Attachment D

East West Connections Report

Options shortlisting – preliminary groundwater assessment

Prepared for NZTA and Auckland Transport

Prepared by Beca Ltd

Revision History

Revision Nº	Prepared By	Description	Date
1	Ann Williams	For discussion	09 October 2014
2			
3			
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5			

Document Acceptance

Action	Name	Signed	Date
Prepared by	Ann Williams	A Williams	Nov 2014
Reviewed by	Nathan McKenzie	[signature]	Nov 2014
Approved by	Andrea Rickard	[signature]	Nov 2014
on behalf of	Beca Ltd		

Executive Summary

The East West Connections project is a joint NZ Transport Agency and Auckland Transport programme to improve freight efficiency, commuter travel, public transport and walking and cycling options over the next 30 years in the area between Onehunga, Penrose, East Tamaki and Auckland Airport. Six options were short-listed for the Onehunga-Penrose connection (a description of each is held in the Detailed Business Case):

- Option A (Long List Option 1): Existing route upgrade
- Option B (Long List Option 2): Upgrade with South Eastern Highway Ramp
- Option C (Long List Option 5): Upgrade with new Galway Street and inland connections
- Option D (Long List Option 8): Upgrade with Gloucester Park interchange and new Galway St and inland connections
- Option E (Long List Option 13): New foreshore connection
- Option F (Long List Option 14): New foreshore and inland connection.

This report provides a high level assessment of the effects of the each of the six options on groundwater levels and flow. Groundwater quality is addressed in a separate assessment.

Existing groundwater levels and flow may be influenced by the project if there are changes to surface water flows and infiltration, where earthworks and subsurface construction require drainage or take place below the seasonal low groundwater level, and where changes to soil permeability occur. A rise or lowering of groundwater level as a consequence of cut or fill construction has the potential to affect:

- Groundwater levels (cause more frequent surface flooding or drawdown induced ground settlement; reduced recharge to water supply wells and/or saline intrusion)
- Existing stream levels/ springs
- Groundwater flow directions (altered discharge to streams or coast)
- The fresh water/ salt water interface
- The migration of contaminants that may be present in groundwater.

Groundwater flow and levels are largely controlled by the ground conditions (soil and rock permeability and layering) and topography (ground elevation and slope, streams and the coastline). A preliminary 3D ground model was developed using existing borehole and groundwater well data with reference to published geological maps. The potential for the above effects to occur was assessed by identifying the proposed cut and fill elements of the options in relation to the ground model. A groundwater flow model was not prepared as part of this high level assessment.

The assessment found that the project is unlikely to have significant effects on groundwater:

- Options A and B are expected to have nil or less than minor effects
- Option C is likely to have a less than minor effect provided fills placed over existing fill are constructed on a granular drainage blanket (or similar)
- The minor to potentially moderate effects of Options D, E and F can be resolved through engineered solutions, however these will present some challenges. Of these, Option E is preferred because it avoids crossing Miami stream and maximises the length of embankment on the seaward side of the foreshore area (i.e. does not cross the existing foreshore landfill area).

If construction is to take place in the Mangere Inlet, construction of the road embankment set back from the toe of the existing foreshore, allowing access to the sea from beneath a bridge beyond Pikes Point would allow existing groundwater flow and discharge to be maintained and the effects on groundwater would be negligible.

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Appendices

1 Introduction

The East West Connections project is responding to the immediate and growing freight access issues at either end of the Neilson Street/Church Street corridor caused by inefficient transport connections and a lack of response to changes in the industry's supply chain strategies. The project is also addressing the inadequate quality of transport choices between Māngere, Ōtāhuhu and Sylvia Park.

The long list of options was developed in a 2-stage process. The option identification process began with identifying changes at a component level (e.g. lane widening; interchange improvements) across the geographical area. To ensure a full spectrum of components was considered, the study area was separated into segments. All components were then assessed through a multi-criteria analysis. Where broadly equivalent components (in terms of either transport performance or social, environmental or cultural outcomes) were identified, the best alternative proceeded to the development of the long list options. If no broadly equivalent alternative component existed, the component was progressed to the development of long list options. All options were assessed through a multi-criteria analysis, which considered a full range of impacts and performance against the project's objectives and the East West Connections outcomes. Six options were identified to progress to the short list for the Onehunga-Penrose connection. These options range from low investment to high investment.

These 6 options are the subject of this assessment and a detailed description of each is held in the Detailed Business Case. The following summarised descriptions have been used as the basis for the following assessment of effects on groundwater.

Option A (Long List Option 1): Existing route upgrade

This option looks to upgrade the existing roads. This includes improving capacity on SH20, Neilson Street and Church Streets. It also provides freight lanes.

- Auxiliary lanes / capacity improvements on SH20 (Queenstown Road to Gloucester Park)
- Some widening of Onehunga Harbour Road at Gloucester Park (e.g. around the Onehunga Port area, beneath SH20 and potential to increase this from 2 to 3 lanes up to Neilson Street / Onehunga Mall intersection).
- Upgrading of the intersection at Onehunga Mall / Neilson Street intersection (potentially including widening of bridge over the rail line) to provide for dedicated movements between Onehunga Mall / Neilson Street.
- Capacity improvements on Neilson St, for example extending the 4-laning from Alford St to Church St (potential impact on some road frontages, but looking to minimise)
- New signalised intersection to provide access to Metroport (for example, providing for dedicated turning median).
- Cycleway uses Hugo Johnston Road (within the road corridor), may impact on tree planting etc in existing road reserve, will then connect to Church Street East and Great South Road (level crossing) to connect to existing cycle path to Sylvia Park.
- Freight lane priority at Mt Wellington Interchange where this can fit beneath existing bridge constraints.

Option B (Long List Option 2): Upgrade with South Eastern Highway Ramp

This option proposes an upgrade of existing roads with new ramp connections from Church Street to SH1 and South Eastern Highway.

- Auxiliary lanes / capacity improvements on SH20 (Queenstown Road to Gloucester Park).

- Some widening of Onehunga Harbour Road at Gloucester Park is likely (e.g. around the Onehunga Port area, beneath SH20 and potential to increase this from 2 to 3 lanes up to Neilson Street / Onehunga Mall intersection.
- At Onehunga Mall / Neilson Street intersection, upgrading of intersection is required (potentially including widening of bridge over the rail line) to provide for dedicated movements between Onehunga Mall / Neilson Street.
- Looking at capacity improvements on Neilson St, for example extending the 4-laning from Alford St to Church St (potential impact on some road frontages, but looking to minimise).
- New signalised intersections and upgrades to intersections at Metroport (for example: providing for a dedicated turning median), Church St, Hugo Johnston Drive and Great South Road (grade separation at Hugo Johnston Drive and Great South Road may be considered).
- Cycleway using Hugo Johnston Road (within the road corridor), may impact on tree planting etc in existing road reserve, will then connect to Church Street East and Great South Road (level crossing) to connect to existing cycle path to Sylvia Park.
- New connections for ‘southern’ traffic on SH1, with ramps from the South Eastern Arterial (looking at ramps of 2-lanes in each direction to connect from interchange to tie in with SH1 at Mt Wellington). This requires an auxiliary lane extension on SH1 down to Princes Street interchange.

Option C (Long List Option 5): Upgrade with new Galway Street and inland connections

This option proposes a new connection from Onehunga Harbour Road to Galway Street, and upgrade of Neilson and Angle Streets and Sylvia Park Road, and a new connection for Angle Street to Sylvia Park Road and to SH1.

