



ASSESSMENT OF GROUNDWATER EFFECTS

NZ Transport Agency Waka Kotahi
Mill Road Stage 1

AUGUST 2026

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QUALITY REVIEW AND APPROVAL RECORD

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EXECUTIVE SUMMARY

In this report, we assess potential groundwater related effects of the Mill Road Project Stage 1 (**the Project**). In this assessment we confirm that most road cuts are unlikely to require dewatering, with only two sections of the alignment: 286 -310 Redoubt Road and the cut west of Cheesman's Bush, expected to intersect groundwater. While these works are likely to meet the Permitted activity standard E7.6.1.10 of the Auckland Unitary Plan (**AUP**) for diversion, the permanent nature of groundwater interception means the activity does not meet standard E7.6.1.6 and is classified as a Restricted Discretionary under rule E7.4.1(A28). As a result, a full groundwater assessment is required to support the consenting process.

Groundwater assessments for five key road cut locations along the Project corridor indicate minimal risk of groundwater drawdown or settlement:

- At the 186–200 Redoubt Road, the Murphy's Road, and 367-375 Redoubt Road cut locations, groundwater levels are below the maximum cut depths. As a result, no drawdown is expected, even with temporary over-excavation.
- At the 286–310 Redoubt Road cut, the road cut intercepts groundwater, with an estimated drawdown of 1.3 m. However, for the settlement assessment we have conservatively assumed 2 m, and this has resulted in a calculated settlement of less than 3 mm, and differential settlement flatter than 1:2000. These effects diminish rapidly with distance and are not expected to impact nearby assets, services, or consented water takes.
- At the road cut west of Cheesman's Bush bridge, groundwater levels are close to the maximum cut depth, with an estimated drawdown of approximately 0.2 m. This very small drawdown is unlikely to cause ground settlement.

Groundwater diversion away from nearby streams is calculated to be negligible (with < 5% of the groundwater contribution to streamflow in winter, and no diversion in summer) due to these streams being predominantly rain-fed, and no detectable environmental impacts are anticipated. No adverse effects are anticipated for consented water takes in the area.

Calculated settlement effects on nearby buildings and services at the 286-310 Redoubt Road cut are minimal, with values well below commonly accepted thresholds for damage (Burland, 2012). While no adverse effects are expected, we recommend pre- and post-construction condition surveys for adjacent structures and buried services to rule out any residual risk. These recommendations are set out below.

Effect of the Project	Assessment	Recommendation
Seasonal diversion of groundwater from the cut at 286–310 Redoubt Road and from the cut the west of Cheesman's Bush	Very low drawdown and negligible ground settlement are expected at the cut at 286 – 310 Redoubt Road. Negligible drawdown and settlement are expected at the cut to the west of Cheesman's Bush.	Conduct pre- and post-condition surveys of the following dwellings: • 286 Redoubt Road • 298 Redoubt Road • 304 Redoubt Road • 315 Redoubt Road • 323 Redoubt Road And the buried water pipes located at: • 286-323 Redoubt Road

We consider the potential groundwater effects from the Project to be negligible to very low. However, if there are significant changes to road alignment, excavation depth, drainage design, or finished surface levels, this assessment will need to be revisited as such changes could increase drawdown and settlement impacts.

1 INTRODUCTION

Stage 1 of the Mill Road Project (**the Project**) involves significant improvements, including widening and realignment, to Redoubt Road and Mill Road over a stretch of about seven kilometres, along with the construction of a new four-lane route connecting the State Highway 1 interchange to Mill Road at Phillip Road. A description of the Project and drawing showing the Project extent is provided in the Substantive Application Report.

The purpose of this report is to assess potential groundwater effects associated with the Project, set out monitoring of those effects and to recommend mitigation measures (if required). The potential environmental effects include drawdown and settlement effects to nearby assets, roads and services. In addition, the potential groundwater effect to nearby wetlands and surface water bodies has also been evaluated.

This report provides the site hydrogeological information and an assessment of effects relevant to the proposed works, in particular:

- Geological setting and hydrogeological description and interpretation;
- Description of the proposed works in relation to potential effects;
- Description of the existing environment;
- Groundwater drawdown and settlement assessments;
- Assessment of potential flow depletion or diversion to nearby streams and wetlands;
- Assessment of effects to consented water takes in the vicinity of the Project; and
- Assessment of effects and mitigation recommendations.

2 EXISTING ENVIRONMENT

2.1 Geology

The geology of the Project extent is described in the Mill Road Geotechnical Interpretive Report (AECOM, 2025)¹, which has informed this assessment. The dominant geology in the Project extent includes the following units:

- Weathered East Coast Bays Formation soils (wECBF, E4);
- East Coast Bays Formation rock moderately weathered to unweathered (ECBF Rock, E2 to E3); and
- Southern Landslide colluvium and soils (ES4).

In addition, the Project extent includes streams where Holocene Alluvium (Hc) is present. Some of the Project extent include Engineered Fill materials (F1g). The ECBF rock may include volcanoclastic deposits at depth (E2g).

The Project extent goes through an area of relatively low elevation in the south (10 to 50 mRL) and then goes along ridges of high elevation (100 to 150 mRL) to the north (Figure 2-1).

The majority of the alignment, at elevations between 50 and 150 mRL, goes through areas dominated by the ECBF unit. High elevation ridgelines have wECBF soils and ECBF rock close to the surface and, as these materials tend to have low permeability, groundwater is present as perched aquifer systems (AECOM, 2025).

In the south, at lower elevations (< 50 mRL), alluvium sediments of the Tauranga Group tend to be present at the surface.

¹ AECOM. (2025). Mill Road Geotechnical Interpretive Report.

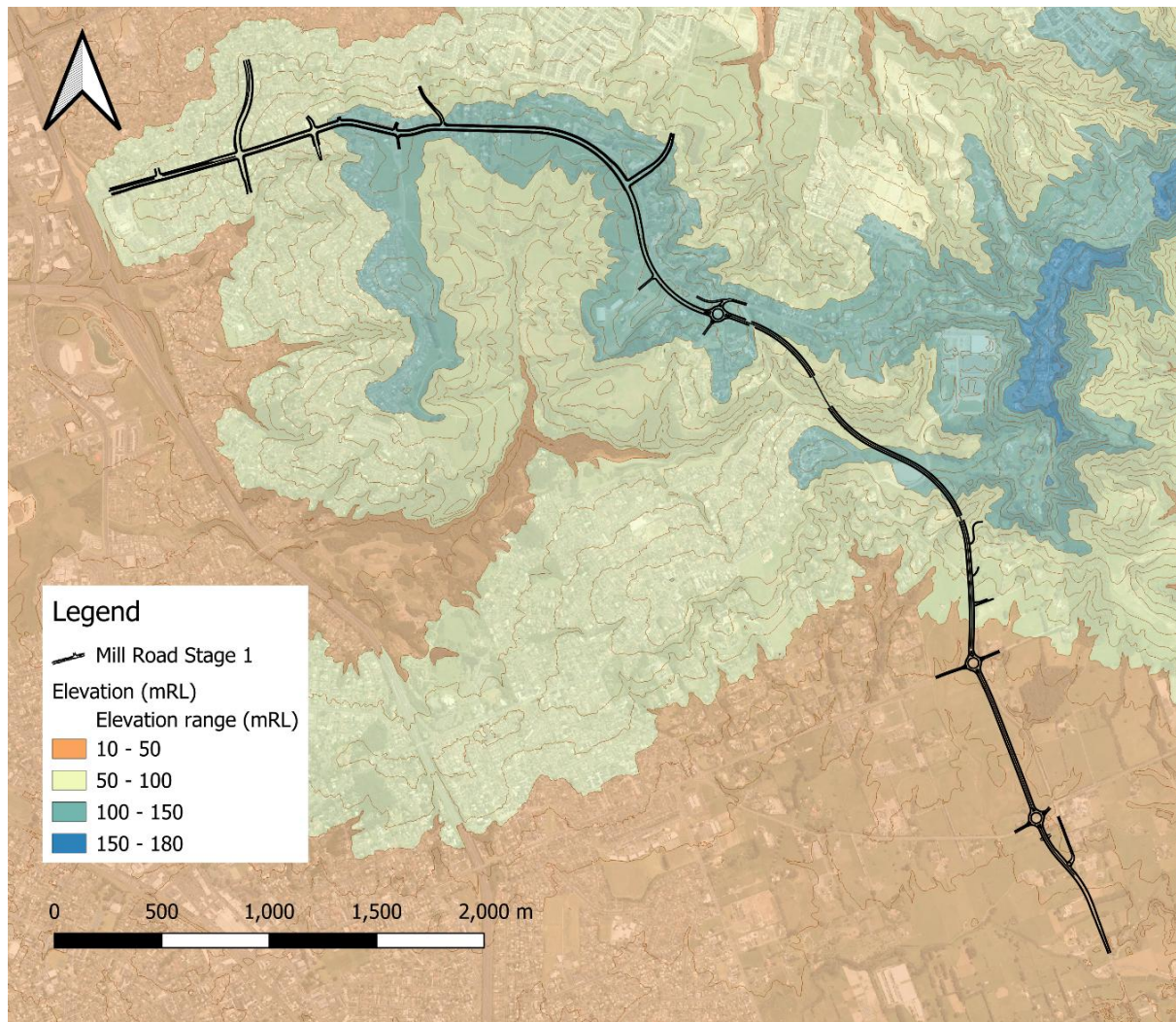


Figure 2-1: Project elevations

2.2 Hydrogeological framework

Groundwater flow in the Project extent primarily occurs as rainfall infiltrates through surface soils (ES4 and ECBF soils) and deeper through the moderately weathered to unweathered ECBF rock (E2 to E3). The permeability of these units is considered relatively low and controlled by the presence of fractures (in the rock) and fines (in the soils).

For ECBF rock, hydraulic conductivity can vary significantly based on the connectivity and openness of fractures, bedding plane partings, and fissures. In addition, in areas dominated by clay or silt weathering products, the hydraulic conductivity decreases due to the loss of secondary porosity, typically occurring on ridge tops where the ECBF rock is close to the surface.

2.3 Groundwater levels

Previous investigations carried out in 2020-2022, resulted in a total of 19 piezometers in the Project extent (Figure 2-2). These piezometers were screened within wECBF, ECBF rock, and the Takaanini Formation. Automatic groundwater level monitoring using level loggers took place between December 2020 and February 2023. A detailed review of groundwater levels measured in these piezometers and historic rainfall data is included in AECOM (2025) and is summarised below.

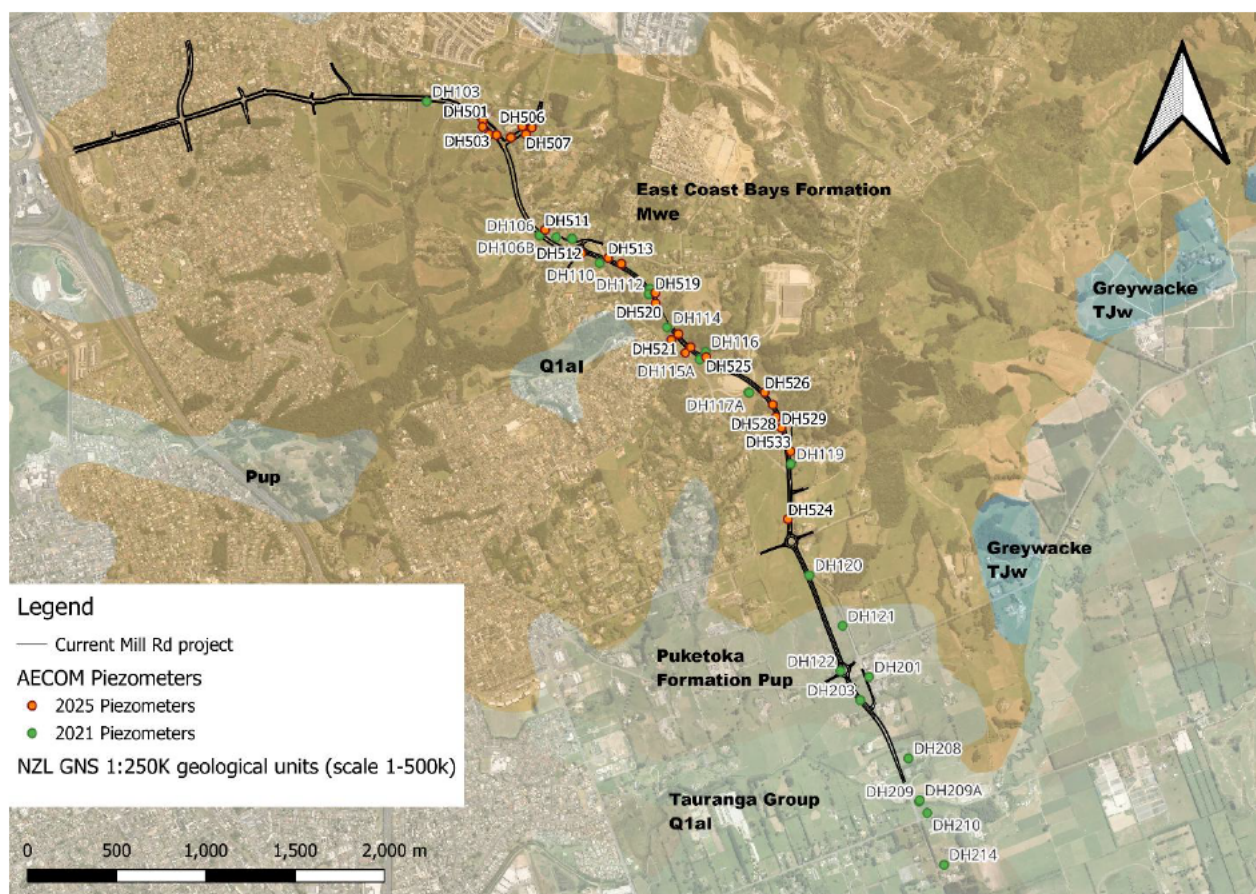


Figure 2-2: Location of project piezometers

An additional groundwater investigation was conducted between May and July 2025 to assess groundwater levels at the Murphy's Road, Redoubt Road, and west of the Cheesman's Bush project areas (Figure 2-2). Piezometer depths and the geology encountered at screen intervals are summarised in Table 2-1. Following installation and development, the piezometers were manually dipped several times during winter 2025 to measure groundwater levels (Table 2-2). Automatic level loggers were also installed and are currently recording level data. To date, only winter groundwater levels are available in the new piezometers, and it is noted that these levels correspond to seasonal highs.

