15 September 2025

Attn: Thomas Trevilla
SLR Consulting
Thomas.Trevilla@slrconsulting.com

Response to Further Information request under Section 92 of the Resource Management Act – (BUN60453058) Queen Street Wastewater Diversion Programme - Mayoral Alignment

Dear Thomas,

Thank you for your Section 92 "Further Information Request" for resource consent (BUN60453058), dated 24 July 2025. We have prepared a response to the s92 Request in this letter and the attachments.

- **Attachment A** – Full s92 Response
- **Attachment B** – Construction Methodology for Consenting (dated 28 May 2025)
- **Attachment C** – Dewatering and Settlement Assessment R2
    - **Appendix E** – Addendum detailing further Assessment of P4MH1 and P4MH2
    - **Appendix F** – Updated Draft GSMCP
- **Attachment D** – ENGEO Interim Summary of Static Settlement and Deflection Analysis

Section 92 Response

Attachment A contains a table listing each item requested by the Council on 24 July 2025, as well as additional items identified during the application meeting on 6 August 2025, along with our corresponding responses.

Matter of clarification 1

It is acknowledged that two different revisions of the construction methodology were submitted with the AEE. The version included as Appendix C of the AEE, dated 28 November 2024, was an earlier draft and has since been superseded. The updated methodology, dated 28 May 2025, was provided as Appendix B within the Dewatering and Settlement Assessment R1, also submitted with the AEE. For clarity and consistency, **Attachment B** of this s92 Response Letter now provides the indicative construction methodology for consenting purposes, which replaces the outdated version previously submitted as Appendix C of the AEE.

Notwithstanding the above, the Dewatering and Settlement Assessment R1 submitted with the AEE had already assessed settlement effects based on shaft dimensions larger than those proposed in the construction methodology. This approach provided a conservative assessment of effects and allowed flexibility in shaft design without requiring reassessment for minor changes in shaft dimensions.

To address items raised in the s92 Further Information Request, the dewatering assessment has since been updated and is now titled "Dewatering and Settlement Assessment R2" (**Attachment C** of this s92 Response Letter).

Following these updates, it was recently identified that existing stormwater services beneath the alignment between Mayoral Shafts P4MH1 and P4MH2 are deeper than originally assumed. As a result, the depth of these shafts may need to increase by approximately 1.0 m. To avoid reworking the Dewatering and Settlement Assessment R2, an addendum has been prepared to evaluate whether this change affects settlement outcomes. This addendum, titled "Dewatering and

Settlement Assessment – Addendum Detailing Further Assessment," is provided as **Appendix E** of the Dewatering and Settlement Assessment R2 report.

Matter of clarification 2

To provide clarity, the conservative shaft dimensions that have been assessed as part of both the Dewatering and Settlement Assessment R2 report and the Addendum by the dewatering specialists are detailed below:

Table 1: Conservative shaft dimensions assessed by the dewatering specialists

Shaft/Manhole ID	Width (m bgl)	Length (m bgl)	Depth (m bgl)
P4MH3	5	5	6.5
P4MH2	5	7.5	9.8
P4MH1	5.5	12	10.1
P5MH2	5	6.5	8.5
P1MH2	5	6	6.5

Further information provided

The ENGEO Interim Summary of Static Settlement and Deflection Analysis (dated 1 August 2025) is provided to this s92 Response Letter as **Attachment D**.

The draft GSMCP has been updated in response to the s92 Further Information Request. This updated GSMCP is provided as **Appendix F** of the Dewatering and Settlement Assessment R2 report.

AEE revision not required

As per the findings within Dewatering and Settlement Assessment R2 and the Addendum to Dewatering Assessment, the settlement effects from diverting groundwater and dewatering from the project on nearby services, footpaths, buildings and structures are categorised as 'negligible' to 'very slight'. Consequently, the damage category and degree of severity remain as concluded in the R1 assessment, and the AEE does not require revision, as the settlement effects and the overall effect remain the same.

Overall, there are no additional infringements, reasons for consent, or additional effects, and the statutory assessment does not require revision.

Draft conditions

A set of draft conditions will be provided to Council following receipt of their response to our Section 92 Response Letter, to support project efficiency and ensure alignment among both parties.

Please do not hesitate to contact us should you require any further information or clarification.

Sincerely,

Emily Ireland - Resource Management Planner
Email: emily.ireland@wsp.com

Jessica Rainford - Senior Planner
Email: jessica.rainford@wsp.com

Attachment A

Attachment A: Full Response to Request under s92 of the RMA

Section 92 Request for Information: BUN60453058 – Queen Street Wastewater Diversion Programme – Mayoral Alignment			
Item	Information Request	Applicant's Response	Council Response
1.	The shaft details (width, length and depth) given in Table 3.1.2 of the FH Construction Methodology report dated 15 February 2025, rev 05 are different from those given in Table 4-2 of the WSP Dewatering Assessment. Please provide clarification of the proposed shaft details and confirm that the correct shaft dimensions have been used in the dewatering assessment (e.g., FH indicate that shaft P4MH3 is 7m wide and 14.5m long and WSP indicate that P4MH3 is 5m wide and 5m long).	The construction methodology submitted with the AEE as Appendix C has been replaced (refer Attachment B of s92 Response Letter). The shafts assessed within the Settlement and Dewatering Assessment R2 are all somewhat larger than the shafts in the construction methodology. This approach provided a conservative assessment of effects and allowed flexibility in shaft design without requiring reassessment for minor changes in shaft dimensions. It was recently identified that existing stormwater services beneath the alignment between Mayoral Shafts P4MH1 and P4MH2 are deeper than originally assumed. As a result, the depth of these shafts may need to increase by approximately 1.0 m. To avoid reworking the Dewatering and Settlement Assessment R2, an addendum has been prepared to evaluate whether this change affects settlement outcomes. This addendum, titled "Dewatering and Settlement Assessment – Addendum Detailing Further Assessment," is provided within Appendix E of the Settlement and Dewatering Assessment R2. The s92 Response Letter provides a table [Table 1) with the full set of shaft dimensions that have been assessed by the dewatering specialists for clarity.	
2.	It is noted that the majority of the shaft excavations are rectangular. Section 6.2 of the WSP Dewatering Assessment states:	Confirmed with ENGEO that their approach provided the most conservative outputs. They were based on adopting the orientation/direction that	

