

Environment
Effects Statement

Technical Report 0

Contamination and soil





North East Link Project

North East Link Environment Effects Statement

Technical report O – Contamination and soil

Prepared for North East Link

April 2019

This publication is prepared to inform the public about the North East Link. This publication may be of assistance to you but the North East Link Project (a division of the Major Transport Infrastructure Authority) and its employees, contractors or consultants (including the issuer of this report) do not guarantee that the publication is without any defect, error or omission of any kind or is appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

Table of contents

Executive summary	vi
Structure of the EES.....	xi
Abbreviations.....	xii
Glossary	xiii
1. Introduction	1
1.1 Purpose of this report.....	1
1.2 Why understanding contamination and soil is important	1
2. EES scoping requirements	3
2.1 EES evaluation objectives	3
2.2 EES scoping requirements	3
3. Project description.....	6
3.1 Overview	6
3.2 Construction.....	6
3.3 Operation	7
3.4 Activities and design considerations relevant to contamination and soil.....	7
4. Legislation, policy, guidelines and criteria.....	8
4.1 Legislation, policy and guidelines	8
4.2 Commonwealth legislation.....	8
4.3 Victorian legislation and guidelines.....	9
4.4 Local planning schemes	10
4.5 Policies, guidelines and standards	11
5. Method	12
5.1 Overview	12
5.2 Study area.....	13
5.3 Existing conditions	14
5.4 Risk assessment.....	16
5.5 Impact assessment.....	19
5.6 Rationale.....	19
5.7 Limitations, uncertainties and assumptions.....	19
5.8 Stakeholder engagement.....	21
5.9 Community feedback	22
6. Existing conditions	23
6.1 Desktop review of existing conditions.....	23
6.2 Summary of existing conditions	47
6.3 Preliminary field investigations	53
7. Spoil assessment.....	77
7.1 Volume and characteristics of spoil	77

7.2	IWRG soil hazard categorisation	77
7.3	Acid sulfate soils and rock volume estimate	79
7.4	Spoil Management Strategy	81
7.5	Avoidance	82
7.6	Reuse.....	82
7.7	Recycling and energy recovery	84
7.8	Treatment.....	85
7.9	Containment.....	86
7.10	Disposal	86
7.11	Asbestos	87
7.12	Onsite spoil management	87
8.	Risk assessment	88
9.	Impact assessment	89
9.1	M80 Ring Road to northern portal	89
9.2	Northern portal to southern portal.....	99
9.3	Eastern Freeway.....	107
9.4	Alternative design options.....	112
9.5	Cumulative impacts.....	113
10.	Environmental Performance Requirements	117
11.	Conclusion	122
12.	References	127

Table index

Table 2-1	Scoping requirements relevant to contamination and soil	3
Table 2-2	Linkages to other technical reports.....	5
Table 5-1	Likelihood of an event occurring	18
Table 5-2	Risk matrix	18
Table 5-3	Stakeholder engagement undertaken for contamination and soil	21
Table 5-4	Community consultation feedback addressed by contamination and soil	22
Table 6-1	Study area drainage.....	25
Table 6-2	Results of private groundwater well search.....	26
Table 6-3	Potentially contaminated areas and contaminating activities	30
Table 6-4	Historical title review	31
Table 6-5	Former landfills and fill sites	32
Table 6-6	Groundwater quality restricted use zones (GQRUZ) surrounding North East Link.....	44
Table 6-7	Element 1 – M80 Ring Road to northern portal – Potential source of contamination.....	48

Table 6-8	Element 2 – Northern portal to southern portal – Potential source of contamination.....	50
Table 6-9	Element 3 – Eastern Freeway – Potential source of contamination.....	52
Table 6-10	Contaminated soil disposal options	54
Table 6-11	Beneficial uses of groundwater (from Water SEPP).....	58
Table 6-12	Study area groundwater salinity	59
Table 6-13	Groundwater quality indicators and objectives	59
Table 6-14	Assessment of relevance of beneficial uses.....	61
Table 6-15	Texture-based action criteria for classifying acid sulfate soil (EPA Victoria, 2009b)	66
Table 6-16	Criteria for classifying acid sulfate rock (EPA Victoria, 2009b)	66
Table 6-17	Summary of acid sulfate rock classification.....	68
Table 6-18	Conceptual site model	75
Table 7-1	Indicative spoil volumes estimate (m ³ in situ).....	77
Table 7-2	Indicative spoil volume characterisation estimate (m ³ in situ)	78
Table 7-3	Indicative spoil volume acid sulfate estimate (m ³ in situ)	80
Table 8-1	Risk register for contamination and soil impact assessment.....	88
Table 9-1	Construction compounds proposed for M80 Ring Road to northern portal	90
Table 9-2	Construction compounds proposed for northern portal to southern portal	100
Table 9-3	Construction compounds proposed for Eastern Freeway	107
Table 9-4	Indicative estimate of spoil volume for major infrastructure projects	114
Table 10-1	Environmental Performance Requirements.....	117
Table 10-2	Relevant EPRs from other disciplines	119
Table 11-1	Indicative spoil volume characterisation estimate (m ³ in situ)	124
Table 11-2	Indicative spoil volume estimates	124
Table 11-3	Indicative spoil volume waste acid sulfate material estimate (m ³ in situ)	125

Figure index

Figure 3-1	Overview of North East Link	7
Figure 5-1	Overview of assessment method.....	12
Figure 5-2	Risk analysis process	17
Figure 6-1	Geology of the proposed North East alignment.....	24
Figure 6-2	Registered private groundwater wells in the vicinity.....	27
Figure 6-3	Industrial area at Manningham Road and Bulleen Road intersection	28
Figure 6-4	Watsonia railway station and adjacent industrial/commercial area	29

Figure 6-5	Fuel service station at the corner of Greensborough Road and Yallambie Road, Yallambie.....	29
Figure 6-6	Approximate location and extent of the M80 Ring Road/Greensborough Bypass Quarry and Landfill and AK Lines Reserve Landfill, Element 1.....	34
Figure 6-7	Approximate location and extent of the Borlase Reserve former landfill, Element 2	35
Figure 6-8	Approximate location and extent of former Bulleen Oval landfill and former quarry in the Bulleen area, Element 2	35
Figure 6-9	Approximate location and extent of the former Camberwell landfill and Freeway Public Golf Course landfill, Element 3	36
Figure 6-10	Approximate location and extent of the former Greythorn landfill, Element 3	36
Figure 6-11	Approximate location and extent of the former Koonung Creek Linear Park Landfill, Element 3	37
Figure 6-12	Location of GQRUZs within the proposed North East Link alignment (red dots)	45
Figure 6-13	Extract from <i>Atlas of Australian Acid Sulfate Soils</i>	46

Appendices

Appendix A – Figures
Appendix B – Historical aerial photographs
Appendix C – Aerial photograph interpretation
Appendix D – Historical certificates of title
Appendix E – EPA audit sites
Appendix F – Borehole logs
Appendix G – Spoil Management Strategy
Appendix H – Soil and groundwater sampling methodology
Appendix I – Laboratory reports
Appendix J – Tables of results
Appendix K – Landfill gas report
Appendix L – GEM report
Appendix M – Spoil volume report
Appendix N – Risk assessment

Executive summary

This technical report is an attachment to the North East Link Environment Effects Statement (EES). It has been used to inform the EES required for the project, and defines the Environmental Performance Requirements (EPRs) necessary to meet the EES objectives.

Overview

North East Link is a proposed new freeway-standard road connection that would complete the missing Link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The Major Transport Infrastructure Authority (MTIA) is the proponent for North East Link. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.

North East Link Project (NELP) is an organisation within MTIA that is responsible for developing and delivering North East Link. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.

On 2 February 2018, the Minister for Planning declared North East Link to be 'public works' under Section 3(1) of the *Environment Effects Act 1978*, which was published in the *Victorian Government Gazette* on 6 February 2018 (No. S 38 Tuesday 6 February 2018). This declaration triggered the requirement for the preparation of an EES to inform the Minister's assessment of the project and subsequent determinations of other decision-makers.

The EES was developed in consultation with the community and stakeholders and in parallel with the reference project development. The reference project has been assessed in this EES. The EES allows stakeholders to understand the likely environmental impacts of North East Link and how they are proposed to be managed.

GHD was commissioned to undertake a contamination and soil impact assessment to understand the likely environmental impacts of North East Link and how they are proposed to be managed.

Project elements

For the purpose of this study, North East Link has been divided into three elements. The elements represent distinct geographical divisions from north to south but are also characterised by the main type of works proposed for the project:

- Element 1 – M80 Ring Road to the northern portal – above ground and cut and cover works
- Element 2 – Northern portal to southern portal – the main tunnel section
- Element 3 – Eastern Freeway – modifications to the Eastern Freeway.

Contamination and soil context

Major road infrastructure projects within urban and suburban environments such as North East Link have the potential to encounter contaminated soil and groundwater and other material that require specific management under Victorian regulations. Sources of this material can be from anthropogenic activities such as industrial land uses and practices and former landfilling or can be naturally occurring such as elevated metals and acid sulfate soil and rock. These materials can potentially impact the scheduling, budgets and health and safety aspects of the project but can be managed utilising a range of methods successfully tried and tested in projects throughout Australia and overseas.

Scoping requirements and objective

The scoping requirements for the EES issued by the Minister for Planning set out the specific environmental matters to be investigated and documented in the North East Link EES, which informs that scope of the EES technical studies. The scoping requirements include a set of evaluation objectives. These objectives identify the desired outcomes to be achieved in managing the potential impacts of constructing and operating North East Link.

The following evaluation objectives from the scoping requirements document are relevant to the assessment and management of contamination and soil:

- Waste Management – to manage excavated spoil and other waste streams generated by the project in accordance with the waste hierarchy and relevant best practice principles
- Catchment Values – to avoid or minimise adverse effects on surface water, groundwater and floodplain environments.

Given this overarching objective, specific objectives for this study included:

- Identify the potential sources of contamination and acid sulfate soils/rocks
- Assess their existing risk to the human health and the environment
- Assess whether North East Link activities would increase the risks posed by the material to human health and the environment
- Develop strategies to mitigate those risks.

The key construction activities associated with North East Link relevant to contamination and soil include:

- Earthworks involving excavation, tunnelling, cut and cover, trench structures, pilling and minor embankment fills
- Onsite waste management including stockpiling, management and disposal of:
 - Excavated soil and rock
 - Extracted groundwater
 - Solid inert waste and asbestos
- Onsite management of other wastes generated by the construction activities, such as fuels and oils for vehicles, wash-down bays, sediment and soil traps and general rubbish
- Transportation offsite of soil, excavated material and other waste materials generated by the project.

To meet these objectives, an existing conditions study was conducted, followed by a preliminary field investigation. These are summarised below.

Existing conditions

The review of historical land use identified a generally low risk for the presence of widespread contamination along North East Link. The majority of the alignment was historically used for agricultural activities, before being rezoned for residential, open space recreation or commercial/industrial land use.

Eleven areas were identified as having an industrial/commercial historic land use or the potential to have been used for landfilling. These 11 areas included eight former landfills/potential areas of land filling. The historical analysis also identified the potential for acid sulfate soils and rock along the alignment of the Yarra River and within Silurian aged Siltstone rock.

Preliminary field investigations

A preliminary soil, groundwater and landfill gas investigation was undertaken to assess whether contaminants of concern were present along the alignment and to confirm observations made during the desktop study. The investigation consisted of collection of samples from geotechnical boreholes and some additional environmental sample points. Access to private properties was not included as part of the preliminary field investigations scope of work for the EES.

Additional investigation works may be required before construction starts to determine the soil and groundwater quality on the private properties and inform the Spoil Management Strategy. Limited sampling has been undertaken on Simpson Barracks. This has meant specific targets within areas of concern on private land, notably the Bulleen industrial area, have not been assessed. Further assessment of this area would be required at the detailed design stage, once access permissions have been granted.

The results of soil analysis did not identify broad scale contamination across the project boundary. Concentrations of contaminants of concern in the former Bulleen Oval area exceeded upper Category B limits (at depths of 0.75 mbgl and 1.5 mbgl) defined by EPA guidelines, but additional sampling around this location indicated this material is likely to be limited in extent. Cement sheet potentially containing asbestos was also identified in boreholes at Bulleen Oval.

Assessment of the potential for acid sulfate soil and rock along the alignment, identified that moderately weathered to fresh Silurian aged Siltstone rock exceeded Victorian EPA criteria adopted to assess acid sulfate soil risks. The assessment also confirmed that Quaternary aged alluvial soils may present a risk of acid generation although field data is limited in extent and the majority of samples did not exceed adopted criteria.

Groundwater samples were collected from locations along the alignment. Elevated metal concentrations were detected in groundwater from several wells, but the metals are likely to represent natural groundwater conditions. Elevated levels of petroleum hydrocarbon contaminants were reported in one well on Simpson Barracks. The source of this contamination could be the nearby service station, located on the corner of Yallambie Road and Greensborough Road.

Per- and polyfluoroalkyl substances (PFAS) were detected in groundwater from two wells in the Bulleen area and one minor occurrence in the Watsonia railway station car park. PFAS are a group of over 3,000 compounds with multiple applications including water proofing, detergents (including car washing), fabric and carpet protection, fire-fighting products, electroplating mist suppressants, non-stick coverings (such as Teflon), pesticides and many others. PFAS are also found in landfills where products containing or impregnated with these chemicals have been disposed historically. The source of the PFAS at Bulleen is not confirmed but is likely to be from the nearby Bulleen industrial/commercial area. There is no obvious source of PFAS at Watsonia.

In the Bulleen area, North East Link construction activities may extract PFAS-contaminated groundwater which would need to be managed. Modelling conducted by the hydrogeology team has predicted that areas where PFAS was found would be within the area subject to groundwater drawdown during construction (refer to Technical report N – Groundwater). Once dewatering ceases, there should be no further extraction of groundwater and therefore, no further potential exposure to PFAS via this route.

The occurrence of PFAS at a concentration close to the laboratory LOR in Watsonia may require further assessment to establish its extent. However, this occurrence does not fall within the zone of influence of drawdown based on the groundwater modelling presented in Technical report N – Groundwater. Therefore, specific management of PFAS-impacted water in this area may not be required.

The PFAS issue would need to be considered by the contractor in any management approach.

Analytical results from soil and rock samples identified that moderately weathered to fresh Silurian aged Siltstone and Quaternary aged alluvial soils may be considered waste acid sulfate soils (WASS).

Spoil assessment

Based on the available field data and the historical information, a preliminary estimate of in situ spoil quantity of Fill Material and Prescribed Industrial Waste (PIW) was undertaken and is summarised in the table below.

Location by element	Fill material	Estimated volumes (m ³ in situ)				
		Contaminated spoil (PIW)				Subtotal
		Cat A	Cat B	Cat C	Total PIW	
M80 Ring Road to Lower Plenty Road	2,120,000	-	3,000	32,000	35,000	2,155,000
Northern portal to southern portal	3,111,000	5,500	11,500	137,000	154,000	3,265,000
Eastern Freeway	612,000	500	1,500	66,000	68,000	680,000
Total	5,843,000	6,000	16,000	235,000	257,000	6,100,000

Based on the initial calculations of spoil volume and PIW from each element, the great majority of the excavated spoil is likely to be classified as Fill Material. These estimates would require further confirmation in the field at later stages of the project design.

Based on the laboratory results collected:

- Quaternary alluvial soils along the section of the Yarra River in Element 2 (northern portal to southern portal), may be considered WASS
- Moderately weathered to fresh Silurian aged Siltstone is considered WASS. These rocks form the basement of the entire alignment and are generally found close to surface.

Spoil on North East Link would be managed in accordance with the waste hierarchy, consistent with the *Environment Protection Act 1970 (Vic)* and with the Spoil Management Strategy described in the report, within the spatial constraints of North East Link. The waste hierarchy designates the most preferable method as avoidance to the least preferred approach, disposal.

The contaminants encountered during this study are typical of those found on many other sites throughout Victoria. The assessment and management of these contaminants in both soil and groundwater has become a mature and well developed industry based on decades of experience. Consequently, there is a large number of tried and tested approaches that can be employed on the project to reduce risks to human health and the environment. It is likely that a combination of approaches would be employed to manage the spoil. These are likely to include some treatment of soils and groundwater to reduce waste categories to less-sensitive ones, onsite reuse where possible, offsite reuse, offsite treatment and reuse and/or disposal.

Risk assessment, impact assessment and environmental performance requirements

A risk assessment of project activities was performed in accordance with the methodology used consistently throughout the EES. Risks were assessed for the construction and operational phases of North East Link. On review, a series of 13 risk items were identified. All the risk items were considered to have a residual risk rating of 'low', taking into account the initial Environment Performance Requirements (EPRs).

Cumulative spoil impacts were assessed taking into account the Metro Tunnel, the West Gate Tunnel Project and the Level Crossing Removal Projects (Edithvale and Bonbeach). Based on the initial calculations of spoil volume and prescribed industrial waste from each project, the estimated volume of Category B waste spoil across the four projects could exceed the current total existing landfill capacity for this type of waste by 50 per cent. This calculation does not take into account Category A waste, which may be treated and reclassified as Category B. It is noted the estimates are likely to vary significantly from the final volumes, due to the adoption of conservative assumptions in the absence of detailed information. However, noting that construction of North East Link is not likely to start until 2020, there is a long lead in time before landfill capacity would be needed. The 'market' (that is, landfills) has recently indicated to NELP they expect to have sufficient capacity by the time construction of North East Link begins.

Structure of the EES

Summary Report

EES main report

- | | | |
|----------------------------------|----------------------------------|--|
| 1. Introduction | 11. Surface noise and vibration | 21. Ground movement |
| 2. Project rationale | 12. Tunnel vibration | 22. Groundwater |
| 3. Legislative framework | 13. Land use planning | 23. Contamination and soil |
| 4. EES assessment framework | 14. Business | 24. Surface water |
| 5. Communications and engagement | 15. Arboriculture | 25. Ecology |
| 6. Project development | 16. Landscape and visual | 26. Greenhouse gas |
| 7. Urban design | 17. Social | 27. Environmental management framework |
| 8. Project description | 18. Human health | 28. Conclusion |
| 9. Traffic and transport | 19. Historical heritage | |
| 10. Air quality | 20. Aboriginal cultural heritage | |

Technical reports

- | | | |
|--------------------------------|---------------------------------|---------------------------|
| A. Traffic and transport | G. Arboriculture | M. Ground movement |
| B. Air quality | H. Landscape and visual | N. Groundwater |
| C. Surface noise and vibration | I. Social | O. Contamination and soil |
| D. Tunnel vibration | J. Human health | P. Surface water |
| E. Land use planning | K. Historical heritage | Q. Ecology |
| F. Business | L. Aboriginal cultural heritage | R. Greenhouse gas |

Attachments

- | | | |
|----------------------------|-------------------------------------|--------------------------------|
| I. Sustainability approach | IV. Stakeholder consultation report | VI. Works Approval Application |
| II. Urban design strategy | V. Draft Planning Scheme Amendment | |
| III. Risk report | | |

EES Map Book

Abbreviations

Term	Description
AASS	Actual acid sulfate soil
AHD	Australian Height Datum
AMG	Australian Map Grid
AS	Australian Standard
bgl	Below ground level
bTOC	below top of casing
DELWP	Department of Environment, Land, Water and Planning
DNRE	Department of Natural Resources and Environment
EC	Electrical conductivity
EPA	Environment Protection Authority
EPBC	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
EPR	Environmental Performance Requirement
GIS	Geographic Information System
IWRG	Industrial Waste Resource Guidelines
mbgl	Metres below ground level
MTIA	Major Transport Infrastructure Authority
NATA	National Association of Testing Authorities, Australia
NELP	North East Link Project
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NRMMC	Natural Resource Management Ministerial Council
PAHs	Polycyclic aromatic hydrocarbons
PASS	Potential acid sulfate soil
PFAS	Per and polyfluoroalkyl substances
PIW	Prescribed industrial waste
SEPP	State Environment Protection Policy
SWL	Standing water level
TBM	Tunnel boring machine
TDS	Total dissolved solids
TPH	Total petroleum hydrocarbons
WASS	Waste acid sulfate soil
WWTP	Wastewater treatment plant

Glossary

Term	Description
Acid sulfate soil and rock	Natural soils or rocks that contain iron sulphides which when exposed to oxygen can release acid that may damage or otherwise adversely impact built structures and ecosystems.
Aquifer	A geological formation, group of formations or part of a formation, which contains sufficient saturated permeable material to transmit and yield significant quantities of water.
Alluvial	Pertaining to, or composed of, alluvium or other deposits from streams and rivers.
Alluvium	A general term for unconsolidated material deposited during recent geological time by a stream or other body of running water. Typically forms a sorted or semi-sorted sediment in stream beds, floodplains, deltas or as fan at the base of a mountain slope.
Asbestos-containing material	A group of manufactured material that contains asbestos minerals. They can be friable (loose and easily crumbled) or non-friable (bonded) asbestos.
Basalt	A dark coloured, fine grained, mafic volcanic rock.
Bedrock	A general term for rock, usually solid, that underlies soil or other unconsolidated material.
Beneficial uses	With regards to soil and groundwater, beneficial uses are the uses that soil or groundwater could be put to if they were not contaminated and require protection under EPA Victoria's SEPPs.
Borehole log	A written description of the soil and rock encountered while drilling a borehole. It would include a description of the geology, moisture and indications of contamination.
Colluvium	Unconsolidated material that accumulates at the foot of a steep slope.
Conceptual site model	A representation of the biological, physical and chemical processes that determine the ways contaminants move through the environment. It may be graphical, tabulated and/or text.
Contaminant	A substance, element, or compound that has an adverse effect on the quality of soil and water.
Department of Transport	The Victorian Department of Transport is responsible for delivering the government's transport infrastructure agenda. It was formed on 1 January 2019 when the former Victorian Department of Economic Development, Jobs, Transport and Resources transitioned into the Department of Transport and the Department of Jobs, Precincts and Regions.
Dewatering	The lowering of static groundwater levels through extraction, usually by means of pumping from one or several groundwater bores.
Discharge	Any process by which water is removed from an aquifer. Includes water that flows to a surface feature, such as a spring, river or wetland, as well as water which flows to an adjacent aquifer.
Drawdown	The change in groundwater head level that can be attributed to the operation of a pumping bore.
Ecosystem	A system that is made up of a community of animals, plants, and bacteria and its interrelated physical and chemical environment.
Ex situ	In the case of soil it refers to soil that has been removed from its original place of deposition or formation (that is, excavated or drilled).

Term	Description
Fill Material	A designation of waste material defined by EPA Victoria. Often referred to as 'clean fill'.
Groundwater	Water occurring naturally below ground level or water pumped, diverted and released into a bore for storage underground.
Groundwater dependent ecosystem	An ecosystem that is partially or wholly reliant on groundwater for its survival. This can include terrestrial, subsurface and marine ecosystems.
Groundwater monitoring well	A well installed with the purpose to: determine the nature and properties of subsurface ground conditions; provide access to groundwater for measuring level, physical and chemical properties; and permit the collection of groundwater samples and conduct of aquifer testing.
Groundwater quality restricted use zone	A formal instrument imposed by EPA Victoria over an area of known groundwater contamination to prevent all or specific extractive uses of the groundwater. It may be imposed on one property or a broader area.
Inert waste	Waste which is neither chemically nor biologically reactive and will not decompose, such as concrete, building rubble.
In situ	In the case of soil it refers to soil that has not been removed from its original place of deposition or formation.
Landfill gas	A complex mix of different gases created by the action of microorganisms within a landfill. Usually developed from biological degradation of putrescible organic material. Generally mostly methane
Lithology	The physical character of a rock or rock formation.
Major Transport Infrastructure Authority	The Major Transport Infrastructure Authority is the proponent for North East Link. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.
North East Link Project	North East Link Project is an organisation within MTIA that is responsible for developing and delivering North East Link. NELP was formerly known as the North East Link Authority prior to 1 January 2019. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.
Palaeozoic Era	A time period in earth's geological history between approximately 252 million to 359 million years ago.
Permeability	The property or capacity of a porous rock, soil or sediment for transmitting a fluid; it is a measurement of the relative ease of fluid flow within a material.
Pollution	The introduction of contaminants into the natural environment that cause adverse change.
Preliminary site investigation	Usually comprising a desktop study of existing information on a site to identify potential contaminating activities and practices. It may include a site visit and some preliminary sampling.
Prescribed industrial waste	Any industrial waste or mixture containing industrial waste as defined by EPA Victoria's Industrial Waste Resource Guideline.
Quaternary Period	Period in earth's geological history starting approximately 2.5 million years ago.
Recharge	The process of adding water, or the amount of water added, to the volume of water stored in an aquifer.
Salinity	A measure of the dissolved salt content of water or soil.
Siltstone	Indurated sedimentary rock composed predominantly of silt sized material.

Term	Description
Spoil	Waste material brought up during the course of an excavation, tunnelling or a dredging or mining operation.
Spoil management plan	A plan that provide details on the spoil management measures to be implemented to comply with the Spoil Management Strategy.
Spoil management strategy	An overarching strategy that provides guidance for spoil management and disposal during the construction to mitigate potential human health and environmental risks.
Standing water level	The level of water in a well or bore that is not being affected by pumping of groundwater.
Surface water	Any water that collects as a surface features, including rivers, streams, lakes, wetlands and the ocean.
Tertiary Period	Period in earth's geological history between approximately 2.5 million to 65 million years ago.
Total dissolved solids	The total mass of all solids dissolved in a water sample, measured in mg/L.
Waste hierarchy	A hierarchical system of preferred waste handling approaches defined by EPA Victoria in the <i>Environment Protection Act 1970 (Vic)</i> . The approaches from most preferred to least preferred include avoidance, re-use, recycling and energy recovery, treatment, containment and disposal.
Water table	The surface between the vadose zone and the saturated zone of unconfined groundwater. This can also be defined as the surface at which groundwater pressure is equal to atmospheric pressure.
Water quality	The physical, chemical and biological characteristics of water, frequently used by reference to a set of standards against which compliance can be assessed.

1. Introduction

1.1 Purpose of this report

North East Link is a proposed new freeway-standard road connection that would complete the missing Link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The Major Transport Infrastructure Authority (MTIA) is the proponent for North East Link. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.

North East Link Project (NELP) is an organisation within MTIA that is responsible for developing and delivering North East Link. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.

On 2 February 2018, the Minister declared the works proposed for North East Link as Public Works and issued a decision confirming that an Environment Effects Statement (EES) is required for the project due to the potential for significant environmental effects.

Similarly, the project was referred to the Australian Government's Department of the Environment and Energy on 17 January 2018. On 13 April 2018 the project was declared a 'controlled action', requiring assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999 (Cwlth) (EPBC Act)*. Separate to this EES, a Public Environment Report (PER) is required to be prepared to satisfy the EPBC Act requirements, and assess the impacts of the project on Commonwealth land and matters of national environmental significance (MNES).

The purpose of this report is to assess the potential contamination and soil impacts associated with North East Link and to define the Environmental Performance Requirements (EPRs) necessary to meet the EES objectives

1.2 Why understanding contamination and soil is important

Major road infrastructure projects within urban and suburban environments have the potential to encounter contaminated soil and groundwater. North East Link is no exception, with known and potentially contaminated sites identified within or near the project boundary.

Historical commercial, industrial and quarrying activities combined with historically poor environmental management and waste disposal can potentially leave a legacy of contamination, which can pose potential threats to human health, the environment and the durability of building materials. It can also have significant economic, legal and planning impacts and must be managed appropriately and in accordance with Victorian regulations and guidelines.

The definition of potentially contaminated land is defined in the *General Practice Note – Potentially Contaminated Land*, dated June 2005 (prepared by the Department of Sustainability and Environment) as:

...land used or known to have been used for industry, mining or the storage of chemicals, gas, wastes or liquid fuel (if not ancillary to another use of land). This practice note also deals with land that may have been contaminated by other means such as by ancillary activities, contamination from surrounding land, fill using contaminated soil or agricultural uses.

In essence, contaminated land has been contaminated by human activities.

This definition has been considered throughout the EES assessment undertaken for North East Link.

2. EES scoping requirements

2.1 EES evaluation objectives

The scoping requirements for the EES issued by the Minister for Planning set out the specific environmental matters to be investigated and documented in the project's EES, which informs the scope of the EES technical studies. The scoping requirements include a set of evaluation objectives. These objectives identify the desired outcomes to be achieved in managing the potential impacts of constructing and operating the project.

The following evaluation objectives are relevant to the contamination and soil assessment:

- Waste Management – to manage excavated spoil and other waste streams generated by the project in accordance with the waste hierarchy and relevant best practice principles
- Catchment Values – to avoid or minimise adverse effects on surface water, groundwater and floodplain environments.

2.2 EES scoping requirements

The aspects from the scoping requirements relevant to the contamination and soil evaluation objectives, are shown in Table 2-1, as well as the location where these items have been addressed in this report.

Table 2-1 Scoping requirements relevant to contamination and soil

Aspect	Scoping requirement	Section addressed
Key issues	Management of substantial quantities of excavation and tunnelling spoil, including temporary stockpiling and on-site treatment, transporting material away from works sites and reuse or disposal.	Section 7.4: Spoil management strategy Section 7: Spoil assessment. The transport of waste is addressed in Technical report A – Traffic and transport
	Management of a range of waste streams from the project.	Section 7: Spoil management strategy Technical report N – Groundwater Technical report P – Surface water
	Potential for migration or disturbance of anthropogenic contaminated soil or groundwater or naturally occurring acid forming materials.	Section 6.1: Desktop review of existing conditions Section 6.2: Summary of existing conditions Section 6.3: Preliminary field investigations
Priorities for characterising the existing environment	Review geology and land use history, previous studies and relevant registers to identify likely occurrence of acid forming materials, contaminated soil, and other potential sources of contaminated materials in the project area.	Section 6.1: Desktop review of existing conditions
	Identify indicative volumes and characteristics of excavated spoil.	Section 7.1: Volume and characteristics of spoil

Aspect	Scoping requirement	Section addressed
	Characterise other key waste streams from the project.	Section 6.1: Desktop review of existing conditions Section 6.2: Summary of existing conditions Section 6.3: Preliminary field investigations Section 7: Spoil assessment
	Identify suitable reuse, recycling, remediation or off-site disposal options for waste materials based on consideration of the waste hierarchy.	Section 7.4: Spoil management strategy Section 7.5: Avoidance Section 7.6: Reuse Section 7.7: Recycling and/or energy recovery Section 7.8: Treatment Section 7.9: Containment Section 7.10: Disposal
	Identify possible capacity issues that could affect either the management of waste on-site or disposal off-site, particularly given other proposed project works (such as the Melbourne Metro Rail Project and the West Gate Tunnel Project) that might generate spoil around the same time.	Section 9.5: Cumulative effects
	Identify known and potentially contaminated sites and ground conditions including acid-forming materials.	Section 6.1: Desktop review of existing conditions Section 6.2: Summary of existing conditions Section 6.3: Preliminary field investigations
Design and mitigation measures	Identify options for treating, reusing or disposing of excavation spoil with reference to the waste hierarchy and relevant best practice principles, including for both contaminated and clean materials, and identify the routes and destinations for spoil material to be transported away from the project work sites.	Section 7.4: Spoil management strategy Section 7.5: Avoidance Section 7.6: Reuse Section 7.7: Recycling and/or energy recovery Section 7.8: Treatment Section 7.9: Containment Section 7.10: Disposal Technical report A – Traffic and transport: Section 10.2: Proposed haulage routes
	Describe and evaluate proposed design, management or site protection measures that could avoid or mitigate potential adverse effects of the excavated spoil or other waste streams generated by the project on land or water values, especially with regard to the project construction activities.	Section 9: Impact assessment

Aspect	Scoping requirement	Section addressed
Assessment of likely effects	Analyse residual effects on land and water values from project waste streams. Assess residual effects on surface and groundwater users or environmental values from contaminated soil, acid forming materials or contaminated groundwater.	Section 8: Risk assessment Section 9: Impact assessment Section 10: Environmental Performance Requirements
Approach to manage performance	Describe the environmental performance requirements to set spoil and other waste stream outcomes that the project must achieve.	Section 10: Environmental Performance Requirements

2.2.1 Linkages to other reports

This report relies on or informs the technical assessments as indicated in Table 2-2.

Table 2-2 Linkages to other technical reports

Specialist report	Relevance to this impact assessment
Technical report N – Groundwater	Provides an assessment of North East Link's potential impacts on groundwater flow. The presence of contaminated soil can act as a source of contamination to groundwater through rainwater leaching. Dewatering during construction may lead to the mobilisation of contaminants towards extraction points which would require management.
Technical report P – Surface water	Provides an assessment of North East Link's potential impacts on surface water bodies along the alignment. Specific to contamination, the project may create runoff of soil and sediments to the surface water that may be contaminated and thereby impact water quality.
Technical report Q – Ecology	Provides an assessment of North East Link's potential impacts on aquatic and groundwater-dependent ecosystems and communities in surface water bodies along the alignment. Specific to contamination, the ecology helps define the protected beneficial uses of surface water and the levels of protection from contamination.
Technical report E – Land use planning	Provides information on land use planning for North East Link. The requirement for handling and management of excavated contaminated soil will require various planning approvals, depending on the end use of the soil; that is, reuse, treatment or offsite disposal.
Technical report B – Air quality	Provides an assessment of North East Link's potential impacts on air quality. This is relevant to spoil management, notably for the protection of any stockpiled soil and generation of dust during construction works which might liberate contamination.
Technical report J – Human health	Provides an assessment of North East Link's potential impacts on human health. Contamination in soil can occur at concentrations in excess of guidelines protective of human health. Understanding these concentrations is important in developing health and safety plans and mitigation measures to limit possible exposures during construction and transport of soil through the community, such as appropriate PPE.
Technical report A – Traffic and transport	Provides an assessment of appropriate transport routes for trucks carrying contaminated soil from the project boundary, through communities to landfill. The design of transport routes would reduce the potential for impact to communities in the unlikely event of a spill.

3. Project description

3.1 Overview

The North East Link alignment and its key elements assessed in the Environment Effects Statement (EES) include:

- **Element 1 – M80 Ring Road to the northern portal** – from the M80 Ring Road at Plenty Road, and the Greensborough Bypass at Plenty River Drive, North East Link would extend to the northern portal near Blamey Road utilising a mixture of above, below and at surface road sections. This would include new road interchanges at the M80 Ring Road and Grimshaw Street.
- **Element 2 – Northern portal to southern portal** – from the northern portal the road would transition into twin tunnels that would connect to Lower Plenty Road via a new interchange, before travelling under residential areas, Banyule Flats and the Yarra River to a new interchange at Manningham Road. The tunnels would then continue to the southern portal located south of the Veneto Club.
- **Element 3 – Eastern Freeway** – from around Hoddle Street in the west through to Springvale Road in the east, modifications to the Eastern Freeway would include widening to accommodate future traffic volumes and new dedicated bus lanes for the Doncaster Busway. There would also be a new interchange at Bulleen Road to connect North East Link to the Eastern Freeway.

These elements are illustrated in Figure 3-1.

North East Link would also improve existing bus services from Doncaster Road to Hoddle Street with the Doncaster Busway and pedestrian connections and the bicycle network with connected walking and cycling paths from the M80 Ring Road to the Eastern Freeway.

For a detailed description of the project, refer to North East Link EES Chapter 8 – Project description.

3.2 Construction

Key construction activities for North East Link would include:

- General earthworks including topsoil removal, clearing and grubbing vegetation
- Relocation, adjustment or installation of new utility services
- Construction of retaining walls and diaphragm walls including piling
- Ground treatment to stabilise soils
- Tunnel portal and drive shaft construction
- Storage and removal of spoil
- Construction of cross passages, ventilation structures and access shafts
- Installation of drainage and water quality treatment facilities
- Installation of a Freeway Management System
- Tunnel construction using tunnel boring machines (TBMs), mining and cut and cover techniques
- Installation of noise barriers
- Restoration of surface areas.

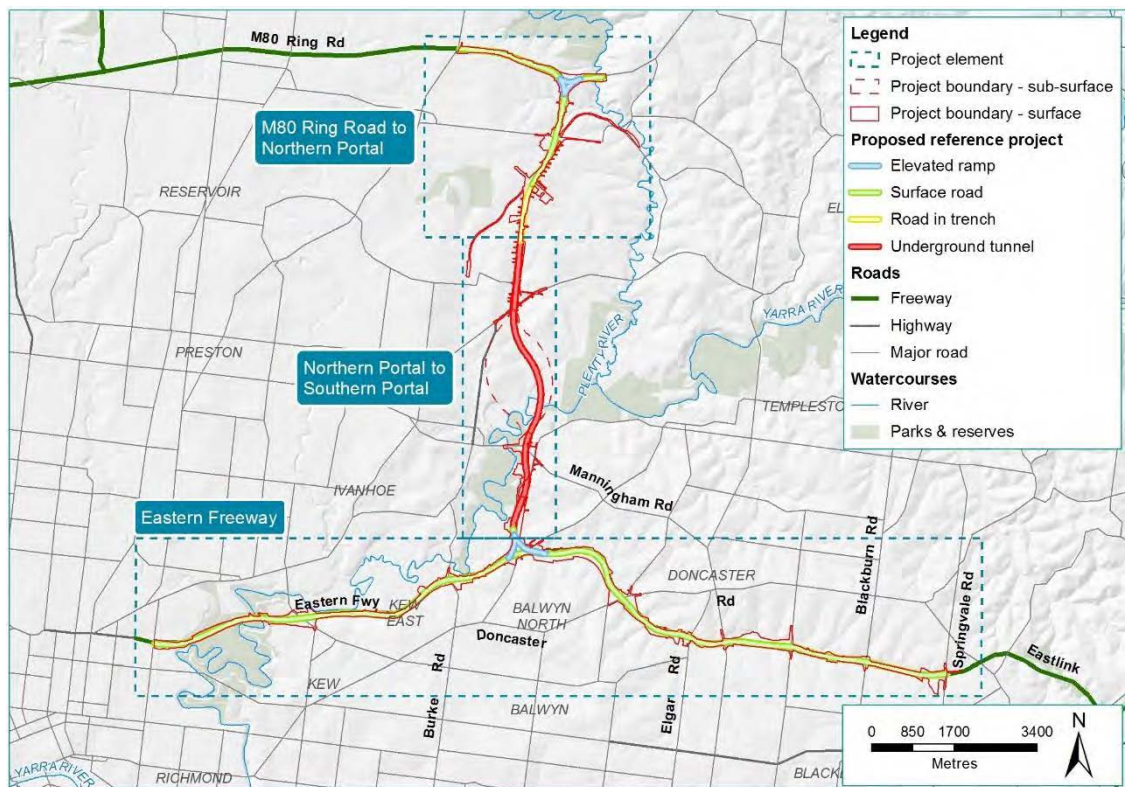


Figure 3-1 Overview of North East Link

3.3 Operation

Following construction of North East Link, the key operation phase activities would include:

- Operation and maintenance of new road infrastructure
- Operation and maintenance of Freeway Management System
- Operation of North East Link motorway control centre
- Operation and maintenance of the tunnel ventilation system
- Operation and maintenance of water treatment facilities
- Operation and maintenance of the motorways power supply (substations)
- Maintenance of landscaping and Water Sensitive Urban Design (WSUD) features.

3.4 Activities and design considerations relevant to contamination and soil

The key construction activities associated with North East Link relevant to the assessment of land contamination include:

- Earthworks involving excavation, cut and cover, trench structures, pilling and minor embankment fills
- Demolition of existing infrastructures and buildings and possible residual wastes
- Onsite waste management including stockpiling, management and disposal of excavated soil, rock and groundwater
- Onsite management of other wastes generated by the construction activities, such as fuels and oils for vehicles, wash-down bays, sediment and soil traps and general rubbish
- Transport of soil and excavated material offsite.

Note this report has not considered the potential for contamination of soil to occur during demolition of buildings or removal of infrastructure.

4. Legislation, policy, guidelines and criteria

4.1 Legislation, policy and guidelines

The key legislation, policy and guidelines that apply to the contamination and soil impact assessment for North East Link are summarised below.

4.2 Commonwealth legislation

Commonwealth legislation relevant to North East Link includes:

- *National Environmental Protection (Assessment of Site Contamination) Measure 1999* ('ASC NEPM'), as amended in 2013. Developed and issued by the National Environment Protection Council (NEPC) under the *National Environment Protection Council Act 1994*
- *Work Health and Safety Act 2011* and *Work health and Safety Regulations 2011* which provide for management of asbestos.

The ASC NEPM is the main guidance document for the assessment of land contamination in Victoria, including for North East Link. The ASC NEPM provides a national approach to the assessment of potentially contaminated sites to ensure effective sound environmental management practices and provide adequate protection of human health and the environment where known contamination has occurred.

In Victoria, the ASC NEPM is mainly implemented through Victorian Government policies (subordinate legislation, such as the State Environment Protection Policies) and guidelines described below. The ASC NEPM is divided into two schedules:

- Schedule A – identifies the general process for the Assessment of Site Contamination
- Schedule B – identifies general guidelines for the Assessment of Site Contamination.

Assessment of Commonwealth land also needs to consider the *Environment Protection and Biodiversity Conservation Act 1999* ('EPBC Act'). It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as matters of national environmental significance. Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of national environmental significance require approval from the Australian Government's Minister for the Environment. The Minister will decide whether assessment and approval is required under the EPBC Act. The EPBC Act also protects the environment, where actions proposed are on, or will affect Commonwealth land and the environment.

Commonwealth land within the North East Link project boundary is limited to Simpson Barracks, which is owned and occupied by the Department of Defence, and the vacant land immediately south of the barracks which is accessible to the public.

4.3 Victorian legislation and guidelines

Legal and regulatory obligations relating to contaminated land in Victoria are set out in the *Environment Protection Act 1970* (Vic) ('Environment Protection Act') administered by EPA Victoria, which makes provisions with respect to the powers, duties, and functions of EPA Victoria and the protection of the environment.

