

Environment
Effects Statement

Chapter 21

Ground movement



Chapter 21

Ground movement

This chapter provides an assessment of the ground movement impacts associated with the construction and operation of North East Link. This chapter is based on the impact assessment presented in Technical report M – Ground movement.

Ground movement describes the horizontal and vertical movements of ground due to sub-surface activities. Where ground movement is severe enough, built structures and environmental features can be damaged or degraded.

The EES scoping requirements set out the following evaluation objective:

- **Land stability** – To avoid or minimise adverse effects on land stability from project activities, including tunnel construction and river and creek crossings.

To assess the potential impacts of North East Link a ground movement impact assessment was undertaken. The assessment included consideration of the geological and hydrogeological conditions within the study area and the sensitive receptors that may be affected by tunnelling or sub-surface activities. Sensitive receptors can include buildings, utilities, landscapes and environmental features.

Other aspects closely related to the ground movement evaluation objective include erosion, which is addressed in the following reports:

- Chapter 24 and Technical report P – Surface water.

21.1 Method

Informed by the risk assessment described in Chapter 4 – EES assessment framework, the ground movement assessment involved the following key tasks:

- A review of relevant national, state and local legislation and policy
- The establishment of a study area for ground movement, defined by the geographic area that may be impacted by ground movement
- The identification of sensitive receptors, such as residential properties, community facilities, heritage places, utilities, environmental features and other built structures within the study area

- Consultation with councils, utility asset owners and facility managers, and site visits to characterise existing conditions
- A risk assessment prioritised the impact assessment, which was informed by a process of preliminary, second stage and detailed assessment of sensitive receptors
- An assessment of the potential ground movement effects, based on risk of reduced 'serviceability' in the case of utilities or the damage risk classification for built structures as described in Table 21-1
- In response to the impact assessment, Environmental Performance Requirements (EPRs) were developed to set the required environmental outcomes for North East Link. The residual risk ratings and the assessment of impacts presented in this chapter assume implementation of the EPRs. Refer to Chapter 27 – Environmental management framework for the full list of EPRs.

What are the risk categories?

Risk levels were categorised as very low, low, medium, high or very high. When an impact is a known consequence of the project the rating is indicated as 'planned'. The results of the initial risk assessment were used to prioritise the focus of the impact assessments.

Table 21-1 Damage risk classification applied to built structures

Classification	Description
Negligible	Hairline cracks.
Very slight	Fine cracks easily treated during normal redecoration. Close inspection may reveal some cracks in external brickwork or masonry.
Slight	Cracks easily filled. Redecoration probably required. Some repointing may be required to ensure water-tightness. Some repainting may be required for weather-tightness. Doors and windows may stick slightly.
Moderate	Cracks may require cutting out and patching. Re-pointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weather tightness often impaired.
Severe	Extensive repair involving removal and replacement of sections of walls especially over door and windows. Window and door frames distorted. Floor slopes noticeably. Walls lean or bulge noticeably. Some loss of bearing in beams. Service pipes disrupted.
Very severe	Major repair required involving partial or complete reconstruction. Beams lose bearing, walls lean badly and required shoring. Windows broken by distortion. Danger of instability.

21.2 Existing conditions

This section outlines the existing conditions for North East Link study area that relate to ground movement.

The existing conditions assessment established the regional setting for the project by considering the geology and hydrogeology of the study area. Sensitive receptors in the study area that may be subject to ground movement were then identified including utilities, community facilities, residential properties, places of heritage value and other built structures.

In some cases the names of sensitive receptors have been altered from the official name to provide geographic context. Utilities for example may extend through a number of suburbs, but there is only a particular section of utility that may be impacted.

The sensitive receptors have been presented by the project elements – M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the northern portal, northern portal to southern portal and the Eastern Freeway.

21.2.1 Regional setting

Geology

The geology underlying the study area encompasses a sequence of marine, alluvial, sedimentary and volcanic deposits laid down over a time interval of more than 400 million years. A geological long section of the study area is presented in Figure 21-1.