- Auxiliary lanes / capacity improvements on SH20 (Queenstown Road to Gloucester Park)
- Some widening of Onehunga Harbour Road at Gloucester Park is likely (e.g. around the Onehunga Port area, beneath SH20.
- New connection from Onehunga Harbour Road onto Galway Street (may impact on traffic movements / access to SH20 from Onehunga Mall / Onehunga Harbour Road)
- 4-lanes on Galway Street with upgraded intersection to Neilson Street, upgrading of intersection required (potentially including widening of bridge over the rail line) and to address increased traffic from Onehunga Mall to Galway Street.
- Looking at capacity improvements on Neilson St, for example extending the 4-laning from Alford St to Angle St and upgrading of Angle Street (e.g. up to 4-lane, which may require some additional land).
- New connection from Angle Street to Great South Road for between 2 and 4 lanes, and where practicable on land between Transpower towers and foreshore (not reclamation).
- At Sylvia Park Road, increasing capacity of some of Sylvia Park Road (e.g. additional lanes) and may require land take and relocation of Transpower towers.
- Ramps over Mt Wellington Highway to connect onto SH1, serving the south, with increased capacity (e.g. auxiliary lanes) on SH1 down to Princes St.
- Waikaraka Cycleway maintained and extended alongside new road sections to connect to Sylvia Park.

Option D (Long List Option 8): Upgrade with Gloucester Park interchange and new Galway St and inland connections

This option proposes an upgrade at Gloucester Park Interchange and a new connection from Onehunga Harbour Road to Galway Street. It also proposes an upgrade of Neilson and Angle Streets and Sylvia Park Road, and a new connection for Angle Street to Sylvia Park Road and to SH1.

- Auxiliary lanes / capacity improvements on SH20 (Queenstown Road to Gloucester Park).
- New interchange at SH20 at Gloucester Park, to restrict access to Neilson Street and divert all traffic onto Onehunga Harbour Road (widening requirements for Onehunga Harbour Road, e.g. 3+ lanes).

- New connection from Onehunga Harbour Road onto Galway Street (may impact on traffic movements / access to SH20 from Onehunga Mall / Onehunga Harbour Road).
- 4-lanes on Galway Street with upgraded intersection to Neilson Street, upgrading of intersection required (potentially including widening of bridge over the rail line) and to address increased traffic from Onehunga Mall to Galway Street.
- Looking at capacity improvements on Neilson St, for example extending the 4-laning from Alford St to Angle St and upgrading of Angle Street (e.g. up to 4-lane, which may require some additional land).
- New connection from Angle Street to Great South Road for between 2 and 4 lanes, and where practicable on land between Transpower towers and foreshore (not reclamation).
- At Sylvia Park Road, increasing capacity of some of Sylvia Park Road (e.g. additional lanes) and may require land take and relocation of Transpower towers.
- Ramps over Mt Wellington Highway to connect onto SH1, serving the south, with increased capacity (e.g. auxiliary lanes) on SH1 down to Princes St.
- Waikaraka Cycleway maintained and extended alongside new road sections to connect to Sylvia Park.

Option E (Long List Option 13): New foreshore connection

This option proposes a new connection from SH20 to SH1 along the foreshore.

- Auxiliary lanes / capacity improvements on SH20 (Queenstown Road to Gloucester Park).
- New interchange at SH20 at Gloucester Park, with access to Neilson Street and onto Onehunga Harbour Road (may require some changes to traffic movements from Onehunga Harbour Road onto SH20).
- New connection from Gloucester Park along foreshore to Great South Road, with local connections at Captain Springs Road, Southdown (Metroport) and Great South Road to connect (via intersection) onto Vesty Drive.
- New bridge from Vesty Road to provide new ramp connection to SH1 at Panama Road (between businesses and residential areas).
- New ramp connections at Panama Road (potentially requiring replacement of Panama Road Bridge) with increased capacity (e.g. auxiliary lanes) on SH1 down to Princes St.
- Waikaraka Cycleway maintained and extended alongside new road sections to Great South Road and then onto alignment around Hamlin's Hill.

Option F (Long List Option 14): New foreshore and inland connection

This option proposes a new connection form SH20 to SH1 (partly along the foreshore and partly inland).

- Auxiliary lanes / capacity improvements on SH20 (Queenstown Road to Gloucester Park).
- New interchange at SH20 at Gloucester Park, with access to Neilson Street and onto Onehunga Harbour Road (may require some changes to traffic movements from Onehunga Harbour Road onto SH20).
- New connection from Gloucester Park along foreshore to Captain Springs Road and then inland to Great South Road.
- New intersections at Captain Springs Road, Southdown (Metroport) and Great South Road (may require relocation of Transpower towers).
- At Sylvia Park Road, increasing capacity of some of Sylvia Park Road (e.g. additional lanes) and may require land take and relocation of Transpower towers.
- Ramps over Mt Wellington Highway to connect onto SH1, serving the south, with increased capacity (e.g. auxiliary lanes) on SH1 down to Princes St.
- Waikaraka Cycleway maintained and extended alongside new road sections to connect to Sylvia Park.

2 Methodology of the Assessment

2.1 Groundwater Effects Overview

Existing groundwater levels and flow may be influenced by the proposed development if there are changes to surface water flows and infiltration, where earthworks and subsurface construction require drainage or take place below the seasonal low groundwater level, and where changes to soil permeability occur. These potential effects are set out below:

- Cuts extending below the groundwater table that require drainage and lowering of groundwater levels extending beyond the cut
- Filling on compressible ground that results in consolidation of the ground beneath the water table and consequent reduction in its hydraulic conductivity. This may cause a rise of groundwater level on the up-gradient side of the constructed fill embankment and a lowering of groundwater level on the down-gradient side of the embankment
- Filling adjacent to or over a groundwater discharge area resulting in a rise of groundwater level up-gradient and reduction in discharge down-gradient
- Reduction in aquifer recharge by constructing a pavement over an aquifer recharge area.

A rise or lowering of groundwater level as a consequence of cut or fill construction has the potential to affect:

- Groundwater levels (cause more frequent surface flooding or drawdown induced ground settlement; reduced recharge to water supply wells and/or saline intrusion)
- Existing stream levels/ springs
- Groundwater flow directions (altered discharge to streams or coast)
- The fresh water/ salt water interface
- The migration of contaminants that may be present in groundwater.

2.2 Assessment Methodology

Groundwater flow and levels are largely controlled by the ground conditions (soil and rock permeability and layering) and topography (ground elevation and slope, streams and the coastline). A preliminary 3D ground model was developed using the available existing geotechnical borehole and groundwater well data (Appendix A) with reference to published geological maps (Kermode & Searle 1966, Kermode 1992). Groundwater level data obtained from Auckland Council and from Beca projects for NZTA was then introduced to the ground model. A groundwater flow model has not been prepared as part of this high level assessment.

The potential for the above effects to occur was assessed by identifying the proposed cut and fill elements of the options in relation to the ground model. The ground model will need to be incorporated into a finite element groundwater flow model to assess in more detail the effects of the finally selected option to both support mitigation through design and consenting.

3 Background Information

3.1 Reliance

This assessment was informed by and relies upon other technical assessments prepared in support of the Project, including the following:

- Assessment of Surface Water and Stormwater effects
- Assessment of Land and Groundwater Contamination effects
- Shortlist options layout plans.

3.2 Ground Conditions

The area is underlain by the Manukau Lava Field built largely by lava flows from One Tree Hill and Mount Smart volcanoes, but also from Mt Wellington volcano in the east. Mt Smart volcano is the oldest of these (38,000 years) and is understood to have erupted on a pre-existing land surface that is now well below sea-level in the mouth of a valley system. The Hopua explosion crater (Gloucester Park) comprises an elevated tuff[1] ring that erupted some 34,000 years ago. When sea-level rose, the tuff ring was breached and marine and organic muds were deposited within. The breach was closed some 70 years ago and the ruff ring reclaimed with both urban refuse and fill. The basalt lava and tuff overlie and are locally interbedded with a variable thickness of Tauranga Group alluvium, comprising pumiceous silt, sand and gravel with muddy peat and non-welded and alluvially reworked ignimbrite and tephra.

The Onehunga Bay and Manukau Inlet foreshore has been progressively reclaimed with landfill and engineered fill. The volcanics are bound to the east by an uplifted block of Waitemata Group sandstone and siltstone, although some lava and tuff from Mt Wellington volcano have flowed around the block from the north-east in the area of Ann's Creek. The geology is described in more detail in Beca (2014). An image of the ground model and a typical cross-section are shown in Figure 1.