The Environment Protection Act:

- Regulates the discharge or emission of waste to water (including groundwater), land or air, by a system of works approvals, licences, permits and pollution abatement notices. It also specifically controls the emission of noise and the disposal and transportation of waste.
- Enables EPA Victoria to require investigation and clean-up of identified impacts.
- Provides the basis for the various State Environment Protection Policies (SEPPs). SEPPs provide more detailed requirements and guidance for the application of the Environment Protection Act to Victoria. It aims to protect the environmental values and 'beneficial uses' from the effects of pollution and waste, such as:
 - Human health and wellbeing
 - Ecosystem protection
 - Visibility
 - Useful life and aesthetic appearance of buildings, structures, property and materials
 - Aesthetic enjoyment
 - Local amenity.
- Incorporates a system of environmental audits to provide authoritative, independent and transparent advice and recommend measures to reduce identified risks to the environment from contaminating activities or conditions, and its suitability for current and future use. The environmental audits forms an integral part of the land use planning and approval processes.
- Includes provision for an Industrial Waste Management Policy (IWMP) that provides Victoria's framework for the management of waste (industrial and hazardous).
- SEPPs are subordinate legislation made under the provisions of the Environment Protection Act, and set out policies to define environmental quality objectives, and establish beneficial uses and values that are to be protected in different segments of the environment. Separate SEPPs have been established for the protection of air, noise, water, land and groundwater. The following are SEPPs relevant to the management of land contamination:
 - State Environment Protection Policy (Prevention and Management of Contamination of Land) – 'to maintain and where appropriate and practicable improve the condition of the land environment sufficient to protect current and future beneficial uses of land from the detrimental effects of contamination by preventing contamination of land; and where pollution has occurred, adopting management practices that will ensure unacceptable risks to human health and the environment are prevented and pollution is cleaned-up or otherwise managed to protect beneficial uses'.
 - State Environment Protection Policy (Waters) – 'This Policy seeks to protect human health and the environment by reducing the harmful effects of pollution and waste, and to contribute to the restoration and protection of the ecological integrity of Victorian waters'.

- The *Environment Protection (Industrial Waste Resource) Regulations 2009* set out the requirements for management of industrial waste and prescribed industrial waste for the purpose of the Environment Protection Act, which include the following relevant policies and guidelines to assist industry to implement the principal of wastes hierarchy as set out in section 11 of the Act:
 - *Industrial Waste Management Policy (Waste Acid Sulfate Soils) 1999 (IWMP WASS)* – ‘provides a framework for management, disposal or reuse of waste acid sulfate soil’. The IWMP WASS defines acid sulfate soil as ‘*any soil, sediment unconsolidated geological material or disturbed consolidated rock mass containing metal sulfides which exceeds criteria for acid sulfate soils specified in Publication 655 entitled ‘Acid Sulfate Soil and Rock’.*’
 - The Industrial Waste Resource Guidelines (IWRG) – provides a framework for transport and disposal of waste, asbestos and the threshold values for hazard categorisation and management of waste soil (including acid sulfate soil and rock) and solid industrial waste. The following IWRGs are relevant to the assessment and management of land contamination:
 - IWRG 621: Soil hazard categorisation and management (June 2009)
 - IWRG 655.1: Acid sulfate soil and rock (July 2009)
 - IWRG 611.2: Asbestos transport and disposal (June 2017)
 - IWRG 701: Sampling and analysis of waters, wastewaters, soils and wastes
 - IWRG 702: Soil sampling (June 2009).
- EPA Victoria Publication 669: *Groundwater sampling guidelines* (April 2000) also provides guidelines on the most appropriate methods of groundwater investigation.

4.4 Local planning schemes

Local planning schemes can provide useful information on the potential for land to have been subject to contaminating activities. This information includes land zoning and planning overlays, described below. Consideration was given to these, along with historical and uses discussed in Section 6.1, in the identification of potentially contaminated land and targets for the preliminary field investigations.

With respect to land zoning, land zoned either commercial (C1Z and C2Z) or industrial (IN1Z and IN3Z) is important to the assessment of land contamination. Industrial and commercial processes and activities (past and present) can lead to an increased potential for contamination compared with land zoned for non-industrial purposes such as residential or recreation. For example, fuel service stations (particularly older ones) are common sites for soil and groundwater contamination related to the storage and use of petroleum products in underground petroleum storage systems (UPSS).

The main planning overlays relevant to North East Link with respect to contaminated land is the Environmental Audit Overlay (EAO). An EAO can provide an indication that land or adjacent land may have had a historic land use which may have contaminated land or groundwater. EAOs indicate that a statutory environmental audit may be required on the land to assess suitability for various land uses. If the land is potentially contaminated and a sensitive use is proposed, *Ministerial Direction No. 1 – Potentially Contaminated Land* (Direction No.1) provides that a planning authority must satisfy itself that the land is suitable through an environmental audit. The EAO is a mechanism provided in the *Victoria Planning Provisions* and planning schemes to ensure the requirement for an environmental audit under Direction No.1 is met before the commencement of the sensitive use or any buildings and works associated with that use.

The application of the overlay, in appropriate circumstances, ensures the requirement will be met in the future but does not prevent the assessment and approval of a planning scheme amendment.

Planning overlays were reviewed during historical land assessment for this investigation.

4.5 Policies, guidelines and standards

The assessment and management of contaminated land in Victoria is largely directed by EPA Victoria and guidelines issued by that authority. EPA Victoria guidelines relevant to this project particularly include the Industrial Waste Resource Guidelines, described in Section 4.3 above, which incorporates a wide range of documents. Other EPA Victoria guidelines include:

- Publication 788.3: Best practice environmental management, siting design, operation and rehabilitation of landfills, (EPA Victoria, 2015)
- EPA Victoria Publication 669 *Groundwater sampling guidelines*.

These documents are directly relevant for the assessment of soils, groundwater and landfills in Victoria and assessment or risk/management of risk to beneficial uses.

Worksafe guidelines applicable to the assessment of contaminated land considered for the project include:

- Asbestos-Contaminated Soil Guidance Note (Worksafe, 2010).

Australian Standards generally applied or considered with respect to contaminated land investigations include:

- AS 4482.1-2005: Guide to the sampling and investigation of potentially contaminated soil – Non-volatile and semi-volatile compounds
- AS 4482.2-1999: Guide to the sampling and investigation of potentially contaminated soil – Volatile substances
- AS/NZS 5667.11:1998: Water quality – Sampling – Guidance on sampling of groundwaters.

5. Method

5.1 Overview

This section describes the method that was used to assess the potential impacts of North East Link. A risk-based approach was applied to prioritise the key issues for assessment and inform measures to avoid, minimise and offset potential effects. An overview of the assessment method is shown in Figure 5-1.

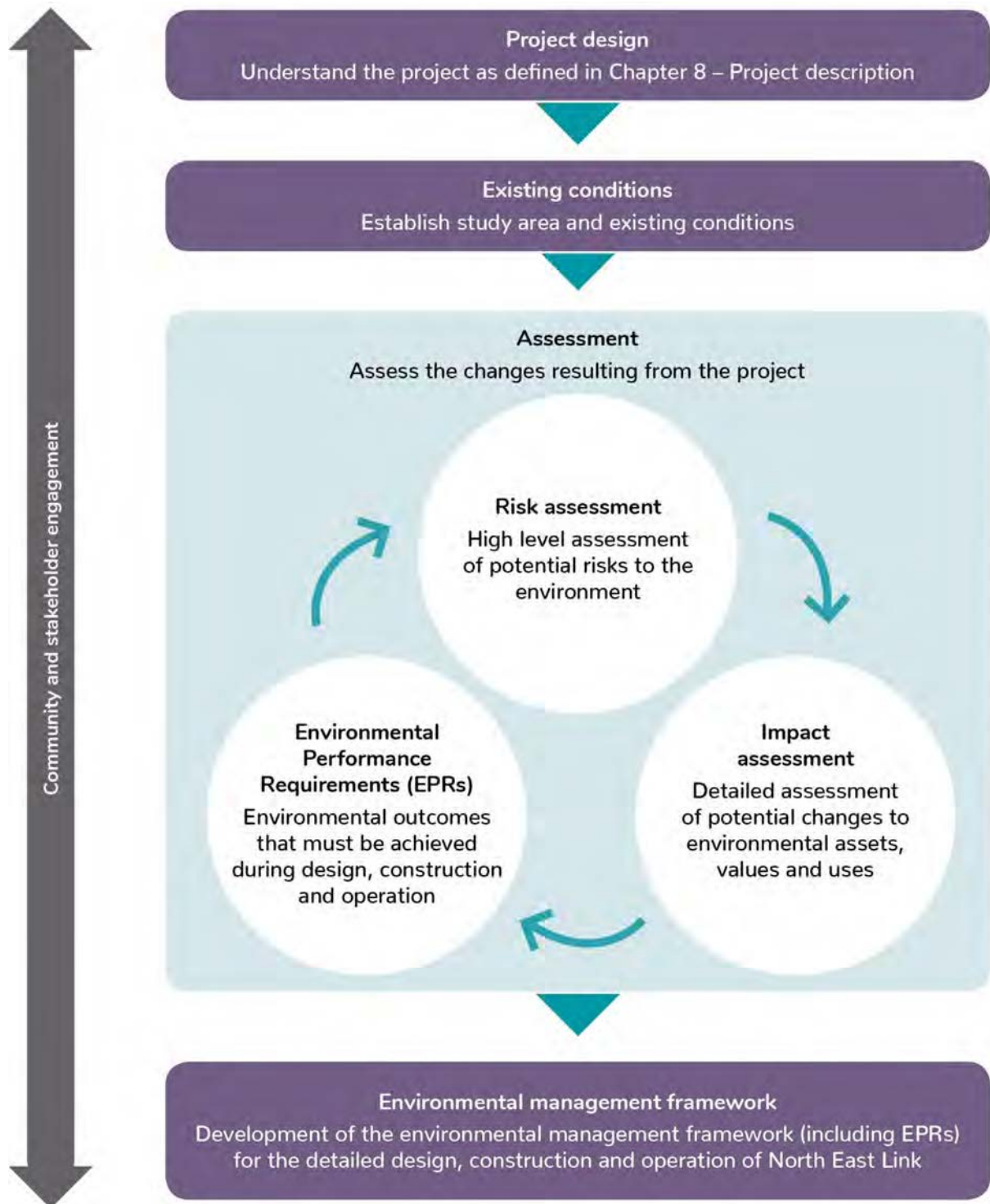


Figure 5-1 Overview of assessment method

The following sections outline the method adopted for the contamination and soil impact assessment.

5.2 Study area

The North East Link alignment is described in terms of three elements:

- M80 Ring Road to the northern portal – above ground and cut and cover works
- Northern portal to southern portal – the main tunnel section
- Eastern Freeway – modifications to the Eastern Freeway.

These elements are illustrated in Figure 3-1.

EES Chapter 8 – Project description, provides further details, including figures illustrating boundaries for the three project elements.

The study area allows for assessment of the historical and current activities that construction activities may impact on, including soil quality and presence of actual or potential acid sulfate soil and rock conditions. Some investigations have extended slightly beyond the alignment footprint to assess the nature of potential contamination source areas, notably, Bulleen Oval and the Bulleen industrial area.

However, contamination and soil assessment focused on areas that have been identified to have higher potential for contamination based on their former or current land uses. These are listed below in approximate geographical order from north to south:

- Commercial/industrial area including the Watsonia railway station in the vicinity of the Watsonia Road and Greensborough Road intersection, Watsonia
- Fuel service station located at the Yallambie and Greensborough Road intersection, Greensborough
- Commercial and industrial area near the Bulleen Road and Manningham Road intersection, Bulleen
- Potential or identified landfill or fill sites within or near the project boundary:
 - Former Camberwell Landfill located at Musca Street Reserve and Freeway Public Golf Course, Balwyn North
 - Former quarry, (backfilled with solid inert and putrescible waste material) located at the M80 Ring Road and Greensborough Bypass, Greensborough
 - Former landfill located at AK Lines Reserve, Watsonia
 - Former landfill located at Borlase Reserve, Yallambie
 - Former landfill located at Bulleen Oval, Bulleen
 - Former Greythorn Landfill located at the corner of Doncaster Road and Eastern Freeway, Balwyn North
 - Former quarry (potentially backfilled with uncontrolled fill) located near Rocklea Road and Yarraleen Place, Bulleen
 - Former landfill located at Koonung Creek Linear Park.

Residential areas have been considered to have a lower potential for land contamination on the basis that:

- Large quantities of chemicals are not typically kept at residential facilities (in ground or above ground)
- Activities are unlikely to result in widespread contamination
- Any contamination would generally be restricted to a small footprint.

5.3 Existing conditions

The assessment of existing conditions was conducted in general accordance with the ASC NEPM. The ASC NEPM recommends a staged approach to site contamination assessment, with each stage informing subsequent stages. The first stage involves a preliminary site investigation (PSI) to identify the site characteristics (site location, Aboriginal heritage considerations, site layout, building construction, geological setting, historical land uses and activities at the site) and a site inspection. The ASC NEPM requires the PSI to be sufficient to enable assessment of potential contaminants of concern and the identification of areas of potential contamination.

The PSI may be supplemented with preliminary sampling of various media, such as soil, groundwater and surface water. Although not necessary, this sampling can provide some confirmation of the presence of contaminants of concern and can inform appropriate health and safety plans for future work at the site.

This report is essentially a PSI with some supporting sampling data.

The existing conditions were assessed by reviewing publicly available information (desktop review) supported by site walkovers and preliminary site investigations, which involved collection of soil and groundwater samples for analysis for contamination. The investigation process is detailed below.

5.3.1 Desktop review

Key elements of the desktop review were:

- Review of current and historic land uses, utilising publicly available literature, to identify potentially contaminating land uses and areas of interest. This includes review of:
 - General history of the study area via online search engines
 - Review of EPA Victoria's Landfills Register which lists all current and known closed landfills in Victoria
 - Comparison of 1945 and current aerial photographs to identify likely industrial commercial sites and quarries or landfills – this was followed by a more detailed review of a series of historical aerial photos at locations identified as being of potential interest for further assessment
 - Historical certificate of titles from sites identified as being of potential interest for further assessment (that is, not the full alignment)
 - Potential for current/historic landfills in the study area based on review of historical Melway maps, EPA Victoria records and historical aerials
 - Review of data held by VicRoads and local council (landfill data where available)
 - Internet search for selected sites where historic land use could not be ascertained.
- Assess the potential for acid sulfate soil/rock conditions via a review of the web-based hazard assessment tool, the *Atlas of Australian Acid Sulfate Soils*. The tool is available on the *Australian Soil Resource Information System* (AIRIS) which provides information about the distribution and properties of coastal and inland acid sulfate soil across Australia.
- Review of Groundwater Quality Restricted Use Zones (GQRUZ) located within the study area, as declared by EPA Victoria.

- Review of EPA Victoria's list of issued Certificates and Statements of Audit. This was initially undertaken to identify the distribution of Environmental Audits undertaken in the study area. Environmental Audits identify specific areas of land on which a Statutory Environmental Audit was conducted. These audits are conducted in response to the identification of contamination that might create a risk to human health or the environment or might impact the uses of that land. It was necessary to review these areas to assess their potential impacts on activities associated with North East Link.
- Review of EPA Victoria's Priority Sites Register to identify the number of potentially contaminated sites in the study area.

5.3.2 Preliminary field investigations

Key elements of preliminary field investigation were as follows:

- Inspection of the proposed alignment and adjacent areas that were identified through desktop review to have a higher potential for contamination. The inspection of these areas was undertaken from 19 to 22 February 2018, and on 19 March 2018. The inspection, which included publicly accessible land only, had the objective of identifying any visual indications of contamination potential, assessing logistics and access constraints for future drilling programs and confirming information obtained through desktop review.
- Monitoring of surface methane emissions and subsurface pits from former landfills (Borlase Reserve, Bulleen Oval, AK Lines Reserve, M80 Ring Road/Greensborough Bypass) using a laser spectrometer (calibrated to 1 part per million [ppm] for methane).
- Inspection of former landfills (Borlase Reserve, Bulleen Park, AK Lines Reserve, M80 Ring Road/Greensborough Bypass) identified by the desktop review were conducted on 8 March 2018. The walkover, which included publicly accessible land only, had the objective of identifying the possible extents and any visual signs of historical landfilling activity and confirming information obtained through desktop review. As of 7 September 2018, the field program to assess presence of contamination included:
 - Drilling and sampling of soil from 113 soil bores (Element 1 – 18 bores, Element 2 – 71 bores and Element 3 – 24 bores). Samples were collected from between 0.1 and 7.95 metres below ground level (mbgl)
 - Sampling of 18 soil samples and 83 rock samples from 53 bores across the study area specifically to assess for the potential of encountering actual or potential acid sulfate soil/rock during construction. Samples were collected from between 0.5 and 48 mbgl
 - Installation of 16 groundwater monitoring wells in areas identified through desktop review to have higher potential for contamination. The areas of interest included the commercial/industrial areas in Bulleen and Watsonia
 - Sampling of 51 new and existing groundwater wells for potential contaminants of concern
 - Analysis of the results of 309 primary soil samples received from the laboratories (Element 1 – 39 samples, Element 2 – 222 samples and Element 3 – 48 samples)
 - Analysis of 55 primary groundwater results received from the laboratories
- Geophysical electromagnetic (GEM) survey at Bulleen Oval was conducted between 23 and 24 April 2018 to assist with delineating the possible extent of landfill.

- Soil sampling program at Bulleen Oval, which consisted of 22 soil samples collected from at surface to 4.5 metres below ground level (mbgl), from four bores to assess presence of contamination at the former landfill. Due to the presence of elevated metals in soil samples collected at the former landfill, an additional assessment was completed at Bulleen Oval. The additional soil sampling program at Bulleen Oval consisted of 63 soil samples collected from surface to 5.0 mbgl from 10 bores to further assess the extent and delineated the presence of contamination at the former landfill. Borehole and sample numbers from Bulleen Oval are included in the aforementioned totals.

5.4 Risk assessment

An environmental risk assessment has been completed to identify environmental risks associated with construction and operation of North East Link. The risk-based approach is integral to the EES as required by section 3.1 of the scoping requirements and the *Ministerial guidelines for assessment of the environmental effects under the Environment Effects Act 1978*.

Specifically the EES risk assessment aimed to:

- Systematically identify the interactions between project elements and activities and assets, values and uses
- Focus the impact assessment and enable differentiation of significant and high risks and impacts from lower risks and impacts
- Inform development of the reference project to avoid, mitigate and manage environmental impacts
- Inform development of EPRs that set the minimum outcomes necessary to avoid, mitigate or manage environmental impacts and reduce environmental risks during delivery of the project.

This section presents an overview of the EES risk assessment process. EES Attachment III Environmental risk report describes each step in the risk assessment process in more detail and contains a consolidated risk register.

This technical report describes the risks associated with the project on [technical discipline]. Wherever risks relating to this study are referred to, the terminology 'risk XX01' is used. Wherever EPRs relating to this study are referred to, the terminology 'EPR XX1' is used. The risk assessment completed for this study is provided as Appendix N.

5.4.1 Risk assessment process

The risk assessment process adopted for North East Link is consistent with AS/NZS ISO 31000:2009 *Risk Management Process*. The following tasks were undertaken to identify, analyse and evaluate risks:

- Use existing conditions and identify applicable legislation and policy to establish the context for the risk assessment
- Develop likelihood and consequence criteria and a risk matrix
- Consider construction and operational activities in the context of existing conditions to determine risk pathways
- Identify standard controls and requirements (Environmental Performance Requirements (EPRs)) to mitigate identified risks
- Assign likelihood and consequence ratings for each risk to determine risk ratings considering design, proposed activities and standard EPRs.

While there are clear steps in the risk process, it does not follow a linear progression and requires multiple iterations of risk ratings, pathways and EPRs as the technical assessments progress. Demonstrating this evolution, a set of initial and residual risk ratings and EPRs are produced for all technical reports. Figure 5-2 shows this process.

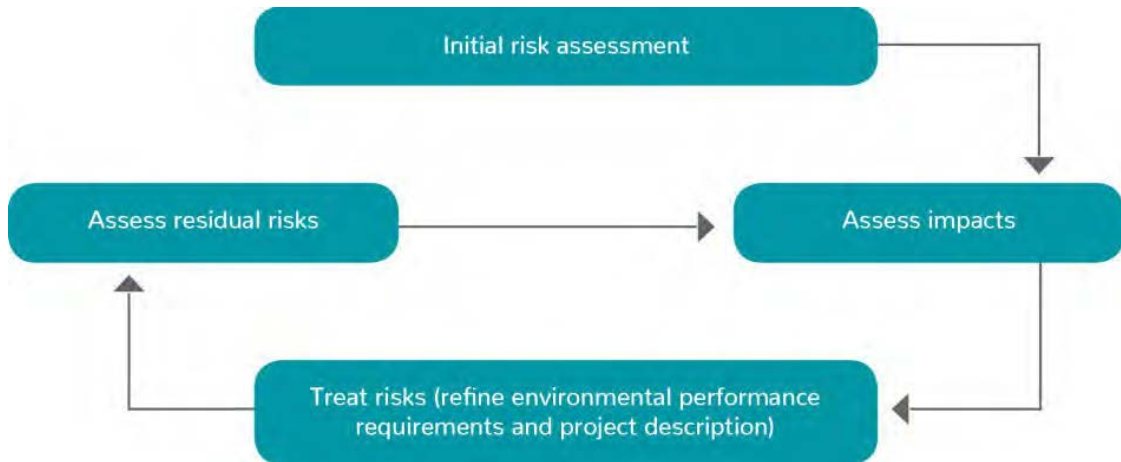


Figure 5-2 Risk analysis process

Rating risk

Risk ratings were assessed by considering the consequence and likelihood of an event occurring. In assessing the consequence, the extent, severity and duration of the risks were considered. These are discussed below:

Assigning the consequences of risks

‘Consequence’ refers to the maximum credible outcome of an event affecting an asset, value or use. Consequence criteria as presented in Chapter 4 – EES assessment framework, were developed for the North East Link EES to enable a consistent assessment of consequence across the range of potential environmental effects. Consequence criteria were assigned based on the maximum credible consequence of the risk pathway occurring. Where there was uncertainty or incomplete information, a conservative assessment was made on the basis of the maximum credible consequence.

Consequence criteria have been developed to consider the following characteristics:

- Extent of impact
- Severity of impact
- Duration of threat.

Severity has been assigned a greater weighting than extent and duration as this is considered the most important characteristic.

Each risk pathway was assigned a value for each of the three characteristics, which were added together to provide an overall consequence rating.

Further detail on the consequence criteria are provided Chapter 4 – EES assessment framework.

Assigning the likelihood of risk

‘Likelihood’ refers to the chance of an event happening and the maximum credible consequence occurring from that event. The likelihood criteria are presented in Table 5-1.

Table 5-1 Likelihood of an event occurring

Planned	The event is certain to occur
Almost certain	The event is almost certain to occur one or more times a year
Likely	The event is likely to occur several times within a five-year timeframe
Possible	The event may occur once within a five-year timeframe
Unlikely	The event may occur under unusual circumstances but is not expected (ie once within a 20-year timeframe)
Rare	The event is very unlikely to occur but may occur in exceptional circumstances (ie once within a 100-year timeframe)

Risk matrix and risk rating

Risk levels were assessed using the matrix presented in Table 5-2.

Table 5-2 Risk matrix

Likelihood	Consequence				
	Negligible	Minor	Moderate	Major	Severe
Rare	Very low	Very low	Low	Medium	Medium
Unlikely	Very low	Low	Low	Medium	High
Possible	Low	Low	Medium	High	High
Likely	Low	Medium	Medium	High	Very high
Almost certain	Low	Medium	High	Very high	Very high
Planned	Planned	Planned	Planned	Planned	Planned

Planned events

North East Link would result in some planned events, being events with outcomes that are certain to occur (ie planned impacts such as land acquisition), as distinct from risk events where the chance of the event occurring and its consequence is uncertain. Although planned events are not risks, these were still documented in the risk register as part of Attachment III – Risk report for completeness and assigned a consequence level in order to enable issues requiring further assessment or treatment to be prioritised.

These planned events were assessed further through the impact assessment process.

Risk evaluation and treatment

The risk assessment process was used as a screening tool to prioritise potential impacts and the subsequent level of assessment undertaken as part of the impact assessment. For example, an issue that was given a risk level of medium or above, or was identified as a planned event with a consequence of minor or above, would go through a more thorough impact assessment process than a low risk.

Where initial risk ratings were found to be ‘medium’ or higher, or were planned events with a consequence of ‘minor’ or higher, options for additional or modified EPRs or design changes were considered where practicable. It should be noted that the consequence ratings presented in the risk register are solely based on the consequence criteria presented in Attachment III – Risk report. Further analysis and evaluation of the impacts potentially arising from both risks and planned events and information on how these would be managed is provided in Section 9.

5.5 Impact assessment

The methodology for the impact assessment included:

- Summarising existing conditions with respect to potentially contaminated land (including landfills), acid sulfate soils and groundwater, including specific information on potential sources of contamination.
- Identifying potential impacts of North East Link's construction and operation, including disturbance of contaminated soil (including landfills) and acid sulfate soils and rocks, treatment and disposal options, spills or leaks, and release of vapours or ground gases.
- Identification of potential receptors of contamination exposed or released to the environment thorough construction and operation activities. These include both human and ecological receptors including local residents and surface water receiving bodies.
- Identification of the migration pathways and exposure routes by which contamination exposed or released by construction or operation activities enters human and ecological receptors. Possible exposure routes for humans and terrestrial and aquatic organisms are ingestion, inhalation and/or dermal sorption. Each are dependent of the chemical involved and its properties.
- Identification of approaches to manage any other wastes encountered or generated during project construction.
- Preparation of a Spoil Management Strategy and a more task-specific Spoil Management Plan to provide guidance for performance-based standards for spoil disposal and management, taking into account EPA Victoria's waste hierarchy – including a preliminary spoil volume estimate and preliminary classification of potential contaminated soil and acid sulfate soil and rock that might be expected to be encountered during construction.

5.6 Rationale

The methodology selected for the investigation is consistent with the guidance provided in the ASC NEPM. The approach was selected to obtain information relevant to potential contamination of land and groundwater across a broad physical area, with no intrusion into private property and minimal public disturbance.

The level of investigation was designed to be suitable for an EES, taking into account the limitations noted in Section 5.7. Where uncertainty remains based on the limitations, the contractor would need to address these in their proposed works plan.

5.7 Limitations, uncertainties and assumptions

The following limitations apply to information in this assessment:

- The desktop study was based on our understanding of conditions that existed at the time of the assessment, as assessed from publicly and readily available information. Its findings and conclusions may be affected by the passage of time, by man-made events (such as construction on or adjacent to the project boundary) and by new releases of contaminants into the environment.

- Historic land use information presented is generally limited to information obtained from local council reports and aerial photographs taken during the late 1940s to mid-1950s. Additional and more recent historical aerial photographs were sourced for identified areas of interest including: in the vicinity of the Bulleen Road and Manningham Road intersection; Watsonia railway station; Simpson Barracks; and former landfill/fill sites identified to be near North East Link.
- The compiled data does not necessarily include all landfill sites. As acknowledged by EPA Victoria, there is a lack of consolidated data on the past life cycles of Victorian landfills. It is noted that landfill sites in and around Melbourne are predominantly former quarry sites (clay pits, sand pits and other large voids) and have tended to be converted into parks or reserves (Taylor, 2013). However, it is considered there is little likelihood of encountering additional landfills along the alignment other than those discussed in this assessment.
- Although the information obtained from Atlas of Australian Acid Sulfate Soils (ASS) map classified the study area as low and extremely low probability of acid sulfate soil occurrence, CSIRO also noted the classification to be provisional, as analytical data was not available when the plan was prepared. Further assessment of acid sulfate conditions may be required.
- The Priority Sites Register (based on EPA Victoria data dated 31 March 2018) does not list all known contaminated sites in Victoria and a site should not be presumed to be free of contamination just because it does not appear on the Register.
- Assessment of historical land use was limited to the 1945 Melbourne aerial photograph comparison website (<<http://1945.melbourne>>), with the exception of the areas of interest and landfill sites.
- The assessment of sites operational at the time of the investigation was limited to the results of a brief internet search and did not involve a site visit or detailed review. No interviews with site owners or operators was undertaken.
- Properties that appeared to be previously and currently used for residential purposes were generally assumed to have a low potential for contamination of soil and groundwater.
- Information in this report is a guide only and more detailed investigations would be required as part of the detailed design and construction of North East Link.
- Investigation locations for assessing land contamination were based on preliminary desktop review and field investigations sited within publicly accessible areas (such as road reserves, car parks and nature strips). Drilling could not be conducted on some private properties due to access and time constraints and many were not scheduled for access at the time of the investigation.
- Interpretation of subsurface conditions and the nature and extent of contamination is based on field observations and laboratory analytical data from widely-spaced sampling locations.

This report details the findings of a desktop study and preliminary sampling program. It is recognised this represents a relatively early stage of the project. As with all projects of this size, further information would need to be obtained to reduce the level of uncertainty and limitations, particularly in relation to the volume of contaminated waste categories. However, the level of information gathered for the assessment is considered adequate for the purpose of the report stated in Section 1.1; that is to assess the *potential* contamination and soil impacts associated with North East Link to inform preparation of the EES.

5.8 Stakeholder engagement

Stakeholders and the community were consulted to support the preparation of the North East Link EES and to inform the development of the project and understanding of its potential impacts. Specific engagement activities in relation to contamination and soil are listed in Table 5-3, with more general engagement activities occurring at all stages of the project. Feedback received during community consultation sessions is summarised in Section 5.9.

Table 5-3 Stakeholder engagement undertaken for contamination and soil

Activity	When	Matters discussed	Outcome
Communication with VicRoads	20 February 2018	Available environmental data from the soil mounds along M80 Ring Road	<ul style="list-style-type: none"> Data was provided for review
Communication with Manningham City Council	4 April 2018	Sought information on a former landfill located at Bulleen Oval and a former quarry located near Rocklea Road, Bulleen	<ul style="list-style-type: none"> Received geotechnical and environmental site assessment reports for the former landfill located at Bulleen Oval and anecdotal evidence that a former quarry was located near Rocklea Road, Bulleen
Communication with Banyule City Council	4 April 2018	Sought information on former landfills located at AK Lines Reserve, Watsonia and Borlase Reserve, Yallambie	<ul style="list-style-type: none"> Received the Municipality contaminated land register, which identified AK Lines Reserve as former landfill
Communication with Boroondara City Council	21 May 2018	Sought information on a former landfill located at Musca Street Reserve and Freeway Public Golf Course, Balwyn North	<ul style="list-style-type: none"> Anecdotal evidence was provided that a landfill is located at Musca Street Reserve and Freeway Public Golf Course, Balwyn North
Communication with Whitehorse City Council	13 June 2016	Sought information on a former landfill located at Koonung Creek Linear Park (Eram Park), Box Hill North	<ul style="list-style-type: none"> Evidence was provided that a landfill is located at Koonung Creek Linear Park (Eram Park), Box Hill North
Communication with VicRoads	2017 to 2018	Geotechnical data was requested	<ul style="list-style-type: none"> Provision of geotechnical reports which included information on contaminated sites and former landfills
Communication with Caltex	5 April 2018	Sought historical groundwater monitoring data and/or access to site to sample existing groundwater monitoring wells	<ul style="list-style-type: none"> Request denied.
Communication with Viva Energy Australia	5 April 2018	Sought historical groundwater monitoring data and/or access to site to sample existing groundwater monitoring wells	<ul style="list-style-type: none"> Request denied
Communication with United Energy Petroleum	5 April 2018	Sought historical groundwater monitoring data and/or access to site to sample existing groundwater monitoring wells	<ul style="list-style-type: none"> Advised no groundwater monitoring wells onsite

5.9 Community feedback

In addition to consultation undertaken with specific stakeholders, consultation has been ongoing with the community throughout the design development and EES process. The key feedback received through consultation relevant to the contamination and soil assessment is summarised in Table 5-4, along with where topics are addressed in this report.

Table 5-4 Community consultation feedback addressed by contamination and soil

Issues raised during community consultation	How it's been addressed
Concerns about contamination of groundwater during tunnel construction.	<p>An assessment of the potential for contamination to exist is covered in Section 9 of this report, and the potential for mobilisation of contaminants in groundwater are covered by Technical report N – Groundwater.</p> <p>Based on the existing conditions assessment in Section 9 limited soil and groundwater contamination has been identified along the alignment. Where potential for contamination has been identified this would be managed through the EPRs listed in Section 10.</p>
Concerns about the disturbance of asbestos across the project boundary and requests for more information about how risks would be managed and materials that contain asbestos identified, safely handled, transported and disposed of.	<p>It is acknowledged through the discussion in Section 9 of this report that there is the potential for asbestos-containing materials (ACM) to be present at limited locations along the alignment.</p> <p>Where earthworks are undertaken in accordance with a Spoil Management Plan (EPR CL1) the risk to human health and the environment is able to be minimised. Furthermore EPR CL5 would require any asbestos encountered to be disposed in accordance with Industrial Waste Management Policies, regulation and relevant guidelines.</p>

6. Existing conditions

This section describes the existing or current conditions for the study area (defined in Sections 3.1 and 5.2) at the time of writing this report. A summary of existing or current conditions for each project element is provided:

- Element 1 – M80 Ring Road to northern portal
- Element 2 – Northern portal to southern portal
- Element 3 – Eastern Freeway.

6.1 Desktop review of existing conditions

6.1.1 Geology, hydrology and hydrogeology

A comprehensive description of the geology and hydrology along North East Link is provided in Technical report N – Groundwater. A summary is provided below.

Geology

A description of the key formations which occur within each element of the study area is summarised below.

M80 Ring Road to northern portal

In the western section of this element, Older Volcanics basalt (Greensborough Basalt) has been mapped in outcrop. Smaller outcrops of Older Volcanic and Newer Volcanic basalt have also been mapped in the eastern part of this element near the intersection of the Greensborough Bypass and Diamond Creek Road. Sub-basaltic sediments (Brighton Group equivalents) have also been mapped in isolated areas where North East Link intersects with the M80 Ring Road/Greensborough Bypass, and further east near Diamond Creek Road.

These basalts and sediments form a thin cover over the Palaeozoic bedrock, which outcrops over much of this element, particularly near the M80 Ring Road, and south towards Yallambie Road and the junction with the northern portal to southern portal element. The bedrock was deposited during the Silurian and Devonian periods and have been differentiated regionally as the Anderson Creek, Melbourne, and Humevale Formations.

Alluvial and colluvial sediments have been mapped along the Plenty River, but these tend to be laterally restricted and in close association with the river and are not encountered in this element.

Northern portal to southern portal

The surface geology of this element is mostly within the Palaeozoic bedrock, except in those areas near the Yarra River floodplain where alluvial sediments rest upon the bedrock. South of Yallambie Road towards Banksia Street/Manningham Road the Palaeozoic bedrock outcrops.

The bedrock rock is buried beneath Quaternary alluvial sediments within the floodplain of the Yarra River, where the topography is flatter. South of Banksia Street/Manningham Road to the Eastern Freeway, North East Link is aligned approximately parallel to the Yarra River floodplain. The Palaeozoic bedrock is exposed in higher elevations, otherwise it is buried beneath the sediments.

At the southern end of this element, near the intersection of the Eastern Freeway and North East Link, the alluvial sediments are of broader extent where the Koonung Creek floodplain joins the Yarra River floodplain.

Eastern Freeway

The geology along the Eastern Freeway element comprises mostly of shallow Quaternary alluvial sediments, as the freeway is generally located within, or on the margins of the floodplain of the Yarra River or Koonung Creek. These alluvial sediments form a thin cover over the Palaeozoic bedrock; but where absent, the bedrock outcrops in some sections of the element. At the western end of the element (Yarra Bend Park and further west), the freeway is located upon Newer Volcanic basalts. A small outcrop of Brighton Group sediments is mapped on the western side of the Chandler Highway.

A plan showing the geology along North East Link is provided in Figure 6-1.

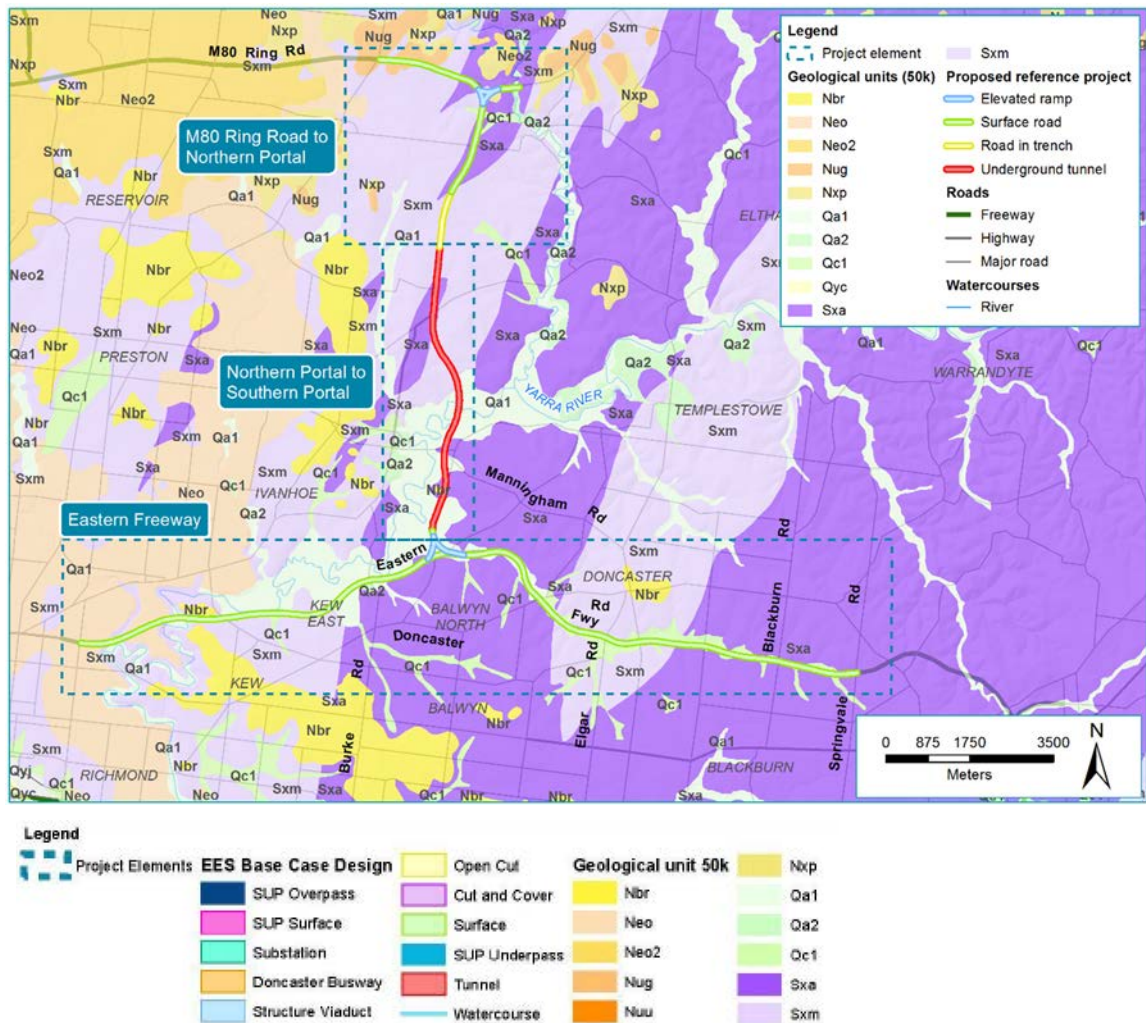


Figure 6-1 Geology of the proposed North East alignment

Topography and drainage

The Palaeozoic bedrock forms undulating, rolling hills, which have been dissected by the Yarra River and its floodplain. The topography is highest around the M80 Ring Road to northern portal element, extending to over 100 metres above sea level.

The topography results in drainage towards the Yarra River floodplain, which generally lies 10 to 20 metres above sea level in the northern portal to southern portal element. Some of the larger drainage lines form permanent or ephemeral waterways and these waterways are summarised in Table 6-1. Further information on waterways is presented in Technical report P – Surface water.

The Yarra River and Bolin Bolin Billabong are considered to be partly recharged by groundwater.

Table 6-1 Study area drainage

Element	Waterway	Description
M80 Ring Road to northern portal	Plenty River	Eastern extent of element ends at Plenty River. The river parallels much of the element, but is offset to the east by typically 1 km or more.
	Salt Creek	Drainage line extends within the Palaeozoic bedrock, offset to the west of the alignment and drains southwards towards before joining with the Yarra River near Banksia Street.
Northern portal to southern portal	Banyule Creek	Drainage line extends within the Palaeozoic bedrock and drains southwards towards before joining with the Yarra River near Banyule Swamp.
	Yarra River	TBM passes beneath Yarra River north Banksia Street/Manningham Road, and then parallels the southern extent of this element.
	Koonung Creek	Parallels much of the east of the Eastern Freeway element (south side of Eastern Freeway) before joining with the Yarra River near Bulleen Road.
Eastern Freeway	Yarra River	Parallels much of the western extent of the element and bridged near the western end of the element.

Hydrogeology

All the geological units described above constitute aquifers to varying degrees. From a high level hydrogeological perspective it is possible to simplify the various geologies into two basic aquifer systems:

1. Fractured Rock Aquifers including the Silurian – Devonian indurated sediments, such as Anderson Creek Formation, Melbourne Formation and Humevale Formation and basalts of the Newer Volcanics and Older Volcanics. The primary porosity (pore spaces between sedimentary grains) of these units is very low and groundwater is (mostly) transmitted by secondary porosity flow mechanisms such as fractures, joints and faults. The fractured rock aquifer occur in each of the three project elements.
2. Porous Media including the Tertiary Brighton Group and the Quaternary (alluvial and colluvial) sediments. Within porous media aquifers groundwater stored and transmitted by primary porosity flow; that is, flow between the interstices and pore spaces of the sedimentary grains. The sediments are potentially more permeable than the fractured rock aquifers, and therefore groundwater flows are potentially higher when they are intersected. The Brighton Group sediments are suspected as underlying the Newer Volcanic basalt and are identified in the western parts of the study area. Quaternary sediments constitute a key aquifer in the study area. The alluvials are laterally restricted to the present day drainage lines and waterways, and in some cases can have high degree of interaction with waterways. Under these conditions, disturbance of groundwater in these sediments has potential environmental implications.