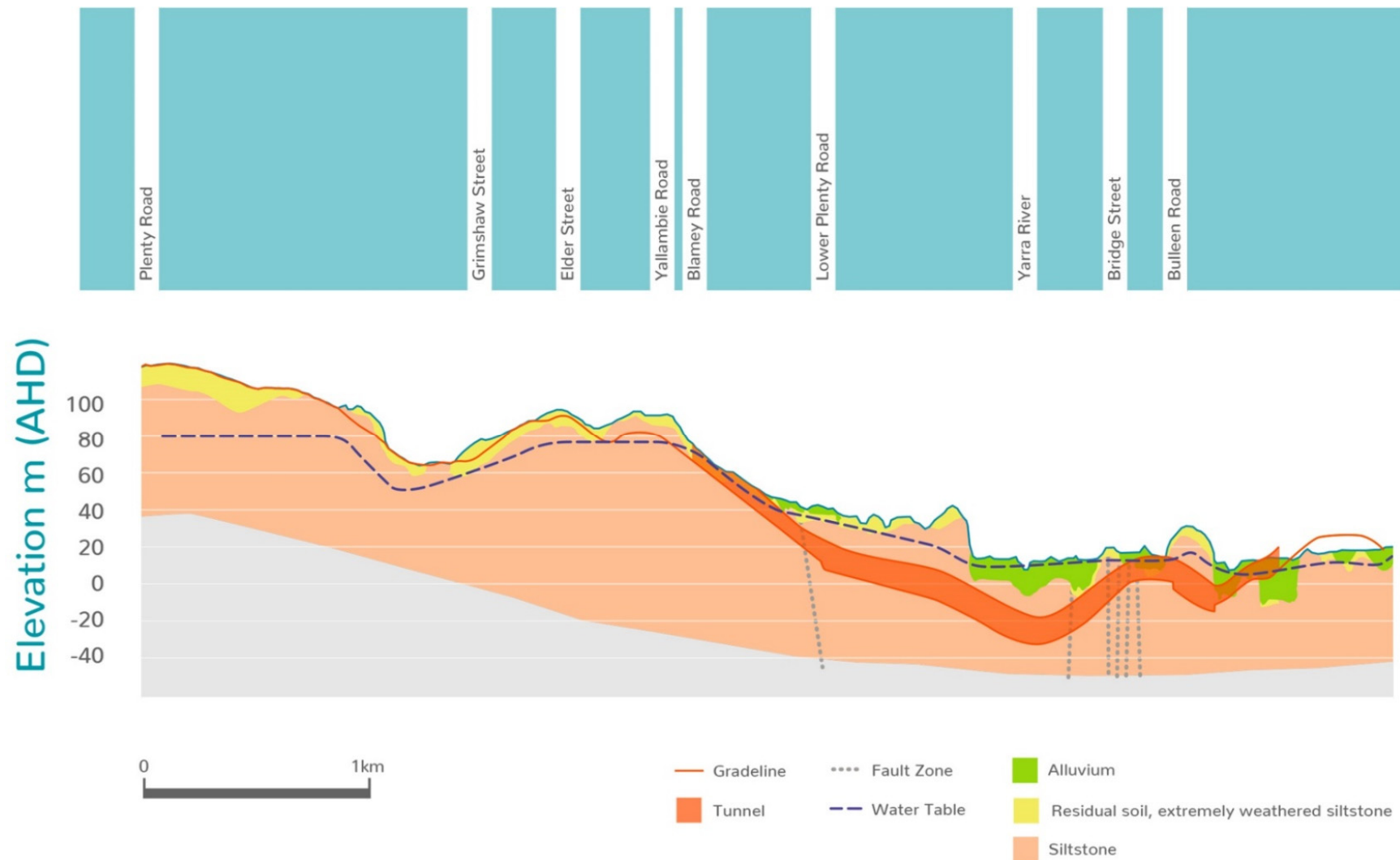


Figure 21-1 Simplified geological long section

The study area, from the M80 Ring Road to the Eastern Freeway and from Hoddle Street to Springvale Road, spans the transition between the Silurian Anderson Creek and Melbourne Formations. These rocks comprise thinly bedded/laminated siltstone and fine sandstone. They have been folded on a north to north-east trending axis, faulted and intruded by igneous dykes over geological time.

The Silurian rocks have typically been weathered to approximately 30 metres below ground. However, within the Yarra River Valley, the Yarra River has historically eroded much of the weathered rock, and deposited Quaternary sediments including organic soils, firm to very stiff clay, medium dense sand and gravel in its place. A number of potentially high persistence faults, made up of crushed rock and clay, lie within the Silurian rock beneath the valley sediments.

To the west, close to the Hoddle Street end of the Eastern Freeway, basalt lavas (called the 'Newer Volcanics') are encountered, such as at Merri Creek. These rocks are not encountered elsewhere on the alignment to the east but are encountered north of the M80 Ring Road and Greensborough Bypass intersection within the Janefield Wetlands area.

Deposits of very stiff to hard clay, and medium dense to very dense sands and silts have been encountered to a depth of around 14 metres beneath the elevated areas around Manningham Road. These deposits are inferred to represent formerly east-west draining alluvial channels that were eroded by the flow of the Yarra River. These deposits are considered to belong to the Red Bluff Sandstone member of the Neogene, Brighton Group.

Hydrogeology

The hydrogeology of the study area broadly consists of an alluvial aquifer (within the Quaternary sediments), and a bedrock aquifer system (within the Silurian bedrock). The two aquifer systems are expected to be connected and have different hydraulic properties.

Currently groundwater abstraction (taking of groundwater) in the study area is limited, due to the urbanised setting, low yields and salinity of groundwater.

The bedrock aquifer groundwater quality averages 5,700 mg/L total dissolved solids. As such, groundwater is too saline for irrigation and potable uses without treatment. Groundwater could be used for stock and industrial applications, although with much of North East Link being within residential areas there is limited likelihood of these uses being realised.

The alluvial aquifer has an average groundwater salinity of 2,658 mg/L total dissolved solids which reflects fresh water input from surface waterways, and shorter recharge pathways.

Water levels across the alignment are typically between five metres and 12 metres below ground. Shallower groundwater levels (generally within six metres of the ground surface) are found within the alluvial floodplains. The deeper groundwater levels occur within the bedrock aquifer, in the topographically elevated parts of the study area.

A comprehensive description of the hydrogeology of the study area is provided in Chapter 22 – Groundwater.

21.2.2 M80 Ring Road to the northern portal

A number of sensitive receptors were identified in the M80 Ring Road to northern portal section of North East Link that may experience ground movement. These are listed below.

M80 Ring Road to Watsonia railway station

- Maroondah Aqueduct – west of the M80 Ring Road and Greensborough Bypass intersection, the aqueduct runs beneath the M80 Ring Road east to west. The aqueduct consists of a 2.16-metre diameter concrete lined steel pipe which is currently in use as a water supply main. The depth to the top of the pipe from the ground surface ranges from 1.1 metres to 1.4 metres.

Watsonia railway station to northern portal

- Elder Street Gas Transmission Pipeline – a transmission pipeline runs along Morwell Avenue in Greensborough, passing under Watsonia railway station and the Greensborough Bypass, and along a dedicated easement. It is a high-pressure gas main, consisting of a 0.45-metre welded steel pipe.
- Simpson Barracks building – a two-storey, L-shaped building, and associated outbuilding, located near the corner of Yallambie Road and Greensborough Road within Simpson Barracks.
- Hurstbridge rail line – a section of the Hurstbridge rail line runs north of Watsonia railway station.