[1] Tuff is compacted volcanic ash and debris varying in size from fine sand to coarse gravel and often stratified

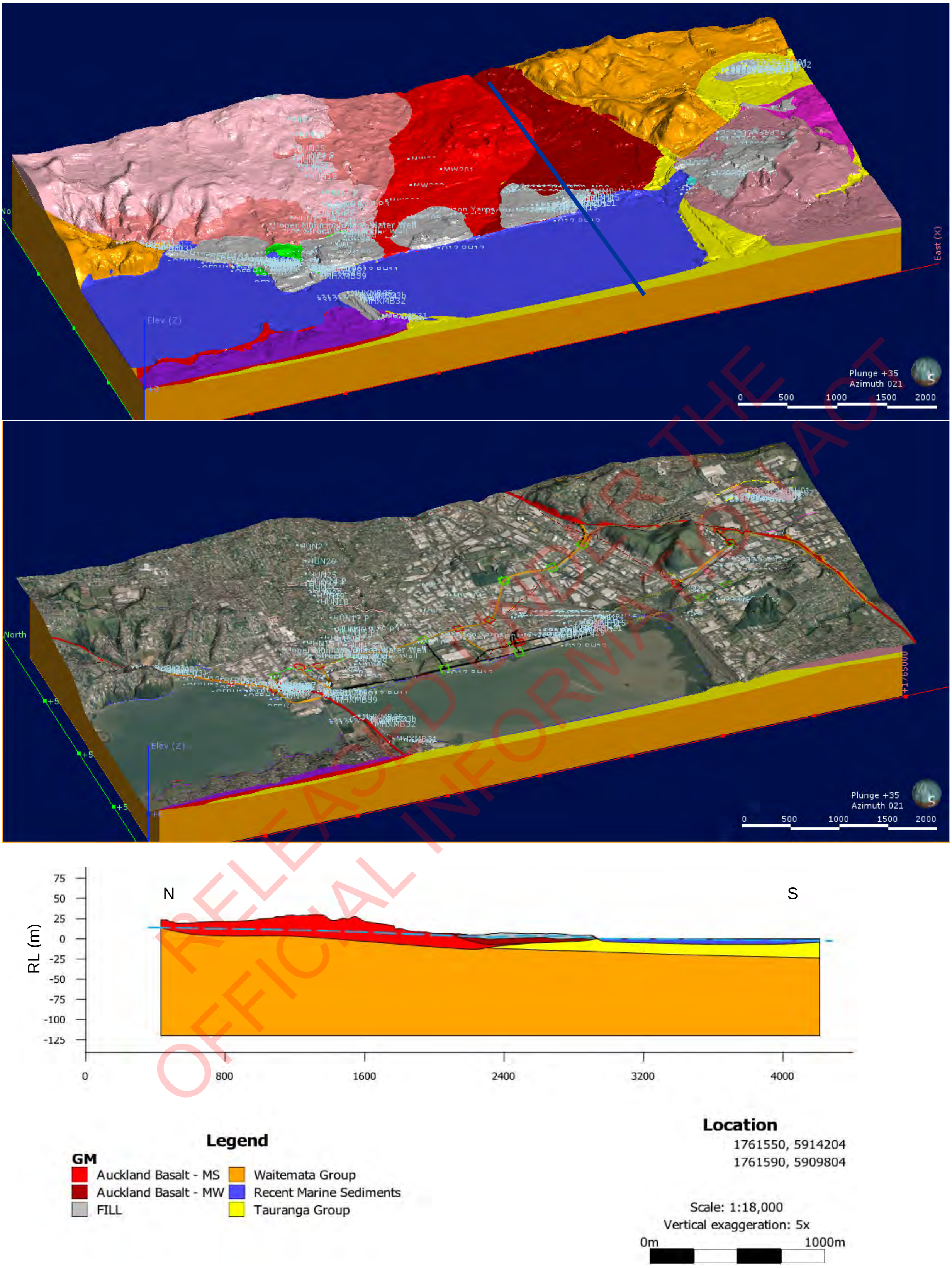

Figure 1: *Upper*: Terrain in the ground model area showing the envelope of options (orange and black lines). *Middle*: Image from the 3D ground model. Pink colours indicate tuff and basalt flows from One Tree Hill volcano, reds from the Mt Smart volcano, green and indigo, from Hopua volcano. These basalt aquifers overlie and are locally intercalated with Tauranga Group alluvium (yellow) and overlie Waitemata Group sandstone and siltstone which forms the basement rocks in the area (orange). Areas of fill are indicated in grey. *Lower*: North – South cross-section (section line shown in upper image); groundwater level indicated approximately by blue dashed line.

3.3 Groundwater Conditions

3.3.1 Hydrogeological units

The basalt lava flows are complex, being locally fractured, rubbly and cavernous and blocked by or over-riding earlier flows and in some places, Tauranga Group alluvium. This means that the hydraulic conductivity can vary by orders of magnitude over short distances, both horizontally and vertically (K = 1 x 10^{-3} m/s to 5 x 10^{-6} m/s).

Groundwater flow through the basalts and tuffs is expected to generally follow topography toward the Manukau Inlet, but actual flow paths may be quite sinuous according to variations in hydraulic characteristics of the lava flows. Vertical flow is constrained by the underlying lower permeability Tauranga Group alluvium and Waitemata Group rocks. Waitemata Group rock rises to the surface at Hamlin Hill, which forms a lateral barrier to groundwater flow. Groundwater flow may be concentrated through lava flows that occupy paleo-valleys. Flow is inferred to be to the northeast below Ann's Creek from at least the vicinity of the Mt Wellington Highway along the historic Wellington valley beneath Ann's Creek towards Mt Wellington, but broadly to the south through the One Tree Hill discharging via the eastern side of Hopua volcano and Te Papapa, and Mt Smart volcanics, discharging beneath Pikes Point).

Typical values of hydraulic conductivity for the lower permeability Tauranga Group and Waitemata Group are of the order of K = 10^{-7} m/s). Hydraulic conductivity of the fills (engineered and landfill) is expected to vary over a wide range (K = 10^{-5} to 10^{-9} m/s) but is generally assumed to have a relatively low permeability (when compared to that of the basalts).

3.3.2 Water levels and gradients

The data available indicates that groundwater in the Onehunga area resides within lava flows derived from the One Tree Hill and Mt Smart volcanoes at approximately 1.5 to 2 m RL (1.2 to 5.5 m below ground level (bgl)). Water levels gradually rise towards the volcanic centres at a shallower rate than the topography with groundwater levels of 3 to 5 m RL (1.5 to 9 m bgl) in the vicinity of Arthur St, some 8 m RL (13 to 14 m bgl) at Grey St, and 28 m RL (6 m bgl) at Mt Smart Road. There is no data available to suggest perched water levels in this area.

URS (2010) identified two basalt aquifers in the Te Papapa area, separated by relatively impermeable ash/tuff. The deeper basalt is thicker and more extensive than the shallow basalt and was interpreted to be part of the Onehunga/ Mt Wellington aquifer system. The shallower basalt is thought to be less extensive than the deep basalt and is only defined where tuff/ash occurs between the two basalt flows. Water levels of 7.0 to 7.5 m RL are recorded in the deeper aquifer in the Mays Rd/ Church St intersection area, dropping steadily towards the southwest to around 2.5 m RL in the Neilson St area. Seasonal variation of up to 1 m was observed in some of the boreholes. The shallow basalt aquifer was mostly dry, indicating intermittent groundwater flow.

The ground model developed from existing data as part of the current study (Figure 1) indicates the presence of Tauranga Group alluvium between some flows, in particular in the east, which would also allow a separate groundwater level to reside in the over and underlying flows.

Data for the Penrose area indicate groundwater levels at 4.2 to 9.5 m RL.

The ground model developed as part of the EWC project indicates groundwater gradients (the drop in groundwater level with distance) of 0.007 to 0.03 (average of 0.02) above (north of) Church Street and of 0.001 to 0.006 (average of 0.003) below (south of) Church Street. These are comparable with the average groundwater gradients reported by Earthtech (1993), which were also low (0.003 to 0.004).