In summary, the depth to groundwater measured over the study area between September 2017 and April 2018 ranged from approximately:

- 7 to 22 mbgl in Element 1
- 3 to 14 mbgl in Element 2
- 3 mbgl in Element 3 (NOTE – this is based on one well NEL_BH072 as more recent wells have not been monitored at the time of this report).

The decrease in depth to groundwater from north to south reflects the fall in land elevation towards the south.

Groundwater flow directions generally mimic topography and flow towards significant surface receiving water bodies. It is expected that groundwater flows in a predominantly southerly direction in Element 1 with a more complex pattern closer to the Yarra River in Elements 2 and 3.

Further detail on aspects of the hydrogeology of the study area are provided in Technical Report N – Groundwater.

6.1.2 Groundwater use

A search was conducted on the State Groundwater Database for existing licensed private groundwater wells within a 1 kilometre radius of the reference project alignment. These are summarised in Table 6-2. This search was conducted to assess whether groundwater was be extracted for any use along the alignment and whether this might be impacted by North East Link.

Table 6-2 Results of private groundwater well search

Registered use	Elements			Totals
	M80 Ring Road to northern portal	Northern portal to southern portal	Eastern Freeway	
Groundwater investigation	0	0	37	37
Stock and domestic	0	3	4	7
Use not known	11	9	52	72
Miscellaneous	0	1	0	1
Irrigation	1	0	0	1
Commercial	0	1	0	1
Observation	1	8	79	88
Total	13	22	172	207

The location of these wells is shown on Figure 6.8 in Technical Report N – Groundwater. A reproduction of the figure is shown in Figure 6-2.

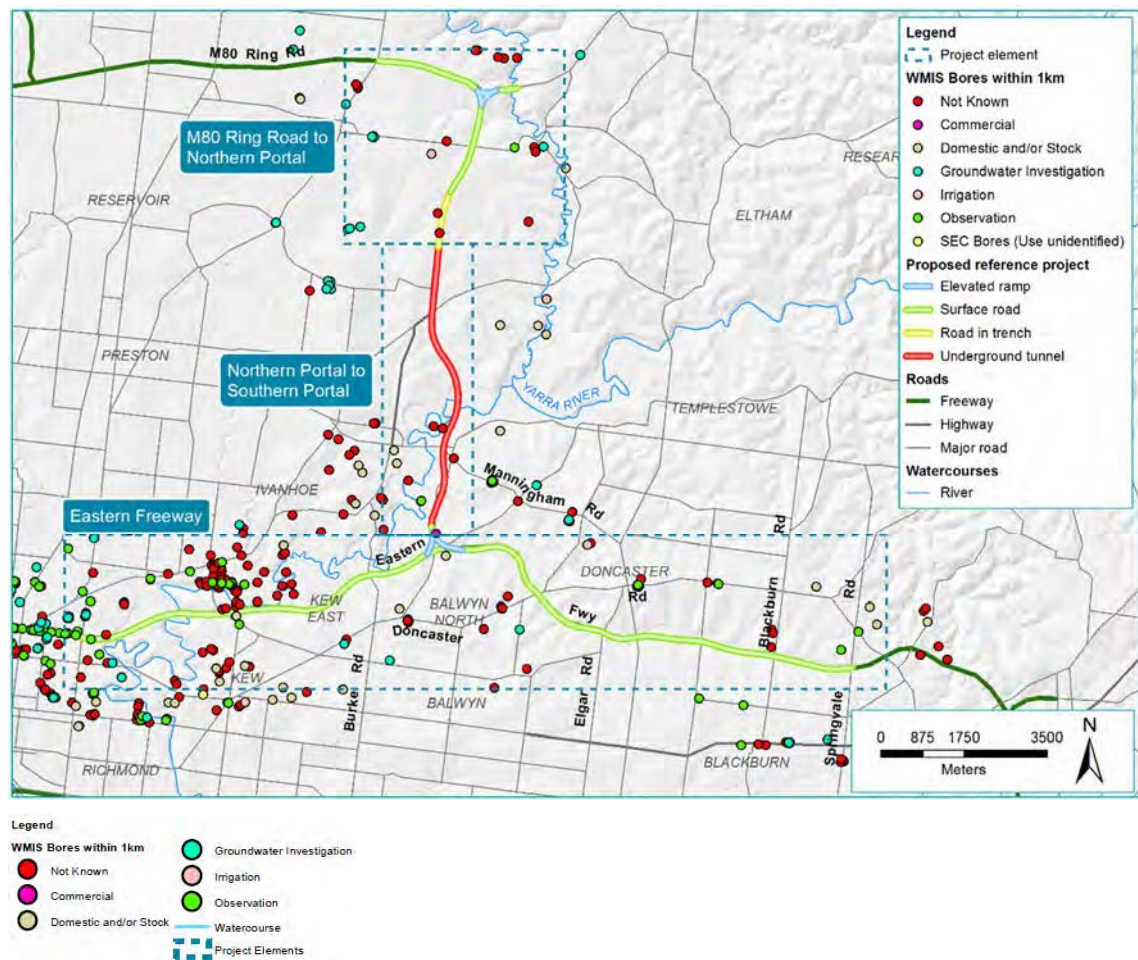


Figure 6-2 Registered private groundwater wells in the vicinity

6.1.3 Existing and historic land uses

Review of publicly available information and selected aerial photographs indicated that existing land uses within the study area includes:

- Residential
- Educational institutions
- Rivers, parks and reserves
- Community and sporting facilities
- Simpson Barracks
- Commercial/industrial including fuel service station
- Freeways, arterial and municipal roads.

The existing land uses are considered to have a relatively low potential for soil and groundwater contamination with the exception of commercial/industrial areas, fuel service stations, Simpson Barracks and potential former landfill/fill sites. Current zoning and planning overlays are described in Technical Report E – Land use planning.

Most large-scale potentially contaminating activities are likely to have occurred in industrial/commercial environments. The risk of contamination from industrial/commercial land use typically increases with age, due to both historically poor environmental practices and accumulation of contaminants over time. Therefore, land currently zoned industrial/commercial or with an industrial/commercial history, have been identified as having an increased potential for contamination.

Within the study area, the majority of sites with an increased potential for contamination were identified in the vicinity of the Bulleen Road and Manningham Road intersection, Bulleen, the Watsonia Road area, Watsonia and the fuel service station located on Greensborough Road, Yallambie. These areas are presented in Figure 6-3, Figure 6-4, Figure 6-5 and are summarised in Table 6-3 below.

No currently operating landfills have been identified within the project boundary.

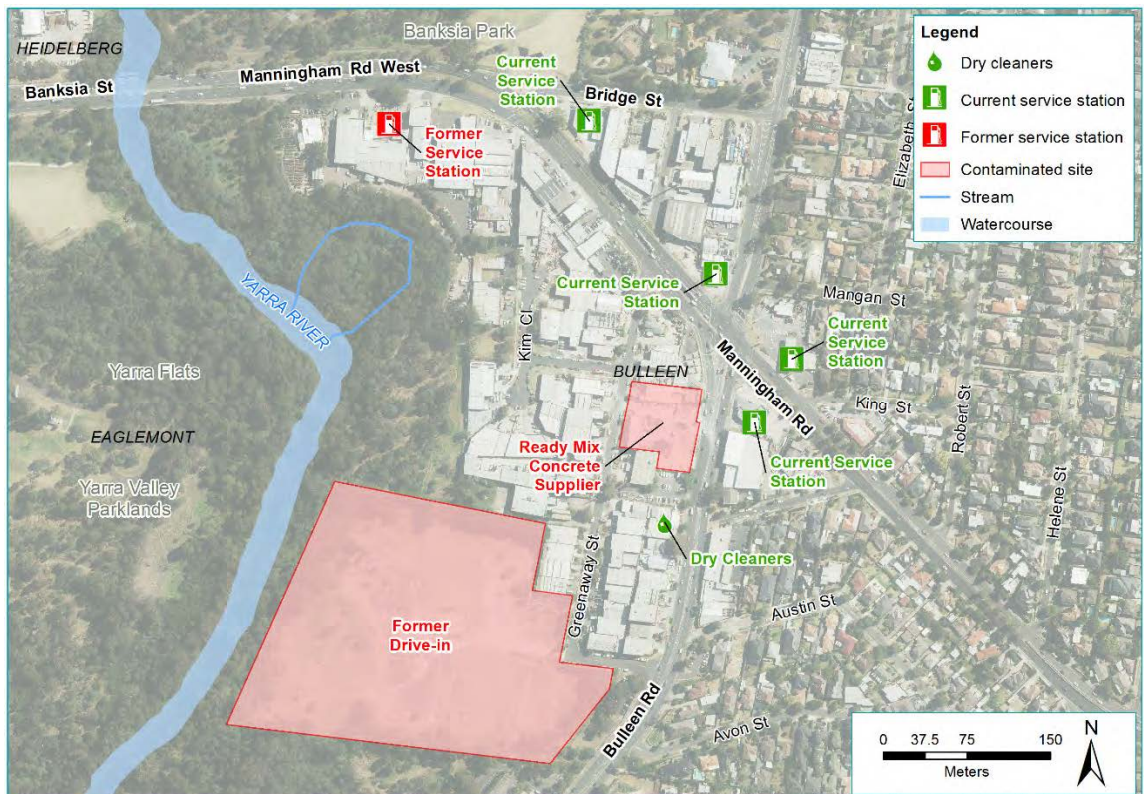


Figure 6-3 Industrial area at Manningham Road and Bulleen Road intersection



Figure 6-4 Watsonia railway station and adjacent industrial/commercial area



Figure 6-5 Fuel service station at the corner of Greensborough Road and Yallambie Road, Yallambie

Table 6-3 Potentially contaminated areas and contaminating activities

Commercial/Industrial area	Existing site activity with potential for contamination
Watsonia commercial and railway area	Dry cleaner.
	One active fuel service station and two former fuel service stations.
	Automotive service/repair centre.
	Car rental.
	Timber & Hardware.
	Watsonia Zone Substation (Electricity).
	Railway line/car park.
Yallambie – Simpson Barracks area	One active fuel service station.
	According to the Defence website, Simpson Barracks was established in the 1940s and occupies approximately 22 hectares of land. Potential or known contaminating activities include bulk fuel storage and distribution, former sewage treatment plant, battery stores and several landfills that have been used to dispose waste from Defence operations. According to the website, the only known contamination issue relates to buried asbestos-containing material (ACM) which have been identified “in many locations across the property”.
Bulleen	Four active fuel service stations and one former fuel service station.
	Automotive service/repair centre/spray painting (multiple properties).
	Vehicle storage yard.
	Mower sales/service centre.
	Demolition and salvage.
	Dry cleaner.
	Ready mix concrete supplier.
	Landscape suppliers.

Historical aerial photographs

Historical photographs from ‘1945 to now’ (Melbourne 1945 Website), covering the entire project boundary, were obtained and reviewed to identify historic land use. Representative aerial photographs for each decade from 1945 to 2014 were obtained for areas surrounding Watsonia, Yallambie, Bulleen, the Eastern Freeway, as well as landfills listed below.

A copy of the aerial photographs are provided in Appendix B. It is noted that image resolution of aerial photographs can vary significantly and as a result, there are uncertainties in interpretation. Interpretation of the aerial photographs are presented in Appendix C. A summary of the main findings of the aerial photograph assessment is provided below.

Historical review of landfills is discussed in Section 6.1.4.

Recent and historical certificates of title

Selected historical title certificates were sourced and reviewed to assist in interpretation of aerial photographs and to provide further information on activities that may contribute to contamination of land. Sites where historical certificates of title were reviewed is summarised in Table 6-4 below. A summary of the title search and copies of the historical certificates of title is provided in Appendix D.

Table 6-4 Historical title review

Properties Address	Lot Plan
254 Greensborough Rd, Macleod	1/TP174834
10 Manningham W Rd. Bulleen	1/TP818236
14 Manningham W Rd. Bulleen	1/TP365553
18 Manningham W Rd. Bulleen	1/TP556906
22 Manningham W Rd. Bulleen	1/TP89520
26 Manningham W Rd. Bulleen	1/LP126108
4 Greenaway St, Bulleen	10/LP10781
4 Greenaway St, Bulleen	11/LP10781
31 Greenaway St, Bulleen	51/LP10781
36 Greenaway St, Bulleen	TP577782
38 Greenaway St, Bulleen	PS514950
219 Bulleen Rd, Bulleen	10/PS346271

Historical investigation records

Two reports were obtained from VicRoads with environmental data pertaining to the northernmost section of North East Link along the M80 Ring Road between Plenty Road and Greensborough Highway. The reports were titled *Metropolitan Ring Road Plenty Road to Greensborough Highway Site Conditions Information Report* (VicRoads, 2015a) and *Geotechnical Interpretative Report* (VicRoads, 2015b). The reports were obtained to assess the quality of soils located in embankments/noise mounds along M80 Ring Road (within the project boundary).

According to those reports, nine soil samples collected from selected test pits and boreholes located on the mounds were submitted to an analytical laboratory and analysed for a wide range of potential contaminants. The results of analysis indicated that chromium, nickel and fluoride exceeded the upper thresholds for Fill Material, and all nine soil samples were classified as Category C in accordance with EPA Victoria IWRG621. The reports, however, recommended further investigation to determine whether the identified contaminants are naturally occurring and could therefore be classified as Fill Material.

The assessment did not identify large quantities of potentially contaminated material within the noise mounds (at the locations sampled).

6.1.4 Landfills and fill sites

A summary of the landfills and fill sites identified within the project boundary is provided in Table 6-5. Discussion of the history and environmental setting of each of the landfills is provided below. The location and approximate extent of the landfills with reference to the project elements are shown in Figures 1 to 5 in Appendix A. Exerts from Figures 1 to 5 are reproduced in Figure 6-6 to Figure 6-11. Historical aerial photographs of the landfills are provided in Appendix B and interpretation of the aerial photographs are provided in Appendix C. Figures showing the inferred landfill extent and North East Link overlay on one historical aerial photograph are also provided in Appendix C.

Table 6-5 Former landfills and fill sites

Site	Waste type	Address	Source of information	Approx. filling period
Former Camberwell Landfill	Likely putrescible waste and solid inert waste	Musca Street Reserve and Freeway Public Golf Course, Balwyn North	Melway Publications 1966, 1970, 1971–72, 1975, 1977. Historical aerial photographs. VicRoads Geological Plan and Section through Camberwell City Tip, Drawings 206066 and 206068 (VicRoads 1970).	1966 to 1977
Former quarry	Backfilled with solid inert and putrescible waste material	Junction of the M80 Ring Road and the Greensborough Bypass	VicRoads M80 upgrade project Report No. GR153-05.04.SCI.Rev0. Historical aerial photographs.	1950s
Former landfill	Waste type unknown	AK Lines Reserve, Watsonia	Banyule City Council Contaminated Land Register. Historical aerial photographs.	Late 1950s to mid-1960s
Former landfill	Solid inert waste and possible putrescible waste	Borlase Reserve, Yallambie	VicRoads Report No. MW-91-01-15-01 (VicRoads 2010). Historical aerial photographs. Preliminary drilling investigation.	Early to mid-1960s
Former landfill	Solid inert waste and possible putrescible waste	Bulleen Oval, Bulleen	Information provided by Manningham City Council. Historical aerial photographs. Preliminary drilling investigation.	Early to late 1960s

Site	Waste type	Address	Source of information	Approx. filling period
Former landfill	Waste type unknown	Junction of Doncaster Road and the Eastern Freeway, Balwyn North – part of Koonung Creek Reserve	Historical aerals and EPA Victoria records.	Late 1970s
Former quarry	Potentially backfilled with uncontrolled fill and waste	Located near Rocklea Road and Yarraleen Place, Bulleen	Historical aerals.	1950s to 1960s
Former landfill	Solid inert waste and putrescible waste	Koonung Creek Linear Park (Eram Park), Box Hill North – north of Eastern Freeway, between Tram Road and Wetherby Road	Historical aerial indicates ground disturbance.	Late 1960s

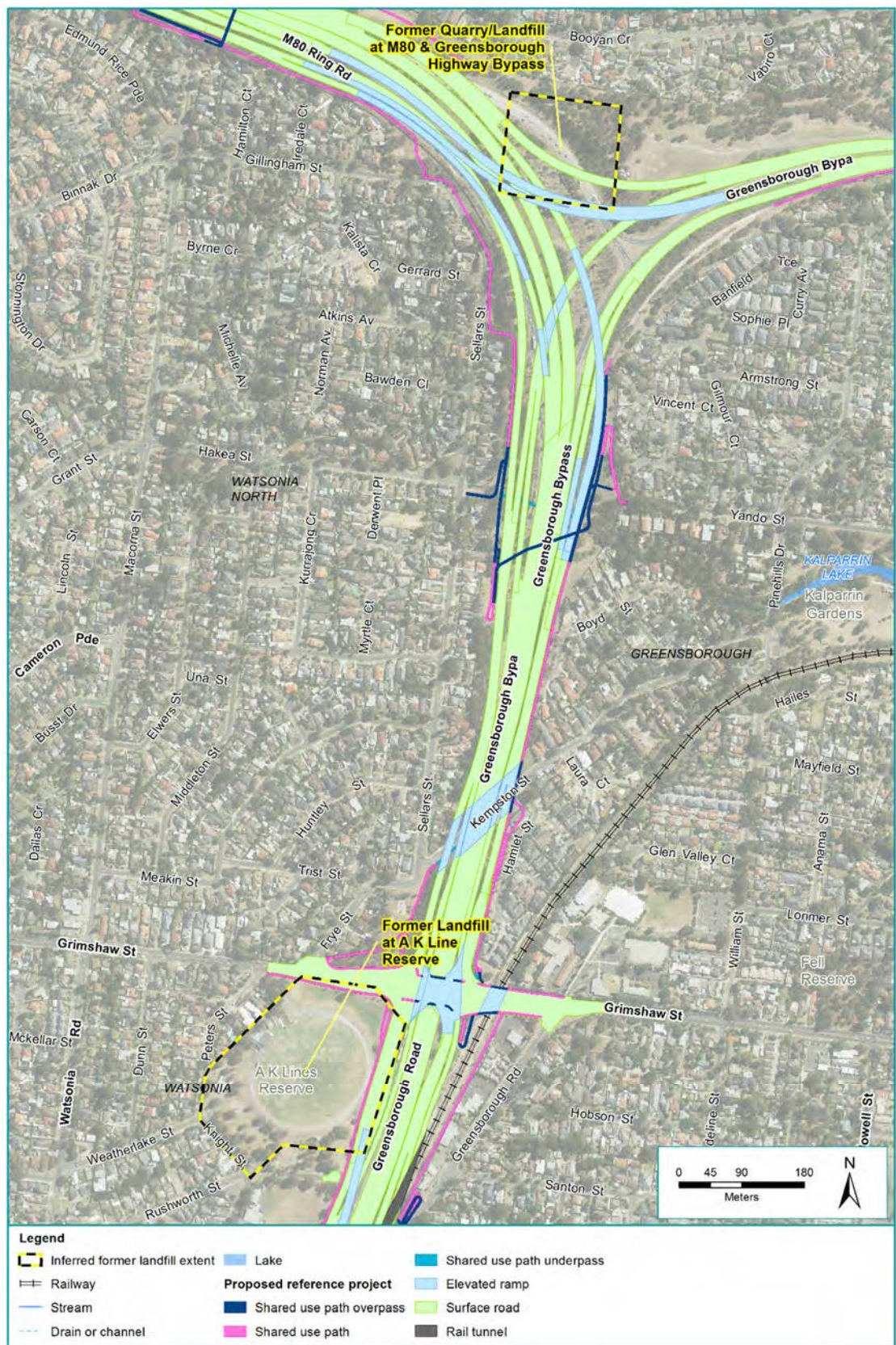


Figure 6-6 Approximate location and extent of the M80 Ring Road/Greensborough Bypass Quarry and Landfill and AK Lines Reserve Landfill, Element 1

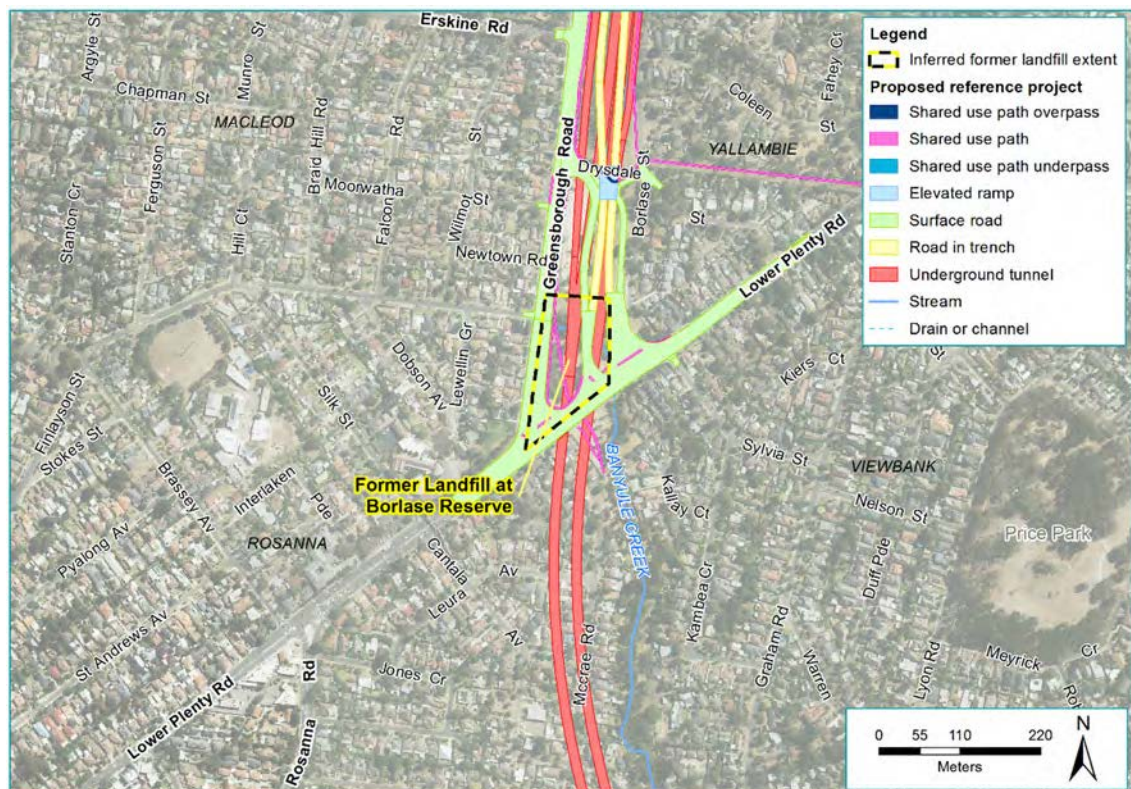


Figure 6-7 Approximate location and extent of the Borlase Reserve former landfill, Element 2

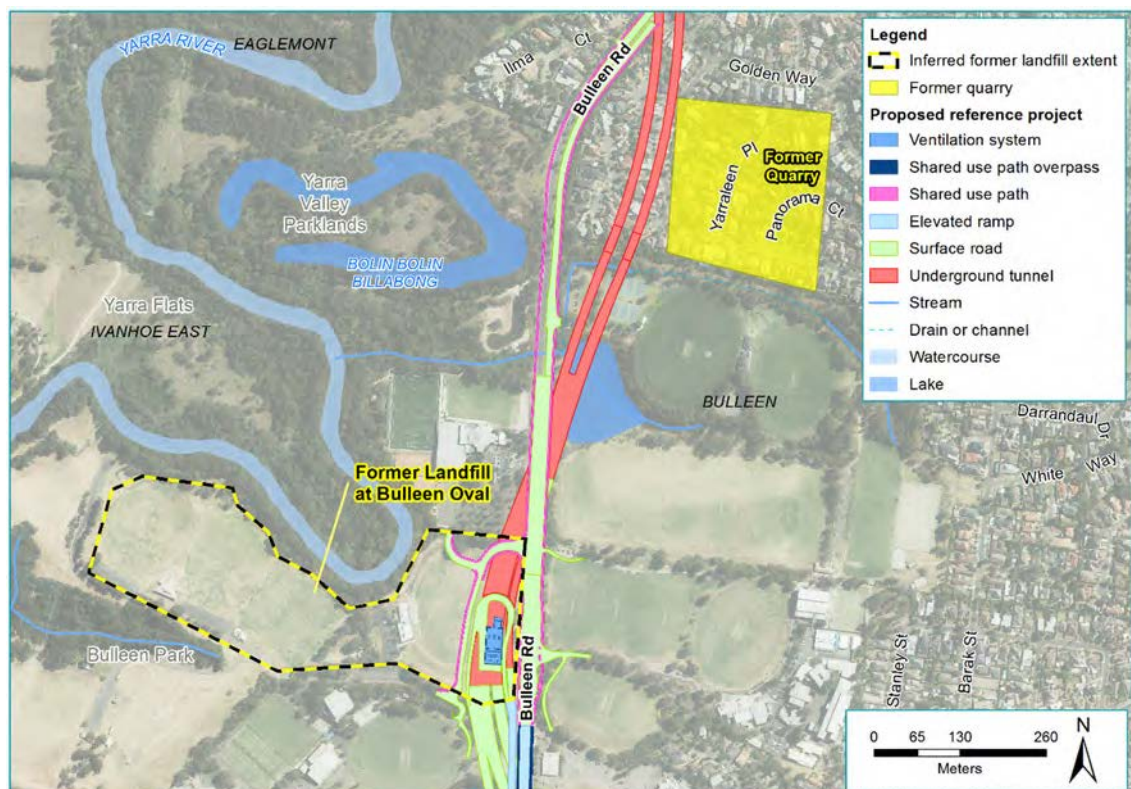
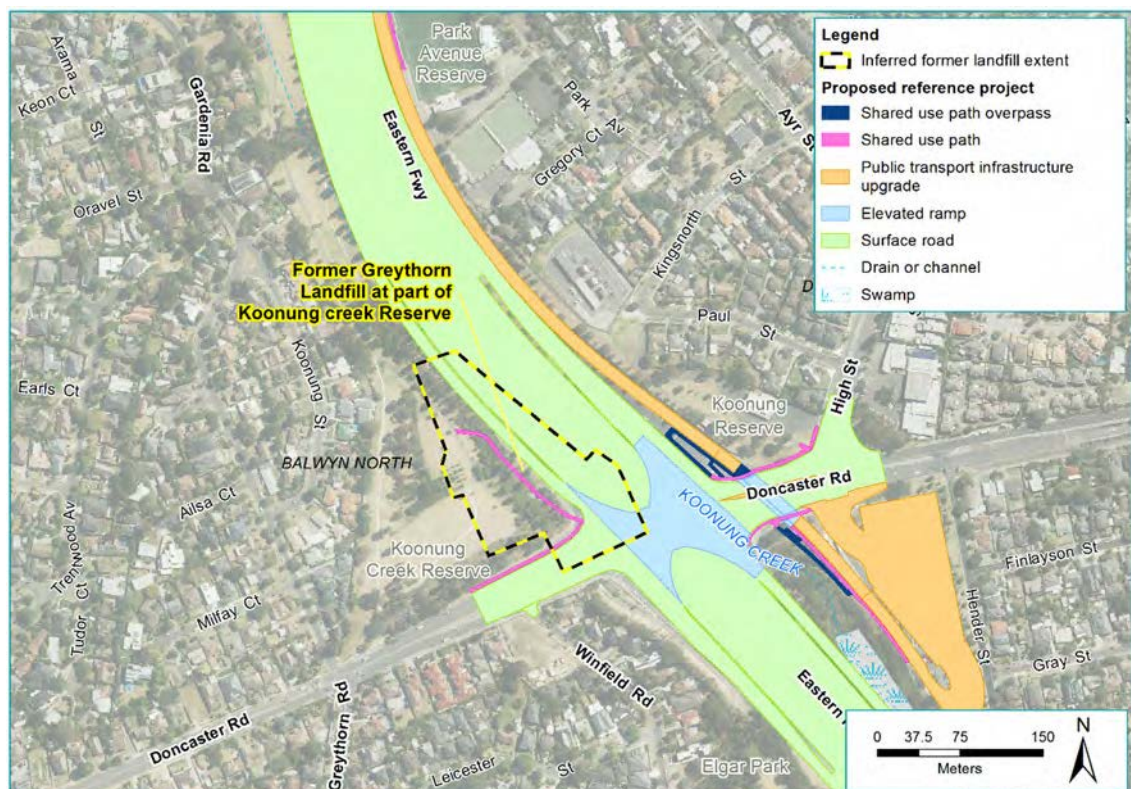
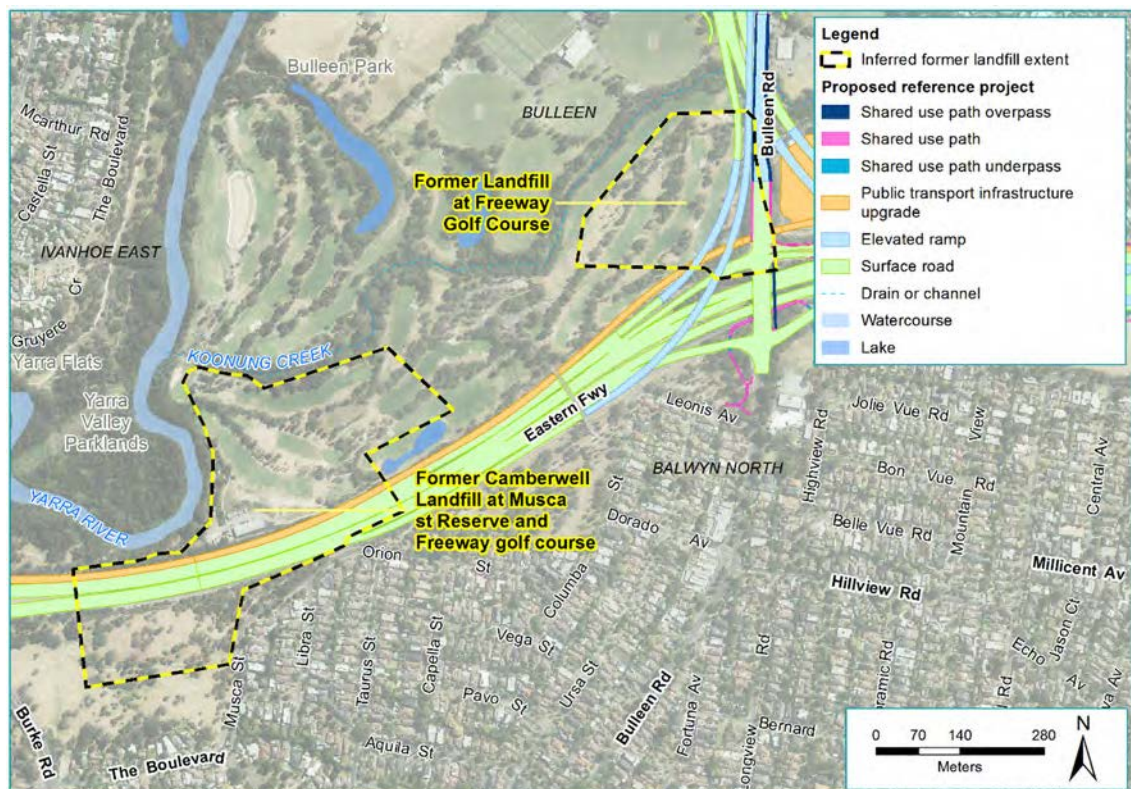


Figure 6-8 Approximate location and extent of former Bulleen Oval landfill and former quarry in the Bulleen area, Element 2



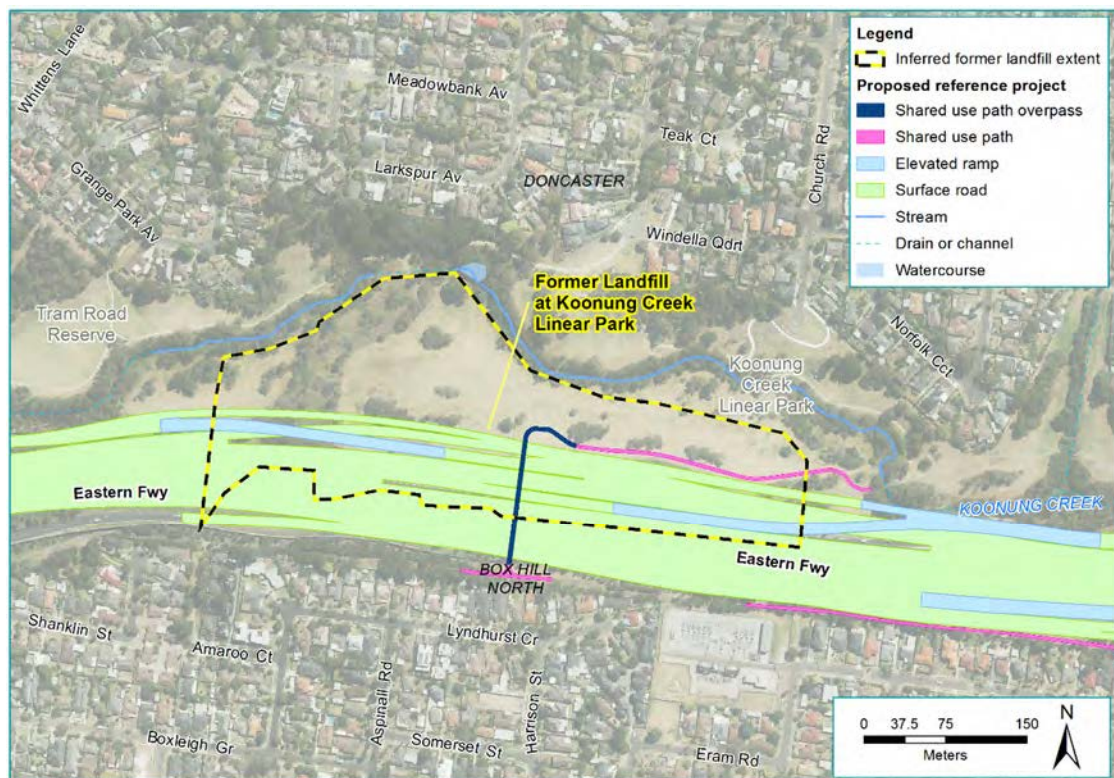


Figure 6-11 Approximate location and extent of the former Koonung Creek Linear Park Landfill, Element 3

Former Camberwell Landfill

The former Camberwell Landfill is located where the current day Musca Street Reserve and Freeway Public Golf Course are situated (based upon historical aerial photographs). Historical Melway maps indicate the former Camberwell Landfill operated from 1966 to 1977.

The project boundary at this location follows the current Eastern Freeway, which is presumed to have been built over the Camberwell Landfill when the freeway was constructed in *circa* 1977. The proposed construction types for this section of North East Link are surface and elevated roads. The current planning zone for the Camberwell Landfill area is predominantly Public Park and Recreation.

VicRoads Geological Plan (Drawing 206066) and Section through Camberwell Landfill (Drawing 206068) (VicRoads 1970) indicates the waste thickness is 5 to 10 metres.

Environmental setting

The area of the former Camberwell Landfill is relatively flat with some undulating hills (~10 metres high) located along the freeway. The majority of the Camberwell Landfill consists of variably sorted, generally unconsolidated alluvial floodplain deposits of gravel, sand and silt. The Anderson Formation is present in some areas along the southern boundary of the Camberwell Landfill, consisting of thick to thin bedded siltstone with minor conglomerate sandstone.

Detailed information from geotechnical investigations undertaken as part of the Eastern Freeway construction (VicRoads 1970) show the geology at the Camberwell Landfill consists of moderately weathered, moderately hard mudstone beneath soft silty clay material, which underlies silty or clayey micaceous sand in some areas of the Camberwell Landfill and soft to medium silty clay sits in others. Fill/waste material appears to have been placed above the silty clays forming the undulating hills, and topsoil placed above the silty clays in other areas of the Camberwell Landfill.

The DELWP Groundwater Resource Report estimates that groundwater at the Camberwell landfill ranges from 5 to 20 metres below ground level (mbgl) with shallower groundwater in the south near the Yarra River. Regional groundwater flow appears to be generally flowing towards the south-east, away from the Yarra River.

Former Bulleen Oval Landfill and Freeway Public Golf Course East Landfill

The former landfill at Bulleen Oval includes Bulleen Oval I, and three sports fields to the west of the football oval. Historical aerials also indicate that filling likely occurred in the eastern portion of the Freeway Public Golf Course, which is situated approximately 200 metres to the south of the Bulleen Oval Landfill. This is confirmed by VicRoads Geological Plan (Drawing 206066) and Section through the Camberwell Landfill (Drawing 206068) (VicRoads 1970), which indicate that filling occurred in the east of Freeway Public Golf Course adjacent Bulleen Road.

Bulleen Oval and the Freeway Public Golf Course are bounded on the east by Bulleen Road. North East Link covers the Bulleen Oval and the east and south-eastern edges of the Freeway Public Golf Course. The construction types proposed at the Bulleen Oval include surface, cut and cover, substation and a shared use path (SUP) surface, and the construction type at the Freeway Public Golf Course includes surface and elevated roads and a small area of open cut and cut and cover. The planning zone for Bulleen Oval is Public Park and Recreation, with the south-eastern corner of the Freeway Public Golf Course also zoned Road – Category 1.

Historical aerial photographs were obtained for 1931, 1945, 1951, 1960, 1968, 1972, 1979, 1987, 1991, 2000, 2009 and 2017. Historical aerial photographs indicate that landfilling operations around the location of Bulleen Oval occurred in the 1960s, with operations starting in approximately 1962 and appearing to have ceased by 1967. An aerial from 1963 indicates the landfill area covered the current day football oval extending to the Yarra River in the west, the current day Veneto Club in the north and to the Bulleen Oval entrance road in the south. Preliminary geotechnical drilling at Bulleen Oval also indicates the landfill likely extended to Bulleen Road in the east.

Environmental setting

The Bulleen Oval and western sports fields are all relatively flat. The western sports field area slopes slightly to the east. The Freeway Public Golf Course appears to be lower than surrounding roads.

The geology in this region belongs to the Quaternary (Holocene) Alluvium (Qa1) overlying Silurian (Wenlock) Andersons Creek Formation (Sxa). The geology over most of the Bulleen Oval is variably sorted and rounded, generally unconsolidated gravel, sand and silt that includes low terrace and alluvial floodplain deposits. The Freeway Public Golf Course consists of thick to thin bedded sandstone and siltstone with minor conglomerate.

The DELWP Groundwater Resource Report estimates that groundwater ranges from 5 to 10 mbgl, except in the south-eastern corner of the Freeway Public Golf Course where the groundwater is at a depth of 20 mbgl.

Previous investigations

A Soil Contamination Assessment undertaken by Landscape Solutions in April 2017 for Bulleen Oval involved test pitting a number of locations at and around the park. Test pits located at Bulleen Oval, Doncaster Aeromodelers Club (south of Bulleen Oval), Yarra Bowmen Archery Club (south of Bulleen Oval), and the western part of the Freeway Public Golf Course (north-west of the area of the Freeway Public Golf Course included in this assessment). The majority of the test pits intercepted buried landfill waste. Some test pits located on the Bulleen Oval and within the Freeway Public Golf Course had evidence of a compacted clay layer overlying the buried waste. The remaining test pits only had a thin layer (0.1 to 0.2 metres) of topsoil/grass overlying the waste.

Bore logs from the Bolin Bolin Stormwater Harvesting geotechnical investigation undertaken by Geotesta (2016) also recorded waste material at this western area of the Freeway Public Golf Course to depths of 3.25 metres.

In 2012, test pitting and borehole investigations were undertaken to the north of the Bulleen Oval and north of the Veneto Club, as part of GHD's investigation at Bolin Bolin Wetland for Manningham City Council. One test pit and one borehole encountered fill soil at depths of up to 4 metres, noting inclusions of timber and metallic fragments.

Former quarry located at the junction of the M80 Ring Road and Greensborough Bypass

A former quarry is located just north of the junction of the M80 Ring Road and the Greensborough Bypass (Greensborough quarry). The area is currently open space, with the quarry being backfilled with waste material. North East Link components proposed for this section are a surface road and elevated road, with a shared use overpass proposed for approximately 400 metres south of the former quarry. The planning zone for the former quarry is Road Category 1.

A VicRoads Report (GR153-05.04.SCI.Rev0) provides details of test pit excavations undertaken as part of the M80 Upgrade Project (VicRoads 2015b). A review of the test pit logs indicate that waste material was found in test pit logs TP85-01 to 06 at depths from 0 to 1.5 mbgl. The waste material consisted of solid inert material (glass bottles, bricks, scrap metal). Waste material was also found in test pit logs TP92-10, 13, 15, 48, 50 and 54 at depths from 3 to 7 mbgl. The waste material consisted of putrescible waste, glass bottles, plastics, car body parts, concrete and ash. A strong ammonia odour was noted in the logs.

To further investigate the waste material found in the test pits, historical aerial photographs were obtained for 1931, 1945, 1951, 1956, 1962, 1968, 1974, 1979, 1981, 1987, 1991, 2005, 2009 and 2017. The aerial photographs indicate the area was likely a former quarry that was backfilled with waste material. The location of the VicRoads test pits are consistent with location of the former quarry shown in the historical aerial photographs. The period in which the Greensborough quarry was backfilled with waste is unknown but historical aerial photographs indicate this likely occurred in the 1950s, as the area was revegetated by 1962.

Environmental setting

The topography of the area is elevated in north and slopes down towards the south, with the M80 Ring Road cut into the hillside.