Table 2-1. Piezometers completed in 2025

ID	Date drilled	Screen Top (mBGL)	Screen Bottom (mBGL)	Screened Geology
DH502	24/06/2025	12	15	MW ECBF
DH504	27/06/2025	4	7	HW ECBF
DH505	22/05/2025	8.5	11.2	HW ECBF
DH506	12/06/2025	9.5	13.5	Residual Soil - HW ECBF
DH506B	12/06/2025	5.8	8.9	ECBF Residual Soil
DH507	27/05/2025	10.5	13.5	HW ECBF
DH511	16/07/2025	4	6	ECBF Residual Soil
DH512	11/07/2025	8	11	HW ECBF
DH513	16/07/2025	7.8	10.8	MW ECBF
DH522	22/05/2025	7	10	HW ECBF

ID	Date drilled	Screen Top (mBGL)	Screen Bottom (mBGL)	Screened Geology
DH523	4/06/2025	12.5	17	HW-MW ECBF
DH525	18/06/2025	5	8	MW ECBF
DH526	15/05/2025	8.8	12	HW ECBF
DH527	15/05/2025	8.8	12	HW-MW ECBF
DH534	24/07/2025	6	9	Alluvial Deposits
Notes:				
- MW = Moderately weathered - HW = Highly weathered				

Table 2-2. Manual groundwater levels for piezometers installed in 2025

ID	Groundwater levels (mBGL)										
	22/05	11/06	12/06	13/06	30/06	18/06	1/07	11/07	23/07	24/07	31/07
DH502	-	12.6	-	-	9.6	-	-	11.0	10.9	-	-
DH504	-	-	-	-	-	-	-	2.6	2.5	-	-
DH505	-	6.8	6.8	-	-	-	6.7	-	6.5	-	-
DH506	-	-	-	-	-	-	9.5	-	9.4	-	-
DH506B	-	-	-	-	-	-	>8.9	-	>8.9	-	-
DH507	-	12.6	12.7	-	-	-	12.7	-	12.7	-	-
DH511	-	-	-	-	-	-	-	-	-	-	3.5
DH512	-	-	-	-	-	-	-	-	-	-	5.0
DH513	-	-	-	-	-	-	-	-	-	-	3.8
DH522	-	-	-	-	-	3.8	3.3	-	-	4.4	-
DH523	-	-	9.2	7.1	-	6.8	6.4	-	-	6.8	-
DH525	-	-	-	-	-	-	2.1	-	-	3.2	-
DH526	6.9	-	-	-	-	-	5.3	-	5.7	-	-
DH527	-	-	-	-	-	-	-	6.7	-	8.1	-
DH534	-	-	-	-	-	-	-	-	-	-	4.0
Notes:											
– symbol denotes no reading											

Groundwater levels have been previously described by AECOM (2025). In general, groundwater levels are as follows:

- Groundwater levels are relatively shallow in the south (Alfriston end).
- Seasonal high groundwater levels at or close to the surface are observed at a number of sites and should be expected in the unconfined weathered ECBF near surface.
- A piezometer pair installed at DH117, comprising a shallow screen in the soil and a deeper screen in the underlying rock, indicates the potential for a perched water level in areas of elevated topography, such as ridges within the Project extent.

Groundwater levels are a critical consideration when assessing project cuts, as intersecting the water table can lead to groundwater seepage into the excavation and cause drawdown effects. These impacts

may extend beyond the immediate cut area, potentially inducing settlement at a distance where drawdown below the summer low level occurs.

Groundwater levels at key project cut locations are shown in Figure 2-5 and are discussed below.

186-200 Redoubt Road

The closest piezometer at this cut is DH103. This piezometer was monitored between December 2020 and February 2023 (AECOM, 2025). The monitoring shows a consistent low groundwater level in March through June in each year monitored, and relatively consistent high levels from September to December (Figure 2-3). This seasonal trend has been identified as typical for piezometers located in areas where the Project is proposed (AECOM, 2025) and consistent with what has been observed in other piezometers screened within low permeability units in the Auckland region. According to this information, the lowest groundwater level registered during the monitoring period is 4.5 mBGL (meters below ground level), which is at or very close to the bottom of the screen. The highest level is 0.2 mBGL.

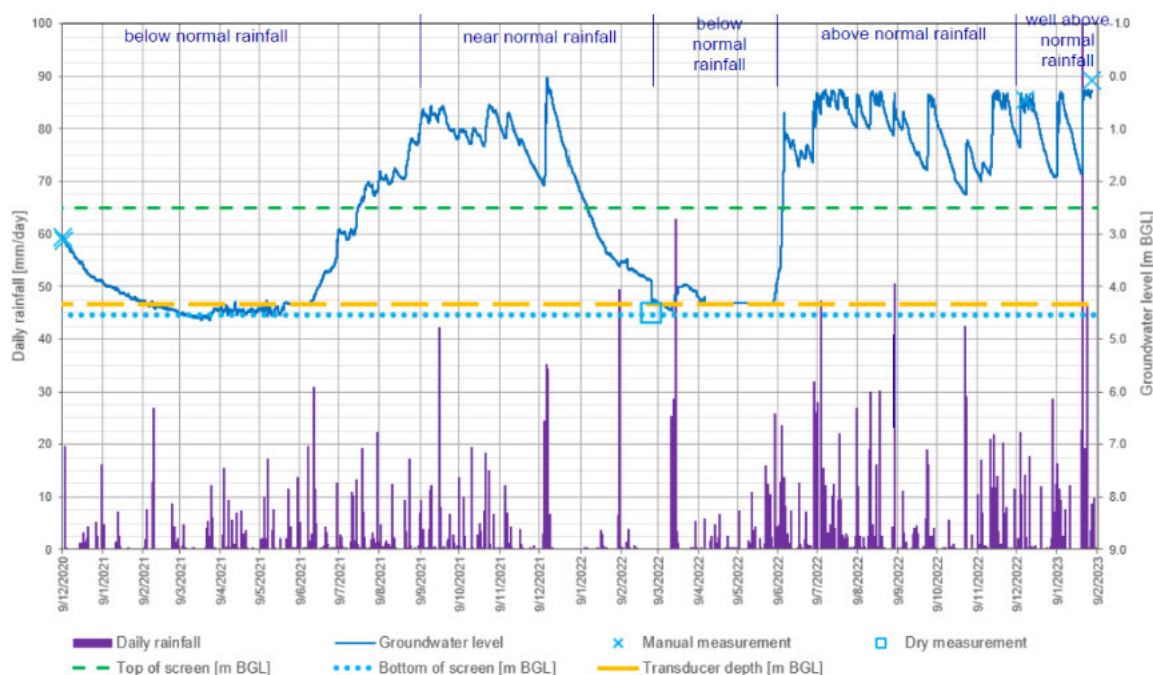


Figure 2-3: Groundwater level record for DH103 (screened in ECBF). Rainfall descriptions as per the NIWA seasonal climate summary, based on Mangere rainfall data. Plotted rainfall from the Albany EWS station.

Murphy's Road cut

There were no piezometers installed at this location during the previous 2020-2022 investigation. However, the 2025 investigation resulted in the installation of DH505, DH506B, and DH507 at the Murphy's Road cut. Only one-off winter groundwater levels are available at this location (Table 2-2), the deepest winter levels, recorded in July 2025, are presented in Table 2-3.

Table 2-3. Deepest winter groundwater levels for Murphy's Road cut, measured in July 2025

Piezometer ID	Screen depths (mBGL)	Screened geology	Surface elevation (mRL)	Groundwater level (mBGL)
DH505	8.5 -11.2	HW ECBF	121.3	6.9
DH506	9.5-13.5	Residual Soil - HW ECBF	123.7	9.5
DH506B	5.8-8.9	Residual Soil	123.7	>8.9*
DH507	10.5-13.5	HW ECBF	126.9	12.7
Notes:				
* water level drops below the bottom of the piezometer screen				

All four piezometers in Table 2-3 indicate July groundwater levels of ~114.2 mRL, i.e. the difference in depths to groundwater appears to be due to variation in ground level across the ridge line.

DH506 and DH506B exhibit similar groundwater level depths, even though DH506B is shallower than DH506 suggesting that there is not a perched (cascading) level here.

The deepest winter groundwater level nearest the location of the maximum cut is 12.7 mBGL, as measured in DH507. A conservative estimate is 9.5 mBGL, based on measurements from DH506. Groundwater levels during the summer are expected to be lower than these values.

286-310 Redoubt Road cut

Piezometers DH106 and DH108A (presented by AECOM (2025)) were installed in 2020 – 2021:

- DH106, is screened from 7 to 10 mBGL in weathered ECBF, and is located on the road alignment, adjacent to the maximum projected cut at this location, which is 8.3 m in depth. Groundwater level data in DH106 has been recorded continuously for the 2020-2021 period (Figure 2-4). The same seasonality previously reported for DH103, was observed at DH106 with consistent low groundwater levels in March through June in each year monitored, and relatively consistent high levels from September to December albeit remaining elevated through the very high rainfall of 2022/2023. The deepest groundwater level for this period is 6.6 mBGL and the highest groundwater level is 2.7m
- Piezometer DH108, screened in ECBF rock, exhibited the same seasonality but its low and high levels are significantly lower at 13.3 mBGL and 8.1 mBGL respectively. Piezometer DH108A is also screened in ECBF rock but at a shallow depth, and its levels range from 1.7 mBGL to 5.5 mBGL. This piezometer pair is located north of the Redoubt Road roundabout at about 150 m east of the projected cut.

Piezometers DH511 and DH512 were installed in residual soil and highly weathered ECBF in 2025:

- DH511 is located at ~45 m to the NE of DH106, and was screened from 4 to 6 mBGL, and has been manually dipped only once, showing a groundwater level of 3.5 mBGL on 31/07/2025 (Table 2-2), since its installation. This reading corresponds to a winter high reading and is similar in magnitude to the observed winter high observations at DH106.
- DH512 is located at the Redoubt Road roundabout, some 260 m to the SE of the location of the maximum cut. This piezometer is screened in weathered ECBF, from 8 to 11 mBGL. However, as DH512 has been recently installed, a long-term groundwater level record is not yet available. A winter level measurement of 5 mBGL was registered in this piezometer on 31/07/2025.

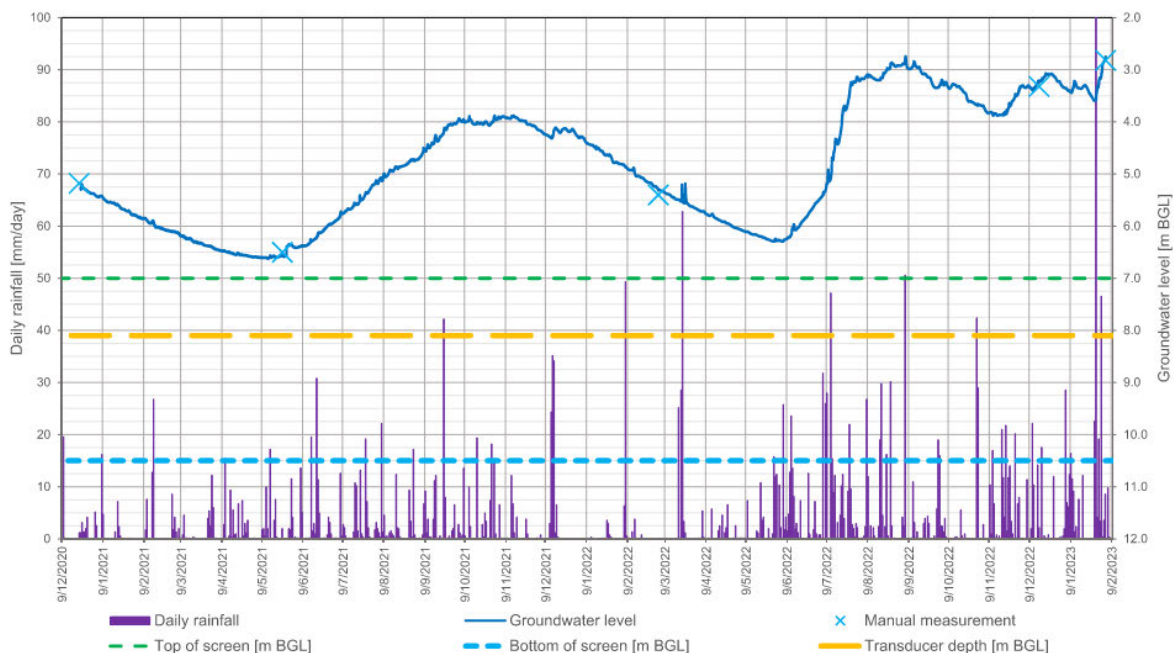


Figure 2-4: Groundwater level record for DH106 (screened in wECBF). Rainfall descriptions as per the NIWA seasonal climate summary, based on Mangere rainfall data. Plotted rainfall from the Albany East weather station.

367-375 Redoubt Road cut

This cut occurs on an area sloping towards the southeast. Piezometer DH112A, which is screened in ECBF rock, is located in close proximity at a distance of 60 to 70 m southeast of the cut. On 7 of April 2021, the groundwater level measured in this piezometer was 4.9 mBGL.

West of Cheesman's Bush

Piezometers DH117 (screened in ECBF rock) and DH117A (screened in weathered ECBF) were installed at a greenfield site, at an elevation of ~106 mRL, about 40 m to the southwest of the projected road (AECOM, 2025). These piezometers were monitored between December 2020 and February 2023. The deepest groundwater level was at least 13 mBGL for DH117 and at least 4.8 mBGL at DH117A (i.e., the groundwater level low dropped below the sensor or screen at these locations). The highest groundwater level was 1.9 mBGL at DH117 and 0.2 mBGL at DH117A.

In 2025, piezometers DH526 and DH527 were installed on the actual projected road at a distance of ~90 m and ~154 m to the west and southwest of DH117, respectively. These piezometers are both installed in highly weathered to moderately weathered ECBF. The maximum cut depth at this location is 8.3 m, and the nearest piezometer is DH527, which is screened from 8.8 mBGL to 12 mBGL. DH527 has been installed at the location of the maximum projected cut, on a ridgeline above the stream east of Cheesman's Bush. Although groundwater level data for DH526 and DH527 is only available for the 2025 winter season, the lowest groundwater level recorded was ~8.1 m and the highest level recorded was ~5.3mBGL (Table 2-2).

