Watercare Services Limited

QUEEN STREET WASTEWATER DIVERSION PROGRAMME: MAYORAL DRIVE ALIGNMENT PROJECT

DEWATERING AND SETTLEMENT ASSESSMENT

27 JUNE 2025

PUBLIC

QUEEN STREET WASTEWATER DIVERSION PROGRAMME: MAYORAL DRIVE ALIGNMENT

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Watercare Services Limited

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REV	DATE	DETAILS
R0	24 June 2025	Draft for client review
R1	27 June 2025	Final draft incorporating client comments for submission.

	NAME	DATE
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ABBREVIATIONS AND DEFINITIONS

AC	Auckland Council
AEE	Assessment of Environmental Effects
AT	Auckland Transport
AUP	Auckland Unitary Plan (Operative in Part)
BH	Borehole
CIRIA	Construction Industry Research and Information Association
CPT	Cone Penetration Test
CRLL	City Rail Link Limited
CSA	Construction Support Area
ECBF	East Coast Bays Formation
GNS	Geological and Nuclear Sciences
GSMCP	Groundwater and Settlement Management and Contingency Plan
K	Hydraulic conductivity
NES	National Environmental Standard
NPS	National Policy Statement
NZGD	New Zealand Geotechnical Database
PZ	Piezometer
RL	Reduced Level (to Sea Level)
RMA	Resource Management Act
The Project	The new wastewater pipeline between Part 3 – Part 4 Connector Tunnel within 329 Queen Street and P1MH1 within Vincent Street
TMPs	Traffic Management Plans
Watercare	Watercare Services Limited
WSP	WSP New Zealand Limited

EXECUTIVE SUMMARY

Watercare Services Limited (Watercare) are proposing to upgrade the wastewater network within the upper (southern) catchment of Auckland City Centre. This report presents an assessment of dewatering effects in relation to Mayoral Drive Project of the Queen Street Wastewater Diversion Programme.

Mayoral Drive Alignment Project comprises the construction of a wastewater pipeline from Mayoral shaft (Part 3) to the Vincent Shaft at the corner of Mayoral Drive and Vincent Street using trenchless technologies. Open excavations will be required to provide access to the pipeline location for the tunnelling equipment, and this may require dewatering during the construction phase.

The Mayoral Drive Alignment Project includes 6 shafts of which 5 have been assessed for environmental effects associated with construction dewatering. Shaft (P5MH1) has been excluded as it does not require dewatering because groundwater levels are deeper than the excavation. All shafts are proposed to be supported with post and panel walls; although, other construction methods may also be used such as sheet piling and/or secant bored piles

The dewatering of the shaft excavations is assessed as a **restricted discretionary activity** under the provisions of the Auckland Unitary Plan (AUP) and a specialist assessment is required as part of the resource consent application process. The activities are thus classified in terms of Activity Table E7.4.1 AUP as:

- *(A20) – Dewatering or groundwater level control associated with a groundwater diversion authorised as a restricted discretionary activity under the Unitary Plan, not meeting permitted activity standards or is not otherwise listed.*
- *(A28) – The diversion of groundwater caused by any excavation, (including trench) or tunnel that does not meet the permitted activity standards or not otherwise listed.*

Existing site investigations indicates thick layers of fill in places, underlain by holocene alluvial river deposits in places and in-turn underlain by residual soils from the East Coast Bays Formation (ECBF) grading into ECBF siltstone and mudstone. Ground models and numerical groundwater models were developed for all 5 shafts to assess the effects of dewatering. The models incorporate the aforementioned geological layers and simulates groundwater flows and levels in response to dewatering under conservative conditions, i.e., conditions that would result in more impact than expected. The settlement modelling and assessments were based on the results of modelling of groundwater drawdown due to dewatering using coupled modelling software. Expected mechanical settlement assessed by ENGEO was superimposed on the settlement assessment results to derive a total expected settlement due to the proposed construction activities.

The results of the assessment indicate negligible effects on neighbouring bores, nearby environmental features (streams and other surface water bodies) and water quality effects from saline intrusion.

The dewatering of the shafts required for access for the tunnelling equipment and pipes for the gravity main may result in land settlement because of the change in pore pressure during dewatering. The settlement analysis indicated that the estimated settlement from the dewatering of the shafts would cause only negligible damage to the nearby buildings:

The maximum settlement is estimated to be 20 mm at the Grand Millennium underpass (within the road reserve of Mayoral Drive), with differential settlement estimated to be approximately 1:250.

The maximum settlement is estimated to be 20 mm at 48 Greys Avenue, with negligible differential settlement.

Minor damage is possible at any of these sites, however it is recommended that groundwater level and settlement monitoring measures and a management plan be implemented near the P4MH2 and P5MH2 shafts, to help manage this risk. This proactive approach will enable the prompt detection of any groundwater drawdown that exceeds what is expected, so that necessary mitigation measures can be implemented prior to damage from settlement effects from the proposed works occurring. Furthermore, it is important to conduct specific investigations and management for existing utilities and services located within 10 m of the shafts. This focused attention on nearby infrastructure will ensure the protection and uninterrupted functionality of these services during the dewatering process.

1 INTRODUCTION

Watercare is proposing to upgrade the existing wastewater network of the upper (southern) catchment of Auckland City Centre. The current network has insufficient capacity to meet future needs based on increased development in the area. The wider programme of works has been split into separate parts for the purpose of design, consenting and construction. The consenting and construction packages of the Queen Street programme are shown in Figure 1-1.

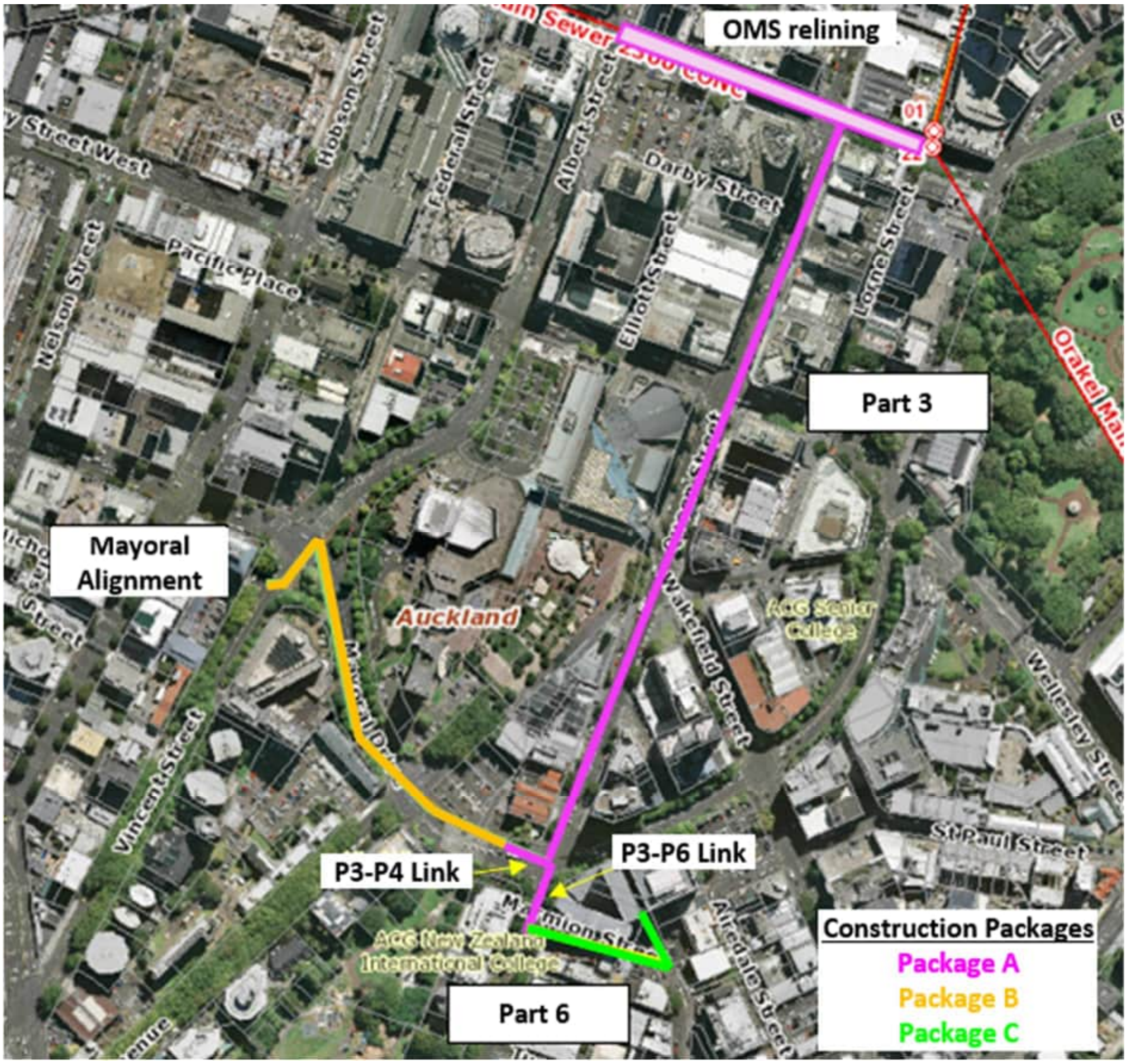


Figure 1-1: Queen Street Wastewater Diversion Programme

The Mayoral Drive alignment involves a new wastewater pipe within or adjacent to the road reserve of Mayoral Drive. The works proposed under this consent ('the Project') include a 375mm – 700mm diameter wastewater pipeline between the P4MH3 shaft within 329 Queen Street and the P1MH1 shaft within Vincent Street (Figure 2-1 below), along with connections to 'engineered overflow points' ('EOPs') and manholes.

1.1 PURPOSE OF THIS REPORT

The purpose of this report it is to provide an assessment of dewatering effects in relation to the Mayoral Drive Alignment Project (Package B) required to support a resource consent application.

2 DESCRIPTION OF EXISTING ENVIRONMENT

The following provides a description of the existing environment applicable to the resource consent application.

2.1 LOCATION AND PHYSICAL ENVIRONMENT

The project is located within Auckland City Centre, on a section of Mayoral Drive between Queen Street and Vincent Street/Cook Street, along with a short extension within Vincent Street (Figure 2-1). In addition, the project works will also occur within a surface carpark at 34-38 Greys Avenue and 329 Queen Street. The Construction Support Area (CSA) site will contain both a section of the proposed wastewater pipeline and the CSA for the Queen Street programme[1].

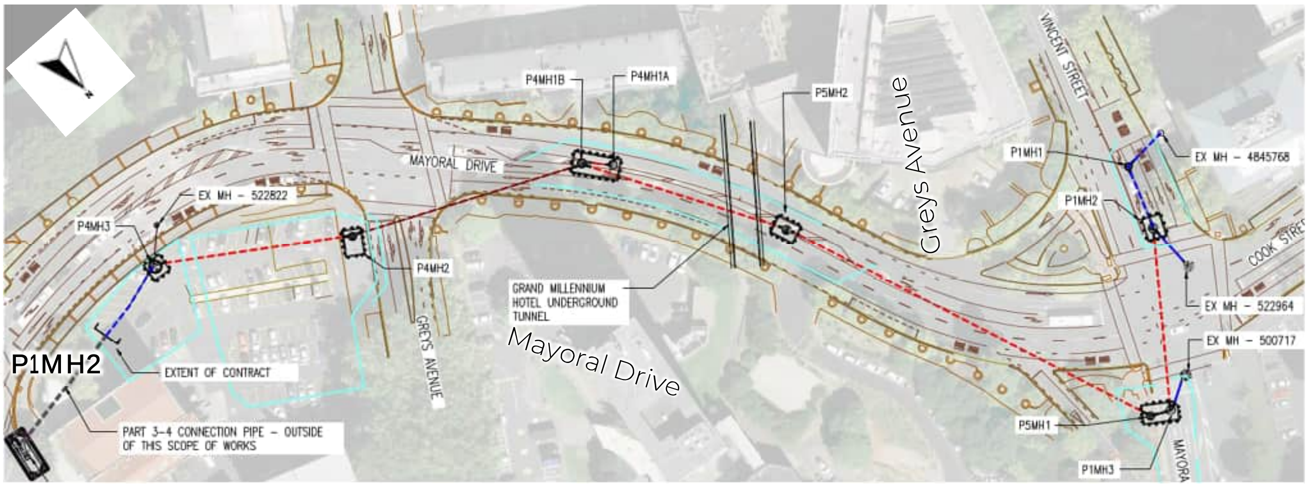


Figure 2-1: Project area

Mayoral Drive is an arterial road linking Wellesley Street, Cook Street and Queen Street and is generally five lanes in width with a painted central median strip. Vincent Street is a typical two-lane tree-lined street that connects Pitt Street and Mayoral Drive.

The land use surrounding the project area is typified by medium and high-density development containing apartments, offices, accommodation, education facilities and entertainment, with retail predominantly occupying the ground level of most buildings. The area contains a combination of heritage and special character buildings and modern buildings. The Auckland Civic Precinct is located a short distance to the north and contains a range of landmarks including Auckland Town Hall, Aotea Square, Aotea Centre and the former Civic Administration building, which has been recently renovated and converted into apartments.

[1] The CSA at 34-38 Greys Avenue and 329 Queen Street has been established under the 'Part 3' consent and retained for the Mayoral Drive alignment construction works.

2.2 NATURAL ENVIRONMENT

The Mayoral Drive shafts are located within a broad valley that contains Myers Park, an inner-city green space. There are no natural streams or rivers within the area[2], but there are some overland flow paths indicated on the Auckland Council Geomaps, including through Myers Park.

There are no wetlands or other ecosystems mapped in the area.

2.3 NATURAL HAZARDS

Auckland Council Geomaps indicate that the low-lying areas of Myers Park are within the flood plain. These are also associated with the overland flow paths as indicated.

2.4 HISTORIC HERITAGE

Myers Park is indicated as a historic heritage site with a historic landscape, including trees and the caretaker's cottage. The caretaker's cottage is at least 200 m from the Mayoral Drive shafts.

2.5 GEOLOGY

2.5.1 REGIONAL GEOLOGY

The published geological map information (Edbrooke, 2001) indicates the Mayoral Drive Shafts are underlain by the East Coast Bays Formation (ECBF), Waitematā Group, comprising alternating sandstone and mudstone with variable volcanic content and interbedded volcaniclastic grits. This is typically considered the basement rock in the area.

There are no faults mapped in the area.

2.5.2 LOCAL GEOLOGY

Eight (8) geotechnical bores were drilled and geologically logged as part of the Mayoral Drive project. Borelogs are presented in the WSP Queen Street Wastewater Diversion – Parts 1-4-5, Geotechnical Factual Report (WSP, 2023).

WSP site-specific investigations revealed that the alignment is underlain by a mixture of fill, underlain by alluvium in places, and further underlain by ECBF residual and rock formations. Observed alluvium within the area of the site was not reported by Edbrooke (2001), however. In addition, onsite data was used to better define the geology around the pit area, which includes geological information from NZGD and relevant property files. This information was incorporated into five ground models developed as sections to undertake drawdown and settlement assessments. These ground models are presented and discussed further in Section 5 below.

[2] The Waihorotiu Stream formerly ran from Myers Park along the Queen Street Valley to the Waitematā Harbour, however this stream was piped in the late 19th century.

2.6 HYDROGEOLOGY

It is generally considered that a dual groundwater system occurs in the City Centre, with a shallow perched, or near surface, aquifer system in the residual soils and a deeper, regional groundwater system within the basement ECBF (T+T, 2017; PDP, 2016; Link Alliance, 2021). This has also been noted in several of the geotechnical studies conducted for various construction projects, including the City Rail Link Limited (CRLL) project (PDP, 2016). The shallow perched aquifer system is considered laterally discontinuous and is typically perched on top of low hydraulic conductivity sediments. The ECBF comprises interbedded sandstone and mudstone and groundwater flow is associated with secondary porosity as a result of jointing and fracturing.

2.6.1 GROUNDWATER LEVELS

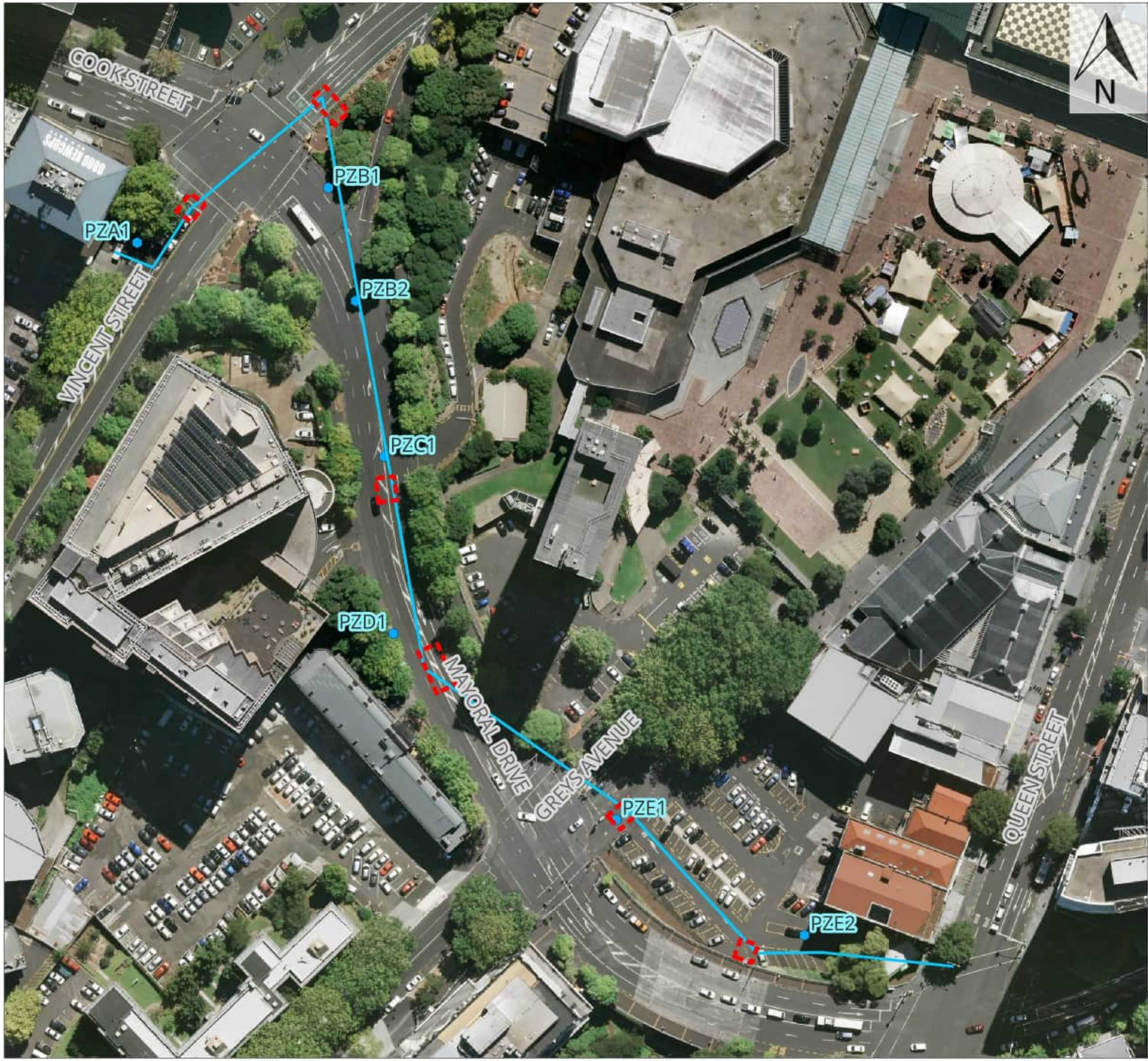
Groundwater level information is needed to assess possible inflows of groundwater to the shafts during construction and to determine the extent of drawdown required to dewater each shaft. Groundwater level measurements were taken and loggers (i.e., automatic pressure transducers) were deployed in PZB2, PZC1, PZD1, PZE1 and PZE2 as part of the monitoring for the Mayoral Drive Project alignment. In addition, PZA1 and PZB1 were constructed as temporary piezometers and manual water levels were taken. The 8th Geotech borehole did not have a piezometer installed as it was drilled for the Greys Avenue Carpark soil investigation only. Piezometer locations are presented in Figure 2-2.

The groundwater levels for all monitoring piezometers for the period February 2023 to early May 2024 are graphed in Figure 2-3. Groundwater levels for PZE2 for the period September 2023 to March 2024 are presented in Figure 2-3. Rainfall records were taken from the weather station MOTAT EWS (agent #41351), located approximately 4 km southwest from the site. The recorded groundwater levels have been incorporated into the ground model in conjunction with NZGD observations. These form inputs for numerical groundwater modelling in Seep/W. Ground model and Seep/W modelling are discussed in Section 5.

2.6.2 HYDRAULIC CONDUCTIVITY

Rising and falling head tests (i.e., slug tests) were undertaken in 4 of the 5 monitoring bores to understand permeabilities along the Mayoral Drive alignment. The data from these tests was then analysed using the software package Aqtesolve to estimate hydraulic conductivities in m/d. Two analysis methods (Bouwer-Rice, 1976, and Hvorlsev, 1951) were used to estimate hydraulic conductivities. Results are presented in Table 2-2.

Data collected in other Queen St Wastewater Diversion projects was adopted for those formations not tested. This includes data gained from the Part 3-Part 4 Connector and the Part 3 Alignment projects. For ECBF highly weathered rock, hydraulic conductivity data from PZE1 (Part 3-Part-4 Connector Project) was adopted, and for the overlying fill layer, PZ01_S data (Part 3 Project) was adopted.



PROJECT

Watercare Services Limited
Auckland
Queen Street Wastewater Diversion - Mayoral Alignment

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FIGURE

Figure 2-2: Locality map showing piezometer locations for groundwater level monitoring.

PROJECT NUMBER	REVISION DATE	REVISION
W-SL001.04	5 March 2025	R0

ATTRIBUTION

Aerial imagery and Roads sourced from Land Information New Zealand (LINZ) data service and licensed by LINZ for re-use under the Creative Commons Attribution 4.0 International.

LEGEND

LEGEND
- Piezometer

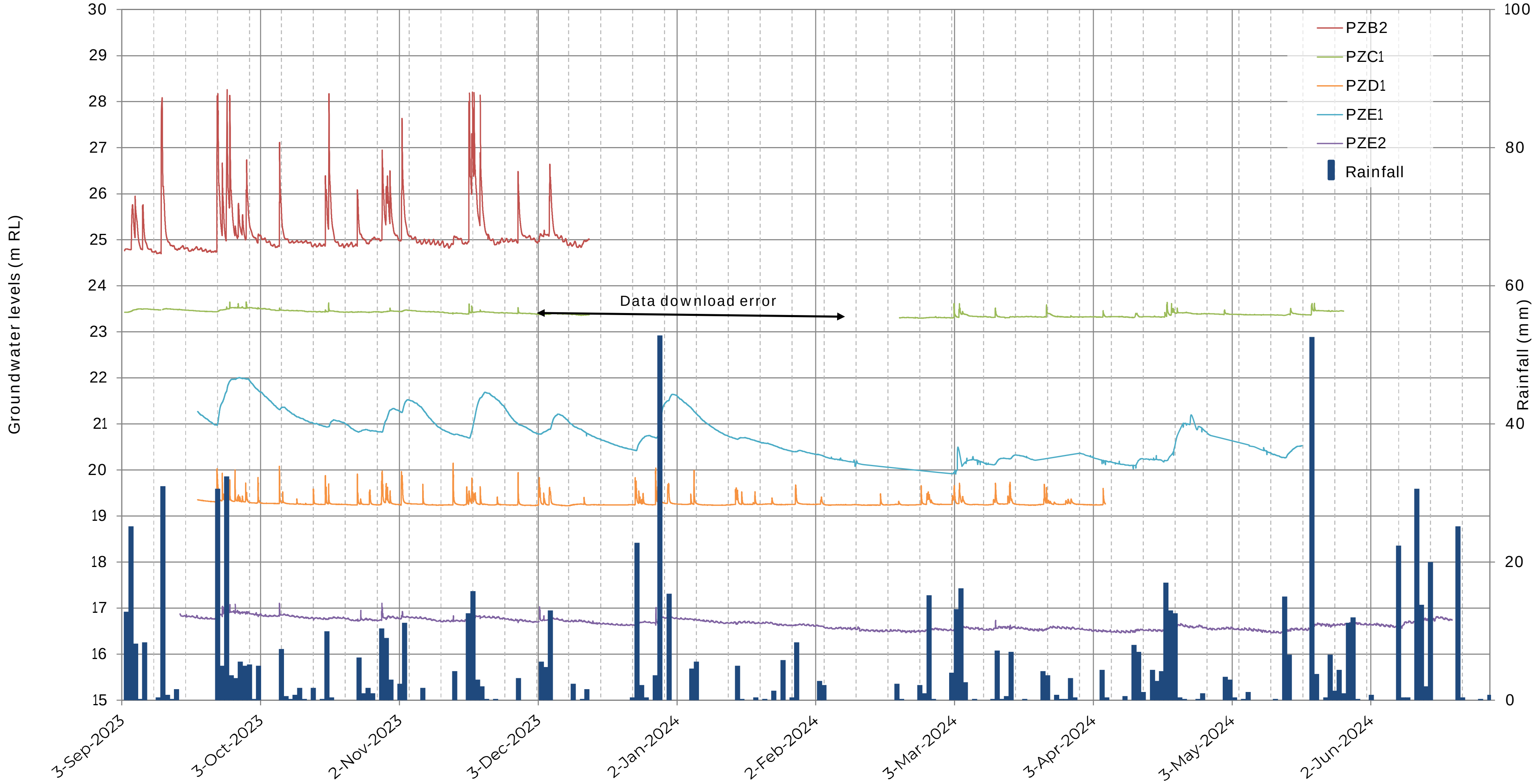
Mayoral alignment
- Pipeline
- Shafts

SCALE

0 25 50 75 m

Table 2- 1: Groundwater level summary information from site investigations.

Piezometer	Bore ID	Easting (m)	Northing (m)	Depth (m bgl)	SWL (m bgl) (Date)	SWL (m RL)	Screen interval (m bgl)	Lithology screened
PZA1	BH23/09	1756960.31	5920074.78	7	5.12 (8 Sept 2023)	29.76	3.85 – 6.85	Puketoka clayey silt and silty clay; Residual soils ECBF clayey silt.
PZB2 - Logged	BH23/07	1757019.36	5920059.04	6.85	5.454 (2 Sept 2023)	24.89	3.85-6.85	Puketoka clayey silt and silty clay; Residual soils ECBF clayey silt.
PZC1 - logged	BH23/06	1757027.06	5920017.03	7.7	4.049 (2 Sept 2023)	23.50	4.7-7.7	Puketoka silty clay and clayey silt; Residual soils ECBF clayey silt grading into highly weathered mudstone.
PZD1 - logged	BH23/05	1757029.56	5919969.20	7.93	6.339 (18 Sept 2023)	19.38	4.93-7.93	Puketoka sandy silt, clayey silt and organic silt.
PZE1 - logged	BH23/04	1757089.81	5919918.94	8	3.433 (18 Sept 2023)	21.39	5-8	Puketoka silty clay and clayey silt; Residual soils ECBF silty sand and silty clay.
PZE2 - logged	BH23/02	1757140.60	5919887.67	8.58	3.2 (15 Sept 2023)	17.20	5.08-8.58	ECBF Sandstone interbedded with mudstone.
PZB1	BH23/08	1757011.9	5920089.59	9	8.175 (28 Aug 2023)	23.49	No screen	Residual soils ECBF clayey silt.



TITLE	Water Level Measurements, September 2023 to May 2024 Queen St Mayoral Alignment Piezometers (m RL)		
DRAWN L. Soltau	DATE 27 May 2023	JOB NO. W-SL001.04	
CHECKED -	SCALE na	DWG. NO. na	
REVIEWED T. Hughes	FILE NO. na	FIGURE NO. na	

Figure 2-3: Groundwater level monitoring for piezometers installed for the Mayoral Drive Alignment Project.

Table 2- 2: Hydraulic Conductivity Testing Results for Mayoral Drive Piezometers.

Well ID	Screening depth (m bgl)	Geology of screened interval	Pre-test water level (m bgl)	Slug testing method	Date time	Test type	Analysis method	K (m/day)	K (m/day) (average)	Notes	Confidence level
PZB2	3.85-6.85	Puketoka clayey silt and silty clay; Residual soils ECBF clayey silt.	5.454	Solid slug	2/9/2023 12:00	Falling head	Bouwer-Rice	0.006	0.00725	High confidence in data and analysis. Shallow, unconfined aquifer considered the residual ECBF and Puketoka. Base of the aquifer equals the top of the highly weathered ECBF.	High
							Hvorslev	0.008			
					3/09/2023 8:25	Rising head	Bouwer-Rice	0.006			
							Hvorslev	0.009			
PZC1	4.7-7.7	Puketoka silty clay and clayey silt; Residual soils ECBF clayey silt grading into highly weathered mudstone.	4.049	Solid slug	2/9/2023 12:30	Falling head	Bouwer-Rice	0.01	0.011	High confidence in data and analysis. Shallow, unconfined aquifer considered the residual ECBF and Puketoka. The piezometer was screened into the top of the highly weathered ECBF	High
							Hvorslev	0.014			
					3/09/2023 8:35	Rising head	Bouwer-Rice	0.01			
							Hvorslev	0.01			
PZD1	4.93-7.93	Puketoka sandy silt, clayey silt and organic silt.	6.339	Solid slug	18/9/2023 16:00	Falling head	Bouwer-Rice	0.031	0.034	High confidence in data and analysis. Shallow, unconfined aquifer considered the Puketoka. Base of the aquifer equals the top of the highly weathered ECBF. Higher hydraulic conductivity associated with sandy silt formation that was screened.	High
							Hvorslev	0.055			
					19/9/2023 8:35	Rising head	Bouwer-Rice	0.02			
							Hvorslev	0.03			
PZE1	5-8	Puketoka silty clay and clayey silt; Residual soils ECBF silty sand and silty clay.	3.433	Solid slug	18/9/2023 16:35	Falling head	Bouwer-Rice	0.009	0.00975	High confidence in data and analysis. Shallow, unconfined aquifer considered the residual ECBF and Puketoka. Base of the aquifer equals the top of the highly weathered ECBF.	High
							Hvorslev	0.012			
					19/9/2023 8:45	Rising head	Bouwer-Rice	0.008			
							Hvorslev	0.01			

2.7 ADJACENT STRUCTURES

The structures adjacent to the shaft include residential and commercial buildings and public infrastructure, such as wastewater and stormwater gravity pipelines, which are described in the following sections in relation to the shafts.

2.7.1 BUILDINGS AND STRUCTURES

There are several buildings and structures in the vicinity of the proposed shafts. The property files were reviewed for the buildings of interest, which are outlined below in Table 2-1 with comments accompanying each structure. The structures of interest are also identified in Figure 2-4.

In addition to the buildings, other structures of interest within proximity to the shafts are:

- Myers Park Overbridge and Retaining Structure
- Grand Millennium Underpass

Table 2-1 Building and structures in the vicinity of the shaft.

Building Address	Nearest Shaft	Minimum Distance from the Shaft (m)	Comments
Myers Park Overbridge and Retaining Structure	P4MH3	2	Piled bridge and crib retaining wall
345-361 Queen Street	P4MH3	35	Multistorey building
323-327 Queen Street	P4MH3	20	Multistorey building (Education), historical / heritage classification
48 Greys Avenue	P4MH3	42	Multistorey commercial building
	P4MH2	40	
22 Greys Avenue	P4MH2	48	Multistorey commercial building, connected to the Auckland Town Hall
100 Mayoral Drive	P4MH1	15	Multistorey commercial building
3 Greys Avenue	P4MH1	36	Multistorey commercial building
	P5MH2	38	
71-87 Mayoral Drive	P4MH1	25	Multistorey hotel building (Grand Millennium Hotel)
	P5MH2	12	
Grand Millennium Underpass	P5MH2	1	Pedestrian tunnel approx. 5 m BGL to invert.
67-101 Vincent Street	P1MH2	14	Multistorey commercial building

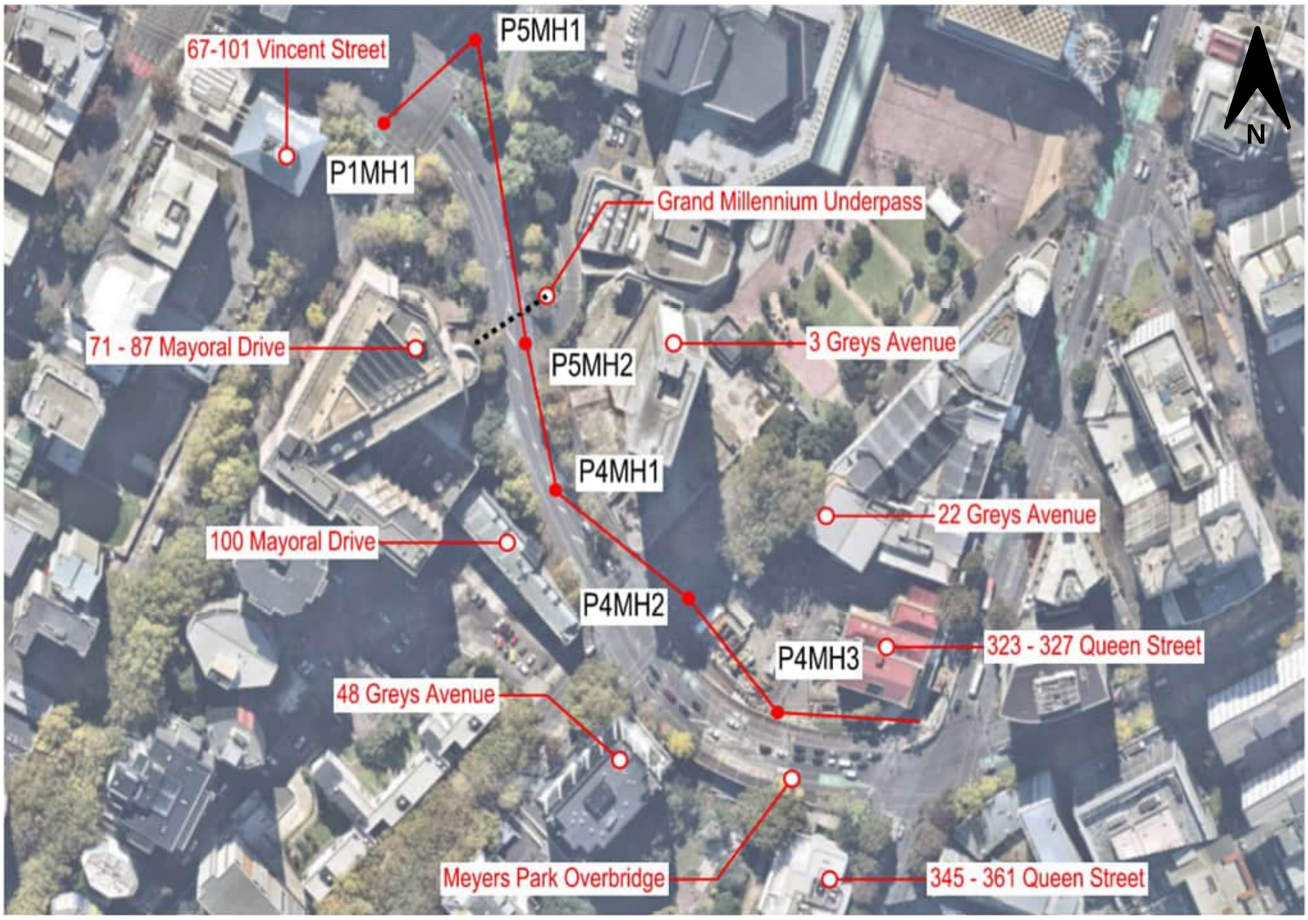


Figure 2-4 Site plan with relevant buildings and structures shown.

2.7.2 UNDERGROUND INFRASTRUCTURE

There are several underground utilities and services present along the project area, including wastewater, potable water, stormwater, and communications. In general, the susceptibility of the buried infrastructure depends on the material (i.e., concrete, steel, etc.) and whether it is a gravity system in the case of stormwater and wastewater systems. To assess the effects, we will specifically consider piped gravity infrastructure. Other notable underground services near the shafts include the Transpower Hobson Street – Penrose transmission line.

Utilities in the vicinity of each shaft are tabulated and presented in Appendix A, including the asset type, material, depth to invert, and diameter, where known. The information was collated from Auckland Council Geomaps and summarised as follows:

- The gravity wastewater and stormwater systems present across the site have a depth to invert varying between 1.5 and 7 m BGL, with some cases being unknown.
- The wastewater pipes include concrete and asbestos concrete, with diameters ranging between 150 and 525 mm.
- The stormwater pipes consist of earthenware, concrete, and asbestos concrete, with diameters ranging between 300 and 1050 mm.

3 NATURE OF WORK (ACTIVITIES) SUBJECT TO ASSESSMENT

The following is a summary of the construction activities to which the resource consent relates. For more details on the nature of the works proposed, refer to the Construction Methodology (**Appendix B**). The Construction Methodology has been based on a likely scenario and has been developed to provide a baseline assessment.

This Project relates to the construction of a new wastewater sewer line within/adjacent to the road corridor of Mayoral Drive, including connections to the existing wastewater network.

The Project will be constructed using a combination of trenchless pilot bore and open-cut trenching excavation, with shafts utilised along the alignment to launch and receive the pilot boring machine. An overview of the proposed construction activities is shown below as Figure 3-1.

To ensure flexibility in the consenting process, a consenting envelope approach has been adopted for all shaft dimensions and the construction compounds. The dimensions specified within the consent allow for changes through the detailed design phase.

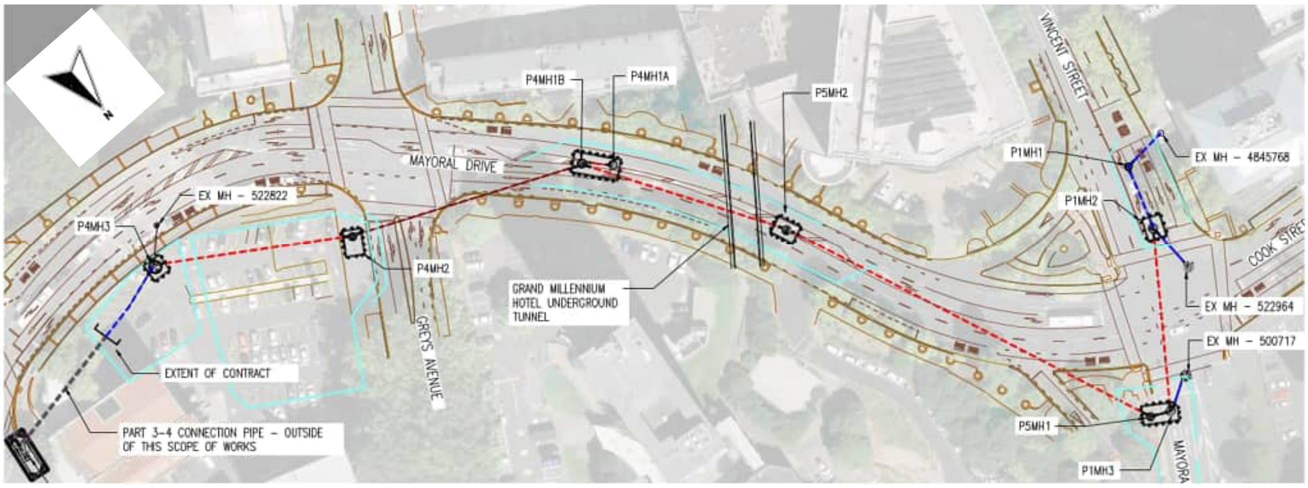


Figure 3-1: Overview of main indicative construction works (red lines are trenchless pipelines, blue are trenched pipelines)

Table provides a high-level overview of the different construction activities and stages, which are provided in greater detail within the Construction Methodology.