The area consists of three different geological units. East of the Greensborough quarry sub-basaltic sediments are present underlying Miocene basalts. The Anderson Creek Formation is present to the west of the Greensborough quarry, with thick to thin-bedded sandstone and siltstone with minor conglomerate. The Melbourne Formation is present in a small area in the south of the Greensborough quarry, with mainly thin-bedded siltstone and sandstone.

The DELWP Groundwater Resource Report indicates the water table at the Greensborough quarry is an estimated 50 mbgl. The regional groundwater flow appears to be in a north-easterly direction towards the Plenty River.

Former landfill located at AK Lines Reserve

The AK Lines Reserve is located to the south-west of Grimshaw Street and Greensborough Highway intersection in Watsonia. In this area, North East Link would run along the Greensborough Highway and extend slightly along Grimshaw Street on either side of Greensborough Highway. The proposed construction types for this section of North East Link are surface, with a shared use path underpass proposed through the eastern section of the reserve. The planning zone for the reserve is Public Park and Recreation.

Banyule City Council's Potentially Contaminated Sites register lists AK Lines Reserve as a former landfill. Historical aerial photographs confirm that filling started in the late 1950s and ceased in the mid-1960s. The reserve is currently a sporting oval.

Environmental setting

The topography of the reserve dips down to a drainage basin to the north-east of the sports oval. There is a steep slope up to the road on the northern and eastern sides of the drainage basin. There is a slight slope along the eastern edge of the reserve from the road towards the sports oval.

The Anderson Creek Formation is present over the majority of the reserve, with predominantly thick to thin bedded sandstone, and siltstone with minor conglomerate. The Melbourne Formation is present in the western third of the reserve with mainly thin-bedded siltstone and sandstone with undisturbed Bouma sequences.

The DELWP Groundwater Resource Report² estimates groundwater at the reserve is generally 5 to 10 mbgl, with an inferred groundwater southerly flow direction.

Former landfill located at Borlase Reserve

Borlase Reserve in Yallambie is bounded on the west by Greensborough Road and to the south by Lower Plenty Road. North East Link at this location would travel directly through the reserve and would cover the majority of the inferred landfill area. The proposed construction types at this location include surface, tunnel entrance/exit, cut and cover, open cut and shared use path surface and underpass. The planning zone for the majority of the reserve is General Residential, with a small section in the north-east corner zoned as Public Park and Recreation. The western and southern boundaries of the reserve along Greensborough Road and Lower Plenty Road are zoned as Road-Category 1.

A VicRoads study, *Geotechnical Assessment of North East Link Transport Corridor, Report No. MW 91-01-15-01* (VicRoads 2010) indicates that a possible former landfill is located at Borlase Reserve. To investigate the location of the former landfill, historical aerial photographs were obtained for 1931, 1945, 1951, 1954, 1962, 1966, 1972, 1979, 1984, 1987, 1991, 2000, 2009 and 2017. Historical aerial photographs indicate that earthworks occurred at the southern end of the reserve in the 1960s and had ceased by 1972, with the southern end of the reserve revegetated by this time. Geotechnical investigative drilling at the oval observed minor amounts of construction and demolition (C&D) waste materials in boreholes BH031, BH055 and BH056. The C&D waste was shallow with a maximum depth of 3 mbgl observed.

² <www.water.vic.gov.au/groundwater/groundwater-resource-reports>

Environmental setting

The topography of Borlase Reserve is flat in the south-west corner and then gently slopes to the south-east towards a drainage line. The Anderson Creek Formation extends under the entirety of the reserve, consisting of thick to thin bedded sandstone and siltstone with minor conglomerate. The DELWP Groundwater Resource Report estimates the water table depth at 5 to 10 mbgl.

Former Greythorn Landfill

The former Greythorn Landfill is located at the intersection of the Eastern Freeway and Doncaster Road (Greythorn Landfill). North East Link at this location would travel along the Eastern Freeway (which is the centre of the former landfill). The construction types at this location include surface and elevated roads. The planning zones at the former landfill include Road – Category 1, and Public Park and Recreation.

EPA Victoria records indicate the former Greythorn Landfill operated for a limited period in the late 1970s. An aerial photograph for 1978 shows an area where earth disturbance has occurred, which is likely the former landfill. It is likely the Eastern Freeway was built over the former landfill.

Environmental setting

The topography of the study area generally slopes downwards to the north-east. The geology over most of the Greythorn Landfill is variably sorted and rounded, generally unconsolidated gravel, sand and silt that includes low terrace and alluvial floodplain deposits. The Anderson Creek Formation is present in the southern part of the Greythorn Landfill, consisting of thick to thin bedded sandstone and siltstone with minor conglomerate.

The DELWP Groundwater Resource Report³ estimates the water table depth at Greythorn Landfill is generally 10 mbgl, with some areas along the northern boundary of the landfill having shallower groundwater at a depth of 5 mbgl. The inferred direction of groundwater flow is to the south.

Former quarry located near Rocklea Road and Yarraleen Place, Bulleen

Historical aerial photographs identified that a quarry and ancillary buildings (potentially a brick manufacturing plant) were formerly located near the current-day Rocklea Road and Yarraleen Place, Bulleen (Bulleen Quarry). The proposed North East Link tunnel construction activities would occur near the former quarry. Historical aerial photographs indicate that a quarry was present in the 1960s, evident in the 1963 aerial photograph. Geotechnical investigations near the historical facility building and immediately south of the facility and quarry did not indicate the presence of waste material in the bores drilled.

Environmental setting

The topography generally slopes downwards to the south-east. Based on the available data, the geology over most of the former quarry consists of thick to thin-bedded sandstone and siltstone with minor conglomerate. The geology in the south-eastern part of the former quarry is variably sorted and rounded, generally unconsolidated gravel, sand and silt that includes low terrace and alluvial floodplain deposits. The accuracy of the published geological data is questionable given the quarry appears to have been worked for clay soils, which for brick manufacturing purposes would not have been expected to contain coarser grained materials such as sands and gravels.

³ <www.water.vic.gov.au/groundwater/groundwater-resource-reports>

The DELWP Groundwater Resource Report estimates the water table depth at the former quarry is generally 10 to 20 mbgl, with some areas along the northern boundary of the former quarry having deeper groundwater at a depth of 50 mbgl, and an area in the south of the former quarry having shallower groundwater at a depth of 5 mbgl.

Former Landfill located at Koonung Creek Linear Park

Koonung Creek Linear Park is located to the north of the Eastern Freeway, between Tram Road and Wetherby Road. North East Link at this location is along the Eastern Freeway, but it extends into the south boundary of Koonung Creek Linear Park. The proposed construction types at this location include surface and elevated roads and shared use path surface and overpass. Historical aerial photographs from the late 1960s to the mid-1970s show significant earth disturbance at Koonung Creek Linear Park that has the potential for historical waste deposition.

Environmental setting

The topography of the Koonung Creek Linear Park is undulating and generally slopes towards the south. The geology over most of the area is variably sorted and rounded, generally unconsolidated gravel, sand and silt that includes low terrace and alluvial floodplain deposits. The Melbourne Formation is present in the southern area of the park, consisting of mainly thin bedded sandstone and siltstone.

The DELWP Groundwater Resource Report⁴ estimates the water table depth is generally 10 mbgl, with some areas along the northern and western boundary having shallower groundwater at a depth of 5 mbgl. The inferred direction of groundwater flow is to the south.

Landfill gas

Disturbance of ground conditions during construction near former landfills or uncontrolled fill material, could cause the migration of landfill gases such as methane, carbon dioxide, hydrogen sulphide and carbon monoxide. Gas migration from a landfill poses a significant health and safety risk. Methane (one of the major constituents of landfill gas) is explosive at concentrations above 5 per cent volume, and can be toxic to humans by asphyxiation, by displacement of oxygen, which can occur in concentrations greater than 33 per cent volume (CIRIA, 2007). Carbon dioxide is also a major component of landfill gas and whilst carbon dioxide is not combustible, it can have major implications on human health. Carbon dioxide can cause headaches and shortness of breath at 3 per cent volume, a loss of consciousness at 10 per cent volume and fatality at 20 per cent volume (CIRIA, 2007).

The World Health Organisation (WHO) (2000) reports that at concentrations of 10–20 ppm hydrogen sulphide causes eye irritation and at 50–100 ppm causes serious eye damage (WHO, 2000). The SEPP Air Quality Management (AQM) specifies design criterion for point sources of hydrogen sulphide with new or expanded emissions with regard to toxicity is 0.32 ppm.

The SEPP (AQM) also specifies a design criterion with regard to carbon monoxide of 25 ppm (parts per million). This criterion refers to the concentration at ground level (averaged over an hour), which a point source (such as a ventilation structures) must be designed to achieve.

⁴ <www.water.vic.gov.au/groundwater/groundwater-resource-reports>

North East Link construction activities could potentially influence the existing gas migration pathways and consequently impacts may need to be considered. Gases may migrate towards the construction activity or may be blocked by construction activity and may migrate in an alternate direction. Assessment works would need to consider risks to human health and the environment during construction and post construction, relating to toxicity and flammability of gases.

Vapours

Disturbance of ground and groundwater conditions during the construction of North East Link could cause vapours associated volatile contaminants—such as petroleum hydrocarbon and solvents—in soils or groundwater to migrate from off-site towards North East Link or onto sites that otherwise may not have been impacted. These vapours may impact on human health and the environment. If volatile organic compounds are below ground, construction activities may deflect or modify existing vapour migration routes and thus widen their physical extent and potential impacts (sub-surface impacts).

The potential for vapour intrusion and migration should be assessed and monitored throughout the construction of North East Link. Areas that may have the potential for vapour intrusion within and near North East Link are typically associated with historic land use practices where contaminant such as fuels and solvents has been released into soil and groundwater.

6.1.5 Contaminated Land Register search

EPA Victoria's Priority Sites Register lists sites that have been issued with a formal Clean up Notice (CUN) or Pollution Abatement Notice (PAN). At these sites, EPA Victoria considers the condition of the site requires assessment/management to reduce risks to human health or the environment.

EPA Victoria issues CUNs and PANs for a broad range of sites, including industrial and commercial sites as well as existing and former landfills and sites where they suspect that contamination has occurred.

A search of EPA Victoria's Priority Sites Register indicated that as of 31 March 2018 there are no priority sites located in the vicinity of the study area.

6.1.6 Statutory Environmental Audits

Statutory Environmental Audits are undertaken by an EPA Victoria-appointed independent Environmental Auditor, typically at the request of a site owner. The fact that an audit has been undertaken on a site is not an indicator of contamination, although it is likely to be an indicator of historic industrial and commercial land use with potential for contamination.

A search of the Victorian EPA Interaction Portal for properties issued with a Certificate or Statement of Environmental Audit as part of a Section 53X audit (*'condition of a segment of the environment'*) or with an audit report prepared in accordance with Section 53V of the *Environment Protection Act 1970* indicates that as of 5 April 2017 there are 14 properties in the vicinity (nominally specified as less than 500 metres) of the study area that had been issued with a Statements or Certificates of Environmental Audit and Section 53v Environmental Audits. The sites are listed in Appendix E.

Statements or Certificates of Environmental Audit are publicly available on the EPA Victoria website at:

https://portal.epa.vic.gov.au/irj/portal/anonymous?NavigationTarget=ROLES://portal_content/epa_content/epa_roles/epa.vic.gov.au.anonrole/epa.vic.gov.au.searchanon&trans_type=Z010>.

A Section 53X audit is most frequently required by the planning authorities to satisfy themselves that specified parcels of land are suitable for their proposed use (with respect to contamination). As part of a Section 53X audit, the auditor verifies that a specified parcel of land is suitable for a range of land uses (or no land uses), either with or without conditions (such as an ongoing management plan, maintaining a capping layer or not permitting contact with surface soils).

The audits listed in Appendix E were reviewed to assess their potential to impact North East Link construction activities. Based on the information reviewed, the proximity of the sites to the project's alignment and the proposed construction methodology adjacent to the sites, it is considered unlikely the sites reviewed would impact on construction activities. It is possible that low concentrations of groundwater contamination from fuel storage at 233 Bulleen Road (a current cement works) and from fuel storage at Simpson Barracks may affect quality on site during excavation/dewatering. This risk is further discussed in Technical Report N - Groundwater.

6.1.7 Groundwater quality restricted use zones (GQRUZ)

Groundwater Quality Restricted Use Zones (GQRUZ) are areas where groundwater pollution is present as a result of previous industrial or other activities, and the site has been assessed as part of a Section 53X audit in accordance with the *Environment Protection Act 1970*.

These zones have been subject to clean-up, in line with the relevant environmental standards, but not all beneficial uses of groundwater have been restored. As such, restrictions remain on what the groundwater can be used for, if it is abstracted or discharged to a surface water body. The presence of polluted groundwater in the study area may present constraints during future excavation and tunnelling activities. GQRUZs in the vicinity of North East Link are presented in Table 6-6 below. The location of GQRUZs are shown in Figure 6-12.

It is considered unlikely that groundwater contamination associated with these sites would have significantly impact on construction activities proposed within the North East Link project boundary, particularly as they are not located near areas of proposed dewatering or within the cone of influence of any dewatering.

Table 6-6 Groundwater quality restricted use zones (GQRUZ) surrounding North East Link

Site address	Restricted uses	Proximity to the North East Link
163–175 Noone Street, Clifton Hill	<ul style="list-style-type: none"> • Drinking water • Livestock water supply • Irrigation of crops (including domestic gardens) and parks • Water used for recreational purposes (such as swimming) 	60 m
204 Noone Street, Clifton Hill	<ul style="list-style-type: none"> • Drinking water • Livestock water supply • Water used for recreational purposes (such as swimming) 	150 m
80–110 Trenerry Crescent, Abbotsford	<ul style="list-style-type: none"> • Drinking water • Livestock water supply • Water used for recreational purposes (such as swimming) 	260 m
14–16 Yambla Street, Clifton Hill	<ul style="list-style-type: none"> • Drinking water • Livestock water supply • Irrigation of crops (including domestic gardens) and parks • Water used for recreational purposes (such as swimming) • Water used for industrial purposes 	300 m

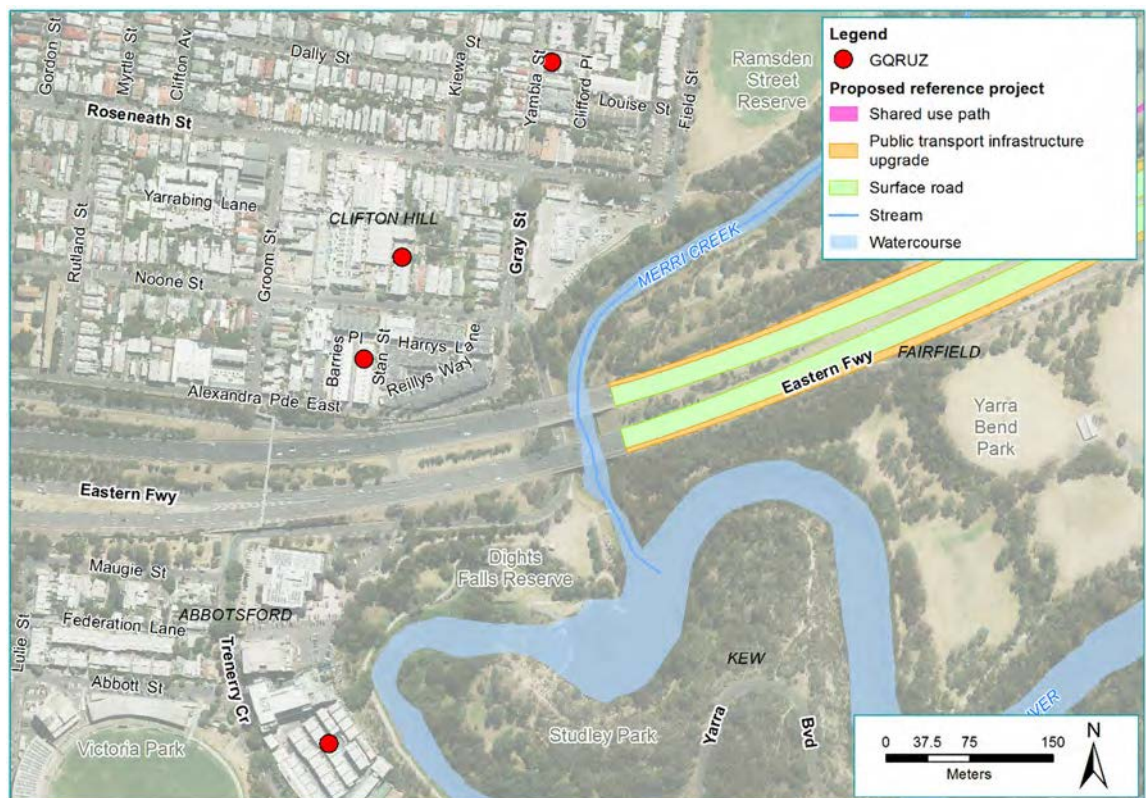


Figure 6-12 Location of GQRUZs within the proposed North East Link alignment (red dots)

6.1.8 Acid sulfate soils and rocks

Acid sulfate soil is the common name given to soils affected by iron sulphide minerals, which can occur naturally in coastal environments such as estuarine systems, mangrove swamps and back-swamps and in inland environments such as river and stream channels, lakes, wetlands, billabongs, floodplains and marshes (Fitzpatrick & Shand, 2008).

Acid sulfate soil can generally be classified into two broad types:

- Potential Acid Sulfate Soils (PASS) materials containing pyrite and/or monosulphides that are still waterlogged but have the potential to produce acid if oxidised
- Actual Acid Sulfate Soils (AASS) material containing sulphuric acid and pyrite, which has already been oxidised.

These soils may contain sulphuric acid (AASS) or have the potential to form sulphuric acid (PASS) in amounts that have a lasting effect on the soil characteristics, cause deoxygenation or release contaminants when the iron sulphide minerals are exposed to oxygen (Fitzpatrick & Shand, 2008).

The presence of actual or potential acid sulfate conditions does not relate to contamination, but to the underlying geology. Most ASS, such as the Coode Island Silt formation in the Melbourne area, were deposited during the Holocene geological age. Acid sulfate soil may also be present as mono-sulfidic black ooze (MBO) – a soft, black coloured soil, with high organic content, enriched with iron monosulphide (FeS), which commonly occurs on the beds of lakes, swamps, drains and channels (EPA Victoria, 2009b).

The occurrence of metal sulphides in rocks, however, is not restricted to any particular rock type, depositional environment or age. Metal sulphides can be found in most rocks but they generally occur at very low concentrations, where the risk of adverse environmental impact due to acid generation is minimal. Metal sulphides are associated with many ore deposits, including coal, metals such as gold, silver, platinum, copper, lead, tin, zinc and uranium. In Victoria, metal sulphides are usually associated with gold-bearing sediments, usually from Cambrian to Middle Devonian age. Sulphide enrichment is also associated with most coal deposits and has also been found in Silurian aged siltstones that underlie the Melbourne/Ringwood/Kilmore area (EPA Victoria, 2009b). Mining activities identified in Plenty, north of the North East Link project boundary, suggests there is an increased potential for sulphide enrichment of the underlying Silurian/Devonian aged bedrock.

The presence of acid sulfate soils and acid sulfate rock can become a potential constraint to construction activities, requiring the implementation of controls to manage the spoil during excavation and tunnelling activities.

Information regarding the potential for acid sulfate soils to be present in the study area was obtained from the *Atlas of Australian Acid Sulfate Soils* as compiled by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The data presented indicated the study area is classified as 'Low Probability/Very Low Confidence (Bn(p4))'. An extract from the *Atlas* is provided in Figure 6-13. The classification is defined as:

- Area with low probability of acid sulfate soil occurrence (6–70% chance) generally within upper metre in wet/riparian areas with Sodosols, Chromosols and Dermosols. The classification is noted to be provisional, as analytical data was not available when the plan was prepared and the classifier has little knowledge or experience with acid sulfate soil.



Figure 6-13 Extract from *Atlas of Australian Acid Sulfate Soils*

Note – the project would large be contained in the area defined as Bn(p4).

6.2 Summary of existing conditions

Existing conditions for the three North East Link elements are summarised below.

6.2.1 Potential sources of contamination

A summary of the potential sources of contamination, their locations in relation to North East Link, how the potential contamination could be interacted with (impact pathway) and the associated potential contaminants of concern is presented in Table 6-7 to Table 6-9.

Table 6-7 Element 1 – M80 Ring Road to northern portal – Potential source of contamination

Potential source of contamination	Location	Potential impact pathway	Potential contaminants of concern
Dry cleaners – leaks and spills from storage, use and disposal of dry cleaning chemicals.	Watsonia Road, adjacent to North East Link project boundary.	Excavation of soil/rock, vapour inhalation and abstraction of groundwater.	Chlorinated hydrocarbons (such as [PCE] tetrachloroethene and daughter products, trichloroethylene, 1,1,1 – trichloroethane, carbon tetrachloride,), volatile organic compounds, surfactants, waterproofing, petroleum hydrocarbons (white spirits).
Two active and two former fuel service station – loss of fuels from the fuel delivery system including the underground and above ground tanks, and fuels/oils/solvents from possible workshop use on site.	Active – Yallambie Rd, within the North East Link project boundary. Watsonia Road, within the vicinity of the North East Link project boundary. Former – Watsonia Road, within the vicinity of North East Link Watsonia railway station car park, within the North East Link project boundary.	Excavation of soil/rock, vapour inhalation and abstraction of groundwater.	Metals (such as copper, chromium, lead, zinc), solvents (including chlorinated hydrocarbons), total petroleum hydrocarbons (TPHs), BTEX, PAHs, phenol, chlorofluorocarbons, acids, alkalis, asbestos from brake replacement activities and antifreeze (ethyl-alcohol, ethylene glycol, isopropyl alcohol, methyl alcohol). Asbestos-containing materials.
Automotive service/repair centre and car rental facilities – leaks and spills from use and storage of fuels and chemicals.	Watsonia Road, adjacent to North East Link.	Excavation of soil/rock, vapour inhalation and abstraction of groundwater.	Metals (such as copper, chromium, lead, zinc), solvents (including chlorinated hydrocarbons), total petroleum hydrocarbons (TPHs), BTEX, PAHs, phenol, chlorofluorocarbons, acids, alkalis, asbestos from brake replacement activities and antifreeze (ethyl-alcohol, ethylene glycol, isopropyl alcohol, methyl alcohol). Asbestos-containing materials.

Potential source of contamination	Location	Potential impact pathway	Potential contaminants of concern
Timber & Hardware.	Watsonia Road, in the vicinity of North East Link project boundary.	Vapour inhalation and abstraction of groundwater.	Chlorinated hydrocarbons, pentachlorophenol, PAHs, organochlorine pesticides, metals (such as arsenic, copper, chromium) and ammonia.
Watsonia Zone Substation (Electricity).	Todman Street, in the vicinity of North East Link project boundary.	Abstraction of groundwater.	Metals (such as copper, lead, tin, mercury), polychlorinated biphenyls, non PCB containing transformer oils and solvents.
Former quarry, backfilled with putrescible and soil inert waste material.	M80 Ring Road and Greensborough Bypass.	Disturbance of waste, abstraction of groundwater, gas migration.	Landfill gas (methane, carbon dioxide, hydrogen sulphide and carbon monoxide), asbestos-containing materials, heavy metals, nutrients (ammonia, nitrate, phosphorous), TPHs, BTEX, PAHs.
Former landfill (waste type unknown).	AK Lines Reserve.	Disturbance of waste, abstraction of groundwater, gas migration.	Landfill gas (methane, carbon dioxide, hydrogen sulphide and carbon monoxide), asbestos-containing materials, heavy metals, nutrients (ammonia, nitrate, phosphorous), TPHs, BTEX, PAHs, monocyclic aromatic hydrocarbons (MAHs).
<p>Simpson Barracks.</p> <p>Defence information from their website confirmed that the property contains several historic landfills, containing waste from Defence operations and potentially asbestos-containing materials.</p> <p>Potential for underground storage tanks (USTs); storing diesel, petroleum and waste oil.</p> <p>Storage/use explosive ordnance.</p>	Simpson Barracks.	Excavation of soil and abstraction of groundwater, vapour migration.	Potential asbestos, heavy metals, TPHs, BTEX, PAHs, MAHs, UXO.

Table 6-8 Element 2 – Northern portal to southern portal – Potential source of contamination

Potential source of contamination	Location	Potential impact pathway	Potential contaminants of concern
Dry cleaners – leaks and spills from storage, use and disposal of dry cleaning chemicals.	Bulleen commercial/industrial area, within the North East Link project boundary.	Excavation of soil and rock, vapour inhalation and abstraction of groundwater.	Chlorinated hydrocarbons (such as perchlorethylene and daughter products, trichloroethylene, 1,1,1 – trichloroethane, carbon tetrachloride,), volatile organic compounds, surfactants, waterproofing, petroleum hydrocarbons (white spirits).
Four active and one former fuel service stations – leaks and spills of fuels from filling vehicles and storing fuels.	Active – Two active fuel service stations located within the Bulleen commercial/industrial area on Manningham Road west and two active fuel service stations on Bulleen Road immediately adjacent to the area. Former – One former fuel service station located to the south of the Bulleen commercial/industrial area on Bulleen Road.	Excavation of soil and rock, vapour inhalation and abstraction of groundwater.	Metals (such as copper, chromium, lead, zinc), solvents (including chlorinated hydrocarbons), total petroleum hydrocarbons (TPHs), BTEX, PAHs, phenol, chlorofluorocarbons, acids, alkalis, asbestos from brake replacement activities and antifreeze (ethyl-alcohol, ethylene glycol, isopropyl alcohol, methyl alcohol). Asbestos-containing materials.
Automotive service/repair centre and car rental facilities – leaks and spills from use and storage of fuels, oils and chemicals.	Multiple locations within the Bulleen commercial/industrial area, within the North East Link project boundary.	Excavation of soil and rock, vapour inhalation and abstraction of groundwater.	Metals (such as copper, chromium, lead, zinc), solvents (including chlorinated hydrocarbons), total petroleum hydrocarbons (TPHs), BTEX, PAHs, phenol, chlorofluorocarbons, acids, alkalis, asbestos from brake replacement activities and antifreeze (ethyl-alcohol, ethylene glycol, isopropyl alcohol, methyl alcohol). Asbestos-containing materials.
Garden supplies – leaks and spills from use and storage of chemicals.	Bulleen commercial/industrial area, Manningham Road west, within the North East Link project boundary.	Excavation of soil and rock, vapour inhalation and abstraction of groundwater.	Metals (such as cadmium, arsenic, copper, lead, mercury, magnesium, aluminium, iron), organochlorine pesticides, organophosphate pesticides, carbamates, TPHs, BTEX, nitrogen compounds, phosphorous.

Potential source of contamination	Location	Potential impact pathway	Potential contaminants of concern
Vehicle storage yard – leaks and spills from use and storage of fuels and chemicals.	Bulleen commercial/industrial area, within the North East Link project boundary.	Excavation of soil and rock, vapour inhalation and abstraction of groundwater.	TPHs, BTEX, solvents, heavy metals, PAHs, waste oil.
Mower sales/service centre – leaks and spills from use and/or storage of chemicals and fuels.	Bulleen commercial/industrial area, within the North East Link project boundary.	Excavation of soil and rock, vapour inhalation and abstraction of groundwater.	Metals (lead), PAHs, TPHs, acids, (including chlorinated hydrocarbons), alkalis and antifreeze (ethyl-alcohol, ethylene glycol, isopropyl alcohol, methyl alcohol).
Timber & Hardware, demolition and salvage.	Bulleen commercial/industrial area, Kim Close, within the North East Link project boundary.	Excavation of soil and rock, vapour inhalation and abstraction of groundwater.	Chlorinated hydrocarbons (such as pentachlorophenol), PAHs, organochlorine pesticides, metals (such as arsenic, copper, chromium) and ammonia, asbestos-containing materials.
Concrete supplier – bulk storage of fuels.	Bulleen commercial/industrial area, Bulleen Road, within the North East Link project boundary.	Excavation of soil and rock, vapour inhalation and abstraction of groundwater.	TPHs, BTEX, solvents, heavy metals, PAHs, waste oil, asbestos-containing materials.
Former landfill (solid inert waste and possible putrescible waste).	Borlase Reserve, Yallambie.	Disturbance of waste, abstraction of groundwater, gas migration.	Landfill gases (methane, carbon dioxide, hydrogen sulphide and carbon monoxide), asbestos-containing materials, heavy metals, nutrients (ammonia, nitrate, phosphorous), TPHs, BTEX, PAHs, MAHs.
Former landfill (solid inert waste and possible putrescible waste).	Bulleen Oval, Bulleen.	Disturbance of waste, abstraction of groundwater, gas migration.	Landfill gases (methane, carbon dioxide, hydrogen sulphide and carbon monoxide), asbestos-containing materials, heavy metals, nutrients (ammonia, nitrate, phosphorous), TPHs, BTEX, PAHs, MAHs.
Former quarry, unclear whether it has been backfilled with potentially uncontrolled fill.	Located near Rocklea Road and Yarraleen Place, Bulleen.	Excavation of soil, abstraction of groundwater, gas migration.	Landfill gases (methane, carbon dioxide, hydrogen sulphide and carbon monoxide), asbestos-containing materials, heavy metals, nutrients (ammonia, nitrate, phosphorous), TPHs, BTEX, PAHs, MAHs.
Former landfill (putrescible waste and solid inert waste).	Freeway Public Golf Course, Balwyn North (eastern section of golf course adjacent to Bulleen Road (former Camberwell Landfill)).	Disturbance of waste, abstraction of groundwater, gas migration.	Landfill gases (methane, carbon dioxide, hydrogen sulphide and carbon monoxide), asbestos-containing materials, heavy metals, nutrients (ammonia, nitrate, phosphorous), TPHs, BTEX, PAHs, MAHs.

Table 6-9 Element 3 – Eastern Freeway – Potential source of contamination

Potential source of contamination	Location	Potential impact pathway	Potential contaminants of concern
Commercial/industrial areas – long history of use.	Clifton Hill, in the vicinity of North East Link.	Excavation of soil and abstraction of groundwater.	Heavy metals, chlorinated hydrocarbons, BTEX, TPH, PAHs, asbestos-containing materials.
Substation (Electricity).	Box Hill North, in the vicinity of North East Link.	Excavation of soil and abstraction of groundwater, soil vapour inhalation.	Metals (such as copper, lead, tin, mercury), non PCB oils, polychlorinated biphenyls and solvents.
Former landfill (putrescible waste and solid inert waste).	Musca Street Reserve and Freeway Public Golf Course, Balwyn North (former Camberwell Landfill).	Disturbance of waste, abstraction of groundwater, gas migration.	Landfill gases (methane, carbon dioxide, hydrogen sulphide and carbon monoxide), asbestos-containing materials, heavy metals, nutrients (ammonia, nitrate, phosphorous), TPHs, BTEX, PAHs, MAHs.
Former landfill (waste type unknown).	Corner of Doncaster Road and Eastern Freeway, Balwyn North (former Greythorn Landfill).	Disturbance of waste, abstraction of groundwater, gas migration.	Landfill gases (methane, carbon dioxide, hydrogen sulphide and carbon monoxide), asbestos-containing materials, heavy metals, nutrients (ammonia, nitrate), TPHs, BTEX, PAHs, MAHs.
Former landfill (solid inert waste and putrescible waste).	Koonung Creek Linear Park.	Disturbance of waste, abstraction of groundwater, gas migration.	Landfill gases (methane, carbon dioxide, hydrogen sulphide and carbon monoxide), asbestos-containing materials, heavy metals, nutrients (ammonia, nitrate, phosphorous), TPHs, BTEX, PAHs, MAHs.

6.3 Preliminary field investigations

Preliminary field investigations were undertaken to provide better understanding of the quality of soil and groundwater, landfills/fill sites and the presence of acid sulfate soil and rocks within the study area. The scope of the preliminary field investigations included:

- Sampling of near surface soils to assess whether soil quality has been impacted by current or historic industrial/commercial land use
- Installation of groundwater monitoring wells to assess presence of contaminated groundwater within the study area
- Sampling groundwater from wells installed as part of this investigation and sampling of groundwater from wells installed as part of the hydrogeological investigations occurring in parallel
- Sampling of soil and rock at depths to assess presence of actual or potential acid sulfate soil and rock
- Monitoring of surface methane emissions and subsurface pits from former landfills (Borlase Reserve, Bulleen Oval, AK Lines Reserve, M80 Ring Road and Greensborough Bypass) using a laser spectrometer (calibrated to detect 1ppm methane)
- Geophysical survey at Bulleen Oval to assist in delineating the extent of the potential landfill.

Borehole logs are provided in Appendix F.

During the development and sampling of BH022 (drilled in Simpson Barracks immediately south of the fuel service station, located on the corner Yallambie Road and Greensborough Road), hydrocarbon odours were detected. Subsequent analytical results of the groundwater sample from this well confirmed the presence of elevated BTEX and TRH (discussed further in Section 6.3.2). A potential source of the hydrocarbons is the fuel service station, located approximately 10 metres to the north of BH022. This would suggest that any petroleum hydrocarbon leaking from infrastructure at the service station may have migrated south from the service station towards BH022.

At the time of writing this report, environmental bores BH003 and BH005 have been drilled in Parks Victoria land in Bulleen. Soil sample analytical results have been included in Appendix J, and indicated slightly elevated in lead in the surface sample from BH005. The groundwater wells installed in BH003 and BH005 have not been sampled by the date of this report.

Other locations have not been attempted due to access to land not granted by land owners or issues with underground services. These include:

- BH004 and BH010 located in the Bulleen industrial/commercial area – issues with underground services
- BH007, BH019, BH020, and BH021 located in the Bulleen Drive-in.

Access to private properties was not included as part of the preliminary field investigations for the EES. Additional investigation works may be required before any construction activities start to determine the soil and groundwater quality on the private properties and inform the Spoil Management Strategy.

6.3.1 Soil contamination investigation

Soil classification for offsite disposal

The classification of soil for offsite disposal is outlined in EPA Victoria Publication 621 *Soil Hazard Categorisation and Management* (IWRG 621, June 2009). All soils are categorised as either Fill Material or prescribed industrial waste (PIW) Category A, B or C, depending upon total and leachable concentration of a broad list of potential contaminants. The disposal of each category must be managed differently, including the requirement for treatment before disposal (Category A soil only) (outlined further in Appendix G Spoil Management Strategy), summarised in Table 6-10.

Table 6-10 Contaminated soil disposal options

Category	Potential treatment	Disposal option
Category A	On site remediation. Off site remediation. Storage pending availability of treatment.	No disposal to landfill until treated to reduce potential impact on the environment. This may involve treatment including destruction or stabilisation of contamination.
Category B	On site remediation. Off site remediation. Licensed facility.	Disposal to licensed facility (SITA, Taylors Road, Lyndhurst – only).
Category C	On site remediation. Off site remediation. Licensed facility.	Disposal to licensed facility (range of licensed landfills).
Fill Material	EPA Victoria does not regulate the use of fill material. However, the <i>Environment Protection Act 1970</i> places general obligations to prevent adverse impacts on the environment and human health. Where there is potential for adverse impacts from the deposit of fill material, advice should be sought from EPA Victoria.	

Soil characterisation – analytical data

The soil investigation included drilling of boreholes for the collection of soil samples within the North East Link project boundary and surrounding areas. The intrusive soil investigation reported here was completed between 10 January 2018 and 8 August 2018.

A total of 290 primary soil samples (and associated QA/QC samples – 13) from 110 geotechnical and environmental bores were collected and analysed by an independent analytical laboratory. To assess the potential requirements for offsite treatment/disposal, soil analytical results were screened against current EPA Victoria Soil Hazard Categorisation and Management Guideline (Publication IWRG 621 – June 2009). Samples were submitted under chain of custody (COC) procedures to ALS Environmental Pty Ltd (primary laboratory) and Eurofins-MGT Pty Ltd (secondary laboratory). Both laboratories are NATA accredited for the analysis requested.

The soil sampling program is outlined in Appendix H. Copies of NATA certified analytical results and chain of custody (COC) documentation are provided in Appendix I. Tabulated results are provided in Appendix J.

All samples were collected with reference to the following guidelines and protocols:

- National Environment Protection (Assessment of Site Contamination) Measure, 1999 (NEPM) as amended in 2013
- Standards Australia, 2005, Australian Standard, Guide to the investigation and sampling of sites with potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds, AS 4482.1 – 2005
- Standards Australia, 2005, Australian Standard, Guide to the investigation and sampling of sites with potentially contaminated soil, Part 2: Volatile Substances, AS 4482.2 – 2005.

Soil samples have been primarily taken from geotechnical bores located within the North East Link project boundary and surrounding areas. Given that desktop review indicated the majority of the historical and current land uses within the project boundary are farmland and residential, the samples collected from the geotechnical bores (with the exception of bores located on/near potential landfill sites) were mainly opportunistic samples collected to provide better understanding of the quality of surface soil throughout the North East Link project boundary.

The environmental bores were located in areas which had been identified through desktop review to have higher potential for contamination, due to historical and current land uses (refer to Section 6.1.3 details). It should be noted that due to restricted access to private properties and the presence of underground and aboveground services, further site investigations would be required to fully characterise soil quality. As such, waste soil classification presented in this report would need to be reassessed once detailed soil quality information is available.

The concentrations of contaminants of concern were generally below laboratory limits of reporting (LOR) and/or the adopted waste classification criteria (IWRG 621). Data exceeding the adopted waste classification criteria can be summarised as follows:

- There were 138 soil samples collected from 78 locations that exceeded the upper Fill Material threshold limits, based on elevated concentrations of fluoride, arsenic, copper, lead, nickel, mercury, tin and zinc and benzo(a)pyrene (BaP). These samples would be categorised as Prescribed Industrial Water (PIW) in accordance with IWRG 621. Of these 138 soil samples:
 - The concentration of copper in soil sample NEL-BH125_0.75 m (Bulleen Oval) exceeded the Category B threshold limits (that is, soil would be categorised as Category A PIW). The leachability concentration for copper in this sample was less than the laboratory LOR. Sample results above (0.4 m) and below (1.0 m) this sample depth reported results below the upper threshold for Fill Material. This suggests the volume of material categorised as Category A based on copper alone is likely to be limited.
 - The concentration of lead in sample NEL-BH125_1.5 m (Bulleen Oval) exceeded the Category C threshold limit. Based on this alone, the soil would be categorised as Category B PIW. However, the leachability concentration of lead exceeded Category B Upper Limits, making the soil Category A PIW. Leachate testing from a sample above (BH125_1.0) reported lead below the laboratory LOR. Leachate testing from sample below (BH125_3.0) reported lead at a concentration that would categorise that sample as Category B PIW.

- There were 67 soil samples collected from 51 locations that exceeded the upper Fill Material threshold limits due to elevated concentrations of fluoride, arsenic, copper, lead, nickel, mercury, tin and zinc and BaP. This soil would be categorised as Category C. A number of lines of evidence suggest the fluoride in particular and possibly most of the metals are naturally occurring and there is a case for re-classification of those soils as Fill Material. The lines of evidence include:
 - The majority of these samples were from the Silurian siltstones
 - Elevated fluoride is commonly found in Silurian siltstones throughout Melbourne
 - The elevated fluoride occurs along the length of the alignment and there are no obvious sources of fluoride over such a large area
 - Elevated nickel is also found in the Silurian siltstones and not within the landfills where elevated metals were identified
 - Metals can become concentrated due to weathering processes in rocks.
- The average metal concentrations, other than those discussed above, are well below the upper limit for Fill criteria.
- BaP was reported above the laboratory LOR from only seven samples out of 269 analyses. BaP is considered an anthropogenic contaminant and further sampling would be needed to assess what volume of material would be classified as Category C based on this compound alone.
- While the presence of the Silurian siltstones would indicate natural material, care must be taken to ensure that no other contaminant sources have impacted the material before it could be considered for reclassification as Fill Material (refer to Section 7.2).
- The concentration of arsenic, tin and zinc in soil samples collected from NEL-BH125 (Bulleen Oval) at depths 1.0, 1.5 and 3 mbgl also exceeded the upper Fill Material threshold limits although the leachable concentrations were below the Category C Upper Limit.
- Trace asbestos at concentrations determined to be below 0.1 g/kg were found in the soil sample collected from NEL-BH125 (Bulleen Oval) at 1.5 m. An additional investigation was completed to further characterise soil at Bulleen Oval. Based on the additional soil sampling results, asbestos was detected in the soil sample collected from bore LFB01 at a depth of 0.5 metres. Trace asbestos at concentrations determined to be below 0.1 g/kg were found in the soil sample collected from LFB01 at a depth of 1 metre.
- Asbestos was detected in the soil sample collected from BH119 (Freeway Public Golf Course) at a depth of 1.8 metres. This bore was drilled through an area of former landfilling activities.
- Low concentrations of C₁₀-C₃₆ total petroleum hydrocarbon detected in NEL-BH-128_1.2 m (120 mg/kg) (Bulleen Oval), NEL-140_0.2m (310 mg/kg) (Bulleen industrial area) and NEL-BH179_0.1 m (360 mg/kg) (east of Bulleen Oval) soil samples.
- Fluoride, copper and zinc concentrations in soil samples collected from NEL-BH128A (Bulleen Oval) at depths 0.45 and 1.2 mbgl exceeded Fill Material threshold limits.
- Fragments of cement sheet, potentially containing asbestos, were observed in borehole BH128 (Bulleen Oval) at a depth of 1.4 metres. A sample was not able to be obtained and therefore the presence or absence of asbestos has not been confirmed.
- The remaining soil samples would be classified as Fill Material.