Earthtech (1993) reviewed groundwater levels in the area as part of an aftercare study for the Pikes Point landfill. They reported landfill leachate levels were 0.3 m to 1.1 m above groundwater levels. However this is likely to have been subsequently altered as a result of a leachate system implemented by Auckland Council in May 1993. Land and groundwater contamination is discussed in the Land and Groundwater Contamination effects assessment.

3.3.3 Saline intrusion

The 2013 – 2014 annual report of water quality monitoring for the Pikes Point Closed Landfill prepared by Envirowaste indicates that the composition of groundwater in the groundwater boreholes monitored is of the order of 20% to 50 % seawater; however the locations of the boreholes referred to is not known.

None of the options as currently proposed are judged to negatively influence the current position of the freshwater/ saltwater interface.

3.4 Elements Considered

3.4.1 Springs and streams

Four surface water courses are known to occur in the project area:

- Miami Stream (also referred to as Green Stream following a contamination incident; URS 2010)
- Captain Springs: a groundwater fed spring that discharges into an open unlined channel and connects to the reticulated stormwater system; the 1959 aerial photographs show a stream crossing the intertidal area originating from discharges between Captain Springs Road and Angle Street
- Bycroft Stream: a wetland groundwater spring fed wetland system. The stream flows for some 100 m and is then diverted into the reticulated stormwater system
- Ann’s Creek.

Aerial photographs for 1951, 1955 and 1959 indicate meandering stream discharges through the tidal alluvium originating:

- In land bound by Princes Street, Galway Street, Victoria Street and Neilson Street to the east of Hopua volcano, aligned broadly North – South; more modern aerial photographs (2001, 2006 and 2008) indicate a discharge from beyond the end of Galway Street into the harbour and from beyond the end of Victoria Street (now likely to be stormwater discharges) and a number of less distinct discharges across the foreshore (E side of Hopua volcano and Te Papapa); and
- In land adjacent to Alfred Street, south of Neilson Street, aligned broadly east – west, joining the more major north south discharge from south of Princes Street; discharges across the intertidal areas are evident from the end of Alfred Street and multiple locations within 150 m east of Alfred Street (Pikes Point).

These features have been filled over in the 1970’s and 80’s; however later aerial photographs continue to show some indication of such discharges, but generally subdued and altered in appearance.

3.4.2 Water supply wells

Watercare owns and operates four wells in Onehunga which have historically provided part of Auckland City’s water supply. Current consents require a minimum groundwater level in the sources of 0.5 m RL. These consents are up for renewal in December 2015. The wells are located between Princes Street and Church Street north of Gloucester Park (Figure 2) as follows:

- At the corner of Pearce St and Upper Municipal Place (the Pearce St well), at approximately RL 11.8 m (well 12.3 m deep)
- Within the Watercare Onehunga Treatment facility (the Rowe St well), at approximately RL 5 m (well 5.5 m deep)
- At the back of the garage of the Onehunga Workingmen's club (the Upper Municipal Place well), at approximately RL 15.7 m (14.5 m deep); the well has not been operated since 2004
- On the berm, next to the pavement on Lower Municipal Place (the Lower Municipal Place well), at approximately RL 8 m (blocked; depth unknown); the well has not operated since 2004.

Groundwater levels in the wells vary between 1.5 m and 4 m above sea level (PDP 2011). It is understood that the average maximum combined daily take is just over 100 l/s (around 9000 m^3/day), but there is provision for abstraction at higher rates provided minimum flows are maintained at Bycroft Stream and existing well users in the vicinity are able to abstract at their consented rate of take. A list of consented groundwater takes in the area is given in Appendix A (Auckland Council bore search, October 2014).

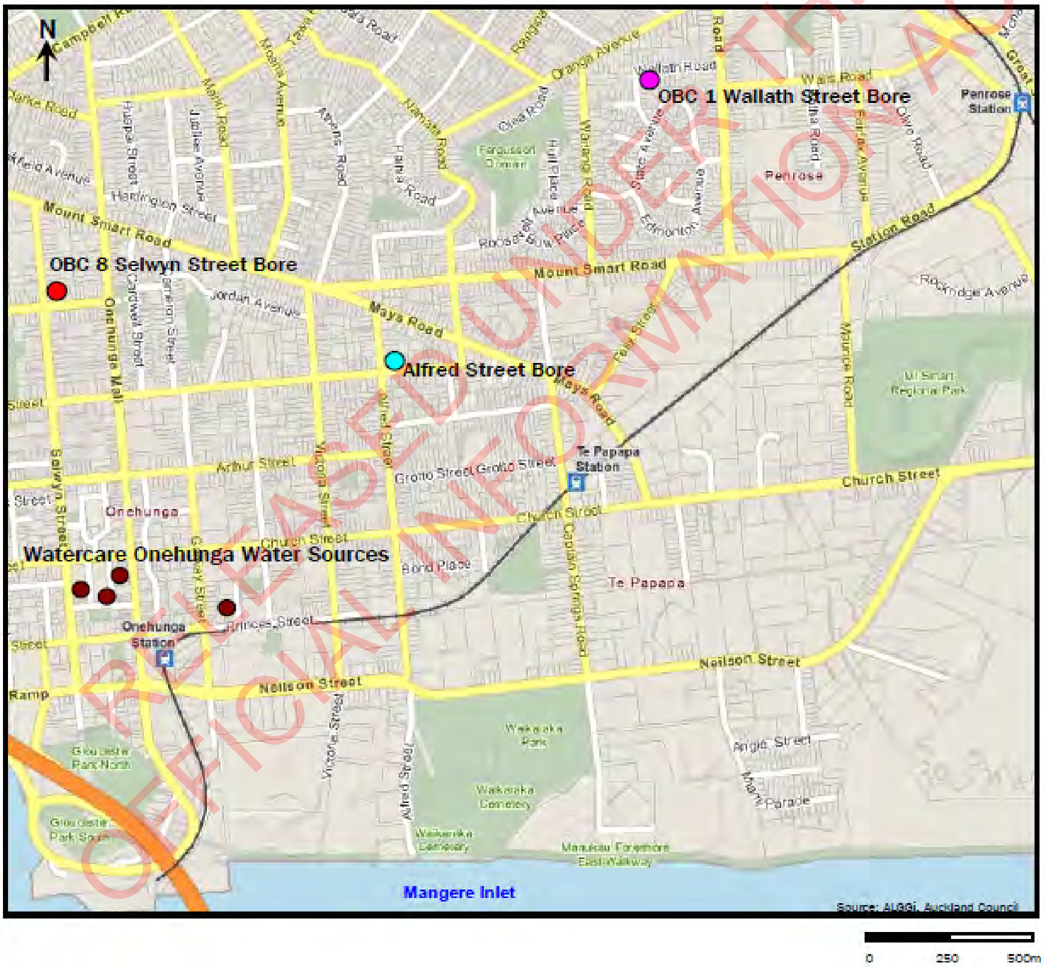

Figure 2: Auckland Council well (brown) and monitoring well locations (blue, red and pink). Source: PDP (2011)

4 Key Design Assumptions

Key elements of the proposed development options that have the potential to affect groundwater are summarised in Table 2. No elements of Option A were assessed to impact groundwater.

None of the options are considered to noticeably affect recharge to the basalt aquifers because the increase in area of permeable aquifer covered by an impervious road surface is judged to be small and the alignments cross the lowest part of the aquifer system.

Along the north shore of Mangere Inlet the proposed design of the foreshore options E and F calls for an embankment approximately 60 m wide to accommodate a four lane road carriageway and a shared path and cycle way with swales for stormwater treatment. It is assumed that the embankment is separate from the existing foreshore and as such it will create an area between the two that can be used for additional treatment and containment of any leachate etc. The construction method could include pre-loading and in-situ drainage (e.g. Wick drains) to reduce long term settlement and the finished road carriageway elevation will be 4.5 m above msl. It is anticipated that some 'headland' features would be constructed to provide a more natural coastal edge. Existing drainage to the Inlet (e.g. from Miami stream) will be provided for using bridges or culverts.