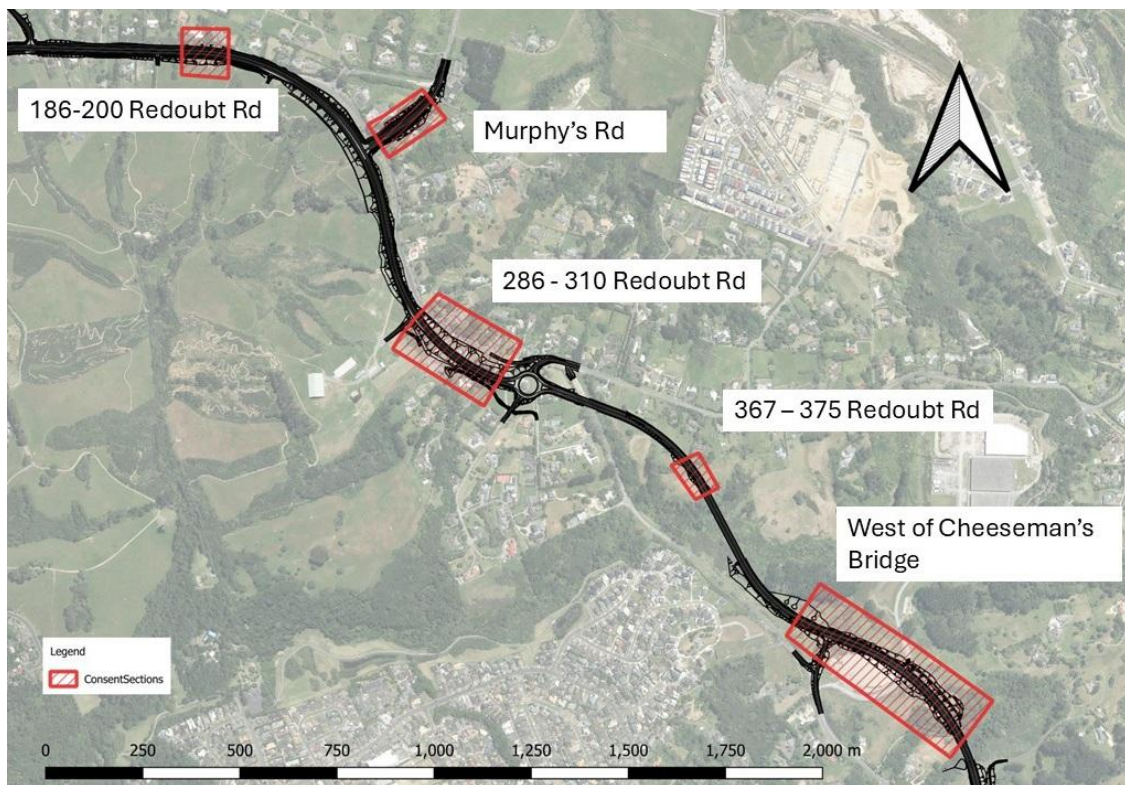


Figure 2-5: Road cuts potentially requiring a consent. Refer to Table 1 for a description of cut depths and maximum expected drawdown.

2.4 Hydraulic conductivity

The wECBF soils and ECBF rock in areas of elevated topography, often have a perched (or series of perched) aquifers. The ECBF rock, whilst of generally low permeability is typically, though not always, of higher permeability than the wECBF, due to the movement of groundwater primarily occurring through bedding plane partings and structurally controlled joints and fractures (AECOM, 2025).

Table 2-4 presents typical hydraulic conductivity values determined by AECOM (2025) from slug tests carried out in 2023.

Table 2-4. Typical hydraulic conductivity determined in 2023 investigation.

Piezometer	Date	Screen interval (mBGL)	Geologic Unit	Hydraulic Conductivity (m/s)
DH201	6/02/2023	3.0-4.2	Takaanini Formation	1×10^{-6}
DH203	6/02/2023	4.1-6.2	Takaanini Formation	1×10^{-6}
DH209	6/02/2023	4.8-7.3	Takaanini Formation	1×10^{-6}
DH103	6/02/2023	2.6-4.6	wECBF (E4)	5×10^{-7}
DH110	6/02/2023	3.6-6.3	wECBF (E4)	5×10^{-7}
DH122	6/02/2023	6.7-5.2	wECBF (E4)	5×10^{-7}
DH208	6/02/2023	4.2-6.2	wECBF/ECBF Rock	1×10^{-5}
DH112A	6/02/2023	9.1-12.1	ECBF Rock (E2)	5×10^{-7}

Table 2-5 shows the hydraulic conductivity determined from testing in 2025 piezometers, to complement the previous investigation. In general, the hydraulic conductivity of residual soils is on the order of $\sim 10^{-8}$ m/s. The weathered ECBF exhibits a broader range, typically between $\sim 10^{-9}$ m/s to 10^{-7} m/s range. The slightly weathered ECBF (e.g., DH502) shows a value within the same order of magnitude as both the residual soils and the weathered ECBF; this is likely attributed to a reduction in secondary porosity.

Table 2-5. Hydraulic conductivity determined through tests carried out during 2025 investigations

Piezometer	Date	Screen interval (mBGL)	Geologic Unit	Hydraulic Conductivity (m/s)
DH502	23/07/2025	12 - 15	MW-SW ECBF (E3+E2)	4×10^{-8}
DH504	23/07/2025	4 - 7	HW ECBF (E4)	2×10^{-7}
DH505	23/07/2025	8.5 - 11.2	HW + MW ECBF (E4+E3)	3×10^{-8}
DH506A	23/07/2025	9.5 - 13.5	Residual Soil + HW ECBF (E6+E4)	9.5×10^{-8}
DH511	31/07/2025	4 - 6	Residual Soil (E6)	8×10^{-8}
DH512	31/07/2025	8 - 11	HW ECBF (E4)	8×10^{-8}
DH513	31/07/2025	7.8 - 10.8	MW ECBF (E3)	4×10^{-9}
DH522	24/07/2025	7 - 10	HW ECBF (E4)	6×10^{-9}
DH523	24/07/2025	12.5 - 17	HW + MW ECBF (E4+E3)	1×10^{-7}
DH525	24/07/2025	5 - 8	MW ECBF (E3)	2×10^{-7}
DH526	24/07/2025	8.8 - 12	HW ECBF (E4)	3×10^{-7}
DH527	23/07/2025	8.8 - 12	CW + MW ECBF (E5+E3)	2×10^{-8}
DH534	24/07/2025	6 - 9	Alluvial Deposits	1×10^{-7}

3 SITE HYDROLOGY

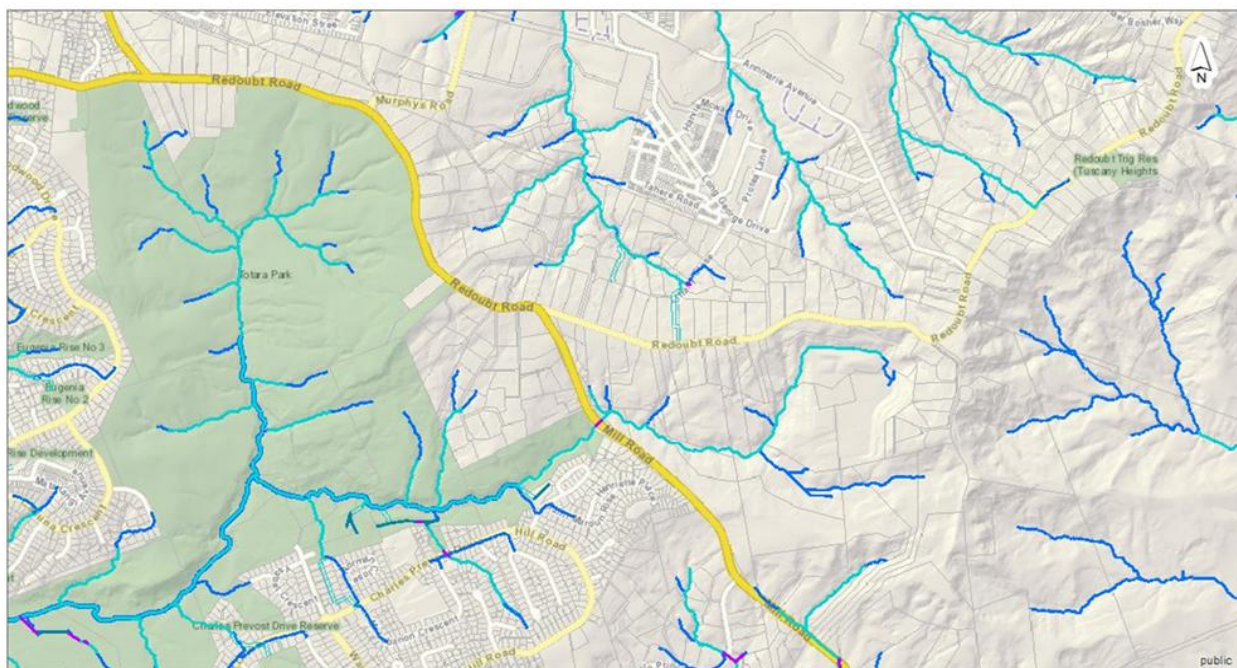
In the northern section of the Project, located between the Southern Motorway and west of Tōtara Park, the road passes through an urbanised area where there are no permanent streams or open water courses. In this area, stormwater is managed through piped watercourses.

To the north and east of Tōtara Park, the road alignment traverses a series of ridges that act as surface water divide between the northern and southern catchments of the Project extent (Figure 3-1). The ridgeline to the north and northwest of Tōtara Park sits at ~100 to ~120 mRL. Rainfall runoff flows down these ridges as overland flow paths, which are classified as ephemeral streams. To the south and southeast of Tōtara Park, overland flow paths become permanent streams at ~80 to ~85 mRL.

According to Auckland Council, overland flow paths become permanent rivers further downstream in the catchment, where they form the primary channels for continuous surface water flow throughout the year under normal seasonal rainfall conditions for the Auckland Region. Groundwater may discharge to permanent streams when there is a hydrologic connection between the stream bed and the aquifer formation, and in these areas some of stream baseflow will be sourced from groundwater.

To the west of Cheesman's Bush, there is a permanent stream crossing the road alignment (under a project bridge). This stream flows from the NE to the SW.

In addition to ephemeral and permanent streams adjacent to the road alignment, several wetlands have been identified both along the ridgeline and in adjacent areas. These wetlands are situated within overland flow paths, suggesting they are unlikely to be sustained by groundwater sources.



LEGEND

Overland Flow Paths - 100ha and above (25,000)

Overland Flow Paths - 100ha and above (25,000)

Overland Flow Paths - 3ha to 100ha (25,000)

Overland Flow Paths - 3ha to 100ha (25,000)

Overland Flow Paths - 1ha to 3ha (15,000)

Overland Flow Paths - 1ha to 3ha (15,000)

Rivers and Permanent Streams

Open Watercourse

Piped Watercourse

Culvert

Pond

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Ephemeral streams and rivers

Scale @ A4
= 1:15,000
Date Printed:
18/08/2025



Figure 3-1: Ephemeral streams and rivers to the north of Tōtara Park

4 WATER TAKE CONSENTS

A total of five current and four legacy (cancelled or expired) groundwater consents, comprising takes and diversions, are noted to be in the vicinity of the proposed road alignment by Auckland Council. The active consents are at least ~200 m from where road cuts are expected to occur. Refer to Figure 4-1 for a plan of groundwater consents relative to the alignment.

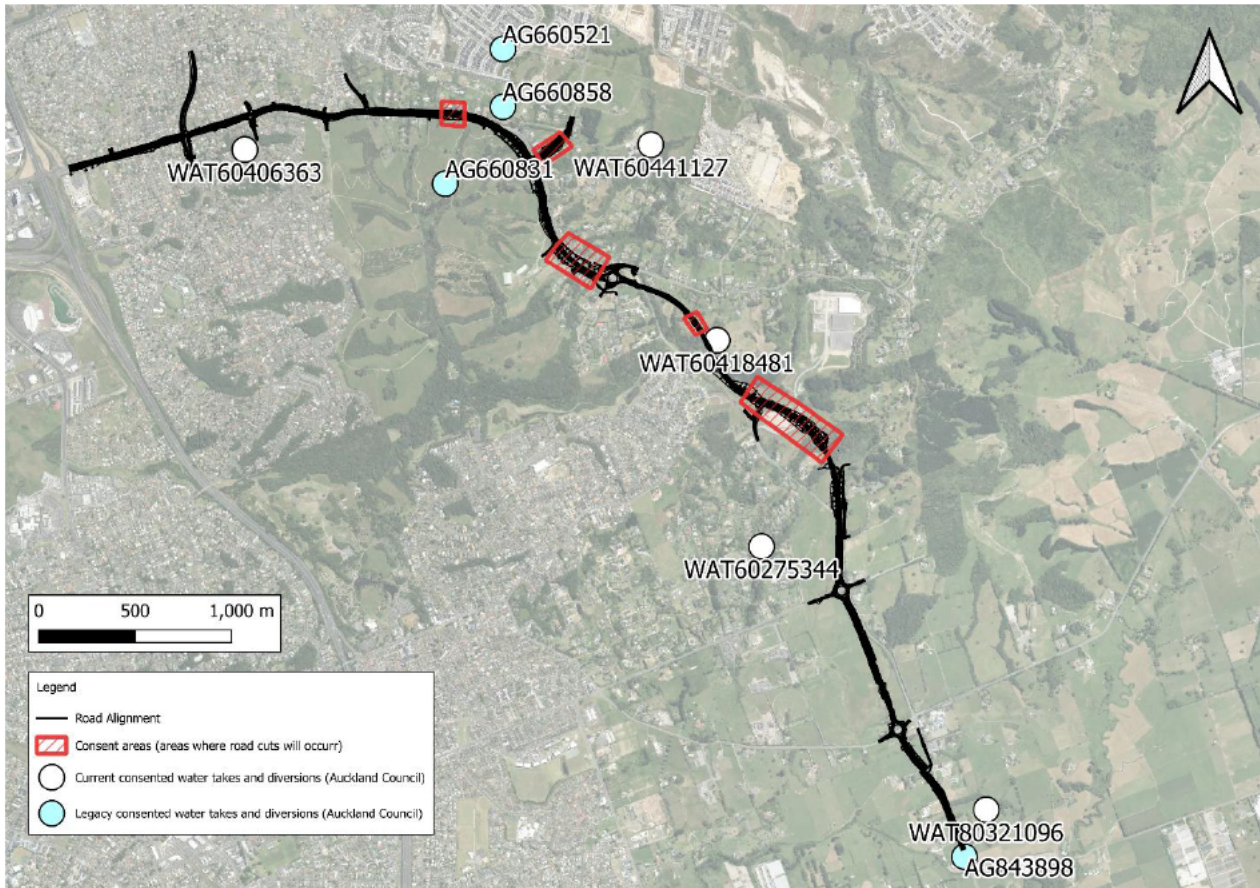


Figure 4-1: Plan of current and legacy groundwater takes and diversions in the vicinity of the Project.

Table 4-1 outlines details of current groundwater consents. Three takes and two groundwater diversions are located at least 140 m from the nearest proposed cut (367-375 Redoubt Road, not expected to intercept groundwater) and at most 2000 m from the cut west of Cheesman's Bush bridge, meaning risk of disturbance or cumulative effects due to road excavation is considered low.

Table 4-1. Summary of current groundwater consents in the vicinity of the Project.

Consent reference	Consent description	Allocation (m ³ /d)	Application subtype	Distance from nearest consent area (m)
WAT80321096	To take water from a bore for irrigation of a 3-ha orchard and 0.8 ha glass house.	N/A	Take	2,000
WAT60275344	To take up to 7.27 m ³ /day from a Bore	7.3	Take	540
WAT60406363	Excavations to construct six new dwellings, undertake earthworks	N/A	Diversion	1,030

Consent reference	Consent description	Allocation (m ³ /d)	Application subtype	Distance from nearest consent area (m)
WAT60441127	To construct a new dwelling on an existing vacant lot. And to take groundwater (dewatering) during construction of building platform & retaining walls and take groundwater long-term.	N/A	Diversion	410
WAT60418481	Take to construct a total of three dwellings, followed by boundary adjustment around the development.	N/A	Take	140

Table 4-2 outlines legacy consents (cancelled or expired as documented in the former Auckland Regional Council consenting system) in the vicinity of the Project, comprising four takes ranging from 6 to 218 m³ per day. Takes were at least 200 m from the nearest cuts (186-200 Redoubt Road and Murphys Road), with the southernmost take more than 2000 m from the cut west of Cheesman's Bush bridge.