As mentioned above, samples recovered from above and below BH125_0.75 indicated a Fill Material category. Further testing of soils around BH125 was conducted to assess the lateral extent of the elevated metals in this original sample. The sample locations are shown on Figure 13 in Appendix A. Of 65 analyses, only five samples reported one or two metals in excess of the Fill Material limit, including fluorine, arsenic, nickel, zinc, tin and mercury. There were no results suggesting any Category B or Category A PIW. This suggests the volume of Category A and B material in the landfill area is likely to be low. However, landfill material can be highly heterogeneous, making assessment of waste categories difficult without a significant density of sampling. For example, the presence of a flake of lead-based paint or metal shaving in a sample with otherwise low metal concentrations can result in a waste categorisation that does not necessarily represent the bulk of that sample. The heterogeneity can thus lead to an overestimate of the volume of various categories of waste. Reducing the uncertainty around this material can only be achieved through a higher sampling density than is currently available, as required through compliance with EPR CL01.

Other detectable significant contaminants of concern that did not exceed criteria, but provide indications of possible contaminant sources, included:

- Low concentrations of C₁₀-C₃₆ total petroleum hydrocarbon (TPH) was detected in:
 - NEL-BH128A_1.2 m (120 mg/kg), NEL-BH195_1.0m (140 mg/kg), NEL-LFB03_2.0m (190 mg/kg), NEL-LFB05_1.0m (130 mg/kg) (Bulleen Oval), NEL-BH140_0.2m (310 mg/kg) (Bulleen industrial area) and NEL-BH179_0.1 m (360 mg/kg) (Yarra Flat parkland) and NEL-BH185_0.2 m (130 mg/kg) (M80 Ring Road) and NEL-EF-BH005_0.2 m (120 mg/kg), NEL-BH201_0.2m (420 mg/kg) (Eastern Freeway) soil samples
- Tetrachloroethene (PCE) was detected in low concentrations in NEL-ENV-BH025_0.3–0.4 (0.09 mg/kg) and NEL-ENV-BH025_1.0–1.1 (0.06 mg/kg) (east of dry cleaners at Watsonia).

Sampling locations and exceedances are shown in Figures 6 to 13 in Appendix A.

6.3.2 Groundwater investigation

The groundwater investigation included the drilling and installation of 16 groundwater wells to collect groundwater samples to indicate the contamination status of groundwater within the North East Link project boundary. These included:

- Eleven groundwater wells installed in the commercial/industrial area in Watsonia and Bulleen, and near the fuel service station at the corner of Greensborough Road and Yallambie Road
- Five shallow groundwater wells installed for the purpose of hydrogeological investigation were also sampled and analysed for a broad suite of contaminants.

A further 35 existing groundwater wells have also been sampled. Fifty-five primary groundwater samples were recovered from these wells between 12 February 2018 and 8 August 2018.

Samples were generally collected in accordance with EPA Victoria Publication 669, Groundwater Sampling Guidelines, 2000 (EPA Victoria Publication 669). Samples were submitted under chain of custody (COC) procedures to Eurofins or ALS Environmental. Both laboratories are NATA accredited for the analysis requested. It is noted the sampling undertaken by the hydrogeological team did not initially meet all the QA/QC requirements of EPA Victoria Publication 669, but the appropriate number of duplicate and triplicate samples have been collected over the course of the groundwater assessment.

The groundwater sampling program is outlined in Appendix G. Copies of NATA-certified analytical results and COC documentation are provided in Appendix I. Tabulated results are provided in Appendix J.

Groundwater sampling locations and exceedances are shown in Figures 14 to 15 in Appendix A.

Groundwater quality

To assess the potential impacts to groundwater, it is necessary to first assess the quality of the groundwater. The quality of the groundwater defines the use it could potentially be put to in its natural (uncontaminated) state. These uses are referred to in Victoria as 'beneficial uses' and include natural ecological uses (maintenance of ecosystems) and extracted uses, such as irrigation and industrial uses.

The document that defined the beneficial uses of groundwater is the State Environment Protection Policy (SEPP) Waters, 2018 (Water SEPP). It defines the beneficial uses of groundwater based on the quality of the groundwater as determined by its salinity (measured in total dissolved solids – TDS). Each segment has specific beneficial uses that require protection. The greater the salinity, the fewer beneficial uses that apply.

The segments defined by the Water SEPP (2018) are summarised in Table 6-11.

Table 6-11 Beneficial uses of groundwater (from Water SEPP)

Beneficial use	Segment (mg/L total dissolved solids – TDS)						
	A1 (0–600)	A2 (601– 1,200)	B (1,201– 3,100)	C (3,101– 5,400)	D 5,400– 7,100)	E (7,101– 10,000)	F (>10,000)
Water-dependent ecosystems and species	✓	✓	✓	✓	✓	✓	✓
Potable water supply – desirable	✓						
Potable water supply – acceptable	✓	✓					
Potable mineral water supply	✓	✓	✓	✓			
Agriculture and irrigation (irrigation)	✓	✓	✓				
Agriculture and irrigation (stock watering)	✓	✓	✓	✓	✓	✓	
Industrial and commercial	✓	✓	✓	✓	✓		
Water-based recreation (primary contact recreation)	✓	✓	✓	✓	✓	✓	✓
Traditional owners' and Aboriginal Victorians' cultural values	✓	✓	✓	✓	✓	✓	✓
Cultural and spiritual values	✓	✓	✓	✓	✓	✓	✓

Beneficial use	Segment (mg/L total dissolved solids – TDS)						
	A1 (0–600)	A2 (601–1,200)	B (1,201–3,100)	C (3,101–5,400)	D (5,400–7,100)	E (7,101–10,000)	F (>10,000)
Buildings and structures	✓	✓	✓	✓	✓	✓	✓
Geothermal properties	✓	✓	✓	✓	✓	✓	✓
Highlighted segments refer to the most representative Segments for alluvial sediments (Segment A2) and bedrock (Segment C)							

The laboratory-determined TDS, as measured during the groundwater monitoring events in February, April and May 2018, ranged from 910 to 9,900 mg/L TDS. This range falls within Segment A2 and Segment E. Generally, the groundwater in the Silurian siltstones is more saline than in the alluvial deposits near the Yarra River due mainly to the longer residence time of the groundwater in the siltstones. A summary of the salinity results is provided in Table 6-12.

Table 6-12 Study area groundwater salinity

Aquifer	Number of samples	Groundwater salinity (mg/L TDS)		
		Minimum	Maximum	Mean
Sediments (alluvial)	7	910	6,100	2,658
Bedrock (Silurian)	26	730	9,900	5,720

In recognition of the differences in groundwater quality near the Yarra River in Bulleen compared with the Silurian siltstones (wider alignment area), the report uses the following groundwater segments:

- Alluvial sediments – Segment A2
- Silurian bedrock (siltstones) – Segment C.

NOTE – Despite the groundwater gTDS indicating a range from Segments A2 to E, the average TDS falls in Segment C. Hence Segment C is adopted for Silurian bedrock.

The protected beneficial uses of Segment A2 and C and groundwater quality indicators and objectives for the beneficial uses of groundwater are summarised in Table 6-13.

Table 6-13 Groundwater quality indicators and objectives

Beneficial use	Indicator	Objective (Groundwater SEPP)
Water-dependent ecosystems and species.	Those specified in the relevant SEPP for surface waters.	Groundwater shall not cause receiving waters to be affected to the extent the level of any water quality indicator is greater than the level of that indicator specified in the relevant SEPP for surface waters. Groundwater quality must not adversely affect the maintenance of environmental values that depend on groundwater.

Beneficial use	Indicator	Objective (Groundwater SEPP)
Potable water supply – acceptable – A2 only.	Those specified in the NHMRC, Australian Drinking Water Guidelines (2011).	Groundwater shall not be affected to the extent the level of any water quality indicator is greater than the level of that indicator specified for raw water for drinking water supply in the NHMRC Australian Drinking Water Guidelines (2011). The constituents of groundwater must not be affected in a manner or to an extent that leads to the aesthetic water qualities being impacted, as defined in the Australian Drinking Water Guidelines.
Potable mineral water supply.	Those specified in the <i>Australian Food Standards Code (1987) Standard 08 Mineral Water</i> .	Groundwater shall not be affected to the extent the level of any water quality indicator is greater than the level of that indicator specified in the <i>Australian Food Standards Code (1987) Standard 08 Mineral Water</i> . The constituents of groundwater must not be affected in a manner or to an extent that leads to the aesthetic water qualities being impacted, as defined in the Australian Drinking Water Guidelines.
Agriculture and irrigation (irrigation) – A2 only.	Those specified for irrigation in the ANZECC Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC 2000).	Groundwater shall not be affected to the extent the level of any water quality indicator is greater than the level specified for irrigation in the Australian Water Quality Guidelines for Fresh and Marine Waters.
Agriculture and irrigation (stock watering).	Those specified for livestock in the ANZECC 2000.	Groundwater shall not be affected to the extent the level of any water quality indicator is greater than the level specified for livestock in the ANZECC 2000.
Industrial and commercial.	Those specified for industrial use in the ANZECC 2000	Groundwater must not be affected to the extent that industrial or commercial water quality is impacted.
Water-based recreation (primary contact recreation).	Those specified for primary contact recreation in the ANZECC 2000.	Groundwater must not be affected to the extent the level of any water quality indicator is greater than the level of that indicator specified for water-based recreation (primary contact recreation) for surface waters in the Groundwater SEPP (2018).
Buildings and structures.	pH, sulfate, redox potential.	Introduced contaminants shall not cause groundwater to become corrosive to structures or building materials.
Geothermal.	Temperature from 30 to 70 degrees Celsius.	No activity must affect the geothermal properties of groundwater.
Traditional Owners' and Aboriginal Victorians' cultural values.	No specific quality indicators and objectives provided. However, water quality must be suitable for Traditional Owner cultural needs and ensure their cultural practices can continue. For example, traditional aquaculture, fishing, harvesting, cultivation of freshwater and marine foods, fish, grasses, medicines and filtration of holistic water holes/camps.	
Cultural and spiritual values.	No specific quality indicators and objectives provided. However, water quality must be suitable for cultural and spiritual needs and enable cultural, spiritual and ceremonial practices to continue. These include the cultural values held by communities (such as water-based festivals and celebrations).	

In assessing the beneficial uses of groundwater, consideration is also given to whether a particular beneficial use is being realised currently or has the potential to be realised in the future. An assessment of this is provided in Table 6-14.

Table 6-14 Assessment of relevance of beneficial uses

Beneficial use	Current use	Future use
Water-dependent ecosystems and species.	Existing. Groundwater from around the study area would discharge into the Yarra River.	Likely. Groundwater from around the study area would discharge into the Yarra River.
Potable water supply – acceptable (Segment A2 only).	Not currently realised.	Unlikely due to the location of this quality water near the Yarra River and its use as an ecological resource. Also, a high quality reticulated mains water supply is available.
Potable mineral water supply.	It is noted that groundwater within the North East Link project boundary is not mineral water as defined in <i>Clause 4</i> of the SEPP (Groundwaters of Victoria) and the area is not a designated mineral spring area. Therefore, this beneficial use is not considered relevant and is not considered further.	
Agriculture and irrigation (irrigation) – A2 only.	Not realised.	<p>Possible but unlikely future use.</p> <p>Groundwater is generally too saline in the bedrock aquifer for long-term irrigation use. The higher quality water near the Yarra River is an important ecological resource.</p> <p>One groundwater bore is registered in Element 1 for irrigation. This bore is located approximately 2 km to the north-west of the proposed northern portal where dewatering may be required and is not within the proposed construction footprint of North East Link.</p>
Agriculture and irrigation (stock watering).	Not currently realised.	<p>Unlikely due to the mainly residential and commercial/industrial land uses along the project alignment. The higher quality water near the Yarra River is an important ecological resource.</p> <p>Three groundwater bores are registered in Element 2 of North East Link and four in Element 3 for 'stock and domestic' use. Two of the Element 2 bores are located approximately 1.5 km to the south-west of the proposed southern portal where dewatering may be required – these are also on the western side of the Yarra River and therefore would not likely be impacted by dewatering. The third bore in Element 2 is located approximately 1 km to the east of the southern portal. None of these bores are located within the proposed construction footprint of North East Link. The bores in Element 3 are located several kilometres from the southern portal and would not likely be impacted by.</p>

Beneficial use	Current use	Future use
Industrial and commercial.	Not currently realised.	Possible but unlikely. The generally brackish groundwater would likely require treatment before industrial use (such as for cooling towers) and a high-quality mains water supply is available. The higher quality water near the Yarra River is an important ecological resource.
Water-based recreation (primary contact recreation).	Existing based on groundwater discharging into the Yarra River. Extractive use for swimming pool top-up is not an existing groundwater use in the area.	Unlikely extractive use for swimming pool top-up. The four 'stock and domestic' bores mentioned under 'Agriculture and irrigation (stock watering)' above could potentially be used for supply for swimming pool top-up. However, these would not likely be impacted. Likely with respect to discharging into the Yarra River where swimming and fishing activities can occur.
Buildings and structures.	Not currently realised. Groundwater is generally too deep to impact current building configurations in the area.	Possible. Tunnelling and piling works are likely to intersect groundwater. However, any possible impacts from groundwater can be planned for at the design stage.
Geothermal.	Not a geothermal area.	Not a geothermal area
Traditional Owners' and Aboriginal Victorians' cultural values.	Existing where groundwater is discharging into creeks, billabongs and sustaining groundwater-dependent ecosystems.	Possible relevant where groundwater is discharging into creeks, billabongs and sustaining groundwater-dependent ecosystems.
Cultural and spiritual values.	Existing where groundwater is discharging into creeks, billabongs and sustaining groundwater dependent ecosystems.	Possible relevant where groundwater is discharging into creeks, billabongs and sustaining groundwater-dependent ecosystems.

In summary:

- Extractive uses of groundwater along the proposed North East Link alignment are either non-existent or unlikely
- Discharge of groundwater to receiving water bodies such as the Yarra River and Bolin Bolin Billabong is a natural endpoint for the groundwater and therefore:
 - Water-dependent ecosystems and species is an existing beneficial use and would remain an existing beneficial use into the future
 - Water-based recreation (primary contact recreation) is an existing beneficial use with respect to use of the Yarra River for swimming or fishing and would remain an existing beneficial use into the future
 - Traditional owners' and Aboriginal Victorian cultural values and cultural and spiritual values potentially exist currently and are a possible ongoing use
 - Extractive uses near the Yarra River is not likely to be allowed as it represents an important ecological resource for the Yarra River.

The following criteria were adopted to assess the groundwater contamination for North East Link:

- ANZECC (2000) Australian Water Quality Guidelines for Fresh and Marine Waters (Aquatic Ecosystems) – Maintenance of freshwater ecosystems (95%) criteria
- ANZECC (2000) Australian Water Quality Guidelines for Fresh and Marine Waters – Agricultural Irrigation Water Long Term Trigger Value (LTV)
- (ANZECC 2000) Livestock Watering (Sheep)
- (NHMRC 2008) Guidelines for Managing Risks in Recreational Waters
- (ANZECC 1992) Industrial – Once through cooling (Brackish)
- (NEPC 2013) Commercial/Industrial Health Screening Level D (HSL D) Groundwater for Vapour Intrusion, Clay 2–4 m, 4–8 m, >8 m
- (NEPC 2013) Recreational Health Screening Level C (HSL C) Groundwater for Vapour Intrusion, Clay 2–4 m, 4–8 m, >8 m
- (CRC Care 2011) Table B2 Groundwater Health Screening Levels (HSL) for Vapour Intrusion (Intrusive Maintenance Workers (Shallow Trench) 2–4 m
- Standards Australia – AS2159 2009 Buildings and Structures
- HEPA (January 2018), PFAS National Environment Management Plan (NEMP). For fresh water environments, 99% species protection is adopted due to the ability of PFAS to bioaccumulate.

Similar to the soil investigation, groundwater investigations completed for the North East Link EES generally utilised bores drilled for geotechnical purposes. These bores provide a general understanding of groundwater quality across the study area. Additional targeted investigation of groundwater may be required by the contractor before construction starts to provide more information on groundwater contamination.

Groundwater samples collected and reported as part of the land contamination assessment are specific to the water table. The depth to groundwater in all wells gauged between the 18 and 22 February varied from 2.4 to 6.2 metres below the surface level (see Table 1 in Appendix J). It is noted that wells were gauged before well development.

The stabilised water quality parameters are presented in Table 2 in Appendix J. The total dissolved solids (TDS) as calculated from field electrical conductivity (EC) readings of groundwater sampled is relatively low, but this is consistent with the upper water table and areas of high infiltration potential in which the wells are located. The only exception to this was well BH040A in which the TDS was 6,100 mg/L. The reason for the higher TDS in well BH040A is unknown but is unlikely to be associated with contamination. In several wells screened within Quaternary aged sedimentary deposits, a slight hydrogen sulphide odour was noted.

The presence of H₂S is generally consistent with low more reducing aquifer conditions. The pH of groundwater assessed during sampling was generally neutral to slightly acidic.

Groundwater characterisation – analytical data

Concentrations of contaminants of concern were generally below laboratory limits of reporting (LORs), but the following exceeded one or more adopted criteria:

- Concentrations of selected metals (copper, manganese, nickel and zinc) exceeded the adopted investigation levels adopted for the protection of maintenance of ecosystems, agriculture, parks and gardens and stock watering beneficial uses in the water table aquifer. The concentrations of selected metals were relatively consistent in groundwater sampled across the study area and may be indicative of naturally occurring background conditions.
- Elevated petroleum hydrocarbons were reported in NEL_ENV_BH022, which was installed on Simpson Barracks approximately 10 m south of the service station on the corner of Yallambie Road and Greensborough Road. Total BTEX was 37.2 mg/L and TRH C₆-C₁₀ was 41.6 mg/L. Although no light non-aqueous phase liquid (LNAPL) was observed, the high concentrations suggest LNAPL could be present in the vicinity. The source of the contamination could be the service station immediately north of this well.
- Concentrations PFAS compounds (perfluorohexane sulphonate [PFHxS] and perfluorooctane sulphonate [PFOS]) were reported above the laboratory LOR in three wells in the Bulleen area – ENV-BH014 (PFHxS+PFOS 0.02 µg/L), NEL-BH062A (PFHxS+PFOS 1.23 µg/L) and NEL_ENV_BH009 (PFHxS+PFOS 0.698 µg/L). To rule out potential laboratory error, NEL_ENV_BH009 was resampled, which confirmed the presence of PFAS.
- PFOS alone was detected in NEL_ENV_BH024 (0.002 µg/L) near the Watsonia railway station car park. To rule out potential laboratory error, this well was resampled, which confirmed the presence of PFOS and also indicated the presence of two other PFAS compounds, PFHxS and 6:2 FtS.
- All the detections exceed the adopted criteria Ecosystems Fresh Water (99%⁵) listed in the NEMP (2018). The Bulleen result for NEL-BH062A also exceeded the recreational guidelines provided in the NEMP (2018). The implications of PFAS are discussed further below.
- The TDS concentration in groundwater ranged from 730 mg/L to 10,000 mg/L. Several wells exceeded the stock watering criteria (5,000 mg/L). It is likely that this reflects natural variation in salinity and it is not considered to be related to contamination. The use of groundwater for stock watering in this area is currently not realised and is considered unlikely in the foreseeable future.

The presence of PFAS in well NEL-BH062A, NEL_ENV_BH009, ENV-BH014 and NEL_ENV_BH024 requires further comment. PFAS presents some unique characteristics that may influence management requirements of extracted water that may contain PFAS:

- The highly stable and persistent nature of the chemicals. This means they cannot be destroyed easily or disposed of to surface waterbodies. However, treatment methods are available.
- The conservative nature of screening criteria protective of human health and ecosystems, mainly due to their ability to bioaccumulate in organisms. This means they cannot be disposed to sewer (without a trade waste agreement) or to surface waterbodies. However, treatment methods are available.

⁵ Due to bioaccumulation of PFAS, 99% species protection is used despite the modified ecosystem

- The uncertainty as to the source of the PFAS in the Bulleen area. This means it is unclear as to how extensive the dissolved phase plume is and how much PFAS might be extracted during dewatering. However, treatment methods are available.

With respect to groundwater, the only exposure route to PFAS is via extraction for a prescribed beneficial use (such as swimming pool top-up) or discharge to the receiving water bodies where PFAS may be present in the water column. As discussed in Table 6-14, the extractive uses of groundwater in this area are not realised and not likely to be realised in the foreseeable future. Therefore, the presence of PFAS in groundwater is only a concern to the receiving water body when discharged. In the case of the Bulleen occurrences of PFAS, the receiving water body is the Yarra River.

In this scenario, PFAS exposure to humans and the ecosystem may occur through:

- Incidental ingestion by people using the river for swimming
- Consumption of edible species harvested from the ecosystem
- Respiration of waters containing dissolved PFAS by aquatic fauna
- Ingestion of sediment containing PFAS by aquatic fauna
- Take up of water containing dissolved PFAS
- Ingestion of impacted fauna or flora by aquatic organisms.

Dermal sorption of PFAS is not considered a significant exposure pathway as it has a low skin penetration index and inhalation of PFAS is not an exposure pathway, as PFAS are generally not volatile. However, these might be relevant exposure pathways for amphibians and fish.

Upon discharge of groundwater, the concentrations of PFAS would be subject to considerable dilution and is therefore considered unlikely to pose a risk to recreational users of the rivers. However, the ecological guidelines for PFAS are currently very conservative due to the bio-cumulative nature of many PFAS compounds.

The source of PFAS in groundwater in this area is unclear and at this stage there is insufficient information to identify a likely source or define the extent of the issue. The highest concentration of PFAS occur in NEL-BH062A and NEL_ENV_BH009 and these wells also contain considerably more PFAS species than the other wells. This might suggest the two wells are in closer proximity to a source or sources than ENV-BH014. PFAS may be migrating from the adjacent industrial area or may be associated with an activity undertaken at the Bulleen Drive-in or may have resulted from a previous fire in the area or historical inappropriate and/or unauthorised discharge of PFAS-containing products.

North East Link construction activities may extract PFAS-contaminated groundwater which would need to be managed. Modelling conducted by the hydrogeology team has predicted that areas where PFAS was found would be within the area subject to groundwater drawdown during construction (refer to Technical report N – Groundwater). Once dewatering ceases, there should be no further extraction of groundwater and therefore, no further potential exposure to PFAS via this route.

The occurrence of PFAS at a concentration close to the laboratory LOR in Watsonia may require further assessment to establish its extent. However, this is not within the current scope of the EES but may be conducted at the detailed design stage. This occurrence does not fall within the zone of influence of drawdown based on the groundwater modelling presented in Technical report N – Groundwater. Therefore, specific management of PFAS-impacted water in this area may not be required.

The PFAS issue would need to be considered by the contractor in any management approach. Modelling has been undertaken to assess the potential for known groundwater contamination to migrate due to groundwater dewatering associated with construction. The results indicate that the petroleum hydrocarbon and PFAS contamination identified above may move toward the North East Link underground structures and be intercepted at that point. However this contamination is not predicted to migrate offsite.

6.3.3 Acid sulfate soils and rock

Waste acid sulfate soils and rock must be managed in accordance with the requirements of the Victorian EPA Industrial Waste Management Policy (*Waste Acid Sulfate Soils*) 1999. The policy defines acid sulfate soil as:

‘... any soil, sediment, unconsolidated geological material or disturbed consolidated rock mass containing metal sulphides, which exceeds criteria for acid sulfate soils specified in EPA Vic Publication 655 entitled ‘Acid Sulfate Soil and Rock’ published by the Authority in 1999 as amended from time to time or republished by the Authority’.

EPA Victoria Publication 655.1 (July 2009) provides guidance on identifying, classifying and managing acid sulfate soils and rock. The criteria for acid sulfate soil and rock classification as extracted from EPA Victoria Publication 655.1 is provided in Table 6-15 (soil) and Table 6-16 (rock).

Table 6-15 Texture-based action criteria for classifying acid sulfate soil (EPA Victoria, 2009b)

Soil or sediment texture	Approximate clay content (%)	Net acidity criteria (1–1000 tonnes)		Net acidity criteria (>1000 tonnes)	
		(%S) (oven-dry basis)	mol H+/tonne (oven-dry basis)	(%S) (oven-dry basis)	mol H+/tonne (oven-dry basis)
Sands to loamy sands	<5	0.03	18	0.03	18
Sandy loams to light clays	5–40	0.06	36	0.03	18
Medium to heavy clays and silty clays	>40	0.1	62	0.03	18

Note – Victoria has adopted the value of 0.03 %S net acidity as the action criterion level to define whether there is a need to manage soils as acid sulfate soil. The figure of < 0.03 %S is the minimum action criterion and does not consider soil texture and buffering capacity.

Table 6-16 Criteria for classifying acid sulfate rock (EPA Victoria, 2009b)

Final NAG pH	NAPP (kg H ₂ SO ₄ /tonne)	Classification
<4.5	Positive	Potentially acid forming
>4.5	Negative	Non-acid forming

The soil and rock sampling program was conducted between 26 April 2017 and 23 April 2018 to assess for the potential of encountering actual or potential acid sulfate soil and rock during construction activities. The program consisted of 114 samples, with 18 soil samples and 96 rock samples collected between 0.5 and 48 mbgl, from 53 bores across the study area.

After collection in the field, the soil samples were stored in a freezer and the rock samples were stored in core boxes to enable laboratory analysis at a later date.

Soil and rock samples were selected based on the desktop assessment, lithology, reference project, vertical alignment and observations in the field. Samples were analysed and assessed in accordance with analysis given in EPA Victoria Publication 655.1 Acid Sulfate Soil and Rock, which include the following:

- Net Acid Production Potential (NAPP)
- Net Acid Generation Potential (NAGP)
- Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS) suite
- Chromium Reducible Sulphur (CRS) suite.

These analyses provide the basis for the classification of acid sulfate soil detailed in Table 6-15 and Table 6-16 above.

The locations for the acid sulfate soils and rock samples are presented in Figures 16 to 20 in Appendix A. The laboratory results assessed against EPA Victoria Publication 655.1 are summarised in Table 6-17 further below.

A summary of all laboratory analytical results are presented in Appendix J.

Soil samples – laboratory results

Of 18 soil samples selected for acid sulfate soil analysis, seven samples were analysed using CRS suite and nine were analysed using the SPOCAS suite. One sample (NEL-BH004_19.5–19.95 m) was analysed using both methods. The results indicated:

- Absence of actual acidity in all the samples except NEL_BH039_9.8
- Potential acidity, as measured by chromium reducible sulphur, was exhibited in eight samples ranging between 0.006 %S (percentage sulfur) and 0.244%S
- Excess acid neutralising capacity (or the soil's inherent capacity to neutralise any acid produced) was reported in one soil sample NEL-BH070_2.0 m at 0.118%S. As such, these soil samples generally do not contain sufficient amounts of carbonate materials to neutralise and buffer the existing acidity or acidity that could be generated as a result of the oxidation of sulphides within the soil
- Net acidity was reported above the laboratory LOR in two soil samples (NEL-BH004_15–15.45 m and NEL-BH039_9.8 m) reported net acidity values of 0.02%S and 0.25%S, respectively, with the later sample exceeding EPA Victoria's guidelines for management
- The net acidity value for NEL-BH039_9.8 m exceeded the criteria for classification for acid sulfate soil
- One sample was analysed for both CSR and SPOCAS suites (NEL-BH004_19.5–19.95 m). Both analyses reported the same net acidity (<0.02%S) indicating consistency across the both methods.

Rock samples – laboratory results

A total of 96 rock samples collected across the alignment were analysed for NAPP and NAG testing. Along with these tests, 40 rock samples were analysed for CRS suite and 23 rock samples were analysed for SPOCAS suite. Three rock samples (NEL-BH073_24.90–25.06m, NEL-BH074_30.0m and NEL-BH084_29.63–29.79m) were analysed for all the tests. The laboratory results indicated that:

- The NAG pH ranged between 3 and 7.9 pH units, with pH<4.5 being reported for 14 samples
- The corresponding NAG (at pH 7.0) ranged between the detection limit (<0.1 Kg H₂SO₄/t) and 10.2 Kg H₂SO₄/t.
- THE NAPP concentrations ranged between -29 Kg H₂SO₄/t and 10.1 Kg H₂SO₄/t. The positive NAPP values were reported for five samples ranging between 0.9 Kg H₂SO₄/t (NEL-BH067_25.0–25.13 m) and 10.1 Kg H₂SO₄/t (NEL-BH084_37.95–38.05 m).
- Based on EPA Victoria Publication 655.1 criteria:
 - Four samples of the 81 samples assessed are classified as rocks with potential to generate acid (Table 6-17 below), and if disturbed must be managed in accordance with the requirements of the *Industrial Waste Management Policy (Waste Acid Sulfate Soils) 1999*. These four were all from Element 2 of North East Link and included: NEL-BH037_25.0–25.08 m in the Bulleen Drive-in; NEL-BH042_45.75 m in Banksia Park, Bulleen; NEL-BH084_37.95–38.05 m on the Yarra Valley Country Club, Bulleen; and NEL-BH057_21.0 m Drysdale Street, View Bank.
 - The results for 11 samples are considered ‘Uncertain’ as the samples exceeded only one of the two criteria. Sample NEL-BH067_25.0–25.13 m reported positive NAPP, but NAG pH >4.5 indicating potential presence of sulfate as gypsum. The remaining 10 samples were assessed as negative NAPP, but the NAG pH <4.5 indicating potential presence of iron carbonates and the reported corresponding Acid Neutralising Capacity may not be sufficient to completely neutralise the acidity.
 - The corresponding NAGP (at pH 7.0) values for the ‘Uncertain’ samples were reported <5 Kg H₂SO₄/t (AMIRA, 2002). These samples may potentially have a lower capacity to produce acid. However, these samples need follow up testing which may include sequential NAG, Kinetic NAG and free draining leach testing to confirm these results.
 - All remaining 66 rock samples were classified as non-acid forming.

Table 6-17 Summary of acid sulfate rock classification

Sample ID	NAPP (Kg H ₂ SO ₄ /t)	NAG pH	Interpretation
NEL-BH037_25.0–25.08 m	3.9	3.3	PAF
NEL-BH042 (45.75 m)	2.5	3.3	PAF
NEL-BH057 (21.0 m)	1.4	3.6	PAF
NEL-BH084_37.95–38.05 m	10.1	3	PAF
NEL-BH067_25.0–25.13 m	0.9	6.7	UC
NEL-BH030 (18.68 m)	-2.8	4.1	UC
NEL-BH042 (31.46 m)	-3.1	4.1	UC
NEL-BH043 (11.57 m)	-0.9	4.2	UC
NEL-BH043 (18.4 m)	<0.5	3.4	UC

Sample ID	NAPP (Kg H ₂ SO ₄ /t)	NAG pH	Interpretation
NEL-BH043 (34.6 m)	<0.5	4	UC
NEL-BH058 (22.85 m)	-1.5	3.7	UC
NEL-BH083_14.84–15.0 m	<0.5	3.6	UC
NEL-BH083_25.0–25.22 m	<0.5	3.6	UC
NEL-BH084_29.63–29.79 m	-1.2	4	UC
NEL-BH099_20.04–20.18 m	-1.9	4.1	UC

Notes – PAF – Potentially Acid Forming, UC – Uncertain or Low capacity PAF

It is noted that sampling frequency undertaken as part of the assessment does not meet the criteria defined in EPA Victoria Publication 655.1. However, for the purpose of this assessment, the dataset is considered to be adequate as a preliminary assessment of the potential for acid sulfate soils/rock along the North East Link alignment.

6.3.4 Landfills

Landfill gas monitoring

To assist in characterising risk and to inform the risk assessment (refer to Section 8), landfill gas monitoring was conducted at the following former landfills:

- M80 Ring Road/Greensborough Bypass, Greensborough
- AK Line Reserve, Watsonia
- Borlase Reserve, Yallambie
- Bulleen Oval Football Oval, Bulleen.

The landfill gas monitoring consisted of the following works:

- Surface methane emissions monitoring across the ground surface areas
- Monitoring of all identified underground services in the vicinity of the former landfills for methane.

Monitoring of landfill gas at the former landfills located at Musca Street Reserve and the Freeway Public Golf Course, Balwyn North and the corner of Doncaster Road and the Eastern Freeway, Balwyn North was not undertaken at the time of reporting due to access restrictions. Further investigation of these former landfills would be required before construction started to assess the potential impacts of landfill gas migration.

Surface methane emissions monitoring

Surface methane emissions monitoring was undertaken from 9 to 10 May 2018.

The monitoring found:

- No elevated methane concentrations (≥ 100 ppm) were recorded during surface emissions scanning at M80 Ring Road/Greensborough Bypass, Borlase Reserve and Bulleen Oval.
- An elevated methane concentration (> 100 ppm) was detected at only one location, the AK Lines Reserve. The concentration of methane detected (160 ppm) was present to the north-east of the centre of the sports oval. The location of this elevated reading is shown in Appendix K. No obvious cracks or protrusions in the ground were identified where the elevated reading was recorded that may have created a preferential pathway for the methane from the ground to the surface. All other readings across the site were ambient (~ 2 ppm methane). The elevated reading suggests that landfilled waste is still decomposing, with methane being generated.

However, as it has been over 40 years since the cessation of waste deposition at the site, it is expected that peak landfill gas generation has already occurred (usually peaks immediately following the closure of a landfill). Methane emissions released to the atmosphere would be expected to rapidly dissipate, and the 160 ppm reading is well below the lower explosive limit for methane (50,000 ppm). In addition, this was not considered an exceedance as EPA Victoria Publication 1684 indicates that an average of the surface emissions is acceptable.

Underground service monitoring

Monitoring of available underground services indicated the following:

- No elevated results ($\geq 10,000$ ppm) were recorded during underground service monitoring at M80 Ring Road/Greensborough Bypass, AK Lines Reserve and Borlase Reserve. It is noted that one sewer pit at Borlase Reserve contained a methane concentration of 486 ppm, which is above ambient level, but this may be attributed to sources other than landfill gas such as the contents of the sewer.
- One underground electricity service pit monitored at Bulleen Oval contained elevated methane of 16,000 ppm or 1.6 % v/v). The location of this elevated reading is depicted in Appendix K. Nearby underground services monitored did not record methane concentrations above ambient levels. The lower explosive limit is 5% v/v methane. While still below this, following a significant atmospheric pressure drop event, higher concentrations of methane could migrate to the service pit.

Surface and underground service methane monitoring will not characterise the presence of potential for landfill gas in the subsurface geology. Therefore, further investigation of the presence of landfill gas in the subsurface geology would be required before construction started to assess the potential impacts of lateral landfill gas migration.

The full results and findings of the surface emissions and underground service monitoring for methane are provided in Appendix K.

Bulleen Oval geophysical electromagnetic (GEM) survey

To assist in assessing the extent of fill at the Bulleen Oval, a geophysical electromagnetic (GEM) survey was undertaken on 23 and 24 April 2018. A report detailing the methodology and findings of the GEM survey is presented in Appendix L, along with figures that show the interpreted landfill extent. The figures should be interpreted in conjunction with reading the report.

The GEM2 electromagnetic method was chosen for rapid geophysical reconnaissance surveying of the apparent electrical conductivity over the site. It was anticipated that the GEM2 method would be effective at identifying anomalies for follow up investigations using higher resolution geophysical methods. On the basis of typical electromagnetic properties of landfill, the anticipated electromagnetic anomalies were anticipated to be either:

- High conductivity features associated with high clay content, refuse containing waste fill, high moisture, and/or water filled cavities; or
- Low conductivity features associated with air filled cavities, fresh limestone or dry sand.

The GEM2 measures the apparent conductivity and also the magnetic susceptibility at each location. The apparent conductivity measures changes in the electrical conductivity of the soil, which is governed primarily by the clay content, water saturation, and the concentration of dissolved ions in solution. The GEM2 instrument takes a series of measurements in rapid succession (up to 10 times per second) along a survey line, measuring the ground response at several operator-determined transmitter frequencies, which is called frequency sounding.

In conducting the survey at Bulleen Oval, data was acquired with the GEM2 along parallel lines spaced at approximately 5 metres. A total of 33,492 data points were collected at an elevation of 1 metre. Three zones of moderate to high electrical conductivity (EC) can be observed within the confines of the survey extent and are more pronounced at higher frequencies. Drainage pipes and channels can also be observed in the high frequency data, particularly in the north-eastern section of the oval. At lower frequencies, high EC values are also observed along the eastern perimeter of the survey area.

Interpreted landfill extents are displayed in Figure 8 of Appendix L and have been constructed from high EC and Q Sum values commonly associated with landfill. The extent of these zones correlate with boreholes BH128, BH125 and BH039 where approximately 3 metres of fill was intersected. The interpreted fill zone to the east correlates with BH126 where approximately 1 metre of fill was intersected.

The Bulleen Oval proved to be a complex site with regard to the GEM2 electromagnetic survey. Large metallic structures were prevalent and isolated metallic objects were observed throughout the area. High EC and Q Sum values observed at Bulleen Oval are interpreted to result from waste fill. However, caution must be taken with this interpretation, as an increase in these values could also result from an increase in moisture content or presence of clay. The GEM2 survey did not image one continuous area, where waste is known to exist from drilling and historical aerials, and so the survey does not provide a clear delineated extent of the former landfill.

6.3.5 Summary of preliminary contamination investigation

Conclusions from the preliminary contamination investigation for North East Link are summarised below.

Soil

The intrusive soil investigation confirmed:

- Minor quantities of fill soils (that is, not naturally occurring as opposed to the IWRG waste classification – *Fill Material*) are likely to be present along the proposed North East Link alignment but this is likely to vary significantly by location. Large fill quantities are only expected in the former landfill and fill sites.
- Concentrations of fluoride, nickel and zinc in soil samples obtained from 14 bores (19% of total samples collected) exceeded the maximum concentration allowed to be disposed of as Fill Material and may affect the potential to be classified as Category C contaminated soil in accordance with EPA Victoria Publication IWRG 621. This is consistent with soil quality identified in historic soil works undertaken for the M80 Ring Road (in part utilised as noise mounds). Further investigation should be undertaken to determine whether the potential contaminants are naturally occurring as it is likely these materials can be reclassified as Fill Material (refer to Section 7.2).
- Detectable concentrations of metals in fill soils from the Bulleen Oval near the proposed North East Link southern portal exceed upper Category B criteria and as such are classified as Category A contaminated soil in accordance with EPA Victoria Publication IWRG 621. An additional soil sampling program was undertaken at Bulleen Oval to further assess the extent and delineate the presence of contamination at the former landfill. The additional soil sampling program consisted of collection of 65 soil samples from surface to 5.0 mbgl from 10 bores. Targeted sampling surrounding bore NEL-BH125 was undertaken to horizontally and vertically assess the extent of the elevated lead and copper concentrations, exceeding Category B and/or Category C IWRG 621 criteria, previously identified.

Based on the results of the additional soil sampling program at the Bullen Oval, the concentrations of metals in the soil samples indicated significantly lower metal concentrations that would be classified as Fill Material or Category C waste in accordance with IWRG 621.

- Cement sheet fragments were observed in boreholes drilled in the Bulleen Oval and due to the age of fill placement is likely to contain asbestos. Asbestos was identified in soil samples collected from NEL-LFB01 at depths of 0.5 mbgl and 1.0 mbgl. The sample collected from 1.0 mbgl reportedly contained asbestos at trace levels below the laboratory limit of reporting of 0.1 g/kg. During the previous investigation at the Bulleen Oval, the soil sample collected from NEL-BH125 at a depth of 1.5 mbgl reportedly contained asbestos at trace levels below the laboratory limit of reporting of 0.1 g/kg.

The majority of soil sampled would be classified as Fill Material in accordance with IWRG 621. It is noted the summary above is based on limited data and that further works would be required to fully assess soil contamination.

Landfill gas

Landfill gas monitoring investigation confirmed:

- At the AK Lines Reserve a single elevated surface methane reading of 160 ppm was detected above the ambient air levels and at Bulleen Oval one underground electricity service pit monitored contained elevated methane of 16,000 ppm or 1.6 % v/v well above the ambient air levels. Further investigation of these former landfills would be required before construction started to assess the potential impacts of landfill gas migration.
- Monitoring of landfill gas at the former landfills located at Musca Street Reserve, the Freeway Public Golf Course, and near the junction of Doncaster Road and the Eastern Freeway, Balwyn North has not yet been undertaken. Further investigation of these former landfills would be required before construction started to assess the potential impacts of landfill gas migration.

Groundwater

The groundwater investigation confirmed:

- Concentrations of some metals (copper, manganese, nickel and zinc) exceeded the adopted investigation levels considered to be protective of maintenance of ecosystems, agriculture, parks and gardens and stock watering and primary contact recreation beneficial uses in the water table aquifer. The concentrations of the metals detected were relatively consistent across the samples recovered and analysed and may be associated with naturally occurring background conditions. Further work is required to assess background water quality.
- Elevated petroleum hydrocarbons were reported in one well on Simpson Barracks near the fuel service station located at the corner of Greensborough Road and Yallambie Road. The levels suggest LNAP may be present in groundwater beneath the fuel service station.
- Extraction of groundwater for stock watering, agricultural use (irrigation), primary contact recreation (swimming pool top-up) and industrial uses are not currently realised along the proposed North East Link alignment and not likely to be realised in the foreseeable future.
- The beneficial uses of maintaining ecosystems is relevant to the proposed North East Link alignment. However, North East Link construction activities are unlikely to generate additional impacts from contaminants generated and are unlikely to increase discharge of existing groundwater contaminants to ecosystems.

- The beneficial use of groundwater primary contact recreation (swimming and fishing) is relevant to the proposed North East Link alignment but the project is unlikely to impact this beneficial use.
- Concentrations PFHxS+PFOS and PFOS were reported above the NEMP (2018) Ecosystems Fresh Water (99%) in groundwater samples obtained from NEL-BH062A, ENV-BH014 and NEL_ENV_BH009 in the Bulleen area and PFOS alone was detected in NEL_ENV_BH024 located near Watsonia railway station. Further investigation may be required to assess the source and extent of the PFAS plume in Bulleen to assess management requirements for PFAS-impacted groundwater recovered during dewatering.
- The pH of groundwater sampled was neutral to acidic and while the criteria adopted to protect the beneficial uses for agriculture, parks and gardens and primary contact recreation was exceeded in groundwater from one well, this may be due to background conditions within the upper alluvial aquifer at that location.
- Total dissolved solids (TDS) was measured at 6,100 mg/L in a groundwater sample obtained from NEL-BH040A located near the Eastern Freeway interchange. It is not known why the higher TDS was encountered but it is considered unlikely this represents contamination.

