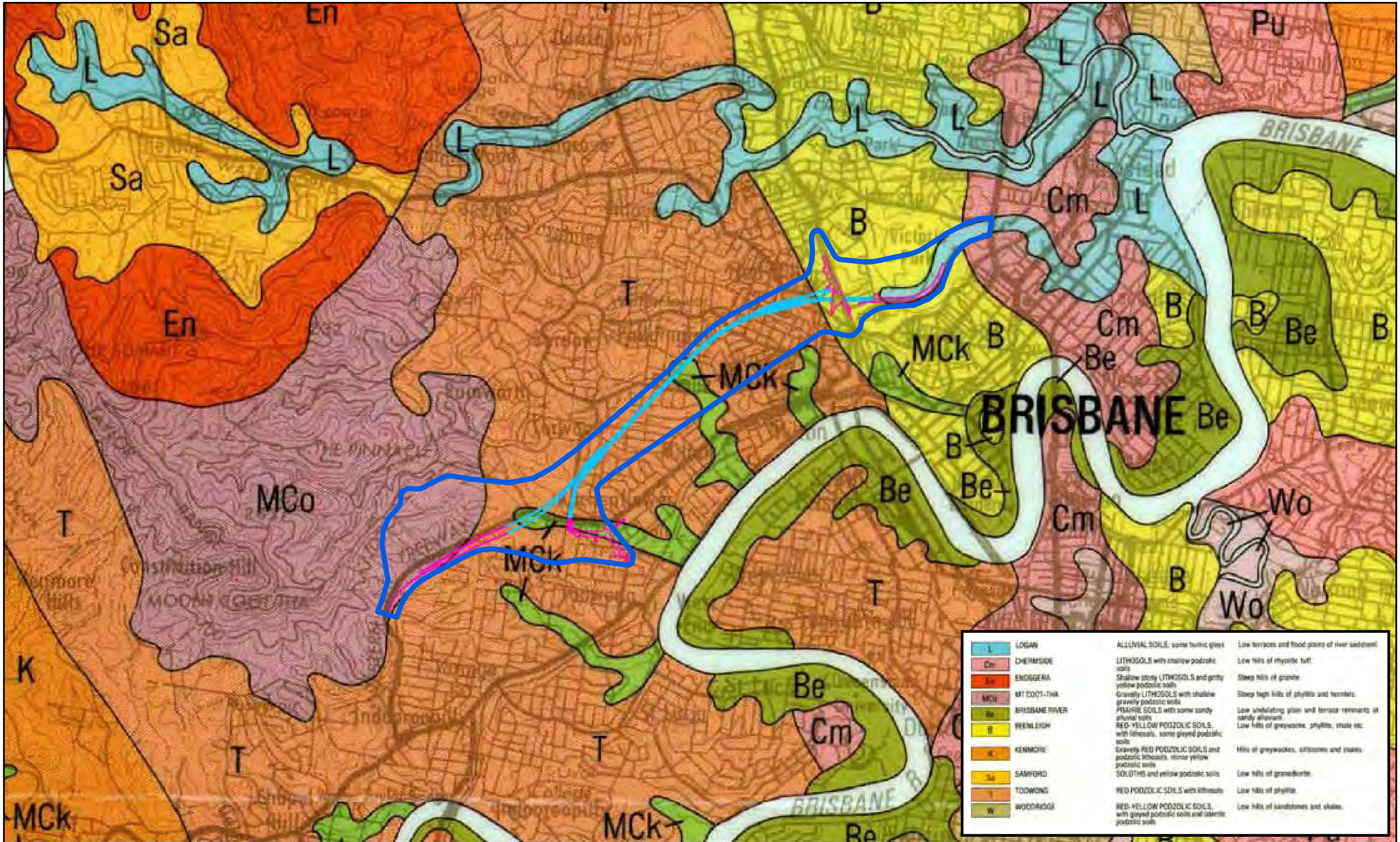
Joints within all of the rocks appear to belong mostly to two major moderate to high angle sets striking north-west to south-east and north-north-east to south-south west. Minor sets of indeterminate orientation also occur. As with the foliation partings, the spacing of the joints increases with depth.

6.1.6 Economic Minerals

An assessment of the potential for economically significant mineral, energy or extractive resources within the study corridor, based on review of the *City of Brisbane Economic Geology Map, Sheet 3 and Sheet 4* (Department of Mines 1965*)* indicates no significant mineral or energy resources and no economically significant minerals have been noted in the core logs. The Mt Coot-tha Quarry, operated by Brisbane City Council, is situated within the study corridor and is a locally important extractive resource.

6.1.7 Soil Types

The *Soil Landscapes of Brisbane and South-eastern Environs 1:100,000 Map* (Beckmann *et al.* 1987) illustrates the soil landscapes and dominant soil groups within the study corridor (**Figure 6-4**). Extending from Mt Coot-tha in the west to Herston in the east, the soil landscape and dominant soil groups are described in **Figure 6-4** and **Table 6-1**.



LEGEND

Study Area Corridor

Proposed Alignment

Surface Work

Tunnel Underground

0 1,000 2,000

metres

Scale 1:50,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 6 - 4

Soil Types

Northern Link

SKM Connell Wagner JOINT VENTURE

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■ **Table 6-1 Soils**

Soil Landscape[1]	Dominant Soil Groups[1]	Landscape and Parent Rock[1]	Location within the Project Area
Mt Coot-tha (MCo)	Gravelly lithosols with shallow gravelly podzolic soils	Steep high hills of phyllite and hornfels	The western extent of the project area at the connection with the Western Freeway alignment and adjacent to the lower southern and south-eastern slopes of Mt Coot-tha.
Toowong (T)	Red podzolic soils with lithosols	Low hills of phyllite	Extending east from the lower south-eastern slopes of Mt Coot-tha to immediately west of Kelvin Grove Road.
Beenleigh (B)	Red-yellow podzolic soils, with lithosols, some gleyed podzolic soils	Low hills of greywacke, phyllite, shale, etc.	Extending east from the vicinity of the Musgrave Road – Hale Street overpass to the south-eastern side of Victoria Park.
Moggill Creek (MCk)	Gleyed podzolic soils with minor prairie and alluvial soils	Creek flats of sandy and clayey alluvium	Narrow deposits of Moggill Creek soils occur in the study corridor (within the Toowong and Beenleigh soils) between Mt Coot-tha Road and Croydon Street, beneath Baroona Road and at the south-east end of Given Terrace. They are associated with topographical depressions, which act as surface drainage lines. Narrow deposits of these soils are also located immediately south of the project area in the vicinity of Moggill Road, Miskin Street and Broseley Road in the west and Roma Street Parklands in the east.
Logan (L)	Alluvial soils, some humic gleys	Low terraces and flood plains of river sediment	A narrow deposit of Logan soil occurs in the vicinity of Victoria Park and the ICB alignment.