Table 4-2. Summary of legacy (cancelled or expired) groundwater consents in the vicinity of the Project.

Consent reference	Consent description	Allocation (m ³ /d)	Application subtype	Distance from nearest consent area (m)
AG843898	To take groundwater for trickle irrigation of a 3-hectare kiwifruit orchard and spray irrigation of 0.8 hectares of glasshouse grapes.	80	Take	2,200
AG660521	Domestic use, dairying	6	Take	340
AG660831	To take from a Bore up to 218.2 cmpd for - Pastoral	218	Take	300
AG660858	Domestic, shed use, stock, milk cooling	6	Take	200

5 ASSESSMENT OF ACTIVITY STATUS

5.1 Approach to determining activity status

Chapter E7 of the AUP dated 10 July 2020 sets out the activities and standards under which the take and diversion of groundwater is considered a Permitted activity in Auckland.

Of specific relevance to the proposed works:

- Standard E7.6.1.10 provides for the diversion (change in level) of groundwater, including any short-term changes that might arise from excavation (including trench), or tunnel.
- Standard E7.6.1.6 provides for a take (volume) of groundwater associated with groundwater level control (where the associated diversion is permitted under Standard E7.6.1.10).

Chapter E7 applies when there is a groundwater take or diversion occurring as part of the proposed activity. If the diversion caused by excavation meets both standards E7.6.1.6 and E7.6.1.10, the activity is

classified as a Permitted activity under rule E7.4.1 (A27). If standard E7.6.1.10 is not met, the activity becomes a Restricted Discretionary activity under rule E7.4.1 (A28).

When drainage is installed to control groundwater levels, the activity may be classified as either Permitted or Restricted Discretionary under Chapter E7. It is a Permitted activity under E7.4.1 (A17) if the associated groundwater diversion meets standard E7.6.1.6 is met. Otherwise, the activity becomes Restricted Discretionary under E7.4.1 (A20).

5.2 E7.6.1.10 Diversion of groundwater caused by any excavation, (including trench or tunnel)

E7.6.1.10 standards are intended to identify where drawdown might be of a level outside of the typical seasonal range, or at a scale that could result in risk of wider effects, including risk of consolidation settlement. The standards also consider proximity of assets to identify works that might be particularly sensitive (i.e., historic buildings) or which might be within an area where significant mechanical movement (due to trench wall instability or retaining wall relaxation) could occur.

Figure 2-5 shows the location of project cuts being assessed for groundwater drawdown and diversion. A description of these cuts is provided in Table 5-1. This table presents the maximum drawdown that could potentially result at these sections once the road is constructed, and assuming retaining wall drainage is at road level. A summary of the proposed Project works relative to standard E7.6.1.10 is provided in Table 5-2, colour coded to indicate if the activity is expected to fully meet the Permitted activity standards. The work will meet the Permitted activity standards in E7.6.1.10 as set out in Table 5-2 below.

Table 5-1. Description of significant project cuts and expected drawdown at their location. Refer to Figure 2-5 for their location.

Chainage	Project Feature	Cut location	Max cut depth (mBGL)	Nearest piezometer	GWL Range (mBGL)	Maximum drawdown (m)
11960-12120	Road with retaining wall	186-200 Redoubt Road	3.1	DH103	0.2 to 4.5	Nil - summer GWL 1.4 m below design level (summer low). Seasonal (winter) intercept of groundwater only
50-220	Road with retaining wall	Murphy's Road	8.7	DH506	9.5 to 13.9	Nil - winter GWL 0.8 m below design level, no intercept of groundwater
13080	Road with retaining wall	286 Redoubt Road	8.3	DH106 DH511	2.8 to 6.6	1.7 m below summer low level, year-round intercept of groundwater expected
13160	Road with retaining wall	304 Redoubt Road	7.9	DH106 DH511	2.8 to 6.6	1.3 m below summer low level, year-round intercept of groundwater expected
13300	Road	310 Redoubt Road	3.5	DH108	8.1 to 13.3	Nil - winter GWL 9.8 m below design level, no intercept of groundwater

Chainage	Project Feature	Cut location	Max cut depth (mBGL)	Nearest piezometer	GWL Range (mBGL)	Maximum drawdown (m)
13730-13870	Road with retaining wall	367-375 Redoubt Road	4.4	DH112A	4.9	Nil – GWL 4.9 mBGL, measured in April 2024, is below design level. Intercept of groundwater might occur only in winter.
14415	Road	North of 97 Mill Road and west of Cheesman's Bush	3.0	DH525	2.3 to 3.2	Nil - winter GWL 0.2 m below design level, but potential for some seasonal (winter) intercept of groundwater only
14660	Road	North of 134A Mill Road and west of Cheesman's Bush	6.0	DH526	5.0 to 6.9	Nil - winter GWL 0.9 m below design level, no intercept of groundwater
14785	Road with retaining wall	North of 134a Mill Road and immediately west of Cheesman's Bush.	8.3	DH527	7.0 to 8.1	0.2 m below winter level, interception of groundwater expected in winter only

Table 5-2. Standard E7.6.1.10. Diversion of groundwater caused by any excavation, including trench or tunnel. The colour green indicates the standard is met and the colour red indicates the standard is not met.

Standard	Activity	Applicability to site
(1)	All of the following activities are exempt from this standard: • Pipes cables or tunnels including associated structures which are drilled or thrust and are up to 1.2m in external diameter • Pipes including associated structures up to 1.5m in external diameter where a closed faced or earth pressure balanced machine is used • Piles up to 1.5m in external diameter • Diversions for no longer than 10 days • Diversions for network utilities and road network linear trenching activities that are progressively opened, closed and stabilised where the part of the trench that is open at any given time is no longer than 10 days	There are four significant project cuts which can potentially result in a groundwater diversion (Figure 2-5 and Table 5-1) for a period longer than 10 days. Hence, the activity is not exempt from this standard and further assessment is required under (2) to (6).

Standard	Activity	Applicability to site
(2)	Any excavation that extends below natural groundwater level, must not exceed: • 1ha in total area; <u>and</u> • 6m depth below the natural ground level. Note: the excavation does not have to comply with both standards. Complying with one of these measurements will suffice.	MEETS: Excavations deeper than 6 m are only proposed at 286 -304 redoubt road and in the cut west of Cheesman's Bush. However, as each of the cuts are less than 1 ha in area, the Project meets this standard.
(3)	The natural groundwater level must not be reduced by more than 2m on the boundary of any adjoining site.	MEETS. All of the road cut sections in the alignment meet this criterion (refer to maximum expected drawdown in Table 5-1).
(4)	Any structure, excluding sheet piling, that remains in place for more than 30 days, that physically impedes the flow of groundwater through the site must not: (a) impede the flow of groundwater over a length of more than 20m; and (b) extend more than 2m below the natural groundwater level. Note: the structure must meet either (a) or (b) for the standard to comply. Exceedance of both will be a non-compliance.	MEETS. The Project retaining walls are longer than 20 m but are drained and there is no physical impedance of flow.
(5)	The distance to any existing building or structure (excluding timber fences and small structures on the boundary) on an adjoining site from the edge of any: (a) trench or open excavation that extends below natural groundwater level must be at least equal to the depth of the excavation. (b) tunnel or pipe with an external diameter of 0.2 - 1.5m that extends below natural groundwater level must be 2m or greater; or (c) a tunnel or pipe with an external diameter of up to 0.2m that extends below natural groundwater level has no separation requirement.	MEETS. The Project road cuts are expected to fully satisfy this standard.
(6)	The distance from the edge of any excavation that extends below natural groundwater level, must not be less than: • 50m from the Wetland Management Areas Overlay; • 10m from a scheduled Historic Heritage Overlay; or • 10m from a lawful groundwater take	MEETS: This standard is met over the Project.

Further commentary is provided in the subsequent sections of this report but in general the assessment presented in Table 5-2 indicates that the works will meet the Permitted activity standards and hence have a manageable level of risk.

Overall, the only project works that could generate detectable levels of drawdown (and hence increased risk of settlement effects), are the cuts between CH13080 and CH13160 (286 -310 Redoubt Road) which

could result in 1.7 m and 1.3 m drawdown respectively. The cut at CH14785 (west of Cheesman's Bush) will generate about 0.2 m drawdown but the alignment goes through a greenfield area with the nearest dwelling at least 100 m from the cut. These drawdown values are less than 2 m and thus these project cuts comply with standard E7.6.1.10.

Pavement design for the road is not available to date. If temporary excavations are considered in this assessment (prior to paving), additional pavement subgrade of up to 300 mm could be assumed in the design, and the excavations would still comply with the specified standard.

In sum, only two road cuts (cuts at CH13080 – CH13160 and CH14785) are expected to require some dewatering. The works are likely to meet the Permitted activity standard E7.6.1.10.

As the Project works met standard E7.6.1.10, the groundwater diversion caused by excavation is a Permitted activity under rule E7.4.1 (A27).

5.3 E7.6.1.6 Dewatering or groundwater level control associated with a permitted groundwater diversion

AUP standard E7.6.1.6, which relates to duration of take, is intended to limit the duration of dewatering such that there is insufficient time for significant drawdown or measurable levels of consolidation settlement to occur.

Table 5-3 presents an assessment of the Project excavation works against AUP Permitted activity standard E7.6.1.6 and is colour coded to indicate whether the activity is expected to fully comply with the Permitted activity standards.

In sections where the road is deeper than the groundwater level the road will result in a permanent water take. Consequently, the water take will be for longer than 30 days at the two road cuts at CH13080 - CH160 and CH14785 and will remain once the road is constructed and is operating. Therefore, the activity does not comply with standard E7.6.1.6 and therefore is a Restricted Discretionary activity under rule E7.4.1 (A20).

Table 5-3. Standard E7.6.1.6. Dewatering or groundwater level control associated with a groundwater diversion permitted under Standard E7.6.10 (all standards must be met). The colour green indicates the standard is met and the colour red indicates the condition is not met.

Standard	Activity	Applicability to site
E7.6.1.6 (1)	The water take must not be geothermal water.	MEETS. There are no indications of geothermal water along the alignment.
E7.6.1.6 (2)	The water take must not be for a period of more than 10 days where it occurs in peat soils, or 30 days in other types of soil or rock.	DOES NOT MEET. Most of the cuts will be through ECBF soil or rock. Peat could be present in the south of the Project extent, but no deep cuts are present in this area so there won't be a water take. However, the two road cuts at CH13080 - CH160 and CH14785 will result in an on-going water take for a period longer than 30 days.
E7.6.1.6 (3)	The water take must only occur during construction.	DOES NOT MEET. The take at cuts CH13080 - CH160 and CH14785 will continue to occur after the road is constructed.

5.4 Activity Status

The Project meets standard E7.6.1.10 but does not meet standard E7.6.1.6 because the water take will be permanent at road cuts CH13080 - CH160 and CH14785, continuing to occur after the Project is completed. Consequently, the Project is a Restricted Discretionary activity under rule E7.4.1 (A20) and requires a Groundwater Assessment.

6 ASSESSMENT OF EFFECTS

This assessment of effects considers potential drawdown and settlement due to project excavations as well as potential flow depletion (or diversion) from nearby streams and wetlands. The assessment focuses on project sections where deep cuts or drains are proposed (Figure 2-5). In the southern portion of the Project (Alfriston end) groundwater is relatively shallow but no dewatering will take place at this location.

6.1 Identification of potential effects

186-200 Redoubt Road

The maximum cut depth at this location is 3.1 mBGL (Table 5-1), while the lowest recorded groundwater level is 4.5 mBGL, which coincides with the base of the piezometer screen (DH103, Figure 2-3). It is noted that the groundwater level may have dropped below 4.5 mBGL on several occasions, as it fell beneath the screen level. Given that the groundwater level is at least 1.4 m below the finished road surface, no drawdown below a summer low level is expected to be induced by the road or any retaining walls at this location. Whilst seasonal (winter) interception of groundwater will occur, groundwater levels in the surrounding area will remain within their natural seasonal range.

Temporary over-excavation may occur during construction. Although pavement thickness data is unavailable, it is assumed that over-excavation to accommodate the road base will not exceed 1.4 m.

As no drawdown below the summer low groundwater level is expected at this location, no groundwater impacts are anticipated.

Murphys Road cut

The maximum cut depth at this location is 8.7 mBGL (Table 5-1), and the lowest recorded groundwater level is 9.5 mBGL (DH506). As this level was measured in July 2025, it is a value recorded during a period of high groundwater levels in winter. Other piezometers at this location are DH507 and DH505 with groundwater levels also measured in winter and corresponding to 12.7 mBGL and 6.8 mBGL. DH507 is located where the maximum cut is projected, on the opposite side of the road from DH506. DH505 is located within metres of Redoubt Road, and no cut is projected at this location i.e. the deeper water level in DH507 is considered the most relevant for assessing the cut.

Figure 6-1 shows the location of Section A and Figure 6-2 shows the current road design elevations as well as geology and the piezometric surface inferred from groundwater level measurements in June and July 2025. This figure shows that the groundwater level is below the finished road surface, or any drainage associated with retaining walls. At the maximum cut depth, adjacent to DH506 and DH507, the inferred high groundwater level is at least 0.8 m below the finished surface. Consequently, no drawdown is expected to be induced by the road or any retaining walls at this location.

Temporary over-excavation may occur during construction. Although pavement thickness data is unavailable, it is assumed that over-excavation to accommodate the road base will not exceed 0.8 m.

As no drawdown is expected at this location, no groundwater impacts are anticipated.