Presence of acid sulfate soils and rocks

The desktop and preliminary field investigation indicated that acid sulfate soils (actual or potential) may be encountered in Quaternary aged organic rich alluvial sediments and acid sulfate rock may be encountered in moderately weathered to fresh Silurian aged siltstones.

The outcome of the acid sulfate soils preliminary investigation can be summarised as:

- Actual acidity was not detected in any soil samples collected
- Residual soil and extremely weathered Silurian aged siltstones (with soil properties) are not considered to represent potential or actual acid sulfate soils
- Selected samples of organic rich alluvial sediments exceeded EPA Victoria's specified criteria but this was not consistently identified across all similar samples in this area
- It is considered that where organic rich alluvial sediments are to be disturbed they would require further detailed assessment and may require treatment and management
- The outcome of the acid sulfate rock preliminary assessment can be summarised as:
- Highly weathered Silurian aged siltstones are not considered to represent acid sulfate rock
- Moderately weathered to fresh Silurian aged siltstones are considered to represent potential acid sulfate rock and require further assessment to inform the design of North East Link. However, the data gathered during this preliminary site investigation is considered adequate for the purpose of the EES report in that it provides an indication of the presence of potential acid sulfate soils and rock and allows for planning to mitigate their potential impacts.

6.3.6 Conceptual site model

A conceptual site model (CSM) is defined in the ASC NEPM as '*a representation of site related information regarding contamination sources, receptors and exposure pathways between those sources and receptors*'. A CSM helps define the extent of an investigation and where a risk may be realised or not. In the context of a major road project through an urban area, there may be a wide range of location specific contamination sources and receptors, although the pathways between sources and receptors are similar. Therefore, a generalised CSM for North East Link has been developed as presented in Table 6-18 to guide this EES assessment.

Potential North East Link contamination sources have been grouped into three key classifications based on the investigations undertaken. These classifications are industrial and commercial land, landfills, and areas where acid sulfate soils or rock may be present.

The pathways relate to North East Link construction and operation activities. North East Link construction and maintenance workers are not considered as a receptor because worker health and safety is beyond the scope of the EES and would be dealt with through occupational, health and safety assessments and documentation prepared by the contractor.

The CSM is a 'living' document and would be further developed and used during the detailed design phase as more data becomes available.

Table 6-18 Conceptual site model

Source	Potential contaminants of concern	Pathway	Receptor
Industrial/commercial land and Commonwealth land use including: dry cleaners, vehicle maintenance, panel beaters, fuel service station	TPHs VOCs PAHs Metals PFAS	Excavation of contaminated soil leading to:	
		Dust from contaminated soil during excavation/stockpile and transport	Surrounding residential and commercial land occupants, users of open space and surrounding roads
		Leaching of contaminants from excavated spoil into surface water	Recreational users of surface water, aquatic biota, consumers of aquatic fauna
		Leaching of contaminants from excavated spoil into groundwater	Abstraction of groundwater for protected beneficial uses
		Release of odorous volatile vapours	Surrounding residential and commercial land occupants, users of open and enclosed space
		Abstraction of groundwater leading to migration of contaminated groundwater beneath a site otherwise un-impacted or to surface water	Surrounding residential and commercial land occupants where groundwater is extracted and enclosed spaces may be present
Landfills	TPHs VOCs PAHs Metals Asbestos PFAS	Excavation of contaminated soil, putrescible waste, construction debris leading to:	
		Dust from contaminated soil during excavation/stockpile and transport	Surrounding residential and commercial land occupants, users of open space and surrounding roads
		Leaching of contaminants from excavated spoil into surface water	Recreational users of surface water, aquatic biota, consumers of aquatic fauna
		Leaching of contaminants from excavated spoil into groundwater	Abstraction of groundwater for protected beneficial uses
		Release of odorous volatile vapours	Surrounding residential and commercial land occupants, users of open and enclosed spaces
		Partial excavation and remediation of wastes leading to a change in methane generation and distribution; that is, potential to be channelled off site	Surrounding residential and commercial land occupants, people entering enclosed spaces

Source	Potential contaminants of concern	Pathway	Receptor
Acid sulfate soils/rock (potential or actual)	pH Metals Aesthetic impacts	Generation of acid leachate as a result of:	
		Excavation of acid sulfate soil or PASS leading to acidification of spoil materials	Localised flora and fauna, nearby surface water or groundwater, possible impact on adjacent structures
		Dewatering for construction/operation leading to generation of acid leachate over a wide area	Surrounding terrestrial flora and fauna
		Loading of soil leading to localised changes in groundwater table and resultant oxidation/acidification	Aquatic flora and fauna in nearest surface water receptor

7. Spoil assessment

There are a number of waste streams that would result from construction of a project of this type and scale. The most significant of these is surplus spoil which can be generated in large volumes, some of which may potentially be contaminated, and requires management to prevent impacts on human health or the environment. This section summarises the anticipated volumes of spoil that would be generated by the project and the proposed management approaches.

Other waste streams generated would include wastewater, solid inert wastes and organic waste. The management of wastewater is covered by Technical report P – Surface water, and the management of waste groundwater is covered in Technical report N – Groundwater. Management of solid inert waste, such as demolition waste and materials such as concrete, are dealt with in this chapter, whereby it is recommended that they be separated from spoil and recycled where possible.

All waste streams, including organic waste and litter (that would be produced in significantly lower volumes), would be managed in accordance with the waste hierarchy, as required by EPR SCC4, specified in EES Chapter 27 – Environmental management framework.

Spoil is waste soil or rock produced during the course of excavation and construction activities. Approximately 6.3 million cubic metres (m³) (in situ) of spoil is expected to be generated for constructing the proposed North East Link tunnels using TBMs, road headers, cut and cover and other open excavations. Note that all calculations have been made of soil and rock volumes in the ground and that once excavated the volume of spoil to be managed would be greater. This bulking factor has not been accounted for in volume estimates below.

7.1 Volume and characteristics of spoil

Indicative in situ spoil volumes for North East Link were calculated using modelling software MX3D by the North East Link technical team. A summary of the indicative in situ spoil volumes, (often referred to as solid volume for North East Link) for each project elements are provided Table 7-1. Note that the numbers in the table have been rounded up from the original calculated volumes as shown in Table 4-2 of the Spoil Volume Estimate report in Appendix M.

Table 7-1 Indicative spoil volumes estimate (m³ in situ)

Project element	Estimated in situ volumes (m ³)
M80 Ring Road to northern portal	2,155,000
Northern portal to southern portal	3,265,000
Eastern Freeway	680,000
Total	6,100,000

7.2 IWRG soil hazard categorisation

Based on the information obtained as part of the historical assessment and preliminary field investigation, spoil has been categorised in accordance with the Victorian EPA Publication 621 *Soil hazard categorisation and management* and is summarised for each North East Link element in Table 7-2.

Further sampling and analysis would be required to meet the minimum sampling density to categorise site soils in accordance with Victorian EPA Publication IWRG 702 *Soil Sampling* and the volumes are in situ calculations.

Based on the information obtained as part of the historical assessment and preliminary field investigation, spoil has been categorised in accordance with the Victorian EPA Publication 621 *Soil hazard categorisation and management* and is summarised for each North East Link element in Table 7-2. Further sampling and analysis would be required to meet the minimum sampling density to categorise site soils in accordance with Victorian EPA Publication IWRG 702 *Soil Sampling* and the volumes are in situ calculations.

Further information and key assumptions are provided in the Spoil Volume Estimate Report in Appendix M, which should be read in conjunction with the data provided here.

It is noted that a large volume of PIW has been attributed to excavation at former landfill sites. However, the actual quantity may be less if putrescible waste is encountered and managed on that basis. No estimate of putrescible waste has been calculated due to the lack of data regarding landfill materials.

Table 7-2 Indicative spoil volume characterisation estimate (m³ in situ)

Location by element	Estimated volumes (m ³ in situ)					
	Fill material	Prescribed industrial waste (PIW)				Subtotal
		Cat A	Cat B	Cat C	Total PIW	
M80 Ring Road to northern portal	2,120,000	-	3,000	32,000	35,000	2,155,000
Northern portal to southern portal	3,111,000	5,500	11,500	137,000	154,000	3,265,000
Eastern Freeway	612,000	500	1,500	66,000	68,000	680,000
Grand total	5,843,000	6,000	16,000	235,000	257,000	6,100,000

Table 7-2 indicates that most spoil to be excavated is likely to be classified as Fill Material. Some of the spoil, notably the Silurian siltstone, is categorised as Category C based on fluoride, which is likely to be naturally occurring. Therefore, some of this material may be able to be reclassified as Fill Material. Under EPA Publication 621, the generator of contaminated soil may submit a classification application to the EPA Victoria for approval, where it can be demonstrated that a different category is appropriate for a particular contaminant or group of contaminants in soil. Reclassification would need to be approved by EPA Victoria, through an application demonstrating that:

- Fluoride levels are equivalent to background concentrations
- Historical activities in the area do not indicate any sources of this substance.

Once this has been demonstrated, a request with all the supporting information can be sent to the EPA Permitting Section of the Development Assessment Unit seeking their approval/acceptance.

7.3 Acid sulfate soils and rock volume estimate

Based on the information obtained as part of the historical assessment and preliminary field investigation, spoil has been categorised in accordance with EPA Victoria Publication 655.1 (July 2009) Acid Sulfate Soil and Rock and is summarised for each North East Link element below. It is noted that further sampling and analysis would be required to meet the specified sample density of the IWRG. Further information and key assumptions are provided in the Spoil Volume Estimate Report in Appendix M, which should be read in conjunction with the data provided here. It is important to note that quantities provided are estimates only taken from preliminary geological cross sections and are likely to vary as more data is collected.

It has been assumed that no Quaternary aged alluvial soils or moderately weathered to fresh siltstone would be encountered between the M80 Ring Road to the northern portal and so the waste acid sulfate materials in that area have been assumed to be zero.

Similarly, it is expected that excavations along the Eastern Freeway would encounter only minor quantities of moderately weathered or better quality siltstone and only minor quantities of alluvial soil at the interchange with Bulleen Road. The quantity of these materials could not be estimated based on available data at the time of preparing this report and so the quantity of acid sulfate materials in this area could not be estimated. Further sampling would be required to assess waste acid sulfate soil (WASS) volumes in this area.

Most of this material is categorised as Fill Material although some meets the definition of Category C Prescribed Industrial Waste, in accordance with IWRG classification. The classification of Category C is based on elevated naturally-occurring elements, notably fluoride and it is envisaged that EPA Victoria approval could see most of this reclassified as Fill Material.

Table 7-3 Indicative spoil volume acid sulfate estimate (m³ in situ)

Location by element	Chainage (approximate)		Potential acid sulfate materials		Approximate WASS volume (m³)		
	Start	End	% Recent Alluvial Soil	% MW, SW, FR Siltstone*	Acid sulfate soil	Acid sulfate rock	Total
M80 Ring Road to northern portal			0%	0%	-	-	-
Northern portal to LPR – ZONE 2A	42,900	43,300	0%	40%	-	161,000	161,000
	43,300	43,600	0%	70%	-	281,000	281,000
TBM tunnels (LPR to Bridge Street) – ZONE 2B	43,600	46,620	0%	100%	-	1,185,000	1,185,000
Manningham/Banksia interchange – ZONE 2C	43,900	47,280	30%	33%	207,000	227,000	434,000
Mined tunnels (under Bulleen Road and Property) – ZONE 2D	47,200	47,700	0%	90%	-	139,000	139,000
Mined tunnels to southern portal – ZONE 2E	47,700	48,400	90%	10%	387,000	43,000	430,000
Eastern Freeway			minor	minor			
				Total	594,000	2,036,000	2,630,000
*MW – moderately weathered SW – slightly weathered FR – fresh							

7.4 Spoil Management Strategy

The Spoil Management Strategy for North East Link is provided in Appendix G. Key elements of the strategy are summarised below. The objectives of the Spoil Management Strategy are to:

- Provide guidance for spoil management and disposal during construction of North East Link to be incorporated into the Spoil Management Plan (SMP) by the contractor
- Identify feasible options for the management of spoil that mitigate potential human health and environmental risks.

7.4.1 Spoil Management Plan (SMP)

The contractor would be responsible for developing and implementing a Spoil Management Plan (SMP). The SMP would provide details on spoil management measures to be implemented to comply with the Environmental Performance Requirements (EPRs) as outlined in the Spoil Management Strategy provided in Appendix G. The SMP must be consistent with the North East Link Environment Management Framework (EMF) (refer to EES Chapter 27 – Environmental Management Framework).

The SMP should also include management measures in accordance with EPA Victoria Publication 480, *Environmental Guidelines for Major Construction Sites*.

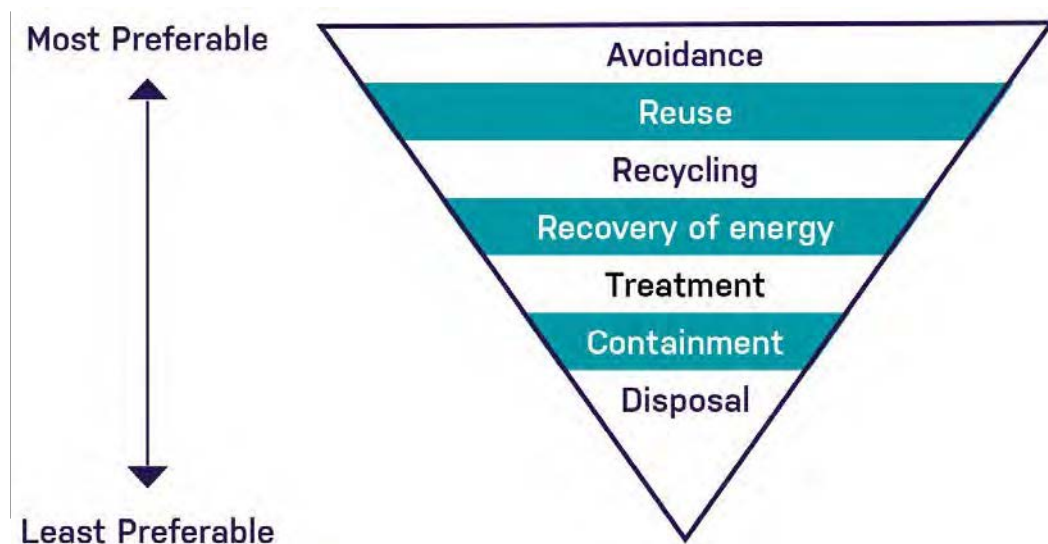
Regular performance monitoring of spoil management measures within the SMP should be conducted by the Environment Representative of the contractor as well as NELP. This must be consistent with the North East Link EMF (refer to EES Chapter 27 – Environmental management framework).

The contractor would need to hold compliance records which include items as outlined in the Spoil Management Strategy provided in Appendix G.

Results and outcomes of inspections, monitoring and auditing would be reported regularly by the contractor. The compliance records would be audited by NELP for conformance.

The SMP would identify the process for identifying, reporting, recording and reviewing non-conformances, which would ensure continual improvement. This document would be periodically reviewed and updated as necessary.

The SMP would consider the waste management hierarchy for North East Link as defined in the *Environment Protection Act 1970 (Vic)* ('Environment Protection Act'), which prioritises management of waste in the following order of preference:



The SMP also requires that any soil reuse on VicTrack land requires approval by VicTrack and be conducted in accordance with *Soil Reuse – Guidelines* for the reuse of potentially contaminated or contaminated soil on VicTrack Land.

The following summary of soil treatment options is taken from the Spoil Management Strategy provided in Appendix G.

7.5 Avoidance

The design of North East Link has reduced excess spoil generation where practicable. Several mitigating measures could be considered during the design refinement, including:

- Refining the design and construction methods to reduce the volume of spoil produced/disturbed (where practicable)
- Using engineering measures such as improving the structural properties of in situ spoil to negate the need for its removal (such as grouting)
- Minimising groundwater disturbance and/or coverage of in situ PASS to reduce the generation of WASS.

7.6 Reuse

Reuse of spoil at the site of origin is possible where it meets human health and ecological criteria and is a preferred option. Spoil designated as PIW (Categories A, B and C) are regulated by EPA Victoria and options for the reuse, treatment or disposal of these materials includes:

- Category A: Offsite treatment at licensed facility
- Category B: Offsite treatment or disposal to licensed facility, or containment onsite
- Category C: Disposal to licensed facility, or reuse onsite.

However, disposal of Fill Material does not face these constraints as its movement and disposal is not regulated and Fill Material is a commodity with many viable uses.

Reuse of spoil classified as PIW, is not possible offsite without treatment and reclassification as Fill Material approved by EPA Victoria.

Reuse of spoil on North East Link can be split in two categories:

- Reuse within the project
- Reuse outside the project.

7.6.1 Reuse within the project

Spoil could potentially be reused within the project boundary for:

- Fill embankments and beneath ramps
- Restoration of any pre-existing contaminated sites within the project boundary
- Reuse topsoil for site restoration.

However, the potential to reuse spoil within the project is limited, due to the objective of minimising the project footprint and the limitations on space in the developed suburban area. The construction sites are narrow and would be congested with construction-enabling equipment, materials and personnel. However, if a need for spoil is identified, an application for a Major Infrastructure spoil management classification and reuse within the project can be made by contacting EPA Victoria's Major Projects Unit.

Fill Material

Fill Material, particularly topsoil, would be recovered and reused wherever practicable, such as for landscaping areas. It is expected the contractor would provide innovative approaches to reuse Fill Material wherever possible. In accordance with the Environment Protection Act, any reuse of Fill Material at the receiving site must not have adverse impacts to human health or the environment.

Contaminated spoil (PIW)

Reuse of less than 1,000 m³ of Category C soil and containment of less than 1,000 m³ of Category B soil onsite requires implementation of a soil management plan that is prepared in consultation with EPA Victoria. Reuse or containment of soils above these volumes would require an EPA Works Approval. It is noted that exceptions to reuse and containment exist under EPA Victoria's *Contaminated soil management and reuse on major infrastructure projects*.

Category A spoil cannot be reused or contained onsite.

WASS (AASS, PASS & ASR)

Reuse of WASS is possible if it is treated or managed appropriately. Classifications for PIW may be issued by EPA Victoria in accordance with Clause 11 of the Environment Protection (Industrial Waste Resource) Regulations 2009. Classifications can specify spoil management options through conditions such as requirements on auditing, tracking, treatment, storing or monitoring.

Reuse of WASS is likely to require treatment (neutralising) and possibly dewatering before it is allowed to be placed in an area away from where it was excavated. Therefore reuse on site of WASS may be considered an impracticable option for North East Link, due to site and program constraints.

7.6.2 Reuse outside the project

Reuse of spoil material outside the project would need to meet the requirements of the Environment Protection Act, and may be subject to a determination by EPA Victoria. PIW (Category B and C) would need to be treated and reclassified as Fill Material with EPA Victoria approval prior to reuse offsite. Category A spoil cannot be reused offsite. Options to reuse material include:

- Construction on other projects
- Manufacturing of construction materials (bricks and tiles)
- Manufacturing of soil conditioners
- Land reclamation
- Land restoration (including filling disused mines or quarries)
- Port and coastal protection works
- Reuse for landfill management.

Options available for the reuse of material are provided in the context of the spoil management hierarchy provided in Appendix G.

Fill Material

Fill Material is preferred to be reused onsite wherever possible. However, given the large total volume of Fill Material, most would not be able to be reused within the project boundary and would be reused offsite. Disposal of Fill Material is not regulated and it is a commodity with many viable uses.

In accordance with the Environment Protection Act, any reuse of Fill Material at the receiving site must not have adverse impacts to human health or the environment.

Contaminated spoil (PIW)

Contaminated spoil is designated by the Environment Protection Act as PIW once it is removed from its original source. Category A PIW, being the most hazardous, cannot be reused and must be treated or disposed at a licensed treatment facility.

Reuse of Category B and Category C PIW offsite would require treatment (possibly at an offsite licensed treatment facility) and reclassification as Fill Material before its reuse. The contractor would be expected to conduct a feasibility study/cost benefit analysis for this option prior to construction.

WASS (AASS, PASS and acid sulfate rock)

Spoil classified as WASS would require treatment before its reuse offsite and may only occur at premises:

- Licensed to dispose of WASS under the Environment Protection Act; or
- Where a CEMP, prepared in accordance with the Industrial Waste Management Policy (Waste Acid Sulfate Soils) 1998, has been approved by EPA Victoria.

North East Link may utilise a combination of licensed receiving facilities or reuse sites approved by EPA Victoria under a CEMP. The treatment requirements for reuse of WASS are considered further in Section 7.8.

In accordance with EPA Victoria Publication 655.1 *Acid Sulfate Soil & Rock* 2009, WASS sourced from a subaqueous environment, which is intended to be directly disposed of to a marine or estuarine spoil ground does not require a CEMP. EPA Victoria must approve this disposal method, oxidation must be minimised, and disposal carried out in accordance with current best practice for dredging.

Solid waste, demolition waste

Solid inert waste material that does not contain contaminated soil (classified in accordance with IWRG621) can be disposed at a landfill facility licensed to accept solid inert waste. Clean fill could be separated from the solid inert waste to minimise total disposal volumes to landfill.

7.7 Recycling and energy recovery

Based on on-going investigations and the nature of the spoil material being excavated on North East Link, recycling and/or recovery of energy opportunities are unlikely to be viable management options for the spoil generated during construction activities. However, opportunities could be further investigated by offsite treatment facilities utilised and implemented where practicable.

Some components of any solid inert waste (such as metal, concrete) should be able to be recycled.

7.8 Treatment

7.8.1 Fill Material

No or minimal treatment is required for reuse or disposal of Fill Material. If the final destination of the Fill Material is not a licensed landfill, some assessment of the receiving environment may be required to ensure this is appropriate.

Construction rubble (such as bricks and concrete), which may be co-mingled with Fill Material, would have to be removed as far as practicable in accordance with the IWRGs.

7.8.2 Contaminated spoil (PIW)

There are various methods for treating PIW depending on the contaminants which are targeted to be removed. EPA Victoria Publication 1589 *Contaminated soil – treatment & disposal* (Draft) 2015 requires the spoil producer to conduct an assessment to determine if treatment is a viable option before PIW can be disposed of at a landfill, against the following tests:

- a. Available — the PIW can be treated or reprocessed to reduce the requirement for residual management, and technology and facilities necessary to realise this potential are practicably accessible
- b. Not available — the PIW cannot be treated or reprocessed to reduce the requirement for residual management, or technology and facilities necessary to realise this potential are not practicably accessible.

Category A PIW must be treated and disposed at a licensed treatment facility. Treatment of Category B and C PIW at a licensed treatment facility before its reuse is preferred for North East Link where practicable. In assessing whether an option is practicable, practicability does not mean the option is the lowest cost option. A preferable option that costs more may still be practicable. EPA Victoria Publication 1589 *Contaminated soil – treatment and disposal* provides examples of how to assess the practicability of an option in terms of technical, logistical and financial factors.

Options for treatment of contaminated spoil include:

- Chemical immobilisation and solidification for the treatment of inorganic and organic contaminants
- Bioremediation for the treatment of organic contaminants, including petroleum hydrocarbons
- Soil washing for the treatment of heavy metals, petroleum hydrocarbons, some VOCs, PCBs, PAHs, acids, pesticides, herbicides, PFAS and cyanides
- Thermal desorption for the treatment of VOCs, SVOCs, PCBs, dioxins and furans
- Thermal destruction for PFAS-impacted soils.

The application of these treatment technologies for the treatment of spoil would be applied to reduce contaminant concentrations and/or leachability and allow for Category A and Category B soils to be reclassified as either Category C soil or Fill Material post treatment. Reclassification of material would require additional testing and application to EPA Victoria. Treatment and subsequent reclassification by EPA Victoria would require stockpiling of the material pending EPA Victoria determination.

7.8.3 WASS (AASS, PASS and acid sulfate rock)

Publication 655.1 *Acid sulfate soil and rock* 2009 and the *Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils* (2010) provide guidance on the treatment methods available for WASS. Due to site constraints on North East Link, WASS spoil would have to be treated offsite at the receiving facility. However if the contractor determines there is sufficient space within another construction site within the project boundary then it could be transported to that site for treatment (with EPA Victoria approval).

The treatment methodology for the WASS would comprise:

- Transport of the WASS in accordance with IWRG licence requirements
- Weighing the spoil (via weighbridge or similar) and placement into a temporarily stockpile
- Review of previous analytical testing together with real-time measurements of the pH and moisture content of the stockpiled spoil
- Addition of an alkaline neutralisation agent (typically lime) at a rate determined from the testing and based on the net acid generating capacity of the spoil
- Reuse and/or disposal as appropriate.

It is possible that any WASS excavated may be saturated. Therefore, some dewatering would be required before trucking offsite. The contractor's SMP would need to address this and provide a means of treating and/or disposing of waste water.

Minimisation of stockpile duration times would be undertaken to reduce the volume of neutralisation agent required wherever practicable. Further information regarding treatment of WASS is provided in *Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils* 2010.

7.9 Containment

Containment is not considered a viable option for PIW or WASS excavated on North East Link, due to site area constraints and limited space within the project boundary. Where removal of PIW or WASS spoil is not required for construction purposes and can remain in situ, it may be viable to assess treatment/management to minimise contaminant migration. Containment option can be considered for selected soils where cut and fill operations are proposed and the contaminant levels and leachable fractions of the spoil are managed so that exposure and release is prevented.

7.10 Disposal

Disposal of spoil is the least preferred management option in relation to EPA Victoria's waste hierarchy. However, it may be required for PIW and WASS due to project, site and program constraints, and the available capacity of treatment facilities.

EPA Victoria has provided an Industrial Waste fact sheet: EPA Victoria Publication 1624 (May 2016) which guides the producer and receiver of Fill Material, PIW and WASS. EPA Victoria also provides a list of licensed disposal locations through its website at www.epa.vic.gov.au/your-environment/waste/landfills.

General response options for each category of PIW and licensed landfills and waste contractors are listed in Table 6-10.

The contractor's SMP would detail the disposal procedures of PIW and WASS generated during construction works. As a minimum, the SMP would need to cover handling, stockpiling and transport of PIW and WASS and mitigation measures to ensure no adverse human health, ecological or reputational outcomes from temporary storage and movement of spoil. Any PIW and WASS leaving the site can only be transported by a licensed operator under a Victorian EPA-approved licence.

The SMP would need to provide reporting and documentation procedures to track PIW and WASS movements. The document system would need to be made readily available for inspection.

7.11 Asbestos

Asbestos may be encountered in spoil from Bulleen Oval and other historical sites and would have to be classified as Asbestos Containing Material (ACM), Asbestos fines or Fibrous asbestos. An occupational hygienist would need to be engaged to prepare an asbestos management plan as part of the contractor's CEMP that would define the procedures and protocol for identifying and managing asbestos-containing waste. The asbestos-containing waste would be managed in accordance with the *Occupational Health and Safety Act 2004* (Victoria) and Regulations 2007 (Victoria). ACM would be handled and transported in accordance with IWRG611.1 *Asbestos Transport and Disposal* 2009.

7.12 Onsite spoil management

With an unprecedented number of major infrastructure projects in Victoria, EPA Victoria has clarified the approval process to control the movement of soil across major infrastructure projects in a way that manages the environmental risk without imposing unreasonable administrative or regulatory burden.

Contaminated spoil would be categorised using the existing waste classifications in accordance with Clause 11 of the Environment Protection (Industrial Waste Resource) Regulations 2009. Exclusions are outlined in the Spoil Management report.

Major infrastructure soil management classifications include the transport, on-site reuse and temporary storage of PIW. The classification does not include off-site reuse.

For a classification to be issued for a major project, the soil management plan (SMP) segment of the CEMP needs to be endorsed by an environmental auditor. During a project, the auditor must also verify that processes used to track PIW have been conducted in accordance with the classification issued.

Applications will be processed by EPA Victoria's Major Projects Unit within 60 working days of receiving a completed application.

8. Risk assessment

A risk assessment of North East Link activities was performed in accordance with the methodology described in Section 5.4. The risk assessment has been used as a screening tool to prioritise the focus of the impact assessments and development of EPRs. The risk pathways link project activities (causes) to their potential effects on the environmental assets, values or uses that are considered in more detail in the impact assessment. Risks were assessed for the construction and operation of North East Link.

Risks were considered with respect to impact on human health and the environment, excluding risks to construction workers, which are understood to be managed under project-specific health and safety requirements.

The identified risks and associated residual risk ratings are listed in Table 8-1. The likelihood and consequence ratings determined during the risk assessment process and the adopted EPRs are provided in Appendix N. There are no planned events for the contamination and soil impact assessment.

Individual risk items are discussed further in Section 9.

Table 8-1 Risk register for contamination and soil impact assessment

Risk ID	Risk pathway	Residual risk rating
Risk CT01	Earthworks requiring excavation, stockpiling, transport and treatment/disposal of contaminated soil causes impacts to human health (via direct contact and vapour inhalation) and the environment	Low
Risk CT02	Earthworks requiring excavation, stockpiling, transport and treatment/disposal of acid sulfate soil and rock causes impacts to human health (via direct contact and vapour inhalation) and the environment	Low
Risk CT03	Encountering asbestos-containing materials that had not been assessed and identified prior to/during excavation results in adverse health (via direct contact and vapour inhalation) and the environment impacts	Low
Risk CT04	Encountering waste materials containing hazardous substances in former landfill(s) and/or uncontrolled fill site(s) (known or unknown) causes impacts to human health	Low
Risk CT05	Excavation of contaminated soil generates offensive odour causing impacts to human health and loss of amenity to sensitive receptors	Low
Risk CT06	Earthworks leading to movement of underground gases that have the potential to build up in enclosed spaces and present a public safety risk.	Low
Risk CT07	Spills and leaks from construction equipment causes contamination of soil leading to impacts to public health and the environment.	Low
Risk CT08	Abstraction of groundwater causes migration of contamination onto sites that otherwise may not have been impacted, resulting in soil impact off site and causes an impact to human health and the environment	Low
Risk CT09	Underground construction causes migration of hazardous vapours, ground gases and/or dissolved methane and causes an impact to human health and the environment.	Low
Risk CT10	Disturbance of contaminated soil in long-term stockpile or disturbance of contamination that remains in situ, notably within landfills, causes impacts to human health (via direct contact and inhalation) and the environment	Low
Risk CT11	Ongoing abstraction of groundwater causes migration of contamination onto sites that otherwise may not have been impacted, resulting in soil contamination off site and causes an impact to human health and the environment	Low
Risk CT12	Ongoing abstraction of groundwater causes migration of hazardous vapours, ground gases and/or dissolved methane and causes an impact to human health and the environment.	Low

9. Impact assessment

The impact assessment in this section is based on the historical and site information collected and presented above and the proposed construction design/approach for North East Link. The impact assessment has been split below into the three project elements, for further discussion. The impact assessment considers all risks identified and detailed in Table 8-1, in the context of the project and the associated EPRs that are required to manage environmental risk.

This assessment has investigated the potential for contaminated soil (including hazardous materials, asbestos, odours and vapours), acid sulfate soil or rock, landfill gases and contaminated groundwater to be encountered during earthworks and cause an impact to human health or the environment during construction and operation.

9.1 M80 Ring Road to northern portal

9.1.1 Construction impacts

Construction of North East Link from the M80 Ring Road to northern portal would involve a mixture of aboveground, belowground and at surface road sections. This includes:

- New and upgraded road sections extending from the M80 Ring Road at Plenty Road and the Greensborough Bypass at Plenty River Drive in the north to Blamey Road in the south as well as alterations to arterial and local roads
- New land bridges over the new road within a trench between Watsonia railway station and Blamey Road, to maintain east to west connectivity
- New interchanges at the M80 Ring Road and Grimshaw Street to separate North East Link through traffic
- Upgrade to the Watsonia railway station car park
- Extending the length of the current Hurstbridge rail underpass (just north of Watsonia railway station) due to the footprint of North East Link main carriageways and Grimshaw Street ramps and service roads. There is also the potential to require upgrades to rail signalling infrastructure
- To meet project noise attenuation objectives, noise walls would be required to mitigate noise in residential areas
- New and modified shared use paths.

Eight possible temporary construction compounds have been identified for consideration at locations listed in Table 9-1. These are subject to availability at the time of construction.

Table 9-1 Construction compounds proposed for M80 Ring Road to northern portal

Site ID	Location name	Area (m ²)	Duration of occupation
1	The AK Lines Reserve or part thereof at the south-west corner of Grimshaw Street and Greensborough Bypass including strip of land east of Concord School (Watsonia campus) and west of Greensborough Road	44,933	5 years
2	Part of Simpson Barracks on the south side of Blamey Road	20,517	5 years
13	Gabiona Avenue Reserve, Gabiona Avenue	35,582	1.5 years
14	Winsor Reserve, Somers Avenue	23,350	5 years
15	Part of Simpson Barracks on the south-east corner of Yallambie Road and Greensborough Road	1,209	5 years
16	Part of Bulleen Oval on the west side of Bulleen Road and to the south of the Veneto Club	15,137	6 years
17	Part of Marcellin College and Trinity Grammar School Sporting Complex on the east side of Bulleen Road	39,256	4 years
19	Immediately north of the M80 Ring Road/Greensborough Bypass interchange	19,398	4 years

The impacts during construction and operation stages, relevant to this assessment are discussed in the sections below in relation to the risks detailed in Table 8-1.

Contaminated soil (risk CT01)

Based on the desktop and preliminary field investigations undertaken, it is expected that some of the excavated soil will be contaminated as a result of existing and historical land uses. Potential sources of contamination and the associated contaminants of concern are summarised in Table 6-7.

As described in Section 7.1, approximately 1,542,000 m³ (in situ)—or 30 per cent of the total spoil expected to be excavated as part of North East Link—would be excavated from the M80 Ring Road to northern portal element. Of this, approximately 3,000 m³ and 32,000 m³ of spoil is potentially to be categorised as Category B and C contaminated soil, respectively. The majority (98 per cent) of spoil is estimated to be categorised as Fill Material. Further assessment in accordance with industry guidelines (notably AS 4482.1-2005) will refine these estimates. That assessment is a requirement of EPR CL1 – Implement a Spoil Management Plan.

This assessment has investigated the potential for earthworks to interact with contaminated soil, and impact on human health (via direct contact and vapour inhalation) or the environment.

Exposure to a human health risk for the public has the potential to be realised under the following scenarios:

- Direct contact between skin and contaminated soil or water
- Ingestion of contaminated soil or water
- Inhalation of contaminated dust or vapours.

Exposure of the environment to an ecological risk has the potential to be realised under the following scenarios:

- Runoff of exposed contaminated soil in stockpiles or open excavations into water courses and drains
- Access to exposed contaminated soil to terrestrial animals and birds.

Due to the land use history within the M80 Ring Road to northern portal project element and surrounds, it is anticipated that minor quantities of contaminated soils would be encountered during the excavation works. These are most likely to be found surrounding the former quarry (backed filled with putrescible and solid inert waste) located at the M80 Ring Road and Greensborough Bypass, a former landfill at AK Lines Reserve, Watsonia and the service station located at the corner of Greensborough Road and Yallambie Road.

Earthworks associated with road widening, construction of elevated roads and land bridges would likely be limited to surface excavation and minor footing excavations. Therefore, generation of spoil within these areas would likely be minimal. However, earthworks associated with the trench section between Elder Street and the cut and cover tunnels section, would generate large portion of spoil within the M80 Ring Road to northern portal element. These materials would be managed at applicable construction compounds, in accordance with EPA CL1 (Implement a Spoil Management Plan). The SMP would be developed in consultation with the EPA Victoria. The preparation of these construction compounds/management areas should minimise potential impacts to the environment and human health through a number of ways including:

- Ensuring all spoil handling and transport is conducted in accordance with the IWRGs
- All stockpile compounds are appropriately secured to prevent access by the public
- All stockpile areas are appropriately secured, lined and bunded to prevent leaching to groundwater
- Stockpiled soils are appropriately covered and bunded to prevent leaching by rainwater and runoff to stormwater or surface water
- Stockpile covering to also prevent dust generation to reduce the risk of inhalation of contaminated dust and to discourage terrestrial animal or bird access (note – odour of stockpiled soils is addressed under the section below – Odours (risk CT05))
- Stockpiling of soil is kept to a minimum and removed to landfill or other use at the earliest possible opportunity.

Opportunities for reuse would be investigated by the contractor and spoil that is unable to be reused would be removed from the storage sites by truck via designated haulage routes (Refer to EES Chapter 8 – Project description for details of truck haulage routes). Transport companies must be licensed by EPA Victoria to carry contaminated soil, so that loads are appropriately secured and covered to reduce the chance of releases along the transport route that might impact communities. Trucking routes must also minimise the potential for impact to communities. This is discussed in detail in Technical report A – Traffic and transport.

Depending on the nature and extent of residual or remaining contamination after construction and within the project boundary, area-specific remediation may be required or desired. This could include on-site treatment techniques that would destroy or remove the contaminants (such as bioremediation) or techniques that may contain the contamination (such as cement stabilisation, thermal desorption or capping). EPA Victoria approval may be required for any on-site soil treatment or containment. Management of contaminated soil at an on-site compound is likely to be limited by available space. The framework for EPA Victoria approval would be outlined in EPR CL1 (Implement a Spoil Management Plan).

Where residual contamination is exposed by construction, this material must be made safe for the public and environment in accordance with EPR CL1. In other words, any contaminated soil exposed must be covered and remain covered so that:

- No access is possible by the public
- The future designated uses of the areas post-construction do not expose buried or covered contamination, such as public pathways and open spaces
- No possible contaminated runoff can be generated when it rains
- No leachate can be generated when it rains.

In the event that future maintenance or modifications within the areas of buried residual or covered contamination that requires subsurface access (that is, drilling or excavation), the SMP must indicate the location of the material and provide information on the chemicals present and appropriate handling methods.

Acid sulfate soil/rock (risk CT02)

Preliminary field investigations undertaken to date indicate that the weathered siltstone materials (that is, residual soil and extremely and highly weathered rock) are unlikely to be ASS, while moderately weathered to fresh siltstone material would be classified as acid sulfate rock in accordance with EPA Victoria Publication IWRG 655.1), indicating that acid sulfate rock may be present. Most of this material is categorised as Fill Material although some meets the definition of Category C Prescribed Industrial Waste, in accordance with IWRG classification.

The classification of Category C is based on elevated naturally-occurring fluoride and it is envisaged that EPA Victoria approval could see most of this reclassified as Fill Material (see Section 23.3.1, *Contaminated soil*).

Earthworks associated with road widening, construction of elevated roads and land bridges are likely to be limited to surface and footing excavations and are not expected to encounter acid sulfate materials. Based on preliminary 2D geological interpretation, undertaken for the geotechnical investigation, it is estimated that earthworks associated with the trench section between Elder Street and the cut and cover tunnels section south of Blamey Road would not encounter potentially acid sulfate soils.

The installation of piles for North East Link is the key activity within this project element that has the potential to encounter or activate acid sulfate soil and acid sulfate rock.

Acid sulfate soil and rock excavated during the construction of North East Link would be managed in accordance with EPR CL2 (Minimise impacts from disturbance of acid sulfate soil) which would reduce the risk of impact on human health and the surrounding environment to low.

Measures adopted to implement EPR CL2 must include:

- Characterise acid sulfate soil and rock before excavation
- Development appropriate stockpile areas including lining, covering and runoff collection to prevent release of acid to the environment
- Identify suitable sites for re-use management or disposal of acid sulfate soil and rock
- Prevent oxidation if possible through cover and/or scheduling practices; that is, ensuring acid sulfate rock is not left in stockpiles for any length of time
- Prevent acid formation by addition of neutralising compounds.

Management of asbestos materials within spoil (risk CT03)

Asbestos-containing materials (ACM) such as bonded cement sheet are commonly found within commercial, industrial and residential properties and isolated fragments of ACM are likely to be identified at numerous points along the North East Link alignment. These occurrences of ACM generally present a low risk to human health and environment, but may be identified throughout the M80 Ring Road to northern portal element.

Soils contaminated with ACM are likely to be encountered where waste soils and/or construction waste has been disposed of (see risk CT04 below). Based on the historic land use along this section of the North East Link alignment, excluding landfills, it is considered the potential of encountering ACM in spoil is low. The main risk posed by asbestos is thorough inhalation of fibres by humans. This risk is considered low for bonded ACM but disturbance of ACM can lead to the release of fibres. Asbestos does not pose an environmental risk. This risk can be mitigated through conducting works in accordance with a Spoil Management Plan (EPR CL1) which would include procedures on:

- Identification of the potential areas where asbestos may be present before works commence
- Identification of asbestos and ACM in the field
- Reporting of occurrences
- Appropriate PPE
- Engaging an occupational Hygienist to assess risks and guide soil movement, storage and disposal of ACM.

Waste materials and unknown contamination (risk CT04)

Within the M80 Ring Road to northern portal element, waste materials containing hazardous substances (including asbestos) could be encountered at the former quarry (backfilled with putrescible and solid inert waste) located at the M80 Ring Road and Greensborough Bypass and the former landfill at AK Lines Reserve. Hazardous materials (including asbestos) could also be encountered in locations that have not been investigated.

Encountering waste materials containing hazardous substances (including asbestos) or unknown contamination in former landfills or uncontrolled fill sites during construction is possible, although the risk to environment, health or amenity is assessed to be low. This is because the potential to encounter waste materials containing hazardous substances or unknown contamination during construction would be minimised by the completion of an in situ intrusive soil investigation in accordance with EPR CL1 (Implement a Spoil Management Plan), which includes EPA Victoria IWRG and Australian Standards for sampling to understand the soil condition, including contaminants of concern and concentrations before excavation works started. To protect the environment and human health, EPR CL1 would also include a health, safety and environmental plan for the management of hazardous substances in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and EPA Victoria. In addition, EPR CL1 would also require that mitigation measures were in place to prevent future exposure to hazardous or contaminated soil left in the ground after construction, so the material poses no future hazard to human health or ecosystems.