Table 2 - Summary of Elements Considered to Potentially Affect Groundwater Flow or Level

Option	Element	Potential Effects
A	None	Nil
B	Cuts adjacent to Hamlin Hill reserve	Cut below water table would result in groundwater drawdown.
	B3 bridge approaches comprising fill over potentially compressible Tauranga Gp sensitive pumiceous alluvium	Fill loading could result in consolidation of underlying sediments with consequent lowering of hydraulic conductivity and reduction of through flow or upgradient water level rise.
	B4 bridge approaches comprising fill over potentially compressible Tauranga Gp alluvium	Fill loading could result in consolidation of underlying sediments with consequent lowering of hydraulic conductivity and reduction of through flow or upgradient water level rise.
	Cut at Tip-top corner	Cut expected to be in basalt with sufficient elevation to be above groundwater level.
C	Approaches to bridge C1 over rail corridor Gloucester Park to Galway St (9 m fill?)	Placement of fill over existing landfill is likely to result in consolidation of the existing fills and reduction in hydraulic conductivity which will alter groundwater flow paths in this area, potentially causing a change in groundwater level on either side.
	Western approach to bridge C2	Requires constructing approach on weak fill adjacent to the coast which could cause ponding of groundwater on the upgradient side.
	Cut at Tip-top corner	Cut expected to be in basalt with sufficient elevation to be above groundwater level.
D	Reclamation west side of Gloucester Park and bridge approach at SH20 off-ramp	Reclamation and approach fill may obstruct groundwater flow through tuff ring below natural crater breach (filled 1930) causing elevated groundwater levels upgradient.
	Western approach to bridge D2	As for bridge C2
E	Approach ramps from Neilson Street	Requires large fills placed over existing fill which may result in consolidation of fill below groundwater level and constrict upgradient flow.
	Reclamation west side of Gloucester Park and bridge	As for D

Option	Element	Potential Effects
	approach at SH20 off-ramp	
	Reclamation fronting the Onehunga foreshore as far as the conclusion of the current filled foreshore	Groundwater flow is broadly north – south. Construction of a partial barrier to groundwater discharge to the harbour that otherwise might occur through basalt and beneath existing fills.
	E2 Bridge eastern approach	Construction of fill over apparent natural drainage feature NW side of Mt Richmond volcano. Assessment: potential to partially obstruct groundwater flow, resulting in ponding of groundwater upgradient
	E3 approaches	Fills likely to be placed over tuff and basalt.
	E4 cuts and fills on-ramp and approaches to SH1	Deep cuts in basalt.
F	Approach ramps from Neilson Street	As for E
	Reclamation west side of Gloucester Park and bridge approach at SH20 off-ramp	As for D and E
	Reclamation fronting about half of the Onehunga foreshore	Groundwater flow is broadly north – south. Construction of a partial barrier to groundwater discharge to the harbour that otherwise might occur through basalt and beneath existing fills.
	Stream crossing adjacent to Miami Parade	The alignment crosses the remaining stream feature as a fill, potentially resulting in ponding of upgradient flow in the depression and drying of the stream bed on the down-gradient (coastal) side.
	Western approach to bridge C2	Requires constructing approach on weak fill adjacent to the coast which could cause ponding of groundwater on the upgradient side.

5 Assessment of Effects on Groundwater

5.1 Assessment of Option A (1)

Option A would be largely constructed at grade over tuff and basalt. The option does not require dewatering or construction of fills over compressible materials. The footprint of impervious surface will not increase by a noticeable amount. Option A is assessed to have no noticeable effects on groundwater levels and flows.

5.2 Assessment of Option B (2)

Elements identified that might impact groundwater level or flow are summarised in Table 3.

Table 3 - Summary of Potential Effects of Option B on Groundwater

Element	Potential Effects	Assessed Effect
Cuts adjacent to Hamlin Hill reserve	Cut below water table would result in groundwater drawdown.	**Less than minor**. Cut in Waitemata Group rock at Hamlin Hill unlikely to intercept permanent groundwater level.
B3 bridge approaches comprising fill over potentially compressible Tauranga Gp sensitive pumiceous alluvium	Fill loading could result in consolidation of underlying sediments with consequent lowering of hydraulic conductivity and reduction of through flow or upgradient water level rise.	**Less than minor**.
B4 bridge approaches comprising fill over potentially compressible Tauranga Gp alluvium	Fill loading could result in consolidation of underlying sediments with consequent lowering of hydraulic conductivity and reduction of through flow or upgradient water level rise.	**Less than minor**.
Cut at Tip-top corner	Cut expected to be in basalt with sufficient elevation to be above groundwater level.	**Nil** effect.

5.3 Assessment of Option C (5)

Elements identified that might impact groundwater level or flow are summarised in Table 4.

Table 4 - Summary of Potential Effects of Option C on Groundwater

Element	Potential Effects	Assessed Effect
Approaches to bridge C1 over rail corridor Gloucester Park to Galway St (9 m fill?)	Placement of fill over existing landfill is likely to result in consolidation of the existing fills and reduction in hydraulic conductivity which will alter groundwater flow paths in this area, potentially causing a change in groundwater level on either side.	**Minor**. As the fills would be aligned roughly north – south they are unlikely to be a significant impediment to groundwater flow and associated changes in groundwater level are likely to be local.
Western approach to bridge C2	Requires constructing approach on weak fill adjacent to the coast which could cause ponding of groundwater on the upgradient side.	**Minor**. May result in wetter ground on the upgradient side of the approach; benefit: reduces the volume of groundwater entering the fill down-gradient of the proposed approach, and therefore the volume of leachate generated.
Cut at Tip-top corner	Cut expected to be in basalt with sufficient elevation to be above groundwater level.	**Nil** effect

5.4 Assessment of Option D (8)

Elements identified that might impact groundwater level or flow are summarised in Table 5.

Table 5 - Summary of Potential Effects of Option D on Groundwater

Element	Potential Effects	Assessed Effect
Reclamation west side of Gloucester Park and bridge approach at SH20 off-ramp	Reclamation and approach fill may obstruct groundwater flow through tuff ring below natural crater breach (filled 1930) causing elevated groundwater levels upgradient.	**Minor**. Fill already exists in and adjacent to the park, therefore the effects may be negligible, but further work needed to explore groundwater flow in this area.
Western approach to bridge D2	Requires constructing approach on weak fill adjacent to the coast which could cause ponding of groundwater on the upgradient side.	**Minor**. May result in wetter ground on the upgradient side of the approach; benefit: reduces the volume of groundwater entering the fill down-gradient of the proposed approach, and therefore the volume of leachate generated.

5.5 Assessment of Option E (13)

Elements identified that might impact groundwater level or flow are summarised in Table 6.

Table 6 - Summary of Potential Effects of Option E on Groundwater

Element	Potential Effects	Assessed Effect
Approach ramps from Neilson Street	Requires large fills placed over existing fill which may result in consolidation of fill below groundwater level and constrict upgradient flow.	**Less than minor.** As this site is located adjacent to natural basalt ground, it is likely that groundwater already discharges around the existing fill (if it is low permeability) and therefore the ramps would have little effect.
Reclamation west side of Gloucester Park and bridge approach at SH20 off-ramp	Reclamation and approach fill may obstruct groundwater flow through tuff ring below natural crater breach (filled 1930) causing elevated groundwater levels upgradient.	**Minor.** Fill already exists in and adjacent to the park, therefore the effects may be negligible, but further work needed to explore groundwater flow in this area
Reclamation fronting the Onehunga foreshore as far as the conclusion of the current filled foreshore	Groundwater flow is broadly north – south. Construction of a partial barrier to groundwater discharge that might otherwise occur to the harbour through basalt and existing fills.	**Beneficial.** Likely to result in ponding of leachate borne in groundwater on upgradient (landward) side and slow or provide some capture of discharge to Mangere Inlet. **Minor to Moderate.** Depending on design may cause a groundwater level rise (and retention of leachate in groundwater) in the upgradient landfill, which would then be more readily available to wells pumping in the area.
E2 Bridge eastern approach	Construction of fill over apparent natural drainage feature NW side of Mt Richmond volcano.	**Minor**. Potential to partially obstruct groundwater flow, resulting in ponding of groundwater upgradient.
E3 approaches	Fills likely to be place over tuff and basalt.	**Less than minor**. Small reduction in recharge through these materials to groundwater.
E4 cuts and fills on-ramp and approaches to SH1	Deep cuts in basalt.	**Less than minor.** Basalt of sufficient elevation that discharge of groundwater to cut unlikely.