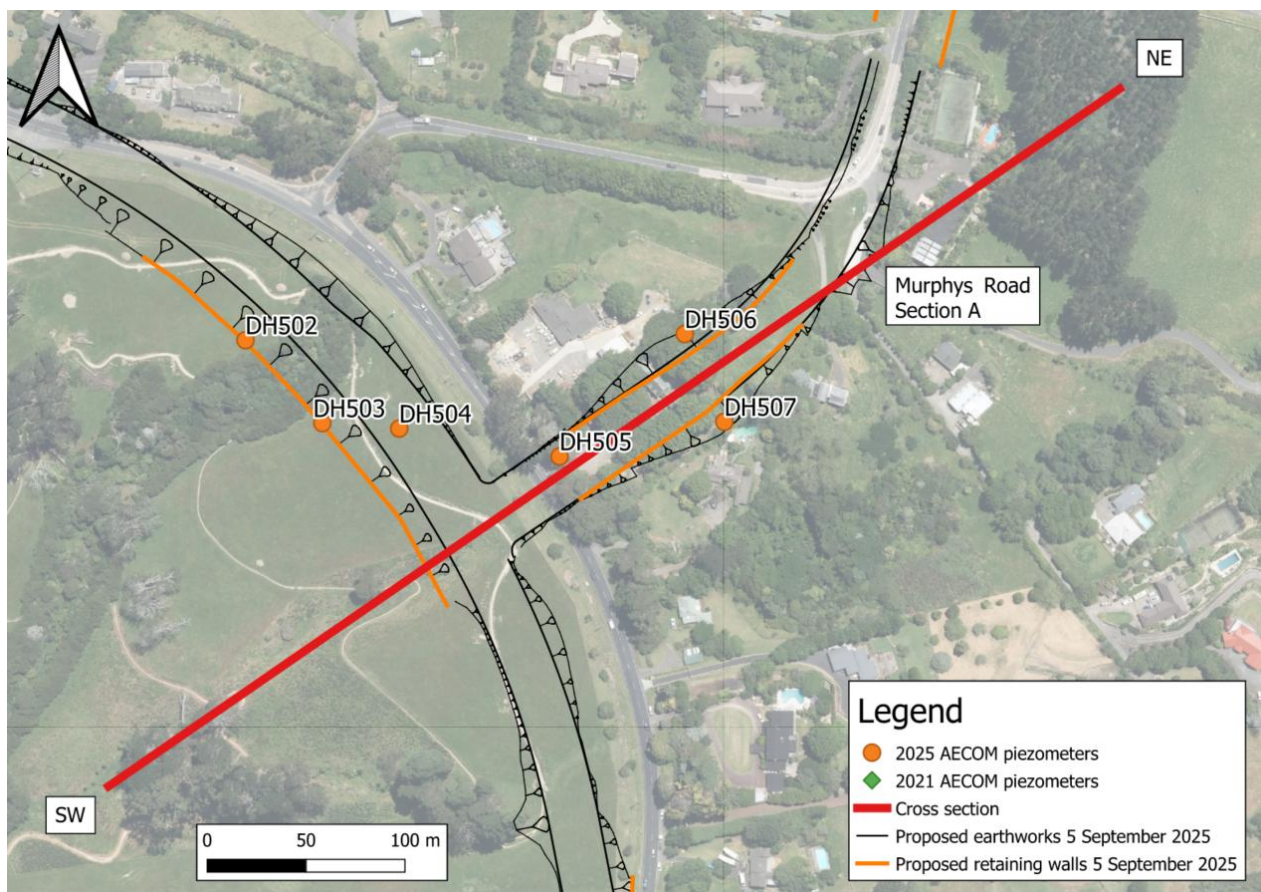


Figure 6-1: Plan showing proposed earthworks, existing retaining walls and piezometers. The plan also shows Section A, in the SW-NE direction, along the Murphys Rd cut.

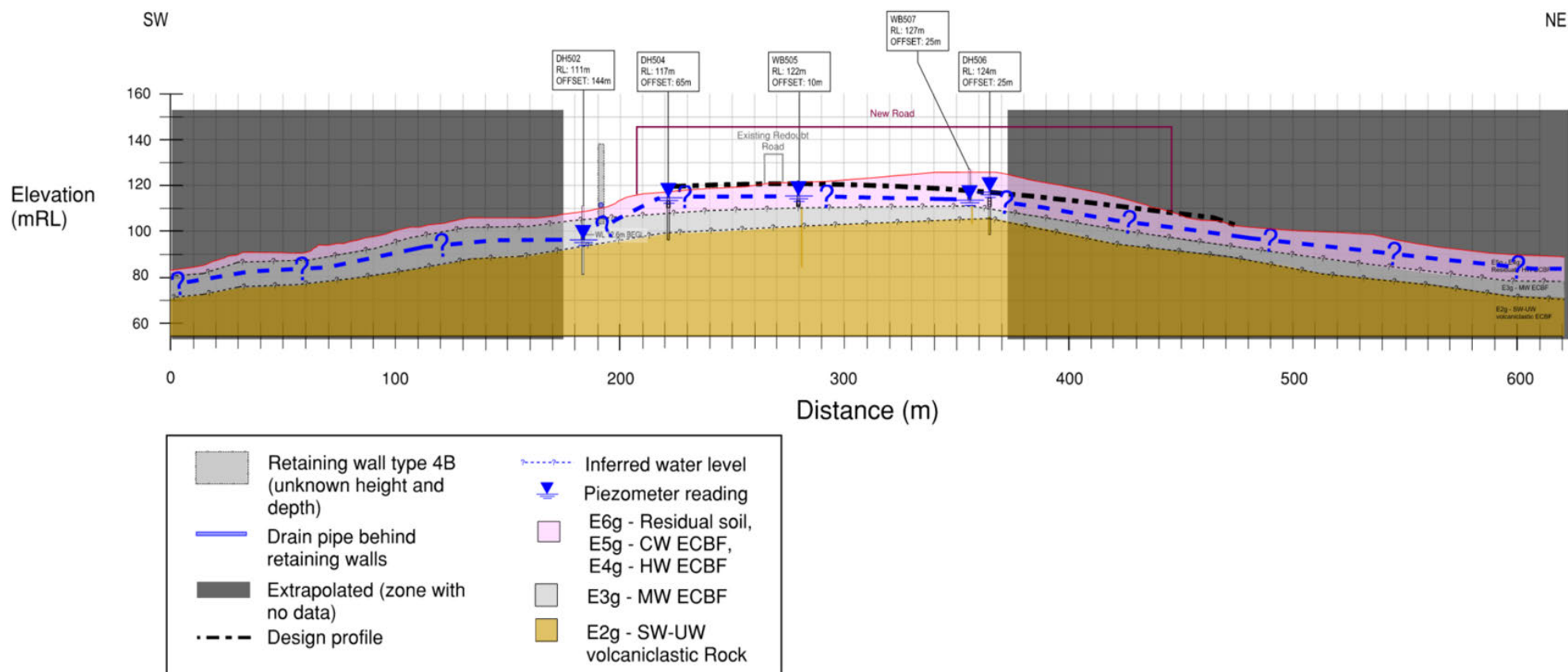


Figure 6-2: Section A (SW-NE) showing the road design, geological units, and groundwater levels (as measured in June - July, 2025) at Murphys Road. The blue line represents the groundwater level and the black dotted line represents the road design.

286-310 Redoubt Road cut

The maximum cut at this location occurs at CH13080 and has a depth of 8.3 m. At this location, the closest piezometer is DH106 which is on the projected road and has a seasonal low groundwater level of 6.6 mBGL. DH511 is also close to the cut and has been completed at a similar depth to DH106. However, only one groundwater level measurement, measured on 31/7/2025, is available for DH511. This 'winter high level' is 3.5 mBGL and similar to the 'winter high' level of 2.7 mBGL for DH106.

The potential for settlement is assessed based on 'seasonal lows' as any drop in water levels that is above the seasonal low is within the range of drawdown which is naturally experienced. Accordingly, the maximum drawdown at this location has been assessed based on the 'seasonal low' measured at DH106. Consequently, the maximum drawdown at this location is 1.7 m. The location of a cross section through Redoubt Road at this location is presented in Figure 6-3. A cross section showing the elevation of the finished road surface in relation to this groundwater level is presented in Figure 6-4.

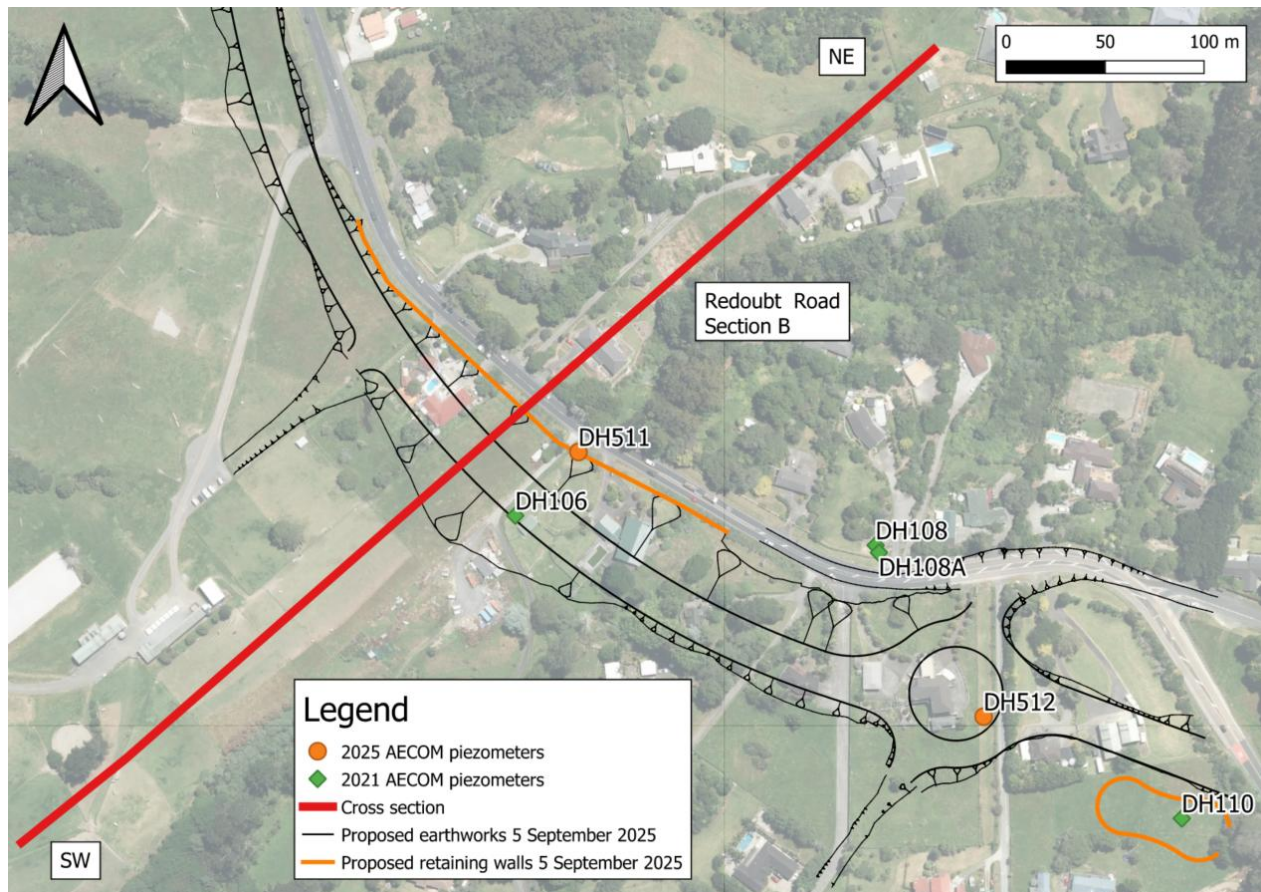


Figure 6-3: Plan showing the location of Section B as well as proposed earthworks, existing retaining walls and AECOM piezometers at the 286-310 Redoubt Road cut.

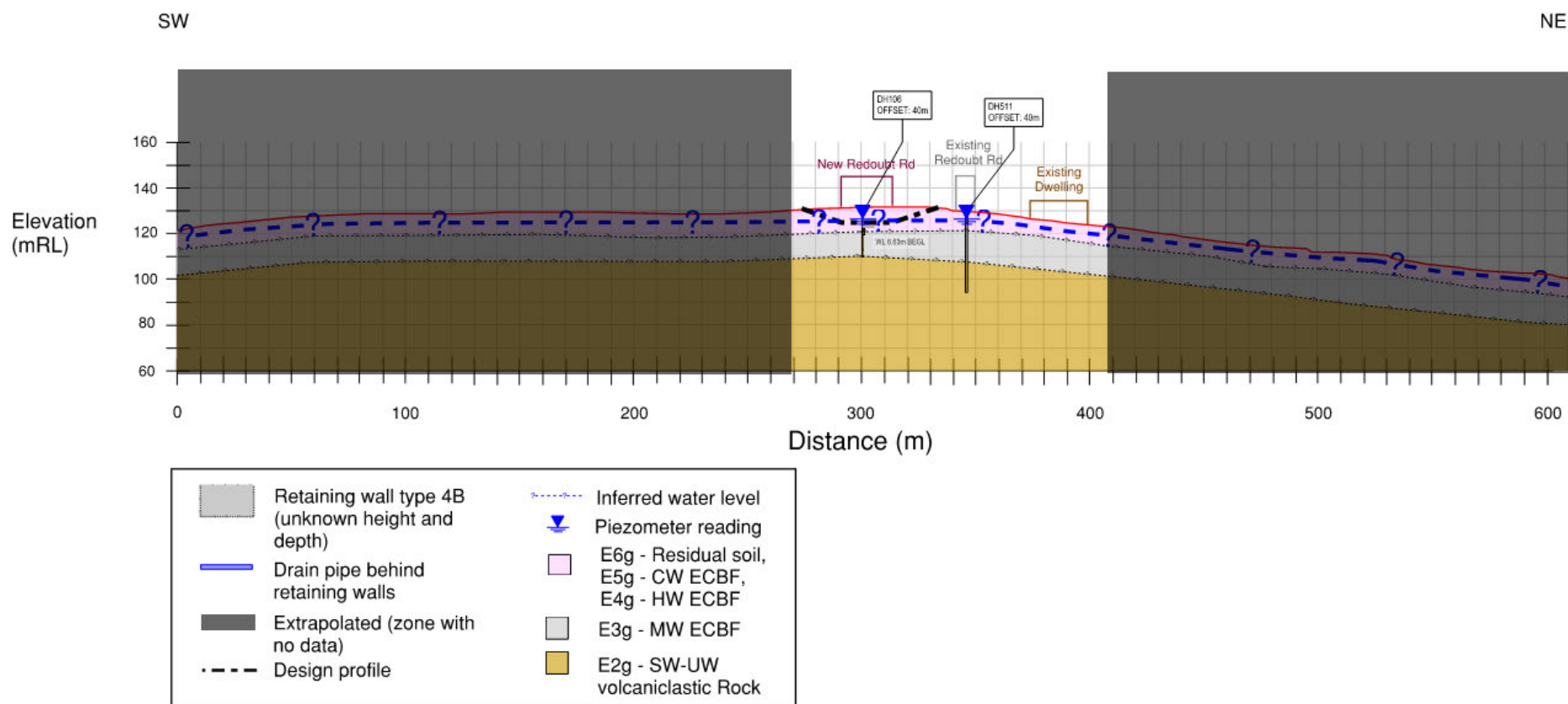


Figure 6-4. Section B (SW-NE) showing the road design, geological units, and groundwater levels (as measured in June - July 2025) at the 286-310 Redoubt Road cut. The blue line represents the groundwater level prior to road construction (slightly higher than the road finished surface), and the black dotted line represents the road design.