	"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 addition, Section 5.4.1 of the WSP Dewatering Assessment states: "The mechanical settlement (assessed by ENGEO) has been assumed to be uniform around the shafts, considering the zone of influence." Please provide confirmation from ENGEO that the above assertions are correct and if not, the plots in Appendix C3 should be updated together with Figures 6-1, 6-3 , 6-5 & 6-7.	generated the profile with the greatest mechanical settlement. This conservative profile was then assumed to be axisymetrical, which presented the most conservative mechanical settlement results.	
3.	The total settlements given in Tables 6-1 to 6-4 are not the same as the total settlement (green line) shown in the plots Figures 6-1, 6-3 , 6-5 & 6-7. Please provide clarification and update the report accordingly, including Figures 5-8 to 5-12.	We have identified minor discrepancies between the tables and the figures, primarily close to the shafts. We note that the mechanical settlement ouputs close to the shafts (within 2-3m) have some anomalies (maybe related to boundary effects) which we will approximate assuming a smoother curve based on published data.	
4.	Please confirm why ENGEO has provided mechanical settlement profiles at depths of 0.1mbgl and 3mbgl for each shaft and subsequently confirm why a particular mechanical settlement profile was chosen by WSP in each of the total settlement profiles in Appendix C3.	We requested ENGEO to produce plots of mechanical settlement at 3m depth to be used as a more representative value in case there were any shallow foundations or important services at approximately that depth. In that case, the estimated mechanical at the surface could be overly conservative. WSP has adopted the 0.1 m depth only, because there was no instances of shallow footings or surfaces at approximately 3.0 m.	
5.	The x-axis labelled "Horizontal Distance" on the mechanical settlement plots in Appendix C1 should commence at 0m adjacent to the shaft and the y-axis labelled "Mechanical Displacement (m)" should be "Mechanical Settlement (mm)".	The plots have been updated. See figures within Section 6.2 of Dewatering and Settlement Assessment R2. Appendix C.1 were provided by ENGEO. We understand and agree that it should commence at 0	

		m from the shaft, WSP had adjusted this in our combined plots. We do not want to change the appendix provided by ENGEO.	
6.	It is noted that the winter groundwater level measured in PZB1 (BH23/08 which was located approximately 15m SW of proposed shaft P5MH1) three days after drilling on 28 August 2023 was at a depth of approximately 8.2m (i.e., below the depth of shaft P5MH1). Hence no dewatering and associated consolidation settlement is considered likely during shaft construction and operation. Section 6.2 of the WSP Dewatering Report states: "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." We do not concur that no land settlements are expected. Please undertake an assessment of the predicted mechanical settlement associated with retaining wall deflection on nearby buildings, structures, infrastructure and public services and update the WSP report, in particular, Appendix C1 and include a mechanical settlement profile and a mechanical settlement contour plot for proposed shaft P5MH1.	The regional plan provisions require settlement to be assessed if the dewatering does not comply with permitted dewatering standards. P5MH1 will not require an assessment because there is no dewatering.	
7.	Please provide clarification why the groundwater level of approximately 5.1mbgl, that was measured on same day as the drilling (8 September 2023) in PZA1 (BH23/09) is given in Table 2-1 in the WSP Dewatering Assessment and why this groundwater level which will have been influenced by drilling fluids has been used in the drawdown assessment for proposed Shaft P1MH2.	Amended Table 2-1 to reflect next day measurement.	
8.	Please annotate Figure 2-3 with the lowest groundwater level measured in each piezometer	Report updated with amended Tables 2-1 and 4-3 demonstrating water levels applied for dewatering	

	during the monitoring period and update Table 2-1 to include this level for PZB2, PZC1, PZD1, PZE1 and PZE2. In addition, please confirm that the lowest measured groundwater level has been used in the groundwater drawdown analysis and assessment and that the groundwater levels given in the assessment against AUP(OP) Standard E7.6.1.10(4b) in Table 4-3 of the WSP Dewatering Assessment are correct.	modelling. An explanation as to what was adopted at the shaft location is presented in Section 5.3.2	
9.	In relation to open cut pipe laying & EOP connections, FH state: “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” (i.e., less than 30 days)” However, in Section 5.1 WSP state: “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.” We do not concur with this assertion based on the information provided in the application the open trenches for pipes and EOP connection will not comply with AUP(OP) Standard E7.6.1.6(2) and an assessment of the predicted settlement effects for each trench is required and the WSP Dewatering Assessment report should be updated accordingly.	There are 2 EOP connections that will be installed in shallow trenches. EOP connection of manhole EX MH500717 to P1MH3 - the invert of the EOP connection at EX MH500717 is 2.65 m bgl and the invert where it connects into manhole P1MH3 is at 2.48 m bgl. The trench is assumed to be 0.5 m below the invert of the pipe, hence the maximum depth of the trench will be 3.15 m bgl at EX MH500717. The groundwater level at shaft P5MH1 (both manholes P1MH3 and P5MH1 will be installed in this shaft) is deeper than 8 m based on the groundwater level measured in the temporary piezometer PZB1. Hence this trench will not require dewatering and hence does not require assessment. EOP connection of manhole EX MH522964 to P1MH2 - the invert of EOP connection at EX MH522964 is 3.42 m bgl and the invert where it connects into manhole P1MH2 is at 2.64 m bgl. The trench is assumed to be 0.5 m below the invert of the pipe, hence the maximum depth of the trench will be 3.92 m bgl at EX MH522964. The groundwater level at shaft P1MH2 is deeper than 5 m based on the groundwater level measured in the temporary piezometer PZA1. Hence this trench will not require dewatering and hence does not require assessment.	

10.	Tables 6-1 to 6-5 in the WSP Dewatering Assessment should be updated to include the predicted total settlement at the edge of the shaft (i.e., 0m from the shaft) and this settlement should reflect that shown on the profile and indicated on the red dashed line on the total settlement contour plan for each shaft.	Added to report Section 6.2.	
11.	We note that the total settlement contour plans for P4MH1, P5MH2, and P1MH2 are incorrectly labelled as Figures 5-9, 5-10 & 5-11 (these should be updated to Figures 5-10, 5-11 & 5-12)	Added to report Section 6.2.	
12.	Please mark-up relabelled Figure 5.11 showing the distance of the Grand Millennium Underpass from proposed shaft P5MH2.	Added to report Section 6.2.	
13.	Please mark-up Figure 5.8 showing the distance of the Myers Park Overbridge and Crib Wall from proposed shaft P4MH3.	Added to report Section 6.2.	
14.	WSP has predicted that the maximum total and maximum differential settlement for the Grand Millennium Underpass is 20mm and 1:250 which indicates potential “Slight” damage in accordance with the Burland Classification. In Section 7.4.4 WSP state: “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	Comments added to report and logs (Section 7.4.4 of the Dewatering and Settlement Assessment R2 report). Scoria is shown at depth in Appendix D of the Dewatering and Settlement Assessment R2 report.	

	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." We do not concur with the this assertion, please undertake a Stage 2 Burland assessment (and if necessary a Stage 3 Burland assessment) for this structure. After the assessment is complete and following a site visit and a review of any construction drawings in the property file or drawings supplied by the asset owner, a Structural Engineer should review the assessment and the predicted total and differential settlements and undertake consultation with the asset owner to discuss the findings of the assessment and obtain their agreement of a draft settlement monitoring plan to include, but not limited to: the specific locations of appropriate settlement pins/markers, the alert and alarm trigger levels and specific requirements of the pre and post construction detailed condition surveys.		
15.	In addition, WSP has predicted that the maximum total and maximum differential settlement for the Myers Park Overbridge and Crib Wall is 25mm and 1:400 which also indicates potential "Slight" damage in accordance with the Burland Classification. Table 7-2 in the WSP Dewatering Assessment indicates that the Burland Category of Damage for the overbridge is "2" however the Degree of severity is indicated to be "Very Slight to Negligible". In Section 7.4.4 WSP state: "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	On the 29th of August 2025, we provided additional information about the bridge and crib wall (plans from 1970s). Also attached as Appendix D to the Settlement and Dewatering Assessment R2 report. Following the workshop on 6th of August, we agreed that the crib wall is flexible towards settlement and that we will include additional monitoring points on the crib wall and overbridge foot path. We have updated the alert/alarm and additional monitoring points in the GSMCP (Section 7.4.4.5).	