Table 3-1: Overview of the different construction activities and stages

Network Utility Relocations	The existing network utilities within and around the proposed shafts will need to be relocated. The exact utilities to be diverted are yet to be confirmed, but will likely include potable water, electricity, wastewater, stormwater and communications. Open-cut progressive trenching will be utilised to relocate any utilities that are required to be relocated. New utilities will be constructed around the proposed shaft locations, and the existing utilities will be removed during shaft construction. Dewatering of the trenches may be required.
Temporary Construction Shafts	Most manhole locations on this alignment will be used as launch/reception pits for the trenchless construction method (axis/pilot bore). Six construction shafts are proposed

	along the Mayoral Drive alignment. The trenchless method requires shafts with maximum internal dimensions of **5.5 m x 12 m** and a maximum depth of **9 m**. The shafts are expected to be constructed using a 'post and panel' type methodology (subject to geotechnical investigations and shaft temporary works design). Refer to Section 3.1 of the Construction Methodology (**Appendix B**) for the steps to construct the temporary shafts.
Trenchless Tunnelling Works	It is proposed to construct the tunnelled sections between manholes P4MH3 (within Greys Avenue Carpark) and P1MH2 (within Vincent Street, opposite the intersection with Mayoral Drive) of the wastewater pipeline using a trenchless pilot-guided boring methodology. Refer to Section 3.2 of the Construction Methodology (**Appendix B**) for more detail of the trenchless tunnelling methodology.
Open Cut Construction Works	Open-cut construction is proposed for two short sections of the proposed pipeline between the shafts for P4MH3 and the P3-P4 Connector Tunnel within 329 Queen Street, and between P1MH1 and the shaft within Vincent Street. Open-cut construction is also proposed for network tie-ins and connections to existing EOPs. Refer to Section 4 of the Construction Methodology (**Appendix B**) for more detail of the trenchless tunnelling methodology.
Construction Support Areas	To support the proposed construction activities, a primary CSA will be used within the public carpark at 38 Greys Avenue and 329 Queen Street. This CSA is already set up as part of the approved Part 3 Alignment and will also be utilised for the Part 3 – Part 4 Connector Tunnel consents. The CSA may be reconfigured to respond to the works proposed for the Project. The CSA contains site offices and welfare facilities, along with some limited site laydown and materials storage areas. The indicative site layout for the Greys Avenue CSA is shown below in Figure 3-2 which reflects the set up for Part 3 construction. Three secondary construction compounds (compounds) will be established within the road corridor of Mayoral Drive and Vincent Street to allow for the construction of shafts and to undertake tunnelling works. In addition, the Greys Avenue CSA will be extended into the footpath at Greys Avenue to accommodate the construction of P4MH2. These compounds are expected to be in place for 6 to 8 months. Temporary concrete or steel barriers with hoardings will be constructed around the perimeter of each, with access gates one or both ends. The indicative compound boundaries around the possible shaft envelopes are shown below from Figure 3-3 to Figure 3-5.

Figure 3-2: Indicative Greys Ave CSA layout (looking north-west towards Greys Ave)

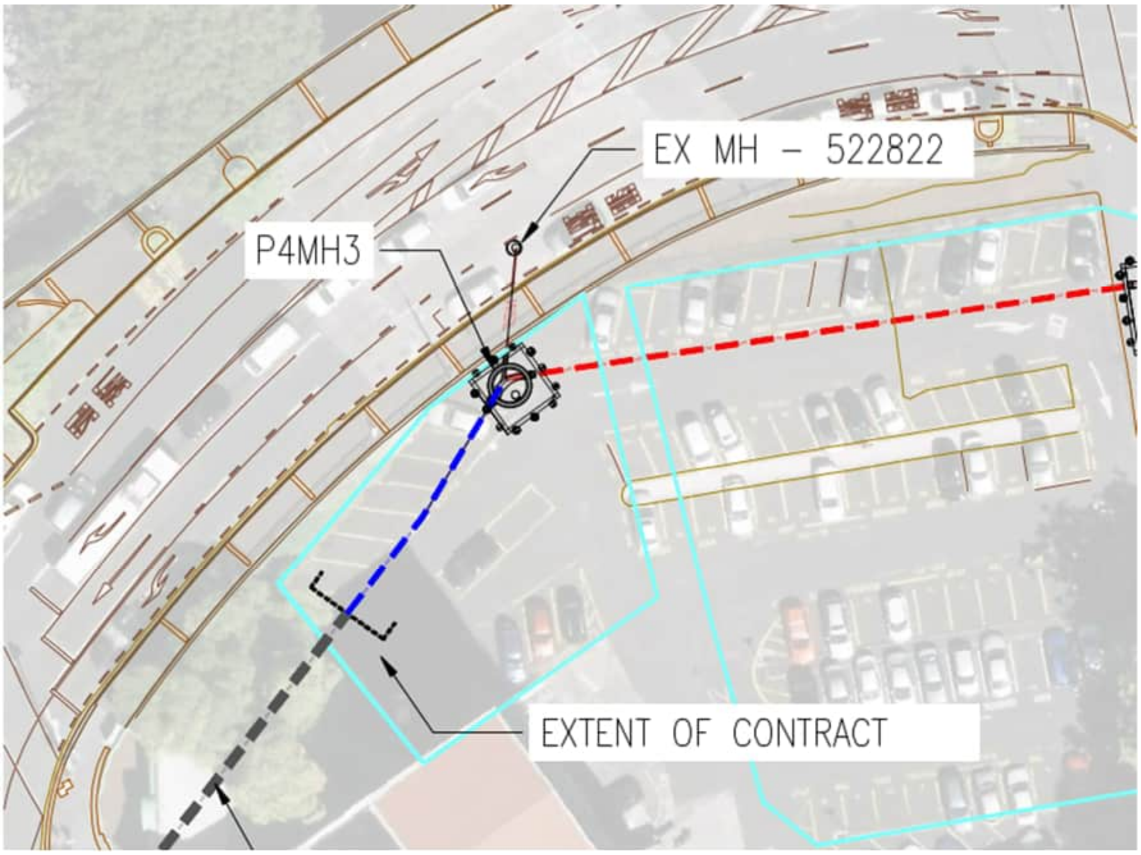


Figure 3-3: Indicative compound around P4MH3 within Greys Ave Carpark (indicative compound extents shown in light blue)

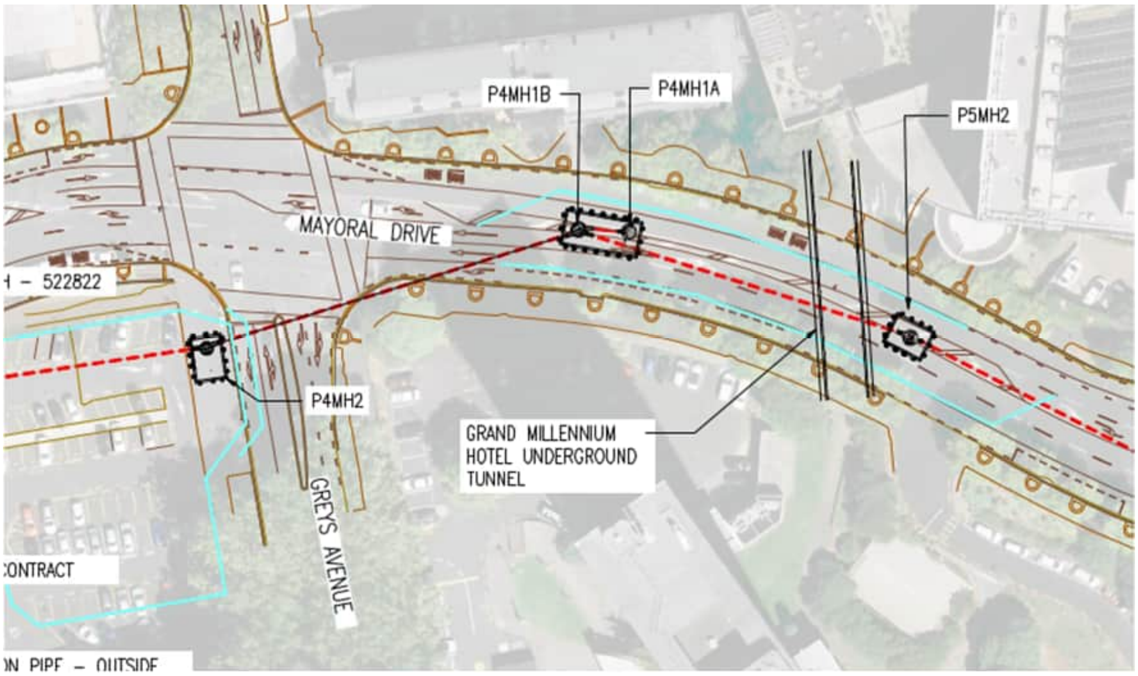


Figure 3-4: Two compounds on Mayoral Drive/Greys Ave outside 299 Queen Street, G05/1 Greys Ave and the CSA in the Greys Ave carpark

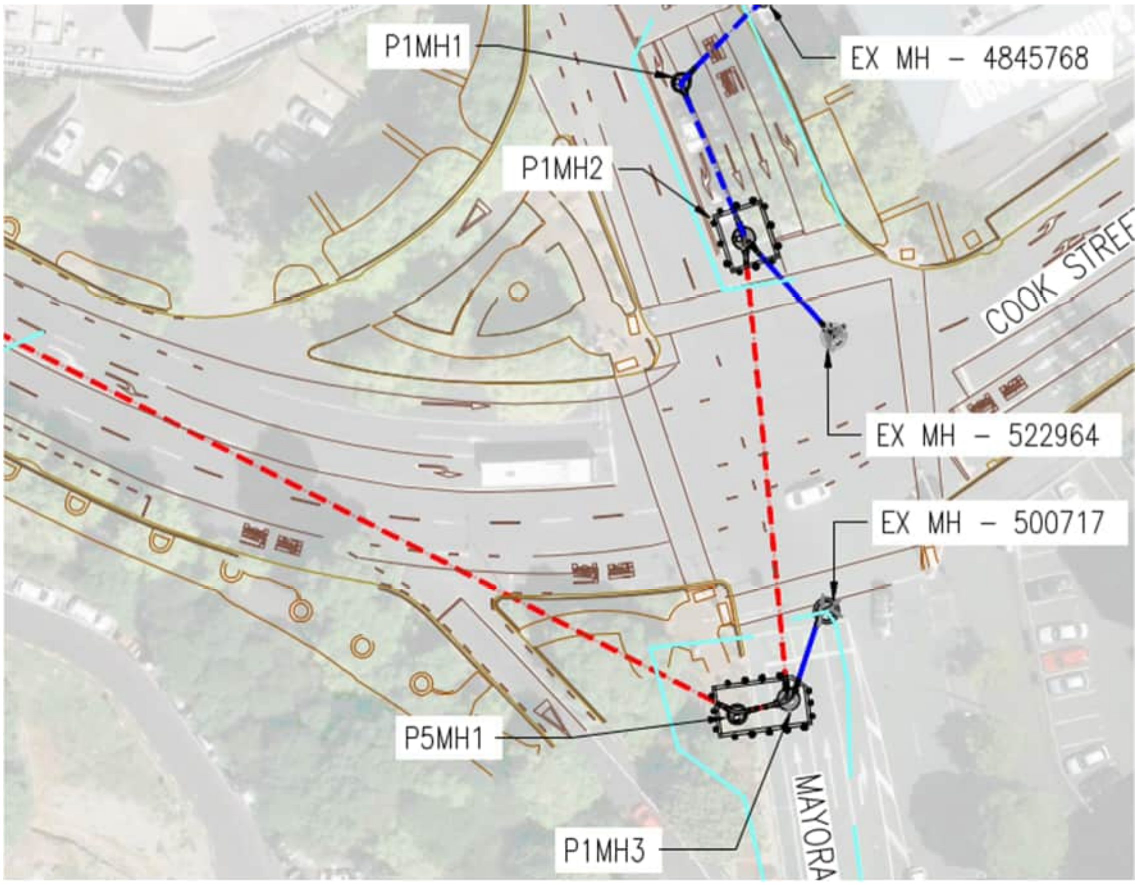


Figure 3-5: Two compounds at Cook St/Mayoral Drive/Vincent St intersection

4 CONSENT RULES TRIGGERED

4.1 INTRODUCTION

Activity Table E7.4 1 of the Auckland Unitary Plan (AUP) specifies the activity status in relation to taking, using, damming and diversion of surface water and groundwater in accordance with section 14(1) and 14(3) of the Resource Management Act 1991 (RMA). The activities summarised in Table 4-1 are considered relevant for the construction of the Mayoral Drive Alignment of the Queen Street Wastewater Diversion Programme.

Activity Table E7.4.1 addresses activity status in terms of All Zones, High-Use Stream Management Areas Overlay or Wetland Management Areas Overlay. The proposed Mayoral Drive Alignment Project is *not* within a High-Use Stream or Wetland Management Areas Overlay, and hence, the activity status is assessed for all zones.

Table 4-1: Relevant Activity Status from Table E7.4.1 of the AUP.

Activity	Activity status
	All Zones
Take and use of groundwater	
(A17) Dewatering or groundwater level control associated with a groundwater diversion permitted under the Unitary Plan	Permitted
(A20) Dewatering or groundwater level control associated with a groundwater diversion authorised as a restricted discretionary activity under the Unitary Plan, not meeting permitted activity standards or is not otherwise listed	Restricted Discretionary
Diversion of groundwater	
(A27) Diversion of groundwater caused by any excavation (including trench) or tunnel	Permitted
(A28) The diversion of groundwater caused by any excavation, (including trench) or tunnel that does not meet the permitted activity standards or not otherwise listed	Restricted Discretionary

The following AUP standards have been assessed to classify the proposed dewatering activity for the proposed Mayoral Drive Alignment Project

Standard E7.6.1.6 – permitted activity standards to divert water for groundwater level control.

Standard E7.6.1.10 – permitted activity standards to divert groundwater due to excavation.

4.2 ASSESSMENT OF ACTIVITY AGAINST THE AUCKLAND UNITARY PLAN STANDARDS.

Table 4-2 and Table 4-3 provide an assessment of the activity against the relevant permitted activity standards (PA) E7.6.1 of the AUP. As mentioned above. the relevant standards are E7.6.1.6 for dewatering or groundwater control and E7.6.1.10 for diversion of groundwater.

Table 4-2 details the assessment of the activity against permitted activity (PA) E7.6.1.6 for dewatering or groundwater control. “Yes” within Table 4-2 indicates the PA standard condition is met. “No” indicates the standard condition is not met, and a comment for clarification is provided. The standard specifies that for the dewatering or groundwater level control to be assessed as permitted, **all** the conditions must be met.

Table 4-3 details the assessment of the activity against permitted activity Standard E7.6.1.10 for diversion of groundwater caused by any excavation (including trench) or tunnel. “Yes” indicates the activity complies with the standard’s condition and “No” indicates the activity does not comply with the standard’s condition.

For both standards (E7.6.1.6 and E7.6.1.10) to be assessed as permitted, all the relevant conditions must be met.

Table 4-2: Assessment Standard E7.6.1.6 – Dewatering or groundwater level control.

Standard	Compliance – Comment						
	P4MH3	P4MH2	P4MH1	P5MH2	P1MH2	Underground utility relocations	Trenching
(1) The water take must not be geothermal water;	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(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; and	No – 240 days of dewatering; no peat expected	No – 240 days of dewatering; no peat expected	No – 240 days of dewatering; no peat expected	No – 240 days of dewatering; no peat expected	No – 240 days of dewatering; no peat expected	Yes, and unlikely any groundwater level control will be required due to shallow depth	No – trenches could be open for longer than 30 days
(3) The water take must only occur during construction.	Yes	Yes	Yes	Yes	Yes	Yes – no water take required	Yes

Table 4-3: Assessment: Standard E7.6.1.10 – Groundwater diversion.

Standard	Compliance – Comment						
	P4MH3	P4MH2	P4MH1	P5MH2	P1MH2	Underground utility relocations	Trenching
(1) All of the following activities are exempt from the Standards E7.6.1.10(2) – (6):							
(a) pipes, cables or tunnels including associated structures which are drilled or thrust and are up to 1.2 m in external diameter;	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Yes	Not applicable
(b) pipes including associated structures up to 1. 5 m in external diameter where a closed faced or earth pressure balanced machine is used;	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Yes	Not applicable
(c) piles up to 1.5 m in external diameter are exempt from these standards;	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
(d) diversions for no longer than 10 days; or	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Yes, no water take required	Yes
(e) 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.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Yes	No
(2) Any excavation that extends below natural groundwater level, must not exceed:							
(a) 1 ha in total area; and	Yes – shaft is 5 m x 5 m	Yes – shaft is 5 m x 7.5 m	Yes – shaft is 5.5 m x 12 m	Yes – shaft is 5. m x 6.5 m	Yes – shaft is 5 m x 9.5 m	Yes	Yes
(b) 6 m depth below the natural ground level.	No – shaft depth is 6.5 m	No – shaft depth is 9 m	No – shaft depth is 9 m	No – shaft depth is 8.5 m	No – shaft depth is 6.5 m	Yes	Yes – all connector pipes requiring open trenching will be less than 6.0 m depth

							with the deepest being approximately 5.0 m bgl.
(3) The natural groundwater level must not be reduced by more than 2 m on the boundary of any adjoining site.	**No** – groundwater level reduction greater than 2.0 at northern adjoining site.	**No** – groundwater level reduction greater than 2.0 at northern adjoining site.	**Yes** – groundwater level reduction is less than 2.0 at adjoining site boundaries.	**No** – groundwater level reduction greater than 2.0 at western adjoining site.	Yes – groundwater level reduction is less than 2.0 at adjoining site boundaries.	Yes– groundwater level reduction is less than 2.0 at adjoining site boundaries.	Yes– groundwater level reduction is less than 2.0 at adjoining site boundaries.
(4) Any structure, excluding sheet piling that remains in place for no 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 20 m; and	Yes – maximum dimensions of the shaft is 5.0 m x 5.0.	Yes – maximum dimensions of the shaft is 5.0 m x 7.5.	Yes – maximum dimensions of the shaft is 5.5 m x 12.	Yes – maximum dimensions of the shaft is 5.0 m x 6.5	Yes – maximum dimensions of the shaft is 5.0 m x 6.0.	Yes	Yes
(b) extend more than 2 m below the natural groundwater level.	**No** – excavation extends approximately 3.15 m below natural groundwater level	**No** – excavation extends approximately 6.00 m below natural groundwater level	**No** – excavation extends approximately 2.66 m below natural groundwater level	**No** – excavation extends approximately 4.30 m below natural groundwater level	Yes – excavation extends approximately 1.50 m below natural groundwater level	Yes – excavations are unlikely to extend below groundwater level	Yes – excavations will extend only 1.0 m bgl at the most
(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;	**No** – Depth of shaft is 6.5 m, distance to overbridge crib wall is less than 1.0 m approximately.	Yes – Depth of shaft is 9.0 m and nearest affected structure is 40 m (48 Greys Avenue)	Yes – Depth of trench is 9.0 m and nearest affected structure is 15 m (100 Mayoral Drive)	**No** – depth of shaft is 8.5 m, distance to Millennium underpass is less than 5.0 m.	Yes – Depth of shaft is 6.5 m and nearest affected structure is 14 m (101 Vincent Street)	Yes	Yes
(b) tunnel or pipe with an external diameter of 0.2 - 1.5 m that extends below natural groundwater level must be 2 m or greater; or	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Yes	Yes
(c) a tunnel or pipe with an external diameter of up to 0.2 m that extends below natural groundwater level has no separation requirement.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
(6) The distance from the edge of any excavation that extends below natural groundwater level, must not be less than:							
(a) 50 m from the Wetland Management Areas Overlay;	Yes – there are no wetlands mapped in the area.	Yes – there are no wetlands mapped in the area.	Yes – there are no wetlands mapped in the area.	Yes – there are no wetlands mapped in the area.	Yes – there are no wetlands mapped in the area.	Yes – there are no wetlands mapped in the area.	Yes – there are no wetlands mapped in the area.
(b) 10 m from a scheduled Historic Heritage Overlay; or	Yes – the closest edge of the shaft to the nearest heritage site is 17 m.	Yes – the closest edge of the shaft to the nearest heritage site is 21 m.	Yes – the closest edge of the shaft to the nearest heritage site is 14 m.	Yes – the closest edge of the shaft to the nearest heritage site is 20 m.	Yes – the closest edge of the shaft to the nearest heritage site is 57 m.	Yes	Yes
(c) 10 m from a lawful groundwater take.	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Based on the AUP, the dewatering and diversion of groundwater caused by any excavation (including trench) or tunnel that does not meet the permitted activity standards is a restricted discretionary activity. The assessment of permitted activity standards for dewatering and diversion of the Mayoral Drive Alignment works is as follows:

Table 4-2 and Table 4-3 demonstrate that permitted standards E7.6.1.6(2) and E7.6.1.10.(2b, 3,4b) cannot be met. A restricted discretionary resource consent is therefore required under:

- Activity Rule E7.4.1 (A20) Take and use of groundwater for dewatering
- Activity Rule E7.4.1 (A28) Diversion of groundwater caused by any excavation (including trench) or tunnel that does not meet the permitted activity standards

The matters of discretion for assessment of the restricted discretionary activity are summarised in Table 4-4 (based on Table E7.8.1 in the AUP).

Table 4-4: E7.8.1 Assessment – Restricted discretionary activities. Matters of discretion for (6) diversion of groundwater.

Matters of Discretion	Comment
(a) how the proposal will avoid, remedy or mitigate adverse effects:	
(i) on the base flow of rivers and springs;	Not applicable – No rivers or springs occur in proximity to the works
(ii) on levels and flows in wetlands;	Not applicable – No wetlands occur in proximity to the works
(iii) on lake levels;	Not applicable – No lakes occur in proximity to the works
(iv) on existing lawful groundwater takes and diversions;	To be assessed
(v) on groundwater pressures, levels or flow paths and saline intrusion;	To be assessed
(vi) from ground settlement on existing buildings, structures and services including roads, pavements, power, gas, electricity, water mains, sewers and fibre optic cables;	To be assessed
(vii) arising from surface flooding including any increase in frequency or magnitude of flood events;	To be assessed
(viii) from cumulative effects that may arise from the scale, location and/or number of groundwater diversions in the same general area;	To be assessed
(ix) from the discharge of groundwater containing sediment or other contaminants;	Managed via consent condition through on-site treatment (settlement tanks) prior to discharge of water.
(x) on any scheduled historic heritage place; and	Not applicable
(xi) on terrestrial and freshwater ecosystems and habitats.	To be assessed

Matters of Discretion	Comment
(b) the need for mineral extraction within a Special Purpose - Quarry Zone to carry out dewatering or groundwater level control and diversion and taking of groundwater in the context of mineral extraction activity.	Not applicable – site is not a quarry operation
(c) monitoring and reporting requirements incorporating, but not limited to:	
(i) the measurement and recording of water levels and pressures;	To be confirmed pending settlement analysis
(ii) the measurement and recording of the settlement of the ground, buildings, structures and services	To be confirmed pending settlement analysis
iii) the measurement and recording of the movement of any retaining walls constructed as part of the excavation or trench; and	To be confirmed pending settlement analysis
(iv) requiring the repair, as soon as practicable and at the cost of the consent holder, of any distress to buildings, structures or services caused by the groundwater diversion.	To be confirmed pending settlement analysis
(d) the duration of the consent and the timing and nature of reviews of consent conditions;	Proposed consent conditions
(e) the requirement for and conditions of a financial contribution and/or bond; and	Not applicable
(f) the requirement for a monitoring and contingency plan or contingency and remedial action plan.	To be confirmed pending settlement analysis

5 ASSESSMENT METHODOLOGY

5.1 GENERAL

The preliminary assessment of the activity against the AUP standards (presented in Section 4 of this report) for dewatering and diversion of groundwater (E7.6.1.6 and E7.6.1.10) has been completed using the existing information presented in Sections 2 and 3 to determine which of the proposed works comply with permitted activity standards and which require consenting under the AUP. The preliminary assessment indicated:

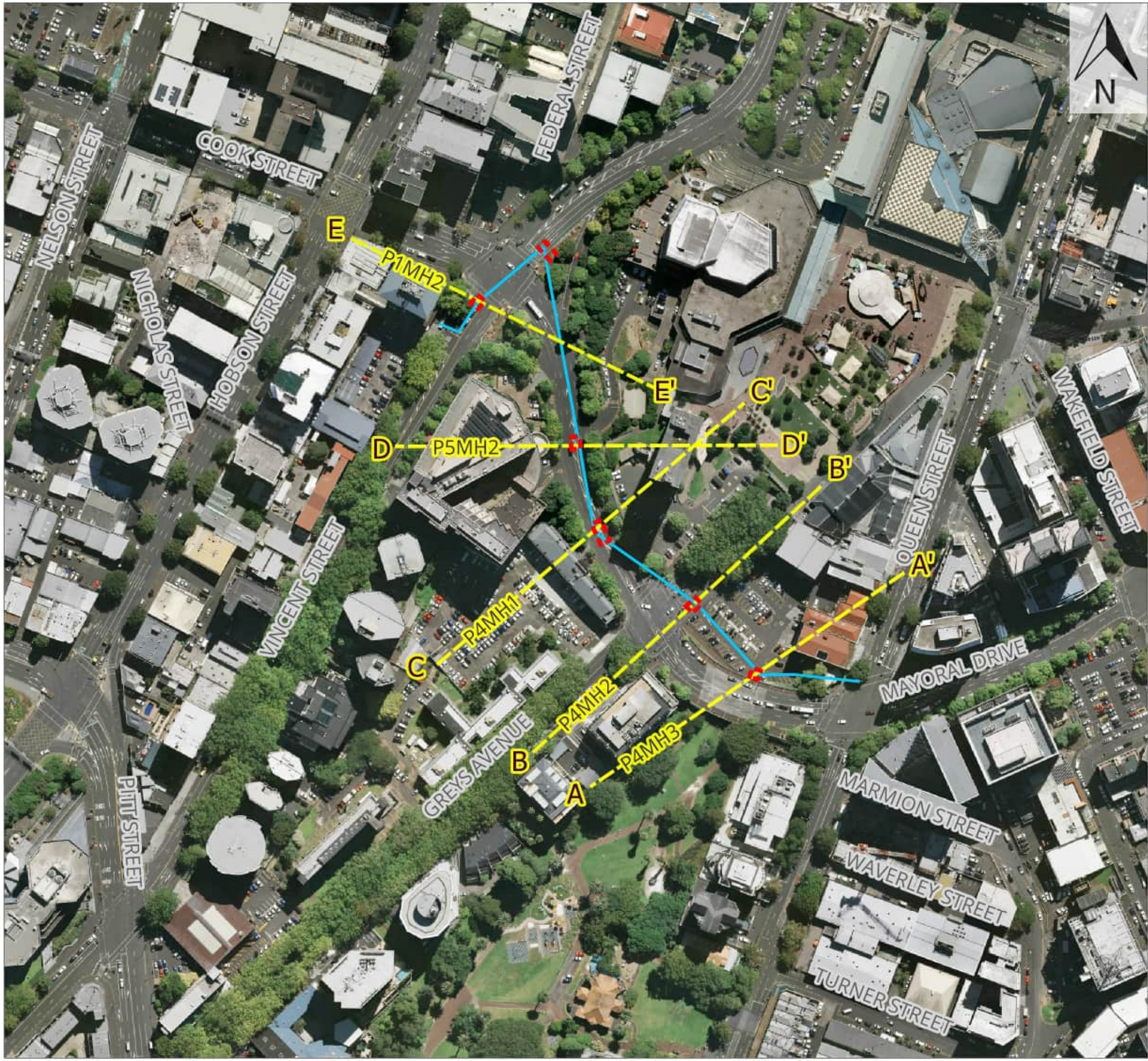
- The trenchless pipe installation using Pilot Guided Boring is exempted from assessment based on AUP standard E7.6.1.10(a).
- The dewatering and diversion during construction of the Mayoral Shafts access does not comply with all permitted activity standards for dewatering and diversion (E7.6.1.6 and E7.6.1.10) and will thus require a resource consent for dewatering and diversion, which will require specialist assessment for dewatering.
- Some service relocations and proposed trenching for connector pipes to the manholes will likely be open for more than 30 days, however not all service relocations and trench sections will be open for this long and service works are yet to be confirmed in detail. No service relocations nor open trenching will require groundwater to be drawdown more than 2.0 m (as per Standard E7.6.1.10(3)) and therefore will not require specialist assessment for groundwater drawdown or settlement effects.

To assess potential effects associated with dewatering and groundwater drawdown, WSP developed several ground models and cross-sectional numerical groundwater models. The set up and testing of these models are described in this section. The effects assessment results are presented in Section 6.

5.2 GROUND MODEL

The groundwater and settlement modelling are based on a ground model inferred primarily on the investigations near the shaft locations. Five (5) ground models were prepared on critical cross-sections passing through or close to the nearest structures. Their locations are presented in Figure 5-1. Shaft P5MH1 does not require an assessment because the depth of groundwater in the immediate vicinity is below the depth of excavation, hence no dewatering is required during construction. Ground models for each of the 5 shafts are presented in Figures 4-2 through to 4-6. The ground models were developed from the existing site information, GNS Webmaps and the NZGD database. In addition, property file information was used to further define the local geology:

- Mayoral Drive Overbridge (Auckland City Council, 1972). The logs of four boreholes drilled at the corners of the existing Mayoral Drive underpass are available along with a plan with their locations. The boreholes extended between 9 and 12 m bgl. All the bores encountered extremely to very weak ECBF at approximately 6 m to 10 m bgl.
- Myers Park Geotechnical Investigation Report (GHD, 2020). It contains the findings of one machine borehole to 13 m depth, three shallow CPTs to 4.5 m depth and the findings of investigations undertaken by Riley (2015), comprising 18 no. hand auger holes.



PROJECT

Watercare Services Limited
Auckland
Queen Street Wastewater Diversion - Mayoral Project

WSP Auckland
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Level 3, The Westhaven
100 Beaumont Street
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FIGURE

Figure 5-1: Site plan and cross sections used for 2D cross sectional modelling.

PROJECT NUMBER	REVISION DATE	REVISION
W-SL001.04	13 Jan 2025	R0

ATTRIBUTION

LEGEND

LEGEND
Cross-sections
Mayoral alignment
Pipeline
Shafts

SCALE

0 50 100 150 m

Original Sheet Size: A4 [W = 297, H = 210]   Plot Date: 2025-06-27 18:28:12 by Soltau, Louise (NZLS30680)   File Ref: U:\ProjectsNZ\3a\3-AWE40.00 Queen Street WW Diversions\Home\98_Hydrogeology\GIS\Mayoral\Mayoral_Base.qgz

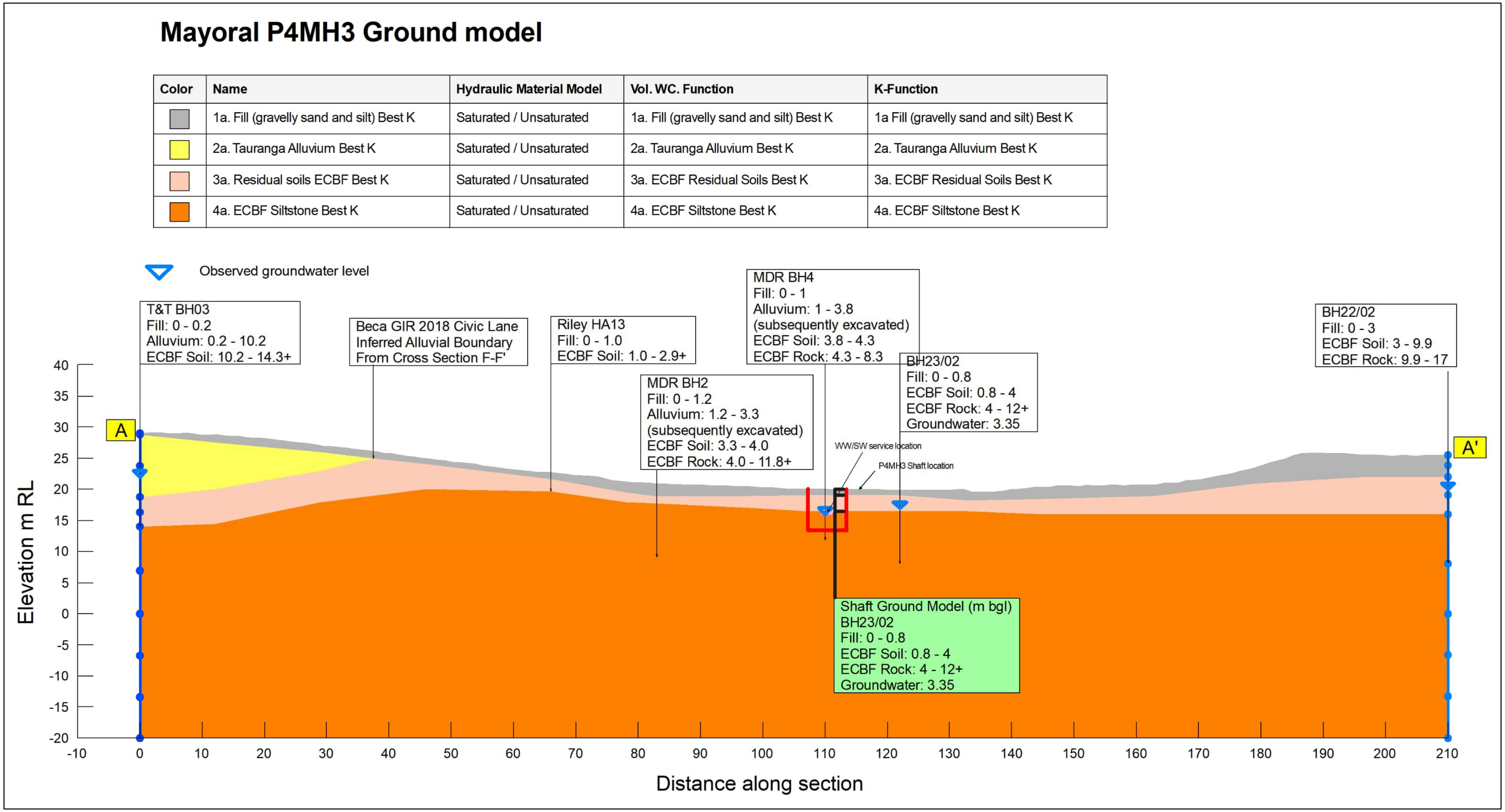


Figure 5-2: P4MH3 ground model cross section (all depths recorded in text boxes are in m bgl).

Mayoral P4MH2 ground model

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function
(grey)	1a. Fill (gravelly sand and silt) Best K	Saturated / Unsaturated	1a. Fill (gravelly sand and silt) Best K	1a Fill (gravelly sand and silt) Best K
(yellow)	2a. Tauranga Alluvium Best K	Saturated / Unsaturated	2a. Tauranga Alluvium Best K	2a. Tauranga Alluvium Best K
(pale pink)	3a. Residual soils ECBF Best K	Saturated / Unsaturated	3a. ECBF Residual Soils Best K	3a. ECBF Residual Soils Best K
(orange)	4a. ECBF Siltstone Best K	Saturated / Unsaturated	4a. ECBF Siltstone Best K	4a. ECBF Siltstone Best K

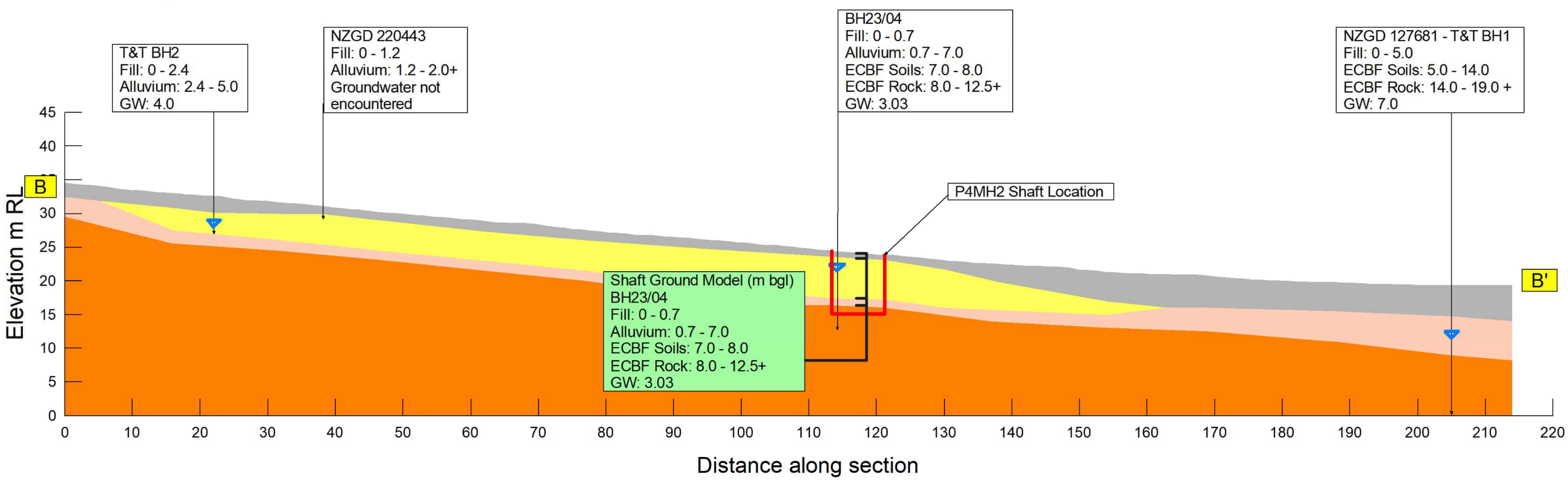


Figure 5-3: P4MH2 ground model cross section (all depths recorded in text boxes are in m bgl).