Table Note:

[1] Beckmann *et al.* (1987)

Within the Mt Coot-tha landscape, lithosols 20-40cm thick are dominant and occupy the crests and upper slopes, while gravelly red podzolic soils occur on the mid to lower slopes and are generally less than 50cm thick. Thicker bodies of parent material including accumulated colluvial material of deeper red and yellow podzolic soils dominate the lower slopes (Beckmann *et al.* 1987).

Soils associated with the Toowong soil landscape are dominated by shallow to moderately deep red podzolic soils with fine angular quartz and phyllite gravel within the A horizon and structured or moderately dense red heavy clay B horizons. Higher parts of the landscape tend to comprise thin gravelly lithosols with a pale pinkish subsurface horizon intermingled with shallow red podzolic soils. Moister lower slopes within this soil landscape tend to indicate deep, mottled red-yellow podzolic soils with a coarsely mottled yellow-brown and light grey stiff plastic to friable clay horizon in the deep subsoil. Where alluvial material has accumulated on the drainage floors, minor areas of gleyed podzolic soils and humic gleys are recorded (Beckmann *et al.*1987).

Within the Beenleigh soil landscape red-yellow podzolic soils are dominant, with red profiles more common on hill crests and on some upper slopes and the mottled or yellow profiles on lower slopes. Lithosols with loam textures are common on many hill crests and on some of the steeper slopes. Most of these soils are hard setting at the surface (Beckmann *et al.* 1987).

Soils within the Moggill Creek soil landscape have a tendency to be poorly drained and are dominated by gleyed podzolic soils with sandy to loamy surface horizons and mottled grey and yellow-brown sandy clay or heavier subsoils (Beckmann *et al.* 1987).

Within the Logan soil landscape alluvial and prairie soils tend to occupy stream banks, with gleyed clays and humic clays on lower parts of plains. Gleyed clays tend to be more common on flood plains higher upstream (Beckmann *et al.* 1987).

6.1.8 Acid Sulfate Soils

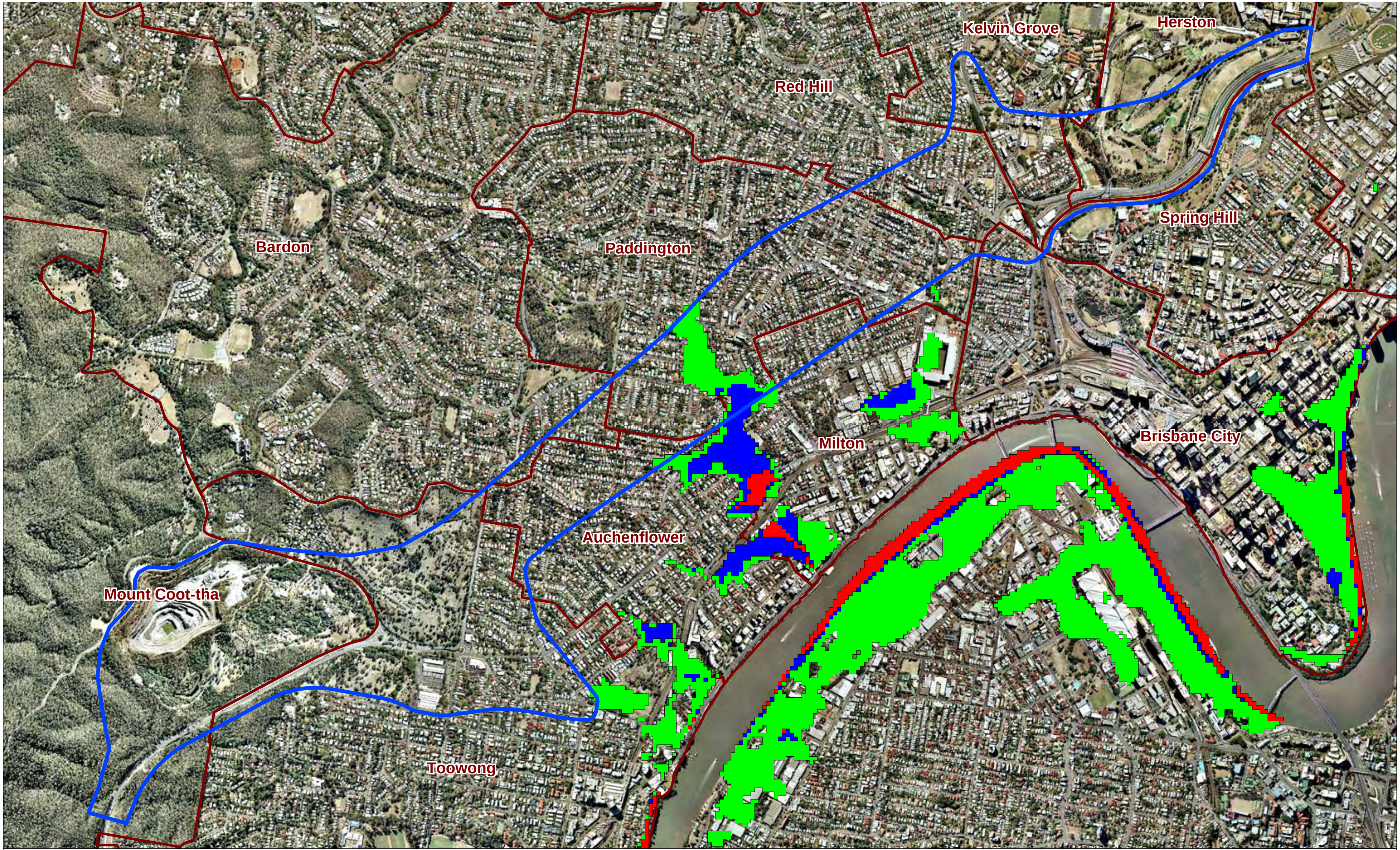
Acid Sulfate Soils (ASS) are a characteristic feature of lowland coastal environments in Queensland, particularly where landform elevations are below 5m AHD. ASS contain iron sulfides generally in the form of pyritic material that is a product of the natural interaction between iron-rich organic matter and sulfate-rich seawater present in anaerobic low energy estuarine environments. Undisturbed, these soils are generally present in an anaerobic state within the subsurface profile (below the water table) of Holocene marine muds and sands in the form of Potential Acid Sulfate Soils (PASS). Actual Acid Sulfate Soils (AASS) are the oxidised (disturbed) form, which may occur as a result of natural or anthropogenic disturbance from changes in groundwater levels and/or exposure to oxygen (Powell and Ahern, 1999).