	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". We do not concur with the this assertion, please undertake a Stage 2 Burland assessment (and if necessary a Stage 3 Burland assessment) for this structure. After the assessment is complete and following a site visit and a review of any construction drawings in the property file or drawings supplied by the asset owner, a Structural Engineer should review the assessment and the predicted total and differential settlements and undertake consultation with the asset owner to discuss the findings of the assessment and obtain their agreement of a draft settlement monitoring plan to include, but not limited to: the specific locations of appropriate settlement pins/markers, the alert and alarm trigger levels and specific requirements of the pre and post construction detailed condition surveys. In addition, please provide a copy of the construction or as-built drawings which show the		

	pile layout and depths for the overbridge and the crib wall foundations.		
16.	Please identify any non-Watercare services which are to remain in the vicinity of the six shafts and assess the predicted maximum total and differential settlement against the criteria given in the 1982 paper by O'Rourke and Trautmann, in the draft GSMCP please provide a plan showing the extent of all services for which pre and post construction CCTV surveys are proposed	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. Current settlement monitoring and trigger levels will therefore suffice for services monitoring.	
17.	Please provide the report by ENGEO which includes the assessment of retaining wall deflection and associated mechanical settlement for all six shafts. The findings of the ENGEO report should be included in updated WSP Dewatering Assessment. Further queries may arise following the review of this report.	The ENGEO memo is attached as Attachment D of the s92 Response Letter.	
18.	Following the review of the above items, please review the Draft GSMCP for any required updates. This plan should be based on the predicted settlements from the updated WSP Dewatering Assessment report and the ENGEO report. Further queries may arise following the review of the updated plan.	The GSMCP has been updated with additional monitoring markers for the crib wall and Myers Park overbridge as well as changes as in trigger levels for monitoring markers around shafts P4MH1 and P4MH3 as a result of the increased depth of these shafts.	
19.	Please provide comment on the extent to which any actual or potential effects on mana whenua values as a result of the diversion and dewatering activities	As detailed in Section 6.2 of the AEE report, Watercare has a long-standing relationship with Mana Whenua of Tāmaki Makarau and they have	

	are avoided, remedied or mitigated, per assessment criteria E7.8.2(1)(a).	been engaged regularly throughout the planning of these works to ensure that they are aware of the infrastructure's positive effects. The purpose of this project is to construct a new wastewater pipeline to improve the resilience of the wastewater network. A carefully developed construction methodology has been selected to minimise adverse effects on the environment. A predominantly trenchless pilot bore tunnelling construction methodology has been selected for its lesser impact on groundwater quality and quantity compared to trenching methods. It is a water-efficient method of pipe laying as it requires less excavation and reduces the amount of water taken from dewatering. As per the findings within the Settlement and Dewatering Assessment R2 (Attachment C of the s92 Response Letter) and the Addendum to Dewatering Assessment (Appendix E of Settlement and Dewatering Assessment R2), the settlement effects from diverting groundwater and dewatering from the project on nearby buildings, structures, services and footpaths remain categorised as 'negligible' to 'very slight'. Consequently, no adverse effects are expected for Mana Whenua from the dewatering activities.	
20.	Please revise the application / AEE should any additional infringements, reasons for consent, or additional effects and statutory assessments be required as a result of the items above	As per the findings within the Dewatering and Settlement Assessment R2 report (Attachment C of the s92 Response letter) and the Addendum to Dewatering Assessment (Appendix E of Settlement and Dewatering Assessment R2), the settlement effects from diverting groundwater and dewatering from the project on nearby services, footpaths,	

		buildings and structures are categorised as 'negligible' to 'very slight'. Consequently, the damage category and degree of severity remain as concluded in the R1 assessment, and the AEE does not require revision as the settlement effects and the overall effect remain the same. Overall, there are no additional infringements, reasons for consent, or additional effects, and the statutory assessment does not require revision.	
21.	**Post-lodgment of AEE (11/07/25)** Section 2.5.2 of the WSP Dewatering Report contains logs of eight boreholes along Mayoral Drive "WSP Queen Street Wastewater Diversion – Parts 1-4-5, Geotechnical Factual Report", (WSP 2023). Please provide this report.	The WSP Geotechnical Factual Report was provided to council on 16 August 2025.	
22.	**Post- AC meeting request (6/8/25)** I noticed that the consolidation settlement profile – blue line on Figure 6-1 appears to show less settlement (approx. 2mm) at the proposed shaft P4MH3 and more settlement (approx 5mm) at 25m - see attached mark up It could be reasonably expected that there would be greater groundwater drawdown at a shaft and hence greater consolidation settlement at the shaft. This contrasts with the consolidation settlement profile – blue line on Figure 6-3 which shows more settlement (approx. 25mm) at proposed shaft P4MH2 and less settlement approx. 5mm at 80m – see attached mark-up. Please provide an explanation as to why Figure 6-1 indicates that there is greater consolidation settlement at a distance of 25m from shaft P4MH2 than at the shaft.	In Figure 6-1, the higher dewatering settlement away from the shaft is related to the stratigraphy and the initial groundwater conditions: the only practically compressible layer that experiences dewatering is the residual soil. There is more dewatering predicted in the residual soils away from shaft rather than close to it, which results in higher dewatering settlement at some distance from the shaft. The answer to the differences in the consolidation settlement is provided above.	

	Please prove an explanation as to why the mechanical settlement and consolidation settlement profiles Figure 6-1 & 6-3 are so different for P4MH3 & PH4M2.		

Attachment B: Construction Methodology for Consenting (dated 28 May 2025)