A numeric model was constructed to assess the extent of drawdown at this location (**Appendix B**). The model is perpendicular to the road cut, in the NE-SW direction. Modelling indicates drawdown of 1.3 m, i.e. at the lower end of the range of indicated in preceding sections (1.3 to 1.7 m), however the calculation of consolidation settlement has assumed a conservative upper bound of 2 m. Settlement Calculations are presented in **Appendix C**.

The potential magnitude and extent of ground consolidation settlement (mm) due to drawdown has been estimated using one-dimensional consolidation theory:

$$S_c = m_v \times \Delta P \times t$$

where:

m_v = coefficient of volume compressibility (m^2/MN)

ΔP = change in pressure due to dewatering (kN/m^2)

T = thickness of each soil layer (m)

Settlement derived using the above equation assumes that full pore pressure dissipation occurs over the longer-term duration of dewatering. All drawdown is occurring within residually weathered ECBF rock, which is 20 to 25 millions of years old and has likely experienced significant groundwater level fluctuations over time and is therefore generally considered incompressible, with a low risk of settlement

Drawdown, total settlement, and differential settlement at set distances from the cut are presented in Table 6-1. The maximum drawdown occurs at the excavation edge, and total settlement at this location conservatively assuming 2 m of drawdown is calculated to be < 3 mm (i.e. at a level that is close to survey accuracy). The assumption of 2 m allows for some undercut whilst still considering the works to fully comply with the Permitted activity standards for diversion. At 60 m from the excavation edge, drawdown is 0.8 m and total settlement is 1 mm. Differential settlement is calculated to be about 1:2000 at the excavation edge and, is negligible beyond this distance (being practically flat).

Table 6-1. Groundwater modelling results: drawdown and settlement values

Distance from excavation edge (m)	Drawdown (m)	Total Settlement (mm)	Differential Settlement
0	2.0	2.5	1:2000
20	1.0	~1	Negligible
40	0.9	~1	Negligible
60	0.8	1	Negligible
80	0.75	< 1	Negligible
100	0.7	< 1	Negligible
150	0.5	Negligible	Negligible
200	0.4	Negligible	Negligible
250	0.2	Negligible	Negligible

The finished road surface will have an elevation of about 115 mRL to 125 mRL along this section of the road. Permanent streams to the NE are present at elevations of 80 mRL to 86 mRL at distances greater than 250 m from the cut. Similarly, stream elevations to the NW and SE are 88 mRL and 81 mRL at distances greater than 300 m. Consequently, due to these differences in elevation and distances, stream depletion due to the road cut will not take place. The numeric model predicts a negligible groundwater diversion due to this cut (<5% reduction in groundwater flow reporting to the stream). As these streams are primarily rain-fed, groundwater discharge from the low permeability soils and rock is unlikely to be a significant component of baseflow, and this groundwater diversion resulting from the cut is unlikely to result in a measurable reduction of groundwater discharging to the streams.

Consented water takes are at least 600 m from the cut. It is considered that given the low seepage and drawdown due to the road cut at this location, the works will not result in any adverse effects to the consented water takes.

367 – 365 Redoubt Road

The maximum cut depth at this location is 4.4 m, and this occurs at CH13825. The nearest piezometer, DH112A, is located at approximately 60 to 70 m southwest of the cut. In April 2021 (autumn period), the groundwater level recorded at this piezometer was 4.9 mBGL.

Based on the groundwater level data from April 2021 and the maximum cut depth, no groundwater drawdown is expected at this location during the summer low period. Therefore, drawdown is likely to occur only during seasonal highs (winter), and settlement is not anticipated at this location.

Cut to the west of Cheesman's Bush bridge

The maximum cut at this location occurs at CH14785 and has a depth of 8.3 m. At this location, the closest piezometer is DH527 which is on the projected road and has a groundwater level of 8.1 mBGL, measured in July 2025 ('winter high'). The location of a cross section along this cut is presented in Figure 6-5 and the actual cross section showing the road finished surface and the inferred groundwater level, estimated with July 2025 data, is presented in Figure 6-6.

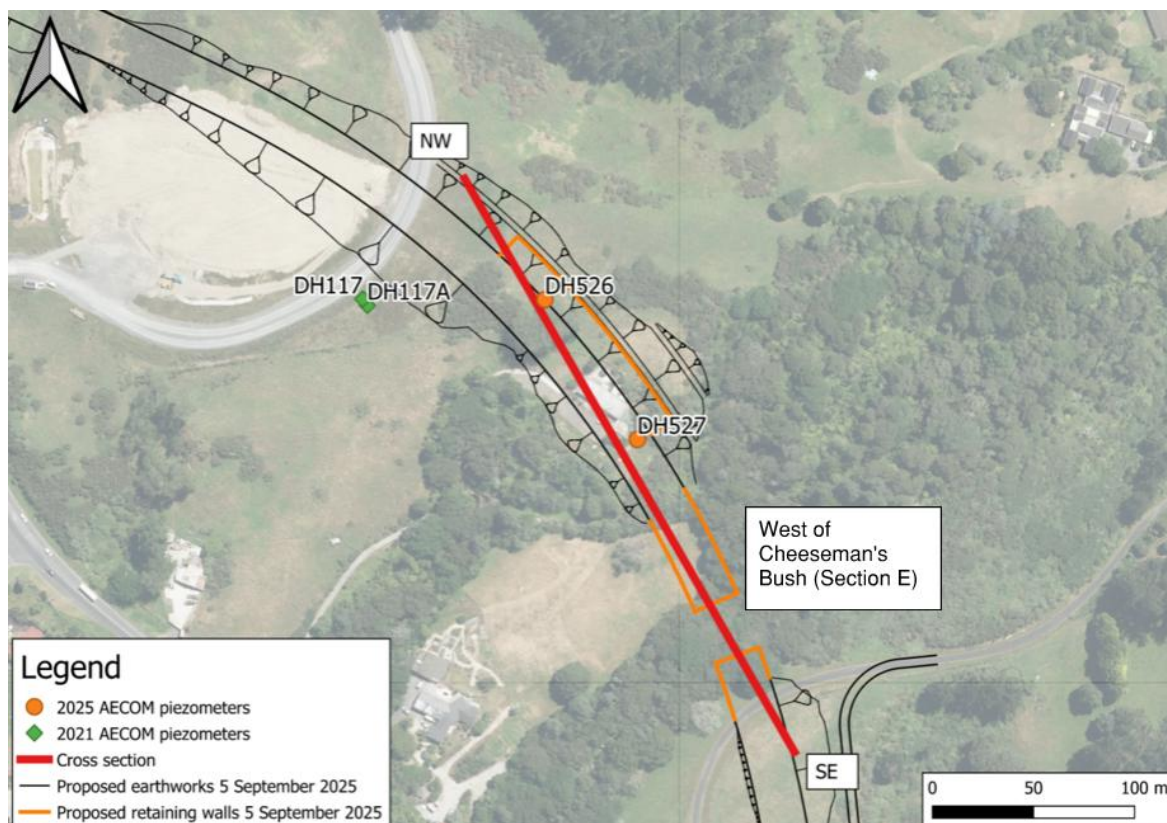


Figure 6-5. Plan showing proposed earthworks, existing retaining walls and AECOM piezometers west of Cheesman's Bush bridge.

Based on the July 2025 groundwater level data at location DH527 and the maximum cut depth, a drawdown of approximately 0.2 m is expected. Given that this represents a 'winter high' groundwater level, it is unlikely to result in any ground settlement at this location. However, drawdown at this location could result in seasonal diversion of groundwater that would otherwise discharge in the stream located to the east of Cheesman's Bush.

A numeric model (**Appendix B**) has been assembled to quantify groundwater diversion to the stream due to the cut, and considers both the cut itself and the loss of recharge due to the pavement. This model has indicated the groundwater discharge towards the down-gradient stream, over the width of the road, could be reduced by 25% relative to the baseline contribution. However, the road width (24 m) accounts for only a small proportion of the overall stream reach (450 m), and so this reduction represents less than 5% of

the total **groundwater contribution** to stream baseflow. This value is considered negligible, especially since this river will be predominantly rain-fed during winter due to overland flow discharges. The 5% reduction in groundwater discharge is unlikely to be detectable against natural fluctuations in stream flow. In summer ('seasonal low'), the groundwater level is likely below the cut so no diversion would occur during this season.

It is considered that given the low seepage and drawdown due to the road cut at this location, the works will not result in any adverse effects to consented water takes, which are at least 540 m from the cut.

6.2 Risk of settlement effects on adjacent buildings and services

Apart from the 286-310 Redoubt Road cut, there is no risk of settlement at adjacent buildings or services throughout the Project.

For the 286-310 Redoubt Road cut, the maximum total settlement at the base of the excavation has been estimated to be ~3 mm with a maximum differential settlement gradient of flatter than 1:2000. Total settlement to the NE and SW of the road cut, is calculated to be less than 1 mm at distances beyond 60 m from the excavation and differential settlement practically becomes unnoticeable.

Table 6-2 and Table 6-3 show the structures and services adjacent to the 286-310 Redoubt Road cut. Predicted settlement for these is less than 1.1 mm and differential settlement is flatter than 1:110,000.

Table 6-2. Structures near the 286-310 Redoubt Road cut

Address	Description	Distance from cut (m)	Predicted settlement (mm)	Predicted differential settlement
286 Redoubt Road, Tōtara Park, Auckland	Dwelling	75 to the NE	1	Negligible
298 Redoubt Road, Tōtara Park, Auckland	Dwelling	45 to the NE	1	Negligible
304 Redoubt Road, Tōtara Park, Auckland	Dwelling	70 to the NE	1	Negligible
315 Redoubt Road, Tōtara Park, Auckland	House/shed	20 to the SW	1	Negligible
323 Redoubt Road, Tōtara Park, Auckland	Dwelling and car port	20 to the SW	1	Negligible

Table 6-3. Services near the 286-310 Redoubt Road cut

Address	Description	Distance from cut (m)	Predicted settlement (mm)	Predicted differential settlement
286-323 Redoubt Road, Tōtara Park, Auckland	buried water pipe (PE)	20m to the NE	1	Nil along the length of the pipe – a total settlement of 1.0 mm is unlikely to result in significant differential settlement along the pipe.
286-323 Redoubt Road, Tōtara Park, Auckland	buried water pipe (legacy, PVC-U)	30m to the NE	1	Nil along the length of the pipe– a total settlement of 1 mm is unlikely to result in significant differential settlement along the pipe.

Both total and differential settlement are within the commonly applied, first-pass criteria of the Burland (2012) approach for assessing the nature of building damage, with maximum calculated settlement being less than 10 mm and with differential settlement flatter than 1:500. On this basis, any settlement induced damage is likely to be “negligible” (e.g., aesthetic only) and hence potential effects due to settlement are expected to be very low.

There are no consistently applied common thresholds for assessing risk of damage to service pipes. Based on wider experience in the Auckland area, typical limits of 20 mm total settlement and 1:500 differential settlement are often applied, with differential settlement along the length of the service providing the greatest risk to piped or jointed services. These limits have been adopted here but is noted they are much more conservative than O'Rourke & Trautmann (1982), who suggest that gradients steeper than 1:140 may result in damage to rigid pipelines greater than 200 mm in diameter. The water pipes listed in Table 6-3 have a total settlement of less than 1 mm and will have an associated differential settlement much flatter than 1:500, suggesting the risk of settlement induced damage is likely negligible.

Regardless of the above, noting the proximity of the existing structures and services, a pre- and post-construction condition survey is recommended to confirm the existing condition of these structures and services and provide a baseline against which any claims of project related damage can be objectively assessed.

It is noted that in other project cuts where no settlement will occur, there are a few water pipes crossing the actual road cut. These include the buried PVC-U water pipe at 190-200 Redoubt Road and the distribution lines for the CLS buried Manurewa 1 Watermain and Waikato 1 Watermain. These pipes will be replaced and relocated as part of project works therefore monitoring is not considered necessary.

7 CONCLUSION

Based on our assessment of the road cuts for the Project, we consider the potential adverse effects related to groundwater drawdown or diversion to be low.

We have identified four road cut sections that, due to their depth, could potentially intercept groundwater and induce some dewatering. However, in most cases, the summer groundwater level is at or below the finished road surface. Therefore, the likelihood of adverse effects from dewatering during road operation to be negligible. Given the permanent nature of the road, we have assessed long-term effects where excavations extend below the groundwater level, as the Project does not meet the AUP Permitted activity standards.

At the 186-200 Redoubt Road, Murphy's Road, and 367-375 Redoubt Road cut sections, groundwater levels are below the excavation depths, even when accounting for temporary over-excavation to install road pavement. As such, we do not expect any dewatering or associated adverse effects at these locations.

The road cut at 286-310 Redoubt Road intercepts the groundwater level. We have assessed the maximum drawdown at this location to be approximately 1.7 m, which meets the Permitted activity standards for diversion but any seepage into the cut will be permanent and so cannot meet the Permitted activity standards for take. Our analysis indicates that settlement at the cut is likely to be less than ~3 mm, with both drawdown and settlement effects diminishing rapidly away from the cut. We do not expect any significant adverse effects on nearby dwellings or services (e.g., buried water pipes), even when considering temporary over-excavation.

Some buried services, such as water mains, will require rerouting during construction. An indicative route will be provided once detailed design has been issued and in consultation with the service providers. We expect this rerouting will be agreed with the network utility operator and will include adequate protection against potential settlement such that monitoring is not required.

Permanent streams are located at least 250 m from the cut, and at much lower elevations such that stream depletion will not occur. However, based on groundwater modelling we estimate that some potential diversion of groundwater could occur but will be minimal, less than <5% reduction in groundwater reporting to streams. As these streams are primarily rain-fed, the road cut will not result in a material or measurable reduction in groundwater discharge or in-stream flows.

We have also assessed the road cut west of Cheesman's Bush and do not expect any significant drawdown or settlement effects. The estimated diversion of groundwater to the stream east of the cut is approximately <5% during winter, which we consider negligible, especially given the stream is predominantly rain-fed during that season. No diversion is expected in summer, as groundwater levels are likely to be below the cut.

We anticipate that given the low levels of seepage and drawdown associated with any of the road cuts, there will be no adverse effects on consented water takes in the vicinity of the project.

Should there be any significant changes to the construction methodology such as alterations to road alignment, excavation depth, drainage design, or finished surface levels, this assessment will need to be revisited, as such changes could result in higher drawdown and settlement values than currently predicted.

In summary, we consider the potential groundwater effects resulting from the construction of this project to be negligible to low.

APPENDIX A STATEMENT OF QUALIFICATIONS AND EXPERIENCE AND CODE OF CONDUCT

My full name is Mauricio Enrique Taulis.

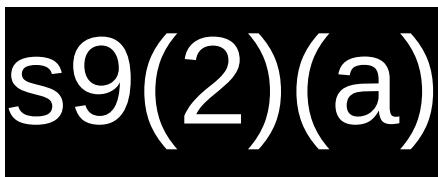
I hold a Master of Engineering (Natural Resources) from Lincoln University, which I completed in 2003, and a PhD in Civil Engineering (Environmental) from the University of Canterbury, completed in 2007. I have approximately 20 years of experience in hydrogeology, including around 15 years working as a consulting hydrogeologist. Over this time, I have undertaken groundwater investigations and assessments, data analysis and interpretation, and prepared technical reports to support development and infrastructure projects across New Zealand and Australia.