21.2.3 Northern portal to southern portal

A number of sensitive receptors were identified in the northern portal to southern portal section of North East Link that may experience ground movement. These are listed below.

Northern portal to Lower Plenty Road

- Greensborough Road water main – 600 to 900-millimetre diameter water main which runs along the east side of Greensborough Road.
- Strathalan – an aged care facility on Greensborough Road which contains three heritage places that are subject to a council heritage overlay (Banyule – HO164). The three places are a masonry house built in 1906, the associated mature pine trees and a red gum tree near the property entrance.

- Residential properties – a number of low-rise residential properties on Greensborough Road and Borlase Street, which are predominantly one and two-storey brick veneer, timber-framed structures.
- Lower Plenty Road Water Main – three water mains of 375 millimetre, 600 millimetre and 1350 millimetre-diameter located near Lower Plenty Road.

Lower Plenty Road to Banyule Flats

- Residential properties – a number of one and two-storey brick clad and weatherboard structures, located south of Lower Plenty Road, near Banyule Creek Reserve.
- Viewbank House aged care facility and Goodstart Early Childhood Centre – facilities located on Banyule Road in Rosanna.
- Banyule Creek Sewer – a section of sewer runs near Banyule Creek. The asset consists of a 450-millimetre diameter clay sewer pipe constructed in 1963.

Banyule Flats to Manningham Road

- Banyule Homestead – a heritage property located in Buckingham Drive in Heidelberg. The homestead is listed on the Victorian Heritage Register (VHR H0926) and is also subject to a council heritage overlay (Banyule – HO13). Built in 1846, the homestead is a two-storey structure of rendered brick on sandstone footings.
- Banyule Flats north slope – a steep slope, dipping at an angle of around 30 degrees into the Banyule Flats.
- Banyule Swamp – an artificial retention pond is located within the Banyule Flats. Currently, the pond covers approximately seven hectares and is retained on the west side by a low-level earth embankment and spillway structure.
- Heide Museum of Modern Art – ‘Heide’ is an art gallery and sculpture park located on Templestowe Road in Bulleen. The property contains two heritage places on the Victorian Heritage Register, Heide I (VHR H0687) and Heide II (VHR H1494). Specific installations with potential to experience ground movement include:
 - Crescent House – constructed in 2013, the installation comprises a small timber framed pavilion structure, clad with ‘yakisugi’ cedar wood panelling. An aluminium panel painted in micaceous iron oxide forms the east facing wall of the structure.
 - Theoretical Matter – a welded steel installation consisting of reinforced steel welded into a three-dimensional grid, sitting on a lightly reinforced concrete slab.
- Electricity transmission towers – two high voltage electricity transmission towers are located near Heide Park. The towers are of a trussed steel frame construction, with pylon style footings and short piles.

- **Helmet** – constructed in 2007, this is a sculptural installation owned by Manningham City Council and located in Banksia Park. The sculpture is inspired by Ned Kelly and made from painted corten steel.
- **Journeys End** – a residential property located at Bridge Street, Bulleen. Journeys End is subject to a council heritage overlay (Manningham – HO26) and is of local architectural and historical significance. The structure is a timber, two-storey, 'craftsman' style bungalow. Cypress trees on the property boundary with Bridge Road are also subject to a council heritage overlay (Manningham – HO25).
- **Residential house** – a neighbouring residential property similar in construction to Journeys End, located on Bridge Street in Bulleen.

Manningham Road interchange

- **Banksia Street Pipe Bridge** – located approximately 330 metres west of Manningham Road interchange on Banksia Street, the bridge is a heritage place listed on the Victorian Heritage Inventory (VHI H7922-0210).
- **Bulleen Road sewer** – a section of the Yarra East Main Sewer runs along Bulleen Road between Manningham Road and the Bulleen Swim Centre. The sewer has a diameter of 1.75 metres and consists of a reinforced concrete pipe.
- **Manningham Interchange slope** – a slope at the edge of the Yarra River, near the Manningham Interchange. It is estimated the slope angle is approximately 20 degrees. The slope is likely to be comprised of highly weathered to moderately weathered siltstone overlain by approximately six to seven metres of alluvium.

Avon Street to Rocklea Road

- **Residential properties** – a number of houses located in St Andrews Crescent, Golden Way, Claremont Avenue, Rocklea Road and Killara Mews may be subject to ground movement. Buildings in this location are mostly one to two-storey brick clad and weatherboard houses.
- **Clarendon Eyre** – a heritage-listed residential property (Manningham – HO147) located on Robb Close in Bulleen. It is a large Italianate, two-storey brick house. Nearby, there is a Moreton Bay Fig tree that is subject to a separate heritage overlay (Manningham – HO25).

Rocklea Road to Bulleen Oval

- Trinity Grammar School Sporting Complex – located to the east of Bulleen Road in Bulleen. This complex consists of a number of sports fields, a water storage lake and associated buildings and infrastructure. Further south, the Marcellin College Sporting Complex was also considered as part of the assessment.
- The Bolin Bolin Integrated Water Facility – located near Bulleen Road, the facility was constructed in 2017 as part of the Bolin Bolin Integrated Water Management Project. The facility consists of a 1.5 megalitre combined wetland and storage lake, adjacent to Bolin Bolin Billabong, and a 3.33 megalitre storage facility within the Freeway Public Golf Course. These are connected by a distribution pipeline.
- Veneto Club – an Italian social club built in the 1960s on Bulleen Road in Bulleen. This complex comprises a three-storey reinforced concrete framed structure in a 'brutalist' architectural style. While the building itself lies outside the expected zone of influence of tunnelling settlement, structures at the entrance to the club including a steel and concrete portico structure, as well as a monumental column, may be affected by ground movement.

21.2.4 Eastern Freeway

A number of sensitive receptors were identified in the Eastern Freeway of North East Link that may experience ground movement. These are summarised below.