Construction Methodology

Queen Street Wastewater Diversion – Package B

Contract No: CT7754

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

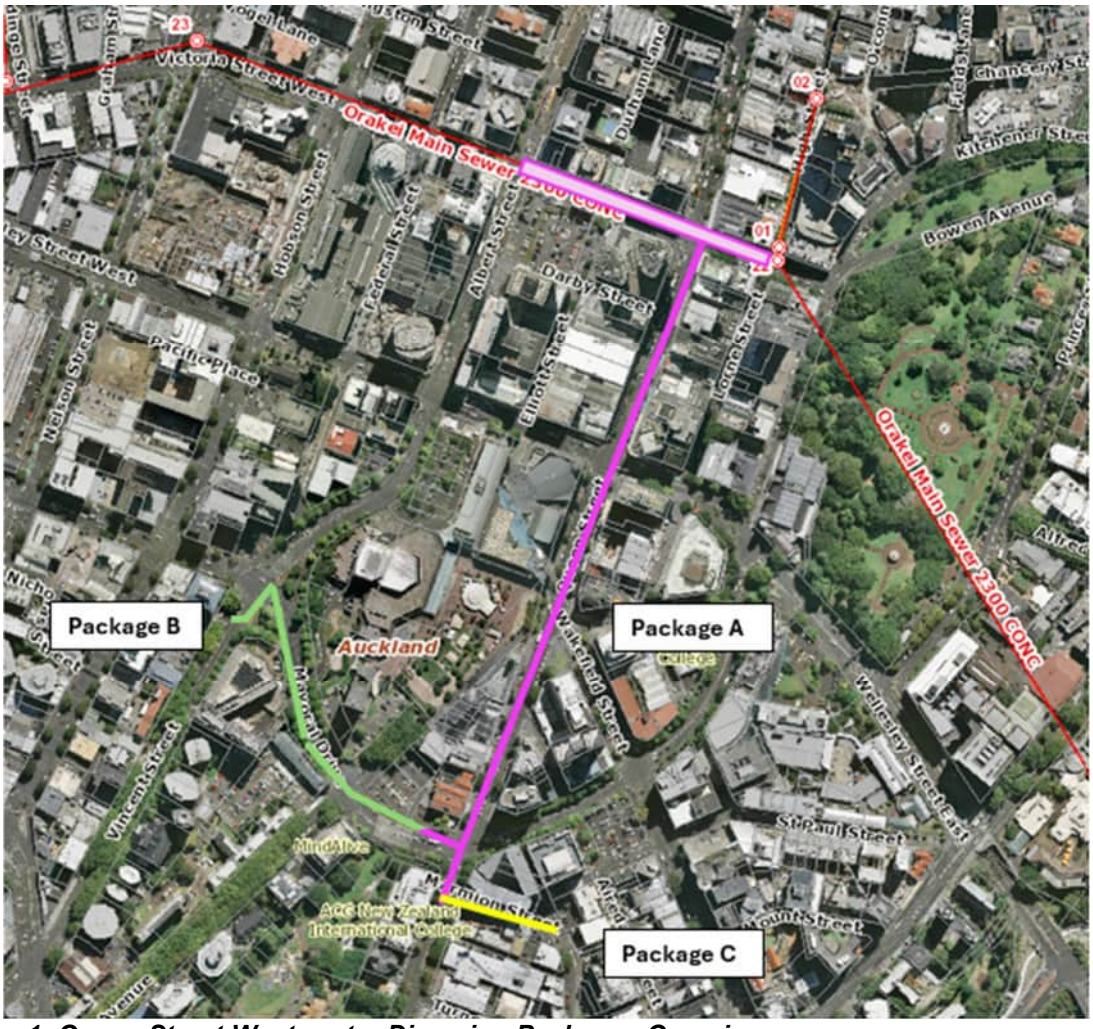

Figure 1: Queen Street Wastewater Diversion Packages Overview

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).

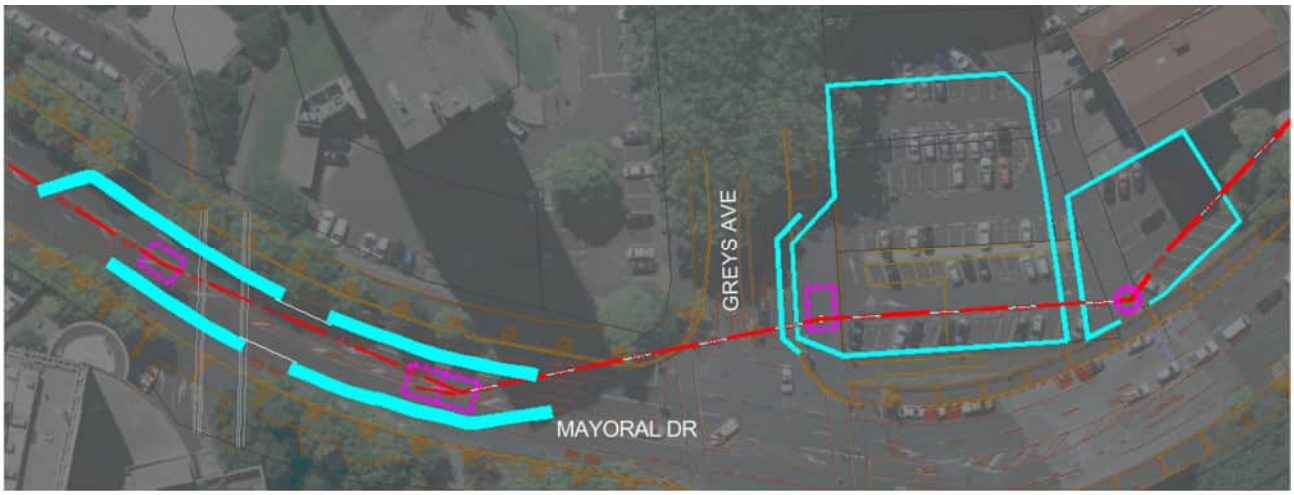

Figure 3: Two long-term compounds on Mayoral Drive/Greys Avenue (compound extents shown with blue line)

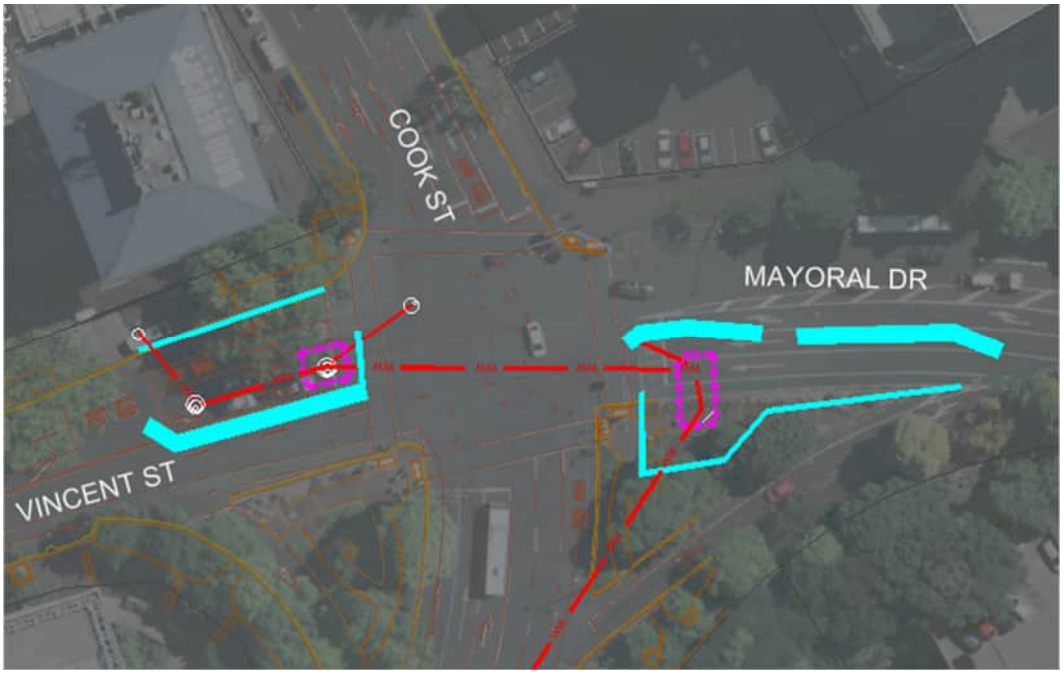

Figure 4: Two long-term compounds at Cook St/Mayoral Drive/Vincent St intersection (compound extents shown with blue lines)

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.