Mayoral P4MH1 ground model

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function
	1a. Fill (gravelly sand and silt) Best K	Saturated / Unsaturated	1a. Fill (gravelly sand and silt) Best K	1a Fill (gravelly sand and silt) Best K
	2a. Tauranga Alluvium Best K	Saturated / Unsaturated	2a. Tauranga Alluvium Best K	2a. Tauranga Alluvium Best K
	3a. Residual soils ECBF Best K	Saturated / Unsaturated	3a. ECBF Residual Soils Best K	3a. ECBF Residual Soils Best K
	4a. ECBF Siltstone Best K	Saturated / Unsaturated	4a. ECBF Siltstone Best K	4a. ECBF Siltstone Best K

Observed groundwater levels

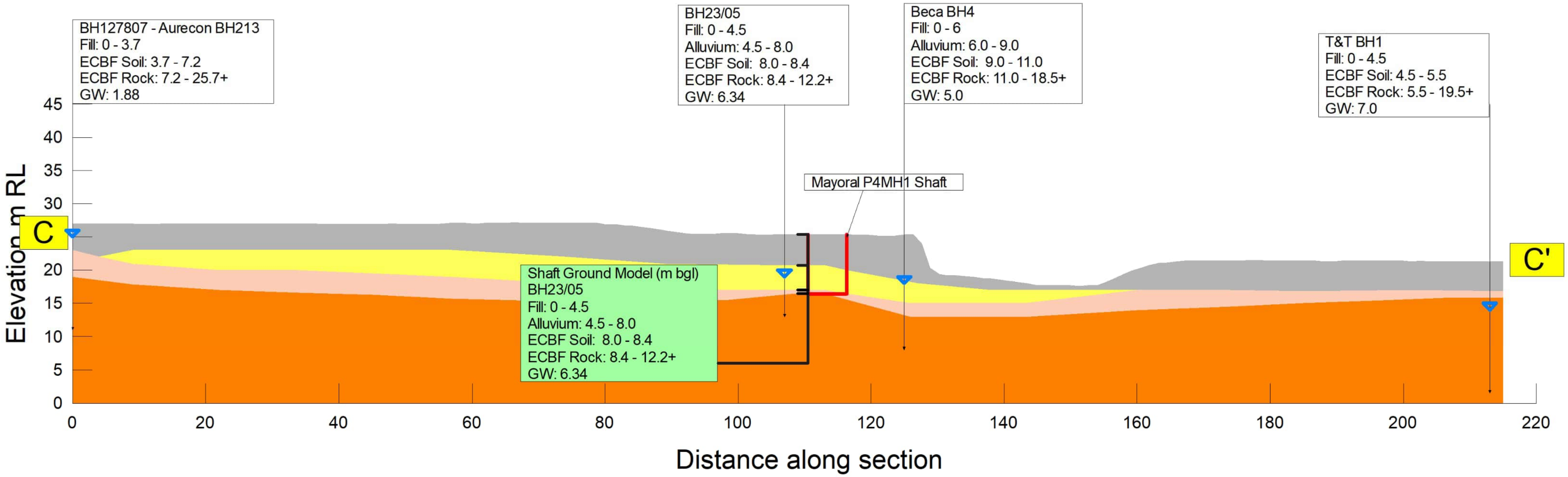


Figure 5-4: P4MH1 ground model cross section (all depths recorded in text boxes are in m bgl).

Mayoral P5MH2 ground model

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function
	1a. Fill (gravelly sand and silt) Best K	Saturated / Unsaturated	1a. Fill (gravelly sand and silt) Best K	1a Fill (gravelly sand and silt) Best K
	3a. Residual soils ECBF Best K	Saturated / Unsaturated	3a. ECBF Residual Soils Best K	3a. ECBF Residual Soils Best K
	4a. ECBF Siltstone Best K	Saturated / Unsaturated	4a. ECBF Siltstone Best K	4a. ECBF Siltstone Best K

Observed groundwater levels

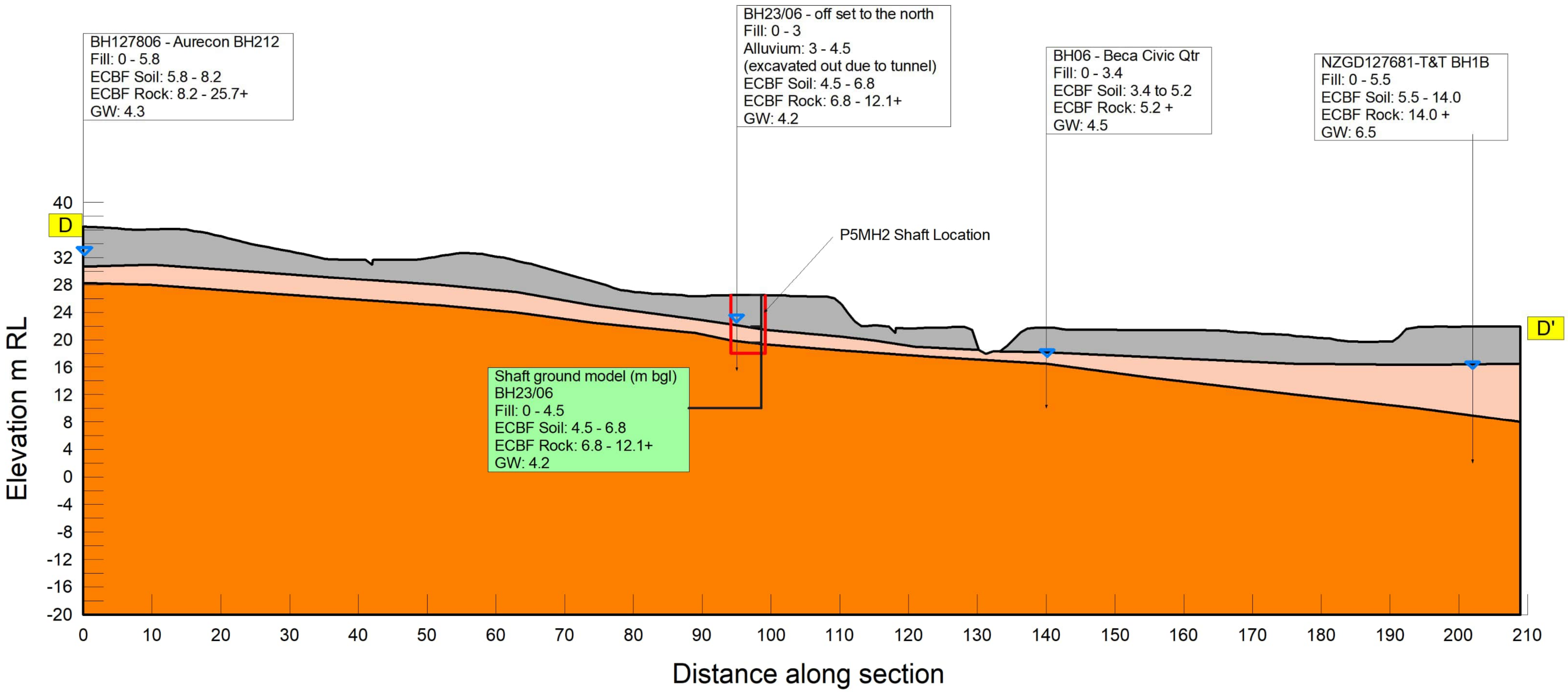


Figure 5-5: P5MH2 ground model cross section (all depths recorded in text boxes are in m bgl).

Mayoral P1MH2 ground model

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function
(grey)	1a. Fill (gravelly sand and silt) Best K	Saturated / Unsaturated	1a. Fill (gravelly sand and silt) Best K	1a Fill (gravelly sand and silt) Best K
(yellow)	2a. Tauranga Alluvium Best K	Saturated / Unsaturated	2a. Tauranga Alluvium Best K	2a. Tauranga Alluvium Best K
(pink)	3a. Residual soils ECBF Best K	Saturated / Unsaturated	3a. ECBF Residual Soils Best K	3a. ECBF Residual Soils Best K
(orange)	4a. ECBF Siltstone Best K	Saturated / Unsaturated	4a. ECBF Siltstone Best K	4a. ECBF Siltstone Best K

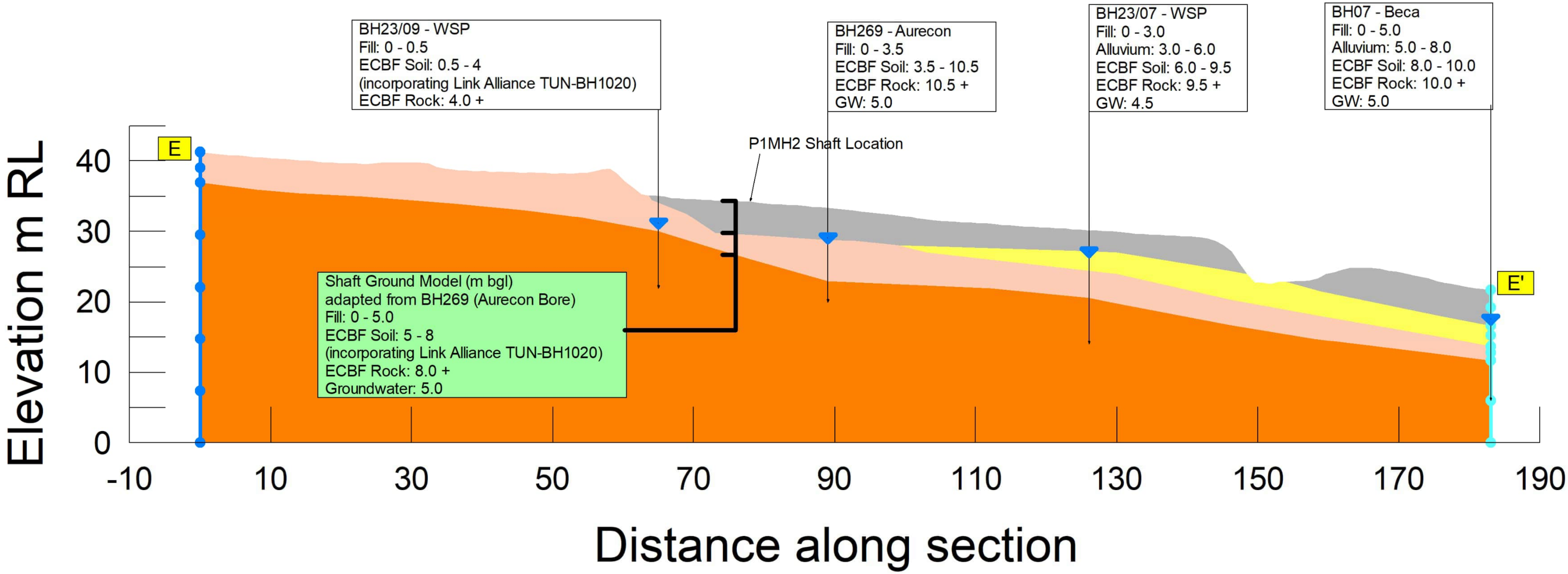


Figure 5-6: P1MH2 ground model cross section (all depths recorded in text boxes are in m bgl).

5.3 GROUNDWATER MODELLING

Cross-sectional groundwater modelling was undertaken to assess groundwater drawdown from dewatering. The resulting groundwater drawdowns were subsequently used for settlement modelling to assess effects from dewatering of the Mayoral Shafts during construction works.

The dewatering induced groundwater drawdown during construction of the access shafts for the Pilot Guided Boring Machine has been modelled using a cross-sectional numerical groundwater model that was developed using SEEP/W. SEEP/W is a finite element numerical modelling software for groundwater flow in porous media, developed by Seequent (2021). SEEP/W can model simple saturated steady-state problems or sophisticated transient analyses accounting for saturated and unsaturated groundwater flow.

Groundwater modelling was not deemed to be required for the relocation of utilities as part of the construction works. The utility relocation will typically be in shallow excavations (up to 3 m deep), which are unlikely to intersect groundwater and will thus not require dewatering.

5.3.1 HYDROSTRATIGRAPHY

A hydrostratigraphic unit can be defined as a part of a body of rock that forms a distinct hydrologic unit with respect to the flow of groundwater (Maxey, 1964). It is a body of lithological material that have specific hydraulic properties that govern groundwater flow within the unit and is distinct from the properties of adjacent units.

The Ground Model as described in Section 5.2 and historically observed groundwater level point data has been used to define the hydrostratigraphic units as summarised in Table 4- 1 below.

Table 5- 1: Hydrostratigraphic unit interpretation for the Mayoral Shaft locations and adjacent surrounds.

Hydrostratigraphic units	Description	Thickness range (m)
Fill	Clayey silt, silty clay, and silt	1 - 10
Tauranga Alluvium	Clayey silts, silty clays	1 – 10.0
Residual soils ECBF	Fine sand, silty fine sand, and silt	1 - 10
ECBF rock	Weathered, very weak sandy siltstones, mudstones and sandy silt stones	> 30 m

5.3.2 MODELLING APPROACH AND SETUP

Cross-sectional models have been developed across the Mayoral Shaft excavations. The sections for the models are shown in Section 5.1 above. Note the following details on the model set-up:

Shaft locations are presented in Figure 5-1 above.

The shaft dimensions are presented in Table 5.2 below

Shaft walls are post and panel and are generally unsupported and will let groundwater seepage through.

Constant head boundary conditions were applied at the lateral limits of the models to represent regional groundwater levels given the geology and elevation. The groundwater head boundaries were estimated based on observed groundwater levels across the section length obtained from WSP field investigations and desktop information (NZGD and property files) and are presented in the ground model sections above. The constant head boundary details are presented in Table 4-3 below.

Table 4-2: Access shaft dimension details.

Shaft/Manhole ID	Width (m)	Length (m)	Depth (m)	Duration that shaft is open
P4MH3	5	5	6.5	6 to 8 months
P4MH2	5	7.5	9	6 to 8 months
P4MH1	5.5	12	9	6 to 8 months
P5MH2	5	6.5	8.5	6 to 8 months
P1MH2	5	6	6.5	6 to 8 months

Table 4-3: Constant Head Boundary Levels (m RL)

Shaft/Manhole ID	Section End	Level (m RL)	Section End	Level (m RL)
P4MH3	A	20	A’	22
P4MH2	B	29.5	B’	10
P4MH1	C	25	C’	14
P5MH2	D	32	D’	16.5
P1MH2	E	35	E’	17

A seepage face boundary condition has been applied to the excavation bottom and sides to simulate the effect of dewatering the access shafts. The seepage face boundary removes any groundwater that would seep into the excavation. It is assumed that the flows are low and that the shaft base will be dewatered using sump pumps to a low point in the pit until the base is sealed with concrete.

The hydraulic conductivity (K) values were obtained from field testing and are presented in Table 4-4 below. These values are termed “Best Estimate” as they represent the most likely hydraulic conductivity values. However, they have been varied by one order of magnitude in the modelling to understand the sensitivity of drawdown to a range of different parameters values.

Table 4- 4: Hydraulic Conductivity (K) Values for "Best Estimate" Scenarios (m/d)

Shaft/Manhole ID	K – Fill (m/d)	K – Alluvium (m/d)	K – ECBF Residual Soils (m/d)	K - ECBF mudstone/sandstone (m/d)
P4MH3	0.005	0.01	0.02	0.07
Value obtained from	PZ01-S field test	PZE1 – field test	PZ02-S field test	PZE2 field test
P4MH2	0.005	0.01	0.02	0.07
Value obtained from	PZ01-S field test	PZE1 – field test	PZ02-S field test	PZE2 field test
P4MH1	0.005	0.03	0.02	0.07
Value obtained from	PZ01-S field test	PZD1 – field test	PZ02-S – field test	PZE2 field test
P5MH2	0.005	0.01	0.02	0.07
Value obtained from	PZ01-S field test	PZC1 – field test	PZ02-S – field test	PZE2 field test
P1MH2	0.005	0.01	0.02	0.07
Value obtained from	PZ01-S field test	PZC1 – field test	PZ02-S – field test	PZE2 field test

Rainfall recharge boundaries have not been applied to the model to provide for a more conservative assessment (introducing groundwater recharge would dampen draw down effects).

A maximum dewatering period of 240 days will be applied. Shafts are likely to open less than this as tunnelling progresses from shaft to shaft.

To avoid water ponding at the surface within low lying points in the topography (valleys), it is assumed that any groundwater seepage at the surface is removed by stormwater drains within these low lying valley areas (such as Greys Avenue carpark in section P4MH3 and the council carpark on the north side of Mayoral Drive along P4MH1 and P5MH2 sections). The presence of these stormwater drains have been confirmed from council records.

5.3.3 SENSITIVITY ANALYSIS

A sensitivity analysis was undertaken to assess uncertainties in assumed hydraulic parameters and the lateral extent of the geological profile. The following cases were investigated for the Mayoral shaft excavations:

Best estimate case represents the hydraulic conductivity (K) values obtained from the nearest piezometer. This is considered the most likely case.

High-K case: represents the highest conceivable hydraulic conductivity and is 1 magnitude higher than has been used in the base case.

Low-K case: represents the lowest estimated hydraulic conductivity which is 1 magnitude lower than the base case.

The three cases listed above will result in three different groundwater level drawdowns, representing a range of possible groundwater drawdown gradients to be considered in the effects assessments.

5.4 SETTLEMENT MODELLING

Land settlement can occur from dewatering activities resulting from the change in porewater pressure from drawdown and mechanical displacements from soil relaxation around temporary trench supports and shafts. Adjacent structures and services can be affected when differential settlement exceeds certain thresholds.

Dewatering-induced settlement modelling was undertaken in Geostudio version 23.1.0.520 using SIGMA/W which was coupled with SEEP/W that simulates the groundwater drawdown from dewatering. Temporary works designers (ENGEO) evaluated the mechanical displacements independently, and those results where superimposed on the dewatering settlements in the coupled modelling mentioned above to estimate the total settlement.

The analyses indicated settlements throughout the full length of the cross-section following 50 days of dewatering.

5.4.1 MODEL SETUP AND INPUTS

The SIGMA/W model was set up along the same cross-section as the dewatering model, using the ground models in Section 5.2. The parameters used for the settlement modelling are presented in Table 5-1, as recommended in the Queen Street Part 1-4-5 Geotechnical Interpretive Report (WSP, 2024), which were based on a combination of laboratory testing, insitu-testing and engineering judgement.

Table 5-1 Material parameters used for the SIGMA/W model setup.

Material Name	**Unit Weight (kN/m^3)**	**Young's Modulus (MPa)**	**Poisson's Ratio**	**Friction Angle (º)**	**Drained Cohesion c' (kPa)**
Fill	17	5	0.3	28	2
Tauranga Group Alluvium	17	9	0.3	28	5
Residual soils ECBF	18	12	0.3	32	3
ECBF SILTSTONE	22	200	0.3	35	100

For the dewatering-induced settlement, only the High-K case was considered, as this corresponded to the most significant dewatering-induced settlement. The Low-K case results in less dewatering and less associated settlement, however it often also leads to a steeper cone of depression and higher differential settlement. On this project, there are no sensitive structures close to the shafts and the cones of depression for the low-K case were not observed to be particularly steep, so the dewatering settlement was calculated for the high-k case only.

The sections have been cut along the critical sections relative to the infrastructure near the shaft. The cross-sections analysed were generally non-symmetrical on either side of the shafts and, therefore, the dewatering-induced settlement along either side of the shaft has been presented for completeness. The mechanical settlement (assessed by ENGEO) has been assumed to be uniform around the shafts, considering the zone of influence.

The settlement results are presented in Section 6.2 and settlement effects are discussed in Section 7.4.

6 TECHNICAL ANALYSIS

6.1 DEWATERING ANALYSIS

Groundwater level drawdowns create a cone shape during abstraction, with the greatest drawdown adjacent to the excavation and ever-less drawdown further from the excavation. As described above, land settlement can occur from dewatering activities and groundwater level drawdown, and affect nearby structures or services, particularly if the degree of settlement differs across the site. Settlement that differs across the site is referred to as differential settlement and damage is most likely to occur where differential settlements are greatest. Because of the difference in drawdown with distance from the shaft, consolidation settlement is expected to be differential. In addition, mechanical settlement due to deflections of the shaft excavations will occur in proximity of the shafts.

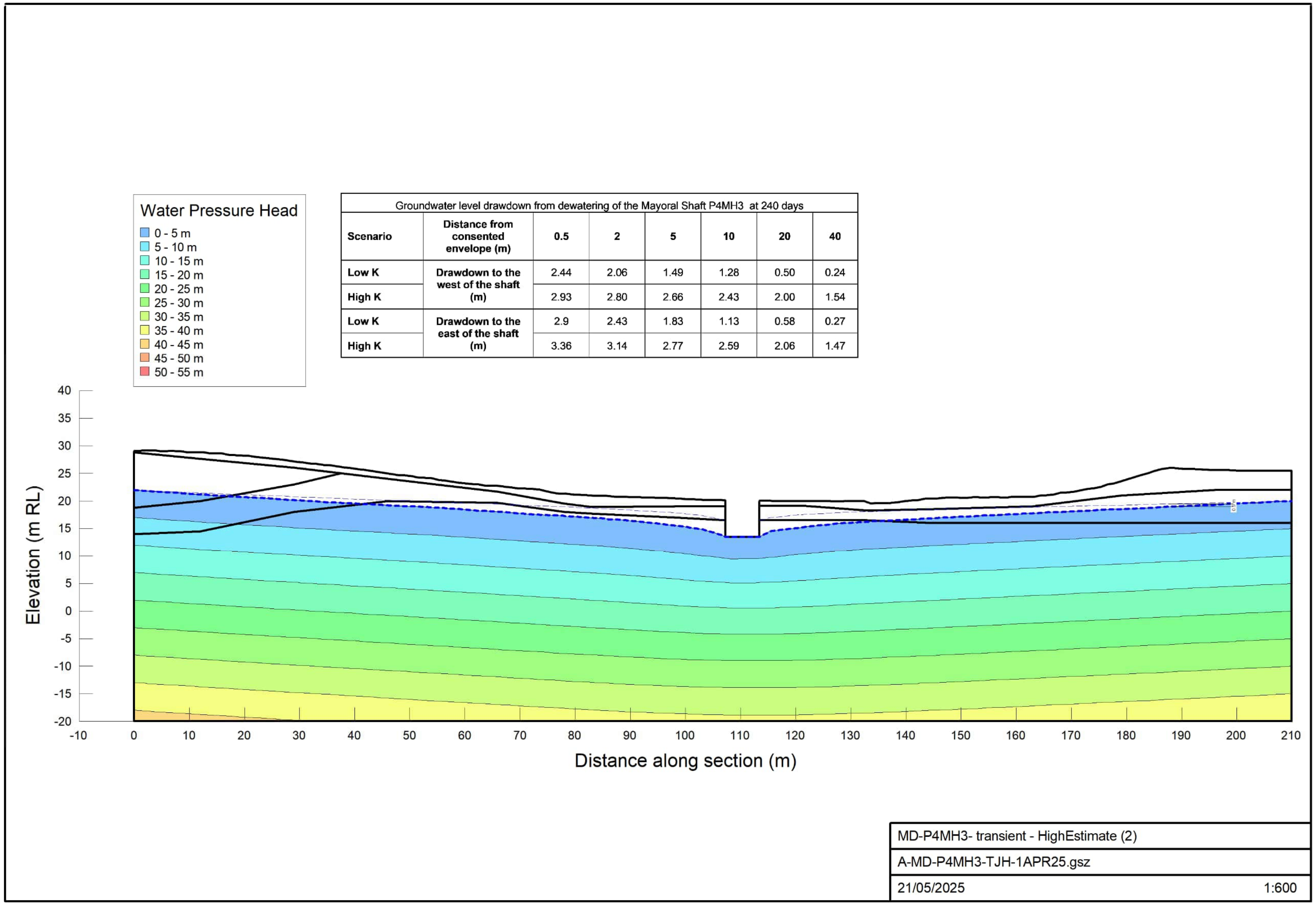
The modelled groundwater level drawdown from dewatering of the Mayoral Shafts along the assessment cross sections are presented in Figures 5-1 to 5-6 for the best estimate case of hydraulic parameter values. A table of drawdowns at selected distances along the section moving out from the sides of the shaft is included in the title block. This table shows how the drawdowns range between the cases of high and low hydraulic conductivity values, which indicates the sensitivity of the assessment. Generally, the sections using the higher hydraulic conductivities are presented for drawdown as they will typically generate a more extensive drawdown cone.

Key matters to note in relation to dewatering and groundwater level drawdown from the dewatering of the Mayoral Shafts are as follows:

1. Dewatering rates are presented in Table 5-1. The maximum dewatering rate for the high-K case after one day of dewatering is 63 m^3/day for Shaft P5MH2. These rates will decline over time and the 240-day dewatering rate for the high-K case is 35 m^3/day.

Table 5- 1: Groundwater dewatering rates.

Shaft	Discharge (m^3/day)	
	Day 1	Day 240
P4MH3	56	28
P4MH2	54	18
P4MH1	35	13
P5MH2	63	35
P1MH2	9	4

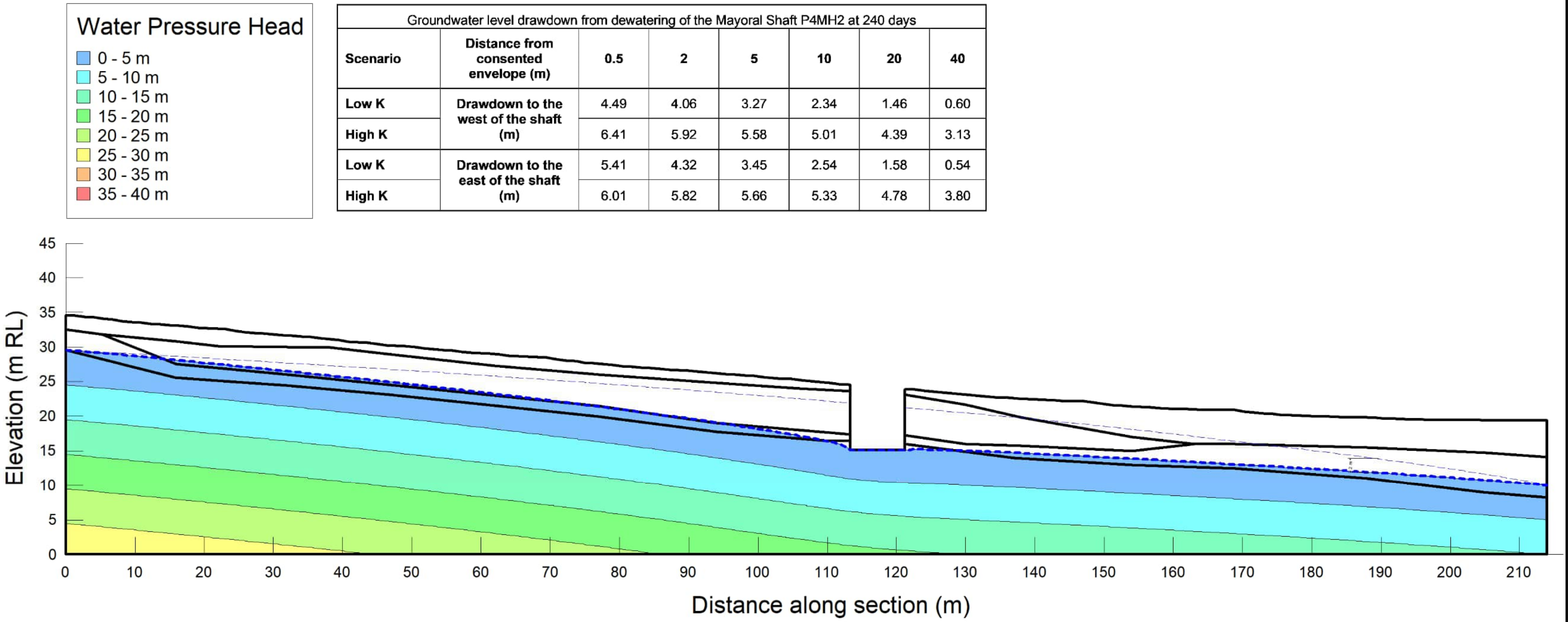


Groundwater level drawdown from dewatering of the Mayoral Shaft P4MH3 at 240 days

Scenario	Distance from consented envelope (m)	0.5	2	5	10	20	40
Low K	Drawdown to the west of the shaft (m)	2.44	2.06	1.49	1.28	0.50	0.24
High K		2.93	2.80	2.66	2.43	2.00	1.54
Low K	Drawdown to the east of the shaft (m)	2.9	2.43	1.83	1.13	0.58	0.27
High K		3.36	3.14	2.77	2.59	2.06	1.47

Figure 5- 1: High K estimate case groundwater drawdown for the P4MH3 Shaft.

Groundwater level drawdown from dewatering of the Mayoral Shaft P4MH2 at 240 days							
Scenario	**Distance from consented envelope (m)**	**0.5**	**2**	**5**	**10**	**20**	**40**
Low K	**Drawdown to the west of the shaft (m)**	4.49	4.06	3.27	2.34	1.46	0.60
High K		6.41	5.92	5.58	5.01	4.39	3.13
Low K	**Drawdown to the east of the shaft (m)**	5.41	4.32	3.45	2.54	1.58	0.54
High K		6.01	5.82	5.66	5.33	4.78	3.80



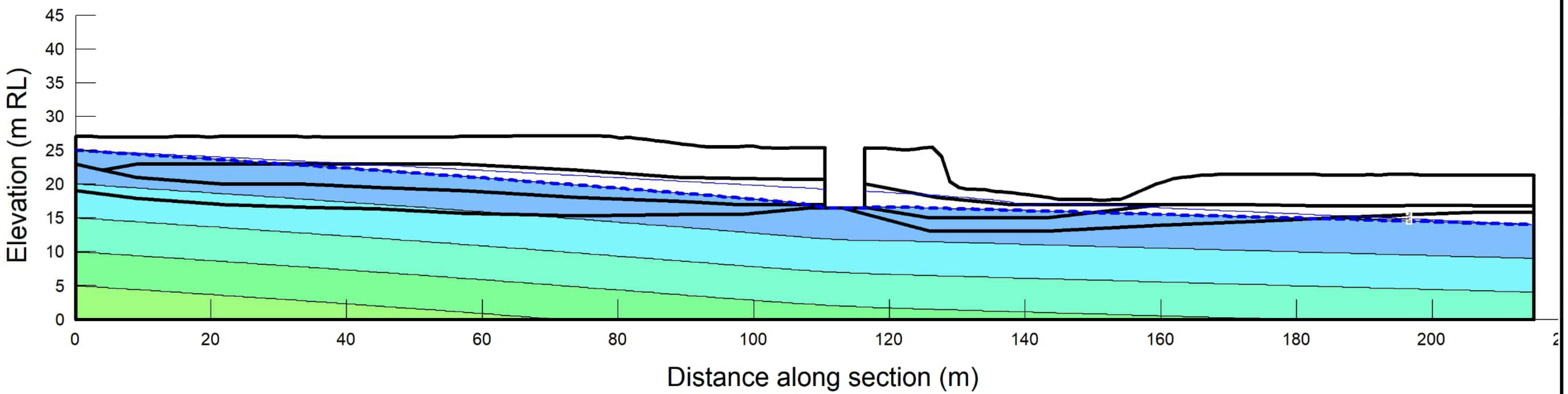
MD-P4MH2 Transient High K
B-MD-P4MH2-TJH.gsz
30/04/2025 1:600

Figure 5- 2: High K estimate case groundwater drawdown for the P4MH2 Shaft.

Water Pressure Head
- 0 - 5 m
- 5 - 10 m
- 10 - 15 m
- 15 - 20 m
- 20 - 25 m
- 25 - 30 m
- 30 - 35 m
- 35 - 40 m
- 40 - 45 m

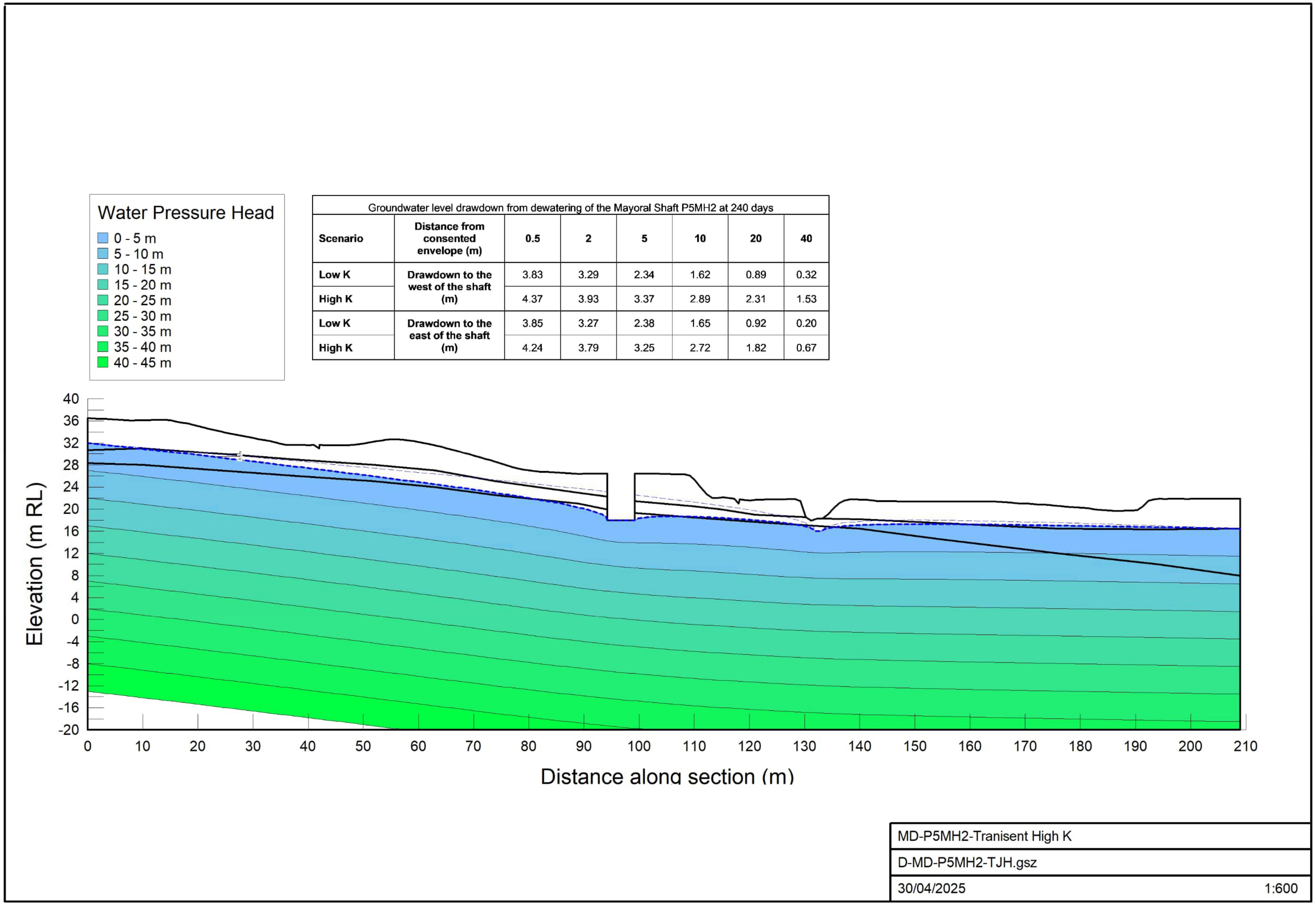
Groundwater level drawdown from dewatering of the Mayoral Shaft P4MH1 at 240 days

Scenario	Distance from consented envelope (m)	0.5	2	5	10	20	40
Low K	Drawdown to the west of the shaft (m)	2.09	1.79	1.36	0.97	0.57	0.24
High K		31.9	2.46	2.29	1.99	1.77	1.37
Low K	Drawdown to the east of the shaft (m)	2.08	1.70	1.31	0.89	0.39	0.10
High K		2.45	2.27	2.12	1.89	1.34	0.99



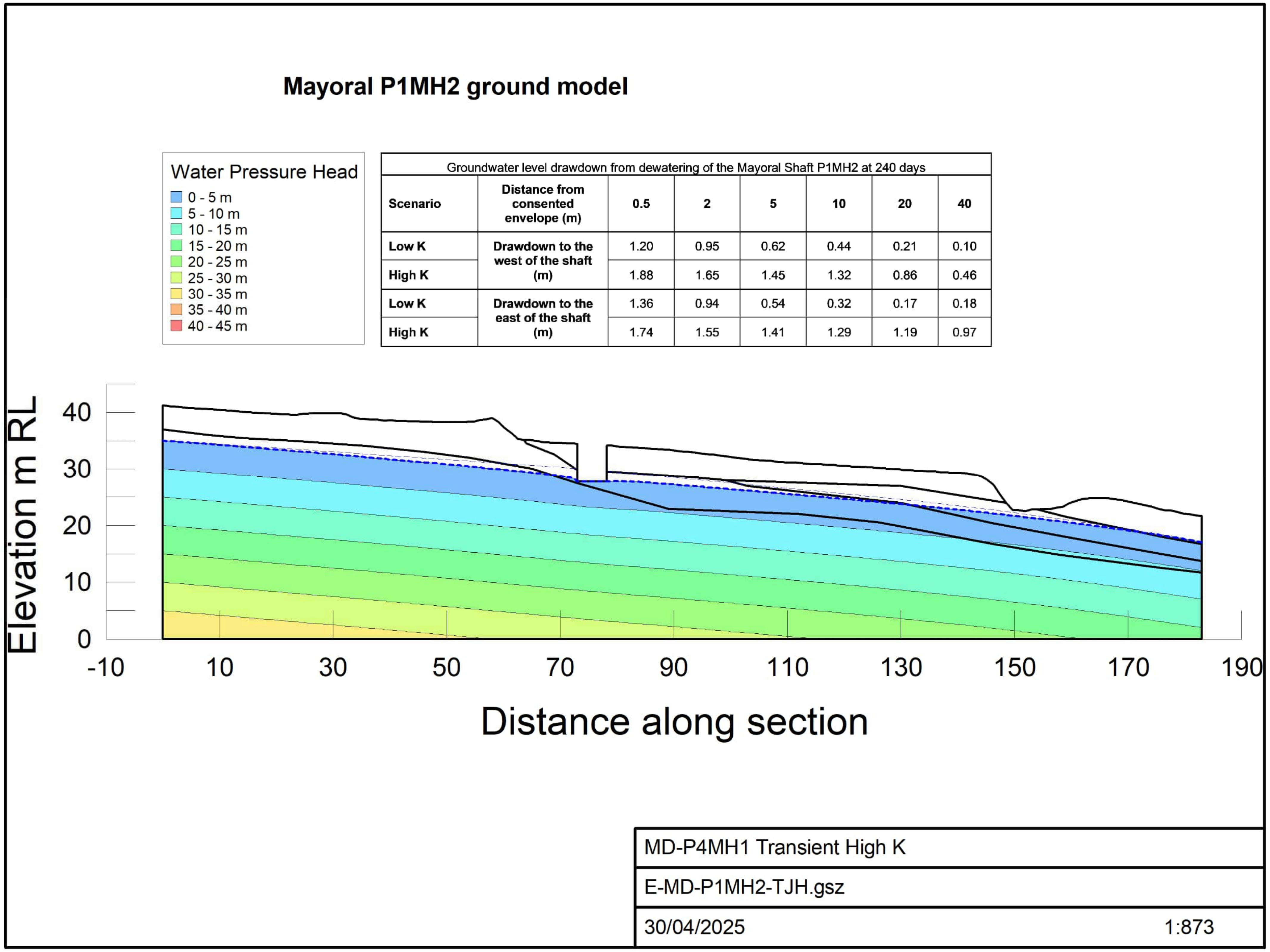
MD-P4MH1 Transient High K
C-MD-P4MH1-TJH.gsz
22/05/2025 1:600

Figure 5- 3: High K estimate case groundwater drawdown for the P4MH1 Shaft.