Since 2021, I have been working in New Zealand for Beca Limited New Zealand Ltd, and prior to that, I worked for Jacobs New Zealand Ltd from 2015. I am a member of the International Association of Hydrogeologists (New Zealand branch), and I served as President of the chapter from 2022 to 2025.

Recent relevant projects I have contributed to include:

- Peer review work for Auckland Council, assessing development applications involving excavation and dewatering activities (2021–2023).
- Co-authoring a report and assisting with Section 92 responses for the Warkworth to Wellsford Project, assessing potential groundwater related environmental issues associated with the project designation (NZTA, Auckland, 2017).
- Leading and co-authoring the Groundwater Assessment Report for the Westhaven Booster Pump Station (2021).
- Authoring a report and assisting with Section 92 responses for the North Harbour 2 Watermain project (Watercare Services Ltd, Auckland, 2015).

I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023, and I have complied with it in preparing this report. I confirm that the issues addressed in this assessment fall within my area of expertise, and I have not omitted any material facts known to me that could alter or detract from the information presented.

A black rectangular box containing the white text 's9(2)(a)' in a large, bold, sans-serif font.

Mauricio Taulis

August 2026

APPENDIX B GROUNDWATER MODELLING

Approach for Groundwater Assessment

The purpose of this Appendix is to quantify the potential groundwater effects associated with two project cuts: Section B-Redoubt Road and Section E – West of Cheesman’s Bush. The Project cuts have been assessed against the Auckland Unitary Plan (**AUP**, Chapter E7) rules in the main body of the NZTA Groundwater Assessment report (2025) to inform the consenting process. In addition, the potential groundwater effect to nearby wetlands and surface water bodies has also been evaluated.

Based on the evaluation of the Project’s activity status under Chapter E7, a further groundwater assessment was undertaken for the cuts where the Permitted activity standards for groundwater cannot be met. Consequently, two 2D sections were modelled to assess potential groundwater effects at these locations: Section B located, at 286 – 310 Redoubt, and Section E, that covers the excavation west of Cheesman’s Bush. See Figure 1 below.

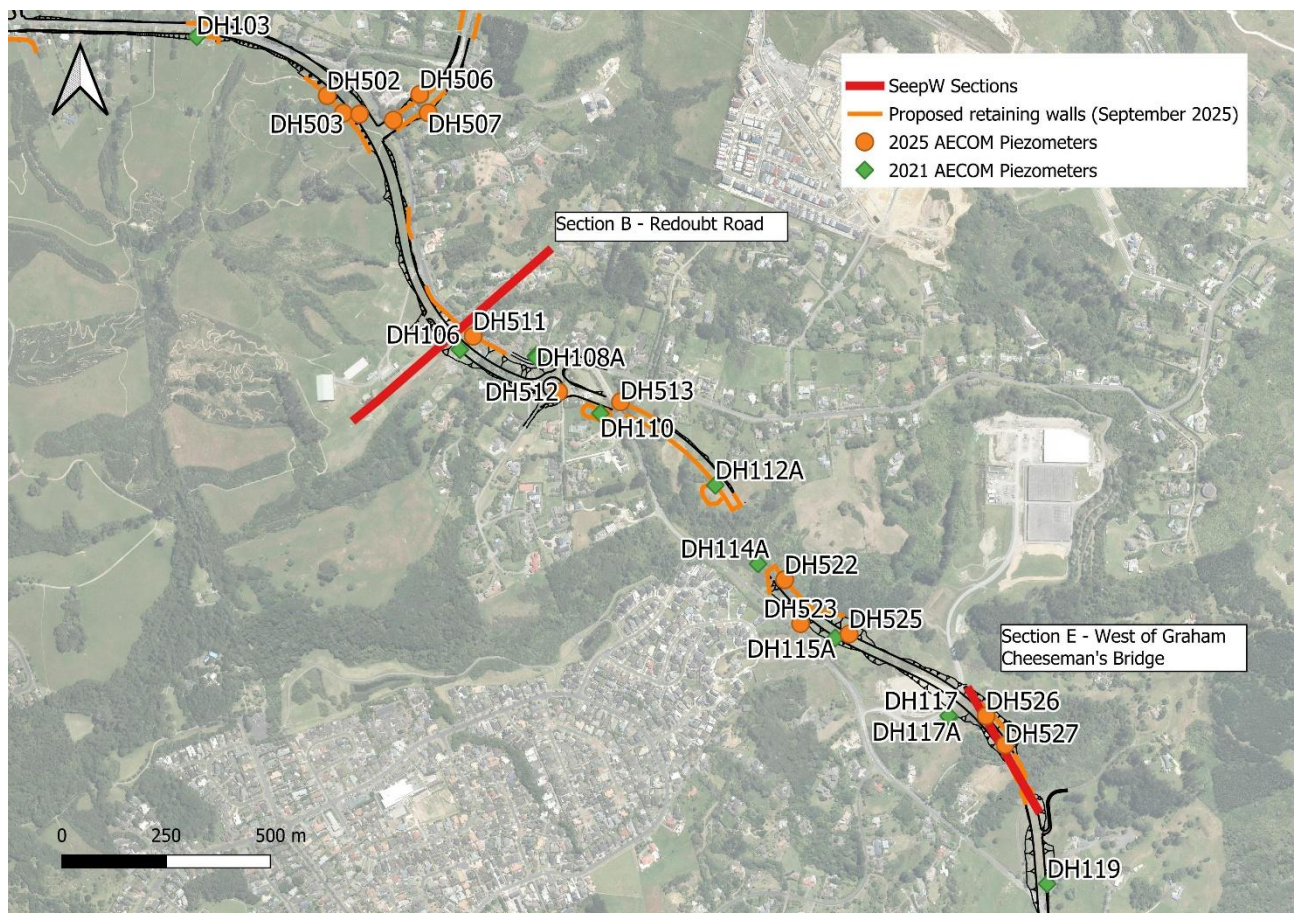


Figure 1: Locations of Sections B and E modelled with SeepW.

2D Groundwater Modelling

Model Code and Software

The groundwater flow models were developed using SEEP/W 2D module within the GeoStudio 2025.1.0 suite designed for modelling 2D groundwater flow in a porous environment. SEEP/W uses finite element analysis to simulate saturated and unsaturated flow conditions.

As 2D SEEP/W models cannot consider flow in three dimensions, the 2D model tends to overestimate magnitude and extent of drawdown (i.e. resulting in conservative drawdown extents and magnitudes). Conversely the model may underestimate inflows to road cuts; however, the models have been aligned to represent the primary flow direction and as inflows are expected to be relatively small regardless, and

manageable with usual construction practices, this is not considered to have a material impact on the analysis and recommendations presented in this Appendix.

Domain and Mesh Geometry

The orientation and the length of the cross sections configured in the SEEP/W modelling were determined considering a range of factors including:

- **Distance from the road cuts to the boundaries.** Leaving enough distance on both sides of the modelled zone of interest minimizes the influence of boundary conditions on the calculated output. If boundaries are placed too close this could result in the flow patterns being artificially constrained which can lead to inaccurate results. To evaluate the influence of summer and winter levels and layer permeabilities, different boundary conditions have been considered in the sensitivity checks.
- **The location and extent of the road cuts.** A deeper road cut is likely to intersect the water table, thus leading to dewatering to manage groundwater inflows into the excavation and associated drawdown effects. The analysed sections were chosen to pass through the locations where the road cut reached their greatest depth below the groundwater level.
- **The groundwater flow direction.** The angle between principal groundwater flow direction and orientation of the cross section will determine the capacity of the model to sufficiently represent the groundwater flow gradient.

Two (2) sections were modelled to assess the drawdown effects and potential reductions in groundwater contributions to surface water bodies. These sections are summarised in Table 1 and shown in Figure 1. Each was strategically aligned to intersect the deepest part of the proposed excavation. Section B is oriented parallel to the principal direction of groundwater flow. This configuration is generally preferred to simulate maximum drawdown and peak inflow conditions into the road cut, to provide a conservative assessment: However, Section E aligns with the proposed road alignment, as this was necessary to consider the localised groundwater flow gradient towards the adjacent stream

- Section B: covers the excavation at 286 – 310 Redoubt. The section is 610m long.
- Section E: covers the excavation west of Cheesman's Bush. The section is 255m long.

For all sections modelled, the SEEP/w mesh has been defined using the quadrilateral elements of 2m in size.

Table 1: Details about the 2D SEEP/W model sections.

Section ID	Orientation	Modelled GW at the excavation	Section Length	Geological units	Closest boreholes
Section B	SW – NE	5.8m BGL	610m	WECCBF	DH106; DH106B; DH511
				MWECCBF	
				ECBF Rock	
Section E	NW – SE	3.9m BGL	255m	wECBF	DH117; NZGD_144918; DH526; DH527; DH528
				MWECCBF	
				ECBF Rock	

The groundwater levels adopted for modelling are higher than those reported in the overarching report; this is as a result of adopting an interpolated level between boreholes at the location of deepest cut.

The projected boreholes and corresponding groundwater levels were marked onto the models and utilized for calibration purposes.

Each section was set up with the same general geological profile but with lithology thickness dictated by the closest boreholes.

Hydraulic parameters

The following approach was used in the selection and calibration of the hydraulic parameters:

- In situ hydraulic conductivity parameters selected were based on testing undertaken in the following piezometers DH502, DH504, DH505, DH506A, DH511, DH512, DH513, DH522, DH523, DH525, DH526, DH527 and DH534.
- The hydraulic conductivity values adopted for the modelling were initially based on the testing results but were further adjusted for calibration. They are provided in Table 2.
- The vertical hydraulic conductivity is generally $K_v = 0.2K_h$. However, variations in K were considered for refinements of groundwater behaviour in the modelling.
- The steady state SEEP/W model pre-excavations were calibrated to the hydrogeological conceptualisation and ground water levels measured in piezometers close to the sections.

Table 2: Adopted conductivity for 2D modelling.

Material	Adopted K values for modelling
East Coast Bays Formation rock	3.8e-08 m/sec
Moderately Weathered ECBF	6.8e-08 m/sec
Weathered ECBF (soil)	9.9e-08 m/sec

Hydraulic conductivity is within the range observed from site testing and observed in this material across the wider Auckland Region.

Boundary Conditions

Constant head boundaries were defined at both ends of the 2D model sections to represent a regional groundwater flow gradient. These boundaries were placed at a distance from the excavations to limit the influence on the results of the simulation. The head boundary conditions that were used in each model are summarised in Table 3.

The head boundary conditions were adjusted to achieve a suitable calibration to monitored levels in boreholes.

Rainfall recharge was added to the surface of the models for calibration and is equivalent to 2.5 % of annual rainfall.

The Project excavation works were modelled using seepage face boundary conditions to simulate seepage behaviour as a result of excavation. All of the models were executed in steady state pre-construction, a transient state after one year of dewatering, and a steady state long term operation condition.

The boundary conditions are summarised in Table 3.

Table 3: Boundary types and conditions

Seep Section	Boundary Location	Hydraulic Boundary Type	Parameter
Section B	Southwest	Water Total Head	115 m
Section B	Northeast	Water Total Head	95 m
Section E	Northwest	Water Total Head	102.5 m
Section E	Southeast	Water Total Head	75 m
All sections	Project excavation works	Seepage Face Review Boundary	Initially set to 0 m ³ /sec, but model adjusts and calculates based on hydraulic conductivity and head conditions)
All sections	Model surface	Water Flux	1e-09 m ³ /sec/m ²

Construction Simulation

All of the models were run in a steady state initially, to simulate the existing groundwater flow regime, without the excavation. The excavation geometry was then created using null elements (i.e., elements with no material properties), and the excavation surface was set as a seepage review boundary to allow for groundwater inflow / drainage in the long term.

Calibration

The models were calibrated according to the local hydrogeological conceptualization, with the groundwater levels from piezometers along the construction alignment that were closest to the seep sections.

The head boundary conditions, and hydraulic conductivity were calibrated, within reasonable bounds, as well as some adjustments to the anisotropy (i.e., K_v/K_h) until the simulated groundwater levels aligned with the lower piezometer readings.

Sensitivity Assessment

The base case ECBF rock, moderately weathered ECBF, and weathered ECBF (soil) hydraulic parameters were systematically adjusted using defined lower and upper bound values to evaluate model sensitivity and quantify uncertainty across lithological units. Hydraulic boundary conditions and rainfall infiltration rates were held constant throughout the simulations to evaluate the influence of each unit properties. Simulations indicate consistent hydrogeological responses to variations in hydraulic conductivity.

The parameters are presented in Table 4:

Table 4: Sensitivity assessment parameters

Unit	Limits	Kh (m/s)
East Coast Bays Formation rock	Upper Bound	3.8e-07
	Lower Bound	3.8e-09
Moderately Weathered ECBF	Upper Bound	6.0e-07
	Lower Bound	6.0e-09
Weathered ECBF	Upper Bound	8.0e-07
	Lower Bound	8.0e-09

When the hydraulic conductivity was increased, infiltrated rainfall percolated more rapidly through the subsurface, resulting in a lowering of the phreatic surface. This increased transmissivity led to a broader spatial extent of drawdown, and the groundwater system responded more dynamically to infiltration inputs. In contrast, reduced hydraulic conductivity lowered vertical and lateral flow, causing groundwater levels to remain elevated. The drawdown depth increased locally but its lateral extent was constrained.

Model Assumptions and Limitations

The model was developed using available datasets, construction statements and the current conceptual understanding of the hydrogeological system surrounding each site. The key limitations are as follows:

- The 2D Seep sections represent an approximation of ground conditions along the 2D alignment. The geology is based on the closest boreholes to each excavation:
 - Section B was based on boreholes DH106, DH106B and DH511.
 - Section E was based on boreholes DH526 and DH527.
- Areas with limited or no ground investigation data are subject to increased uncertainty in the model's interpolations.
- Calibration of the sections was carried out under steady-state pre-construction conditions only.

Modelling Results

Groundwater drawdown at 286 – 310 Redoubt Road

Section B models the deepest part of the proposed cut between 286 – 310 Redoubt Road. The simulation results indicate a maximum groundwater drawdown of approximately 1.3 m at both the southwest and northeast edges of the cut (Figures 2 and 3). The drawdown effect diminishes with distance, reducing to less than 1.0 m within 26 meters from the southwest excavation boundary and 42 meters from the northeast boundary. These results suggest a relatively localized impact near the cut face.

Beyond the immediate vicinity, the model predicts a broader zone of influence with very small drawdown effects. Groundwater drawdown is estimated to reduce to less than 0.5 m at a distance of ~150 m to 190 m from the cut.