Bulleen Oval to Eastern Freeway

- Bulleen Road west sewer – from Bulleen Road, the East Yarra Main Sewer splits into east and west branches. It is only the western section of the sewer that is considered in this assessment, which runs toward the Carey Grammar School Sporting Complex. The sewer consists of a 2.25-metre reinforced concrete pipe.

Eastern Freeway east

- Koonung Creek culvert – this is a minor tributary of the Yarra River enclosed in culvert around three kilometres in length for the construction of the Eastern Freeway in 1982. The Koonung Creek culvert runs parallel and to the south of the Eastern Freeway between Bulleen Road and Doncaster Road. The culvert comprises a 6.6 metre span by four metres high reinforced concrete arch structure on a reinforced concrete slab.
- Kenneth Street water main – a 1.15-metre diameter enamel-lined steel water main crosses under the Eastern Freeway near Kenneth Street in Bulleen. This asset is owned by Melbourne Water and was installed in 1957.

21.3 Construction impact assessment

This section discusses the construction impacts associated with North East Link that relate to ground movement.

The sensitive receptors that may be affected by ground movement effects, identified for the construction phase of North East Link, are grouped as follows:

- Community facilities
- Utilities
- Environmental features and landscapes
- Residential properties
- Heritage places
- Other built structures.

The assessment considered the risk to these sensitive receptors due to ground movement caused by tunnelling, excavation, drilling, increases in load and changes to groundwater levels.

Only the assessments for sensitive receptors with the potential to experience ground movement are discussed in this chapter. Other places within the study area were also considered, but these lie outside the expected zone of influence of ground movement. Further details of these are provided in Technical report M – Ground movement.

Parklands and landscapes that don't have structural elements such as the Banyule Flats, Yarra River parklands and Bolin Bolin Billabong were assessed as part of the ecology assessment presented in Chapter 25 – Ecology based on ground movement contours shown in Appendix B2 and Appendix B3 of Technical report M – Ground movement. Other figures relating to the assessment are provided in Appendix B and Appendix C of Technical report M – Ground movement.

Environmental Performance Requirements that would minimise the ground movement effects of construction for North East Link are summarised in Section 21.5.

21.3.1 Community facilities

Risk pathways associated with community facilities are described in Table 21-2 and potential impacts are discussed below.

Table 21-2 Risk table: Construction – community facilities

Risk ID	Risk pathway	Risk rating
Risk GM05	TBM tunnelling between Lower Plenty Road and Banyule Flats may cause ground movement leading to damage to residential, sensitive or heritage buildings (for example Banyule Homestead, Viewbank house, Goodstart Early Learning).	Very low
Risk GM14	Construction of the cut and cover/retained excavations south of Rocklea Rd causing ground movement leading to damage to the Veneto Club and the Bolin Bolin Integrated Water Facility.	Low
Risk GM17	Excavations and de-watering associated with the Bulleen Road cut and cover section as well as pipe jacking associated with the Bulleen Road sewer diversion works causing ground movement leading to permanent surface settlement/depressions and water ponding in playing fields.	Low
Risk GM18	Pipe-jacking for sewer diversion works in shallow cover beneath Trinity Grammar Sporting Complex causing ground movement leading to localised 'sinkholes' or surface 'blowout' and damage to fields.	Low

Viewbank House aged care facility and Goodstart Early Childhood Centre

The assessment considered the potential for tunnelling between Lower Plenty Road and Manningham Road to impact the kindergarten and aged care facility (risk GM05). These facilities were considered as part of one assessment as they are both located on Banyule Road, Rosanna.

It was estimated that settlement in this location would be between two and 12 millimetres, which is classified as a negligible risk of damage to structures. Nevertheless, due to the sensitivity of these facilities, EPRs would be implemented as discussed in Section 21.5.

Veneto Club

The potential for the construction of the cut and cover and retained excavations south of Rocklea Road to cause ground movement leading to damage to the Veneto Club has been investigated (risk GM14).

The assessment determined that the contribution from de-watering effects on the overall settlement of the main Veneto Club building may be subject to less than one millimetre of ground movement and so impacts are not anticipated.

The large portico archway structure at the building entrance may be subject to the 'net' effects of ground movement due to the excavation of the nearby trench/cut and cover structure. The arch consists of three closed steel box sections, each with large concrete plinth footings. There is also a water feature next to the arch, with a lion sculpture perched atop a column at the centre. Ground movement for these features were found to be between two and six millimetres of ground movement. The risk of damage would therefore be in the negligible risk category and so impact to the portico arch and water feature is not anticipated. EPRs would be implemented during construction to minimise the risk to the Veneto Club from ground movement as discussed in Section 21.5.

Trinity Grammar School Sporting Complex and Marcellin College

Trinity Grammar School Sporting Complex and Marcellin College are located on Bulleen Road, near the proposed cut and cover tunnels and sewer realignment. The assessment considered the potential for ground movement associated with these works to cause settlement, depressions, ponding of water and damage to the playing fields (risks GM17, GM18).

What is settlement?
Settlement is the downward movement of the ground which can be caused by construction works such as bored tunnels, or deep excavations.

It is estimated that approximately five and ten millimetres of settlement could occur at the eastern boundary of the playing fields. This degree of settlement is classified as negligible and would not impact the function of the playing fields. The buildings on the property are set well back from Bulleen Road and would not experience ground movement. A portion of this land would require temporary occupation, including modification of a large water storage lake within the playing fields adjacent to Bulleen Road.

21.3.2 Utilities

Ground movement risk pathways associated with utilities are described in Table 21-3 and potential impacts are discussed below.