Groundwater level drawdown from dewatering of the Mayoral Shaft P5MH2 at 240 days							
Scenario	**Distance from consented envelope (m)**	**0.5**	**2**	**5**	**10**	**20**	**40**
Low K	**Drawdown to the west of the shaft (m)**	3.83	3.29	2.34	1.62	0.89	0.32
High K		4.37	3.93	3.37	2.89	2.31	1.53
Low K	**Drawdown to the east of the shaft (m)**	3.85	3.27	2.38	1.65	0.92	0.20
High K		4.24	3.79	3.25	2.72	1.82	0.67

Figure 5- 4: High K estimate case groundwater drawdown for the P5MH2 Shaft.



Groundwater level drawdown from dewatering of the Mayoral Shaft P1MH2 at 240 days							
Scenario	**Distance from consented envelope (m)**	**0.5**	**2**	**5**	**10**	**20**	**40**
Low K	**Drawdown to the west of the shaft (m)**	1.20	0.95	0.62	0.44	0.21	0.10
High K		1.88	1.65	1.45	1.32	0.86	0.46
Low K	**Drawdown to the east of the shaft (m)**	1.36	0.94	0.54	0.32	0.17	0.18
High K		1.74	1.55	1.41	1.29	1.19	0.97

Figure 5- 5: High K estimate case groundwater drawdown for the P5MH2 Shaft.

The modelled groundwater drawdown from dewatering is used for the environmental effects assessment (Section 7 of this report) and as input into settlement modelling and assessment. The assessment of land settlement caused by dewatering is described in detail in Section 6.2.

Settlement effects are typically considered 'less than minor' for properties near the shafts where drawdowns are less than 2.0 m (based on AUP standard E7.6.1.6(3)). The distances from the consented envelope where drawdowns are expected to be 2.0 m or less are listed in Table 5-2. Some properties are located within the distances listed in Table 5-2 and further assessment of land settlement effects is warranted and included in Section 6.2 of this report.

Table 5-2: Distance away from shaft where drawdown is less than 2.0 m

Shaft	West side (m)	East Side (m)
P4MH3	20	20
P4MH2	63	69
P4MH1	11	8
P5MH2	30	20
P1MH2	No drawdown > 2.0 m along section	No drawdown > 2.0 m along section

Other effects on the environment (nearby wells, ecosystems and surface water bodies) are typically considered less than minor at drawdowns of less than 0.5 m, which is considered the level where groundwater level changes is not measurable above seasonal variations. These drawdowns occur at the distances from the consented envelope as listed in Table 5-3. The assessment of effects on the environment is described in Section 7.

Table 5-3: Distance away from shaft where drawdown is less than 0.5 m

Shaft	West side (m)	East Side (m)
P4MH3	90	75
P4MH2	100	90
P4MH1	83	70
P5MH2	72	35
P1MH2	40	72

6.2 SETTLEMENT ANALYSIS

The results of dewatering-induced settlement and the ENGEO mechanical settlement are summarised in the following sections and also presented in Appendix C. The mechanical settlement was assumed to be axisymmetric and was overlain on the dewatering settlement profiles for the western and eastern sections to calculate the combined settlement results. In most cases, differences in dewatering settlement for the western and eastern sections are negligible, suggesting that the axisymmetrical assumption is also reasonable. But both sides have been presented for completeness.

The combined plots and tabulated summary are presented in the following sections for each shaft location. The summary tables provide results at intervals of 0.5 m, 5 m, 10 m, and 20 m from the edge of the shaft.

As previously stated, shaft P5MH1 does not require an assessment for settlement induced by dewatering, because it is unlikely to require dewatering, and thus no land settlement effects are expected.

6.2.1 P4MH3

Figure 6-1 and Table 6-1 below shows the settlement profile along the modelled section for mechanical, dewatering-induced settlement and the total settlement profile at the ground surface. Structures near P4MH3 include the Myers Park Overbridge, 48 Greys Avenue, 345-361 Queen Street and 323-327 Queen Street. Note that 345-361 Queen Street and 48 Greys Avenue are located approximately 35 m and 42 m from Shaft P4MH1, respectively, and not shown in Figure 6-1 below. There is an anomaly in the mechanical displacements at approximately 17 m from the shaft, which has been discounted from the maximum differential displacements.

Based on the assessment, the maximum anticipated settlement is approximately 25 mm, with a maximum differential of 1/1400, occurring within 5 m of the shaft. Settlement effects on structures and infrastructure are further discussed for P4MH3 in Section 7.4.4.5.

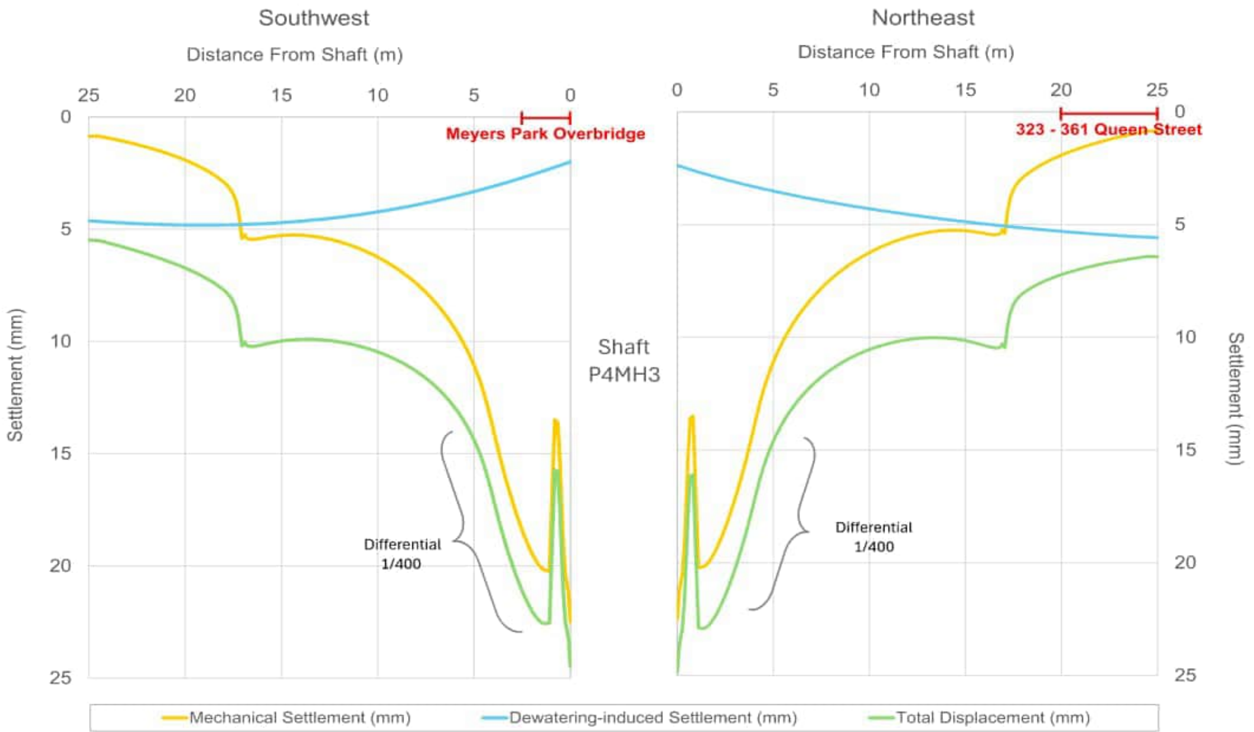


Figure 6-1 Settlement profile across the section for P4MH3.

Table 6-1 Summary of dewatering, mechanical and total settlement with distance from Shaft P4MH3.

Settlement (mm)	Distance from Shaft *Southwest* (m)			
	0.5	**5**	**10**	**20**
Dewatering-induced Settlement (High-K)	*2.2*	*3.3*	*4.2*	*4.8*
Mechanical Settlement (ENGEO)	*15.7*	*11.2*	*6.2*	*1.9*
Total Settlement	*17.9*	*14.5*	*10.4*	*6.7*
Settlement (mm)	Distance from Shaft *Northeast* (m)			
	0.5	**5**	**10**	**20**
Dewatering-induced Settlement (High-K)	*2.5*	*3.5*	*4.3*	*5.3*
Mechanical Settlement (ENGEO)	*15.7*	*11.2*	*6.2*	*1.9*
Total Settlement	*18.2*	*14.7*	*10.5*	*7.2*

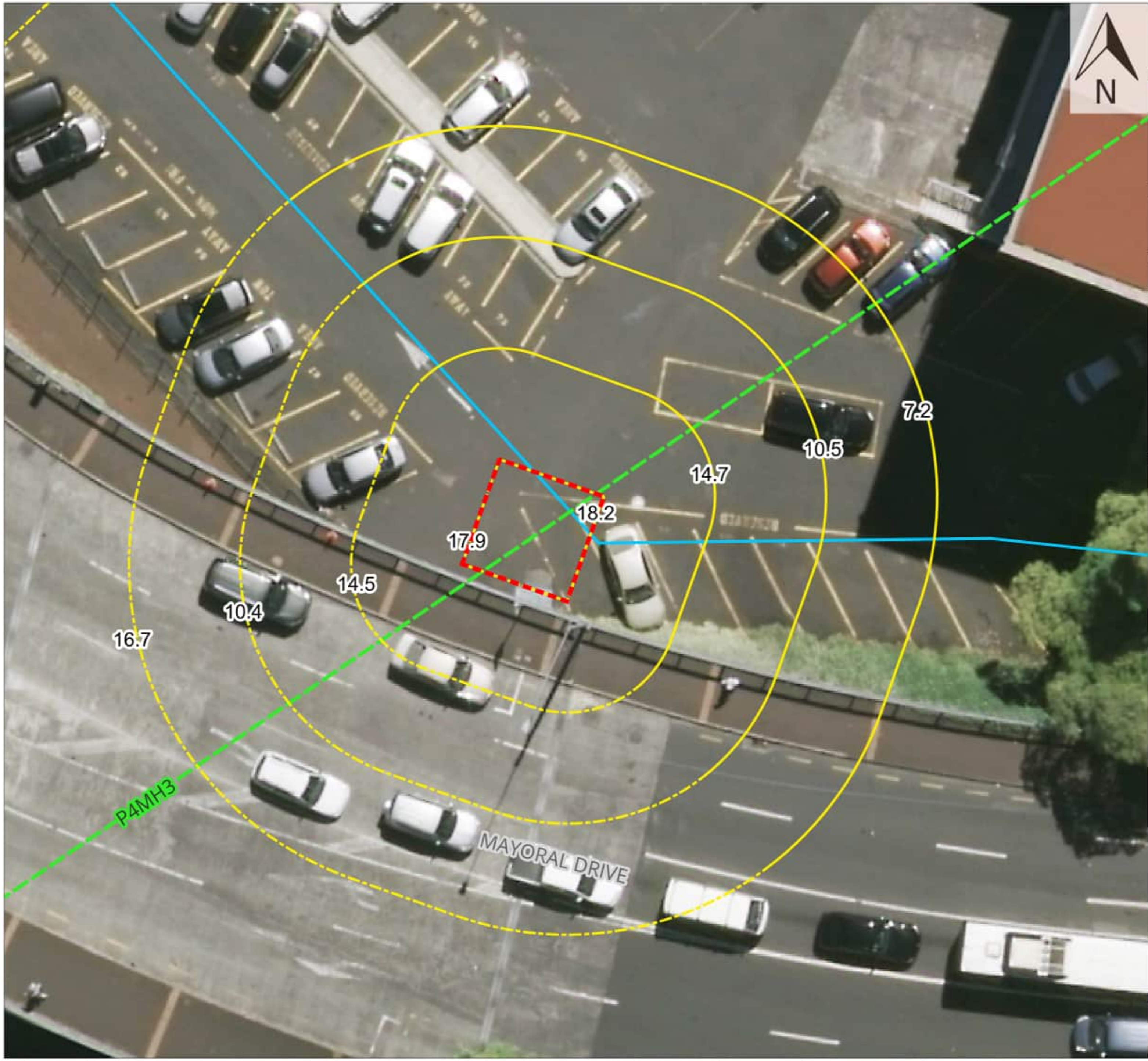


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FIGURE

Figure 5-8: P4MH3 Settlement Contours

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W-SL001.04	26 May 2025	R0

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LEGEND

LEGEND
- Settlement Lines East
- Settlement Lines West
- Dewatering cross-section
- Access Shafts
- Mayoral Drive alignment

SCALE

0 5 10 15 m

Original Sheet Size: A4 [W = 297, H = 210] Plot Date: 2025-05-26 11:09:04 by Hanna, Rebecca (NZRH31984) File Ref: U:\ProjectsNZ\3a\3-AWE40.00 Queen Street WW Diversions\Home\98_Hydrogeology\GIS\Mayoral\Mayoral_Base.qgz

6.2.2 P4MH2

Figure 6-3 and Table 6-2 below shows the settlement profile along the modelled section for mechanical, dewatering-induced settlement and the total settlement profile at the ground surface. Structures near P4MH2 are those at 48 and 22 Greys Avenue as indicated in the Figure below.

Based on the assessment, the maximum anticipated settlement is approximately 32 mm, with a maximum differential of 1/1900, occurring within 5 m of the shaft. Settlement effects on structures and infrastructure are further discussed for P4MH2 in Section 7.4.4.4.

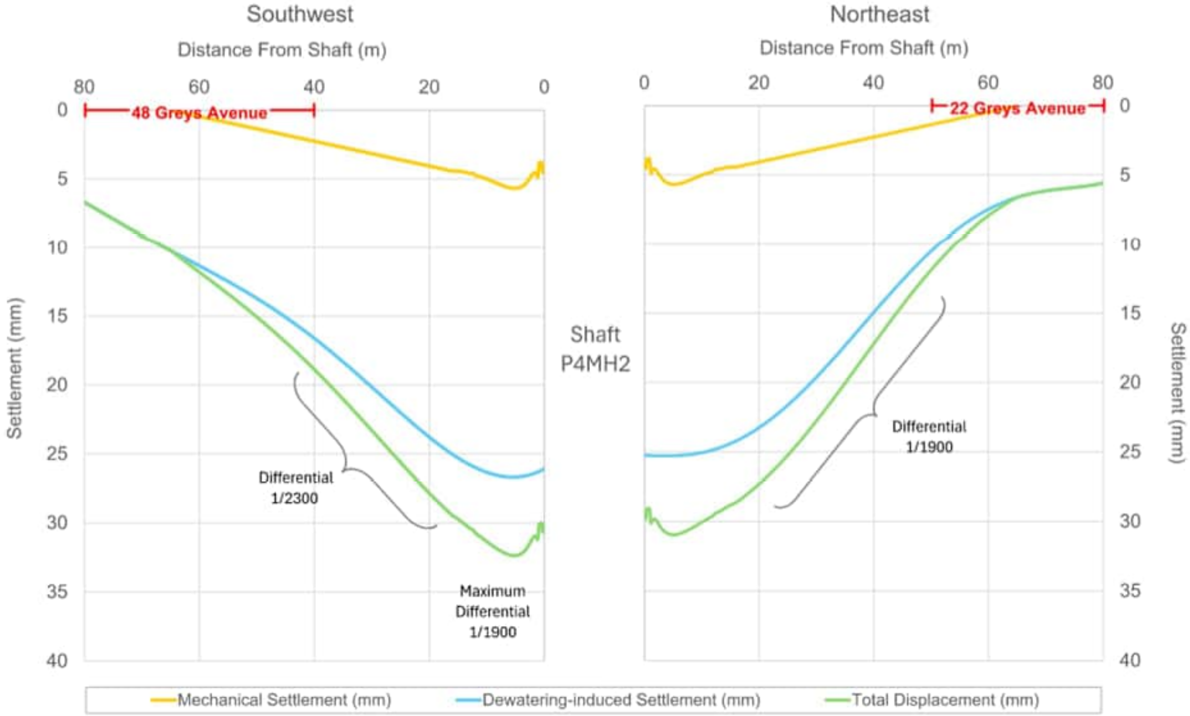

Figure 6-3 Settlement profile of across the section for P4MH2.

Table 6-2 Summary of dewatering, mechanical and total settlement with distance from Shaft P4MH2.

Settlement (mm)	Distance from Shaft *Southwest* (m)			
	0.5	5	10	20
Dewatering-induced Settlement (High-K)	*25.3*	*26.7*	*26.3*	*23.8*
Mechanical Settlement (ENGEO)	*3.8*	*5.7*	*5.0*	*4.1*
Total Settlement	*29.1*	*32.4*	*31.3*	*27.9*
Settlement (mm)	Distance from Shaft *Northeast* (m)			
	0.5	5	10	20
Dewatering-induced Settlement (High-K)	*26.2*	*25.3*	*25.1*	*23.3*
Mechanical Settlement (ENGEO)	*3.8*	*5.7*	*5.0*	*4.1*
Total Settlement	*30*	*31*	*30.1*	*27.4*

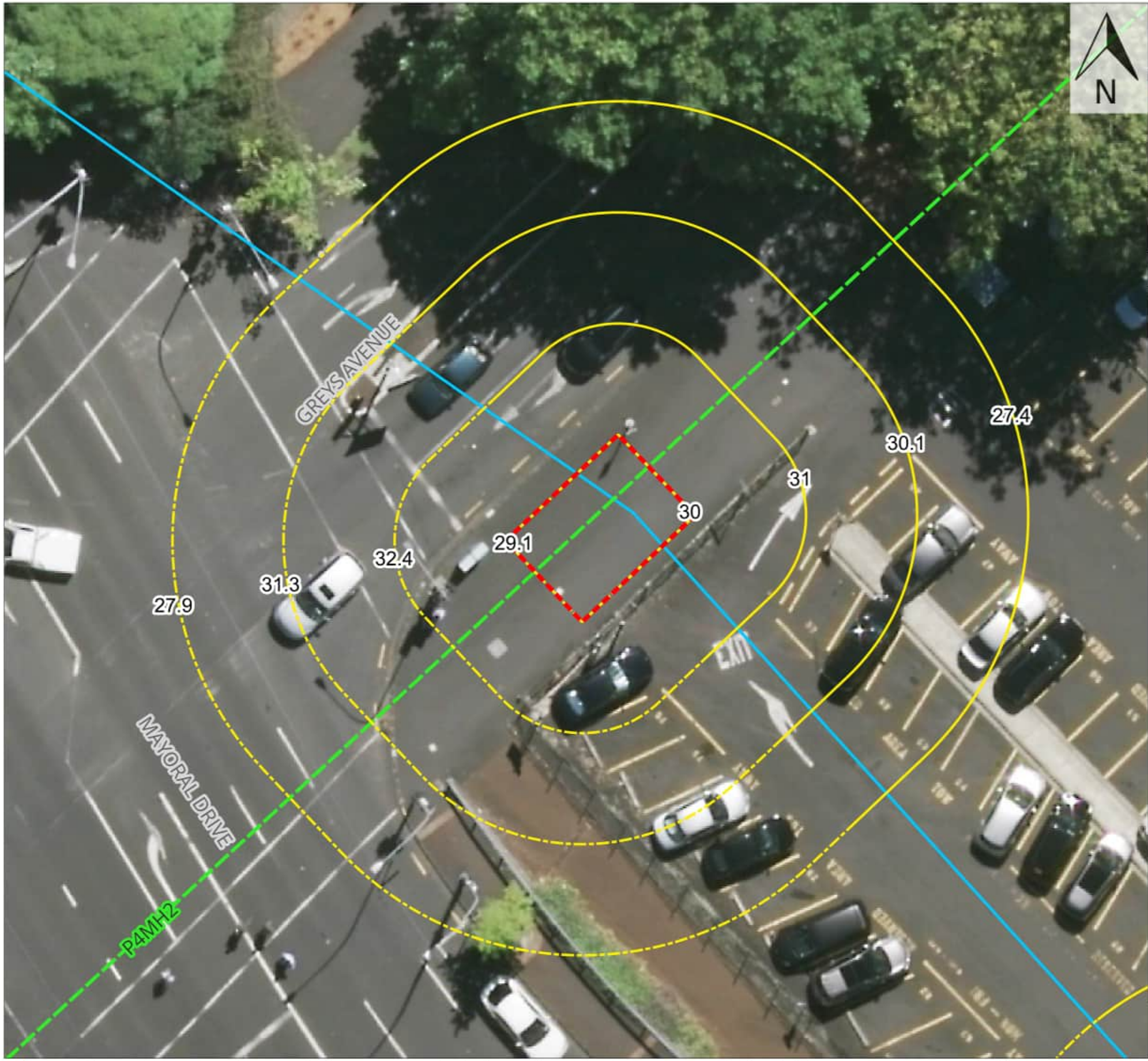

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FIGURE

Figure 5-9: P4MH2 Settlement Contours

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LEGEND

LEGEND
- Settlement Lines East
- Settlement Lines West
- Dewatering cross-section
- Access Shafts
- Mayoral Drive alignment

SCALE

0 5 10 15 m

Original Sheet Size: A4 [W = 297, H = 210] Plot Date: 2025-05-26 11:24:02 by Hanna, Rebecca (NZRH31984) File Ref: U:\ProjectsNZ\3a\3-AWE40.00 Queen Street WW Diversions\Home\98_Hydrogeology\GIS\Mayoral\Mayoral_Base.qgz

6.2.3 P4MH1

Figure 6-5 and Table 6-3 below shows the settlement profile along the modelled section for mechanical, dewatering-induced settlement, and the total settlement profile at the ground surface. Structures near P4MH1 include 71 – 87 Mayoral Drive, 3 Greys Avenue and 100 Mayoral Drive. Note that 3 Greys Avenue is located approximately 36 m from Shaft P4MH1 and not shown in Figure 6-5.

Based on the assessment, the maximum settlement is approximately 22 mm with a maximum differential of 1/100, occurring within 2 m of the shaft. Settlement effects on structures and infrastructure are further discussed for P4MH1 in Section 7.4.4.3.

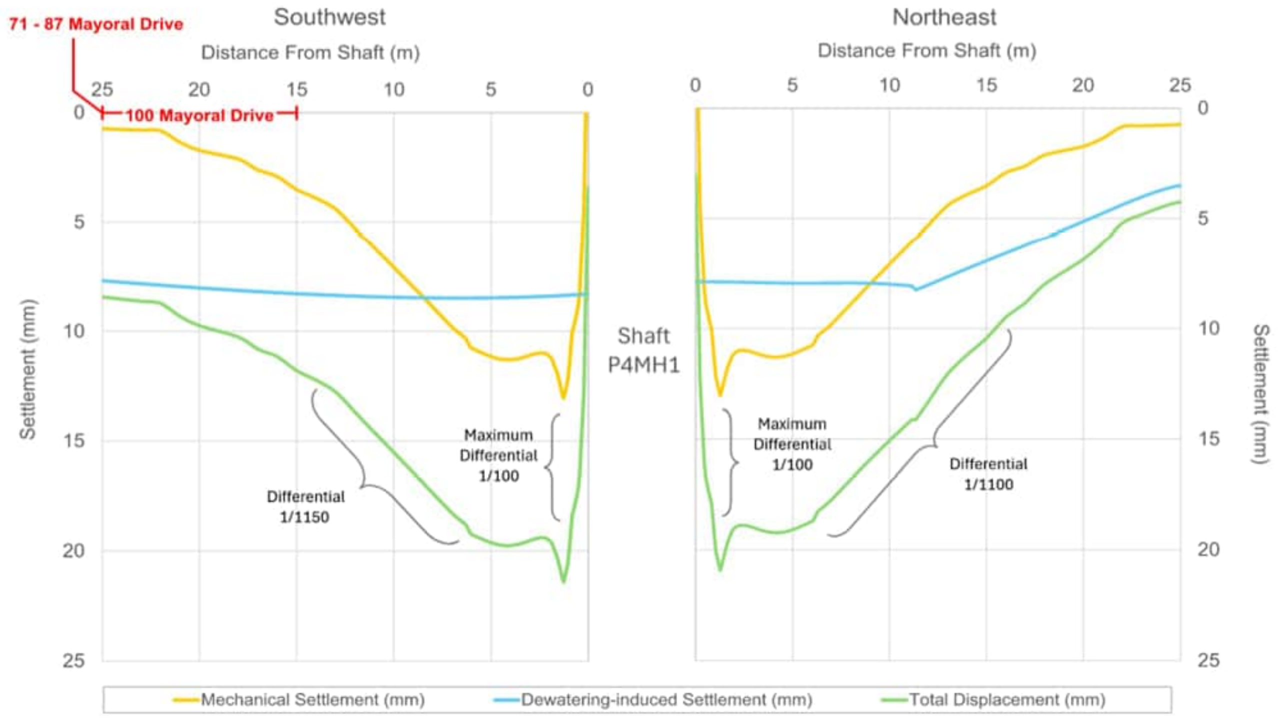

Figure 6-5 Settlement profile of across the section for P4MH1.

Table 6-3 Summary of dewatering, mechanical and total settlement with distance from Shaft P4MH1.

Settlement (mm)	Distance from Shaft *Southwest* (m)			
	0.5	5	10	20
Dewatering-induced Settlement (High-K)	*8.3*	*8.5*	*8.5*	*8*
Mechanical Settlement (ENGEO)	*8.9*	*11.1*	*7.1*	*1.7*
Total Settlement	*17.2*	*19.6*	*15.6*	*9.7*
Settlement (mm)	Distance from Shaft *Northeast* (m)			
	0.5	5	10	20
Dewatering-induced Settlement (High-K)	*7.9*	*7.9*	*8.0*	*5.1*
Mechanical Settlement (ENGEO)	*8.9*	*11.1*	*7.1*	*1.7*
Total Settlement	*16.8*	*19.0*	*17.1*	*6.8*

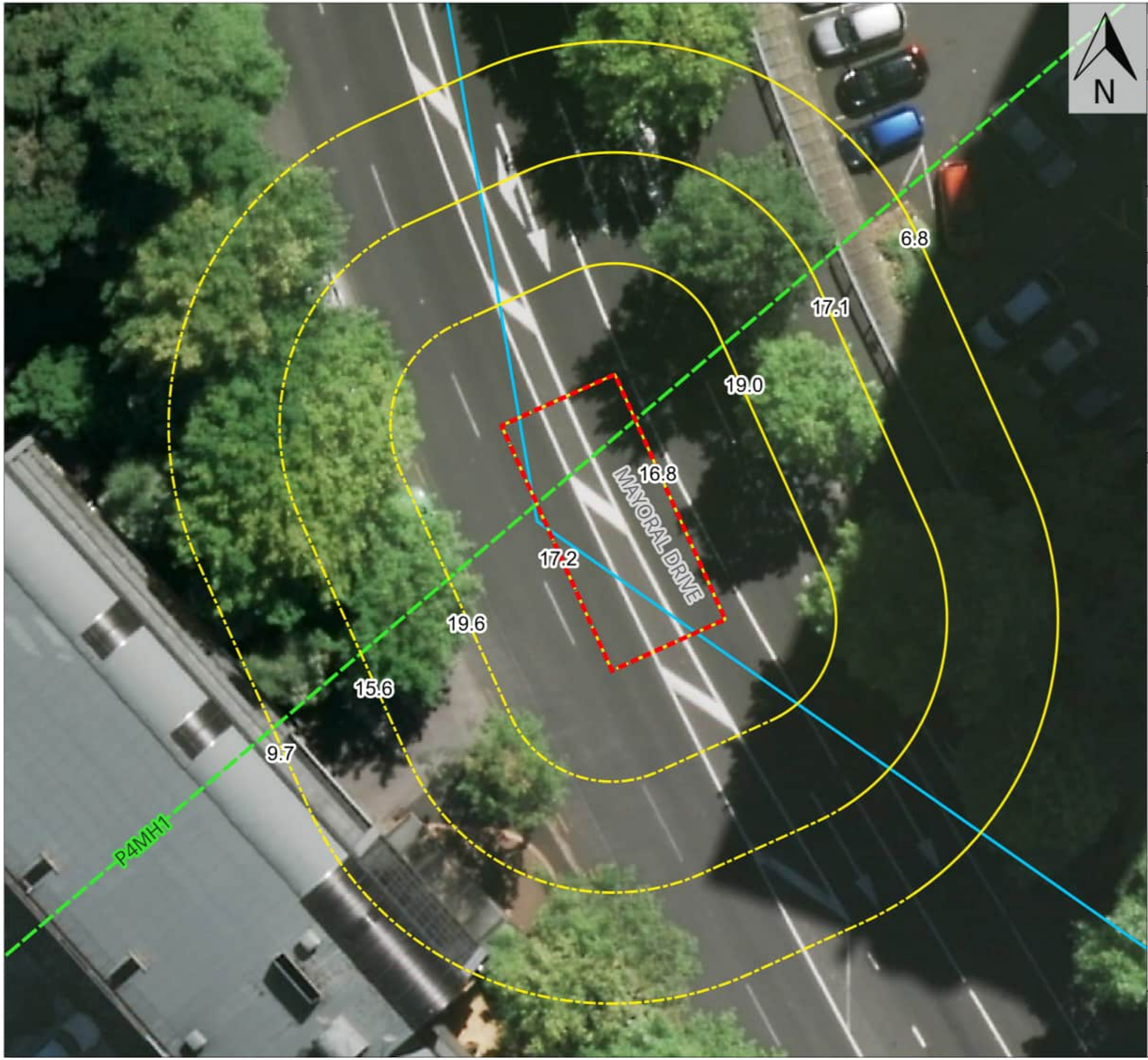

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FIGURE

Figure 5-9: P4MH1 Settlement contour plan

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W-SL001.04	26 May 2025	R0

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LEGEND

LEGEND
- Settlement Lines East
- Settlement Lines West
- Dewatering cross-section
- Access Shafts
- Mayoral Drive alignment

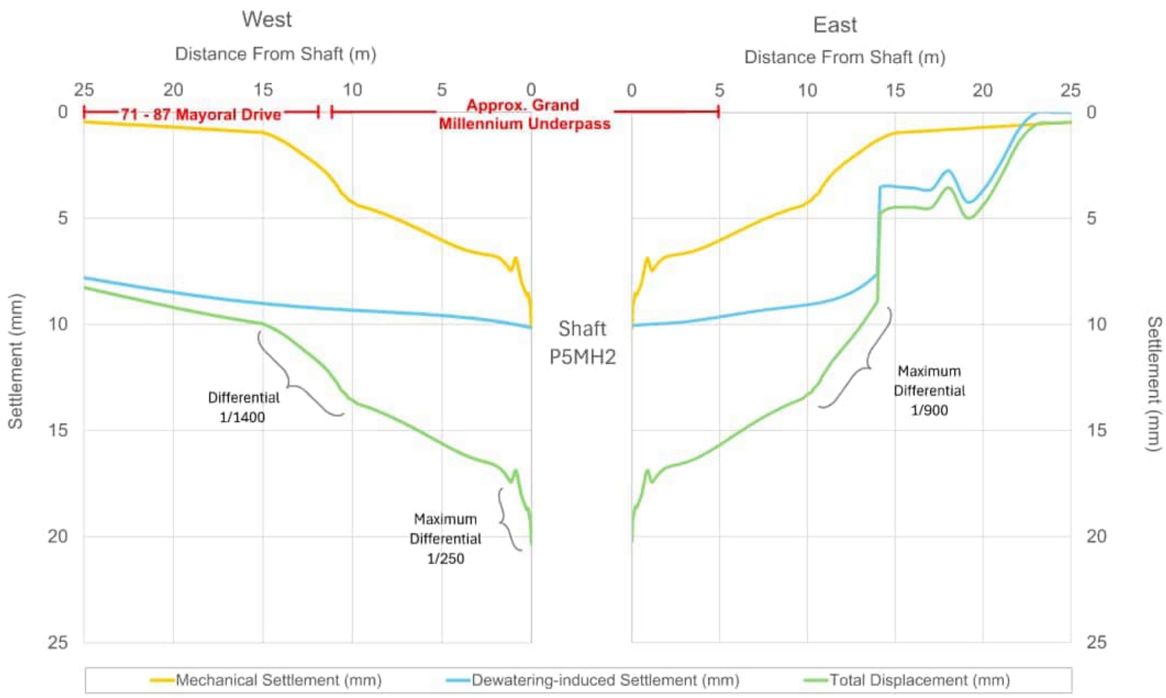
SCALE

0 5 10 15 m

6.2.4 P5MH2

Figure 6-7 and Table 6-4 below shows the settlement profile along the modelled section for mechanical, dewatering-induced settlement and the total settlement profile at the ground surface. Structures near P5MH2 include those at 71-87 Mayoral Drive, the Grand Millennium Underpass, and 3 Greys Avenue. Note that 3 Greys Avenue is located approximately 38 m from Shaft P5MH2 and not shown in Figure 6-7 below.

Based on the assessment, the maximum settlement is approximately 20 mm with a maximum differential under the building of 1/250 within 5 m of the shaft. Settlement effects on structures and infrastructure are further discussed for P5MH2 in Section 7.4.4.2.



8.

Figure 6-7 Settlement profile across the section for P5MH2.

Table 6-4 Summary of dewatering, mechanical and total settlement with distance from Shaft P5MH2.

Settlement (mm)	**Distance from Shaft *West* (m)**			
	0.5	**5**	**10**	**20**
Dewatering-induced Settlement (High-K)	*8.2*	*9.6*	*9.3*	*8.5*
Mechanical Settlement (ENGEO)	*10*	*6.0*	*4.2*	*0.7*
Total Settlement	*18.2*	*15.6*	*13.5*	*9.2*
Settlement (mm)	**Distance from Shaft *East* (m)**			
	0.5	**5**	**10**	**20**
Dewatering-induced Settlement (High-K)	*8.1*	*9.6*	*9.1*	*3.6*
Mechanical Settlement (ENGEO)	*10*	*6.0*	*4.2*	*0.7*
Total Settlement	*18.1*	*15.6*	*13.3*	*4.3*

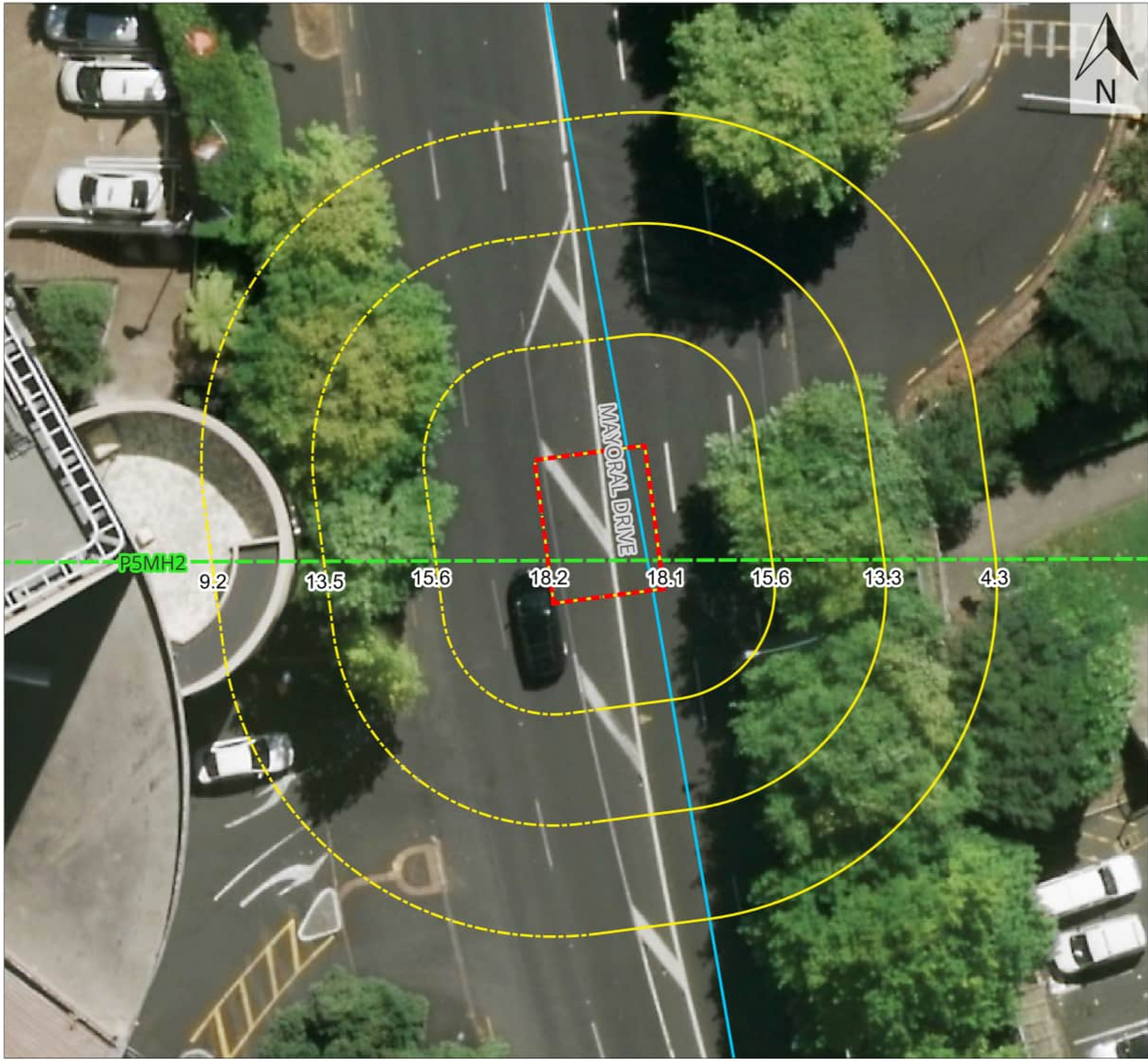


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FIGURE

Figure 5-10: P5MH2 Settlement contour plan

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LEGEND

LEGEND
- Settlement Lines East
- Settlement Lines West
- Dewatering cross-section
- Access Shafts
- Mayoral Drive alignment

SCALE

0 5 10 15 m

6.2.5 P1MH2

Figure 6-9 and Table 6-5 below shows the settlement profile along the modelled section for mechanical, dewatering-induced settlement, and the total settlement profile at the ground surface. The notable structure near P1MH2 is 67 – 101 Vincent Street, approximately 14 m from the shaft.

The maximum settlement evaluated is approximately 20 mm, 2 m from the shaft towards the east. Settlement effects on structures and infrastructure are further discussed for P1MH2 in Section 7.4.4.1.