A review of the Acid Sulfate Soils Tweed Heads to Redcliffe Map 1 (NRW, 2002) illustrated that the project area has been mapped as NA – Land not assessed for ASS. This mapping by the Department of Natural Resources and Water has been taken as the basis of the Brisbane City Council's iBimap assessment of ASS potential shown in **Figure 6-5**.

Digital Elevation Model (**Figure 6-1)** and Acid Sulfate Soils mapping **(Figure 6-5**) have been reviewed in conjunction with topographical and geological mapping information. Small areas with a low risk of ASS have been identified within or closely adjacent to the study corridor, at the following locations:

- within Toowong Memorial Park at the extreme margin of the study corridor;
- the eastern end of Baroona Road around Gregory Park and extending along Nash Street to Fernberg Road; and
- a very small area just outside the study corridor in Neal Macrossan Park on Given Terrace.

However, none of these areas are likely to be excavated or otherwise disturbed during any project construction.



LEGEND

- Study Area Corridor
- Suburbs Boundary

Hazard Rate of Acid Sulphate Soil

- Low
- Medium
- High

0 500 1000

metres

Scale 1: 25,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 6 - 5

Acid Sulphate Soil

Northern Link

SKM Connell Wagner JOINT VENTURE

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6.1.9 Contaminated Land

The linear nature of Northern Link means that a large number of properties are either on the actual route or are in its vicinity. Furthermore, the area which Northern Link traverses is one of the older areas of Brisbane and has been subject to land use changes for more than 100 years. Consequently, there is a likelihood that land uses causing contaminated land may have occurred in the area and it is prudent to undertake a preliminary assessment in order to determine where contaminated land may exist and whether contaminated land may be a constraint upon development of Northern Link. Contaminated sites may comprise either contaminated soils or groundwater. The potential for groundwater drawdown and impacts and mitigation measures associated with groundwater drawdown is considered in the Chapter 7, Hydrology in the EIS.

The Contaminated Sites Assessment is reported in *Technical Report No. 3 - Contaminated Lands in Volume 3* of the EIS. In brief, the area investigated comprised the Northern Link study corridor as identified for the purposes of the EIS together with an additional one kilometre of land surrounding the study area to account for possible groundwater drawdown. Groundwater drawdown has the potential to mobilise contaminated groundwater from a site of origin to a neighbouring site(s).

Regulatory Setting

Legislative requirements covering contaminated land in Queensland are primarily contained in the *Environmental Protection Act 1994* (EP Act) and subordinate policies and regulations. This assessment is based largely on the following Australian guideline publications:

- *National Environment Protection (Assessment of Site Contamination) Measure* (NEPM); and
- draft Guidelines for the Assessment and Management of Contaminated Land in Queensland, (Department of Environment [DoE], 1998, 'the Draft Guidelines').

Appendix 9 of the *Draft Guidelines* provides investigation thresholds for contaminated soils in Queensland. The threshold levels are based on the risk of human exposure to potential contaminants in soil in association with particular types of land use (eg: residential, open space recreation and industrial). The threshold levels do not necessarily take into account environmental concerns such as the protection of a species or ecosystem.

Scope

The investigation to identify contaminated sites that may be of interest for the purposes of this EIS included:

- a review of properties on the Brisbane City Council Environmental Management Register/Contaminated Land Register (EMR/CLR) database;
- a review of historical aerial photographs;
- a review of the potential for Unexploded Ordnance (UXO);
- a review of contaminated land information obtained from Queensland Rail (QR);
- a review of the site investigation report provided by Brisbane City Council on a fuel line leakage at the Toowong Bus Depot; and
- a drive-by survey of the targeted properties within the study corridor.

It was not the intended purpose of this assessment to identify or evaluate the impacts of contaminated properties on human health or the wider environment. Such assessments are the responsibility of the land owner and/or the person(s) having caused the contamination and are outside the scope of this EIS. However, these more detailed assessments may be required on certain properties prior to the commencement of construction activities.

Environmental Management Register (EMR)

The EMR is a land-use planning and management register. Land that has been or is being used for a Notifiable Activity, and of which the EPA has been advised, is recorded on the EMR. The EMR provides information on past and present land uses, including whether the land has been or is being used for a Notifiable Activity, or has been contaminated by a hazardous contaminant.

A review was undertaken of the Environmental Protection Agency's EMR and also Brisbane City Council's EMR. A total of 378 land parcels listed on the EMRs were identified within the Northern Link Study Area. These are identified in **Figure 6-6 (A, B, C)**. Of these:

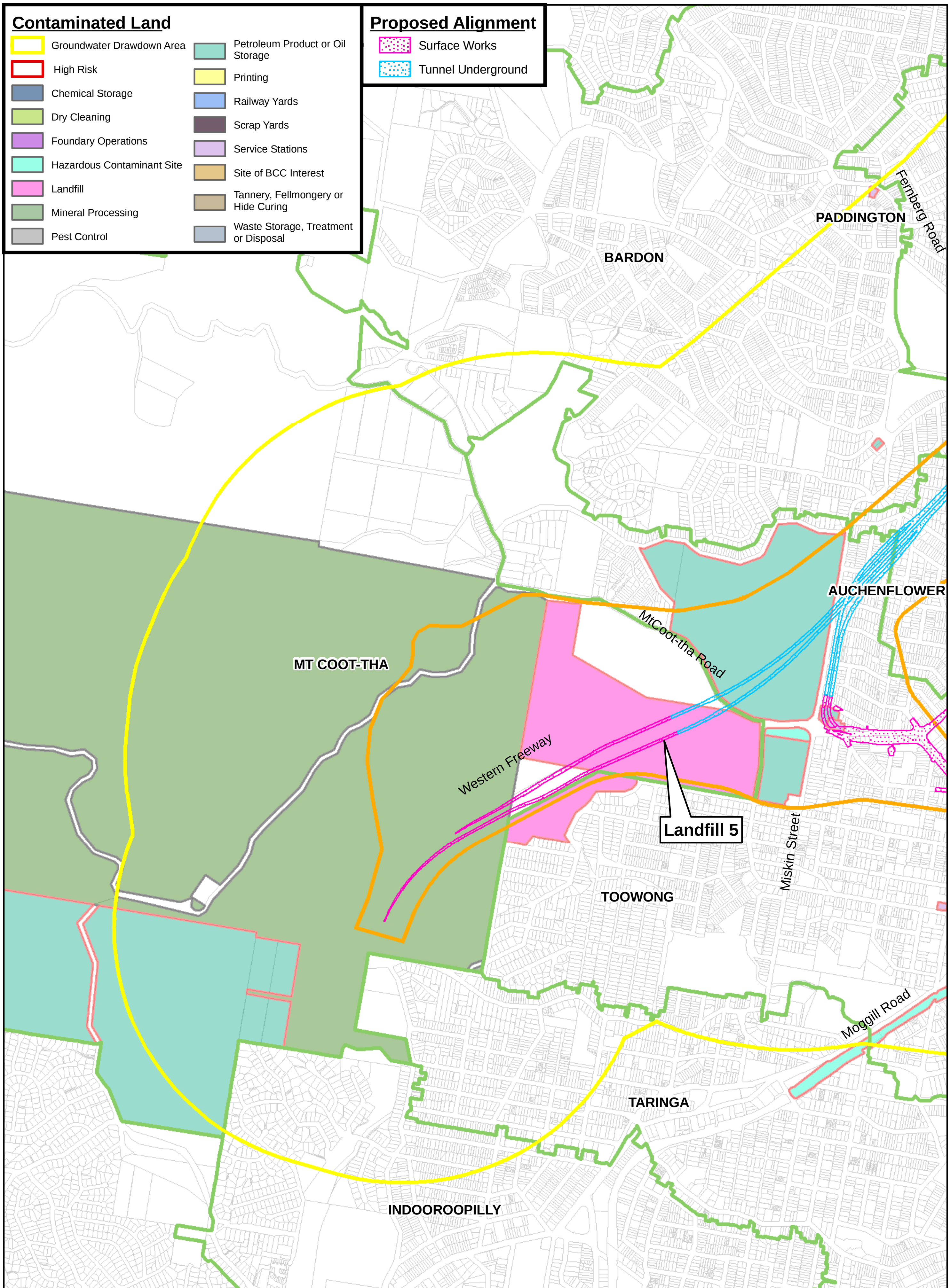
- 28 land parcels are within the study corridor Boundary 22 were high risk and 6 were low; and
- 350 land parcels were identified within the Groundwater Drawdown Area (**Table 6-2**). Of these 291 were high risk and 87 were low**.**