Table 21-3 Risk table: Construction – utilities

Risk ID	Risk pathway	Risk rating
Risk GM01	Upgrade works to M80 pavement/subgrade cause ground movements that lead to damage to the Maroondah Aqueduct.	Low
Risk GM02	Open cut and cut and cover excavations between Watsonia Station and Lower Plenty Road causing ground movement leading to damage to nearby residential properties, infrastructure and utilities adjacent to Greensborough Road.	Very low

Risk ID	Risk pathway	Risk rating
Risk GM06	TBM tunnelling between Banyule Flats and Banksia Street causing ground movement leading to damage to residential, sensitive or heritage buildings (for example Banyule flats, Heide Sculpture Park).	Very low
Risk GM10	Groundwater 'mounding' associated with Manningham Road Interchange retention structures may cause swelling or compaction related ground movements, adversely affecting adjacent utilities, Bulleen Rd, commercial and residential buildings.	Very low
Risk GM19	Tunnelling between Lower Plenty Road and Banyule Flats may cause ground movement leading to damage to Banyule Creek sewer.	Low
Risk GM22	Upgrade works to Eastern Freeway pavement/subgrade causes ground movements that leads to damage to the 1.15 metre diameter pipeline near Kenneth Street (Kenneth Street water main).	Very low
Risk GM23	Construction of the road embankment between Bulleen Oval and the Eastern Freeway causes ground movement leading to damage to the 2.25 metre diameter North Yarra Main Branch sewers (Bulleen Road west sewer).	Low
Risk GM24	Upgrade works to Greensborough Road causing ground movements that lead to damage to the Dandenong – Melbourne ring main (Elder Street gas main).	Very low
Risk GM26	Lower Plenty Rd water mains (conceptual re-alignment) adversely affected by the TBM launch/reception in potentially faulted ground (high VL %)	Low

Maroondah Aqueduct

This assessment considered the potential for the upgrade works to M80 Ring Road at Greensborough to cause ground movement that leads to damage to the Maroondah Aqueduct (risk GM01).

The proposed modifications to the M80 Ring Road are expected to increase vertical loads in places and also reduce vertical loads on the ground surrounding the aqueduct. The ground conditions in this location comprise thin residual soils of less than three metres on highly weathered Silurian siltstone.

The assessment determined that it was expected the pipeline would not be subject to strains in excess of those within the capacity of the pipe, assuming it is in good condition.

Hurstbridge rail line

The assessment considered the potential for ground movement to damage the Hurstbridge rail line (risk GM02).

It was determined the Hurstbridge rail line would not experience ground movement associated with works along Greensborough Road and Greensborough Bypass since it is located in a trench outside the area that would be subject to ground movement.

Banyule Creek sewer

This assessment has considered the potential for TBM tunnelling to damage this section of the Banyule Creek Sewer (risk GM02).

The section of the sewer runs at shallow depth beneath the Banyule Creek reserve on the east side of the tunnel alignment before turning west to cross over the alignment parallel to the pathway below Banyule homestead in the Banyule Swamp.

The tunnels would be constructed by tunnel boring machines (TBMs), requiring no surface works in this location, although the sewer lies within an area of potentially significant settlement of up to 37 millimetres. Nonetheless, the assessment has shown the associated relative joint movements lie well below conservative estimates of serviceability limits so would not be expected to adversely affect its integrity.

EPRs would be implemented to address the risk of damage to the sewer, as discussed in Section 21.5.

Greensborough Road Water Main

This assessment considered the potential for the construction of the trench and cut and cover tunnels between Watsonia railway station and Lower Plenty Road to cause ground movement, leading to damage to the Greensborough Road Water Main (risks GM02, GM19).

Construction works near the water main comprises the excavation of an open cut trench and cut and cover tunnels. The trench and tunnels would run in parallel with the water main.

The assessment determined that settlement at this location would be around seven millimetres, which would not impact the water main.

Electricity transmission towers

The assessment has considered the potential for tunnelling between Banyule Flats and Banksia Street to cause ground movement, leading to damage to the electricity transmission towers (risk GM06).

The assessment determined that the maximum settlement at this location would be around nine millimetres, which is a negligible risk classification.

Bulleen Road sewer and Bulleen Road west sewer

This assessment considered the potential for the proposed works to impact the Yarra East Main Sewer. The sewer was considered in two sections; the section of the sewer that runs along Bulleen Road (risk GM10) and the western section of the sewer that runs from Bulleen Road toward the Carey Grammar Sporting Complex (risk GM23).

For the Bulleen Road section, it is estimated that groundwater levels could rise up ('mound') adjacent to the Manningham interchange retention structures which has potential to cause ground movement. The amount of mounding is expected to be similar during construction and operation. Based on the degree of predicted movement, the sewer is not expected to be adversely affected. Similarly, the section of the sewer running along Bulleen Road lies outside the zone-of-influence of ground movements so would not be subject to ground movement.

The planned road embankments that would connect the Eastern Freeway to the cut and cover section south of the mined tunnels would overlay the western section of the sewer. Additionally, a flood wall would be constructed in this location. These proposed works are expected to induce ground movements in the soil surrounding the pipeline but adverse effects in this section of the sewer are not anticipated.

Kenneth Street Water Main

The assessment considered the potential for lane widening of the Eastern Freeway to cause ground movement leading to damage of the Kenneth Street Water Main (risk GM22).

The widening would include the construction of new road embankments which would increase the vertical load on the water main. It is estimated this water main would be subject to approximately seven millimetres of ground movement which is classified as a negligible risk of damage. As such, damage to the water main is not anticipated.

Elder Street Gas Transmission Pipeline

This assessment considered the potential for works along Greensborough Road to impact the Elder Street Gas Transmission Pipeline (risk GM24). Relevant activities near this location include excavations for the construction of a trench.

Based on these activities the magnitude of settlement at the location of the pipeline was found to be less than 18 millimetres and ground slopes of the order of 1:1000, which is not anticipated to result in adverse effects in the Elder Street Gas Transmission Pipeline.