Odours (risk CT05)

Odorous material can be generated when contaminated soil is excavated that contains odorous wastes (such as petroleum hydrocarbon impacted soils) or when soils containing naturally occurring sulphides are exposed to air and hydrogen sulphide is produced (also known as rotten egg gas). Disturbance of putrescible waste material from former landfills or uncontrolled fill sites also has the potential to generate unpleasant odours. While these soils or wastes are exposed by excavation, in stockpiles or on the side of a trench, they can continue to emit odour that could be considered unpleasant. The odour can also be spread outside of the project boundary as material is transported off-site or during windy conditions. This can lead to a loss in amenity in the surrounding area (risk CT05).

In addition, it may not be logistically feasible to remove all odorous material and some residual material may remain in situ after construction. This may create issues for the operation of North East Link and so must be addressed in the construction design, such as by including vapour barriers or vapour extraction devices.

Given the potential presence of contaminated soils has been identified within the project boundary, it is considered likely the spoil excavation process would expose odorous material. However, the risk that it would result in a loss of amenity is considered low as the material would be managed to minimise odours in accordance with EPR CL3 (Minimise odour impacts during spoil management) developed and implemented for the project. The Odour Management Plan would be developed giving consideration to the following:

- State Environment Protection Policy (SEPP) Air quality management, 2001
- State Environment Protection Policy (SEPP) Ambient air quality, 1999
- EPA Victoria Publication 1666.1 Determination of odour concentration by dynamic olfactometry, 2018
- EPA Victoria Publication 440.1 A guide to the sampling and analysis of air emissions and air quality, 2002
- Standards Australia, AS4323.3 Stationary source emissions. Part 3: Determination of odour concentration by dynamic olfactometry, 2001.

The Spoil management plan must include procedures on:

- Identification of the potential areas of contamination that may pose an odour risk
- Monitoring of the excavated material for possible odour risk
- Implementation of management measures to minimise odour.

EPR CL3 (Minimise odour impacts during spoil management) would also include requirements for the management of residual odorous contamination left in situ, including:

- Design aspects that allow for the capture and treatment of fugitive odours such as odour barriers and/or odour extraction and scrubbers
- Monitoring of odours including setting of trigger values that require action
- Contingencies to address any breaches of trigger values.

Vapour and underground gases (risk CT06, risk CT09)

Vapours associated with contaminated soil and/or contaminated groundwater that could be encountered during excavation activities has the potential to impact human health. Exposure to soil vapours can have an adverse impact on human health through the generation of volatiles, odour, inhalation or flammability and explosion.

Volatile contaminants (such as those generated by a petroleum hydrocarbon plume in groundwater) may be present in soil and/or groundwater, due to existing conditions. Depending on the contaminant concentration and depth, the contaminants associated with existing contamination may not be present at the surface. Excavation of surface soils during construction has the potential to expose volatile contamination at depth, creating a pathway for gases and vapours to migrate from a subsurface source of vapour-forming chemicals (volatile organic compounds such as petroleum hydrocarbons in soil and/or groundwater) into buildings or other enclosed spaces via cracks in the foundation and/or openings for utility lines.

Possible sources of vapour-forming chemicals in the vicinity of the M80 Ring Road to northern portal element include current and former fuel service stations and dry cleaners. The risk is considered to be low as there would be minimal opportunity for the general public to interact with vapours from contaminated soil or contaminated groundwater as this would be more of an odour issue than a vapour risk. For this to be a vapour risk, there would need to be a build-up in an enclosed space which is unlikely to happen with an open excavation or stockpiled soils, particularly after mitigation measures have been put in place. It is envisaged that the construction OHS plan for North East Link would include prohibition of entry into open excavations even where vapour may not be an issue.

The likelihood of the general public to interact with vapours from contaminated soil or contaminated groundwater is further reduced by implementing EPR CL4 (Minimise risks from vapour and ground gas intrusion). Implementation of EPR CL4 would require maintenance of a secure area around any excavations to prevent entry by the public and appropriate signage. It would also require assessment, monitoring and management of intrusive vapour, including potentially flammable or explosive conditions in enclosed spaces or other impacts on human health and the environment.

Post-construction, the presence of vapours and gases may remain. This may create issues for the operation of North East Link and they must be addressed in the construction design.

EPR CL4 would also include requirements for the management of residual vapours and gases left in situ, including:

- Design aspects that allow for the capture and treatment of fugitive vapours and gases such as vapour barriers and/or vapour extraction and scrubbers.
- Monitoring of vapours including setting of trigger values that require action. These would be developed in accordance with EPA Victoria Publication 788 *Best Practice Management; Siting, design, operation and rehabilitation of landfills* (the BPEM) and relevant occupational health and safety regulations and compliance codes.
- Contingencies to address any breaches of trigger values including temporary cessation of work until a reappraisal of risks is conducted, additional monitoring at a higher frequency, implementation of additional safety measures and or vapour extraction systems in response to the risk assessment.

There is also potential for impacts from landfill gas from the former quarry located at the M80 Ring Road and Greensborough Bypass and former landfill at AK Lines Reserve. Monitoring of methane gas at the M80 Ring Road and Greensborough Bypass reported no methane emissions and monitoring of methane gas surface emissions at AK Lines Reserve reported low-level methane emissions through the surface of the Reserve (refer Section 6.3.4). Similar to vapour risk, landfill gas risks are considered to be low as there would be minimal opportunity for the general public to interact with gases and management of potential impacts from landfill gas would be undertaken in accordance with EPR CL4.

Fuel/chemical spills (risk CT07)

During North East Link construction, vehicles, plant and machinery would be operating within designated construction compounds (to be determined) and throughout the project boundary. There is a possibility that spills may occur during the refuelling of vehicles, plant and machinery or the use of chemicals required as part of the construction. The risk of fuel or chemical spills causing contamination to soil is assessed as low, and the risk is further reduced by implementing EPR CL5 (Manage chemicals, fuels and hazardous materials). This would include measures to control exposure for the general public in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and EPA Victoria; procedures detailing monitoring and reporting requirements.

Contaminated groundwater (risk CT08)

Based on desktop review and samples collected during the preliminary investigation, widespread contamination of groundwater has not been identified. The groundwater beneath the Watsonia railway station car park may potentially be impacted by activities, leakages or spills, for example, from the dry cleaning business, automotive repair centre or former fuel service station located on Watsonia Road, or fuel service station that historically operated within the current Watsonia railway station car park area (demolished in the 1980s). Groundwater on the eastern side of the Greensborough Road may potentially be impacted by the Watsonia zone substation located near Elgar Road, and groundwater beneath the fuel service station on Greensborough Road/Yallambie Road has been shown to be impacted by petroleum hydrocarbons from the service station.

Earthworks associated with road widening and the construction of elevated roads and land bridges are likely to be limited to surface excavation and some bored piles. Gauging data included in Technical report N – Groundwater indicated that groundwater levels between the M80 Ring Road and Watsonia railway station car park varies between 11.3 and 22.0 metres top of casing (TOC). Therefore, within this area the potential to encounter groundwater is likely to be associated with bored pile installation only.

Earthwork associated with the trench section and cut and cover tunnels between the Watsonia railway station car park and northern portal would include demolition of the existing fuel service station. This work could potentially encounter groundwater, as gauging data included in Technical report N – Groundwater indicated that groundwater levels were measured between 22.0 metres TOC at BH190 near the Watsonia railway station car park and 4.3 metres TOC at NEL-BH100 near Borlase Reserve. Contamination associated with the service station could include petroleum hydrocarbons in soil and groundwater which would pose a health and safety risk to workers, an aesthetic risk to nearby residents and may require treatment before its disposal. The risks posed by these compounds can be minimised by the completion of an in situ intrusive soil investigation in accordance with EPR CL1 (Implement a Spoil Management Plan) which includes EPA Victoria IWRG and Australian Standards for sampling to understand the soil condition, including contaminants of concern and concentrations, before excavation works started. It would also require additional groundwater investigation to identify the extent and type of any contamination. EPR GW2 (Monitor groundwater) from Technical report N – Groundwater requires a baseline assessment of groundwater quality in the area which must include assessment for contaminants of concern. While the number of wells is not explicitly stated in the EPR GW2, the contractor would need to conduct an adequate assessment of the extent of groundwater contamination in areas of known impact, such as the fuel service station and where dewatering is likely to be conducted.

Pathways to groundwater for contaminant migration or mobilisation may be introduced where piles or excavations are proposed. The potential for contaminant migration would need to be addressed as part of the EPR GW4 (Technical report N – Groundwater) and this may occur during cut and cover activities at the fuel service station on the corner of Greensborough Road and Yallambie Road. This risk is assessed in Technical report N – Groundwater. Abstraction of groundwater would be managed in accordance with EPR GW3 (Minimise changes to groundwater levels through tunnel and trench drainage design and construction methods) and EPR GW4 (Implement a Groundwater Management Plan to Protect groundwater quality and manage groundwater interception) for North East Link. Options for disposal of extracted groundwater are detailed in Technical report N – Groundwater. It is possible, albeit unlikely that some treatment may be required before disposal. Treatment options for groundwater have been tried and tested successfully on projects throughout Victoria where contamination is encountered and options are readily available. Forewarning of the potential contaminants that may be extracted should be documented and included in works planning. On this basis, the risk to human health and environment is considered to be low.

9.1.2 Operational impacts

Contaminated soil (risk CT10)

Opportunities for reuse of excavated spoil may be limited but would need to be assessed by the contractor. Any reuse would need to be managed in accordance with the SMP (EPR CL1) and include measures to ensure only spoil categorised as Fill Material or PIW (Category B or C) is used and that EPA Victoria requirements are met. The SMP would need to include measures to ensure that the area of reuse would not be adversely impacted by the imported spoil, and that future access to the soils is prevented and any cover is adequately maintained.

Risks from contamination remaining in situ are considered low. In situ contamination, by definition, is not disturbed and is likely to have been in place for some time. This applies to all elements of North East Link. Access to this material after construction would be managed at the design and construction stage through a Spoil Management Plan (EPR CL1), which requires maintenance of adequate cover during operation of North East Link, and a record of the location of contaminated soil in case of future excavation of drilling in those areas. It would also be managed during the operation of North East Link in accordance with an Operation Environmental Management Plan (OEMP) referred to in EPR CL6 (Minimise contamination risks during operation).

Odours, vapours, gases (risk CT09), vapour and underground gases (risk CT06, risk CT09)

Parts of the North East Link alignment would be constructed in areas where odorous material may have been present and excavated during its construction or in the vicinity of contaminated groundwater and landfill gases. It is possible this material may present some inhalation/odour risk during operation.

However, the risk posed by this material is considered low as a significant mass of any odorous material would be removed during construction and the design of North East Link would address capture and treatment of odours, vapours and gases in accordance with EPRs CL3 and CL4. In addition, ongoing management of these issues would also be managed during operation in accordance with an OEMP referred to in EPR CL6 (Minimise contamination risks during operation).

Contaminated groundwater (risk CT11) – contaminant migration risk

It is understood that active pumping of groundwater is unlikely during the construction of North East Link and any groundwater abstraction would cease after construction, allowing the groundwater level to recover. The risk of encountering contaminated groundwater during operation is thus considered low. In addition, the engineering option for the M80 Ring Road to northern portal segment of North East Link is tanking the below ground structure, which would reduce the chance of groundwater ingress.

In the unlikely event that groundwater abstraction was required during operation, the risk of contaminated groundwater migration and management is much the same as for risk CT08 and would be managed in a similar way.

Abstraction of groundwater would be managed in accordance with EPR GW3 (Minimise changes to groundwater levels through tunnel and trench drainage design and construction methods) and EPR GW4 (Implement a Groundwater Management Plan to Protect groundwater quality and manage groundwater interception) for North East Link. These measures allow for the capture and treatment and disposal of any potentially contaminated groundwater, removing exposure pathways to local residents and the environment. It is noted however, that widespread groundwater contamination has not been identified in this area and so the risks posed by any contamination are likely to be low. On this basis, the risk to human health or the environment is considered to be low. This is considered applicable for all elements of North East Link.

Contaminated groundwater (risk CT12) – vapour risk

As mentioned above, ongoing abstraction of groundwater is unlikely in the M80 Ring Road to northern portal element of North East Link. Should it be required, there is a low potential to cause migration of contamination onto sites that otherwise may not have been impacted, resulting in potential migration of hazardous vapours, underground gases and/or dissolved methane that impacts on human health and the environment.

Risks associated with CT12 are considered to be low as potential impacts would be managed through EPR GW5 (Manage groundwater during operation) which are detailed in Technical report N – Groundwater and EPR CL4 (Minimise risks from vapour and ground gas intrusion). In addition, the trench and cut and cover tunnel sections would be designed and built as undrained (tanked) structures to minimise effects on groundwater flow and availability and avoid the need to capture and dispose of large volumes of groundwater during operation. Furthermore, ongoing management of these issues would also be managed during operation in accordance with an OEMP referred to in EPR CL6 (Minimise contamination risks during operation).

9.2 Northern portal to southern portal

9.2.1 Construction impacts

Construction of North East Link from the northern portal to southern portal would involve a mixture of aboveground, belowground and at surface road sections. The northern to southern portal project element begins with a cut and cover tunnels section adjacent to Blamey Road, which would transition to the bored tunnels constructed by tunnel boring machine (TBM) at Lower Plenty Road. The TBM tunnels would then extend from Lower Plenty Road to Bridge Street and connect with the Manningham Road interchange. The TBM tunnels would be constructed 30 to 50 metres below the existing ground level (3135006-RD-DRG-W00-01-RD-03001 Rev. UR) and include associated ventilation facilities. A new zone substation would be built at the TBM launch site off the Manningham Road interchange, to power the TBM and other construction activities. The substation would then be used for tunnel-related facilities during operation.

The section from Bridge Street to the southern portal would contain a combination of underground tunnels, surface roads and elevated ramps, with two designs currently being considered for the Manningham Road interchange. Construction impacts from both alternatives are considered to be the same. North East Link main line tunnels would continue south from the Manningham Road interchange, surfacing on the west side of Bulleen Road adjacent to Bulleen Oval at the southern portal. The type of tunnels in this section includes:

- Cut and cover – located over in the following areas:
 - Bridge Street to Avon Street
 - Rocklea Road to Bulleen Oval
- Mined – located from Avon Street to Rocklea Road.

The cut and cover structures of the Manningham Road interchange would be adjacent to and below the Yarra River. Groundwater levels would need to be lowered to at or below the excavation level of these structures to enable their construction. The permanent structure would be progressively constructed, eventually sealing the excavation from water ingress. Management of impacts during this temporary lowering of the water table during construction is discussed in Technical report N – Groundwater.

Five possible temporary construction compounds have been identified at locations listed in Table 9-2. These are subject to availability at the time of construction.

Table 9-2 Construction compounds proposed for northern portal to southern portal

Site ID	Location name	Area (m ²)	Duration of occupation
20	Northern side of Manningham Road immediately west of Bulleen Road	15,638	5 years
21	Southern side of Manningham Road immediately west of Bulleen Road	26,547	5 years
22	Southern side of Manningham Road immediately west of Bulleen Road and Avon Street	104,823	5 years
24	Katrina Street Reserve near Elgar Road	30,743	5 years
25	Lower Plenty Road to Blamey Road	98,784	5 years

The impacts during the construction and operation of North East Link relevant to this assessment are discussed in the sections below, in relation to the risks detailed in Table 8-1.

Contaminated soil (risk CT01)

Based on the desktop and preliminary field investigations, it is expected that some of the excavated soil from the construction of North East Link be contaminated due to existing and historical land uses. Potential sources of contamination and the associated contaminants of concern are summarised in Section 6, Table 6-8.

As described in Section 7.1, approximately 3,186,000 m³ (in situ)—62 per cent of the total spoil expected to be excavated—would be excavated from the northern portal to southern portal element. It is estimated that approximately 5,500 m³, 11,500 m³ and 137,000 m³ of spoil would potentially be categorised as Category A, B and C contaminated soil, respectively. A large proportion (3,032,000 m³ or 95%) of spoil is estimated to be categorised as Fill Material. It is noted that due to lack of field data in key areas within the Bulleen commercial/industrial area, soil category has been conservatively estimated (refer to Spoil Volume Estimate Appendix M). Further assessment in accordance with industry guidelines (notably AS 4482.1–2005) would refine these estimates. Such assessment is a requirement of a Spoil Management Plan (EPR CL1).

Due to construction of the proposed TBM and mined tunnels—which would pass well below the land surface—and the limited historical and current sources of contamination in these areas, the contaminated soil risk between the northern portal and Manningham Road interchange and the Avon Road to Rocklea Road sections is low. However, the Manningham Road interchange area itself has a higher potential for contamination based on site land use and construction methodology (cut and cover/surface) as most soil contamination tends to be shallow as sources are generally at the surface. In particular, areas surrounding the current and former fuel service stations, dry cleaners and automotive service/repair facilities have a high potential to encounter contaminated land.

Data collected from the former landfill at Bulleen Oval indicates that fill materials are potentially contaminated.

It is noted the Bulleen industrial/commercial area would also be used as a temporary construction laydown and processing site. Contaminated soils are also likely to be generated at the former landfill at Borlase Reserve as the proposed construction types involve large-scale excavation.

Spoil from the tunnel excavations would be loaded from the road header directly into articulated spoil trucks or loaders (purpose-built underground mining equipment) that would transport the spoil to stockpile ready to be loaded onto trucks and removed from site. Construction compound 22 (refer to Table 9-2 for details) has been proposed to be used as spoil management facility for spoil from the tunnels construction. Other work areas would generate surplus spoil during the construction. These materials would be managed on the individual construction sites in the vicinity of the works. The generated spoil would be managed in accordance with the Spoil Management Plan (EPR CL1). Opportunities to reuse would be investigated although it is understood that limited opportunities for on-site reuse exist due to limited land area.

As Category A spoil cannot be sent directly to a landfill, this material would be removed to a licensed waste management facility for treatment before being sent to landfill.

Spoil that is unable to be reused would be removed from the storage sites by truck via designated haulage routes. This is discussed in Technical report A – Traffic and transport where haulage routes are considered in terms of potential impacts on communities. The haulage of contaminated soils is regulated by EPA Victoria under the IWRGs and only licensed carriers can be used. Mitigation measures to reduce the risk of impacts on human health and the environment from earth movement and transport are essentially identical to those for risk CT01 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

Depending on the nature and extent of residual or remaining contamination within the project boundary, area-specific remediation may be required or desired. This could include on-site treatment techniques that would destroy or remove the contaminants (such as bioremediation) or techniques that may contain the contamination (such as cement stabilisation, thermal desorption or capping). EPA Victoria approval may be required for any on-site soil treatment or containment. Management of contaminated soil at an on-site compound is likely to be limited by available space. The framework for EPA Victoria approval would be outlined in a Spoil Management Plan (EPR CL1). It is noted that remediation methods for the likely contaminants encountered in the northern portal to southern portal element have been tried and tested on many projects in Victoria and are readily available. The selection of any method would depend on logistical, financial and technical feasibility.

Acid sulfate soil/rock (risk CT02)

The disturbance of acid sulfate soil and acid sulfate rock within the northern portal to southern portal element by excavation is considered to have an initial medium risk of impact on human health and the environment. Preliminary field investigation undertaken to date indicated that 14 samples of Silurian aged siltstone collected taken at depths from 11.6 (mbgs) to 45.8 mbgs are acid sulfate rock, and one sample of alluvial soil collected near the Bulleen Oval is PASS.

The spoil calculation data estimates that approximately 2,036,000 m³ (in situ) of acid sulfate rock from the northern portal to southern portal element would require management. This estimate is based on regional geology as well as the preliminary sampling program results (refer to Section 6.3.3).

Based on the geological sections, the majority of acid sulfate rock would likely be generated from the TBM tunnel (1,185,000 m³) and the mined tunnel (138,510 m³) and the majority of acid sulfate soil generated from the Manningham Road interchange (652,318 m³).

Acid sulfate soil and rock excavated during the construction of North East Link would be managed in accordance with EPR CL2 (Minimise impacts from disturbance of acid sulfate soil). Enacting EPR CL2 as part of North East Link would reduce the risk of impact on human health and the environment to low.

Mitigation measures to reduce the risk of impacts on human health and the environment from the management and transport of acid sulfate soils and rock are essentially identical to those for risk CT02 for the M80 Ring Road to northern portal element discussed in Section 9.1. There may be a need for dewatering excavated alluvial soils to allow for storage and/or transport. This would require an assessment of dewatering technologies and water treatment and disposal options. These options are common and tried and tested on many projects in Victoria.

Management of asbestos materials within spoil (risk CT03)

Asbestos-containing materials (ACM) such as bonded cement sheet are commonly found within commercial, industrial and residential properties and isolated fragments of ACM are likely to be identified at numerous points along the North East Link alignment. These occurrences of ACM generally present a low risk to human health and the environment, but may be identified where surface excavations are required for the northern portal to southern portal element.

Soils contaminated with ACM are likely to be encountered where waste soils and/or construction waste has been disposed of (see risk CT04 below). Based on the historic land use along this section of the North East Link alignment (excluding landfills), it is considered that ACM would most likely be uncovered in the Bulleen industrial/commercial area and/or the open space areas near the southern portal and associated cover and sections. Where earthworks were undertaken in accordance with a Spoil Management Plan (EPR CL1), the risk to human health and the environment is considered to be low. Mitigation measures to reduce the risk of impacts on human health and the environment from the management and transport of asbestos-impacted soils are essentially identical to those for risk CT03 for the M80 Ring Road to northern portal element discussed in Section 9.1.

Waste materials and unknown contamination (risk CT04)

Within the project boundary from the northern portal to southern portal element, waste materials containing hazardous substances (including asbestos) may be encountered at the Borlase Reserve and Bulleen Oval areas. Hazardous materials (including asbestos) could also be encountered in uncontrolled fill material at unknown locations.

At Bulleen Oval, potential ACM was observed in four boreholes (NEL-BH039, NEL-BH125, NEL-BH126 and NEL-BH128). Analytical results of samples reported trace asbestos fibres at concentrations estimated at below 0.1 g/kg in soil samples collected from NEL-BH125 at a depth of 1.5 metres. Encountering waste materials containing hazardous substances (including asbestos) or unknown contamination during the construction of North East Link is possible although the risk to environment, health or amenity is considered to be low. This is because the potential for waste materials containing hazardous substances or unknown contamination to be encountered during construction would be minimised with an in situ intrusive soil investigation in accordance with EPR CL1 (Implement a Spoil Management Plan). This includes EPA Victoria IWRG and Australian Standards for sampling to understand the soil condition, including contaminants of concern and concentrations, before excavation works started. To protect the environment and human health, EPR CL1 would also include a health, safety and environmental plan for the management of hazardous substances in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and EPA Victoria. There is also a risk of contamination being left exposed after excavation works have been conducted, notably in the landfill areas. This material may not meet criteria to protect beneficial land uses remaining after construction. EPR CL5 would also require mitigation measures to prevent future exposure to hazardous or contaminated soil left in the ground after construction.

Odours (risk CT05)

Based on preliminary assessment works undertaken, it is understood that contaminated soils/wastes and waste acid sulfate soils would be encountered within the northern portal to southern portal element. This includes fill and alluvial soils at Borlase Reserve, Bulleen Oval and the Manningham Road interchange. These materials all have the potential to generate odours that may impact on the amenity of receptors outside the project boundary. However, the risk that it would result in a loss of amenity is considered low as the material would be managed to minimise odours in accordance with EPR CL3 (Minimise odour impacts during spoil management) developed and implemented for North East Link. Mitigation measures to reduce the risk of impacts on human health from the odours are essentially identical to those for risk CT05 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

In addition, it may not be logistically feasible to remove all odorous material and some residual material may remain in situ after construction. This may create issues for the operation of the project and so must be addressed in the construction design. EPR CL3 (Minimise odour impacts during spoil management) would also include requirements for management of residual odorous contamination left in situ, including:

- Design aspects that allow for the capture and treatment of fugitive odours such as odour barriers and/or odour extraction and scrubbers
- Monitoring of odours including setting of trigger values that require action
- Contingencies to address any breaches of trigger values.

Vapour and underground gases (risk CT06, risk CT09)

Refer to Section 9.1.1 for the context of vapour and underground gases that could be generated.

Possible sources of vapour-forming chemicals in the vicinity of the northern portal to southern portal element primarily include the Bulleen industrial area and current and former fuel service stations, dry cleaners and automotive service/repair. However, the risk is considered to be low as there would be minimal opportunity for the general public to interact with vapours from contaminated soil or contaminated groundwater, and the likelihood of the general public to interact with vapours or gases from contaminated soil or contaminated groundwater is further reduced by implementing EPR CL4 (Minimise risks from vapour and ground gas intrusion).

There is also potential for impacts from landfill gas in the vicinity of the northern portal to southern portal element from former landfills located at Borlase Reserve and Bulleen Oval. The former quarry (potentially partially backfilled) located in Bulleen near Rocklea Road is also a possible source of vapour and/or landfill gas, but as the proposed tunnel would likely extend at least 15 metres below the base of the former quarry, it is unlikely that vapour risk would be generated for surrounding residents or the environment.

Monitoring of methane gas emissions at Bulleen Oval encountered methane gas within a sub-surface electrical pit of 1.6 % (v/v). Similar to vapours, landfill gas risks are considered to be low due to the minimal opportunity for the general public to interact with gases and management of potential impacts from landfill gas in accordance with EPR CL4 (Minimise risks from vapour and ground gas intrusion). Mitigation measures to reduce the risk of impact to human health and the environment from vapour and gases are essentially identical to those for risk CT06 and risk CT09 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

Post-construction, the presence of vapours and gases may remain. This may create issues during operation and so must be addressed in the construction design.

EPR CL4 would also include requirements for the management of residual vapours and gases left in situ, including:

- Design aspects that allow for the capture and treatment of fugitive vapours and gases such as vapour barriers and/or vapour extraction and scrubbers
- Monitoring of vapours including setting of trigger values that require action
- Contingencies to address any breaches of trigger values.

Fuel/chemical spills (risk CT07)

During the construction of North East Link, vehicles, plant and machinery would be operating within the construction compounds (there are six temporary construction compounds proposed for the northern portal to southern portal element) as well as throughout the project boundary. There is a possibility that spills may occur during the refuelling of vehicles, plant and machinery or the use of chemicals required for construction. The risk of fuel or chemical spills causing contamination to soil is assessed as low, and the risk is further reduced by implementing EPR CL1 (Implement a Spoil Management Plan) and EPR CL5 (Manage chemicals, fuels and hazardous materials). Mitigation measures to reduce the risk of impacts on human health and the environment from fuel and chemical spills are essentially identical to those for risk CT07 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

Contaminated groundwater (risk CT08)

Based on the desktop review, elevated metals and one occurrence of PFAS have been identified in the groundwater. However, the metals are likely to represent background (natural) groundwater concentrations. Other sources of groundwater contamination may be present in the Bulleen Oval and the Bulleen commercial/industrial area, although limited sources of potential groundwater contamination were identified beyond these areas in what is largely a residential area. Such sources might include leakages or spills from dry cleaning, automotive repair centres or current and former fuel service stations. A groundwater sample was collected from the south-west corner of the Bulleen Drive-in, and assessed for a wide range of potential contaminants. The groundwater sample contained traces of metals and PFAS compounds above adopted criteria for stock watering, recreational use and maintenance of ecosystems. Stock watering and recreational use of groundwater does not occur in the area currently and is considered an unlikely future use. These contaminants are considered 'existing' and North East Link is unlikely to increase discharge of these existing groundwater contaminants to ecosystems. In addition, the construction of North East Link in the northern portal to southern portal element is not likely result in additional impacts from any contaminants, given the protections provided by the relevant EPRs.

Abstraction of groundwater for dewatering during the construction of North East Link would generate a waste stream that would need to be managed. Options for treating water containing PFAS have been developed over the past few years and have shown good results in reducing PFAS concentrations to below thresholds suitable for disposal to sewer. They are also likely to be beneficial in reducing other contaminants. This may require the contractor to negotiate a trade waste agreement with the local water authority before construction started to allow for disposal to sewer (or potentially to stormwater).

Limited field data is available from the Bulleen Oval area but it is noted that only trace concentrations of metals exceeded adopted criteria in one well located in this area (NEL-BH125).

The majority of earthworks required within the northern portal to southern portal element would be for tunnel construction using TBMs, cut and cover and other open excavations. Earthwork associated with construction of mined tunnel, cut and cover tunnel and trenches would potentially encounter contaminated groundwater, as gauging data summarised in Section 6.1.1 indicated that groundwater levels were measured between 7 mbgl and 22 mbgl in the M80 Ring Road to northern portal element, and between 3 and 14 mbgl in the northern portal to southern portal element.

EPR GW2 (Monitor groundwater) from Technical report N – Groundwater requires a baseline assessment of groundwater quality in the area which must include assessment for contaminants of concern. While the number of wells are not explicitly stated in the EPR GW2, the contractor would need to conduct an adequate assessment of the extent of groundwater contamination in areas of known or suspected impact, such as the Bulleen industrial area

The bored tunnel beneath the Banyule Flats and Warringal Parklands would use a closed face pressurised TBM, with lining installed immediately behind to create a tanked tunnel to manage groundwater flows during the construction and operation of North East Link. The mined tunnel sections would be drained during construction works. Grouting or freezing of excavation faces may be utilised to manage groundwater inflow during construction works. Abstraction of groundwater would be managed in accordance with EPR GW3 (Minimise changes to groundwater levels through tunnel and trench drainage design and construction methods) and EPR GW4 (Implement a Groundwater Management Plan to Protect groundwater quality and manage groundwater interception). Management of abstracted water can be achieved through disposal to sewer, stormwater or reinjection into the aquifer. These options would be contingent on obtaining approvals from local water authorities, EPA Victoria and Southern Rural Water. As discussed above, there may also be a need for some pre-treatment before disposal.

Pathways to groundwater for contaminant migration or mobilisation may be introduced where tunnels, piles or excavations are proposed. The potential for contaminant migration would need to be addressed as part of the EPR GW4 (Implement a Groundwater Management Plan to Protect groundwater quality and manage groundwater interception). This is relevant along the length of the northern portal to southern portal element. Abstraction of groundwater would be managed in accordance with EPR GW3 (Minimise changes to groundwater levels through tunnel and trench drainage design and construction methods) and EPR GW4 (Implement a Groundwater Management Plan to Protect groundwater quality and manage groundwater interception) prepared and implemented for North East Link. On this basis, the risk to human health or the environment is considered to be low.

9.2.2 Operational impacts

Contaminated soil (risk CT10)

Opportunities to reuse excavated spoil may be limited but would need to be assessed by the contractor. Any reuse would need to be managed in accordance with the SMP (EPR CL1) and include measures to ensure only spoil categorised as Fill Material or PIW (Category B or C) is used and that EPA Victoria requirements are met. The SMP would need to include measures to ensure that the area of reuse would not be adversely impacted by the imported spoil, and that future access to the soils is prevented and any cover is adequately maintained.

Risks from contamination remaining in situ are considered low. In situ contamination, by definition, is not disturbed and is likely to have been in place for some time. This applies to all elements of North East Link. Access to this material after construction would be managed at the design and construction stage through EPR CL1 (Implement a Spoil Management Plan) which requires maintenance of adequate cover during operation and a record of the location of contaminated soil in case of future excavation of drilling in these areas. It would also be managed during operation in accordance with an OEMP referred to in EPR CL6 (Minimise contamination risks during operation).

Odours, vapours, gases (risk CT09), vapour and underground gases (risk CT06, risk CT09)

Parts of the North East Link alignment is located in areas where odorous material may have been present and excavated during the project's construction or in the vicinity of contaminated groundwater and landfill gases. It is possible this material may present some inhalation/odour risk during operation.

However, the risk posed by this material is considered low as a significant mass of any odorous material would be removed during construction works and the design of North East Link would address capture and treatment of odours, vapours and gases in accordance with EPRs CL3 and CL4. It would also be managed during operation in accordance with an OEMP referred to in EPR CL6 (Minimise contamination risks during operation).

Contaminated groundwater (risk CT11) – contaminant migration risk

The risk of contaminated groundwater migration during operation will depend upon the engineering option selected by the contractor (as outlined under risk CT08 above). The risk and management is much the same as for risk CT08 and would be managed in a similar way.

Abstraction of groundwater would be managed in accordance with EPR GW3 (Minimise changes to groundwater levels through tunnel and trench drainage design and construction methods) and EPR GW4 (Implement a Groundwater Management Plan to Protect groundwater quality and manage groundwater interception) prepared and implemented for North East Link. On this basis, the risk to human health or the environment is considered to be low.

After construction of the northern portal to southern portal element, active groundwater abstraction would cease and the groundwater level would be allowed to recover. Therefore, during operation, the risk of encountering contaminated groundwater is considered low.

In the unlikely event that further groundwater abstraction is required during operation, the risk of contaminated groundwater migration and management is much the same as for risk CT08 and would be managed in a similar way.

It is noted that PFAS has been identified in groundwater in the Bulleen area (Bulleen Drive-in). Access to this PFAS can only be through abstraction or when it discharges into a surface water body where recreational activities take place. Groundwater abstraction is not a realised use of groundwater in this area and any discharge of PFAS through natural groundwater discharge is likely to be subject to significant dilution effects in the receiving water. Abstraction for project works is not likely to create a risk to human health in the region as it would be captured and treated appropriately. PFAS is also not volatile and therefore does not pose a vapour inhalation or odour risk.

Contaminated groundwater (risk CT12) – vapour risk

Refer to Section 9.2.1 for a discussion of impacts.

Risks associated with CT12 are considered to be low as potential impacts would be managed through EPR GW5 (Manage groundwater during operation) and EPR CL4 (Minimise risks from vapour and ground gas intrusion) and the cut and cover tunnels section and bored tunnel would be designed and built as undrained (tanked) structures to minimise effects on groundwater flow and availability and avoid the need to capture and dispose of large volumes of groundwater during operation.

Furthermore, ongoing management of these issues would also be managed during operation in accordance with an OEMP referred to in EPR CL6 (Minimise contamination risks during operation).

9.3 Eastern Freeway

9.3.1 Construction impacts

North East Link would be connected to the Eastern Freeway via a new interchange at Bulleen Road. The construction between the southern portal and new interchange at Bulleen Road would involve a mixture of above and at surface road sections, which are included in the Eastern Freeway element.

The Eastern Freeway from around Hoddle Street in the west to Springvale Road in the east would be upgraded and include the widening of surface roads to accommodate future traffic volumes as well as new dedicated bus lanes for the Doncaster Busway.

Twelve temporary construction compounds are proposed (subject to availability at the time of construction) at locations listed in Table 9-3.

The impacts during the construction and operation of North East Link relevant to this assessment are discussed in the sections below, in relation to the risks detailed in Section 8, Table 8-1.

Table 9-3 Construction compounds proposed for Eastern Freeway

Site ID	Location name	Area (m ²)	Duration of occupation
3	Land between Yarra Boulevard and Chandler Highway, on the south side of the Eastern Freeway	24,128	3 years
4	North-east corner of the Chandler Highway/Eastern Freeway interchange currently occupied by construction of the new Chandler Road overpass	10,396	3 years
5	North-west corner of the Chandler Highway/Eastern Freeway interchange currently occupied by construction of the new Chandler Road overpass	11,057	3 years
6	North-west corner of the Burke Road/Eastern Freeway interchange	6,471	3 years
7	South-east corner of the Burke Road/Eastern Freeway interchange	14,507	3 years
8	Eastern Freeway Linear Reserve or part thereof at the south-west corner of the Springvale Road/Eastern Freeway interchange	28,687	3 years
9	Koonung Creek Reserve or part thereof between Mountain View Road and Kwarren Street	63,343	3 years

Site ID	Location name	Area (m ²)	Duration of occupation
10	North-west corner of the Doncaster Road/Eastern Freeway interchange	25,483	3 years
11	South-east corner of the Doncaster Road/Eastern Freeway interchange	21,686	3 years
12	Koonung Reserve or part thereof between Thompsons Road and the Eastern Freeway (east bound) on ramp	9,788	3 years
18	Elgar Park or part thereof at the south-west corner of the Elgar Road/Eastern Freeway interchange	8,992	3 years
23	Southern side of Manningham Road immediately west of Bulleen Road and Avon Street	3,197	3 years

Contaminated soil (risk CT01)

Based on the desktop and preliminary field investigations, it is expected that some soil excavated for North East Link would be contaminated as a result of existing and historical land uses. Potential sources of contamination and the associated contaminants of concern are summarised in Section 6, Table 6-9.

As described in Section 7.1, approximately 374,000 m³ (in situ)—7 per cent of the total spoil—expected to be excavated as part of North East Link would be excavated from the Eastern Freeway element, with 500 m³, 1,500 m³ and 66,000 m³ of spoil potentially to be categorised as Category A, B and C contaminated soil, respectively. A large proportion (306,000 m³ or 82%) of spoil is estimated to be categorised as Fill Material. It is noted that due to lack of field data, particularly with regard to the historical landfills, the contaminated volume has been conservatively estimated (refer to the Spoil Volume Estimate in Appendix M). Further assessment in accordance with industry guidelines (notably AS 4482.1–2005) would refine these estimates. That assessment is a requirement of EPR CL1 (Implement a Spoil Management Plan).

As Category A spoil cannot be sent directly to a landfill, this material would be removed to a licensed waste management facility for treatment before being sent to landfill.

The disturbance of contaminated soil is considered to have an initial medium risk of impact on human health and the environment. Due to the land use history and proposed construction type within the Eastern Freeway element and their surrounds, it is anticipated that relatively small volumes of contaminated soils would be encountered during excavation works. At several former landfill locations it has been calculated that fill would be required (rather than cut), but it is considered probable that underlying fill soils/waste would need to be removed before fill placement, and so this estimate includes allowance for excavation at all landfill locations (refer to Appendix M).

Contaminated soils could be encountered at the former City of Camberwell landfill, the Camberwell Public Golf Course, the former Greythorn Landfill located at the intersection of the Eastern Freeway and Doncaster Road and the former landfill located at Koonung Creek Linear Park. Based on the location of the North East Link southern portal, it is considered that part of the contaminated fill/demolition debris located beneath Bulleen Oval falls within the Eastern Freeway element. Data collected from the former landfill indicates the fill materials are potentially contaminated. Disturbance of any waste materials would need to be managed in accordance with EPR CL1 (Implement a Spoil Management Plan) to mitigate impacts to the environment and human health. Mitigation measures to reduce the risk of impact to human health and the environment from earth movement and transport are essentially identical to those for risk CT01 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

Enacting EPR CL01 as part of North East Link would reduce the risk of impact on human health and the surrounding environment to low.

Depending on the nature and extent of soil contamination within the project boundary, area-specific remediation may be required or desired. This could include on-site treatment techniques that would destroy or remove the contaminants (such as bioremediation) or techniques that may contain the contamination (such as cement stabilisation, thermal desorption or capping). EPA Victoria approval may be required for any on-site soil treatment or containment. Management of contaminated soil at an on-site compound is likely to be limited by available space. The framework for EPA Victoria approval would be outlined in EPR CL1 (Implement a Spoil Management Plan).

Acid sulfate soil/rock (risk CT02)

The disturbance of acid sulfate soil and acid sulfate rock within the Eastern Freeway element during excavation is likely to be very limited. Construction of the bus lane, road widening and upgrade of interchanges are likely to be within weathered Silurian soil/rock, basaltic soils/basalt rock (Newer Volcanics Formation), which are not anticipated to generate ASS. It is noted that development of the North East Link interchange may require removal of limited alluvial soils, which have the potential to be ASS, but the quantity of soils has not been estimated at the time of writing this report. It is expected that limited soil would require excavation/management in this area based on the largely elevated structure proposed (an elevated road).

Acid sulfate soil and rock excavated during the construction of North East Link would be managed in accordance with EPR CL2 (Minimise impacts from disturbance of acid sulfate soil) prepared and implemented for North East Link. Enacting EPR CL2 would reduce the risk of impact on human health and the environment to low. Mitigation measures to reduce the risk of impact to human health and the environment from acid sulfate soils and rock are essentially identical to those for risk CT02 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

Management of asbestos materials within spoil (risk CT03)

Asbestos-containing materials (ACM) such as bonded cement sheet are commonly found within commercial, industrial and residential properties and isolated fragments of ACM are likely to be identified at numerous points along the North East Link alignment. These occurrences of ACM generally present a low risk to human health and the environment, but may be identified wherever fill soils are disturbed. However, ACM would not be expected within engineered fill soils of the existing freeway.

Soils contaminated with large quantities of ACM are likely to be encountered where waste soils and/or construction waste has been disposed of (see risk CT04 below). Based on the historic land use and proposed construction plans (excluding landfills) it is considered that ACM would be limited in the Eastern Freeway element. Where earthworks are undertaken in accordance with a Spoil Management Plan (EPR CL1) the risk to human health and the environment is considered to be low. Mitigation measures to reduce the risk of impacts on human health from asbestos-impacted soils are essentially identical to those for risk CT01 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

Waste materials and unknown contamination (risk CT04)

Within the project boundary for the Eastern Freeway element, waste materials containing hazardous substances (including asbestos) could be encountered at the former City of Camberwell landfill, the Camberwell Public Golf Course, the former Greythorn Landfill and the former landfill located at Koonung Creek Linear Park. Hazardous materials (including asbestos) could also be encountered in uncontrolled fill material at unknown locations.

Encountering waste materials containing hazardous substances (including asbestos) or unknown contamination during construction is possible, although the risk to environment, health or amenity is considered to be low. This is because the potential for waste materials containing hazardous substances or unknown contamination to be encountered during construction would be minimised by the completion of an in situ intrusive soil investigation in accordance with EPR CL1 (Implement a Spoil Management Plan), which includes EPA Victoria IWRG and Australian Standards for sampling to understand the soil condition, including contaminants of concern and concentrations, before excavation works started. To protect the environment and human health, EPR CL1 (Implement a Spoil Management Plan) would also include health, safety and environmental plan for the management of hazardous substances in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and EPA Victoria.