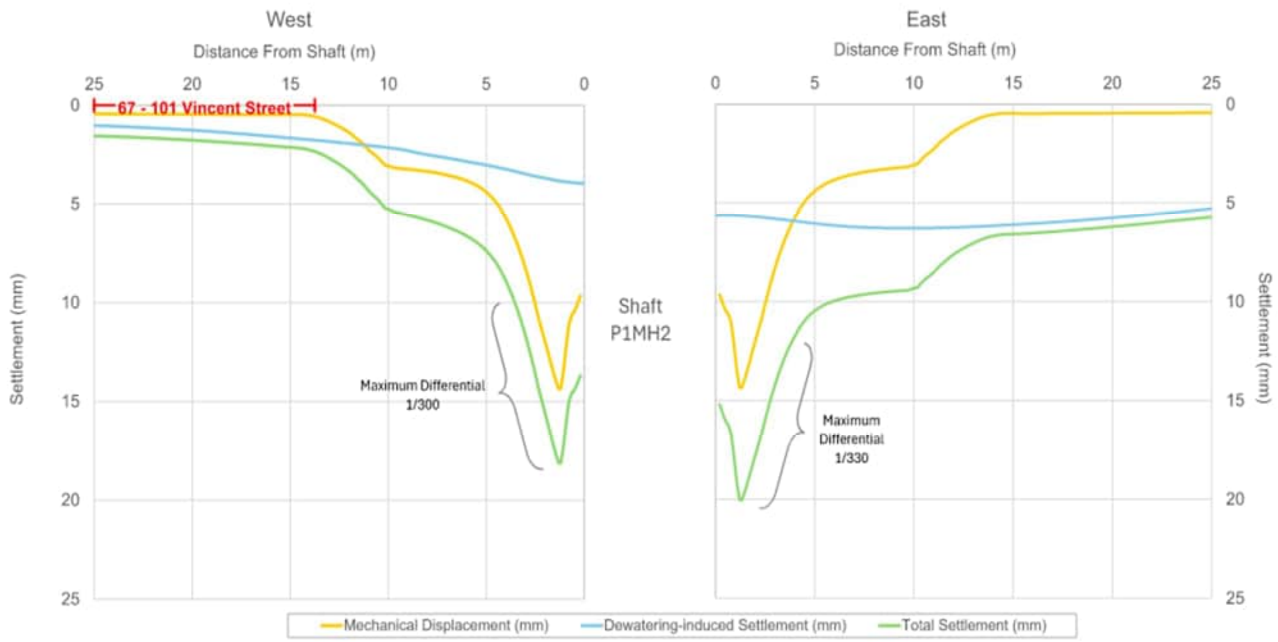

Figure 6-9 Settlement profile of across the section for P1MH2.

Table 6-5 Summary of dewatering, mechanical and total settlement with distance from Shaft P1MH2.

Settlement (mm)	Distance from Shaft *West* (m)			
	0.5	5	10	20
Dewatering-induced Settlement (High-K)	*3.9*	*3.0*	*2.1*	*1.2*
Mechanical Settlement (ENGEO)	*10.3*	*4.4*	*3.1*	*0.4*
Total Settlement	*14.2*	*7.4*	*5.2*	*1.6*
Settlement (mm)	Distance from Shaft *East* (m)			
	0.5	5	10	20
Dewatering-induced Settlement (High-K)	*5.6*	*6.0*	*6.3*	*5.7*
Mechanical Settlement (ENGEO)	*10.3*	*4.4*	*3.1*	*0.4*
Total Settlement	*15.9*	*10.4*	*9.4*	*6.1*

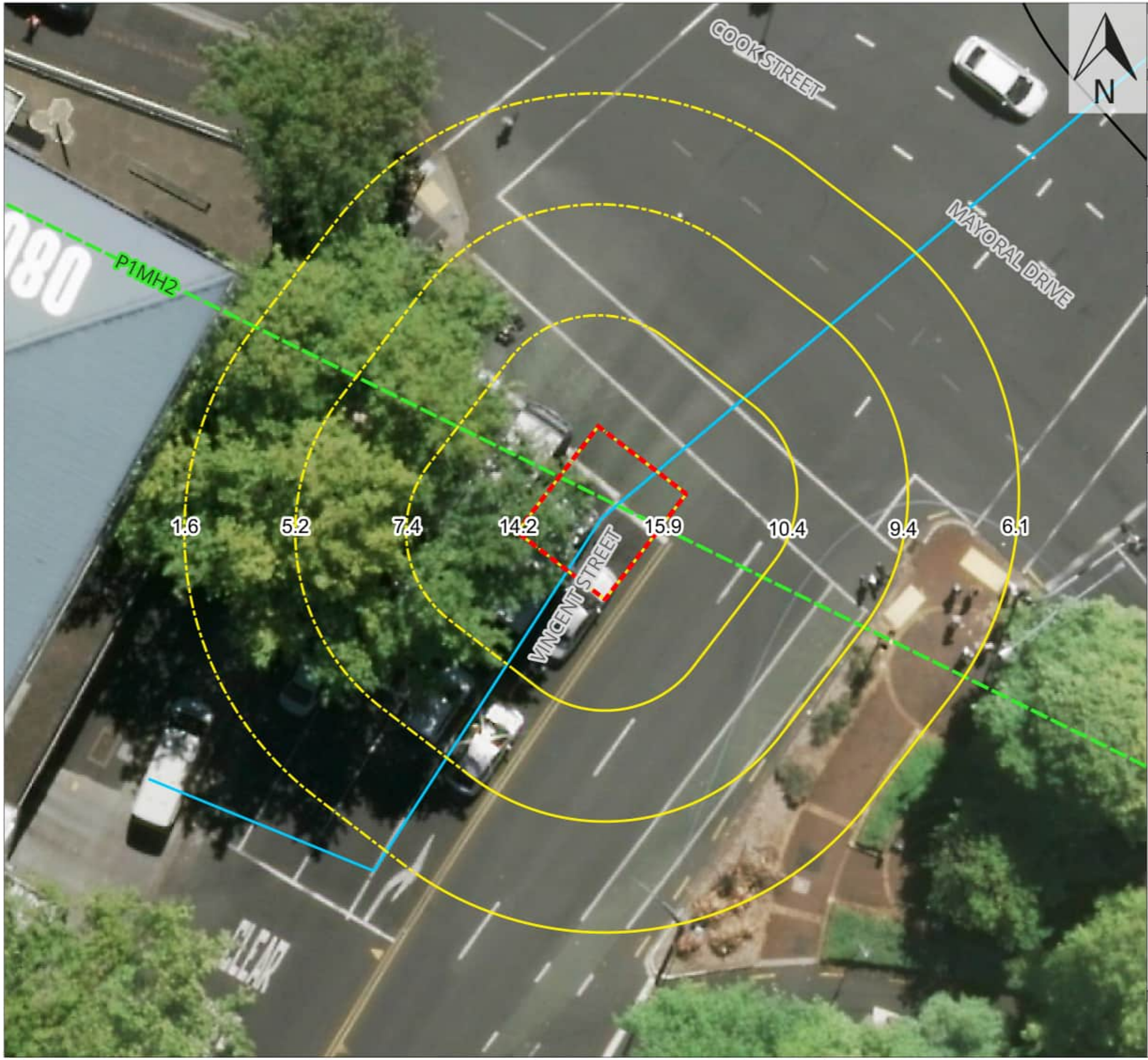

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FIGURE

Figure 5-11: P1MH2 Settlement contour plan

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LEGEND

LEGEND
- Settlement Lines East
- Settlement Lines West
- Dewatering cross-sections
- Access Shafts
- Mayoral Drive alignment

SCALE

0 5 10 15 m

7 EFFECTS ASSESSMENT

7.1 INTRODUCTION

The abstraction of groundwater for dewatering will cause a temporary cone of depression in the groundwater table. If dewatering is required, groundwater levels will generally drop around the excavation, and the depression cone will extend outwards over time until dewatering ceases. Therefore, it needs to be considered that drawdowns may propagate outwards over time.

The Mayoral shafts have been assessed as post and panel construction. The shafts will require some dewatering because of water ingress expected through the base of the excavation as the excavation advances to the target depth. Any groundwater is expected to be managed using a sump pump arrangement.

Based on the technical analysis completed in Section 6, effects will need to be assessed for:

- Effects on neighbouring bores
- Stream depletion effects
- Saltwater intrusion effects
- Land settlement effects on neighbouring properties and utilities due to dewatering
- Surface flooding and water quality effects that may arise from the abstracted groundwater being diverted

7.2 EFFECTS ON NEARBY WATER TAKES

Effects on neighbouring bores are estimated based on the level of groundwater drawdown from the dewatering at the location of the existing bore. The distance where the groundwater level is drawn down by 0.5 m is considered the estimated maximum lateral extent of the drawdown cone where effects on other groundwater users and groundwater-dependent ecosystems should be assessed. It is considered that a groundwater level change greater than 0.5 m could be measurable above natural variation of groundwater levels. The groundwater level drawdown estimation from the best estimate case (Section 6.1) at the end of the dewatering period is used for the assessment.

The lateral extent of the drawdown cone for the Mayoral shafts is approximately a maximum of 100 m based on the modelled drawdown. There are no active groundwater takes for consumption within 100 m of any of the Mayoral shafts. The closest groundwater take consent (WAT60351066) appears to be approximately 460 m to the south of shaft P4MH3, which is outside of where the 0.5 m drawdown extends.

7.2.1 CUMULATIVE EFFECTS

Dewatering of the Mayoral shafts will not occur concurrently with other Queen Street wastewater dewatering project works; therefore, no cumulative effects with those projects are envisaged.

Looking specifically at the Mayoral Drive Alignment works, in the instance where all five of the shafts are dewatered simultaneously, the following considerations are made:

- The 2-dimensional modelling has not taken into account the added drawdowns that might result from simultaneous dewatering of all Mayoral Drive shafts
- For structures that lie some distance and perpendicular to the alignment, we consider that the sensitivity range of the effects assessment accounts for the cumulative drawdown effects that might occur.
- For structures including services that lie along the alignment, it is considered that the types of structures that might be affected by cumulative effects, such as services and pavements, are less susceptible to the adverse effects of settlement and any cumulative effects would be less than their operational limits.

The effect due to accumulation of drawdown during simultaneous dewatering of all Mayoral shafts and other Queen Street diversions are considered to be small.

7.3 EFFECTS ON GROUNDWATER PRESSURES, LEVELS AND FLOW PATHS, AND SALINE INTRUSION

7.3.1 STREAM DEPLETION EFFECTS

There are no surface water bodies or streams in proximity (within the zone of drawdown influence (refer to AC planning maps in Appendix E of the Application) to the shafts, hence the groundwater drawdown will have no stream depletion effects on surface water bodies. No assessment of effects on terrestrial and freshwater ecosystems was conducted.

7.3.2 SALTWATER INTRUSION

Saltwater intrusion typically only establishes after a long period of time with groundwater levels reduced to below average sea level at or near the coast. The time for saline intrusion response will depend on the hydraulic conductivity of the formation that is dewatered, the distance to the coast, the natural groundwater gradient and the average dewatering level near the coast. This typically occurs only after years of groundwater levels reducing below sea level. With lower hydraulic conductivity sediments, the establishment of groundwater drawdown that can result in saline intrusion will take even longer to establish, because of the slow movement of both the fresh groundwater and saline water.

The maximum estimated drawdown extent associated with the dewatering of the Mayoral shafts, assuming the most conservative case (i.e., high-K as described in Section 6.1) is 100 m, which is the maximum extent of the dewatering after 240 days of dewatering. However, the site is 1300 m from the coast. The maximum drawdown level at the shaft location is 6.1 m RL at P4MH2. Despite this level of drawdown, sufficient groundwater pressure will remain so that the groundwater flow direction is not reversed, causing saline intrusion. The drawdown does not extend below sea level at the shaft location and will thus not extend to below sea level further away from the shaft. The likelihood of saltwater intrusion is thus considered negligible.

7.4 SETTLEMENT EFFECTS

The following sections (7.4.1 to 7.4.3) outline the criteria for which buildings, underground services and pavements / surface infrastructure are assessed for settlement effects. Sections 7.4.4 outline the shaft-specific effects, outlining those items impacted.

7.4.1 BUILDINGS

The building effects were assessed using the established methodology by J.B. Burland (Building Response to Ground Movements, ICE Manual of Geotechnical Engineering, 2012). The likely settlement effects on buildings are primarily the combination of the magnitude of

a) The combined settlement and deflection of the shaft excavations (mechanical settlement) and due to dewatering-induced settlement.

b) The slope/grade of the differential settlement.

A settlement less than 10 mm with a differential settlement less than 1:500 poses a negligible risk of any damage to buildings (Mair et al., 1996). Buildings near shafts or that fall outside the settlement criteria have been assessed. Buildings that are anticipated to experience less than 10 mm of settlement have not been assessed.

The building effects for the specific settlements are reported in the following section for the respective shafts.

Table 7-1 Damage criteria for preliminary assessment from Rankin (1988) and Mair et al. 1996.

Building and Structural Damage Classification (Mair et al. 1996)				Equivalent Movements (Rankine 1988)	
Damage Category / Degree of Severity		Description	Limiting Tensile Strain (%)	Settlement (mm)	Slope
0	Negligible	Hairline cracks (damage unlikely but possible)	0 to 0.05	<10	<1/500
1	Very Slight	Fine cracks that are easily treated during normal decoration. Damage is generally restricted to the internal wall finish. Cracks may be visible on external brickwork or masonry.	0.05 to 0.075		
2	Slight	Cracks are easily filled. Redecoration is probably required. Recurrent cracks can be masked by suitable linings. Cracking may be visible externally, and some repointing may be required to ensure weathertightness. Doors and windows may stick slightly.	0.075 to 0.15	10 to 50	1/500 to 1/200
3	Moderate	Cracks require some opening up and can be patched by a mason. Repointing of external brickwork to be replaced. Doors and windows are sticking. Service pipes may fracture. Weather tightness often impaired.	0.15 to 0.3	50 to 75	1/200 to 1/50
4/5	Severe to Very Severe	Extensive repair work involving break-out and replacing sections of walls, especially over doors and windows. Doors and window frames are distorted, and the floor slopes noticeably. Walls leaning or bulging noticeably; some loss of bearing in beams. Utilities disrupted.	>0.3	>75	>1/50

7.4.2 SERVICES

The assessment of effects on services was based on the publication Buried Pipeline Response to Tunnelling Ground Movements by T. D. O'Rourke and C.H. Trautmann (1982). The findings, derived from tunnelling projects, also apply to ground deflections from dewatering and excavation, as in this case. The gravity infrastructure is generally more sensitive to differential settlement, which causes the joints to open and leak. Based on their observations, no damage occurred for settlements up to 50 – 70 mm in similar materials. They also defined a generally acceptable level of differential settlement in pipelines of approximately 1/200 to 1/300.

A services and utilities location process will be implemented, and in collaboration with the utilities' owners and authorities, a programme of relocations, diversions, protection, and monitoring will be undertaken to manage the effects on the services and utilities from the risks associated with the mechanical and dewatering settlements during the works.

Generally, underground services affected by differential settlement are gravity systems, which include wastewater and stormwater systems. Other services, such as pressurised systems for potable water, can better tolerate differential settlement; therefore, the following sections will discuss only the gravity infrastructures.

7.4.3 FOOTPATHS, KERBS AND ASPHALT

Localised damage to footpaths, kerbs, and asphalt near the shaft is likely, mainly due to construction activities and traffic. This damage is anticipated to be primarily aesthetic and not cause significant disruption to public use of the assets. Temporary repairs to restore functionality and safety during construction or permanent repairs after completion are expected to be straightforward to implement.

7.4.4 SUMMARY – SETTLEMENT EFFECTS

The shaft-specific settlement effects for the buildings, structures and infrastructure are discussed in the following sections. A summary of the structures on which the effects are assessed to be above 'negligible' is presented in Table 7-2.

Table 7-2 Summary of structures and/or buildings that the damage severity was greater than "negligible".

Property Address	Nearby Shaft	Minimum Distance from the Shaft (m)	Maximum Estimated Settlement (mm)	Maximum differential Settlement	Damage Category	Degree of Severity
Grand Millennium Underpass	P5MH2	1	20	1/250	2	Very slight to Negligible
100 Mayoral Drive	P4MH1	15	12	1/1200	1	Very slight
48 Greys Avenue	P4MH2	40	20	1/2600	1	Very slight
22 Greys Avenue	P4MH2	48	12	1/1900	1	Very slight
Myers Park Overbridge	P4MH3	2	22	1/400	2	Very slight to negligible

The maximum total settlement at the closest edge of the Grand Millennium Underpass is more than 10 mm with a differential settlement of approximately less than 1/500. This level of estimated settlement is typically classified as within the slight building damage category, based on the damage criteria in Table 7-1. However, the underpass is a robust underground structure, likely with tilt slab concrete panels that would not be affected by this level of settlement, and it considered that the associated damage classification is likely negligible to very slight. Furthermore, damage up to the slight category will be aesthetic and being an underpass will not affect the functioning or the visuals of the underpass, hence, even if slight damage as a result of settlement occurs, it is still considered a minimal effect.

The maximum total settlement for the buildings at 100 Mayoral Drive, 48 Greys Avenue and 22 Greys Avenue is estimated to be more than 10 mm, however the estimated differential settlement for these buildings is significantly less than 1/500. The settlement is classified as within the very slight building damage category, based on the damage criteria in Table 7-1, however due to the very low differential settlement, it is unlikely that any damage will occur due to the dewatering.

Myers Park overbridge is not expected to be affected as it is founded on piles, even though the estimated maximum total settlement is more than 10 mm and the differential settlement is estimated to be approximately 1/400, which is higher than 1/500, as per the slight damage classification. The approach abutments are supported by crib retaining walls and will likely settle. Still, these crib walls are flexible, and it is expected that they will accommodate the anticipated total and differential settlement, with perhaps localised deformations on the face of the wall. It is unlikely that this deformation will propagate to the surface. However, in the event of cracking or minor dips on the footpath or road surface, these are not expected to significantly affect the level of service to users and will be easily repairable upon completion of the work. The damage classification associated with the Myers Park overbridge structure is considered negligible to very slight.

Underground services are largely expected not to be affected. Settlement around shaft P4MH3 showed the potential to affect shallow gravity pipelines outside of Watercare jurisdiction and within 5 m of the shaft. The condition of these services should be assessed prior to the start of dewatering and after dewatering is completed, which will be specified in the GSMCP. Any damage resulting from the construction activities will be repaired.

7.4.4.1 P1MH2

The settlement effect on building(s) and other infrastructure in the vicinity of shaft P1MH2 is presented below.

BUILDINGS AND STRUCTURES

A summary of the effects on building and other structures in the vicinity of the shaft is presented in Table 7-3. Based on the damage criteria, the assessed effects on the nearby building at 67 – 101 Vincent Street are expected to be negligible and are not further discussed.

Table 7-3 Summary of settlement effects for the nearby structures and/or buildings.

Property Address	Structure Type	Minimum Distance from the Shaft (m)	Maximum Estimated Settlement (mm)	Maximum differential Settlement	Damage Category	Degree of Severity
67-101 Vincent Street	Multistorey Commercial Building	14	3.5	1/1000	0	Negligible

SERVICES

Based on the assessment, underground gravity services within 5 m of the shaft may likely experience total settlement up to 25 mm and differential settlement in the order of 1/300. Based on the service damage criteria, damage is unlikely.

7.4.4.2 P5MH2

The assessed settlement effects on building(s) and other infrastructure in the vicinity of shaft P5MH2 are presented below.

BUILDINGS AND STRUCTURES

A summary of the effect on building and other infrastructure in the vicinity of the shaft is presented in Table 7-4.

Table 7-4 Summary of settlement effects for the nearby structures and/or buildings.

Property Address	Structure Type	Minimum Distance from the Shaft (m)	Maximum Estimated Settlement (mm)	Maximum differential Settlement	Damage Category	Degree of Severity
3 Greys Avenue	Multistorey Commercial Building	38	2	>1/2000	0	Negligible
71 – 78 Mayoral Drive	Multistorey residential / Commercial (Grand Millennium Hotel)	12	10	1/1400	0	Negligible
Grand Millennium Underpass	Tunnel	1	20	1/250	2	Very slight to negligible

The maximum total settlement at the closest edge of the Grand Millennium Underpass is estimated to be 20 mm with a differential settlement of approximately 1/250. The estimated settlement is greater than 10 mm with a differential settlement more than 1/500 and hence the settlement effect is classified as within the slight building damage category, based on the damage criteria in Table 7-1. However, the underpass is a robust underground structure, likely with tilt slab concrete panels that would not be affected by this level of settlement, and it considered that the associated damage classification is likely negligible to very slight. Monitoring will be required during construction, which will be specified in the GSMCP. Minor aesthetic repairs following completion of the works will be done if damage to the Underpass results from the dewatering.

The likely effects on the remaining two nearby buildings, which are further away, are expected to be negligible.

SERVICES

Buried infrastructure within 5 m of the shaft comprises pressurised potable water systems and the Transpower transmission line. The effects are likely to be negligible based on the discussion in Section 7.4.2.

7.4.4.3 P4MH1

The estimated settlement effects on buildings and other infrastructure in the vicinity of shaft P4MH1 are presented below.

BUILDINGS AND STRUCTURES

A summary of the effect on building and other structures in the vicinity of the shaft is presented in Table 7-5.

Based on the damage criteria, 'very slight' damage is likely for the building at 100 Mayoral Drive, in the form of fine cracks which may require very minor aesthetic repairs following completion. The effects on the buildings at 3 Greys Avenue and 71 – 87 Mayoral Drive are expected to be negligible.

Table 7-5 Summary of settlement effects for the nearby structures and/or buildings.

Property Address	Structure Type	Minimum Distance from the Shaft (m)	Maximum Estimated Settlement (mm)	Maximum differential Settlement	Damage Category	Degree of Severity
100 Mayoral Drive	Multistorey commercial building	15	12	1/1200	1	Very slight
3 Greys Avenue	Multistorey commercial building	36	3	>1/2000	0	Negligible
71 – 87 Mayoral Drive	Multistorey residential / Commercial (Grand Millennium Hotel)	25	8.5	>1/2000	0	Negligible

The maximum total settlement for the building at 100 Mayoral Drive is 12 mm, with an estimated differential settlement of 1/1200. The settlement is hence classified as within the very slight building damage category, based on the damage criteria in Table 7 1. However, because of the very low differential settlement, damage is unlikely to occur. Monitoring as a contingency measure will be specified in the GSMCP.

The effects on the buildings at 3 Greys Avenue and 71 – 87 Mayoral Drive are expected to be negligible.

SERVICES

No buried gravity infrastructure is within 5 m of the shaft. For gravity infrastructure beyond 5m, settlement is less than 20mm with a differential of 1/1100, which is acceptable based on the service criteria.

7.4.4.4 P4MH2

The settlement effect on building(s) and other infrastructure in the vicinity of shaft P4MH2 is presented below.

BUILDINGS AND STRUCTURES

A summary of the effect on buildings in the vicinity of the shaft is presented in Table 7-6.

Table 7-6 Summary of settlement effects for the nearby structures and/or buildings.

Property Address	Structure Type	Minimum Distance from Shaft (m)	Maximum Estimated Settlement (mm)	Maximum differential Settlement	Damage Category	Degree of Severity
48 Greys Avenue	Multistorey commercial building	40	20	1/2600	2	Very slight
22 Greys Avenue	Multistorey commercial building	48	12	1/1900	2	Very slight

The maximum total settlement for the buildings at 48 and 22 Greys Avenue is estimated to be more than 10 mm, however the estimated differential settlement for these buildings is significantly less than 1/500. The settlement is classified as within the very slight building damage category, based on the damage criteria in Table 7-1. However, because of the very low differential settlement, damage is unlikely to occur. Monitoring as a contingency measure will be specified in the GSMCP.

SERVICES

There are stormwater assets within 5 m of the shaft at an approximate depth of 3.2 m. Based on the assessment, infrastructure within 5 m of the shaft may experience total settlement up to 33 mm and differential settlement <1/500. Based on the service's damage criteria, we do not anticipate damage to these assets and that the associated risks will be managed through the provisions in the GSMCP.

7.4.4.5 P4MH3

The settlement effect on buildings and other infrastructure in the vicinity of shaft P4MH3 is presented below.

BUILDINGS AND STRUCTURES

A summary of the effect on building and other structures in the vicinity of the shaft is presented in Table 7-7.

Table 7-7 Summary of settlement effects for the nearby structures and/or buildings.

Property Address	Structure Type	Minimum Distance from the Consenting Envelope (m)	Maximum Estimated Total Settlement (mm)	Maximum differential Settlement	Damage Category	Degree of Severity
48 Greys Avenue	Multistorey commercial building	42	3	>1/2000	0	Negligible
323 – 327 Queen Street	Multistorey Commercial Building /	20	7	>1/2000	0	Negligible

	Heritage Structure					
345 – 361 Queen Street	Multistorey commercial building	35	3.5	>1/2000	0	Negligible
Myers Park Overbridge	Bridge and retaining wall	2	22	1/400	2	Very slight to negligible

The maximum total settlement at the edge of the buildings at 48 Greys Avenue, 323-327 Queen Street and 345-361 Queen Street is less than 10 mm with a differential settlement less than 1/500, hence the settlement is classified as within the negligible damage category.

The maximum total settlement at the closest edge of the Myers Park Overbridge is estimated to be 22 mm with a differential settlement of approximately 1/400. The settlement is hence classified as within the slight building damage category based on Table 7-1. The likely damage applies to the Myers Park Overbridge approach embankment retaining walls. However, estimated localised deformations on the face of the wall is unlikely to propagate to the surface. Due to the interlocking nature of crib walls, they can accommodate visible differential settlement without compromising their stability, which will likely prevent propagation of the deformations to the road surface. However, in the event of cracking or minor dips on the footpath or road surface, these are not expected to significantly affect the level of service to users and will be easily repairable upon completion of the work. The damage classification associated with the Myers Park overbridge structure thus, is considered negligible to very slight, which will have a minimal effect on the structure.

The bridge itself is piled, and the effects are expected to be negligible. The same applies to the remaining structures in the vicinity of the shaft.

SERVICES

Excluding the assets within WSL jurisdiction, there is a 750 mm diameter stormwater pipe (asset no. 2000134745) within 2 m of the shaft, and based on the assessment, differential settlements of more than 1/100 and total settlement up to 25 mm are anticipated. Associated risks will be managed through the provisions in the GSMCP.

Additionally, there are stormwater assets within 5 m of the shaft, with differential settlements of less than 1/400 and total settlement of up to 15 mm anticipated. Based on the service damage criteria, we do not anticipate damage to these assets.

7.5 SURFACE FLOODING EFFECTS

Water abstracted as a result of dewatering will be treated in clarification tanks prior to discharge to the local wastewater network. As the abstraction rates are anticipated to be low (ranging between 63 m^3/day and 4 m^3/day listed in Table 6-1 any effects on surface flooding will be negligible.

7.6 EFFECTS ON TERRESTRIAL ECOSYSTEMS AND HABITATS

No terrestrial ecosystems or habitats have been identified within the 0.5 m drawdown threshold resulting from the Mayoral shafts dewatering. Effects on terrestrial ecosystems are considered unlikely as a result.

8 MITIGATION MEASURES

It is considered prudent to undertake groundwater level and settlement monitoring adjacent to the Mayoral shafts as a conservative precautionary measure, so that mitigation measures can be put in place, should groundwater drawdown be in excess to what is expected to be observed, and prior to settlement effects developing. The following is indicative of the types of monitoring that should be considered in a groundwater settlement monitoring and contingency plan (GSMCP).

8.1 GROUNDWATER LEVEL MONITORING

The existing piezometer monitoring network can be utilised to monitor groundwater drawdown effects as a result of groundwater level control in all of the Mayoral Drive shafts. The existing monitoring network is presented in Table 2.1 above. Furthermore, each of the shafts has a separate monitoring piezometer installed at a suitable distance (nearby) to appropriately monitor the drawdown effect and to confirm the assessed effects as presented in Section 7 above.

Automated data loggers are recommended to allow for a continuous data record and to reduce the reliance on manual measurements.

Baseline monitoring of groundwater levels should start at least four weeks prior to commencement of excavations and continue until three months after construction is complete.

Groundwater data should be downloaded and assessed twice weekly for the four-week period before commencing dewatering, as well as during dewatering and compared against trigger levels that will be included in the GSMCP. Monitoring data downloads and assessment can be reduced to monthly after construction is completed for three months.

8.2 BUILDING CONDITION SURVEY

It is recommended to carry out a building condition survey of the buildings with estimated maximum total settlement of >10 mm. This includes the buildings at 100 Mayoral Drive, 48 and 22 Greys Ave. The Myers Park overbridge and the Grand Millennium underpass. The building condition surveys should include a pre-construction condition survey within six months of construction starting, followed by monthly assessments during construction. If alarm levels are exceeded during excavation and dewatering, a post-construction condition survey shall be carried out six months after completion of dewatering.

8.3 GROUND SURFACE DEFORMATION MONITORING

Survey markers should be installed at locations where there is a risk to buildings and infrastructure assessed. Markers should be surveyed at least twice within one month before construction commences to set the baseline.

Survey monitoring should be conducted weekly during construction and continue monthly for six months after construction.

Ground surface markers should also be deployed radially out from the excavation location towards the potentially affected buildings, to confirm ground settlement is within modelled levels.

The trigger levels can only be finalised once the initial baseline monitoring data has been assessed, prior to commencement of construction, and included in the GSMCP.

External visual inspections of nearby buildings should be conducted prior to the commencement of any construction, unless the owner provides written approval. This must be followed up with a post-construction survey between six and twelve months of construction completion, if settlement trigger levels are exceeded during monitoring.

Weekly visual inspections can also be conducted in areas with vulnerable paved areas or surfacing. Photographs should be taken for evidential purposes.

8.4 RESPONSE TO ALERT AND ALARM LEVELS

The alert and alarm levels will be determined, and appropriate responses will be presented in the GSMCP.

8.5 MITIGATION

Mitigation measures will be presented in the GSMCP. The mitigation measures need to be discussed and agreed upon with the contractor as part of the appointment process. Mitigation measures for movement detected in the vicinity of the excavation might include:

- Reduced pumping rates/duration
- Installation of additional seep collars
- Staged excavation
- Grouting to seal localised seepage

9 FOR IDENTIFICATION OF AFFECTED PARTIES

All likely effects as a result of dewatering of the access shafts for the construction of the new wastewater sewer line along the Mayoral Drive alignment has been assessed as minimal to negligible. Hence, there are no affected parties within the likely zones of effects around the shafts. However, as stated in Section 7.4, it is recommended that the buildings at 100 Mayoral Drive, 48 Greys Ave and 22 Greys Ave, as well as the Grand Millennium Underpass and the Myers Park overbridge be included in a GSMCP, as a conservative measure.

10 RMA SECTION 104 ASSESSMENT

The matters of discretion for assessment of the restricted discretionary activity table in Section 4 have been updated in Table 10-1.

Table 10-1: E7.8.1 Assessment – Restricted discretionary activities. Matters of discretion for (6) diversion of groundwater – Updated outcomes

Matters of Discretion	Comment
(a) how the proposal will avoid, remedy or mitigate adverse effects:	
(i) on the base flow of rivers and springs;	Not applicable – No rivers of springs occur in proximity to the works.
(ii) on levels and flows in wetlands;	Not applicable – No wetlands have been identified in proximity to the works.
(iii) on lake levels;	Not applicable– No lakes have been identified in proximity to the works.
(iv) on existing lawful groundwater takes and diversions;	Assessed – see Section 7.2 – negligible effect
(v) on groundwater pressures, levels or flow paths and saline intrusion;	Assessed – see Section 7.3 – negligible effect
(vi) from ground settlement on existing buildings, structures and services including roads, pavements, power, gas, electricity, water mains, sewers and fibre optic cables;	Assessed – see Section 7.4– negligible effect
(vii) arising from surface flooding including any increase in frequency or magnitude of flood events;	Assessed – see Section 7.5 – negligible effect
(viii) from cumulative effects that may arise from the scale, location and/or number of groundwater diversions in the same general area;	Assessed – see Section 7.2.1– negligible effect
(ix) from the discharge of groundwater containing sediment or other contaminants;	Managed via consent condition through on-site treatment (settlement tanks) prior to discharge of water.
(x) on any scheduled historic heritage place; and	Not applicable – No historic/heritage buildings have been identified within 10 m of the works.
(xi) on terrestrial and freshwater ecosystems and habitats.	Assessed – see Section 7.6 – negligible effect
(b) the need for mineral extraction within a Special Purpose - Quarry Zone to carry out dewatering or groundwater level control and diversion and taking of groundwater in the context of mineral extraction activity.	Not applicable – site is not a quarry operation
(c) monitoring and reporting requirements incorporating, but not limited to:	
(i) the measurement and recording of water levels and pressures;	GSMCP proposed
(ii) the measurement and recording of the settlement of the ground, buildings, structures and services	GSMCP proposed
iii) the measurement and recording of the movement of any retaining walls constructed as part of the excavation or trench; and	GSMCP proposed
(iv) requiring the repair, as soon as practicable and at the cost of the consent holder, of any distress to buildings, structures or services caused by the groundwater diversion.	GSMCP proposed
(d) the duration of the consent and the timing and nature of reviews of consent conditions;	To be addressed by Auckland Council within the consent conditions.
(e) the requirement for and conditions of a financial contribution and/or bond; and	negligible effect
(f) the requirement for a monitoring and contingency plan or contingency and remedial action plan.	GSMCP proposed

11 CONCLUSIONS AND RECOMMENDATIONS

Watercare Services Limited (Watercare) are proposing to upgrade the wastewater network within the upper (southern) catchment of Auckland City Centre, due to insufficient capacity to meet future demand. This report only presents an assessment of dewatering effects in relation to the Mayoral Drive Alignment Project, which forms part of the Queen Street Wastewater Diversion Programme.

The construction along Mayoral Drive alignment comprises the construction of a wastewater pipeline from Greys shaft (Part 3-4 connector) to Shaft P1MH2 (Vincent Street) using trenchless technologies. However, open excavations will be required to provide access to the pipeline location for the tunnelling equipment, and this may require temporary dewatering.

The dewatering of the shaft excavation is assessed as a restricted discretionary activity and specialist assessment is required as part of the consent application process. The relevant reasons for consent are identified in Table E7.4.1 Activity Table as:

- *(A20) – Dewatering or groundwater level control associated with a groundwater diversion authorised as a restricted discretionary activity under the Unitary Plan, not meeting permitted activity standards or is not otherwise listed.*
- *(A28) – The diversion of groundwater caused by any excavation, (including trench) or tunnel that does not meet the permitted activity standards or not otherwise listed.*

This report addresses the assessment of effects of dewatering required during the installation of the temporary works and pipeline installation.

The assessment of environmental effects indicated effects on neighbouring bores, nearby environmental features (streams and other surface water bodies), and saline intrusion will be negligible.

It is unlikely that the dewatering activity will result in settlement effects on any buildings in proximity to the shaft. However, groundwater level and ground surface deformation settlement monitoring should be undertaken adjacent to the shaft as a precautionary measure, so that mitigation measures can be put in place, should larger than predicted groundwater drawdown be observed and prior to settlement effects developing.

Utilities and services within 10 m proximity to the proposed works may require specific investigation and management.

12 REFERENCES

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13 LIMITATIONS

This report ('Report') has been prepared by WSP New Zealand Limited ('WSP') exclusively for Watercare Services Limited ('Client') in relation to the assessment of dewatering effects along the Mayoral Drive Alignment of the Queen Street Wastewater Diversion, for consenting purposes ('Purpose') and in accordance with the task order number TO-WSP-65 task name Queen Street Wastewater Diversions – Rescoping, dated 03.12.2025. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any use or reliance on this Report, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Report by any third party.

In preparing this Report, WSP has relied upon data, surveys, analyses, designs, plans and other information ('Client Data') provided by or on behalf of the Client. Except as otherwise stated in this Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable for any incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

APPENDIX A: UNDERGROUND UTILITIES SUMMARY

Undergound Services

VC = vitrified clay; CI = Cast Iron; MS = mild steel; CLS = concrete lined steel; AC = Asbestos Concrete; PE = Polyethylene

P1MH2

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID
Wastewater	Gravity	Approx. 5 m	2.7	300	VC	852360
Wastewater	Gravity	< 5 m	2.7	150	AC	852395
Wastewater	Gravity	Approx. 5 m	2.7	150	AC	837687
Wastewater	Gravity	Approx. 10 m	1.7	300	VC	4845769
Wastewater	Manhole	< 5 m	2.7			522964
Stormwater	Gravity	< 5 m	2.8	300	Ceramic	2000612464
Stormwater	Gravity	Approx. 5 m	Approx. 2.5	525	Concrete	2000666607
Stormwater	Gravity	< 5 m	Approx. 3	675	Concrete	2000323342
Stormwater	Gravity	Approx. 10 m	Aprox. 1.5	375	Concrete	2000402476
Stormwater	Gravity	Approx. 10 m	Approx. 2.6	300	Concrete	2000145591
Stormwater	Manhole	Approx. 10 m	Unknown	1050	NA	3000201840
Stormwater	Manhole	Approx. 10 m	2.8	1050	NA	2000139871
Water Supply	Pressure	< 5 m	Unknown	150	AC	2798400 / 2804156
Water Supply	Pressure	> 10 m	Unknown	100	CI	81019106

P5MH2

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID
Water Supply	Pressure	< 5 m	Unknown	250	CLS	2770075
Water Supply	Pressure	> 10 m	Unknown	150	CLS	2790072
Water Supply	Pressure	< 5 m	Unknown	50	MS	2768961
Transpower	Transmission line	Approx. 5 m	NA	NA	NA	Hobson Street - Penrose Cable
Stormwater	Gravity	Approx. 30 m	Approx. 6	525	Concrete	2000546896
Stormwater	Gravity	Approx. 30 m	Approx. 6	450	Concrete	2000040295 / 2000595730
Stormwater	Gravity	Approx. 30 m	Approx. 1.9	225	Concrete	2000782379

P4MH1

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID
Transpower	Transmission line	Approx. 5 m	NA	NA	NA	Hobson Street - Penrose Cable
Wastewater	Gravity	Approx. 20 m	Approx. 4.5 - 7	300	PE	852388
Wastewater	Gravity	Approx. 20 m	Unknown	150	AC	852290
Wastewater	Gravity	Approx. 30 m	Unknown	525	Concrete	852291
Stormwater	Gravity	Approx. 10 m	1.2	225	Concrete	2000416268
Stormwater	Gravity	Approx. 10 m	6.7	525	Concrete	2000546896
Stormwater	Gravity	Approx. 20 m	Approx. 1.1	225	Concrete	2000873862

P4MH2

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID
Stormwater	Gravity	< 5 m	3.2	450	Concrete	2000534535
Water Supply	Pressure	< 5 m	Unknown	20	PE	2044195
Water Supply	Pressure	< 5 m	Unknown	100	MS	2657704
Water Supply	Pressure	< 5 m	Unknown	300 / 375	CLS	2804152 / 2791453
Water Supply	Pressure	Approx. 10 m	Unknown	200	CLS	81024923
Stormwater	Gravity	Approx. 20 m	3.4	450	Concrete	2000079935

P4MH3

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID
Stormwater	Gravity	< 5 m	1.2	750	Concrete	2000134745
Stormwater	Gravity	< 5 m	Approx. 1.5 - 4 m	1050	Concrete	2000022613
Stormwater	Gravity	< 5 m	Approx. 1.4 - 3	900	Concrete	2000811674
Stormwater	Gravity	Approx. 5	Approx. 2.5 - 3	1050	Concrete	2000044962
Stormwater	Gravity	Approx. 5	Approx. 8.3	225	Concrete	2000923017
Stormwater	Gravity	Approx. 5	Approx. 1.2	750	Concrete	2000311777
Wastewater	Gravity	< 5 m	Approx. 3	300	AC	837665
Wastewater	Gravity	Approx. 5 m	Approx. 3	300	AC	832739
Wastewater	Gravity	Approx. 5 m	Approx. 3	300	AC	851940
Water Supply	Pressure	Approx. 5 m	Unknown	250	CLS	2770075

APPENDIX B: CONSTRUCTION METHODOLOGY

Construction Methodology

Queen Street Wastewater Diversion – Package B

Contract No: CT7754

Project Manager:	Dominic Wakeland	Date: Document No: Revision: Status:	28 May 2025 QSSD-CS-XXXX 05 For Consenting

Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
00	08/09/23	J Gordon	D Wakeland		Draft
01	22/09/23	J Gordon	D Wakeland		For Consenting
02	15/10/24	D Wakeland	WSP Planning Team	D Wakeland	For Consenting – Updated Alignment
03	15/11/24	D Wakeland	WSP Planning Team	D Wakeland	For Consenting
04	28/11/24	C Miles (WSP)	D Wakeland	D Wakeland	For Consenting
05	28/05/25	M Gerecke	D Wakeland	D Wakeland	For Consenting

Revision Details

Revision	Details
00	Draft methodology
01	Updated as per WSP comments
02	Updated to reflect change to alignment
03	Updated to clarify items as requested by WSP Planning Team
04	Shaft sizes updated by WSP post WSL Operations/WSL/WSP/FH Mayoral Drive Workshop
05	Shaft and compound sizes updated to reflect current Package B alignment and temp works

Document Details

Document Name:	Construction Methodology
Status:	For Consenting
Document No:	QSSD-CS-XXXX
Author:	D Wakeland

Contents

1. Introduction

The purpose of this high-level construction methodology statement is to provide an understanding of how the Project (Mayoral Drive section of the Queen Street Wastewater Diversion Project) will be implemented by Fulton Hogan (FH) for consent purposes under the Resource Management Act 1991.