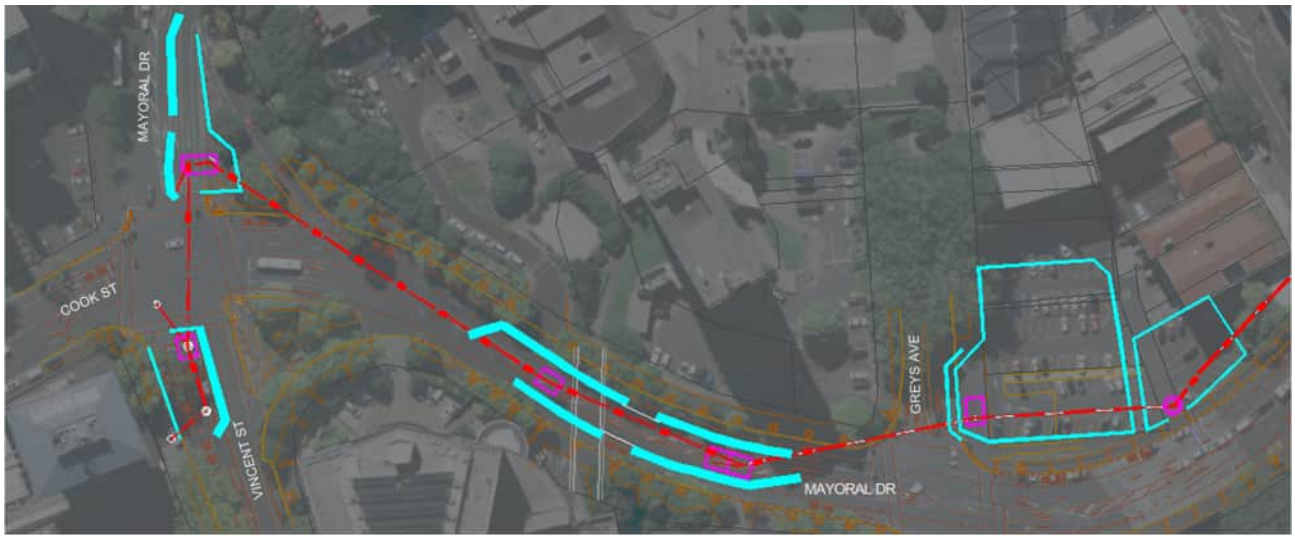

Figure 5: Main Construction Works Overview

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.

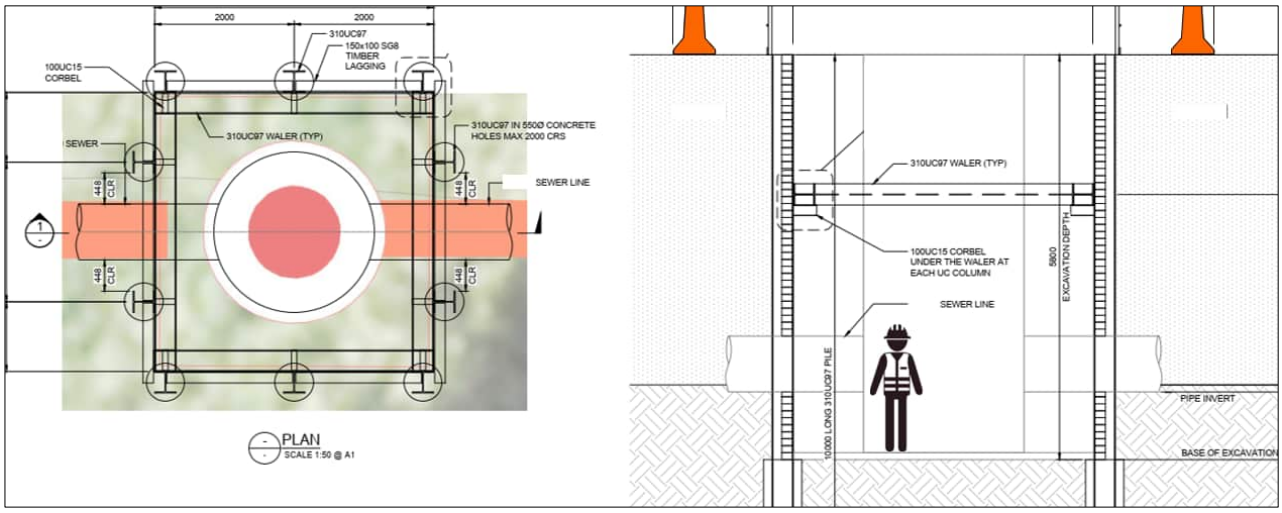

Figure 6 – Typical temporary works detail for shafts (A. O'Sullivan & Associates)

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).