Property description information including lot and plan number, street address, EMR status and Notifiable Activity for each of the 378 land parcels is presented in Appendix A of *Technical Report No. 3 - Contaminated Land in Volume 3* of the EIS.

The land uses comprise such uses as dry cleaning, landfill, mineral processing, petroleum product or oil storage and rail yards. Land uses of interest within the groundwater drawdown area comprise chemical storage, foundry operations, landfill and pest control.

- **Table 6-2 EMR Listed Properties within the Groundwater Drawdown Area**

Notifiable Activity	EMR Results		
	Listed	SMP Managed	Total
Chemical Storage	10	-	10
Foundry Operations	1	1	1
Hazardous Contaminant	68	10	68
Landfill	64	23	64
Mineral Processing	4	-	4
Pest Control	1	-	1
Petroleum Product or Oil Storage	95	10	95
Printing	33		33
Railway Yards	8	-	8
Scrap Yards	1	-	1
Service Stations	33	4	33
Tannery, Fellmongery or Hide Curing	14	10	14
Waste Storage, Treatment or Disposal	2	2	2
Other (BCC Site of Interest)	16	1	16
TOTAL	**350**	**61**	**350**



NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 6 - 6A

Potentially Contaminated Sites

Northern Link
SKM Connell Wagner
JOINT VENTURE

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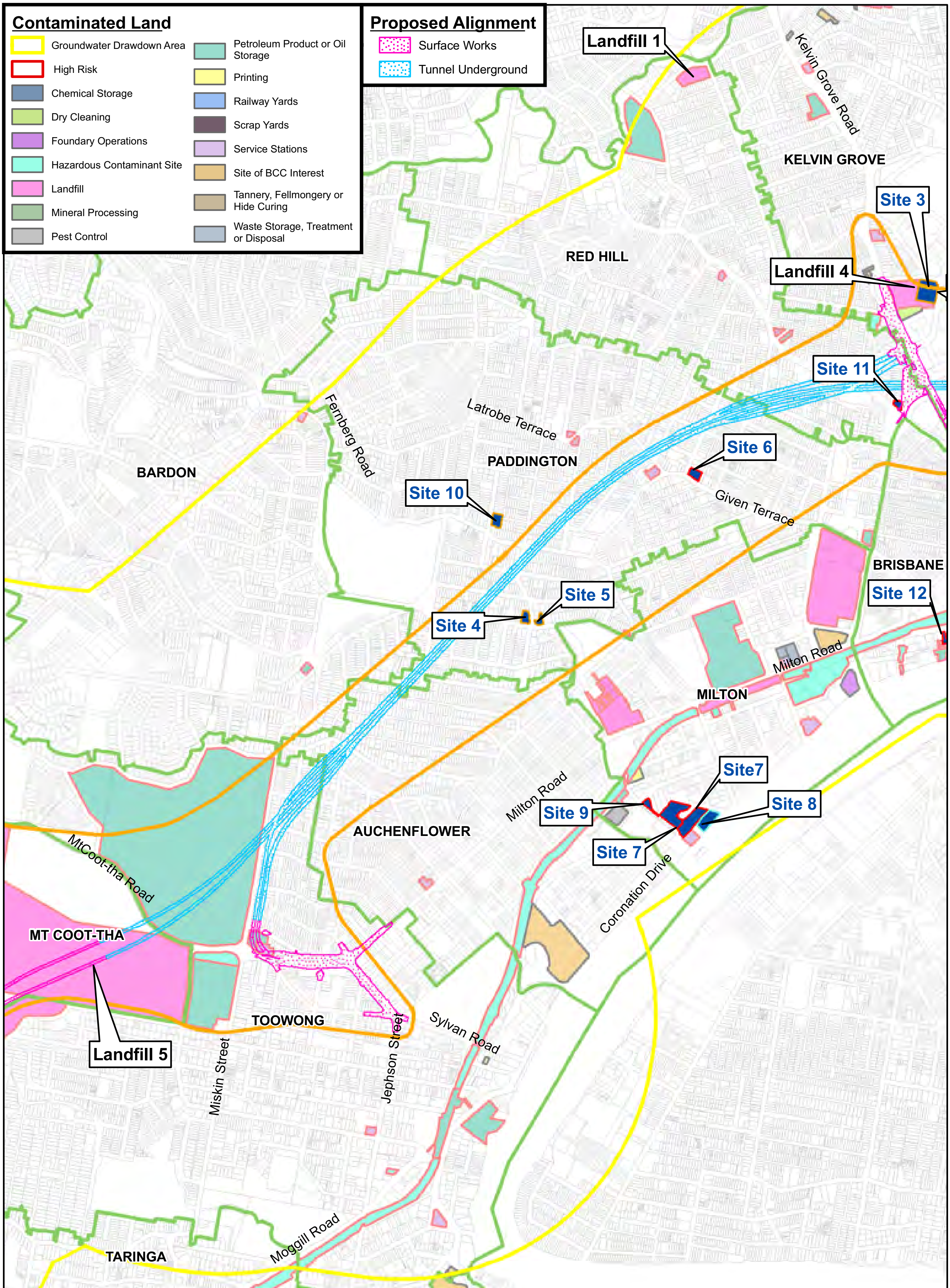