The Project works generally comprise the construction of a new wastewater pipe to collect flows from the north end of Vincent Street and convey them to southern of Part 3 of the project, adjacent to the intersection of Mayoral Drive and Queen Street.

The Mayoral Drive Alignment is made up of 3 sections (Part 1, Part 4 and Part 5) as shown in Figure 1 below. The scheme also includes making connections to and taking wastewater flows from several existing Engineered Overflow Points (EOPs)along the alignment.

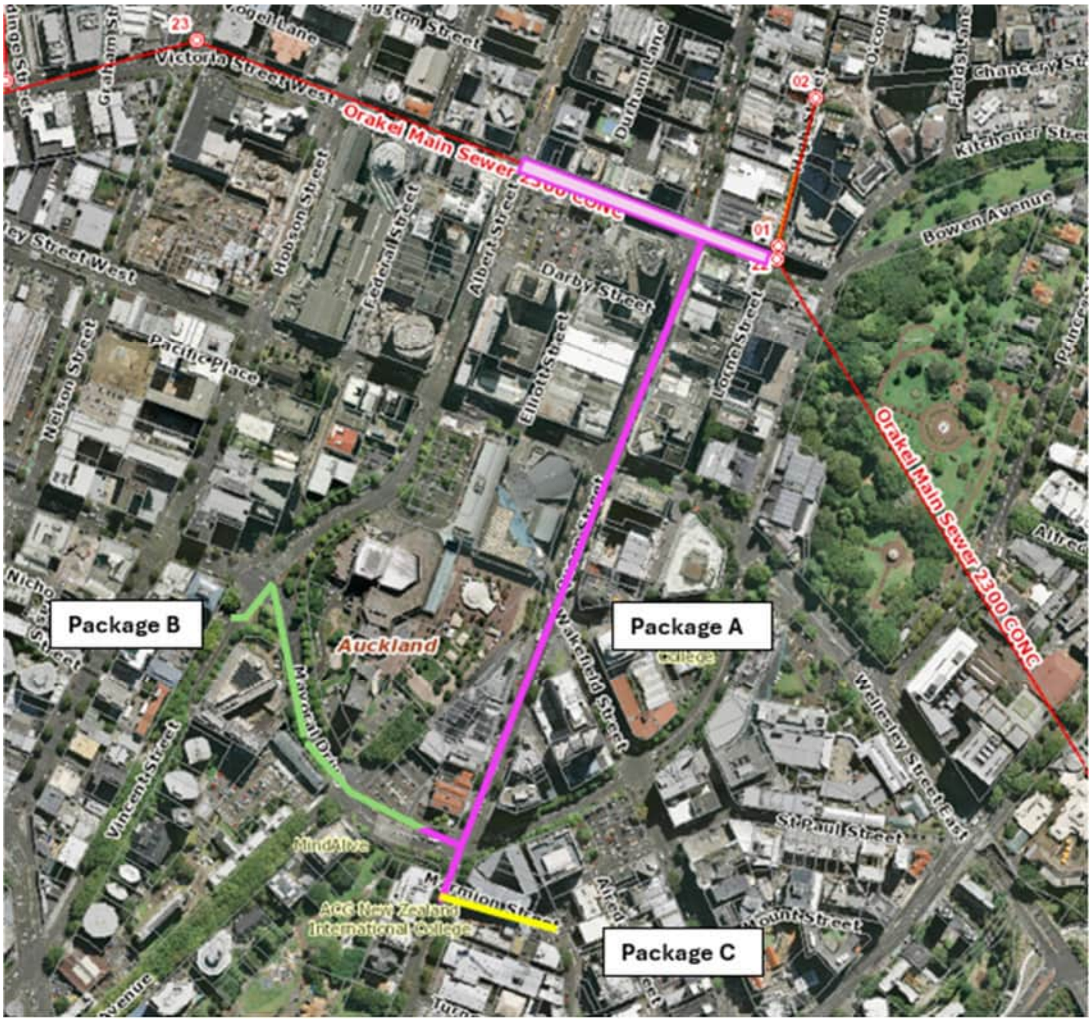


Figure 1: Queen Street Wastewater Diversion Packages Overview

This document has been created prior to issue of GFR, GIR, GBR or detailed design. Likewise, various stakeholder impacts will need to be assessed, and their constraints accommodated including assets, street trees, traffic needs, services, etc. As such, broad assumptions have been made and this methodology is subject to change as a result of new information becoming available.

This document covers the general sequencing and methodology for the construction of temporary shafts, pipelines, connections, manholes and associated works. It should be reviewed in conjunction with the FH high level construction programme (refer **Appendix A**).

2. Site Set Up and Enabling works

A construction support area (CSA) will be located within the Greys Avenue Carpark and will utilise the space previously established during the Part 3 (package A) works. Some office/cabin reconfiguration may be required (refer Figure 2 below).

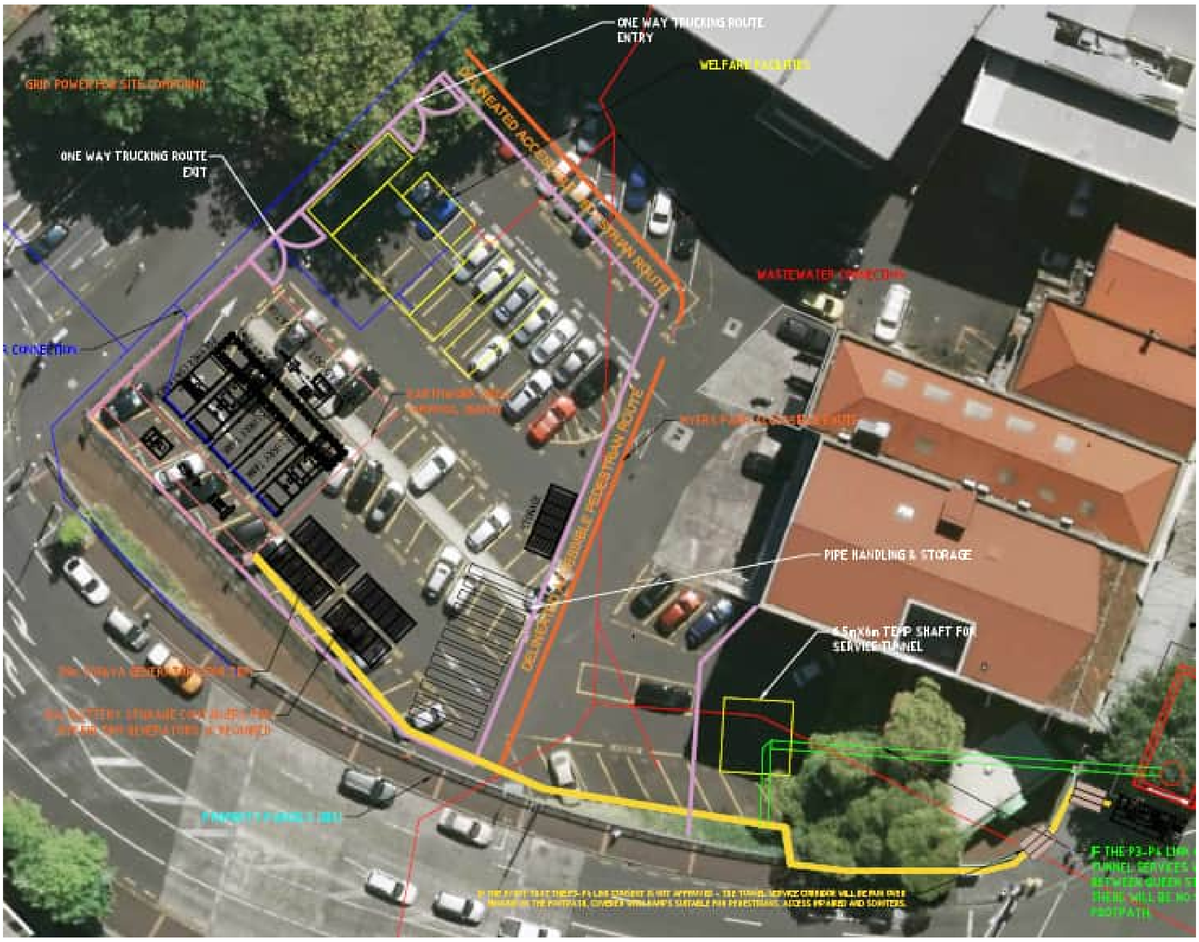


Figure 2: Layout for Construction Support Area

Limited site laydown/materials storage will be accommodated within the CSA. Most excavated materials and construction materials (pipes, aggregates, etc.) will be removed/delivered to the site on a “just-in-time” basis.

Traffic management will be setup in advance of compound construction ensuring all agreed vehicle, pedestrian and property access requirements are adhered to.

Four long-term site compounds (6 to 8 months) will be established within Mayoral Drive and Vincent St traffic lanes to allow construction of temporary shafts and tunnelling works. For these compounds, temporary steel barriers and temporary fencing/hoarding will be constructed around the perimeter of each, with access gates one or both ends. Indicative site compound layout plans are provided below and are subject to final design, traffic impact assessments and TMP’s. The traffic restrictions required to accommodate these compounds are also indicatively shown in Figures 3 and 4 below. The compound widths have been driven by the shaft temporary works requirements and the barrier protections required for these deep shafts (refer Figure 5).

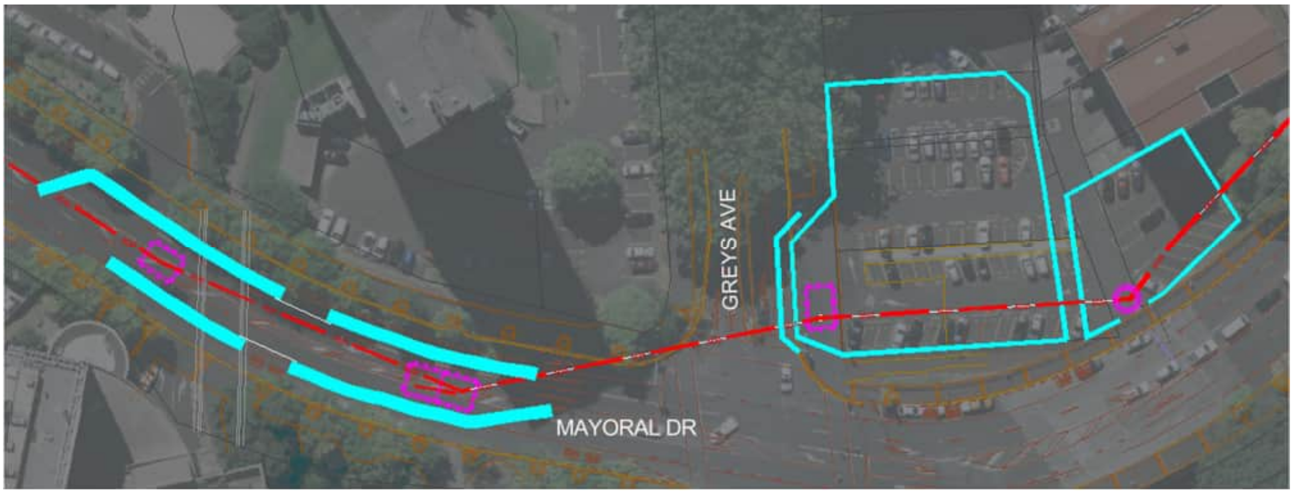


Figure 3: Two long-term compounds on Mayoral Drive/Greys Avenue (compound extents shown with blue line)

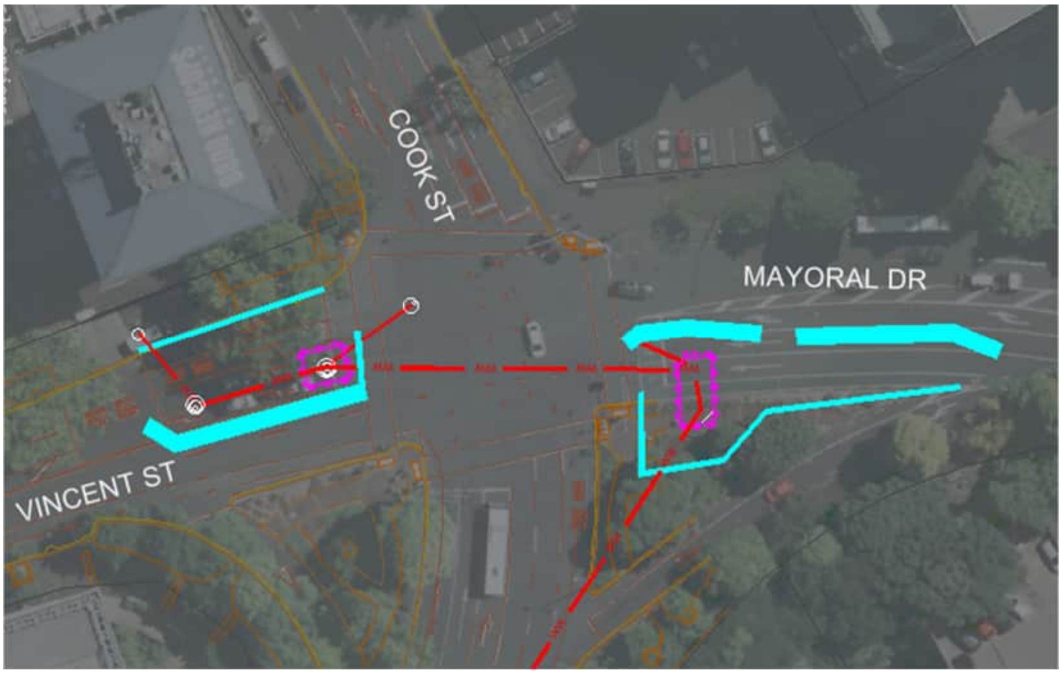


Figure 4: Two long-term compounds at Cook St/Mayoral Drive/Vincent St intersection (compound extents shown with blue lines)

General site working hours will be Monday-Saturday 7 am-6 pm. Sunday and night work will only be carried out if required by traffic management or WSL operational restrictions such as for tie-ins/connections to existing pipe work.

Heavy vehicle movements between the compounds and Greys Avenue CSA will be 40 movements per day at peak.

2.1. Utility Diversions

There will be a need for utility diversions to enable shaft construction ahead of main works start. NUOs have been engaged early in the design to assist with the diversion planning process. The depth and geotech conditions of the existing and proposed underground service diversions will guide the need for any trench shoring. Based on the diversions required, some trenches will need to remain open longer than 10 days. Service locations will be marked out for any existing services prior to any intrusive works, and then the trench will be opened up for diversion works to begin. A hydro or air vac will be used to safely uncover all underground utilities within the trench. Dewatering may be required within the trench. Necessary utilities will be diverted, the trench will be backfilled, and area returned to its original condition.

Table 2.2.1 – Diversion Plant Summary

Activity	Plant List
Excavating trench	8-15t excavator with breaker attachment
	6-wheeler truck
	Hydro or Air Vacuum Truck
Dewatering	Submersible pump & lamella clarifier tank
	Silenced Generator 60kVA
Backfilling	6-wheeler truck
	8-15t excavator
	Plate compactor
Reinstatement	Asphalt truck, concrete truck and pump

3. Main Construction Works Overview

Construction methodologies are outlined in Figure 5 below and details for each are provided within the subsections below.

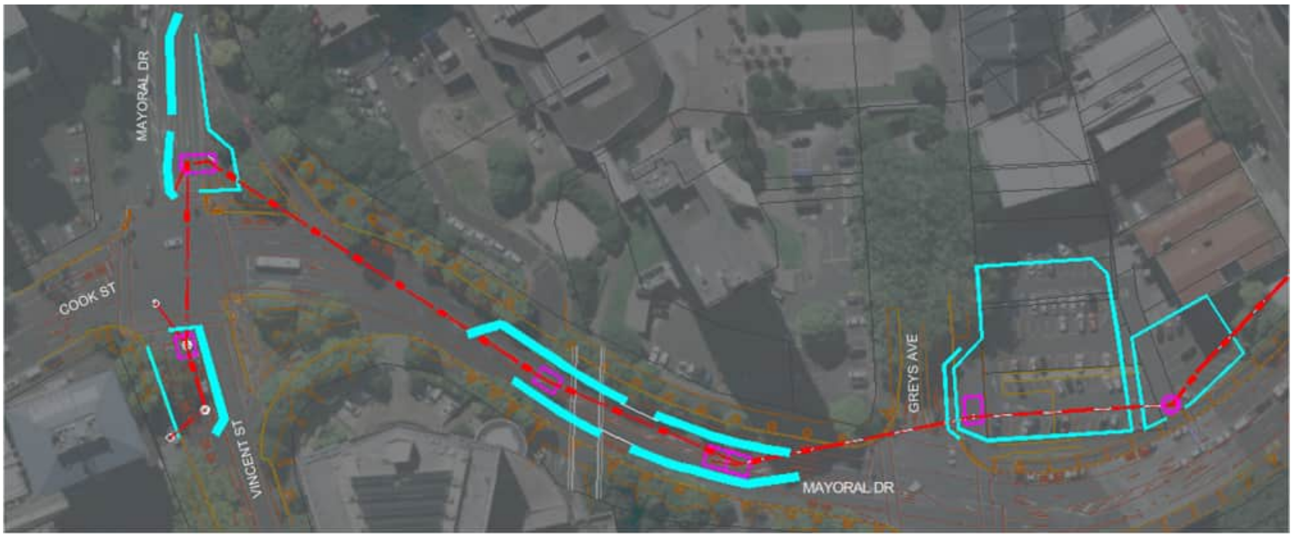


Figure 5: Main Construction Works Overview

3.1. Shaft Construction

Most manhole locations on this alignment will be used as launch/reception pits for the trenchless construction method (axis/pilot bore). The trenchless method requires shafts with minimum internal dimensions of 4.5m x 4.5m; however, some shafts will contain two manholes and / or existing EOP infrastructure and will need to be oversized. The shoring technique required to support these shafts will be subject to geotechnical conditions and shaft temporary works design but will most likely be a post and panel-type construction method. The shaft sizes for each location are shown in Table 3.1.2 below. The basic steps required to construct temporary post and panel shafts are outlined below and in Figure 6.

- An auger attachment on a 10 – 35t excavator or small piling rig (GEAX EK60) will be used to drill 600mm dia holes. Piles will typically be drilled 4m below pipe inverts. Steel H-columns will be set into each with sand or concrete backfill. A mobile crane will likely be required to pitch and install the steel columns, depending on pile depth

- The shaft will be excavated from the top using an excavator at surface level to a depth of approximately 1m below pipe invert. Six-wheeled trucks will be used to remove spoil off site. Shaft excavations are expected to occur over 1 – 2 weeks, depending on the size and depth of the shafts.
- Steel road plates or timber lagging will be cut and installed between H-columns as the excavation advances.
- Forced air ventilation may be required using a fan at surface level with ventilation ducting into each shaft during work hours.
- The shaft base will be lined out with 300 to 500mm of aggregate and/or 100mm of blinding concrete to provide a solid and level working platform.
- If dewatering is required, a submersible pump will be used to remove water from the excavation. The water will be pumped into a clarifying tank for treatment before discharging to stormwater. The pumps will run continuously while the shaft is open (6-8 months) and will be powered by a silenced diesel generator.
- Once the shaft has been used for tunnelling, a manhole will be constructed, and the shaft reinstated.

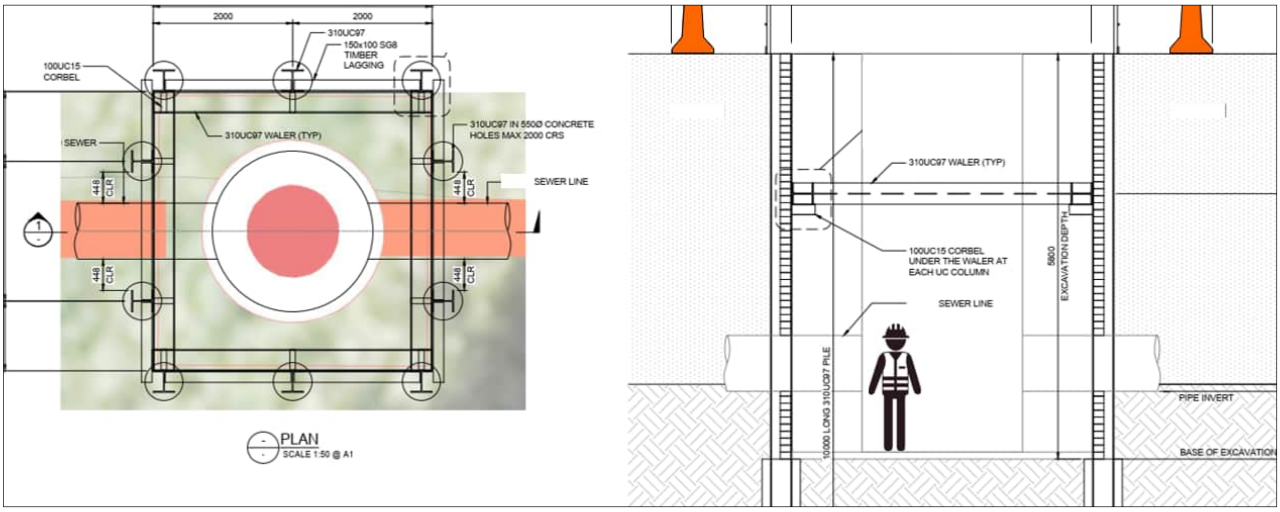


Figure 6 – Typical temporary works detail for shafts (A. O'Sullivan & Associates)

Table 3.1.1 - Shaft Plant Summary

Activity	**Plant List**
Drilling and installing steel posts	10 – 35t excavator/GEAX EK60, 30-35T mobile crane
Excavating shaft	20 – 35t excavator
Spoil removal	6-wheeler or artic trucks
Concrete base	Concrete truck/concrete pump truck
Dewatering	Submersible pump & lamella clarifier tank
Dewatering	Silenced Generator 60kVA
Ventilation	Fan

Table 3.1.2 - Shaft Earthworks Summary

	Shaft Details (internal dimensions)				
Manhole ID	**Width (m)**	**Length (m)**	**Depth (m)**	**Volume (m3)**	**Duration Shaft Open**
P4MH3 (secant pile round)	3.5	-	6	58	6 to 8 months
P4MH2	4.4	7	8.4	259	6 to 8 months
P4MH1A and B	5	11.5	8.3	478	6 to 8 months
P5MH2	4.4	6	8.1	214	6 to 8 months
P5MH1 and P1MH3	4.5	8.8	6.5	258	6 to 8 months
P1MH2	4.4	5.5	6	146	6 to 8 months

3.2. Trenchless Construction – Pilot Guided Auger Bore

Due to the pipe depths and shallow grades for this alignment, the most appropriate pipe laying methodology will be a trenchless pilot guided auger (or vacuum) bore rig. It has been assumed that this methodology will be used for the five pipe runs between P4MH3 and P1MH2.

The basic steps for this trenchless methodology are outlined below:

- Setup power pack, pump, vacuum truck, and water tank on surface adjacent to launch pit.
- Lift pilot bore rig into pit and survey into position.
- Drill pilot hole to reception pit using laser guided steering head.
- Install cutting reamer and pull back to launch pit.
- An auger (or vacuum) with sucker truck will be used to remove spoil from the drive and it will be disposed of offsite using 6-wheelers or sucker trucks. Approx wet tunnel spoil volume will be 0.3 m^3/m of DN450 pipe (0.6 m^3/m for DN700 pipe). For a DN450 pipe between P4MH4 and P1MH2, this equates to 95 m^3 (15 to 25 return six-wheeler truck trips).
- Simultaneously jack glass reinforced plastic (GRP) pipes between shafts.
- Clean up and flush drill slurry out of pipe by jetting and vacuum truck.
- CCTV inspection and low-pressure air test on completion.

It has not been decided which exact pilot bore rig will be used, therefore it should be assumed that any of the six shafts could be used as either a launch or reception shaft (or both).

Refer to Figures 7, 8 and 9 below of a typical pilot bore operation (note that exact methods vary between different machines).

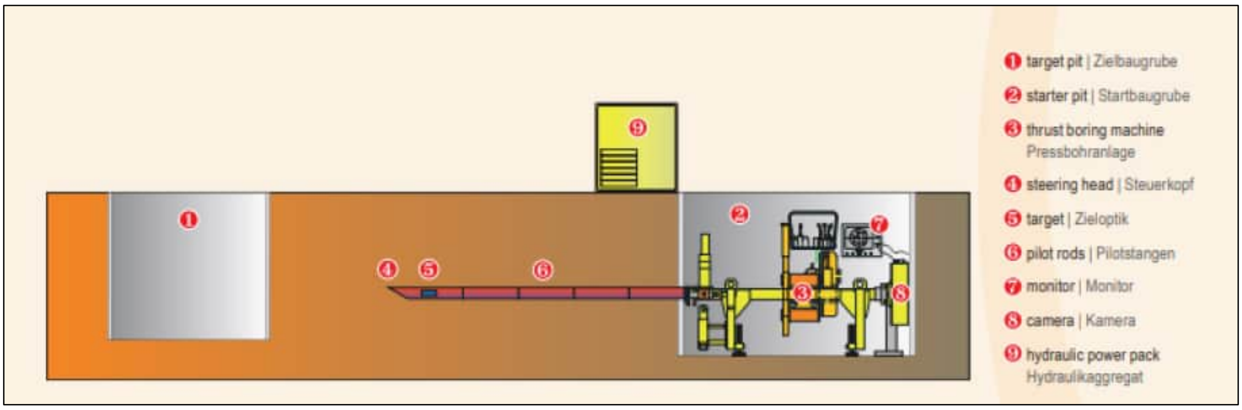


Figure 7 – Typical pilot bore – pilot process

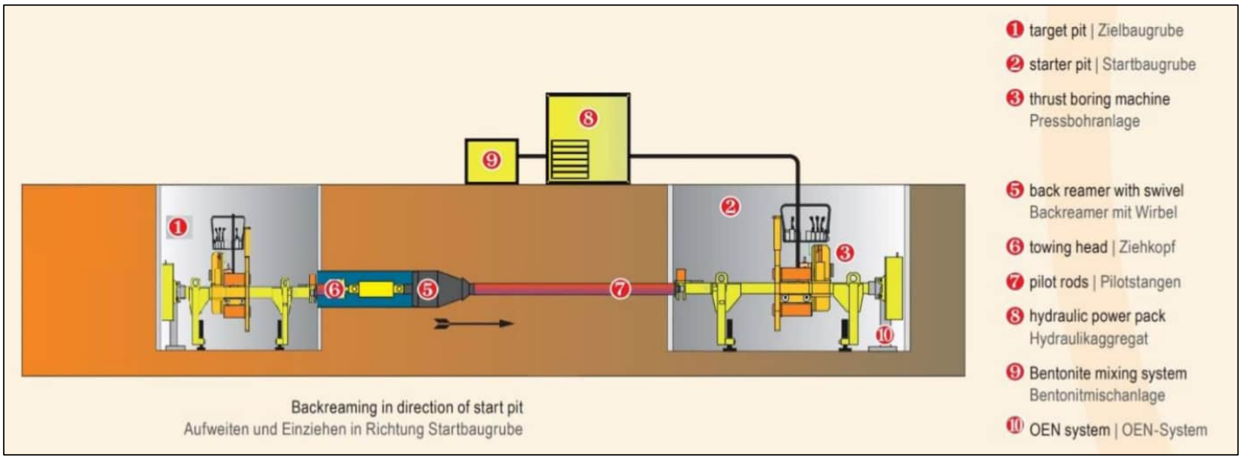


Figure 8 – Typical pilot bore – cutting back

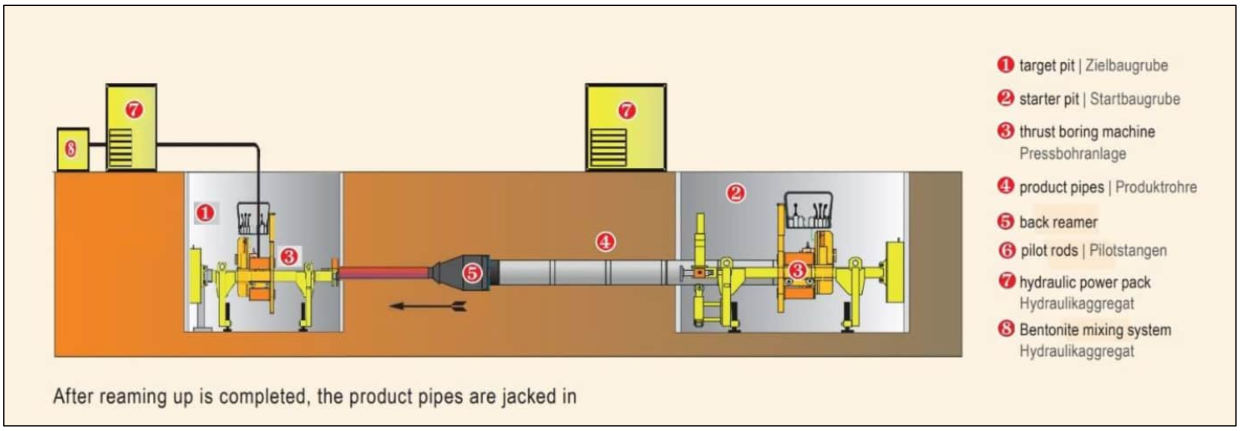


Figure 9 – Typical pilot bore – jacking pipes in

Table 3.2.1 - Tunnelling Plant Summary

Activity	**Plant List**
Pilot Boring – Launch Shafts	Crane HIAB truck
	10 – 20t excavator
	Power pack container
	Pilot boring machine
	6-wheeler or artic trucks truck (or vacuum truck)

	Tool truck
Pilot Boring – Reception Shafts	Crane HIAB truck
	10 – 20t excavator
	Power pack container
	Pilot boring machine
	Tool truck

4. Open Cut Pipe Laying & EOP Connections

For shallow or short pipe runs for existing/EOP connections, an open-cut pipe laying methodology will be used. The steps for this method are listed below:

- For any sections of pipeline outside of the temporary compounds, short-term traffic management will be setup in accordance with approved TMPs, which will likely be staged to allow only short sections of pipeline to be constructed at one time.
- Trench shields and manhole boxes will be used for all trenching over 1.5m depth, which will be most pipeline and connections (refer Figure 11 below). Approximately 10 to 25m of trench will be open at any one time for up to 4 weeks at a time. **NOTE:** *Where existing services cross the trench, the shoring method will change to a driven steel H-pile support method with vertical timbers to accommodate existing services.*
- Expected total trench volumes are:
  - 90m^3 (P1MH2 to EX MH 522964)
  - 62m^3 (P5MH1 to EX MH500717)
  - 71m^3 (P1MH2 – P1MH1)
  - 38m^3 (P1MH1 – EX MH4845867)
- The total estimated earthworks volume for open-cut trenching is 261m^3.
- Pipe lengths and precast manholes will be delivered to site on flatbed trucks and unloaded within the site using HIAB trucks or excavators.
- A leading excavator will be used to trench to the required depths and install trench shields as the excavation advances. Wider trench boxes will be provided at manhole locations.
- Excavated materials will be cut to waste as clean, managed or contaminated fill (dependent on contamination testing results).
- If dewatering is required (to be determined by ground investigations), a submersible pump will be used to remove water from excavations. The water will be pumped into a clarifying tank for treatment before discharging to stormwater. The pumps will run continuously while the shaft is open and will be powered by a silenced diesel generator. Noise mitigation will be used such as barrier screens for overnight dewatering if required.
- Pipe bedding material will be carted to the worksite directly from source in 6 or 8-wheeled trucks, spread into the trench using an excavator and compacted using 300 to 800kg plate compactors in specified layers.
- Excavators will be used to lift pipe lengths into the trench.
- Side haunching, overlay bedding and hard fill to pavement level will be constructed as per pipe bedding material (refer to item above).

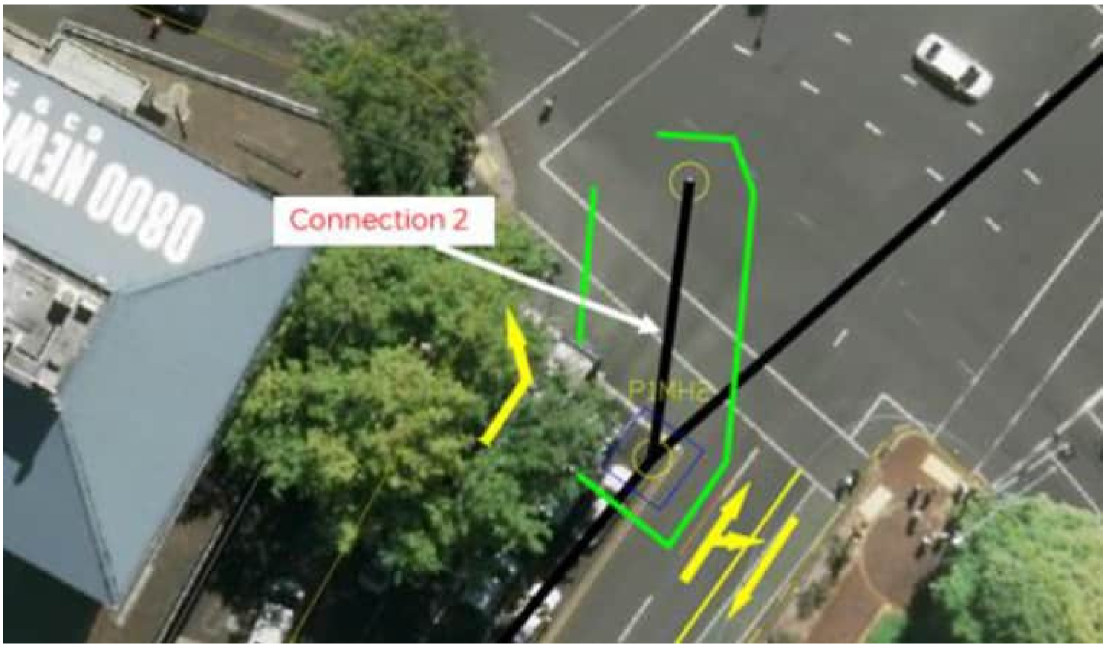


Figure 10 – Plan view of short-term TM for an EOP connection using opencut method

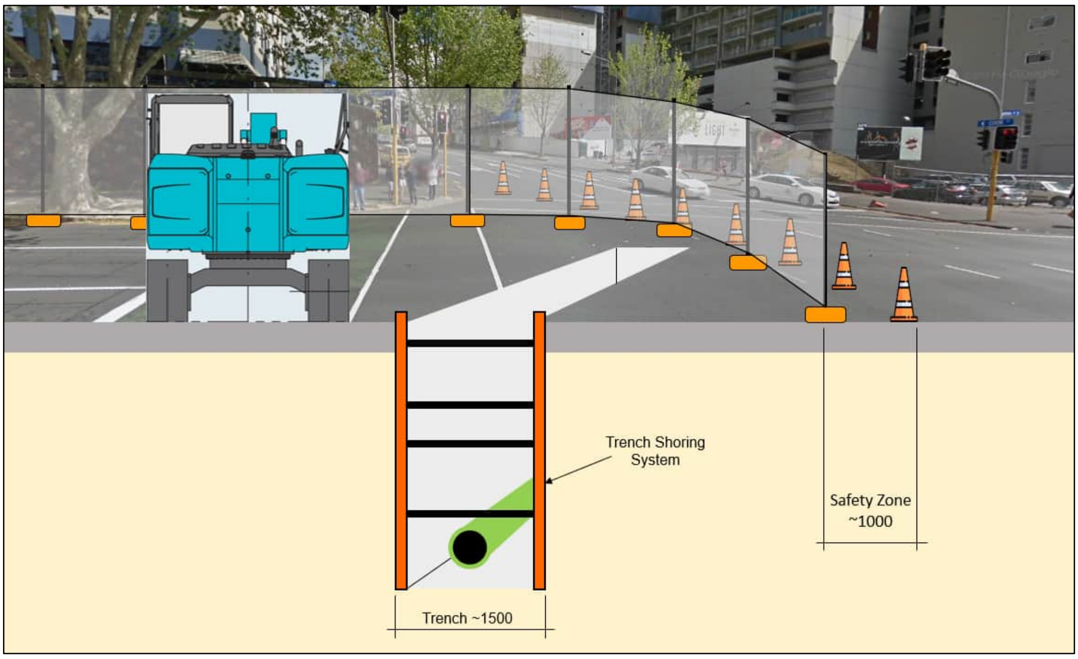


Figure 11 – Trench shoring system for EOP connection using the opencut method

Open Cut Pipe Laying Plant Summary Table

Activity	Plant List
Open cut pipe work / manholes	14 – 35t excavator
	Excavator Movax/Vibro
	Trench shoring/H-Piles
	Six-wheelers or artic trucks
	Hydro excavator
	Concrete truck
	Plate compactor

5. Manhole Construction (at shafts) and Road Pavement Reinstatement

The basic construction steps for manhole construction are detailed below.

- Form and pour concrete manhole base using concrete pump truck or excavator located adjacent to shaft. Alternatively, install a flanged precast manhole base and riser with the excavator.
- Lift in precast manhole riser sections using HIAB or excavator.
- Form and pour connection corbels on outside of precast riser using concrete pump truck or excavator located adjacent to shaft.
- Form and pour manhole benching using concrete pump truck or excavator located adjacent to shaft.
- Lift in and fix any pipe droppers within manholes.
- Backfill void between shaft and manhole with plate compacted aggregates or low strength concrete.
- Cut and abandon shaft temporary works 1.5m below road level as backfill progresses.
- Construct road pavements layers using excavator, plate compactor and vibratory roller.