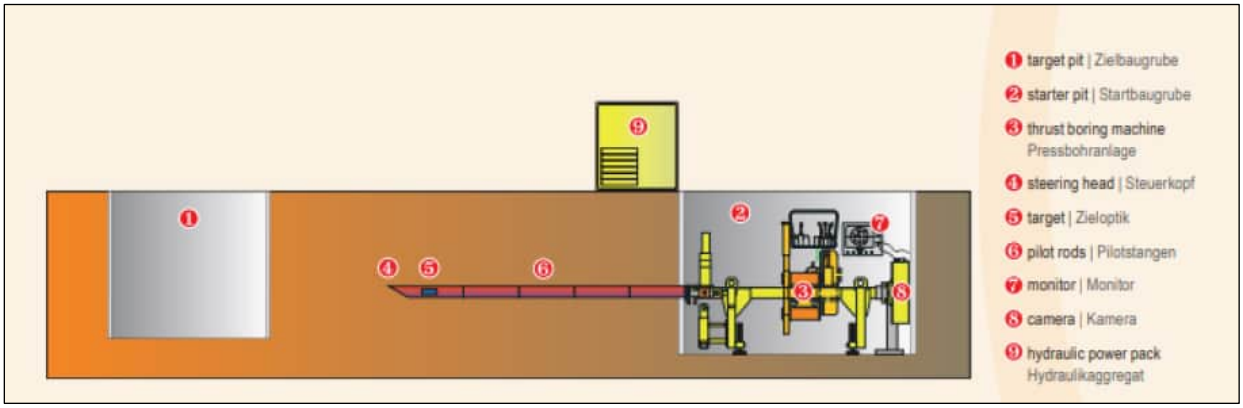

Figure 7 – Typical pilot bore – pilot process

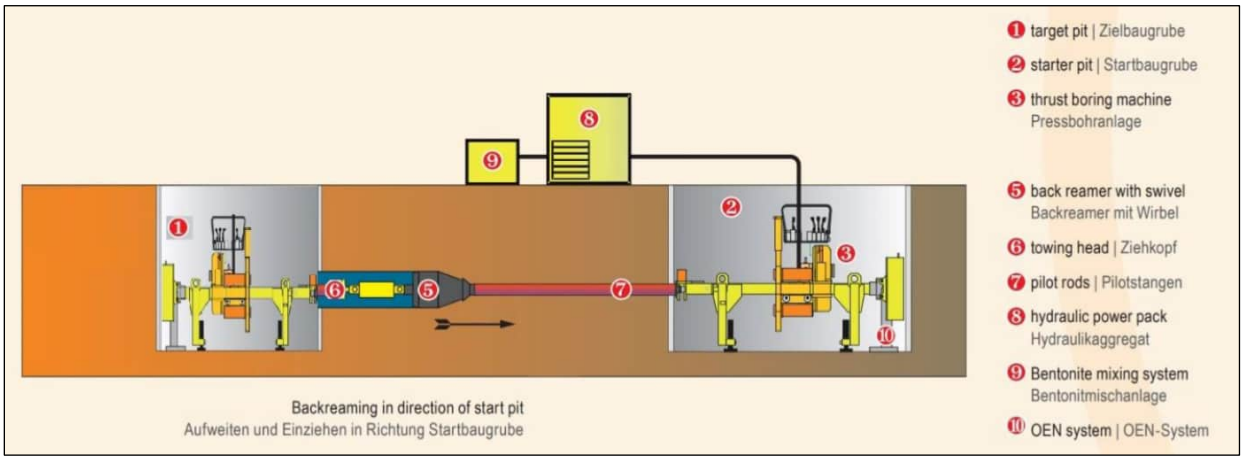

Figure 8 – Typical pilot bore – cutting back

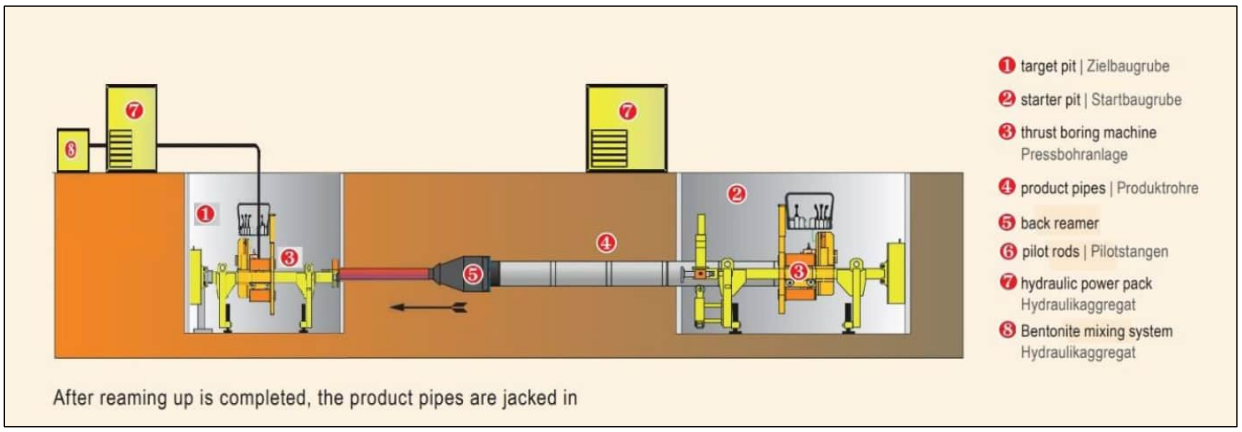

Figure 9 – Typical pilot bore – jacking pipes in

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).

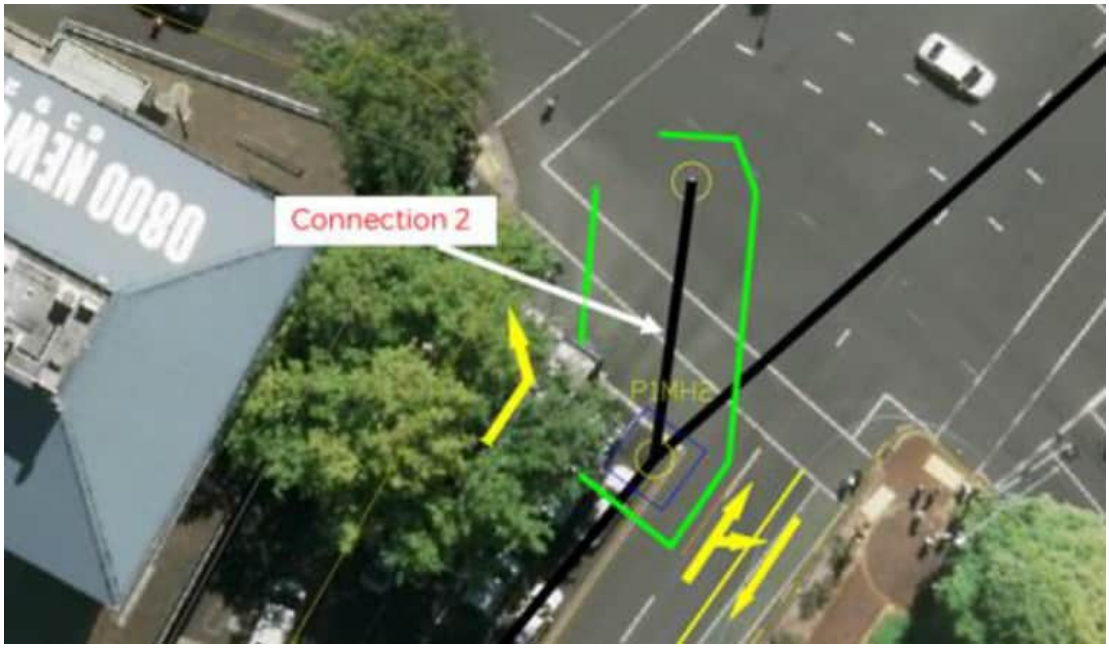

Figure 10 – Plan view of short-term TM for an EOP connection using opencut method