LEGEND

Study Area Corridor

Suburb Boundary

Identified Properties

No Risk

High Risk

Low Risk

0 400 800

metres

Scale 1:20,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 6 - 6B

Potentially Contaminated Sites

Northern Link

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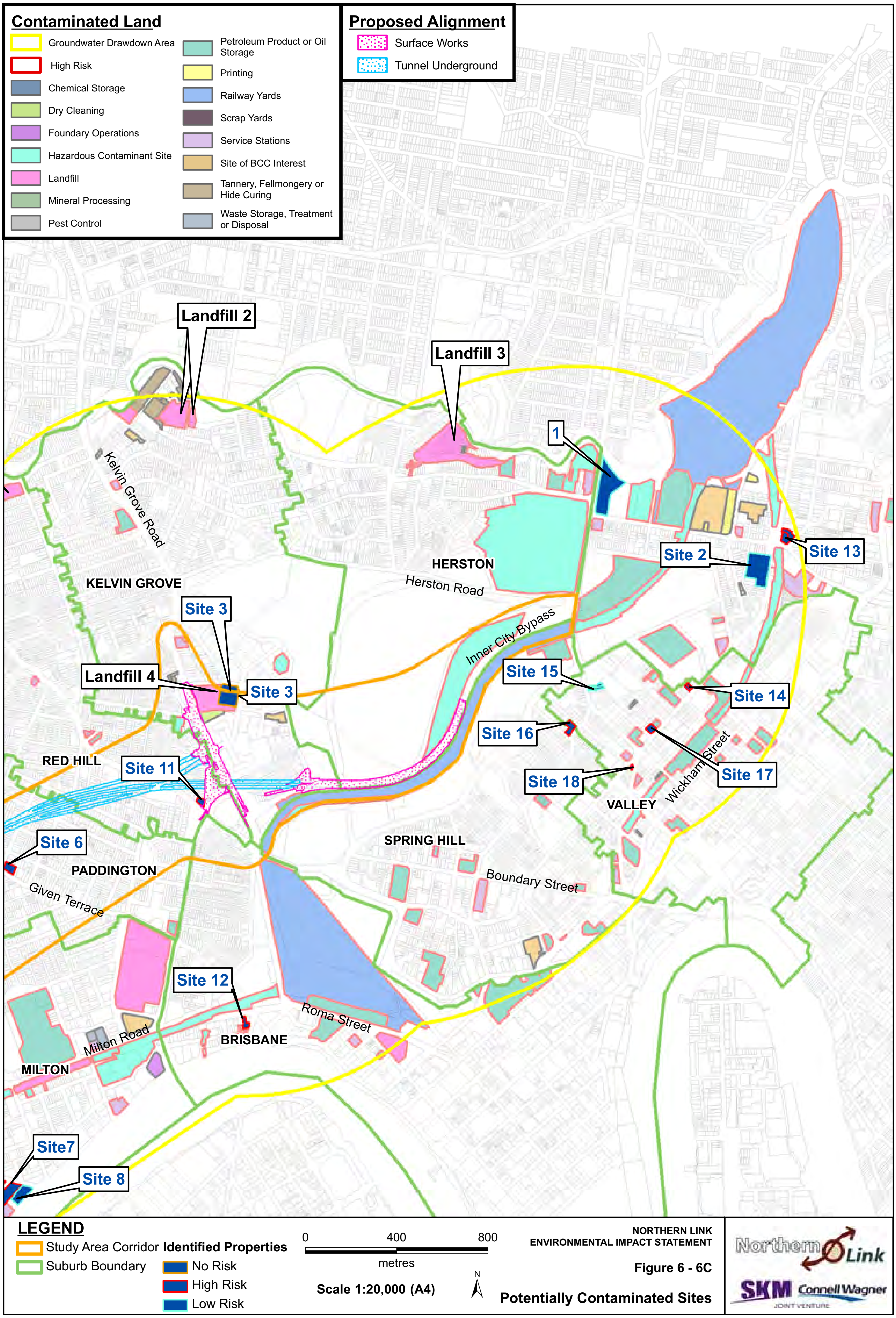

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Historical Aerial Photograph Review

18 additional sites were identified from review of available aerial photography (DNRW) and a drive-by survey (marked on **Figure 6-6 (A, B, C)**) as having/had potentially contaminating land uses. These properties include:

- landfill (Site 3);
- petroleum product storage (Sites 7 and 9);
- scrap yard (Site 1);
- service station (Sites 4, 5 and 6); and
- unidentified fill (Sites 2 and 8).

Further Information Supplied by Brisbane City Council

Brisbane City Council was contacted to determine if any of the 18 additional sites were historically listed on the EPA's EMR/CLR and have subsequently been removed. 14 of the sites had never been listed on the EMR and the remaining four had been listed but subsequently removed or in one instance was not a Notifiable Activity.

A high or low risk was assigned to each site. Ten were assigned a high risk, five were assigned a low risk and three were not assigned a risk as these sites had been removed from the EMR. Unidentified fill was characterised as having a low risk (Sites 2 and 8).

Potential for Unexploded Ordnance

Sites which are known or suspected of having been used for military activity are categorised according to the assessed potential for UXO on that site. The Australian Department of Defence maintain a webpage[1] that provides information on sites with the potential for UXO. These are usually associated with a military activity which has occurred on the site. Based on information provided through this web page, no potential for UXO was identified within the Project Study Area.

Queensland Rail Contaminated Land Review

Queensland Rail (QR) and the Environmental Protection Agency (EPA) acknowledge that past practices may have resulted in soil and/or groundwater contamination within any railway land in Queensland. Potential contaminating activities that may be associated with railway land in Queensland typically include:

- disposal of ash material;
- stockpiling of fill and ballast;
- use of herbicides/pesticides; and
- petroleum product or oil storage.

Regarding QR managed land within the Project Study Area, the following anecdotal information was provided by QR.

- Typically, QR corridor land is listed on the EMR for hazardous contaminant for arsenic residue from herbicide/pesticide spraying during the 1940s and 50s. Limited soil sampling and testing has been conducted within metropolitan corridors however it is expected that levels of arsenic are low as procedures

[1] http://www.defence.gov.au/uxo/UXO_Website/index.htm

were in place to prevent or limit the herbicide treatment in sensitive areas near residential buildings, creeks, etc. The application of herbicide was limited by equipment, only a thin strip spray was directed on the track. Residues of arsenic still exist in track formation soils as arsenates bind well to soil particles. There has been no indication of arsenic contamination effects on groundwater in any QR land.