Manhole and Pavement Plant Summary Table

Activity	**Plant List**
Manholes	14 – 35t excavator
	Trench shoring/H-Piles
	Excavator Movax/Vibro
	Six-wheeler trucks
	HIAB crane
	Concrete truck
	Concrete pump truck
Road Pavement Reinstatement	14 – 35t excavator
	Plate compactor
	Vibratory roller
	Pilot boring machine
	Tool truck

6. Sequence of work & Programme Durations

Refer Appendix 1 for high level construction programme.

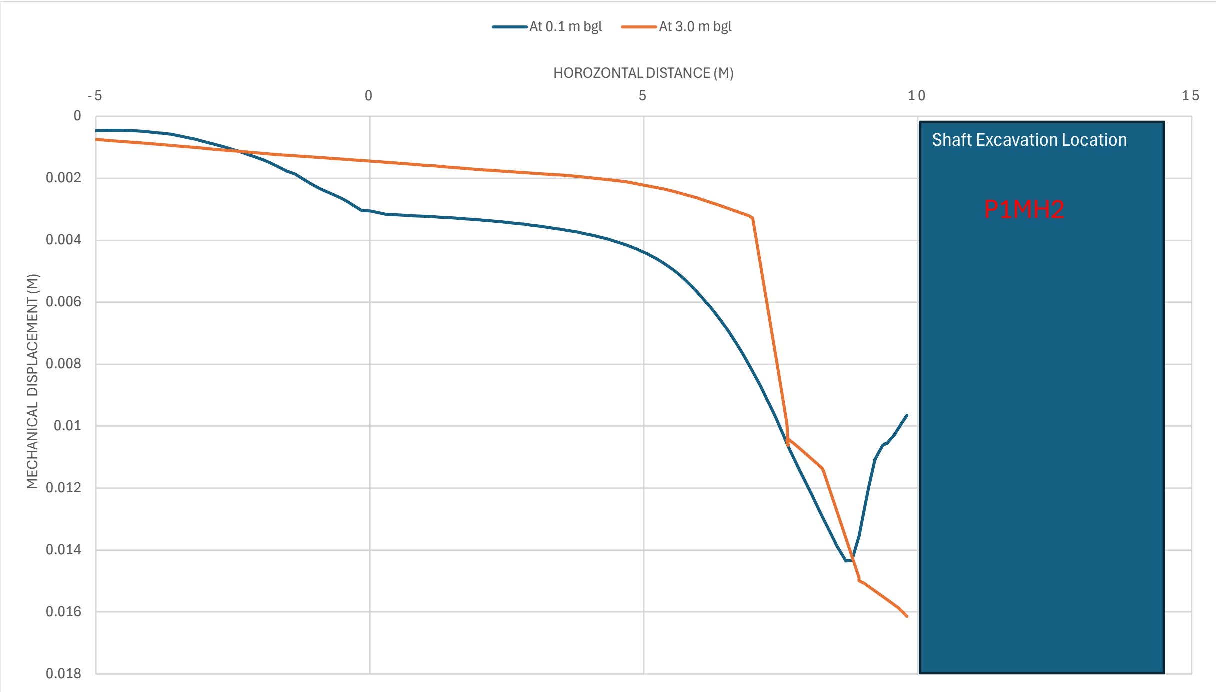
APPENDIX C: SETTLEMENT RESULTS

Queen Street WW ECI Temporary Works Support - Queen Street Wastewater Diversion - Package B, Auckland (FH Contract No. CT7754)

CONCEPT ONLY - NOT FOR CONSTRUCTION

ENGEO Summary of static settlements at 0.1m and 3.0m depth for shaft locaiton P1MH2

Date of issue: **28/03/2025**



At 0.1 m bgl		At 3.0 m bgl	
X [r	|u| [m]	X [m]	|u| [m]
9.80E+00	9.66E-03	9.80E+00	1.61E-02
9.69E+00	9.94E-03	9.65E+00	1.59E-02
9.69E+00	9.95E-03	9.65E+00	1.59E-02
9.58E+00	1.03E-02	9.62E+00	1.58E-02
9.58E+00	1.03E-02	9.62E+00	1.58E-02
9.43E+00	1.06E-02	9.02E+00	1.51E-02
9.43E+00	1.06E-02	9.02E+00	1.51E-02
9.40E+00	1.06E-02	8.92E+00	1.50E-02
9.40E+00	1.06E-02	8.92E+00	1.49E-02
9.36E+00	1.06E-02	8.28E+00	1.14E-02
9.36E+00	1.06E-02	8.28E+00	1.14E-02
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9.10E+00	1.19E-02	7.63E+00	1.04E-02
9.10E+00	1.19E-02	7.63E+00	1.06E-02
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8.68E+00	1.44E-02	6.32E+00	2.84E-03
8.55E+00	1.39E-02	5.97E+00	2.64E-03
8.55E+00	1.39E-02	5.97E+00	2.64E-03
8.50E+00	1.38E-02	5.56E+00	2.44E-03
8.50E+00	1.38E-02	5.56E+00	2.44E-03
8.46E+00	1.37E-02	5.38E+00	2.36E-03
8.46E+00	1.37E-02	5.38E+00	2.36E-03
8.32E+00	1.32E-02	4.68E+00	2.12E-03
8.32E+00	1.32E-02	4.68E+00	2.12E-03
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8.20E+00	1.27E-02	4.48E+00	2.07E-03
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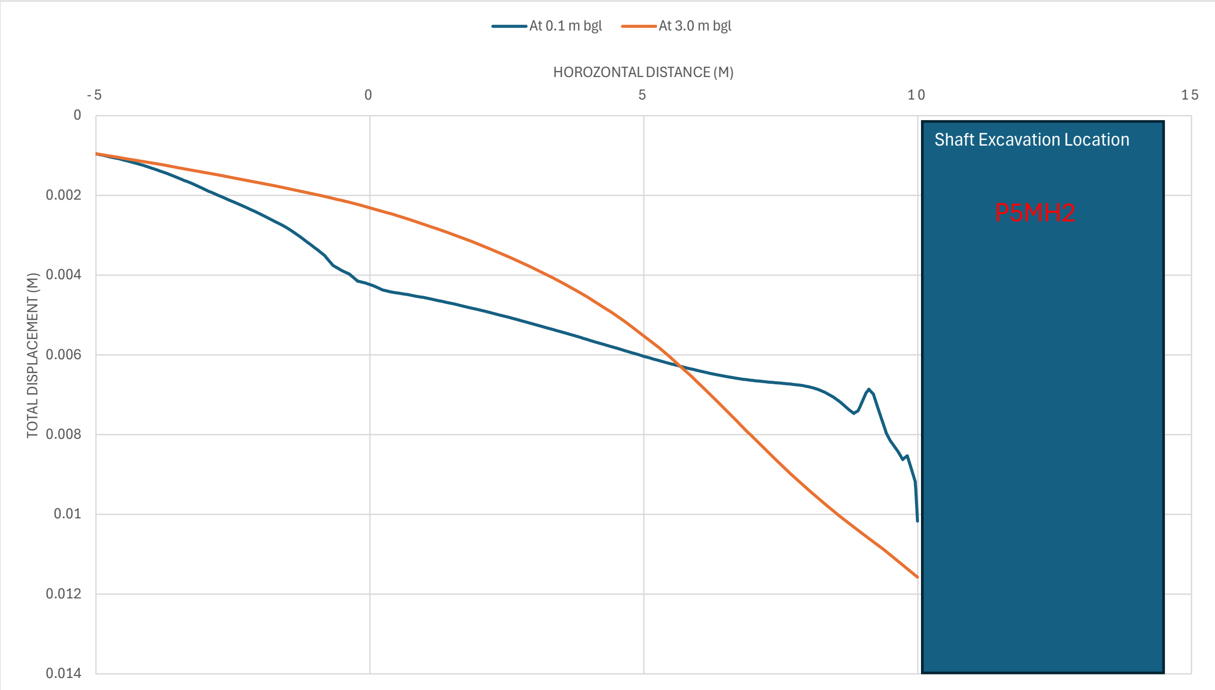
8.08E+00	1.23E-02	3.65E+00	1.92E-03
7.92E+00	1.17E-02	3.52E+00	1.90E-03
7.92E+00	1.17E-02	3.52E+00	1.90E-03
7.88E+00	1.16E-02	3.39E+00	1.89E-03
7.88E+00	1.16E-02	3.39E+00	1.89E-03
7.83E+00	1.14E-02	2.35E+00	1.76E-03

Queen Street WW ECI Temporary Works Support - Queen Street Wastewater Diversion - Package B, Auckland (FH Contract No. CT7754)

CONCEPT ONLY - NOT FOR CONSTRUCTION

ENGEO Summary of static settlements at 0.1m and 3.0m depth for shaft locaiton P5MH2

Date of issue: 28/03/2025



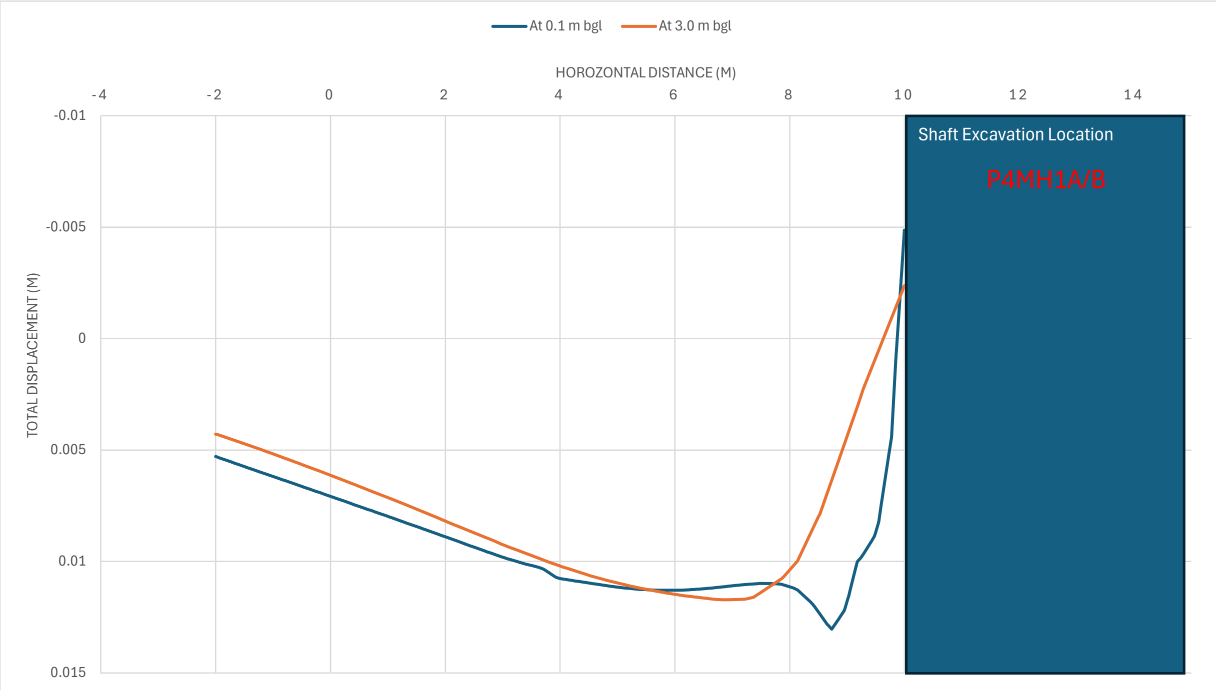
At 0.1 m bgl		At 3.0 m bgl	
X [r	u_x [m]	X [m]	u_x [m]
1.00E+01	1.02E-02	1.00E+01	1.16E-02
9.96E+00	9.22E-03	9.39E+00	1.09E-02
9.96E+00	9.18E-03	9.39E+00	1.09E-02
9.81E+00	8.53E-03	9.18E+00	1.07E-02
9.81E+00	8.53E-03	9.18E+00	1.07E-02
9.73E+00	8.62E-03	8.69E+00	1.02E-02
9.73E+00	8.62E-03	8.69E+00	1.02E-02
9.65E+00	8.43E-03	8.57E+00	1.00E-02
9.65E+00	8.43E-03	8.57E+00	1.00E-02
9.50E+00	8.16E-03	8.43E+00	9.88E-03
9.50E+00	8.16E-03	8.43E+00	9.88E-03
9.42E+00	7.94E-03	7.95E+00	9.32E-03
9.42E+00	7.92E-03	7.95E+00	9.32E-03
9.34E+00	7.59E-03	7.67E+00	8.97E-03
9.34E+00	7.59E-03	7.67E+00	8.97E-03
9.19E+00	6.98E-03	7.39E+00	8.61E-03
9.19E+00	6.98E-03	7.39E+00	8.61E-03
9.11E+00	6.86E-03	6.96E+00	8.02E-03
9.11E+00	6.87E-03	6.96E+00	8.02E-03
9.06E+00	6.96E-03	6.84E+00	7.85E-03
9.06E+00	6.96E-03	6.84E+00	7.85E-03
8.91E+00	7.41E-03	6.72E+00	7.69E-03
8.91E+00	7.41E-03	6.72E+00	7.69E-03
8.84E+00	7.47E-03	6.33E+00	7.16E-03
8.84E+00	7.47E-03	6.33E+00	7.16E-03
8.76E+00	7.39E-03	6.06E+00	6.79E-03
8.76E+00	7.39E-03	6.06E+00	6.79E-03
8.61E+00	7.22E-03	5.87E+00	6.54E-03
8.61E+00	7.22E-03	5.87E+00	6.54E-03
8.53E+00	7.13E-03	5.47E+00	6.04E-03
8.53E+00	7.13E-03	5.47E+00	6.04E-03
8.45E+00	7.05E-03	5.31E+00	5.86E-03
8.45E+00	7.05E-03	5.31E+00	5.86E-03
8.31E+00	6.94E-03	5.25E+00	5.79E-03
8.31E+00	6.94E-03	5.25E+00	5.79E-03
8.23E+00	6.89E-03	4.70E+00	5.21E-03
8.23E+00	6.89E-03	4.70E+00	5.21E-03
8.14E+00	6.85E-03	4.39E+00	4.92E-03
8.14E+00	6.85E-03	4.39E+00	4.92E-03
8.00E+00	6.80E-03	3.98E+00	4.56E-03

Queen Street WW ECI Temporary Works Support - Queen Street Wastewater Diversion - Package B, Auckland (FH Contract No. CT7754)

CONCEPT ONLY - NOT FOR CONSTRUCTION

ENGEO Summary of static settlements at 0.1m and 3.0m depth for shaft locaiton P4MH1A/B

Date of issue: **17/04/2025**



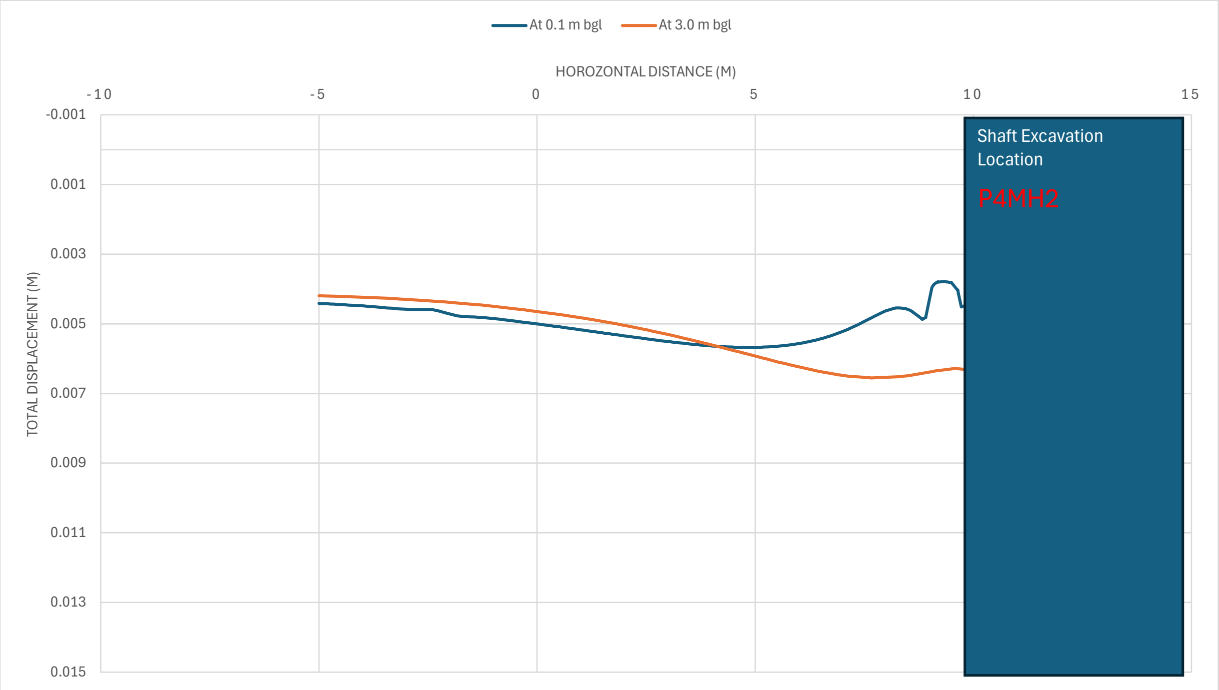
At 0.1 m bgl		At 3.0 m bgl	
X [r	u_x [m]	X [m]	u_x [m]
1.00E+01	-4.87E-03	1.00E+01	-2.37E-03
9.85E+00	9.84E-04	9.30E+00	2.13E-03
9.85E+00	9.84E-04	9.30E+00	2.13E-03
9.78E+00	4.41E-03	9.19E+00	2.95E-03
9.78E+00	4.41E-03	9.19E+00	2.95E-03
9.55E+00	8.21E-03	8.52E+00	7.87E-03
9.55E+00	8.21E-03	8.52E+00	7.87E-03
9.48E+00	8.88E-03	8.50E+00	8.01E-03
9.48E+00	8.88E-03	8.50E+00	8.01E-03
9.25E+00	9.80E-03	8.14E+00	9.98E-03
9.25E+00	9.80E-03	8.14E+00	9.98E-03
9.18E+00	1.00E-02	7.89E+00	1.07E-02
9.18E+00	1.00E-02	7.89E+00	1.07E-02
9.03E+00	1.16E-02	7.87E+00	1.08E-02
9.03E+00	1.16E-02	7.87E+00	1.08E-02
8.95E+00	1.22E-02	7.37E+00	1.16E-02
8.95E+00	1.22E-02	7.37E+00	1.16E-02
8.73E+00	1.30E-02	7.23E+00	1.17E-02
8.73E+00	1.30E-02	7.23E+00	1.17E-02
8.66E+00	1.28E-02	6.86E+00	1.17E-02
8.66E+00	1.28E-02	6.86E+00	1.17E-02
8.44E+00	1.20E-02	6.66E+00	1.17E-02
8.44E+00	1.20E-02	6.66E+00	1.17E-02
8.36E+00	1.18E-02	6.15E+00	1.15E-02
8.36E+00	1.18E-02	6.15E+00	1.15E-02
8.14E+00	1.13E-02	5.93E+00	1.14E-02
8.14E+00	1.13E-02	5.93E+00	1.14E-02
8.07E+00	1.12E-02	5.46E+00	1.12E-02
8.07E+00	1.12E-02	5.46E+00	1.12E-02
7.85E+00	1.10E-02	5.24E+00	1.11E-02
7.85E+00	1.10E-02	5.24E+00	1.11E-02
7.77E+00	1.10E-02	4.77E+00	1.08E-02
7.77E+00	1.10E-02	4.77E+00	1.08E-02
7.55E+00	1.10E-02	4.55E+00	1.07E-02
7.55E+00	1.10E-02	4.55E+00	1.07E-02
7.48E+00	1.10E-02	4.04E+00	1.02E-02
7.48E+00	1.10E-02	4.04E+00	1.02E-02
7.25E+00	1.10E-02	3.82E+00	1.00E-02
7.25E+00	1.10E-02	3.82E+00	1.00E-02
7.18E+00	1.10E-02	3.13E+00	9.37E-03

Queen Street WW ECI Temporary Works Support - Queen Street Wastewater Diversion - Package B, Auckland (FH Contract No. CT7754)

CONCEPT ONLY - NOT FOR CONSTRUCTION

ENGEO Summary of static settlements at 0.1m and 3.0m depth for shaft locaiton P4MH2

Date of issue: **1/04/2025**



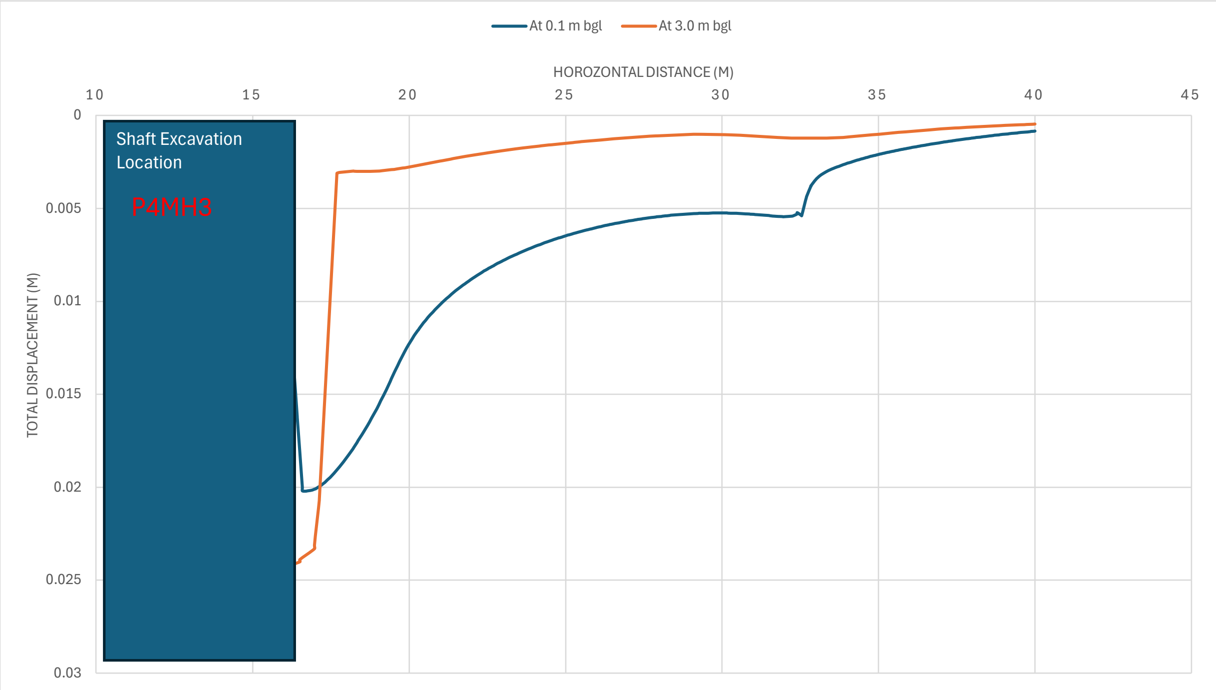
At 0.1 m bgl		At 3.0 m bgl	
X [m]	u_x [m]	X [m]	u_x [m]
10.00	0.0040	1.00E+01	6.33E-03
9.95	0.0041	9.57E+00	6.28E-03
9.95	0.0041	9.57E+00	6.28E-03
9.81	0.0045	9.12E+00	6.36E-03
9.81	0.0045	9.12E+00	6.36E-03
9.72	0.0045	9.01E+00	6.38E-03
9.72	0.0045	9.01E+00	6.38E-03
9.64	0.0040	8.51E+00	6.49E-03
9.64	0.0040	8.51E+00	6.49E-03
9.50	0.0038	8.35E+00	6.51E-03
9.50	0.0038	8.35E+00	6.51E-03
9.41	0.0038	8.31E+00	6.52E-03
9.41	0.0038	8.31E+00	6.52E-03
9.33	0.0038	7.64E+00	6.55E-03
9.33	0.0038	7.64E+00	6.55E-03
9.19	0.0038	7.59E+00	6.55E-03
9.19	0.0038	7.59E+00	6.55E-03
9.10	0.0039	7.11E+00	6.50E-03
9.10	0.0039	7.11E+00	6.50E-03
9.05	0.0040	6.88E+00	6.46E-03
9.05	0.0040	6.88E+00	6.46E-03
8.91	0.0048	6.57E+00	6.39E-03
8.91	0.0048	6.57E+00	6.39E-03
8.83	0.0049	6.42E+00	6.35E-03
8.83	0.0049	6.42E+00	6.35E-03
8.75	0.0048	5.80E+00	6.18E-03
8.75	0.0048	5.80E+00	6.18E-03
8.61	0.0047	5.75E+00	6.16E-03
8.61	0.0047	5.75E+00	6.16E-03
8.53	0.0046	5.52E+00	6.09E-03
8.53	0.0046	5.52E+00	6.09E-03
8.45	0.0046	5.25E+00	6.01E-03
8.45	0.0046	5.25E+00	6.01E-03
8.31	0.0045	5.15E+00	5.98E-03
8.31	0.0045	5.15E+00	5.98E-03
8.22	0.0045	4.75E+00	5.85E-03
8.22	0.0045	4.75E+00	5.85E-03
8.14	0.0046	4.53E+00	5.77E-03
8.14	0.0046	4.53E+00	5.77E-03
8.00	0.0046	4.01E+00	5.61E-03

Queen Street WW ECI Temporary Works Support - Queen Street Wastewater Diversion - Package B, Auckland (FH Contract No. CT7754)

CONCEPT ONLY - NOT FOR CONSTRUCTION

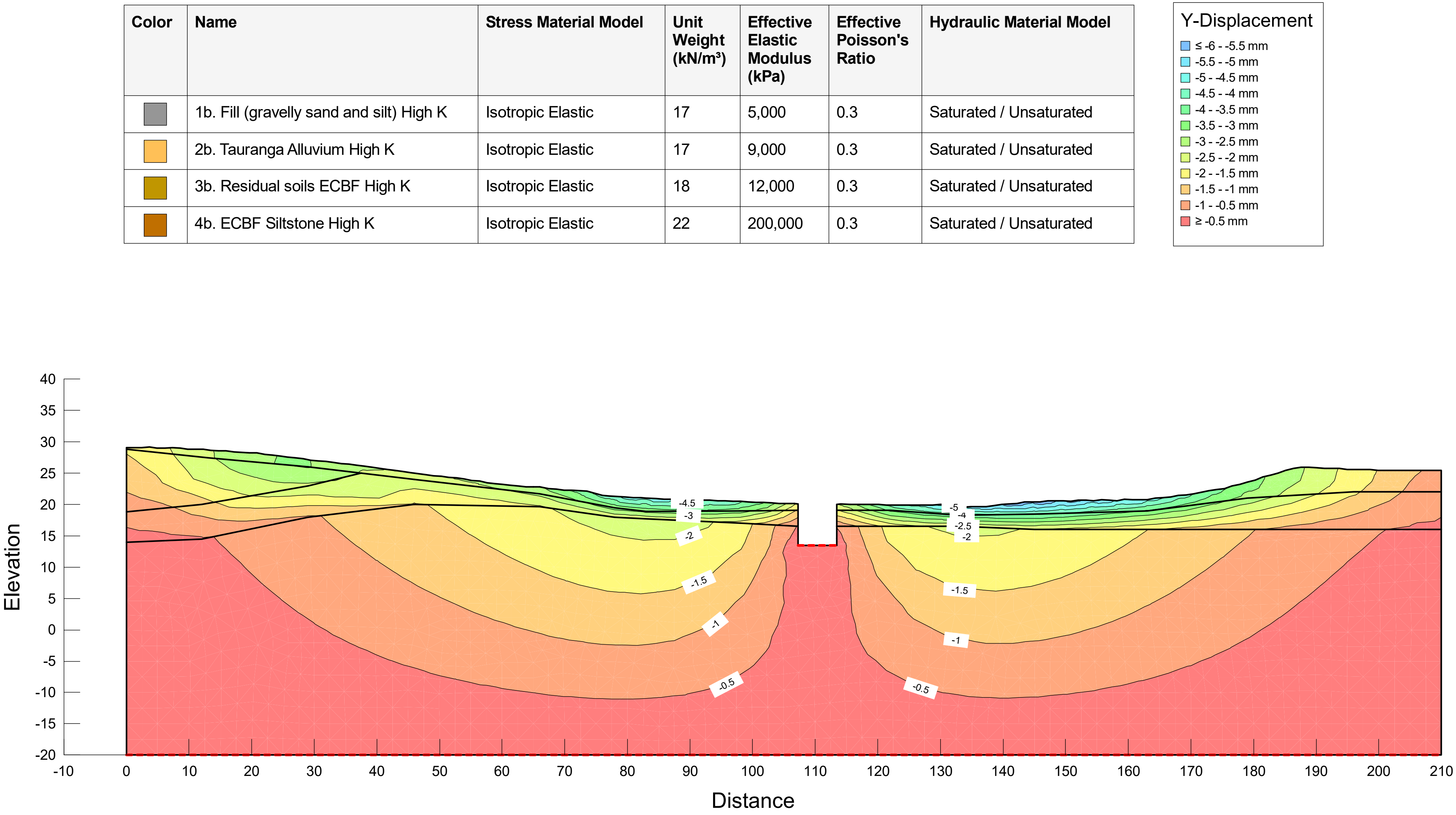
ENGEO Summary of static settlements at 0.1m and 3.0m depth for shaft locaiton P4MH3

Date of issue: 5/03/2025



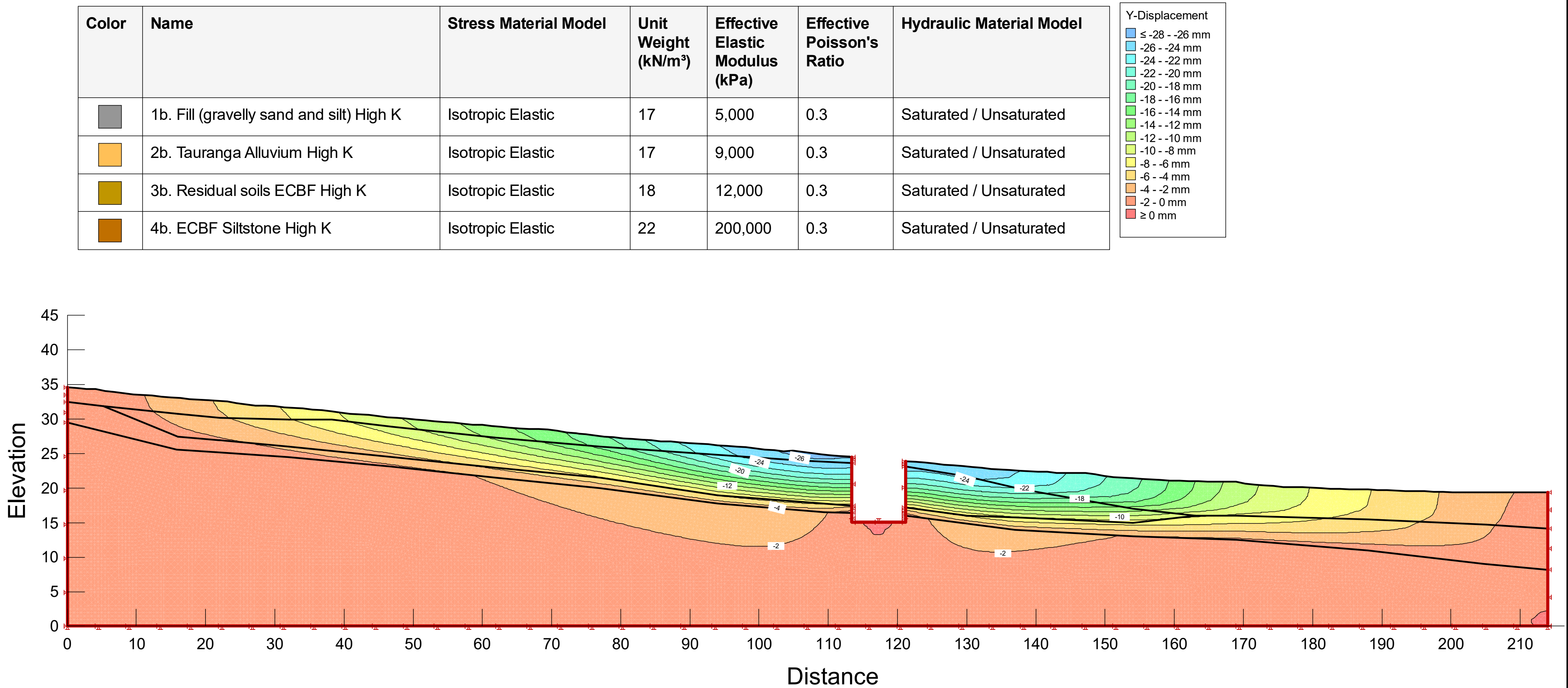
At 0.1 m bgl		At 3.0 m bgl	
X [n	|u| [m]	X [m]	|u| [m]
1.55E+01	2.25E-02	1.55E+01	2.52E-02
1.56E+01	2.12E-02	1.59E+01	2.44E-02
1.56E+01	2.12E-02	1.59E+01	2.44E-02
1.58E+01	2.05E-02	1.60E+01	2.43E-02
1.58E+01	2.06E-02	1.60E+01	2.43E-02
1.59E+01	1.89E-02	1.65E+01	2.40E-02
1.59E+01	1.89E-02	1.65E+01	2.39E-02
1.60E+01	1.58E-02	1.70E+01	2.33E-02
1.60E+01	1.57E-02	1.70E+01	2.31E-02
1.62E+01	1.36E-02	1.71E+01	2.07E-02
1.62E+01	1.36E-02	1.71E+01	2.07E-02
1.63E+01	1.35E-02	1.77E+01	3.11E-03
1.63E+01	1.35E-02	1.77E+01	3.11E-03
1.64E+01	1.62E-02	1.77E+01	3.10E-03
1.64E+01	1.62E-02	1.77E+01	3.10E-03
1.66E+01	2.00E-02	1.78E+01	3.06E-03
1.66E+01	2.02E-02	1.78E+01	3.06E-03
1.67E+01	2.02E-02	1.82E+01	3.00E-03
1.67E+01	2.02E-02	1.82E+01	3.00E-03
1.69E+01	2.02E-02	1.84E+01	3.01E-03
1.69E+01	2.02E-02	1.84E+01	3.01E-03
1.70E+01	2.01E-02	1.88E+01	3.01E-03
1.70E+01	2.01E-02	1.88E+01	3.01E-03
1.72E+01	1.99E-02	1.91E+01	2.99E-03
1.72E+01	1.99E-02	1.91E+01	2.99E-03
1.73E+01	1.97E-02	1.95E+01	2.90E-03
1.73E+01	1.97E-02	1.95E+01	2.90E-03
1.75E+01	1.95E-02	1.99E+01	2.82E-03
1.75E+01	1.95E-02	1.99E+01	2.82E-03
1.76E+01	1.92E-02	2.02E+01	2.71E-03
1.76E+01	1.92E-02	2.02E+01	2.71E-03
1.78E+01	1.89E-02	2.06E+01	2.59E-03
1.78E+01	1.89E-02	2.06E+01	2.59E-03
1.79E+01	1.86E-02	2.10E+01	2.47E-03
1.79E+01	1.86E-02	2.10E+01	2.47E-03
1.81E+01	1.83E-02	2.14E+01	2.33E-03
1.81E+01	1.83E-02	2.14E+01	2.33E-03
1.82E+01	1.79E-02	2.18E+01	2.21E-03
1.82E+01	1.79E-02	2.18E+01	2.21E-03
1.84E+01	1.75E-02	2.23E+01	2.06E-03

Color	Name	Stress Material Model	Unit Weight (kN/m³)	Effective Elastic Modulus (kPa)	Effective Poisson's Ratio	Hydraulic Material Model
	1b. Fill (gravelly sand and silt) High K	Isotropic Elastic	17	5,000	0.3	Saturated / Unsaturated
	2b. Tauranga Alluvium High K	Isotropic Elastic	17	9,000	0.3	Saturated / Unsaturated
	3b. Residual soils ECBF High K	Isotropic Elastic	18	12,000	0.3	Saturated / Unsaturated
	4b. ECBF Siltstone High K	Isotropic Elastic	22	200,000	0.3	Saturated / Unsaturated



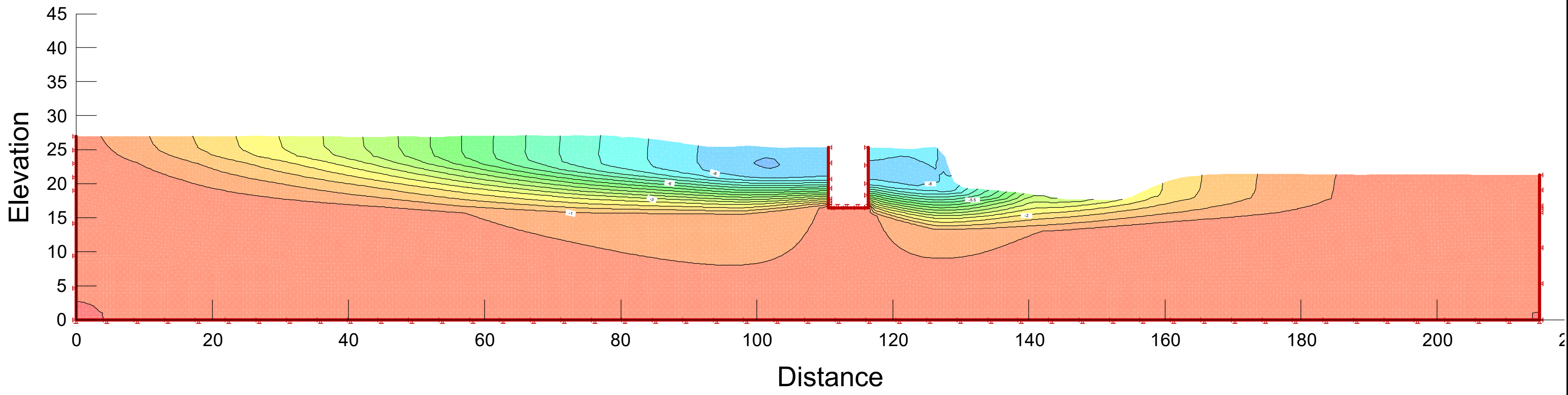
Load/Deformation [0 - 240d]
A-MD-P4MH3-TJH-1APR25.gsz
30/04/2025

Color	Name	Stress Material Model	Unit Weight (kN/m³)	Effective Elastic Modulus (kPa)	Effective Poisson's Ratio	Hydraulic Material Model
	1b. Fill (gravelly sand and silt) High K	Isotropic Elastic	17	5,000	0.3	Saturated / Unsaturated
	2b. Tauranga Alluvium High K	Isotropic Elastic	17	9,000	0.3	Saturated / Unsaturated
	3b. Residual soils ECBF High K	Isotropic Elastic	18	12,000	0.3	Saturated / Unsaturated
	4b. ECBF Siltstone High K	Isotropic Elastic	22	200,000	0.3	Saturated / Unsaturated