Lower Plenty Road Water Main

This assessment considered the potential for ground movement to impact three water mains located near Lower Plenty Road (risk GM26).

These water mains would be realigned as part of enabling works. Through detailed design, further assessment would be undertaken to determine the potential for ground movement generated by tunnelling to impact the water mains once realigned.

The risk of damage to the water mains would be addressed through EPRs as discussed in Section 21.5.

21.3.3 Environmental features and landscapes

Ground movement risk pathways associated with environmental features are described in Table 21-4 and potential impacts are discussed below

Table 21-4 Risk table: Construction – environmental features and landscapes

Risk ID	Risk pathway	Risk rating
Risk GM07	TBM tunnelling between northern edge of Banyule Flats and Banksia Street causing localised heave or settlement leading to permanent visible changes to landforms.	Very low
Risk GM09	Groundwater drawdown associated with temporary dewatering of Manningham Road Interchange excavations may cause drawdown settlement related ground movements, adversely affecting parklands and landscape areas including Bolin Bolin Billabong and Manningham Interchange Slope.	Low
Risk GM14	Construction of the cut and cover/retained excavations south of Rocklea Rd causing ground movement leading to damage to the Veneto Club and the Bolin Bolin Integrated Water Facility.	Low
Risk GM25	Tunnelling beneath Banyule Flats may cause ground movement leading to damage to parklands and landscape areas, including the Banyule Swamp.	Low

Banyule Swamp

The assessment considered the potential for impacts to the Banyule Swamp due to tunnelling works under Banyule Flats and associated ground settlement (risks GM07, GM25). The swamp lies immediately east of the proposed tunnel alignment with the tunnels passing at around 25 metres below the Banyule Flats.

The swamp is maintained by a levee that is likely to be constructed of local soil or weathered rock. Changes to swamp water levels would not occur unless the levee was lowered substantially due to settlement.

To address the potential for ground movement to impact the levee, a survey would be undertaken before construction and remedial actions undertaken if necessary. Ground movement impacts would be further minimised through EPRs as discussed in Section 21.5.

Bolin Bolin Integrated Water facility

The assessment considered the potential impacts to the Bolin Bolin integrated water facility due to ground movement from tunnelling works (risks GM09, GM14).

It is estimated this facility would experience approximately five millimetres of settlement which would not be expected to compromise the facility.

Manningham Interchange slope

The assessment considered the potential for impact to Manningham Interchange slope due to construction of the Manningham Road Interchange (risk GM09).

Given the slope is around 35 metres from the nearest significant excavation and the slope is assumed to have relative stability, it is not anticipated to be impacted by ground movement.

Banyule Flats north slope

The assessment considered the potential for impact to a slope running into Banyule Flats due to ground movement associated with tunnelling (risk GM25).

It was determined that tunnelling in this location is not anticipated to impact the stability of Banyule Flats north slope.

21.3.4 Residential

Ground movement risk pathways associated with residential structures are described in Table 21-5 and potential impacts are discussed below.

Table 21-5 Risk table: Construction – residential

Risk ID	Risk pathway	Risk rating
Risk GM03	Construction of the northern portal (TBM) temporary retention structures causing ground movement leading to damage to adjacent residential properties (and minor utilities).	Very low
Risk GM05	TBM tunnelling between Lower Plenty Road and Banyule Flats may cause ground movement leading to damage to residential, sensitive or heritage buildings (for example Banyule Homestead, Viewbank house, Goodstart Early Learning).	Very low
Risk GM06	TBM tunnelling between Banyule Flats and Banksia Street portal causing ground movement leading to damage to residential, sensitive or heritage buildings (for example Banyule flats, Heide Sculpture Park).	Very low

Risk ID	Risk pathway	Risk rating
Risk GM09	Groundwater drawdown associated with temporary dewatering of Manningham Road Interchange excavations may cause drawdown settlement related ground movements, adversely affecting parkland and landscape areas including Bolin Bolin Billabong and Manningham Interchange Slope.	Low
Risk GM10	Groundwater 'mounding' associated with Manningham Road Interchange retention structures may cause swelling or compaction related ground movements, adversely affecting adjacent utilities, Bulleen Rd, commercial and residential buildings	Very low
Risk GM11	Sequential Excavation Method (SEM) mined tunnelling beneath the area between Bulleen Road and Rocklea Road, causing ground movement leading to damage to adjacent utilities, Bulleen Rd, and residential buildings.	Low
Risk GM13	Construction of the cut-and-cover/retained excavations south of Rocklea Road causing ground movement leading to damage to adjacent residential properties and minor utilities.	Low
Risk GM21	Tunnelling beneath Banksia Park at Banksia St portal in addition to the cut-and-cover excavation may cause ground movement leading to damage to 'Journey's End' heritage building (and adjacent property).	Very low
Risk GM27	Excavation of TBM retrieval shafts at the southern end of the TBM tunnels adversely impacting residential properties on Bridge Street.	Low

Lower Plenty Road area

The assessment has considered the potential for the construction of the northern portal to cause ground movement leading to damage to residential buildings (risk GM03).

Settlement due to tunnelling in this area has been estimated to be between five millimetres and 29 millimetres. The risk of damage to these residential structures would therefore be within the slight category, which indicates there could be a risk of some cosmetic damage.

The risk of damage to residential properties due to ground movement would be minimised through EPRs as discussed in Section 21.5. This would include undertaking condition surveys before and after construction to assess damage to residential buildings.

Banyule Creek area

The assessment has considered the potential for tunnelling between Lower Plenty Road and the Manningham interchange to cause ground movement leading to damage to residential buildings (risks GM05, GM06).

It is estimated that settlement in this location would range between two and 12 millimetres, classified as a negligible risk of damage to buildings.

The risk of damage to residential properties due to ground movement would be further minimised through EPRs as discussed in Section 21.5.