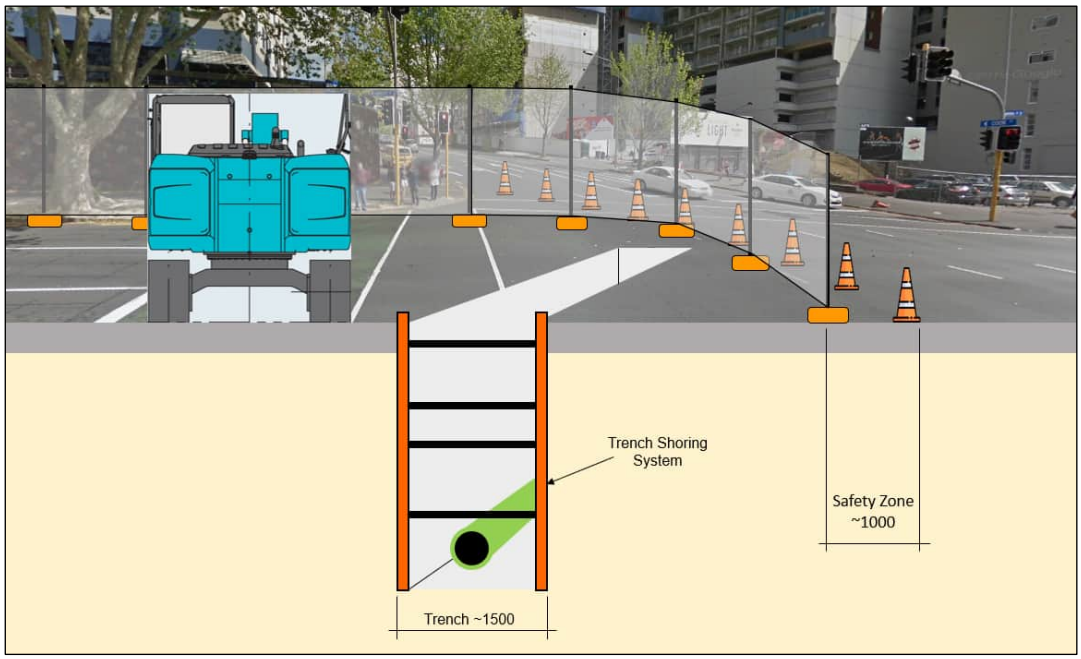

Figure 11 – Trench shoring system for EOP connection using the opencut method

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.

Attachment C: Dewatering and Settlement Assessment R2

Watercare Services Limited

QUEEN STREET WASTEWATER DIVERSION PROGRAMME: MAYORAL DRIVE ALIGNMENT PROJECT

DEWATERING AND SETTLEMENT ASSESSMENT

10 SEPTEMBER 2025

PUBLIC

QUEEN STREET WASTEWATER DIVERSION PROGRAMME: MAYORAL DRIVE ALIGNMENT

DEWATERING AND SETTLEMENT ASSESSMENT

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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.
R2	10 September 2025	Draft incorporating s92 amendments and addendum report for increased depth for Shafts P4MH1 and P4MH2.

	NAME	DATE
Prepared by:	Terry Hughes and Vassilis Houssiadas	26 August 2025
Reviewed by:	Louise Soltau, Alireza Mohammadinia and Emily Ireland	10 September 2025
Approved by:	Philip McFarlane	10 September 2025

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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 very slight to 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.

Note for Addendum (Appendix E).
This specialist report (R1) was updated in response to a Section 92 request for information from Auckland Council (this revision R2). In addition, it was discovered that existing stormwater services underlying the alignment between Mayoral Shafts P4MH1 and P4MH2 were deeper than originally assumed and the depth of these shafts may need to be increased by 1.0 m. Further assessment has been conducted on these two shafts and is presented in the Addendum report attached as Appendix E. The effects assessment has not changed as a result of this additional depth for the two shafts. However, as a conservative measure, the trigger levels for monitoring pins around these two shafts have been updated in the groundwater and settlement monitoring and contingency plan (GSMCP) accompanying this package.

1 INTRODUCTION

1.1 REPORT BACKGROUND

The Mayoral Drive Alignment Project assessment of dewatering effects report Revision 1 (R1) was submitted to Auckland Council on 21 July 2025. A section 92 request for further information from Auckland Council was received on the 28th July 2025. In addition, it was discovered that existing stormwater services underlying the alignment between Mayoral Shafts P4MH1 and P4MH2 were deeper than originally assumed and the depth of these shafts may need to be increased by 1.0 m. These shafts thus required further assessment to define any likely increase in effects due to the increased depth. The updated dewatering and settlement modelling are addressed in the addendum report in Appendix E.

The effects assessment has not changed as a result of this additional depth for the two shafts, though the settlement has increased for both shafts by less than 5 mm. The likely damage classification for structures near these two shafts remain the same. However, as a conservative measure, the trigger levels for settlement monitoring have been updated in the groundwater monitoring and contingency plan (GSMCP) accompanying this package.

1.2 OVERVIEW

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.

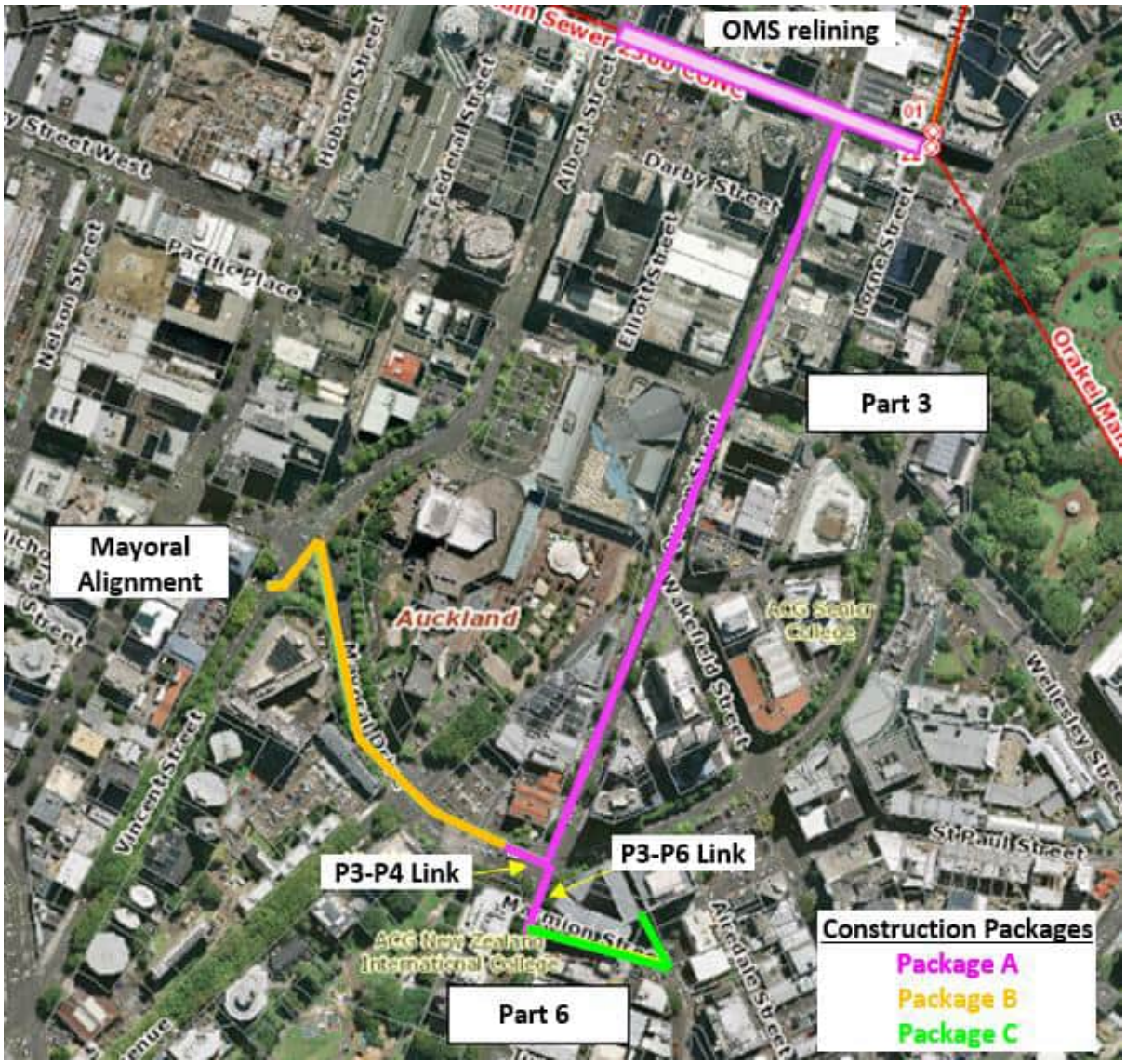


Figure 1-1: Queen Street Wastewater Diversion Programme

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.