02_Load/Deformation High [0-240d]
B-MD-P4MH2-TJH.gsz
30/04/2025

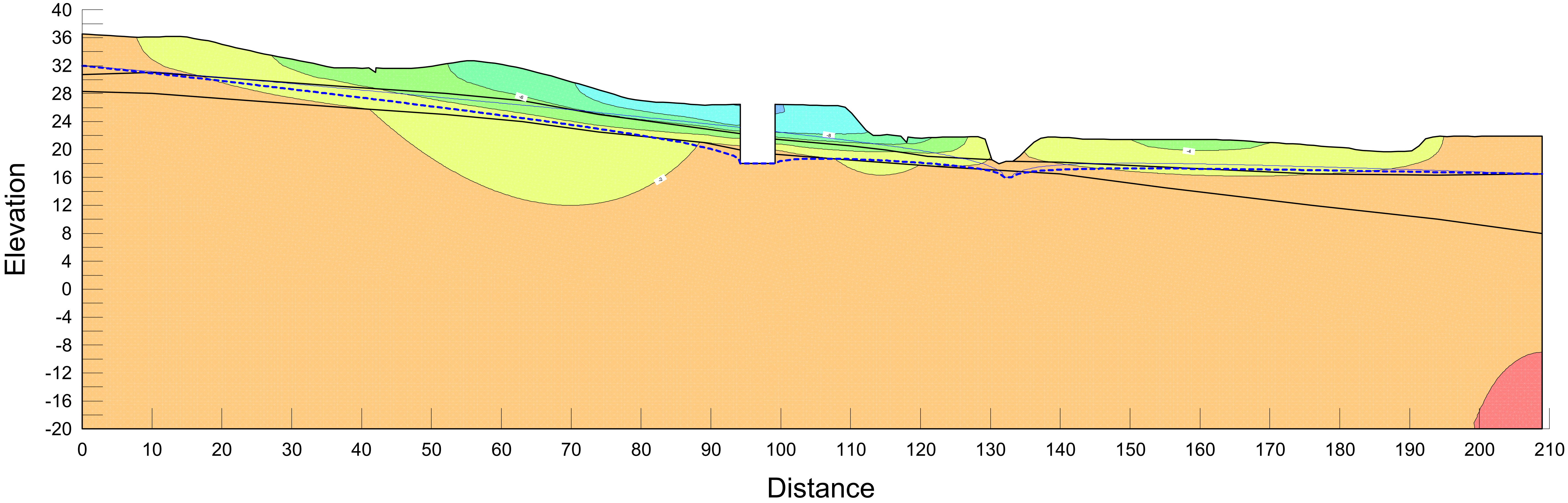
Color	Name	Stress Material Model	Unit Weight (kN/m³)	Effective Elastic Modulus (kPa)	Effective Poisson's Ratio	Hydraulic Material Model
	1a. Fill (gravelly sand and silt) Best K	Isotropic Elastic	17	5,000	0.3	Saturated / Unsaturated
	2a. Tauranga Alluvium Best K	Isotropic Elastic	17	9,000	0.3	Saturated / Unsaturated
	3a. Residual soils ECBF Best K	Isotropic Elastic	18	12,000	0.3	Saturated / Unsaturated
	4a. ECBF Siltstone Best K	Isotropic Elastic	22	200,000	0.3	Saturated / Unsaturated



Load/Deformation High [0-240d]
C-MD-P4MH1-TJH.gsz
30/04/2025

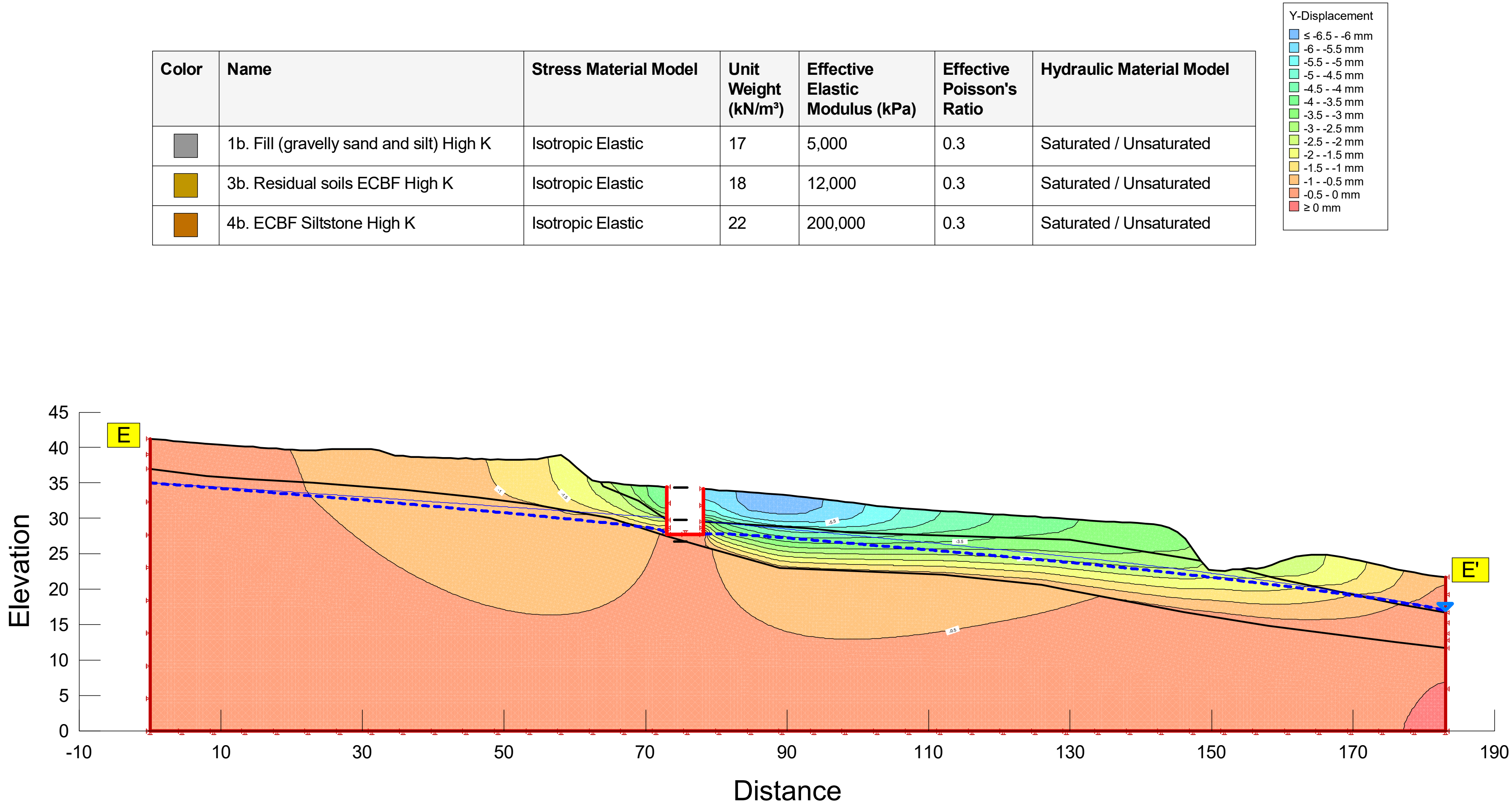
Color	Name	Stress Material Model	Unit Weight (kN/m³)	Effective Elastic Modulus (kPa)	Effective Poisson's Ratio	Hydraulic Material Model
	1b. Fill (gravelly sand and silt) High K	Isotropic Elastic	17	5,000	0.3	Saturated / Unsaturated
	3b. Residual soils ECBF High K	Isotropic Elastic	18	12,000	0.3	Saturated / Unsaturated
	4b. ECBF Siltstone High K	Isotropic Elastic	22	200,000	0.3	Saturated / Unsaturated

Y-Displacement
- ≤ -12 - -10 mm
- -10 - -8 mm
- -8 - -6 mm
- -6 - -4 mm
- -4 - -2 mm
- -2 - 0 mm
- ≥ 0 mm

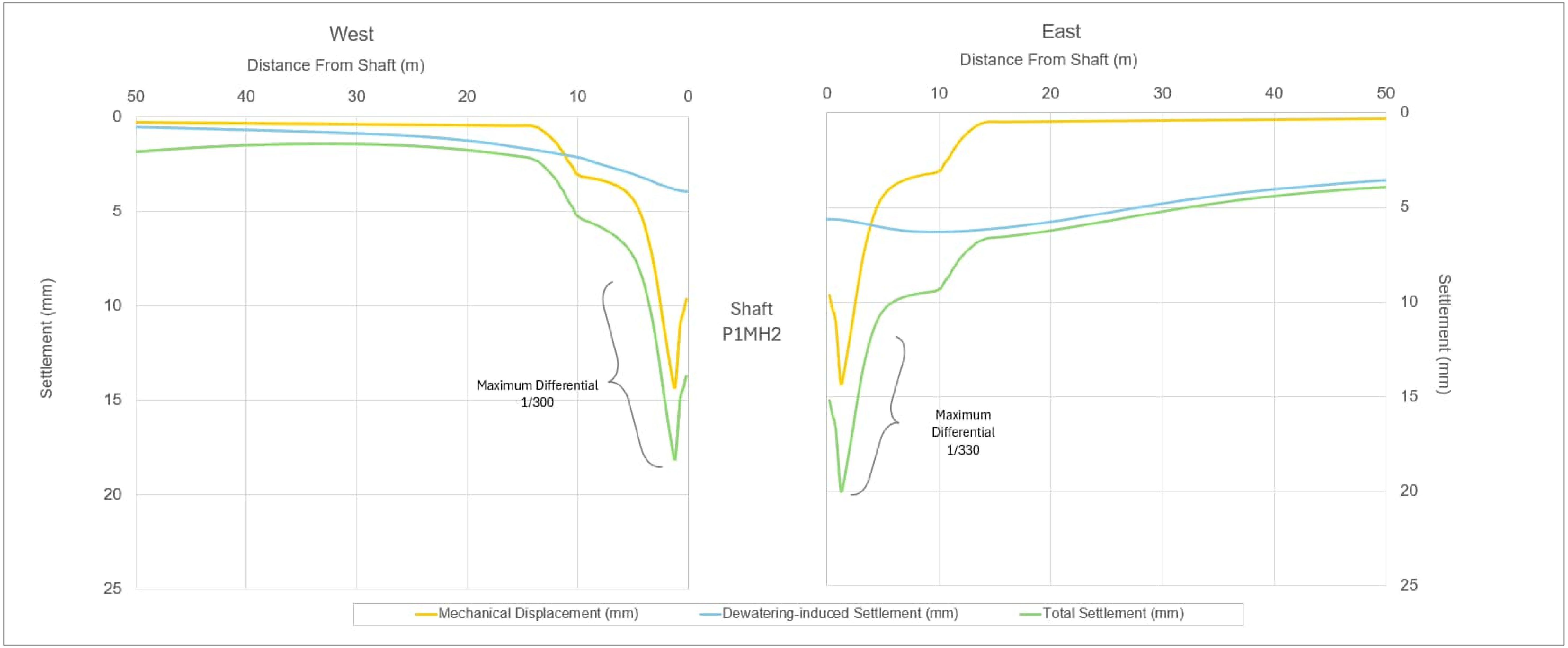


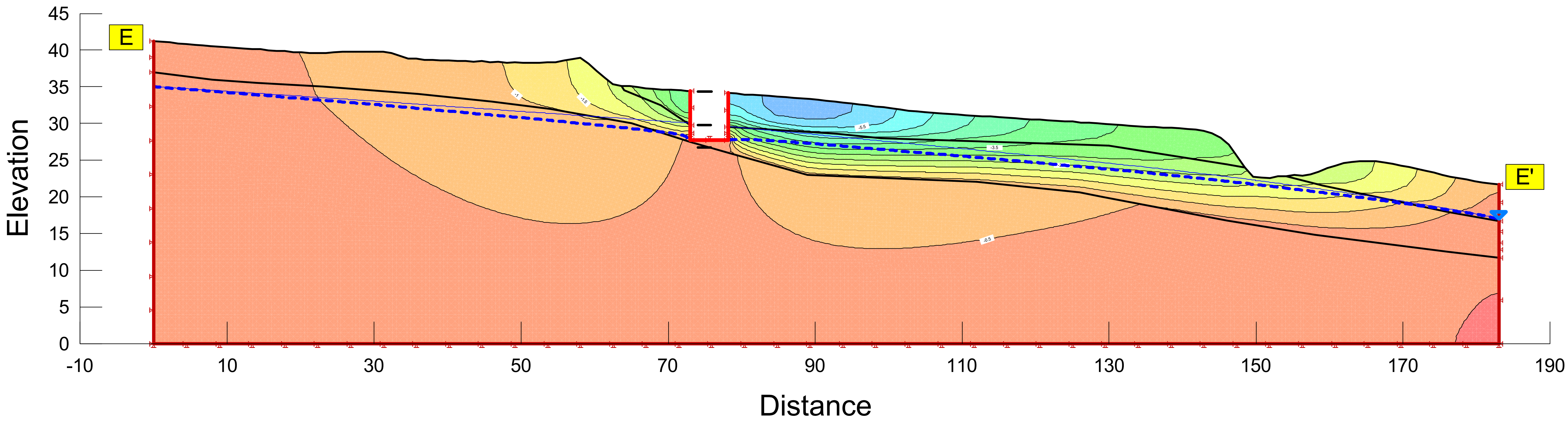
02_Load/Deformation High [0-240d]
D-MD-P5MH2-TJH.gsz
30/04/2025

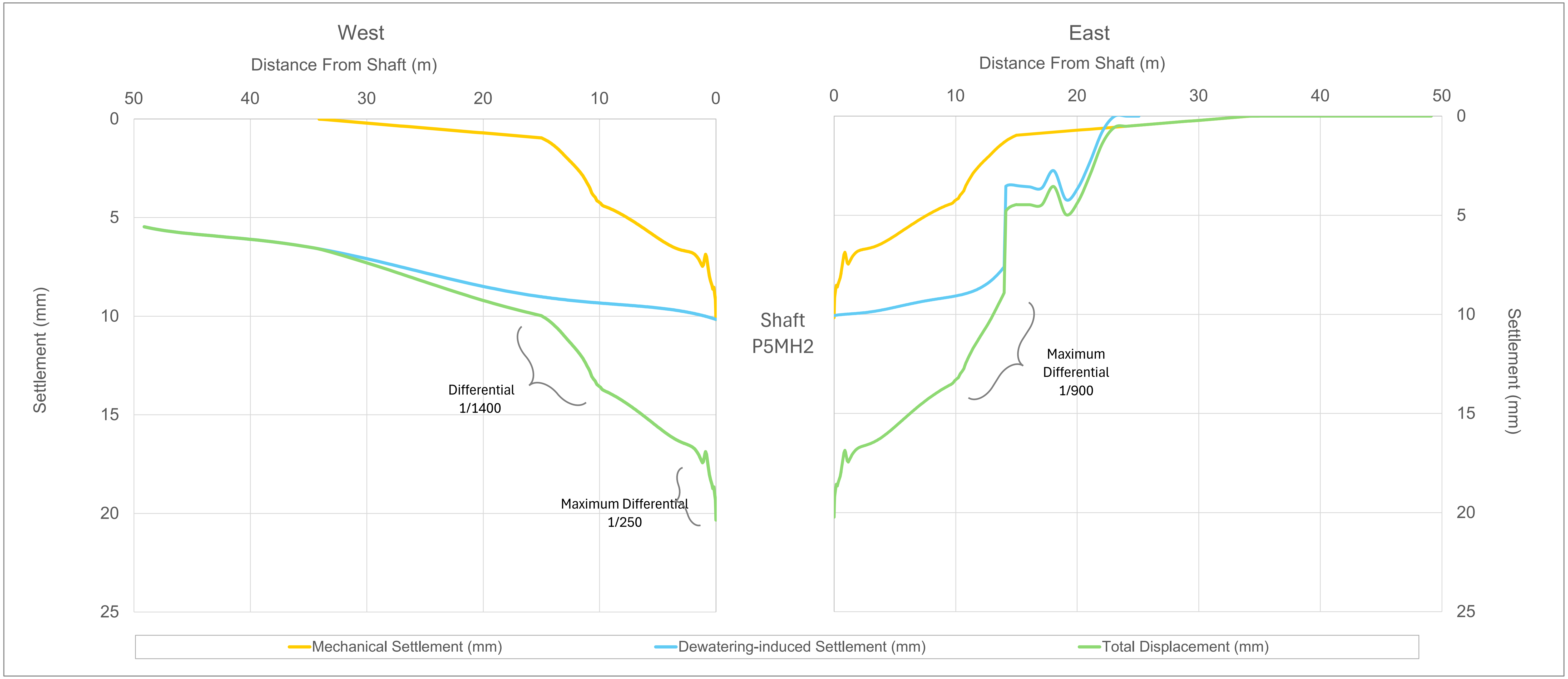
Color	Name	Stress Material Model	Unit Weight (kN/m³)	Effective Elastic Modulus (kPa)	Effective Poisson's Ratio	Hydraulic Material Model
	1b. Fill (gravelly sand and silt) High K	Isotropic Elastic	17	5,000	0.3	Saturated / Unsaturated
	3b. Residual soils ECBF High K	Isotropic Elastic	18	12,000	0.3	Saturated / Unsaturated
	4b. ECBF Siltstone High K	Isotropic Elastic	22	200,000	0.3	Saturated / Unsaturated

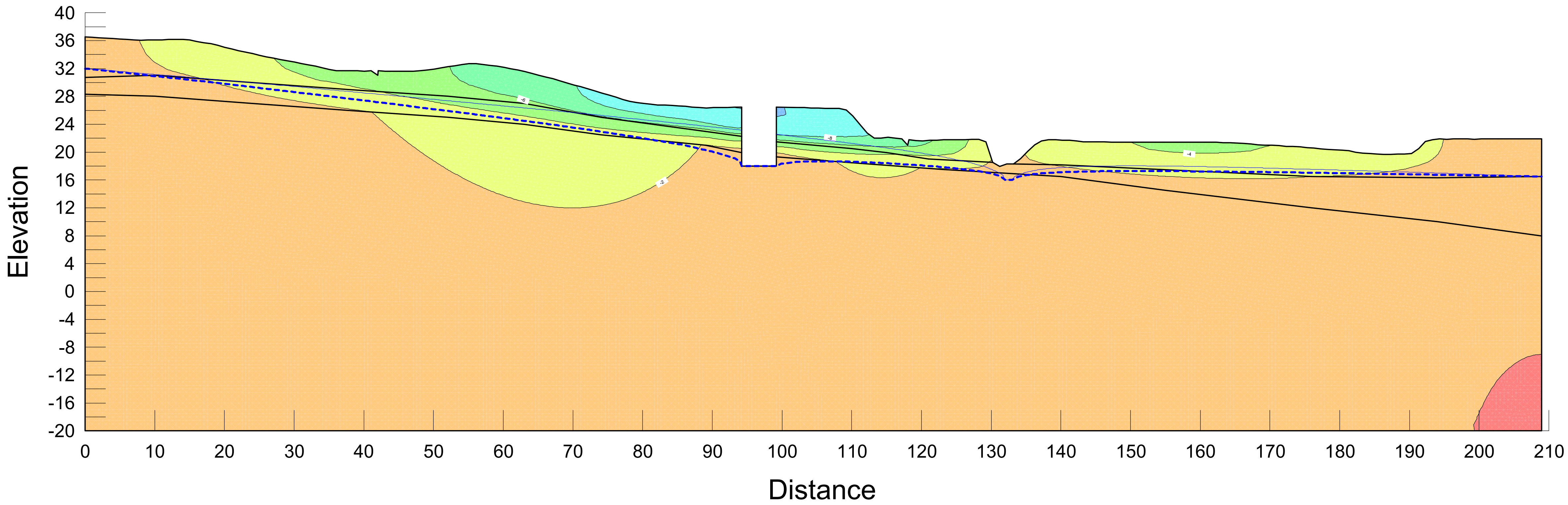


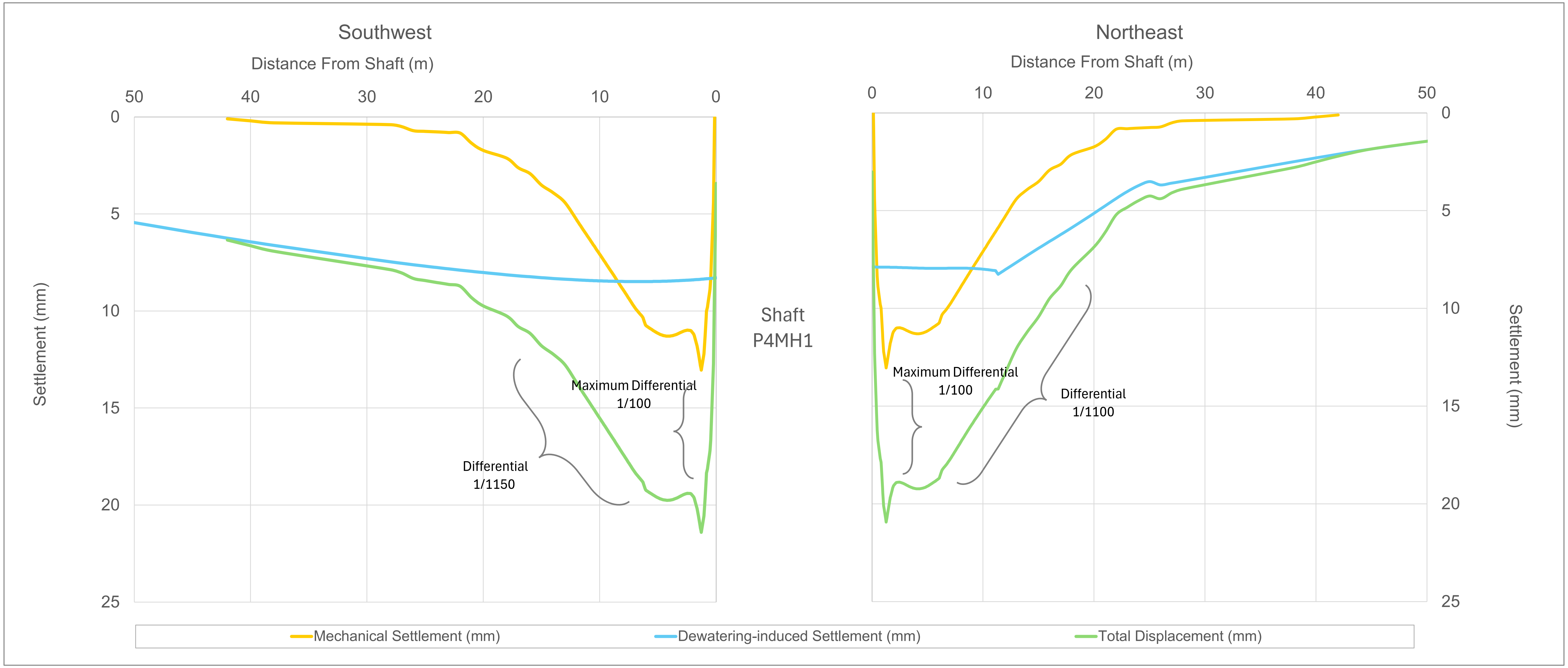
02_Load/Deformation High [0-240]`
E-MD-P1MH2-TJH.gsz
30/04/2025


West
Distance From Shaft (m)
50
40
30
20
10
0
Settlement (mm)
0
5
10
15
20
25
Maximum Differential
1/300
Shaft
P1MH2
East
Distance From Shaft (m)
0
10
20
30
40
50
Settlement (mm)
Maximum
Differential
1/330
Mechanical Displacement (mm)
Dewatering-induced Settlement (mm)
Total Settlement (mm)

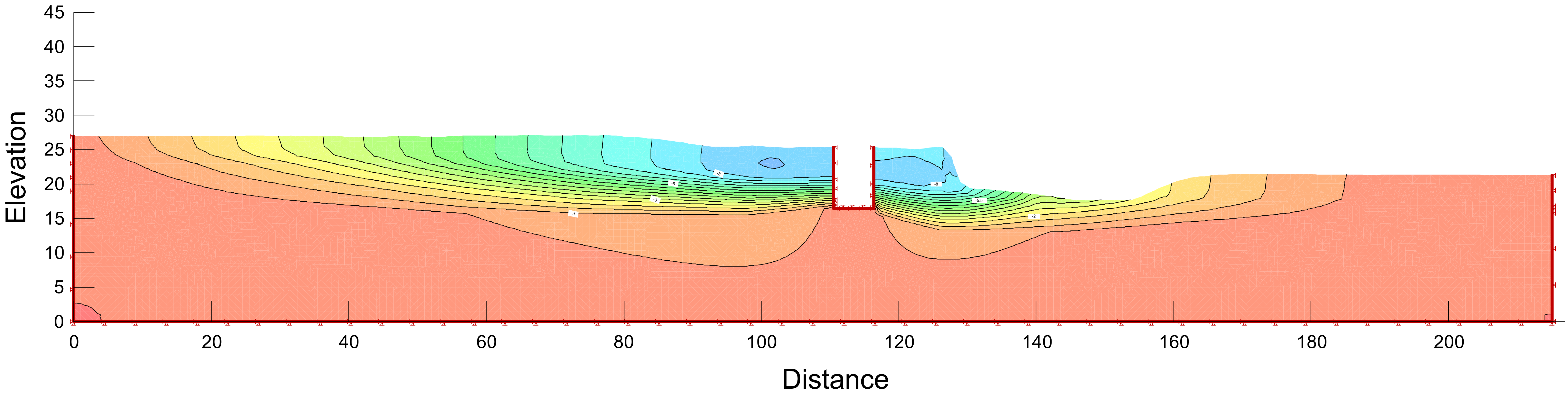

Elevation
45
40
35
30
25
20
15
10
5
0
E
E'
-10
10
30
50
70
90
110
130
150
170
190
Distance


West
Distance From Shaft (m)
50
40
30
20
10
0
Settlement (mm)
0
5
10
15
20
25
Differential
1/1400
Maximum Differential
1/250
Shaft
P5MH2
East
Distance From Shaft (m)
0
10
20
30
40
50
Maximum
Differential
1/900
Settlement (mm)
Mechanical Settlement (mm)
Dewatering-induced Settlement (mm)
Total Displacement (mm)

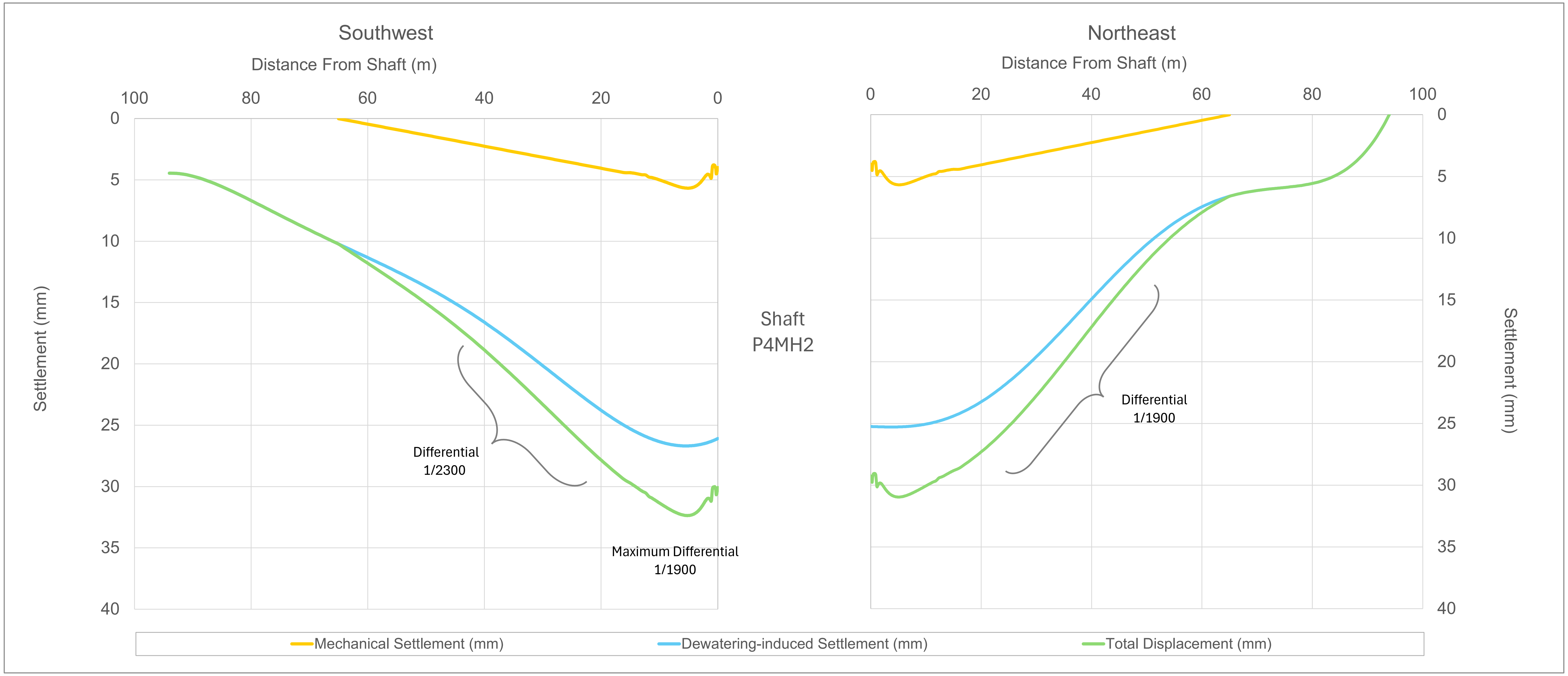

Elevation
40
36
32
28
24
20
16
12
8
4
0
-4
-8
-12
-16
-20
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Distance

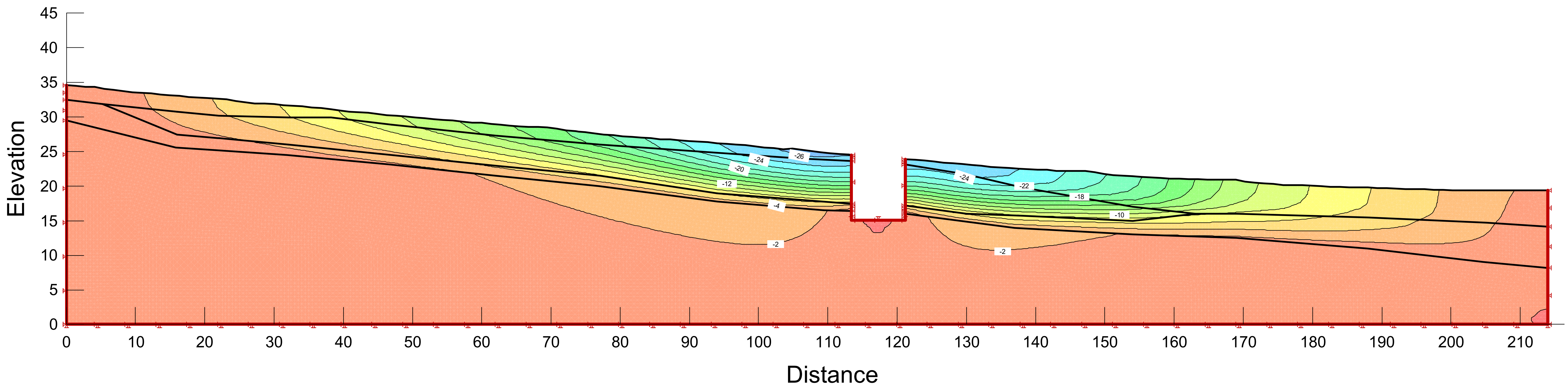


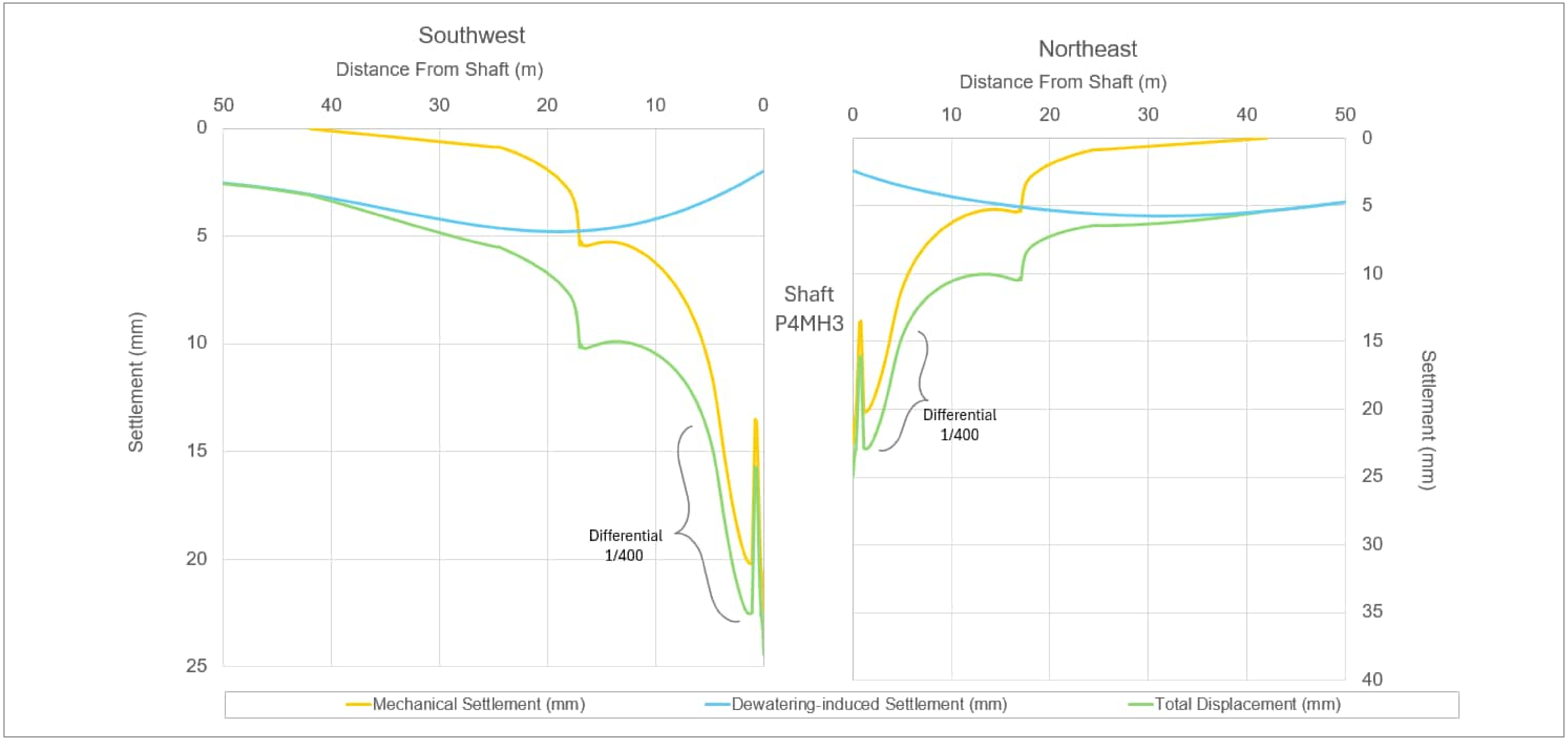
Southwest
Distance From Shaft (m)
50
40
30
20
10
0
Settlement (mm)
0
5
10
15
20
25
Maximum Differential
1/100
Differential
1/1150
Shaft
P4MH1
Northeast
Distance From Shaft (m)
0
10
20
30
40
50
Settlement (mm)
Maximum Differential
1/100
Differential
1/1100
Mechanical Settlement (mm)
Dewatering-induced Settlement (mm)
Total Displacement (mm)

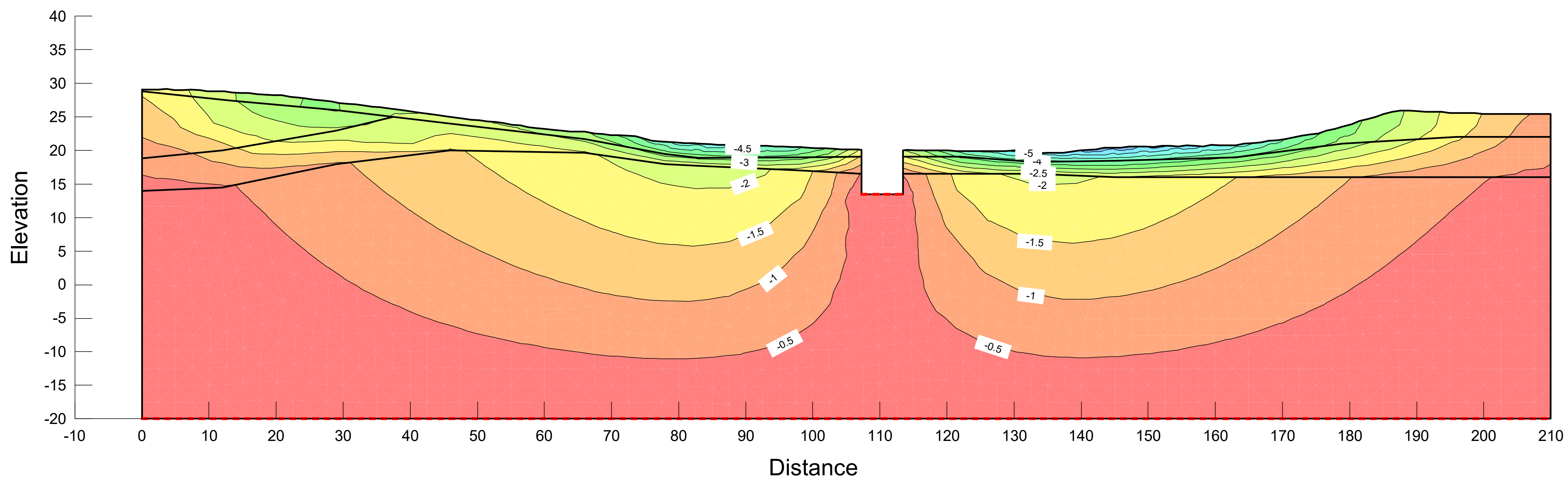


Elevation
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
200
Distance


Southwest
Distance From Shaft (m)
Northeast
Distance From Shaft (m)
Settlement (mm)
Settlement (mm)
Shaft
P4MH2
Differential
1/2300
Maximum Differential
1/1900
Differential
1/1900
Mechanical Settlement (mm)
Dewatering-induced Settlement (mm)
Total Displacement (mm)


Elevation
Distance


Southwest
Distance From Shaft (m)
50
40
30
20
10
0
5
10
15
20
25
Settlement (mm)
Differential
1/400
Shaft
P4MH3
Northeast
Distance From Shaft (m)
0
10
20
30
40
50
0
5
10
15
20
25
30
35
40
Settlement (mm)
Differential
1/400
Mechanical Settlement (mm)
Dewatering-induced Settlement (mm)
Total Displacement (mm)


Elevation
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Distance