- Railway stations adjacent to the study corridor service the passenger network and typically do not have contamination issues other than minor arsenic contamination in soil along railway tracks as mentioned above.

Flammable and Combustible Liquids

Brisbane City Council maintains a register of Flammable and Combustible Liquids (F&C) stored on properties having current and/or cancelled licenses under the *Dangerous Goods Safety Management Regulation 2001*. The EPA make use of this register to identify any F&C licences that exceed threshold limits set by the EPA that require listing on the EMR as a Notifiable Activity. Examples of Notifiable Activities that would also require an F&C licence include, but are not limited to, chemical storage, petroleum product or oil storage and service stations. If a property with an F&C licence does not meet the threshold limits set by the EPA (for Notifiable Activities), it is not listed on the EMR.

Brisbane City Council Landfills

There are five land fills which are maintained by Brisbane City Council and which are found in the area investigated. These are:

- Site 1: Lot 1 on RP90610 (38 Murray Street, Kelvin Grove) listed on EMR in 1994. No details about the type of fill or duration of filling available;
- Site 2: Lot 2 on RP69590 (59 Picot Street, Kelvin Grove) listed on EMR in 1999. Site supposedly used to bury asbestos material and Lot 34 on RP17303 (72 Picot Street, Kelvin Grove) listed on EMR in 1993. 5m of fill (primarily soils and organic mater) on site. Fibro sheeting was historically dumped at the landfill. Site partially remediated with only the batters capped with 0.5m of capping material;
- Site 3: 28 individual land parcels (Butterfield Street, Rasey Park, Herston). Listed on EMR in 2006. Operated as a landfill between the 1930’s and 1940’s. Waste predominately domestic refuse and ash approximately 2.5m in depth;
- Site 4: Lot 556 on SP133445 (137 Kelvin Grove Road, Kelvin Grove) listed on EMR in 1994. No details about the type of fill or duration of filling available; and
- Site 5: Lot 1 on RP18899 (170 Mt Coot-tha Road, Mt Coot-tha). The following information related to Anzac Park which is within the south eastern section of the lot. Area gazetted as part of the Toowong General Cemetery in 1861. By 1877 no internments had taken place and the site was gazetted as a rifle range (QLD Rifle Association). By 1918 the rifle range had been decommissioned and the area became a memorial park. Lot 3 on SP159806 (200 Broseley Road, Toowong) listed on EMR in 1994. No further information was found for the site.

Brisbane City Council Reports

Inspection of a storm water pipeline in June 2000 identified diesel fuel entering the drainage system below the Toowong Bus Depot. The diesel leakage had resulted in significant soil contamination within fill material along the northern boundary of the bus depot underlying the bus maintenance building and the main entrance. Free-phase hydrocarbon product was detected at the base of fill material that appeared to form a ’channel’ crossing the bus depot from west to east and into the park-n-ride property below the bus lane. Brisbane City Council

(2002) were unable to determine whether the 'channel' of fill material extended beyond the park-n-ride boundary below Miskin Street (Brisbane City Council 2002).

Brisbane City Council (2002) determined that the contamination had not significantly impacted the underlying natural soil or rock and associated aquifer system. However, Brisbane City Council (2002) recommended that hydrocarbon contamination may be present adjacent to the bus depot and park-n-ride areas and that adequate management plans must be prepared and implemented prior to the commencement of any underground works.

6.2 Potential Impacts and Mitigation Measures

6.2.1 Topography

A longitudinal cross section of the tunnel, shown in Figure 4-2 in Chapter 4, Project Description, provides information about the depth of the tunnel beneath ground along the alignment. The tunnel would be up to 70m below the peaks of ridges that it passes beneath and 12m beneath the floors of valleys other than at the portal entrances.

The topography has had a significant impact upon tunnel design in that it was necessary to provide tunnel depths which accommodated not only safe design gradients but also accommodated the extreme variance in topography throughout the study corridor.

6.2.2 Effects on Economic Minerals

The *City of Brisbane Economic Geology Map (Sheet 3 and 4)* show no significant mineral or energy resources and no economically significant materials have been noted in the core logs. Proximity of the Mt Coot-tha quarry and quality of the tunnel spoil are significant factors in the proposal to transport spoil on conveyor directly from the tunnel exit to the quarry where it would be handled in the same way and for the same purposes as quarried materials. This proposal would not affect the ability of the quarry to maintain its supply to industry. The project would have no other impact upon existing economic mineral deposits.

6.2.3 Soil Erosion

Potential Impacts

Potential erosion impacts have been considered for worksites, tunnel portals, areas associated with cut and cover tunnel works and the spoil disposal sites, and impacts are possible during construction works, vehicle access and spoil removal activities.

The Western Connection worksite is likely to intercept the Mt Coot-tha soil type, Frederick Street worksite is likely to intercept the Toowong Soil type, and the Lower Clifton Terrace worksite is likely to intercept the Beenleigh Soil type. These soils are considered to be moderately dispersive and there is the potential for erosion impacts if appropriate erosion and sediment control measures are not implemented and maintained during site works. The proposed works at each of the sites, during construction, are likely to include, but not be limited to, the following activities:

- vegetation clearing and site preparation;
- construction of laydown, material storage, handling, preparation and spoil stockpile/treatment areas;
- construction of embankments for the elevated road alignment;
- construction of new bridges and overpasses including placement of abutments, piers and footings;
- modification of existing road infrastructure;
- installation/construction of stormwater/drainage control and sediment control measures;

- construction of haul routes and vehicular access tracks; and
- construction sites.

Potential impacts resulting from soil erosion to the environment within these worksites, portal areas and spoil disposal sites for construction and access purposes include:

- potential surface water quality impacts from sediment and contaminants entrained in surface runoff resulting from construction related activities such as exposed soils, spoil stockpiles or material storage;
- loss of valuable topsoil during site preparation and from stripping and stockpiling for extended periods;
- erosion due to vegetation clearing and soil disturbance to create space for the stockpiling of material, laydown activities and to establish access routes;
- erosion of exposed vulnerable soils by wind or water action; and
- embankments constructed over weak alluvium may undergo settlement.

Mitigation Measures

Mitigation measures would be implemented throughout various stages of the project to control and reduce the risk of erosion due to construction and operation activities. Proposed erosion control measures would be based upon reducing the risk of erosion during construction by:

- reducing impacts from sediment and contaminants upon surface water;
- managing the stripping and stockpiling of topsoil material from worksites;
- managing the extent of soil disturbance and vegetation clearing as well as reducing the exposure of vulnerable soils to erosion by wind or water action;
- planning construction works to provide for progressive and timely stabilisation and rehabilitation of disturbed areas; and
- undertaking finishing and landscaping works for ongoing sediment and erosion control around the worksites following construction.