5.6 Assessment of Option F (14)

Elements identified that might impact groundwater level or flow are summarised in Table 7.

Table 7 - Summary of Potential Effects of Option F on Groundwater

Element	Potential Effects	Assessed Effect
Approach ramps from Nelson Street	Requires large fills placed over existing fill which may result in consolidation of fill below groundwater level and constrict upgradient flow.	As this site is located adjacent to natural basalt ground, it is likely that groundwater already discharges around the existing fill (if it is low permeability) and therefore the ramps would have little effect. Less than minor
Reclamation west side of Gloucester Park and bridge approach at SH20 off-ramp	Reclamation and approach fill may obstruct groundwater flow through tuff ring below natural crater breach (filled 1930) causing elevated groundwater levels upgradient.	Fill already exists in and adjacent to the park, therefore the effects may be negligible, but further work needed to explore groundwater flow in this area
Reclamation fronting about half of the Onehunga foreshore	Groundwater flow is broadly north – south. Construction of a partial barrier to groundwater discharge that might otherwise occur to the harbour through basalt and existing fills.	**Beneficial.** Likely to result in ponding of leachate borne in groundwater on upgradient (landward) side and slow or provide some capture of discharge to Mangere Inlet. **Minor to Moderate.** Depending on design may cause a groundwater level rise (and retention of leachate in groundwater) in the upgradient landfill, which would then be more readily available to wells pumping in the area.
Stream crossing adjacent to Miami Parade	The alignment crosses the remaining stream feature as a fill, potentially resulting in ponding of upgradient flow in the depression and drying of the stream bed on the down-gradient (coastal) side.	**Moderate** effect.
Western approach to bridge C2	Requires constructing approach on weak fill adjacent to the coast which could cause ponding of groundwater on the upgradient side.	**Minor**. May result in wetter ground on the upgradient side of the approach; benefit: reduces the volume of groundwater entering the fill down-gradient of the proposed approach, and therefore the volume of leachate generated.

6 Recommended Mitigation Required

Options for mitigating the effects identified as minor or more are summarised below.

6.1 Options A and B

It is assumed that there will be no works below the groundwater table and no requirements for groundwater drawdown for these options. The effects on groundwater are expected to be nil or less than minor and no mitigation is proposed.

6.2 Option C

A permeable drainage blanket (e.g. gravel) is recommended for embankments of more than 3 m height to limit the potential for up-gradient groundwater rise and down-gradient lowering.

6.3 Option D

Recommended mitigation measures for Option D are summarised in Table 8.

Table 8 - Mitigation of Potential Effects of Option D on Groundwater

Element	Potential Effects	Potential Mitigation Options
Reclamation west side of Gloucester Park and bridge approach at SH20 off-ramp	Reclamation and approach fill may obstruct groundwater flow through tuff ring below natural crater breach (filled 1930) causing elevated groundwater levels upgradient.	Groundwater discharge through basalt and tuff in this area is not apparent, however mitigation could include construction of a stormwater pond that could also collect groundwater that might discharge in this area or drainage through the embankment to allow existing flows to be maintained
Western approach to bridge D2	Requires constructing approach on weak fill adjacent to the coast which could cause ponding of groundwater on the upgradient side.	As there is a potential benefit in reducing the volume of contaminated discharge to the coast, consideration may be given to constructing a leachate collection system on the upgradient side of the fill that connects with the existing Council operated system, or alternatively constructing the embankment over a permeable drainage blanket to maintain the status quo.

6.4 Option E

Recommended mitigation measures for Option E are summarised in Table 9. Only elements not already considered above are addressed.

Table 9 - Mitigation of Potential Effects of Option E on Groundwater

Element	Potential Effects	Potential Mitigation Options
Reclamation fronting the Onehunga foreshore as far as the conclusion of the currently filled foreshore	Groundwater flow is broadly north – south. Construction of a partial barrier to groundwater discharge that might otherwise occur to the harbour through basalt and existing fills.	Construction of the road embankment set back from the toe of the existing foreshore, allowing full access to the sea from beneath bridge E2 to maintain regular tidal removal of any groundwater discharge and associated contaminants (i.e. avoid potential groundwater level rise); opportunities to capture or slow discharge flow to improve quality of water discharging to the Inlet. *If* the road embankment is constructed in partial or full connection with the existing foreshore, upgradient capture/ treatment of groundwater will be required. This could be achieved in part by the longer flow path through the newly constructed embankment materials.
E2 Bridge eastern approach	Construction of fill over apparent natural drainage feature NW side of Mt Richmond volcano/ stormwater fed branch of Ann's Creek.	Provide for culvert under fill

6.5 Option F

Recommended mitigation measures for Option F are summarised in Table 10. Only elements not already considered above are addressed.

Table 10 - Mitigation of Potential Effects of Option F on Groundwater

Element	Potential Effects	Potential Mitigation Options
Stream crossing adjacent to Miami Parade	The alignment crosses the remaining stream feature as a fill, potentially resulting in ponding of upgradient flow in the depression and drying of the stream bed on the down-gradient (coastal) side.	Culvert or bridge over Creek depending on ecological value; or consider Option variant proposed by the Contaminated Land Assessment, which would continue along the coastal margin of the fill in this area

7 Conclusion and Recommendation

The project is unlikely to have significant effects on groundwater; however there are some differences in effect between the options currently under consideration:

- Options A and B are expected to have nil or less than minor effects.
- Option C is likely to have a less than minor effect provided fills placed over existing fill are constructed on a granular drainage blanket (or similar)
- The minor to potentially moderate effects of Options D, E and F can be resolved through engineered solutions, however these will present some challenges. Of these, Option E is preferred because it avoids crossing Miami stream and maximises the length of embankment on the seaward side of the foreshore area
- If construction is to proceed in the Mangere Inlet, construction of the road embankment set back from the toe of the existing foreshore, allowing access to the sea from beneath bridge E2 would allow existing flows and discharges to be maintained and the effects on groundwater to be negligible.

8 References

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Appendix A

Summary of Groundwater Borehole Data

EWC - Boreholes considered in model

Bore ID	Easting	Northing	Elevation (mRL)	Depth (mbgl)
2509687_03/08_MB1	1761475.433	5911862.028	2.65	12.5
2509687_03/08_MB2	1761552.671	5911901.609	3.75	11.2
2509687_03/08_MB3	1761409.931	5911889.746	3.4	14.2
2509687_03/08_TP20	1761498.316	5911844.804	2.7	5
2930234/BH01	1764418	5913076	15	4.95
2930234/BH02	1764436	5913030	15	25.5
2930234/BH03	1764287	5913007	15	4.95
2930234/BH04	1764212	5913002	15	4.95
2930234/BH05	1764239	5913028	15	25.39
2930234/BH06	1764185	5913027	15	4.95
2930234/BH07	1764178	5913000	15	24.2
2930234/BH08	1764302	5913008	15	24.4
3121330/BH1	1759032.744	5910807.564	1.7	18.05
3121330/BH2	1759030.651	5910854.557	0.7	20.65
3290050/MB04	1761461.43	5911923.952	3.59	9.7
3290050/MB05	1761510.906	5911928.127	3.9	12
3290050/MB06	1761434.232	5911869.225	2.74	6
3290050/TP22	1761575.172	5911906.388	5.05	5
3290050/TP34	1761439.479	5911864.687	3	5
HUN1 P	1759170.476	5911436.793	7.3	8
HUN10 P	1759643.841	5911770.696	4	8
HUN11	1759651.45	5911819.764	3.5	8
HUN12 P	1759645.565	5911901.688	2.9	8
HUN13 P	1759639.325	5912007.723	5.8	8
HUN14	1759628.59	5912135.645	7	8
HUN15 P1	1759620.853	5912225.605	11.8	14
HUN15 P2	1759437.044	5912178.297	11.5	15
HUN15 P3	1759833.849	5912234.066	6.5	15
HUN15 P4	1759238.077	5912165.875	10.7	15
HUN16 P	1759615.818	5912261.605	14.1	15
HUN17 P	1759621.576	5912410.626	21.9	15
HUN18	1759586.804	5912672.018	29.7	8
HUN19	1759578.849	5912760.981	32.5	8
HUN2	1759218.457	5911429.903	6	8
HUN20	1759572.75	5912826.006	32.7	8
HUN21	1759569.606	5912861.471	33.3	8
HUN22	1759560.194	5912947.461	34.7	8
HUN23 P	1759572.412	5912991.543	34.4	8
HUN24 P	1759603.277	5913032.58	33.1	15
HUN25	1759623.396	5913109.122	39.2	13.8
HUN26	1759678.566	5913290.735	44.6	8
HUN27	1759669.417	5913493.642	56.7	8
HUN3 P	1759230.41	5911475.891	3.9	8
HUN4 P	1759214.199	5911561.906	3.2	10
HUN6	1759346.116	5911637.18	5.66	5
HUN7	1759428.032	5911637.264	5.6	8
HUN9	1759618.03	5911667.654	4	8
HUN96	1759240.855	5911580.917	5.1	15