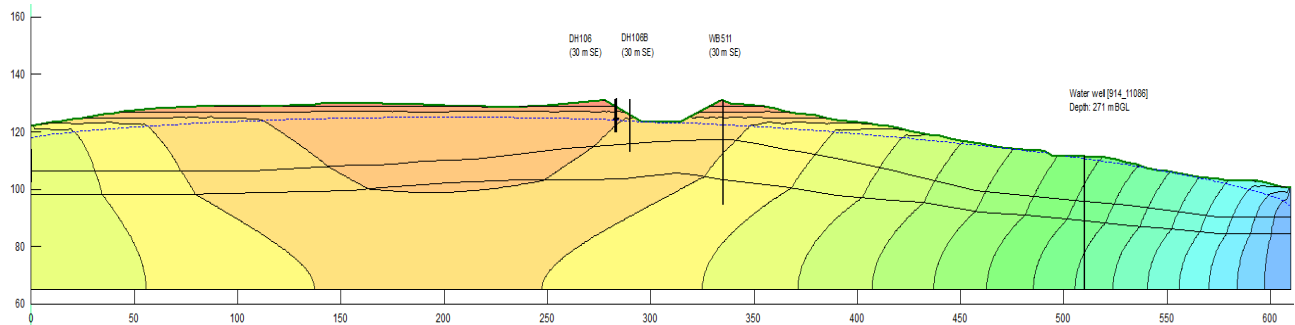


Figure 2: Modelled long term groundwater level due to the proposed road cut at 286 – 310 Redoubt Road (section B).

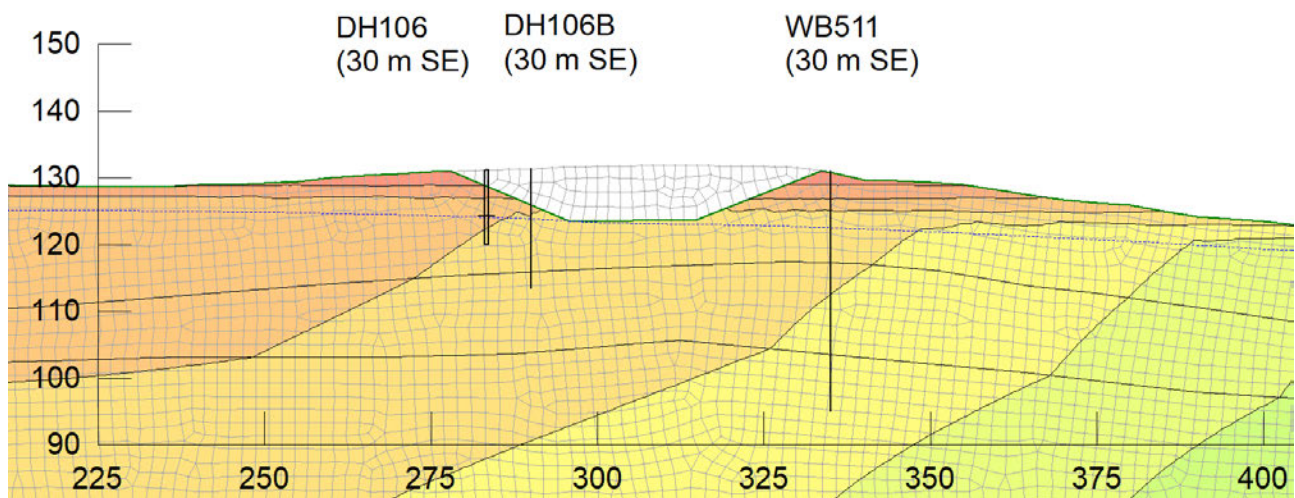


Figure 3: Close up of modelled long-term groundwater due to the proposed road cut at 286 – 310 Redoubt Road.

Figure 4 below presents the predicted drawdown profile relative to distance from the excavation.

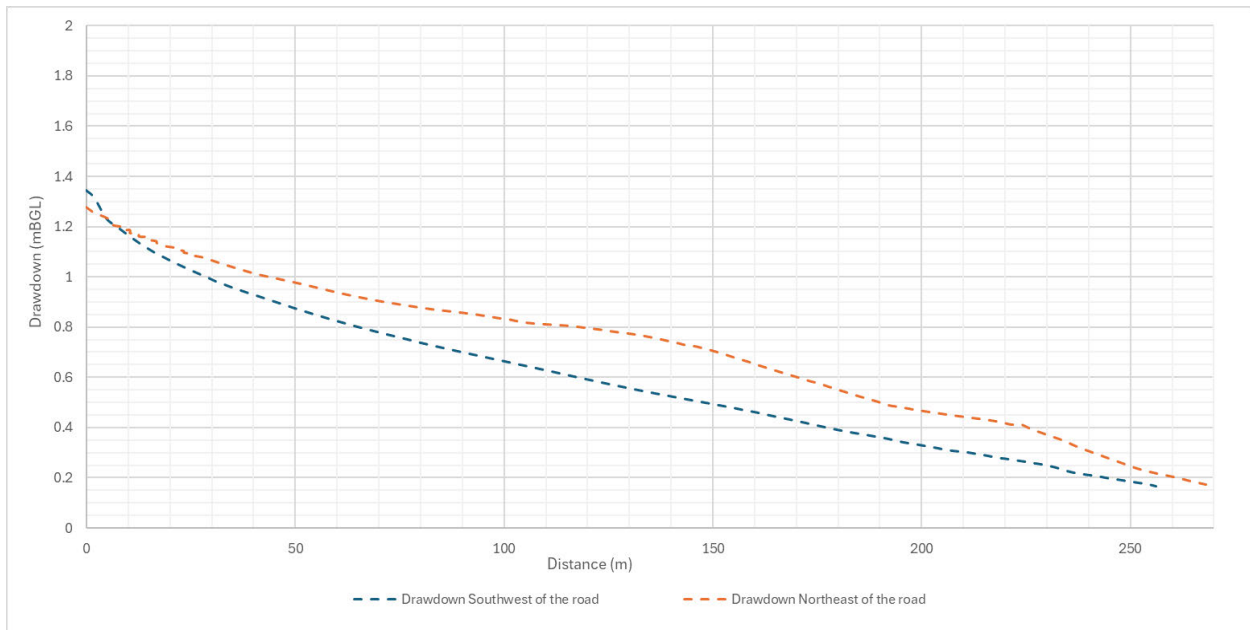


Figure 4: Simulated drawdown from the base of the excavation.

Potential diversion to Cheesman's stream

Section E covers the excavation west of Cheesman's stream (Figure 5). Anticipated drawdown during winter is estimated to be less than 20 cm, however drainage of groundwater into the excavation combined with reduced rainfall infiltration along the road could potentially divert part of the groundwater flow away from the down-gradient wetland and stream.

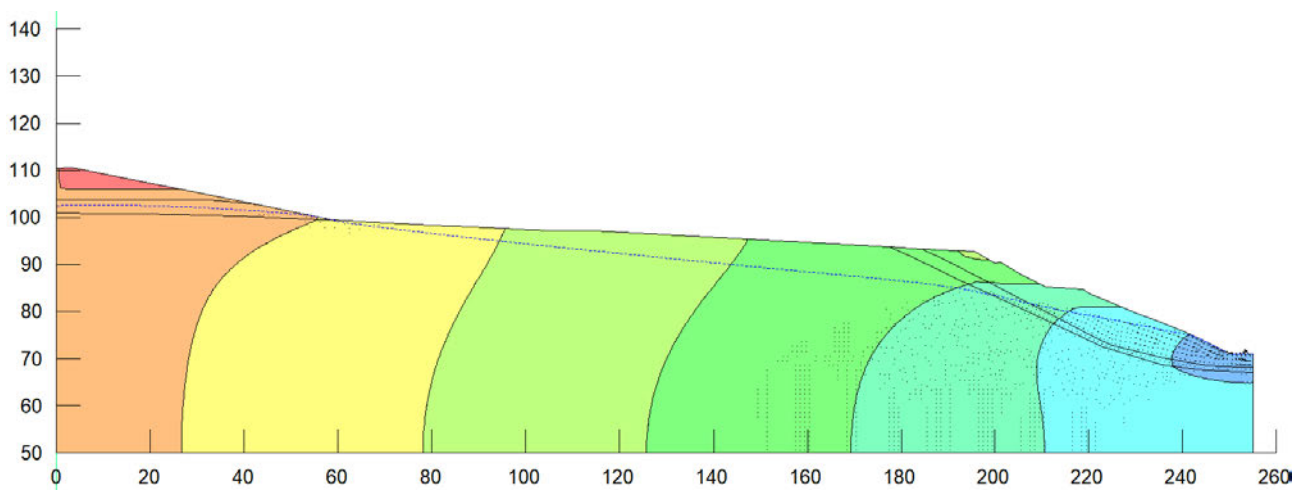


Figure 5: Modelled long term groundwater level due to the proposed road cut at Cheesman's stream

The model suggests that the groundwater discharge towards the down-gradient stream, over the width of the road, could be reduced by 25% relative to the baseline contribution. However, the road width (24 m) accounts for only a small proportion of the overall stream reach (450 m), and so this reduction represents less than 5% of the total **groundwater contribution** to stream baseflow.

It is important to note that this is the groundwater component of stream baseflow only, which is likely to be very small compared to instream flow from upgradient and overland flow / stormwater run-off. The 5% reduction in groundwater discharge is unlikely to be detectable against natural fluctuations in stream flow. Nevertheless, stormwater drainage is also designed to capture this groundwater seepage and to redirect it

into a gully located immediately south of the cut, which may potentially contribute to flows in the eastern stream.

Applicability Statement

This model was prepared by Beca Limited for informational purposes and is based on a simplified stratigraphic interpretation. It has been provided to AECOM/ NZ Transport Agency Waka Kotahi and is solely for their use and reliance. Any use or reliance by any person contrary to the above, to which Beca Limited has not given its prior written consent, is at that person's own risk and Beca Limited shall have no liability for such use.

Should you be in any doubt as to the applicability of this model, and/or encounter materials on site that differ from those interpreted herein, it is essential that you discuss these issues with the authors before proceeding.

References

- AECOM. (2025). *Mill Road Geotechnical Interpretive Report*.
- Beca Limited. (2025). Assessment of Hydrogeological Effects. Mill Road Stage 1.

APPENDIX C SETTLEMENT CALCULATIONS

Settlement Calculations, AECOM September 2025.

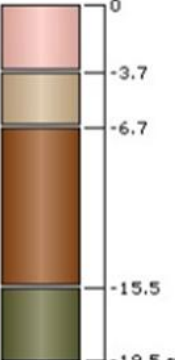
Below are the soil properties and ground profile used (based on DH106, closest to the excavation). Distances in the spreadsheet start at the centre of the excavation/road alignment.

Soil Properties

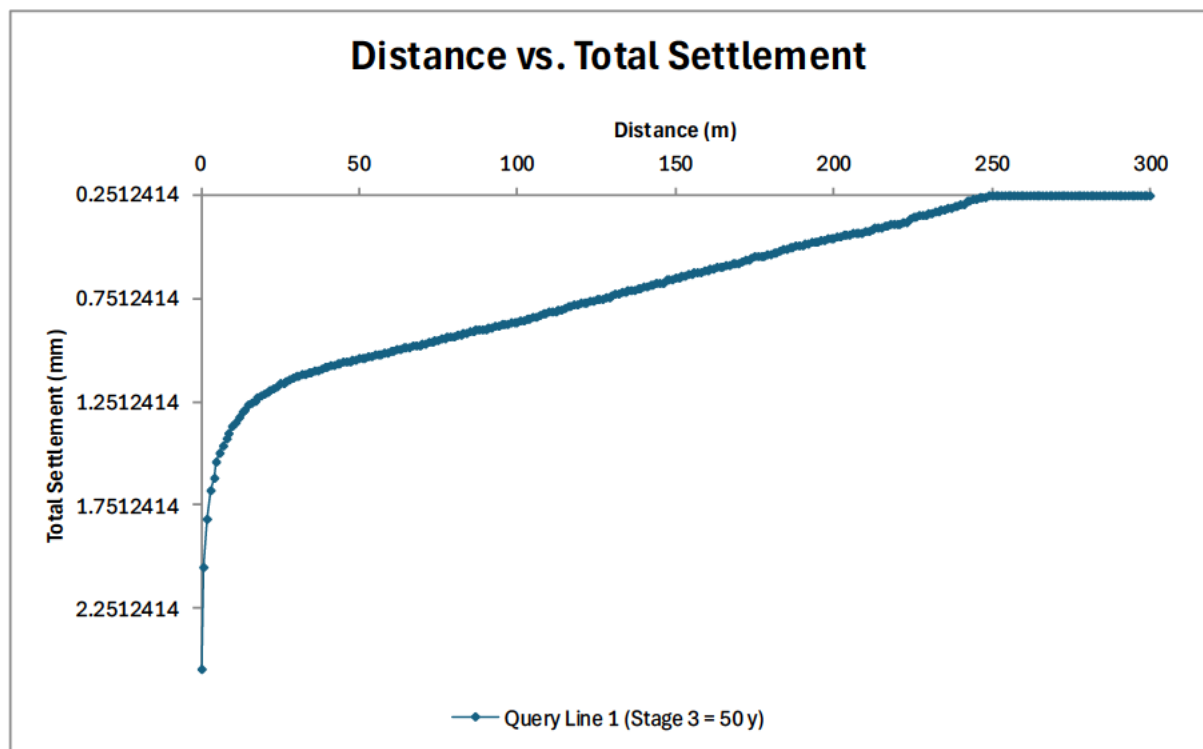
Property	E5g	E4g	E3g	E2g
Color				
Unit Weight [kN/m3]	18	18	18	18
Saturated Unit Weight [kN/m3]	18	18	18	18
K0	1	1	1	1
Primary Consolidation	Enabled	Enabled	Enabled	Disabled
Material Type	Linear	Linear	Linear	
mv [m2/kN]	5e-05	3e-05	1.7e-05	-
mvur [m2/kN]	5e-05	3e-05	1.7e-05	-
Cv [m2/y]	1	1	1	-
Cvr [m2/y]	-	-	-	-
B-bar	1	1	1	-
Undrained Su A [kN/m2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Grid Name	Staged	Staged	Staged	Staged

Soil Layers

Ground Surface Drained: Yes				
Layer #	Type	Thickness [m]	Elevation [m]	Drained at Bottom
1	E5g	3.7	0	No
2	E4g	3	-3.7	No
3	E3g	8.8	-6.7	No
4	E2g	4	-15.5	No



0
-3.7
-6.7
-15.5
-19.5 m



Distance (m)	Total Settlement (mm)	Differential Settlement (mm)	Differential Settlement Ratio
0	2.54	0.49	1:2041
5	1.54	0.04	1:22622
10	1.37	0.02	1:56992
20	1.21	0.01	1:110145
40	1.08	0.00	1:239923
60	1.01	0.00	1:259693
80	0.93	0.00	1:253160
100	0.86	0.01	1:152017
150	0.65	0.00	1:275034
200	0.46	0.00	1:295215
250	0.25	0.00	1:1411415
300	0.26	0.26	1:3894