Detailed measures would be developed during the design phase of the project and incorporated into the EMPs prepared for the construction and operation of the project. Site specific erosion and sediment control plans would be prepared and adopted for all areas of surface disturbance to ensure that erosion and sediment control measures are implemented and adequate to the nature and scale of disturbance and would include site reinstatement measures once works are complete.

6.2.4 Settlement

Potential Impacts

Settlement resulting from tunnel excavation/construction activities may arise due to:

- elastic ground settlements caused by the excavation of the tunnel; and
- consolidation settlements caused by dewatering of porous rock formations from groundwater drawdown into the tunnel.

An assessment has been made of the potential for settlement of land above and adjacent to the tunnel, due to tunnel construction. Acceptable settlement criteria have been determined for selected buildings and compared with predicted settlements. Where predicted settlements may exceed acceptable settlements, mitigation actions are required. Such actions typically include one or more of the following:

- More detailed analysis of specific buildings, including (where necessary) structural analysis, to allow a more accurate assessment.
- Tunnelling works design to minimise impacts.
- Minor crack repairs.

Where the building assessment indicates excessive settlement impacts on a building, mitigation would be proposed. Such mitigation could include one or more of the following:

- Upgrading of tunnel support type to reduce settlement;
- Changing sequence of the tunnelling works; and/or
- Underpinning or strengthening to the existing building

Where settlement impacts may be of concern, monitoring would be implemented to assess settlement effects progressively during tunnelling. If such field monitoring indicates higher than predicted settlements, mitigation measures may be introduced prior to the tunnel excavation impacting on the subject building.

The greatest level of settlement predicted is 31mm directly above the westbound tunnel alignment at Mt Coot-tha Road and 20mm on Hayward Street directly above the eastbound tunnel alignment. The results of this assessment are mapped across the entire tunnel alignment in Maps EIS-SC-01 to EIS-SC-07 in Volume 2 of the EIS. These findings would inform the detailed design of the Project so that mitigation of the potential impacts in areas such as Mt Coot-tha Road and Hayward Street can be undertaken through specific design elements to strengthen roof support in those and other areas and avoid ground settlement. Further modelling of potential settlement impacts would be undertaken during the detailed design phase when the final project design is determined. From this detailed modelling the contractor would identify individual properties that may be potentially impacted and initiate consultation with those property owners and tenants with a view to undertaking pre-construction condition reports of the individual properties including improvements. Such reports would be the starting point for any subsequent claims of damage due to settlement.

Excavation induced settlement of ground adjacent to transition structures and cut and cover tunnels are controlled by limiting lateral deflection of the walls. This is achieved using pre-tensioned ground anchors and/or propping (by the roof in cut/cover tunnels). Lateral deflections resulting after this approach are usually quite small. Transition structures and cut and cover tunnels are at least 10m from any adjacent buildings, so that excavation induced settlement of buildings adjacent to Northern Link transition structures and cut and cover tunnels is considered to be negligible. Existing buildings located above cut and cover tunnels would be demolished or relocated.

Tunnels of all types can cause drawdown of the water table, with subsequent consolidation settlements of susceptible soils. Given the generally impermeable bedrock and its moderate to high strength, the hydrogeological study concludes that along the tunnel alignment consolidation settlement due to groundwater drawdown can be expected to be negligible.

Mitigation Measures

Where elastic ground settlement and consolidation settlement combine, some areas of damage may be predicted if no mitigation measures are implemented. To minimise the risk associated with settlement, it is important to adhere to suitable engineering practices and ensure that effective management and monitoring approaches are implemented and reviewed from the onset of construction.

Appropriate mitigation measures would be identified during the detailed design process. Issues which would require careful consideration at that stage include tunnel face loss, design of tunnel support and liners, stability assessment of portals, as well as the driven tunnel and groundwater modelling of any impact by the tunnel. Comprehensive geotechnical investigations are required to fully define the subsurface profile and materials along the alignment.

All buildings and structures within the areas where surface settlements and possible damage are predicted would have a building condition survey completed. Surveys and other displacement monitoring would be used to monitor the effects of settlement, if any, from tunnelling. The actual settlements would be compared to predicted settlements and further mitigating measures taken where adverse departures from predictions are noted.

6.2.5 Acid Sulfate Soils

Potential Impacts

It is not expected that any Acid Sulfate Soils (ASS) would be disturbed during project construction. The nearest areas with a low possibility of encountering ASS are in the vicinity of Toowong Memorial Park on Sylvan Road, the eastern end of Baroona Road and Neal Macrossan Park.

A variety of potential impacts and their severity are possible from ASS as outlined in *Technical Report No. 6 – Flooding in Volume 3* of the EIS however none of these are expected during construction of the project.

Mitigation Measures

Mitigation measures for the project would implement best management and monitoring practices (eg: commencing from the reference design phase and extending through to the pre-construction and construction phases) to ensure potential environmental impacts associated with ASS, if any, are minimised and controlled. The site specific ASS mitigation measures would be developed in consultation with the Department of Natural Resources and Water and would incorporate the hierarchy of ASS management principles in line with the *Queensland Acid Sulfate Soil Technical Manual Soil Management Guidelines (version 3.8)* (2002).

If necessary, the State Planning Policy 2/02- Planning and Managing Development involving Acid Sulfate Soils and the EPA's 2001 Instructions for the Treatment and Management of Acid Sulfate Soils would be implemented.

In particular, the ASS mitigation measures would specifically ensure:

- minimisation of any changes in natural groundwater levels;
- that the acid generating potential of material to be excavated, is adequately treated and managed throughout the construction phase;
- where ASS may be disturbed, soil treatment with fine agricultural lime or other project approved neutralising agents would be used on site to prevent the downstream or offsite impacts from acid leachate drainage;

- the ASS material treatment pads and stockpiling areas, if required, would be constructed, bunded and prepared prior to commencement of construction and located in areas where overland flow can be adequately controlled and diverted; and
- all fill used on-site would be certified as ASS free or first evaluated for the presence of ASS and if found, would be treated with fine agricultural lime or other project approved neutralising agents.

Water management is one of the key elements for the management and mitigation of potential impacts resulting from the disturbance of ASS material. Therefore, it is essential to identify runoff and drainage control points within and exiting the construction site and design suitable control measures and structures to be installed during construction that would divert or contain runoff from ASS areas.

Design considerations would incorporate the following measures as a minimum.