EWC - Boreholes considered in model

Bore ID	Easting	Northing	Elevation (mRL)	Depth (mbgl)
HUN97P	1759296.735	5911627.891	5.1	15
HUN98P	1759564.859	5911664.337	4.2	15
HUN99	1759649.041	5911716.59	4.4	15
HUP30(70)	1759077.936	5911318.286	7.92	47
HUP31(70)	1759089.656	5911303.067	7.77	64.6
HUTT_BH100	1759241.192	5911572.109	5.1	15.5
MBBH1	1759032.744	5910807.564	1.7	18.05
MBBH2	1759030.651	5910854.557	0.7	20.65
MHXBH10A	1758625.749	5911582.7	3.6	22.8
MHXBH11	1758725.825	5911531.839	4.8	24.4
MHXBH12	1758715.105	5911493.031	4.9	24.1
MHXBH13	1758725.918	5911482.829	2.2	27.4
MHXBH14	1758815.57	5911463.166	4.7	44.7
MHXBH15	1758818.032	5911542.135	2.8	34.5
MHXBH16	1758723.881	5911588.885	3.6	24.4
MHXBH17	1758622.99	5911649.762	3.7	19
MHXBH22	1758731.787	5911529.728	5	24.2
MHXBH22(07)	1758745.842	5911424.45	4.2	9.45
MHXBH23	1758718.901	5911535.968	4.2	19.5
MHXBH23(07)	1758771.93	5911428.968	2.2	12.5
MHXBH24(07)	1758571.739	5911690.718	2.9	7.54
MHXBH3(04)	1757443.404	5912331.704	9.5	15.2
MHXBH30	1758727.436	5911564.815	3.6	11
MHXBH4(03)	1757511.744	5912295.433	7.8	15.1
MHXBH5(03)	1757597.989	5912253.831	5.9	15.45
MHXBH5(06)	1759099.654	5911302.882	10.35	17.7
MHXBH6(06)	1758972.082	5911435.265	3.1	31.4
MHXBH7(03)	1757515.3	5912271.363	16.8	12.4
MHXBH7(06)	1758683.443	5911619.638	3.5	12.9
MHXBH8(03)	1757427.962	5912307.985	20.6	16.7
MHXBH8(06)	1758501.38	5911726.026	4.55	9.3
MHXBH9	1758592.236	5911609.324	3.5	12
MHXBH9(06)	1758722.991	5911756.93	3.75	10
MHXBHP11(07)	1758709.198	5911606.16	2.9	13.2
MHXMB29	1759467.757	5910262.187	3.2	15.45
MHXMB30	1759478.669	5910268.086	3.5	30.125
MHXMB31	1759502	5910264.153	10.4	28.7
MHXMB32	1759396.629	5910590.861	10.6	34.625
MHXMB33b	1759374.064	5910673.993	12.2	58.52
MHXMB34	1759358.545	5910737.992	3.2	50.05
MHXMB35	1759337.089	5910810.801	2.7	47
MHXMB39	1759188.095	5911169.122	4.1	49.095
MHXMB40	1759155.407	5911229.537	2.8	49.55
OFBH100	1758310.617	5911794.447	3.39	9
OFBH101	1758436.839	5911700.374	3.2	13.5
OFBH102	1758210.62	5911861.509	3.26	19.61
OFBH103	1757888.39	5912061.936	3.13	18.135
OFBH104	1758238.399	5911910.404	2.41	19.61

EWC - Boreholes considered in model

Bore ID	Easting	Northing	Elevation (mRL)	Depth (mbgl)
OFBH105	1758597.084	5911427.72	-0.65	13.5
OFBH106	1758492.116	5911338.646	-2.45	19.1
OFBH107	1758417.137	5911637.207	-0.35	6.7
OFBH108	1758377.037	5911575.448	-0.615	7
OFBH109	1758153.676	5911818.064	-1.145	11.075
OFBH110	1758089.826	5911759.225	-1.155	12.06
OFBH111	1757856.439	5911976.752	-1.795	8.63
SKMBH1	1761587.9	5911550.2	6.22	9
SKMBH10	1761546.3	5911453.7	6.5	22.68
SKMBH11	1761640.2	5911525.8	6.5	24.35
SKMBH12	1761703	5911500.6	6.5	12
SKMBH13	1761884.3	5911463.6	6.5	22.95
SKMBH14	1761963.6	5911503.3	6.5	9
SKMBH15	1762052.9	5911523.8	6.5	7.5
SKMBH16	1762198.5	5911585.3	6.5	6
SKMBH17	1761570.1	5911495.3	6	9
SKMBH18	1761679.2	5911460.9	5	12
SKMBH19	1761793.6	5911461.6	5	12.45
SKMBH2	1762091.3	5911566.1	6.79	9
SKMBH20	1761858.5	5911503.9	6	9
SKMBH21	1761986.1	5911465.6	5	10.95
SKMBH7	1761866.4	5911580.7	6.8	10.5
SKMBH9	1761420.6	5911535	6.5	21.32
Angle St	1760818	5911693	4	25
DORMW3	1761125	5911626	5.5	6
Horizon Yarns	1760626	5911833	7	14.4
MW105	1760353	5911798	5.5	21
MW201	1760933	5912394	15	20
MW203	1760562	5912284	9	5
MW206	1760257	5912161	4	5
MW207	1760691	5912676	15	11.3
MW1	1760586	5912435	11.71	23
MW2	1760628	5912389	12.3	21.8
MW3	1760740	5912373	11.62	21
MW3a	1760741	5912374	11.65	6
Mays Road	1760149	5912796	19.9	42.1
Cemetary	1769882	5911508	4.09	16.4
MW208	1760951	5912574	18.98	18.5
Rowe St	1759381	5911988	4.4	6.6
4541	1762376	5912232	9	110
20297	1761128	5911510	5	5
1366	1760300	5911300	7	6
21872	1760218	5911953	5	5
22170	1760378	5912020	6	2
20374	1760840	5911620	4	6
22369	1762706	5912458	10	3
4540	1762200	5912375	6	9
20375	1759960	5911680	3	6

EWC - Boreholes considered in model

Bore ID	Easting	Northing	Elevation (mRL)	Depth (mbgl)
952	1760700	5911500	4	17
349	1760816	5911690	4	25
5540	1760500	5911400	7	15
4501	1762260	5912510	10	14
951	1760500	5911600	5	16
22158	1760530	5911410	7	8
737	1760600	5911820	7	14
5676	1762610	5912890	14	9
5513	1762594	5912768	11	9
4594	1761900	5912600	17	9
21953	1762104	5912620	23	19