There is also a risk of contamination being left exposed after excavation works have been conducted, notably in the landfill areas. This material may not meet criteria to protect beneficial land uses remaining after construction. EPR CL1 would also require mitigation measures to prevent future exposure to hazardous or contaminated soil left in the ground after construction, so the material poses no future hazard to human health or ecosystems.

Odours (risk CT05)

Based on preliminary assessment works undertaken, it is understood that contaminated soils/wastes and potentially minor waste acid sulfate soils would be encountered within the Eastern Freeway element. This primarily includes landfill locations along the Eastern Freeway and Bulleen Oval. These materials all have the potential to generate odours that may impact on the amenity of receptors outside the project boundary. However, the risk that it would result in a loss of amenity is considered low as the material would be managed to minimise odours in accordance with EPR CL3 (Minimise odour impacts during spoil management). Mitigation measures to reduce the risk of impacts on human health from odours are essentially identical to those for risk CT05 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

In addition, it may not be logistically feasible to remove all odorous material and some residual material may remain in situ after construction. This may create issues during operation and so must be addressed in the construction design. EPR CL3 (Minimise odour impacts during spoil management) would also include requirements for the management of residual odorous contamination left in situ, including:

- Design aspects that allow for the capture and treatment of fugitive odours such as odour barriers and/or odour extraction and scrubbers
- Monitoring of odours including setting of trigger values that require action
- Contingencies to address any breaches of trigger values.

Vapour and underground gases (risk CT06, risk CT09)

Refer to Section 9.1.1 for the context of vapour and underground gases generation for North East Link.

Possible sources of vapour-forming chemicals in the vicinity of the Eastern Freeway element primarily include landfill locations along the Eastern Freeway and at Bulleen Oval.

Monitoring of methane gas emissions at Bulleen Oval encountered methane gas within a sub-surface electrical pit of 1.6 % (v/v) (refer Section 6.3.4). Similar to vapours, landfill gas risks are considered to be low due to the minimal opportunity for the general public to interact with gases and management of potential impacts from landfill gas in accordance with EPR CL4 (Minimise risks from vapour and ground gas intrusion).

With the exception of Bulleen Oval, no landfill gas monitoring has been undertaken at the location of landfills. However, landfill gas risks are considered to be low based on the age of waste, minimal opportunity for the general public to interact with gases and management of potential impacts from landfill gas in accordance with EPR CL4 (Minimise risks from vapour and ground gas intrusion). Mitigation measures to reduce the risk of impact to human health from vapours and gases are essentially identical to those for risk CT06 and risk CT09 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

Post-construction, the presence of vapours and gases may remain. This may create issues during operation and so must be addressed in the construction design.

EPR CL4 would also include requirements for management of residual vapours and gases left in situ, including:

- Design aspects that allow for the capture and treatment of fugitive vapours and gases such as vapour barriers and/or vapour extraction and scrubbers
- Monitoring of vapours including setting of trigger values that require action
- Contingencies to address any breaches of trigger values.

Fuel/chemical spills (risk CT07)

During the construction of North East Link, vehicles, plant and machinery would be operating within the construction compounds (there are 12 temporary construction compounds proposed for the Eastern Freeway element) as well as throughout the project boundary. There is a possibility that spills may occur during the refuelling of vehicles, plant and machinery or the use of chemicals required for construction works. The risk of fuel or chemical spills causing contamination to soil is assessed as low, and the risk is further reduced by implementing EPR CL1 (Implement a Spoil Management Plan) and EPR CL5 (Manage chemicals, fuels and hazardous materials). Mitigation measures to reduce the risk of impacts on human health and the environment from fuel and chemical spills are essentially identical to those for risk CT01 for the M80 Ring Road to northern portal element discussed in Section 9.1.1.

Contaminated groundwater (risk CT08)

Based on the desktop review, the potential for groundwater contamination within the Eastern Freeway element is relatively high in Clifton Hill and within the former landfills that border the freeway. It is also possible that contaminated groundwater may exist near Bulleen Oval and the proposed Bulleen Road interchange. The remaining section of the Eastern Freeway is assessed as being a low risk of encountering contaminated groundwater based on historical land uses.

The groundwater beneath the Eastern Freeway in Clifton Hill may potentially be impacted by industrial activities within the area, which date back to before the 1930s.

Earthworks associated with Eastern Freeway upgrades are likely to be limited to surface excavation and potentially some bored piles. It is thus likely that little, if any, groundwater would need to be abstracted, although further assessment is required to confirm actual excavation depths and groundwater levels in the area as per EPR GW2. On this basis, it is considered this risk would not be realised within the Eastern Freeway element.

9.3.2 Operational impacts

Contaminated soil (risk CT10)

Opportunities for reuse of excavated spoil may be limited but would need to be assessed by the contractor. Any reuse would need to be managed in accordance with the SMP (EPR CL1) and include measures to ensure only spoil categorised as Fill Material or PIW (Category B or C) is used and that EPA Victoria requirements are met. The SMP would need to include measures to ensure that the area of reuse would not be adversely impacted by the imported spoil, and that future access to the soils is prevented and any cover is adequately maintained.

Risks from contamination remaining in situ are considered low. In situ contamination, by definition, is not disturbed and is likely to have been in place for some time. This applies to all elements of North East Link. Access to this material after construction works would be managed at the design and construction stage through EPR CL1 (Implement a Spoil Management Plan) which requires maintenance of adequate cover during operation and a record of the location of contaminated soil in case of future excavation of drilling in these areas. It would be managed during operation in accordance with an OEMP referred to in EPR CL6 (Minimise contamination risks during operation).

Odours, vapours, gases (risk CT09), vapour and underground gases (risk CT06, risk CT09)

Parts of the North East Link alignment may be constructed in areas where odorous material may have been present or in the vicinity of contaminated groundwater and landfill gases. It is possible this material may present some inhalation/odour risk during operation.

However, the risk posed by this material is considered low given the nature of the works scheduled for the Eastern Freeway element and as a significant mass of any odorous material would be removed during construction and the design of the project would address the capture and treatment of odours, vapours and gases in accordance with EPRs CL3 and CL4. It would also be managed during operation in accordance with an OEMP referred to in EPR CL6 (Minimise contamination risks during operation).

Contaminated groundwater (risk CT11) – contaminant migration risk

It is understood that groundwater is not required to be abstracted to facilitate the construction or operation of North East Link in the Eastern Freeway element. It is unlikely that groundwater would be encountered other than through piling where volumes of groundwater are likely to be low and probably in the form of saturated drill cuttings, which would be contained and disposed of by the drilling contractor. However, further assessment is required to confirm groundwater levels in the area. On this basis, it is considered that risk CT11 would not be realised.

9.4 Alternative design options

Although the reference project for North East Link has largely been finalised, there are currently two design options being considered for the arrangement of the Manningham Road interchange, and two locations for the launch of the tunnel boring machine (TBM) being considered. For information on the design options, refer to EES Chapter 8 – Project description.

This section explains how the potential impacts associated with the alternative design options would differ from the impacts associated with the project design assessed in Section 9.1 (M80 Ring Road to northern portal) and Section 9.2 (northern portal to southern portal).

9.4.1 Manningham Road interchange alternative

The potential contamination impacts of the alternative design for the Manningham Road interchange have been reviewed. The alternative road design offers minor changes with respect to the type of road construction (that is, surface v trenched roads) but the overall footprint of the alternative is not materially different from the reference project. There is an additional road through the existing Bulleen industrial area that is partly trenched. However, it is likely this entire area would be significantly altered in both scenarios.

An area of trenched road is also indicated in the alternative alignment for the Bulleen Drive-in area as opposed to the originally proposed surface road. This area is not considered likely to contain significant contamination as it is removed from the main industrial area. The possible presence of PFAS in this area (as indicated by minor groundwater PFAS impact) suggests further soil sampling is warranted to avoid having to manage any PFAS-impacted soil. That additional assessment is in accordance with EPR CL1. However, the presence of PFAS in groundwater does not necessarily indicate a source in the soils in this area as it can migrate considerable distances in groundwater.

With consideration of the comments above, the alternative alignment would not result in a change to the assessment provided in Section 9.1 and Section 9.2 since it does not raise any issues with respect to contamination that are not already identified, and new mitigation measures are not required.

9.4.2 Northern tunnel boring machine (TBM) launch

The potential contamination impacts of the alternative TBM launch site in the M80 Ring Road to northern portal have been reviewed. It is considered this would not result in a change to the assessment provided in Section 9.1 and Section 9.2 since the mitigation measures and risks are not predicated on where the tunnels start but rather the contamination and spoil volumes, which are the same for both approaches.

9.5 Cumulative impacts

The disposal of excess spoil to landfill and the capacity of the existing landfills to accept the spoil generated during the construction of North East Link may be impacted by other major infrastructure projects being developed at the same time.

Other major infrastructure projects currently proceeding within the Melbourne region that would require significant landfill space include the Metro Tunnel, the West Gate Tunnel Project and the Edithvale and Bonbeach Level Crossing Removal projects. Given North East Link is scheduled to start construction in 2020, there is expected to be some overlap in the construction period between each of these projects and North East Link. For the West Gate Tunnel Project, it is expected the majority of the spoil-generating activities and associated disposal would be concluding before the major spoil generating activities for North East Link are progressed.

The estimated quantity of spoil requiring excavation and disposal/reuse during North East Link construction makes up 59 per cent of the total spoil estimated to be generated during North East Link, the Metro Tunnel, West Gate Tunnel Project, and the Edithvale and Bonbeach Level Crossing Removal projects.

A comparison of the indicative estimate of spoil volumes requiring excavation/disposal/reuse from the five projects is provided in Table 9-4. For comparison purposes, a bulking factor of 1.3 has been assumed and used to calculate ex-situ indicative estimate volumes. This bulking factor is applied here, as opposed to the use of in situ volume estimates elsewhere in this report, to indicate the nature of the material that would be received by the landfills. It is noted the material would mostly likely be subject to compaction by the landfills.

Table 9-4 Indicative estimate of spoil volume for major infrastructure projects

Spoil category	West Gate Tunnel	Metro Tunnel	Edithvale Level Crossing Removal	Bonbeach Level Crossing Removal	North East Link	Sum of projects
	(m ³ ex situ)	(m ³ ex situ)	(m ³ ex situ)	(m ³ ex situ)	(m ³ ex situ)	(m ³ ex situ)
Fill Material	2,150,200	1,754,090	120,341	145,639	4,176,900	8,347,170
Solid Inert Waste	257,400					
Contaminated Spoil – Prescribed Industrial Waste (PIW)						
Category A	3,900	20,410	-	50	7,800	32,160
Category B	18,200	33,930	-	50	20,800	72,980
Category C	202,800	118,820	11,440	28,704	305,500	667,264
Waste Acid Sulfate Soil (WASS)						
Waste Acid Sulfate Soil (WASS)	110,500	716,300	43,355	8,515	3,419,000	4,297,670
Total	2,743,000	2,643,550	175,136	182,958	7,930,000	13,674,644

* As the volume of Fill Material is calculated as the Total Spoil minus the sum of the PIW and WASS, the volume of Fill Material is likely to increase. Note that the presence of PIW and WASS are likely to overlap, although the overlap has not been estimated for this project.

The indicative estimate of ex-situ quantities of spoil categories requiring disposal off-site from North East Link, the Metro Tunnel, West Gate Tunnel Projects, and the Edithvale and Bonbeach Level Crossing Removal projects indicates that:

- 60 per cent is estimated to be categorised as Fill Material
- 33 per cent is estimated to be categorised as WASS
- <1 per cent is estimated to be categorised as Category A contaminated soil
- <1 per cent is estimated to be categorised as Category B contaminated soil
- 5 per cent is estimated to be categorised as Category C contaminated soil.

The remainder of the material is expected to comprise solid inert waste.

EPA Victoria does not regulate the transport, disposal or reuse of Fill Material and re-use of this soil does not require EPA Victoria approval. As the use of Fill Material off-site is not regulated and is not required to be disposed to an EPA Victoria licensed landfill, it is considered there is sufficient capacity to reuse or dispose to landfill the combined estimated volume of Fill Material expected to be generated.

Category C contaminated soil is accepted at a number of licensed landfills in Victoria, but Category B can currently only be disposed of without treatment at the Lyndhurst Landfill, located at 890 Taylors Road, Dandenong South.

Category A soil is required to be treated before it can be disposed and the final disposal category would depend on the treatment undertaken.

The application of treatment technologies for the treatment of spoil could potentially be applied to reduce contaminant concentrations and/or leachability allowed for Category C soil to be re-categorised as Fill Material post-treatment. It is also possible that a significant volume of spoil categorised as Category C could be reclassified as Fill Material. This is relevant to the excavation of the Silurian siltstones which is largely categorised as Category C based on naturally occurring elements such as fluoride.

Further, Category A and B soils can also potentially be re-categorised as Category C soil post-treatment. Re-categorisation of material would require additional testing and application to EPA Victoria. Treatment would be required at a facility licensed to receive and treat the particular material.

As part of the West Gate Tunnel Project, the capacity of existing landfills was investigated and determined there was:

- Landfills with capacity of at least 960,000 m³ (ex situ) with the ability to accept Category C PIW are available and built
- Landfill capacity of over 52,000 m³ (ex situ) with the ability to accept Category B PIW available and built. Furthermore, there are a number of treatment facilities able to accept and treat Category B soil
- Treatment facilities with approval to treat over 24,000 m³ (ex situ) of Category A PIW.

Based on the information obtained as part of the West Gate Tunnel Project and the summary provided above, there is considered to be sufficient capacity within EPA Victoria licensed landfills to accommodate the approximately 660,000 m³ (ex-situ) of Category C contaminated soils to be generated during North East Link, the Metro Tunnel, West Gate Tunnel Project and the Edithvale and Bonbeach Level Crossing Removal projects.

However, based on the preliminary estimates of Category B PIW to be generated by these projects (78,000 m³), the existing (current) landfills may not be sufficient. It is noted that estimates are likely to vary significantly from the final volumes due to the adoption of conservative assumptions in the absence of detailed information. However, noting that construction of North East Link is not proposed to start until 2020, there is a long lead in time before landfill capacity would be needed.

The 'market' (that is, landfills) has recently indicated to NELP they expect to have sufficient capacity by the time construction of North East Link begins. However, the volume of available landfill space for PIW would be verified by the contractor with the market, closer to construction commencement. Based on the current constraints in relation to Category A and Category B prescribed industrial wastes and notwithstanding the requirement for EPA Victoria approval, it is anticipated that the market would respond to the demand with new disposal or treatment facilities. However, since this is not certain, the Spoil Management Plan required under EPR CL1 would require the contractor to develop contingencies in the event that landfill capacity is exceeded. These contingencies would be expected to include treatment of Category A and Category B prescribed industrial wastes to achieve Category C status if required.

The estimates of Category A PIW to be generated by all the projects also exceeds the estimate of available treatment space, but the option for on-site treatment should be considered by the contractor before being discounted. Similar to Category B PIW, conservative assumptions may have increased the Category A volume substantially.

The volumes of available space would be verified by the market closer to when construction of North East Link started. Should constraints on the capacity of identified spoil sites be observed by the market, this could open the opportunity for new spoil disposal or treatment sites. It is also noted the cost associated with disposal of PIW is likely to drive assessment of alternative options to landfill disposal, such as treatment and/or onsite encapsulation, but the limited space available at many of the urban and suburban sites is likely to restrict these options.

10. Environmental Performance Requirements

The recommended Environmental Performance Requirements (EPRs) relevant to the contamination and soil assessment are listed in Table 10-1.

Table 10-1 Environmental Performance Requirements

EPR Code	Environmental Performance Requirements
EPR CL1	<p>Implement a Spoil Management Plan</p> <p>Prepare and implement a Spoil Management Plan (SMP) in accordance with relevant regulations, standards and best practice guidelines. The SMP must be developed in consultation with the EPA Victoria and include processes and measures to manage spoil. The SMP must define roles and responsibilities and include requirements and methods for:</p> <ul style="list-style-type: none"> • Complying with applicable regulatory requirements • Completing a detailed site investigation (in accordance with Australian Standard AS 4482.1:2005 Guide to the investigation and sampling of sites with potentially contaminated soil and the EPA Victoria Industrial Waste Resource Guidelines) prior to any excavation of potentially contaminated areas to identify location, types and extent of impacts and to characterise spoil to inform spoil and waste management. • Identifying the nature and extent of spoil (clean fill and contaminated spoil) • Storage, handling, transport and disposal of spoil in a manner that protects human health and the environment and is consistent with the transport management plan(s) required by EPR T2. This includes requirements and methods for the appropriate treatment/remediation of any contaminated excavated spoil and contaminated residual material left on site • Design and management of temporary stockpile areas • Minimising impacts and risks from disturbance of acid sulfate soils (as per EPR CL2), odour (as per EPR CL3) and vapour and ground gas intrusion (as per EPR CL4) • Management of hazardous substances, including health, safety and environment procedures that address risks associated with exposure to hazardous substances for visitors and general public; contain measures to control exposure in accordance with relevant regulations, standards and best practice guidance and to the requirements of WorkSafe and EPA Victoria; and include method statements detailing monitoring and reporting requirements • Identifying where any contaminated or hazardous material is exposed during construction (notably through former landfills, service stations and industrial land) and how it will be made safe for the public and the environment. Beneficial uses of land and National Environment Protection (Assessment of Site Contamination) Measures 2013 guidance on criteria protective of those beneficial uses must be considered for the land uses in these areas. This must include methods for: • Construction of appropriate cover (soil, concrete, geofabric etc) such that no contamination is left exposed at the surface or where it may be readily accessed by the public and such that it cannot generate runoff or leachate during rain events. • Maintenance of the cover • Identification of the nature and depth of the contaminants • Mitigating impacts during sub-surface works in those areas, eg drilling and excavation • Monitoring and reporting • Identifying locations and extent of any prescribed industrial waste (PIW), other waste, and the method for characterising PIW and other waste prior to excavation

EPR Code	Environmental Performance Requirements
	<ul style="list-style-type: none"> Identifying and managing potential sites for re-use, management or disposal of any spoil in accordance with the Environment Protection Act 1970 waste management hierarchy Identifying suitable sites for disposal of any waste. This includes identifying contingency arrangements for management of waste, where required, to address any identified capacity issues associated with the licensed landfills' ability to receive PIW and other waste.
EPR CL2	<p>Minimise impacts from disturbance of acid sulfate soil</p> <p>The SMP referenced in EPR CL1 must include requirements and methods to minimise impacts from disturbance of acid sulfate soil, including but not limited to:</p> <ul style="list-style-type: none"> Characterising acid sulfate soil and rock prior to excavation Developing appropriate stockpile areas including lining, covering and runoff collection to prevent release of acid to the environment Identifying suitable sites for re-use management or disposal of acid sulfate soil and rock Preventing oxidation that could lead to acid formation if possible through cover and/or scheduling practices, ie ensuring acid sulfate soil and rock is not left in stockpiles for any length of time and/or addition of neutralising compounds <p>Requirements and methods must be in accordance with the Industrial Waste Management Policy (Waste Acid Sulfate Soils), EPA Victoria Publication 655.1 Acid Sulfate Soil and Rock, and the Department of Sustainability and Environment's Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soil.</p>
EPR CL3	<p>Minimise odour impacts during spoil management</p> <p>The SMP referenced in EPR CL1 must include requirements and methods for odour management (in accordance with EPA Victoria requirements) during the excavation, stockpiling and transportation of contaminated material including:</p> <ul style="list-style-type: none"> Identifying the areas of contamination that may pose an odour risk Monitoring of the excavated material for possible odour risk Management measures to minimise odour.
EPR CL4	<p>Minimise risks from vapour and ground gas intrusion</p> <p>Relevant North East Link sections must be designed and constructed to prevent ingress of vapours and gases associated with any construction that interfaces with landfill sites or contaminated areas.</p> <p>The SMP referenced in EPR CL1 must include requirements for assessment, monitoring and management of intrusive vapour including potentially flammable or explosive conditions in enclosed spaces or other impacts on human health and the environment. The plan must address vapour risks associated with excavation of impacted soils, extraction of impacted groundwater, open excavations and stockpiles and gases associated with landfills. This must include, where relevant:</p> <ul style="list-style-type: none"> Securing of the excavation and stockpile area from the public and signage warning of open excavations Monitoring of vapours and odours while excavations are open and stockpiles remain onsite Mitigation measures to prevent fugitive releases of vapours and gasses during construction.

EPR Code	Environmental Performance Requirements
EPR CL5	<p>Manage chemicals, fuels and hazardous materials</p> <p>The CEMP and OEMP must include requirements for management of chemicals, fuels and hazardous materials including:</p> <ul style="list-style-type: none"> Minimise chemical and fuel storage on site and store hazardous materials and dangerous goods in accordance with the relevant guidelines and requirements. Comply with the Victorian WorkCover Authority and Australian Standard AS1940 Storage Handling of Flammable and Combustible Liquids and EPA Victoria publications 480 Environmental Guidelines for Major Construction Sites and 347 Bunding Guidelines. Develop and implement management measures for dangerous substances, including: <ul style="list-style-type: none"> Creating and maintaining a dangerous goods register Disposing of any hazardous materials, including asbestos, in accordance with Industrial Waste Management Policies, regulation and relevant guidelines Implementing requirements for the installation of bunds and precautions to reduce the risk of spills. Contingency and emergency response procedures to handle fuel and chemical spills, including availability of on-site hydrocarbon spill kits.
EPR CL6	<p>Minimise contamination risks during operation</p> <p>The OEMP must include requirements and methods for minimising contamination risks during operation and maintenance of North East Link including:</p> <ul style="list-style-type: none"> Maintaining relevant controls and preventing impacts during operation from contaminated material, odour, vapour and gas. Maintaining controls implemented to make any known areas of contamination or hazardous material that were exposed during construction (notably through former landfills) safe for the public and the environment. Mitigating impacts during sub-surface works in identified areas of contamination or hazardous materials, eg drilling and excavation. Implementing contingency measures, where required, to address potential contamination, odour, vapour or gas impacts or incidents.

Additional EPRs that are relevant to contaminated land but were derived from other reports are listed in Table 10-2.

Table 10-2 Relevant EPRs from other disciplines

EPR Code	Environmental Performance Requirements
EPR GW2	<p>Monitor groundwater</p> <p>Develop and implement a pre-construction and construction groundwater monitoring program to:</p> <ul style="list-style-type: none"> Establish baseline water level and quality conditions throughout the study area Calibrate the predictive model prior to commencement of construction, manage construction activities and verify model predictions Assess the adequacy of proposed design and construction methods, and where required, identify and implement any additional measures required to mitigate impacts from changes in groundwater levels, flow and quality.

EPR Code	Environmental Performance Requirements
	<p>A post-construction groundwater monitoring program must be developed and implemented to:</p> <ul style="list-style-type: none"> • Confirm the acceptability of resultant water quality and water level recovery (and potential mounding) as predicted by the numerical groundwater model. Acceptability is to be assessed with consideration to the Groundwater Dependent Ecosystem Monitoring and Mitigation Plan (as required by EPR FF6) and other identified beneficial uses of groundwater • Confirm the effectiveness of applied measures as identified in the Groundwater Management Plan (refer EPR GW4) and if required, identify and implement contingency measures to restore groundwater to an acceptable level. <p>The duration of post-construction monitoring must be a minimum of two years or until acceptable restoration of groundwater has been confirmed. The monitoring program must be developed in consultation with EPA Victoria and be consistent with EPA Victoria Publication 668 Hydrogeological assessment groundwater quality guidelines, EPA Victoria Publication 669 Groundwater Sampling Guidelines, and the State Environment Protection Policy (Waters).</p>
EPR GW3	<p>Minimise changes to groundwater levels through tunnel and trench drainage design and construction methods</p> <p>Design long term tunnel and trench drainage and adopt construction methods which limit minimise changes to groundwater levels during construction and operation to manage, mitigate and/or minimise to the extent practicable:</p> <ul style="list-style-type: none"> • Requirements for groundwater management and disposal • Mobilisation of contaminated groundwater • Dewatering and potential impacts of acid sulfate soils, including both unconsolidated sediments and lithified sedimentary rock • Potential impacts on waterways and potential groundwater dependent ecosystems, including terrestrial ecosystems • Any other adverse impacts of groundwater level changes such as subsidence. <p>Design and implement engineering control measures and/or ground treatment to limit to the extent practicable groundwater inflow and groundwater drawdown during excavation, construction and operation of tunnels and trenches, cross passages and subsurface excavations.</p> <p>The Groundwater Management Plan (as required by EPR GW4) must contain measures and/or controls to minimise groundwater inflow during construction to excavations and groundwater drawdown, including contingency measures should monitoring indicate adverse impacts are occurring. These must include measures to:</p> <ul style="list-style-type: none"> • Minimise to the extent practicable reduction or loss of groundwater discharge to waterways or loss of water availability for terrestrial ecosystems. • Manage, mitigate and minimise the oxidation of acid sulfate soil materials and acidification of groundwater • Manage, mitigate and minimise any movement of contamination that is identified • Manage, mitigate and minimise impacts on beneficial uses and risk of vapour intrusion • Ensure that groundwater seepage is collected, treated and disposed during construction in accordance with the Environment Protection Act 1970 waste management hierarchy and EPA Victoria requirements. Obtain a trade waste agreement from the relevant water authority where disposal to sewer is required or approval from EPA and the relevant water authority (as required) if discharge to waterways is determined to be appropriate.

EPR Code	Environmental Performance Requirements
EPR GW4	<p>Implement a Groundwater Management Plan to Protect groundwater quality and manage groundwater interception</p> <p>A Groundwater Management Plan must be developed in consultation with EPA Victoria and implemented to protect groundwater quality and manage interception of groundwater including documenting the measures required to achieve EPR GW2 and EPR GW3. The Groundwater Management Plan must be informed by the groundwater modelling required by EPR GW1 and updated where required in response to modelling results and assessment of the adequacy or effectiveness of controls</p> <p>The Groundwater Management Plan must include requirements and construction methods to protect groundwater quality including where appropriate, but not limited to:</p> <ul style="list-style-type: none"> • Selection and use of sealing products, caulking products, lubricating products and chemical grouts during construction that will not diminish the groundwater quality • Selection and use of fluids for artificial recharge activities that will not diminish the groundwater quality • Requirements to ensure compatibility of construction material with groundwater quality to provide long term durability for infrastructure design life • Design and development of drainage infrastructure that minimises clogging and maintenance risks from dissolved constituents in groundwater precipitating out of solution • Measures to assess, remove and dispose of contaminated groundwater and impacted soils associated with excavation and construction • Reinjection borefields for hydraulic control of drawdowns (or contaminated groundwater plumes) • Remedial grouting. <p>The Groundwater Management Plan must include requirements and methods for management of groundwater interception during construction including where appropriate, but not limited to:</p> <ul style="list-style-type: none"> • Identification, treatment, disposal and handling of contaminated seepage water and/or slurries including vapours in accordance with relevant legislation and guidelines • Assessment of barrier/damming effects • Subsidence management • Dewatering and potential impacts on acid sulfate soils, including both unconsolidated sediments and lithified sedimentary rock • Protection of waterways and potential groundwater dependent ecosystems • Management of unexpected contaminated groundwater eg using treatments, hydraulic controls, grouting and exclusion methods. • Contingency actions when interventions are required. <p>The Groundwater Management Plan must also include a review to confirm the status of potential use of extraction bores within the estimated construction drawdown area. Where required, measures must be developed and implemented, to the satisfaction of Southern Rural Water, to maintain water supply to identified, impacted groundwater users.</p>
EPR GW5	<p>Manage groundwater during operation</p> <p>Prepare as part of the OEMP and implement measures for management, monitoring, reuse where possible and disposal of groundwater inflows during operation that comply with relevant legislation and guidelines, including but not limited to:</p> <ul style="list-style-type: none"> • State Environment Protection Policy (Waters) • State Environment Protection Policy (Prevention and Management of Contaminated Land) • Water Industry Regulations 2006 • <i>Occupational Health and Safety Act 2004</i> and Occupational Health and Safety Regulations 2017. <p>The OEMP must include contingency measures and emergency response plans if unexpected groundwater contamination is encountered and requires disposal.</p>

11. Conclusion

This technical report addresses the EES scoping requirements for North East Link for the risks associated with contaminated land, acid sulfate soil/rock and spoil management. The impact assessment has been undertaken to assess the potential impacts of contamination and acid sulfate soils/rock from North East Link. Management and mitigation options to reduce these impacts have also been identified.

Existing conditions

The assessment undertaken to characterise potential environmental risks associated with the project, split the site into two land areas, based on site history including:

- Former or existing industrial/commercial land use and or former or existing land likely to have been filled
- Former open space or agricultural land rezoned and used for predominantly residential land use.

On the basis of the above assessment, the following areas of concern were identified within the three North East Link elements:

M80 Ring Road to northern portal

- Fuel service station located at the corner of Yallambie Road and Greensborough Road, Greensborough
- Former quarry (backfilled with solid inert and putrescible waste material) located at the M80 Ring Road and Greensborough Bypass, Greensborough
- Former landfill located at AK Lines Reserve, Watsonia.

Northern portal to southern portal

- Commercial/industrial area in the vicinity of Bulleen Road and Manningham Road intersection, Bulleen
 - Former landfill located at Borlase Reserve, Yallambie
 - Former landfill located at Bulleen Oval, Bulleen
- Former quarry (potentially backfilled with uncontrolled fill) located near Rocklea Road and Yarraleen Place, Bulleen.

Eastern Freeway

- Former Camberwell Landfill located at Musca Street Reserve and Freeway Public Golf Course, Balwyn North
- Former Greythorn Landfill located at the corner of Doncaster Road and the Eastern Freeway, Balwyn North
- Former landfill located at Koonung Creek Linear Park.

The desktop assessment also identified the potential for soil (particularly Quaternary aged alluvial soil) and Silurian aged Siltstone to present a risk of actual or potential acid sulfate soil and rock.

Preliminary field investigations

Field investigations have been undertaken at selected areas along the proposed North East Link alignment. The investigations have largely utilised geotechnical borehole locations to provide a preliminary understanding of contaminant presence and types along the alignment.

Based on the location of the sampling locations, the preliminary field investigations have not identified widespread soil contamination. Soil impacts were identified, particularly in the Bulleen Park area, where potential ACM was observed and soil contamination concentrations would classify the soil up to Category A (in accordance with IWRG 621). Additional soil sampling would be required to provide a statistically significant data set to more firmly classify the soils in accordance with IWRG guidelines.

Assessment of the potential for acid sulfate soil and rock along the proposed North East Link alignment identified that moderately weathered to fresh Silurian aged Siltstone rock exceeded EPA Victoria criteria adopted to assess acid sulfate soil risks. The assessment also confirmed that Quaternary aged alluvial soils may present a risk of acid generation although field data is limited in extent and the majority of samples did not exceed adopted criteria.

Preliminary groundwater investigations have identified elevated metals which are considered to represent background (natural) conditions.

PFAS compounds were identified in three wells in the Bulleen industrial area (beneath the Bulleen Drive-in, at Kim Close and Banksia Street) and one well at the Watsonia railway station. Concentrations of PFOS+PFHxS exceeded the adopted criteria for maintenance of ecosystems in all the Bulleen samples and the recreational use criteria for one of the Bulleen samples. PFAS are a group of over 3000 compounds with multiple applications including water proofing, detergents (including car washing), fabric and carpet protection, fire-fighting products, electroplating mist suppressants, non-stick coverings (such as Teflon), pesticides and many others. PFAS are also found in landfills where products containing or impregnated with these chemicals have been disposed historically. It is likely an industrial process at Bulleen has been responsible for the impact but the exact cause would require more targeted assessment.

Elevated levels of petroleum hydrocarbon contaminants were reported in one well on Simpson Barracks. The source of this contamination could be the nearby service station, located on the corner of Yallambie Road and Greensborough Road.

Extractive uses of groundwater are not realised currently and are not likely to be realised in the foreseeable future. As groundwater discharges into the Yarra River, the presence of PFAS may affect aquatic ecosystems and primary contact recreation relating to swimming and fishing, however, any impact has already likely occurred and the construction North East Link would not increase discharge of existing contaminants to the river. Management of PFAS and other existing groundwater contaminants in abstracted groundwater can be achieved through assessment of volumes of abstracted water and appropriate treatment options.

Assessment of landfill gas did not identify methane vapours at the surface or within adjacent service pits or trenches, except at one location within the AK Lines Reserve. It is noted that further assessment of landfill risk is required for characterisation.

Spoil assessment

Based on modelling discussed in Section 7.1, the indicative spoil estimates have been developed for North East Link and these are summarised in Table 11-1.

Table 11-1 Indicative spoil volume characterisation estimate (m³ in situ)

Project element	Estimated volumes (m ³)
M80 Ring Road to northern portal	2,155,000
Northern portal to southern portal	3,265,000
Eastern Freeway	680,000
Total	6,100,000

The volumes described above were used to help assess possible waste category volumes. Indicative volume estimates of IWRG waste categories were based on the desktop study, limited field works undertaken at the time of report generation and a number of assumptions and judgements. These assumptions and judgements included the area and depth of contamination and judgements on how much volume to assign to the various IWRG Categories. Quantifiable levels of certainty regarding these assumptions and judgements are not assigned in this report and the contractor would need to conduct its own due diligence in the assigning of volumes to waste categories. This is likely to involve additional sampling and analysis to meet at least minimum sampling densities defined in the IWRGs. The indicative estimates of soil categories are shown in Table 11-2..

Table 11-2 Indicative spoil volume estimates

Element	Fill material	Estimated volumes (m ³ in situ)				
		Contaminated spoil (PIW)				Subtotal
		Cat A	Cat B	Cat C	Total PIW	
M80 Ring Road to the northern portal	2,120,000	-	3,000	32,000	35,000	2,155,000
Northern portal to southern portal	3,111,000	5,500	11,500	137,000	154,000	3,265,000
Eastern Freeway	612,000	500	1,500	66,000	68,000	680,000
Grand Total	5,843,000	6,000	16,000	235,000	257,000	6,100,000

The assessment of acid sulfate conditions was undertaken based on a linear density of one bore per 500 metres (refer to Section 6.3.3) and is considered satisfactory for initial assessment, but is not considered satisfactory to determine an appropriate category in accordance with EPA Victoria assessment guidelines. The conditions are summarised in Table 11-3.

Table 11-3 Indicative spoil volume waste acid sulfate material estimate (m³ in situ)

Element	Potential acid sulfate materials % Recent Alluvial Soil	% MW, SW, FR Siltstone	Approximate acid sulfate soil volume (m ³)	Acid sulfate rock volume (m ³)	Total WASS volume (m ³)
M80 Ring Road to northern portal	0%	0%	-	-	-
Northern portal to LPR – ZONE 2A	0%	40%	-	161,000	161,000
	0%	70%	-	281,000	281,000
TBM tunnel (LPR to Bridge Street) – ZONE 2B	0%	100%	-	1,185,000	1,185,000
Manningham/Banksia interchange – ZONE 2C	30%	33%	207,000	227,000	434,000
Mined tunnel (under Bulleen Road and Property) – ZONE 2D	0%	90%	-	139,000	139,000
Mined tunnel to southern portal – ZONE 2E	90%	10%	387,000	43,000	430,000
Eastern Freeway	minor	minor			
		Total	594,000	2,036,000	2,630,000

Further assessment is required to assess the potential for acid sulfate conditions along the Eastern Freeway, although based on desk top assessment only minor soil/rock in this area is likely to be acid sulfate soil and require special management.

Spoil management

Spoil on the project should be managed in accordance with the waste hierarchy outlined in the *Environment Protection Act 1970 (Vic)*.

No management approach has been set as part of this report, as it is considered that multiple options remain open and available for consideration. However, EPRs set outcomes to be achieved (refer to Section 9). Further assessment of onsite soil is required to make an accurate assessment of waste classes, volumes and management options.

However, the limited available land space for processing contaminated soil or WASS and the limited ability to reuse soils on site would suggest that off-site reuse, followed by off-site treatment and reuse and/or disposal are the likely management options.

Risk assessment, impact assessment, Environmental Performance Requirements

A risk assessment of project activities was performed in accordance with the methodology described in Section 5.4. Risks were assessed for the construction and operation of North East Link. On review, 12 risk items were identified. All the risk items were considered to have a residual risk rating of 'low', taking into account the EPRs.

Cumulative spoil impacts were assessed taking into account the Metro Tunnel, the West Gate Tunnel Project and the Edithvale and Bonbeach Level Crossing Removal projects. Based on the initial calculations of spoil volume and PIW from each project, the great majority of the excavated spoil is likely to be classified as Fill Material.

Estimated volumes of Category B waste spoil across the projects exceeds the total existing landfill capacity for this type of waste. This does not take into account Category A waste, which may be treated and reclassified as Category B. It is noted that estimates are likely to vary significantly from the final volumes due to the adoption of conservative assumptions in the absence of detailed information. However, noting that construction of North East Link is not proposed to start until 2020, there is a long lead time before landfill capacity would be needed. The 'market' (that is, landfills) has recently indicated to NELP they expect to have sufficient capacity by the time construction on North East Link started. Should disposal be discounted as a feasible option, other treatment or containment opportunities would be considered.

12. References

ASRIS CSIRO Atlas of Australian Acid Sulfate Soils:

<www.asris.csiro.au/themes/AcidSulfateSoils.html> (date viewed 2 July 2018).

Australian and New Zealand Environment and Conservation Council (ANZECC), Australian Water Quality Guidelines for Fresh and Marine Waters, 2000.

CIRIA UK (Construction Industry Research and Information Association), Publication C665 – *Assessing Risks posed by Hazardous Ground Gases to Buildings*, 2007

CRC CARE, CRC CARE Technical Report no. 27, *Defining the philosophy, context and principles of the National Framework for remediation and management of contaminated sites in Australia*, CRC for Contamination Assessment and Remediation of the Environment, Adelaide, Australia, 2013

Department of Sustainability and Environment (Victoria), Potentially Contaminated Land. General Practice Note, 2005,

Department of Sustainability and Environment (Victoria), *Best Practice guidelines for assessing and managing acid sulfate soils*, 2010.

EPA Victoria, Publication 480, *Environmental Guidelines for Major Construction Sites*, 1996.

EPA Victoria, Industrial waste management policy, *Waste Acid Sulfate Soils*, 1999.

EPA Victoria, Publication 669, *Groundwater Sampling Guidelines*, 2000.

EPA Victoria, State Environment Protection Policy (SEPP), *Prevention and Management of Contamination of Land*, 2002.

EPA Victoria, State Environment Protection Policy (SEPP), (*Waters*), 23 October 2018.

EPA Victoria, Publication IWRG621, *Soil Hazard Categorisation and Management*, 2009a

EPA Victoria, Publication IWRG655.1, *Acid Sulfate Soil and Rock*, 2009b.

EPA Victoria, Publication IWRG702, *Soil Sampling*, 2009c.

EPA Victoria, Publication 788.3, *Best Practice Environmental Management, Siting Design, Operation and Rehabilitation of Landfills*, 2015.

EPA Victoria, Publication IWRG611.2, *E Asbestos Transport and Disposal*, 2017.

EPA Victoria, Publication 1684, *Landfill gas fugitive emissions monitoring guideline*, 2018.

R Fitzpatrick & P Shand, *Inland acid sulfate soil systems across Australia*, CRC LEME Open File Report 249, CRC LEME, Perth, p. 303, 2008.

Food Standards Australia New Zealand (FSANZ), 1987, Australian Food Standards Code.

Geotesta, *Soil Contamination Assessment Report, Bolin Bolin Stormwater Harvesting, Bulleen Park, Bulleen*; prepared for Manningham City Council, 2016.

Heads of EPA (HEPA), PFAS National Environment Management Plan (NEMP), 2018

National Environment Protection Council (NEPC), *National Environment Protection (Assessment of Site Contamination) Measure 1999*, as amended. Schedule A: Recommended General Process for Assessment of Site Contamination, National Environment Protection Council Service Corporation, Canberra, 2013.

National Health and Medical Research Council (NHMRC), Australian Drinking Water Guidelines, 2011.

National Health and Medical Research Council (NHMRC), *Guidelines for Managing Risks in Recreational Waters*, 2008.

Standards Australia, AS/NZS 5667.11:1998: Water quality – Sampling, 1998.

Standards Australia, AS 4482.1–2005: Guide to the sampling and investigation of potentially contaminated soil – Non-volatile and semi-volatile compounds, 2005.

Standards Australia, AS 4482.2–2005: Guide to the sampling and investigation of potentially contaminated soil – Volatile substances, 2005.

Standards Australia, AS/NZS ISO 31000:2009 Risk Management Process, 2009.

Standards Australia, AS 2159 Buildings and Structures, 2009.

UK Environment Agency, Guidance on the management of landfill gas (LFTGN03), 2004.

VicRoads, *Site Conditions Information Report, Metropolitan Ring Roads Plenty Road to Greensborough Highway*, Report No. GR153-05.04.SCI.Rev0, 14 July 2015, 2015a.

VicRoads, *Interpretative Report, Metropolitan Ring Roads Plenty Road to Greensborough Highway*, Report No. GR153-05.05.INT.Rev0, 17 July 2015, 2015b.

VicRoads, Eastern Freeway Geological Plan Camberwell City Tip, Drawing No. 206066, 1970.

VicRoads, Eastern Freeway Section through Camberwell City Tip, Drawing 206068, 1970.

VicRoads, *Geotechnical Assessment of North East Link Transport Corridor*, Report No. MW 91-01-15-01, 27 June 2010, 2010.

Worksafe Victoria, *Asbestos-Contaminated Soil*, Guidance Note, version 1.0, 29 October 2010, Worksafe Victoria, <https://www.worksafe.vic.gov.au/__data/assets/pdf_file/0020/211349/ISBN-Asbestos-contaminated-soil-guide-2010-10.pdf> (viewed 27 March 2018), 2010.