- Diversion and runoff control measures are to be implemented, with respect to the protection of nearby waterways and containment of runoff from disturbed areas and stockpile/treatment areas.
- Minimisation of disturbance of the natural surface and subsurface drainage regimes, such as retaining/maintaining existing flow pathways and directions for both surface water and groundwater resources and minimising changes to water table levels.
- Design of embankments and other construction activities should incorporate measures to minimise/prevent subsidence, uncontrolled settlement of unconsolidated alluvial material, settlement creep, surface or subsurface heaving or deformation.
- Avoidance of disturbance/construction activities in areas rated as having moderate to extreme risk for ASS to ensure that disturbance is minimised and rehabilitation/reinstatement is progressive and timely.

6.2.6 Contaminated Land

Potential Impacts

The level of impact that a potentially contaminated land parcel may have on the Project due to the disturbance of contaminated soil and/or groundwater from construction activities is unknown. Information outlined in *Technical Report No. 3 - Contaminated Land in Volume 3* of the EIS has identified land parcels that are listed on the EMR as having a Notifiable Activity. Therefore land parcels located within a one kilometre radius of the study corridor that are listed on the EMR, depending on the Notifiable Activity, have a greater potential to impact the Project than land parcels that are not listed on the EMR. To accurately evaluate the impacts of each EMR listed land parcel, additional information would be required from either the land owner, Brisbane City Council and/or the QLD EPA. It is most likely that the land parcel would require further investigation, in accordance with State and/or National guidelines. This applies to all potentially contaminated land parcels identified in the existing environment section above.

Identified EMR listed and additional identified land parcels were compared to property land acquisition information detailed in the *Northern Link Project Definition Report* (SKM-CW Joint Venture 2008). The disturbance of potentially contaminated soil is potentially possible at 17 EMR listed and additional identified land parcels that are tabulated in **Table 6-3** and summarised in *Technical Report No. 3 - Contaminated Land in Volume 3* of the EIS.

Table 6-3 Land Parcels for Consideration During Construction.

Northern Link Corridor Section	Land Parcels for Consideration During Construction	EMR (Notifiable Activity)	Construction Activities
Toowong Connection	Lot 1 on Plan RP868488 - MT COOTHA RESERVE (200 MT COOTHA RD TOOWONG)	Mineral Processing	Surface Works & Interface Earthworks
	Lot 3 SP159806 (216 BROSLEY RD TOOWONG)	Landfill	Interface Earthworks
	Lot 1 RP18899 - MT COOTHA RESERVE & ANZAC PARK (108 DEAN ST TOOWONG)	Landfill	Surface Works, Transition Structure, Interface Earthworks, Cut and Cover Tunnel, & Cross Passages
	Lot 5 SL12786 - TOOWONG CEMETERY (124 BIRDWOOD TCE TOOWONG)	Petroleum Product or Oil Storage	TBM Excavated Driven Tunnel & Cross Passages
	Lot 3 RP886311 (601 MILTON RD TOOWONG)	Petroleum Product or Oil Storage	Elevated Structure & Surface Works
	Lot 5 RP127711 (581 MILTON RD TOOWONG)	Service Station	Elevated Structure & Surface Works
	Lot 1043 SL7078 - TOOWONG BUS DEPOT (29 MISKIN ST TOOWONG)	Petroleum Product or Oil Storage	Nil
	Lot 1042 SL9242 PARK-N-RIDE (27 MISKIN ST TOOWONG)	Hazardous Contaminant Site	Nil
Kelvin Grove Connection	Lot 1 RP181929 (43 MUSGRAVE RD RED HILL)*	Service Station	Surface Works
	Lot 1 RP142701 (6 VICTORIA ST KELVIN GROVE)	Hazardous Contaminant Site	Nil
	Lot 1 RP891412 (113 KELVIN GROVE RD KELVIN GROVE)	Dry Cleaning	Nil
	Lot 556 SP133445 (137 KELVIN GROVE RD KELVIN GROVE)	Landfill	Nil
	Lots 1,2 & 3 SP179651 (150 KELVIN GROVE RD KELVIN GROVE)	Site of BCC Interest	Nil
	Lot 2 SP113018 (39 KELVIN GROVE RD KELVIN GROVE)	Railway Yards	Nil
	Lot 4 SP113018 (29 GILCHRIST AVE HERSTON)	Railway Yards	Nil
	Lot 32 SP122215 (GILCHRIST AVE HERSTON)	Railway Yards	Surface Works
	Lot 5 SP123915 (18 BOWEN BRIDGE RD HERSTON)	Hazardous Contaminant Site	Surface Works & Interface Earthworks

Disturbance of potentially contaminated soil during operational stages of the Project are considered low or not applicable. It is not anticipated that the operational stage of the Project would require substantial disturbance of potentially contaminated soil and if it does, appropriate incident management plans, required by the Operational EMP, would be in place to deal with such situations.

Depending on the nature and extent of potentially contaminated groundwater at a site, potential disturbance and/or migration of potentially contaminated groundwater is likely to occur at the 17 land parcels identified in **Table 4.1** of *Technical Report No. 3 - Contaminated Land in Volume 3* of the EIS.

Mitigation Measures

The EPA *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland* provide information on how contaminated site investigations are to be progressively assessed and managed through a staged approach.

During this staged approach, site activities relating to the disturbance, excavation, removal and/or disposal of contaminated soil and/or groundwater require approvals as noted in the Permits and Approvals section of Chapter 4 in the EIS. To achieve this outcome, specific procedures must be developed and implemented. These procedures should be developed by a person whose qualifications and experience complies with the requirements of section 381 of the EP Act. A suitably qualified individual must also supervise the activities.

Procedures would be developed prior to commencement of site activities and would consider as a minimum:

- the staging of site activities to minimise the extent of disturbed areas and to reduce the potential for contaminated run-off;
- any odour emissions which occur during or as a result of excavation activities must be immediately mitigated by use of water sprays, odour suppressants and/or the odour-causing material covered by plastic or mulch;
- dust emissions and their management;
- stormwater controls around stockpiles and/or excavations to minimise the potential for the off-site migration of contaminants;
- minimising the exposure of humans and the environment from potentially contaminated material during excavation activities;
- controls for material haulage (eg: covering loads, wetting material to reduce airborne dust emissions);
- documentation of all contaminated material transport operations (including the descriptions of processes, personnel and organisations involved in the removal, transportation and receipt of contaminated material); and
- throughout construction and development phases, details of inspections, the monitoring of contaminated material movement and disposal, and Workplace Health and Safety compliance needs to be documented.

For infrastructure projects where pre-existing contaminated material is likely to remain onsite, current practices to prevent contact with the general public and the environment is to provide adequate protection or contaminant capping (ie: to remove the exposure pathway). Pavements, building foundations and garden areas typically achieve this objective.