Jeremy collar RL estimate

EWC - Water level data

Bore ID	Easting	Northing	Elevation (mRL)	Depth (mbgl)	Water level (bgl)	Water Level (rl)	Screen top	Screen Bottom	Comments
MHXMB35	1759337	5910811	2.7	47.0	15.0	-12.3			No screen data, deep bore
MHXMB39	1759188	5911169	4.1	49.1	15.0	-10.9			No screen data, deep bore
MHXMB34	1759359	5910738	3.2	50.1	10.0	-6.8			No screen data, deep bore
MHXMB40	1759155	5911230	2.8	49.6	9.0	-6.2			No screen data, deep bore
MHXMB33b	1759374	5910674	12.2	58.5	18.0	-5.8			No screen data, deep bore
MHXMB30	1759479	5910268	3.5	30.1	9.0	-5.5			No screen data, deep bore
SKMBH9	1761421	5911535	6.5	21.3	10.1	-3.6			No screen data, deep bore
MHXMB29	1759468	5910262	3.2	15.5	6.0	-2.8			No screen data, deep bore
OFBH103	1757888	5912062	3.1	18.1	5.5	-2.4			No screen data, deep bore
OFBH100	1758311	5911794	3.4	9.0	5.5	-2.1			No screen data
AC_951	1760500	5911600	5.0	16.0	4.7	0.3	13	14	
OFBH101	1758437	5911700	3.2	13.5	2.7	0.5			No screen data
3121330/BH2	1759031	5910855	0.7	20.7	0.0	0.7			No screen data, deep bore
MBBH2	1759031	5910855	0.7	20.7	0.0	0.7			No screen data, deep bore
AC_20375	1759960	5911680	3.0	6.0	1.8	1.2			No screen data
OFBH102	1758211	5911862	3.3	19.6	2.0	1.3			No screen data, deep bore
AC_349	1760816	5911690	4.0	25.0	2.4	1.6	8	15	
HUN12 P	1759646	5911902	2.9	8.0	1.2	1.7	4.5	8	
AC_952	1760700	5911500	4.0	17.0	2.3	1.7	15	16	
3121330/BH1	1759033	5910808	1.7	18.1	0.0	1.7			No screen data, deep bore
MBBH1	1759033	5910808	1.7	18.1	0.0	1.7			No screen data, deep bore
2509687_03/08_TP20	1761498	5911845	2.7	5.0	1.0	1.7			No screen data
Cementary	1769882	5911508	4.1	16.4	2.2	1.9	10.4	16.4	Average, multiple measurements
HUN1 P	1759170	5911437	7.3	8.0	5.4	1.9	4.5	7	
HUN10 P	1759644	5911771	4.0	8.0	2.1	1.9	3	5	
3290050/TP22	1761575	5911906	5.1	5.0	3.0	2.1			No screen data
HUN4 P	1759214	5911562	3.2	10.0	1.1	2.1	3.5	6	
AC_737	1760600	5911820	7.0	14.0	4.8	2.2			No screen data
3290050/MB04	1761461	5911924	3.6	9.7	1.3	2.3			No screen data
AC_22158	1760530	5911410	7.0	8.0	4.7	2.3			No screen data
AC_20374	1760840	5911620	4.0	6.0	1.7	2.3			No screen data
Angle St	1760818	5911693	4.0	25.0	2.3	2.4	9.5	15.5	Average, multiple measurements
3290050/TP34	1761439	5911865	3.0	5.0	0.6	2.4			No screen data
OFBH104	1758238	5911910	2.4	19.6	0.0	2.4			No screen data, deep bore
SKMBH12	1761703	5911501	6.5	12.0	3.8	2.7			No screen data
Rowe St	1759381	5911988	4.4	6.6	1.7	2.7			Average, multiple measurements

EWC - Water level data

Bore ID	Easting	Northing	Elevation (mRL)	Depth (mbgl)	Water level (bgl)	Water Level (rl)	Screen top	Screen Bottom	Comments
HUN15 P1	1759621	5912226	11.8	14.0	9.0	2.8	7.8	11.5	
Horizon Yarns	1760626	5911833	7.0	14.4	4.6	2.9			Average, multiple measurements
2930234/BH07	1764178	5913000	15.0	24.2	12.0	3.0			No screen data, deep bore
DORMW3	1761125	5911626	5.5	6.0	0.9	3.3	3.9	5.9	Average, multiple measurements
HUN16 P	1759616	5912262	14.1	15.0	10.8	3.4	11.5	15	
SKMBH13	1761884	5911464	6.5	23.0	3.1	3.4			No screen data, deep bore
2509687_03/08_MB3	1761410	5911890	3.4	14.2	0.0	3.4			No screen data
SKMBH17	1761570	5911495	6.0	9.0	2.6	3.4			No screen data
AC_21872	1760218	5911953	5.0	5.0	1.5	3.5	2	5	
HUN13 P	1759639	5912008	5.8	8.0	2.3	3.5	4.5	8	
HUN15 P2	1759437	5912178	11.5	15.0	7.9	3.6	6.5	15	
HUN15 P4	1759238	5912166	10.7	15.0	7.0	3.7	8.5	15	
AC_20297	1761128	5911510	5.0	5.0	1.0	4.0	3	5	
AC_4540	1762200	5912375	6.0	9.0	1.8	4.2	4	9	
SKMBH14	1761964	5911503	6.5	9.0	2.2	4.3			No screen data
SKMBH10	1761546	5911454	6.5	22.7	2.2	4.3			No screen data, deep bore
AC_5540	1760500	5911400	7.0	15.0	2.6	4.4	1	4	
AC_22170	1760378	5912020	6.0	2.0	1.6	4.4	0	2	
Mays Road	1760149	5912796	19.9	42.1	15.2	4.7			Average, multiple measurements, probably deep screen
AC_5513	1762594	5912768	11.0	9.0	6.3	4.8			No screen data
SKMBH15	1762053	5911524	6.5	7.5	1.7	4.8			No screen data
HUN15 P3	1759834	5912234	6.5	15.0	1.5	5.1	11.5	15	
AC_4541	1762376	5912232	9.0	110.0	0.9	5.1			No screen data, depth probably typo, cannot verify
AC_1366	1760300	5911300	7.0	6.0	1.1	5.9	4	6	
AC_4501	1762260	5912510	10.0	14.0	3.2	6.8			No screen data
MHXMB32	1759397	5910591	10.6	34.6	3.0	7.6			No screen data, deep bore
HUN17 P	1759622	5912411	21.9	15.0	13.7	8.2	11.5	15	
AC_22369	1762706	5912458	10.0	3.0	1.7	8.3	1	3	
AC_5676	1762610	5912890	14.0	9.0	5.3	8.7	0	9	
AC_4594	1761900	5912600	17.0	9.0	7.5	9.5	3	8	
AC_21953	1762104	5912620	23.0	19.0	10.0	13.0	7	17	Deep screen
2930234/BH02	1764436	5913030	15.0	25.5	0.6	14.4			No screen data, deep bore
HUN23 P	1759572	5912992	34.4	8.0	6.1	28.3	4.5	8	

EWC - Auckland Council Consented Wells

Bore ID	Easting	Northing	Elevation (mRL)	Depth (mbgl)	Water level (bgl)	Water Level (rl)	Screen top	Screen Bottom	Comments
345	1759980	5911820		15					No screen or water level information
346	1759900	5911900		5					No screen or water level information
737	1760600	5911820	7	14	4.8	2.2			No screen information
2663	1761080	5911960							No borehole depth, screen or water level information
2669	1761200	5912200		18					No screen or water level information
4501	1762260	5912510	10	14	3.23	6.77			No screen information
4541	1762376	5912232	9	110	0.93	8.07			No screen information
4605	1760300	5911800							No borehole depth, screen or water level information
21931	1762183	5912455	9	12					No screen or water level information
23582	1762226	5912453	9	12					No screen or water level information
23616	1762199	5912494	8	13					No screen or water level information
23684	1762250	5912460	9	18					No screen or water level information
23685	1762248	5912470	9	17					No screen or water level information
23686	1762258	5912520	8	19					No screen or water level information