Bulleen area

The assessment has considered the potential for construction associated with the Manningham Road interchange and the mined tunnels to cause ground movement leading to damage to residential buildings (risks GM09, GM10, GM11, GM13).

Residential properties that may be subject to ground movement are located in St Andrews Crescent, Golden Way, Claremont Avenue, Rocklea Road and Killara Mews.

It is estimated these residential buildings could be subject to between seven and 36 millimetres of settlement. For those structures experiencing the highest amount of settlement, it would be categorised as very slight risk of damage. This indicates that ground movement could cause some minor visible effects, but these would be minimised through EPRs as discussed in Section 21.5.

The assessment determined that groundwater mounding in this area would not cause ground movement that would impact these residential buildings.

Residential house

The assessment considered the potential for tunnelling to cause ground movement leading to damage to the residential house on Bridge Street (risks GM21, GM27).

The assessment determined that this house would not experience ground movement.

The assessment considered the potential for an alternative design for the tunnel boring machine retrieval shafts at Banksia Park to cause impacts to the residential property on Bridge Street. Ground movement associated with the alternative design increases the extent of ground movement within Banksia Park to include the residential house neighbouring Journey's End. The assessment classified the risk to the residential property as negligible.

EPRs would be implemented to address the risk of damage to the property as discussed in Section 21.5.

21.3.5 Heritage places

Ground movement risk pathways associated with heritage values are described in Table 21-6 and potential impacts are discussed below.

Table 21-6 Risk table: Construction – heritage places

Risk ID	Risk pathway	Risk rating
Risk GM03	Construction of the northern portal (TBM) temporary retention structures causing ground movement leading to damage to adjacent residential properties (and minor utilities).	Very low
Risk GM05	TBM tunnelling between Lower Plenty Road and Banyule Flats may cause ground movement leading to damage to residential, sensitive or heritage buildings (for example Banyule Homestead, Viewbank house, Goodstart Early Learning).	Very low
Risk GM06	TBM tunnelling between Banyule Flats and Banksia Street portal causing ground movement leading to damage to residential, sensitive or heritage buildings (for example Banyule flats, Heide Sculpture Park).	Very low
Risk GM09	Groundwater drawdown associated with temporary dewatering of Manningham Road Interchange excavations may cause drawdown settlement related ground movements, adversely affecting parkland and landscape areas including Bolin Bolin Billabong and Manningham Interchange Slope.	Low
Risk GM12	Sequential Excavation Method (SEM) mined tunnels may cause unacceptable strains on Historic Clarendon Eyre House (6 Robb Close) if variable ground conditions (deep weathering, paleo-channel deposits) are encountered.	Very low
Risk GM21	Tunnelling beneath Banksia Park at Banksia St portal in addition to the cut-and-cover excavation may cause ground movement leading to damage to 'Journey's End' heritage building (and adjacent property).	Very low

Strathalan

The assessment considered the potential for TBM tunnelling to cause ground movement that damages Strathalan (risk GM03).

The assessment found that Strathalan is outside the area that would be subject to ground movement.

Banyule Homestead

The assessment considered the potential for TBM tunnelling to cause ground movement that damages the Banyule Homestead (risks GM05, GM06).

The assessment found the homestead is outside the area that would be subject to ground movement and would experience less than one millimetre of settlement associated with groundwater drawdown. As such it there would not be impacts associated with ground movement.

Journeys End

The assessment considered the potential for excavation works for the construction of the Manningham Road interchange to cause ground movement leading to damage to Journeys End (risk GM21).

The assessment found Journey's End is outside the area that would be subject to ground movement and would experience less than one millimetre of settlement associated with groundwater drawdown. As such it there would not be impacts associated with ground movement.

Banksia Street Pipe Bridge

The assessment considered the potential for the cut-and-cover tunnels to cause ground movement that damages the Banksia Street Pipe Bridge (risk GM09).

It was determined that Banksia Street Pipe Bridge would not be subject to ground movement.

Clarendon Eyre house

This assessment considered the potential for the excavation of the mined tunnels to cause ground movement and subsequent damage to Clarendon Eyre and the associated Moreton Bay Fig (risk GM12).

It was determined the house and tree would not be subject to ground movement and so would not be affected.

21.3.6 Other built structures

Ground movement risk pathways associated with other built structures are described in Table 21-7 and potential impacts are discussed below.

Table 21-7 Risk table: Construction – other built structures

Risk ID	Risk pathway	Risk rating
Risk GM04	Construction of the trench south of Yallambie Road causing ground movement leading to damage to buildings in Simpson Barracks.	Very low
Risk GM06	TBM tunnelling between Banyule Flats and Banksia Street portal causing ground movement leading to damage to residential, sensitive or heritage buildings (for example Banyule flats, Heide Sculpture Park).	Very low
Risk GM16	Eastern Freeway upgrade works parallel to/and above the Koonung Creek culvert causing ground movements leading to damage of the concrete (BEBO) arch structure in areas where it is not bridged over.	Low
Risk GM17	Trenched excavations and de-watering associated with the Bulleen Road cut and cover section as well as pipe jacking associated with the Bulleen Road sewer diversion works causing ground movement leading to permanent surface settlement/depressions and water ponding in playing fields.	Low
Risk GM20	Tunnelling beneath Banksia Park at Banksia St portal in addition to the Manningham Interchange cut-and-cover excavation may cause ground movement leading to damage to 'Helmet', a sculptural installation owned by Manningham Council.	Medium

Simpson Barracks buildings

The assessment has considered the potential for the construction of the trench and cut and cover tunnels south of Yallambie Road to cause ground movement leading to a risk of damage to buildings at Simpson Barracks (risk GM04).

The L-shaped main building could not be inspected nor were structural details available for this assessment. Making a conservative assumption about the nature of this structure, there is a low risk of damage and EPRs would be implemented as discussed in Section 21.5.

An assessment of the outbuilding determined that the settlement at this location could be up to 19 millimetres at a 1:400 slope. However, considering the relative axial stiffness of the structure, the damage risk category was determined to be slight.

The risk to structures within Simpson Barracks due to ground movement would be further minimised through EPRs as discussed in Section 21.5.

Crescent House

The assessment has considered the potential for the TBM tunnelling beneath the Yarra River valley north of Banksia Street to cause ground movement leading to a risk of damage to sensitive features near the Heide Museum of Modern Art, including a sculptural installation, Crescent House (risk GM06).

Settlement at this location caused by TBM tunnelling to construct the northbound tunnel is estimated to be from 13 to 18 millimetres. The risk of damage to this structure is therefore negligible to slight.

Visual inspection of Crescent House suggests it is in relatively good condition. In addition, when the flexibility of the timber frame and the foundation design are taken into account, it is considered likely the structure would have a high degree of tolerance to ground movement. Nevertheless, because of its artistic and community value, EPRs would be implemented as discussed in Section 21.5.

Theoretical Matter

The assessment has considered the potential for the TBM tunnelling to cause ground movement leading to damage to the sculptural installation, Theoretical Matter (risk GM06).

The structure is supported on a rectangular concrete slab footing with an average slab thickness of approximately 100 millimetres and assumed to be reinforced with a single layer of mesh. It is assumed the slab is relatively flexible when subjected to ground movement. The structure appears to be resting on the footing slab with no visible fixing and so is assumed to have little interaction with the foundation.

It was determined the damage risk to Theoretical Matter from ground movement would be negligible. Nevertheless, because of the artistic and community value, EPRs would be applied as discussed in Section 21.5.

Helmet

The assessment has considered the potential for the excavation of the Manningham Road interchange and tunnelling beneath Banksia Park to cause ground movement leading to damage to the sculptural installation, Helmet (risk GM20).

It is estimated that settlement in this location may be over 92 millimetres. The principal ground movement related risks to the sculpture are the cracking of the concrete retaining wall and ground bearing slab, as well as possible damage to the fixings.

In light of this, the installation would be temporarily removed and stored during construction works and reinstated once the tunnels and nearby Manningham Road interchange works are complete.

EPRs would be implemented to address impacts to this installation as discussed in Section 21.5.

In the case the northern TBM launch option is adopted, Helmet would still require relocation.

Koonung Creek culvert

The assessment considered the potential for Eastern Freeway upgrade works to adversely affect the structural integrity of the Koonung Creek culvert (risk GM16).

Studies indicate the Koonung Creek culvert under the Eastern Freeway would not tolerate the additional loading from the widened freeway. As a result, it is proposed to protect the Koonung Creek culvert by a concrete slab at the locations where it passes underneath the enlarged Eastern Freeway embankments. This would minimise the ground movement at the depth of the culvert and would minimise the risk of damage.

EPRs would be implemented to address the risk of damage to the culvert as discussed in Section 21.5.

21.4 Operation impact assessment

One operational risk for ground movement was identified and is described in Table 21-8 with the potential impact discussed below.

Table 21-8 Risk table: Operation – groundwater mounding

Risk ID	Risk pathway	Risk rating
Risk GM10	Groundwater 'mounding' associated with Manningham Road Interchange retention structures may cause swelling or compaction related ground movements, adversely affecting adjacent utilities, Bulleen Rd, commercial and residential buildings.	Very low

The assessment considered the potential for groundwater mounding during operation to cause ground movement impacting residential buildings (risk GM10).

The assessment determined that, while there is potential for some long term mounding, this is not anticipated to lead to damage of structures near the Manningham Road interchange.

EPRs would be implemented to address the risk of damage to the residential buildings, as discussed in Section 21.5.

21.5 Environmental performance requirements

EPRs have been developed to address the potential impacts to sensitive receptors due to ground movement.

A geotechnical model would be developed to inform the tunnels design and the construction techniques to be applied for the various geological and groundwater conditions. The model would also be used to assess potential ground movement effects and triggers for mitigation (EPR GM1).

A ground movement plan would be developed to address the location of assets and structures that may be susceptible to damage due to ground movement. This would include identifying baseline conditions, ground movement acceptability criteria, appropriate mitigation and monitoring requirements (EPR GM2).

Condition surveys would be undertaken of property and infrastructure predicted as being at risk of damage by ground movement before construction started. Post-construction assessments would ascertain if the project works had caused any damage (EPR GM3).

For any properties and assets affected by ground movement, repair works would be undertaken in consultation with the property or asset owner. For any affected places listed on the VHR, consultation would be undertaken with Heritage Victoria (EPR GM4).



21.6 Conclusion

This chapter has identified and assessed existing conditions, potential impacts and risks associated with ground movement for North East Link.

Overall, the impacts to sensitive receptors due to ground movement were determined to be within the negligible to slight damage categories for the majority of structures considered.

The key findings of the assessment are:

- There is potential for ground movement to impact a sculptural installation, Helmet, during tunnelling beneath Banksia Park based on the reference project. Therefore the sculpture is likely to require relocation for the duration of the tunnelling works in this location. Preparation of a geotechnical model and assessment based on the final design would confirm the need for relocation.
- All other sensitive receptors assessed were classified between negligible and slight risk of damage and so are not anticipated to be adversely affected by ground movement.

Application of the project EPRs (described in full in Chapter 27 – Environmental management framework) would minimise impacts associated with ground movement by developing a geotechnical model, a ground movement plan, undertaking condition surveys and remediation of any damage caused by ground movement.

In response to the EES evaluation objective described at the beginning of this chapter, effects of the project on sensitive receptors due to ground movement have been assessed and EPRs have been identified to minimise or avoid impacts.