1.3 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].

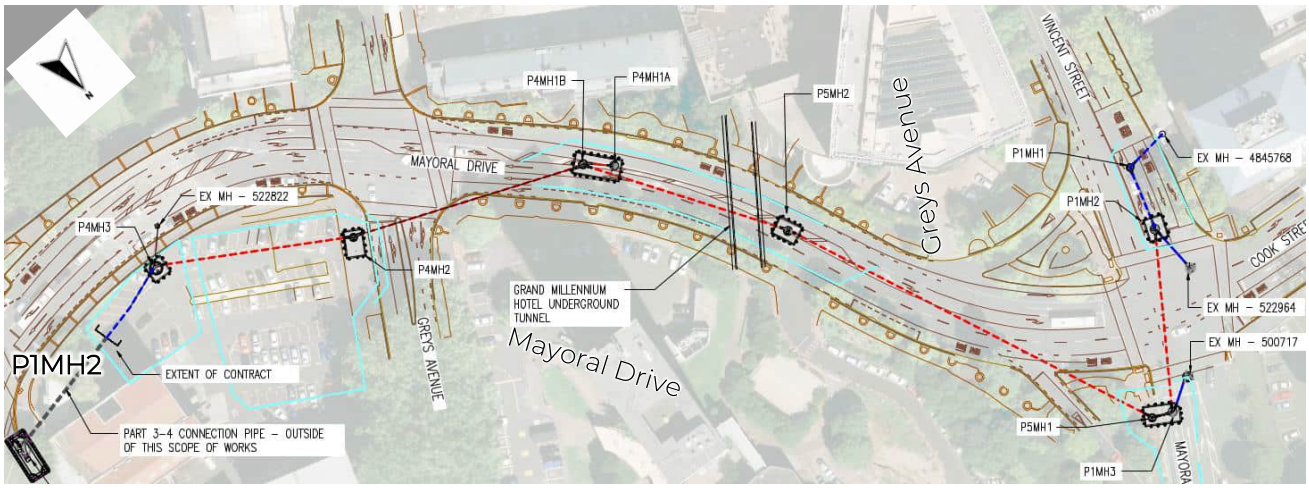


Figure 2-1: Project area

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.

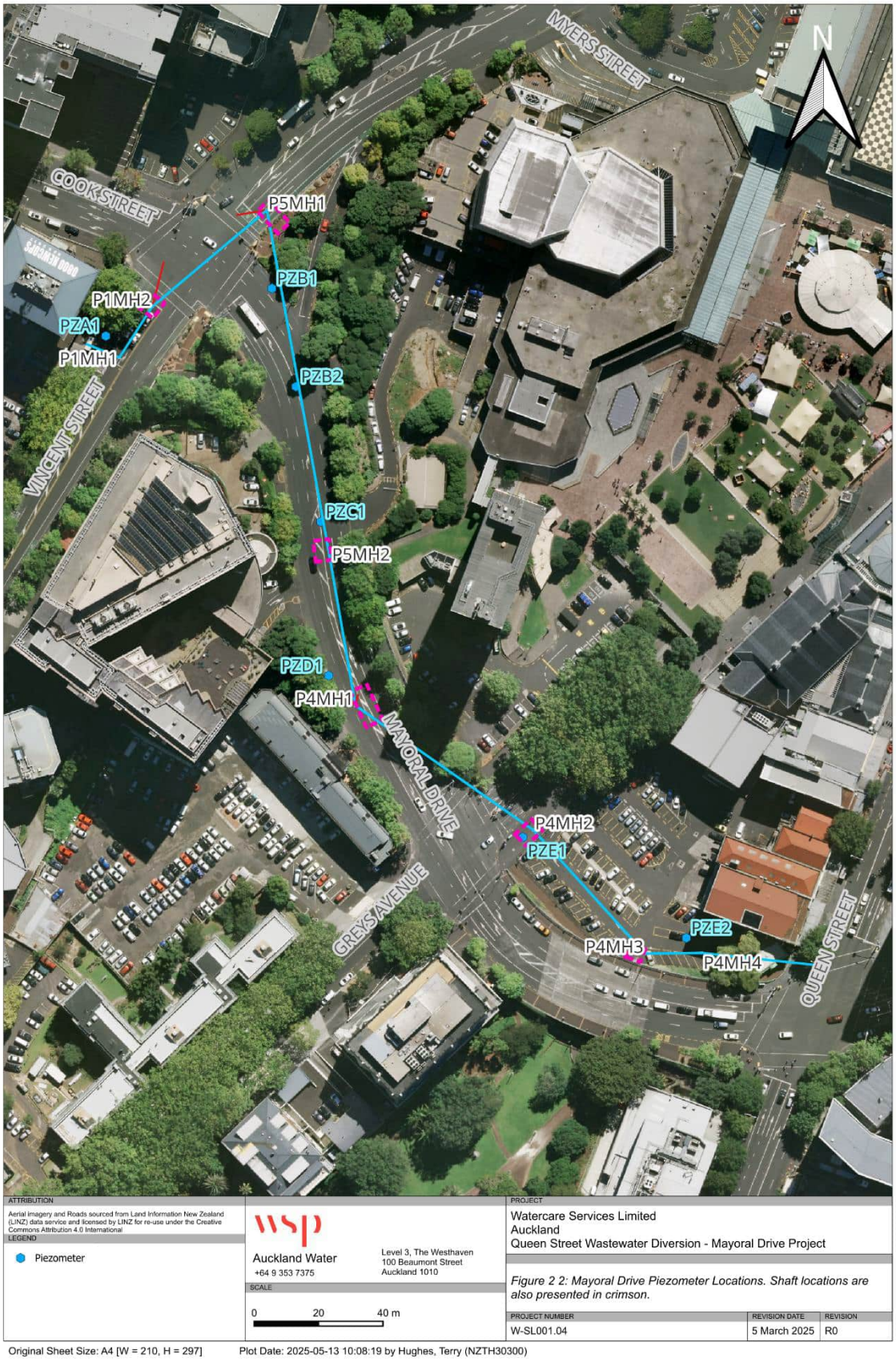
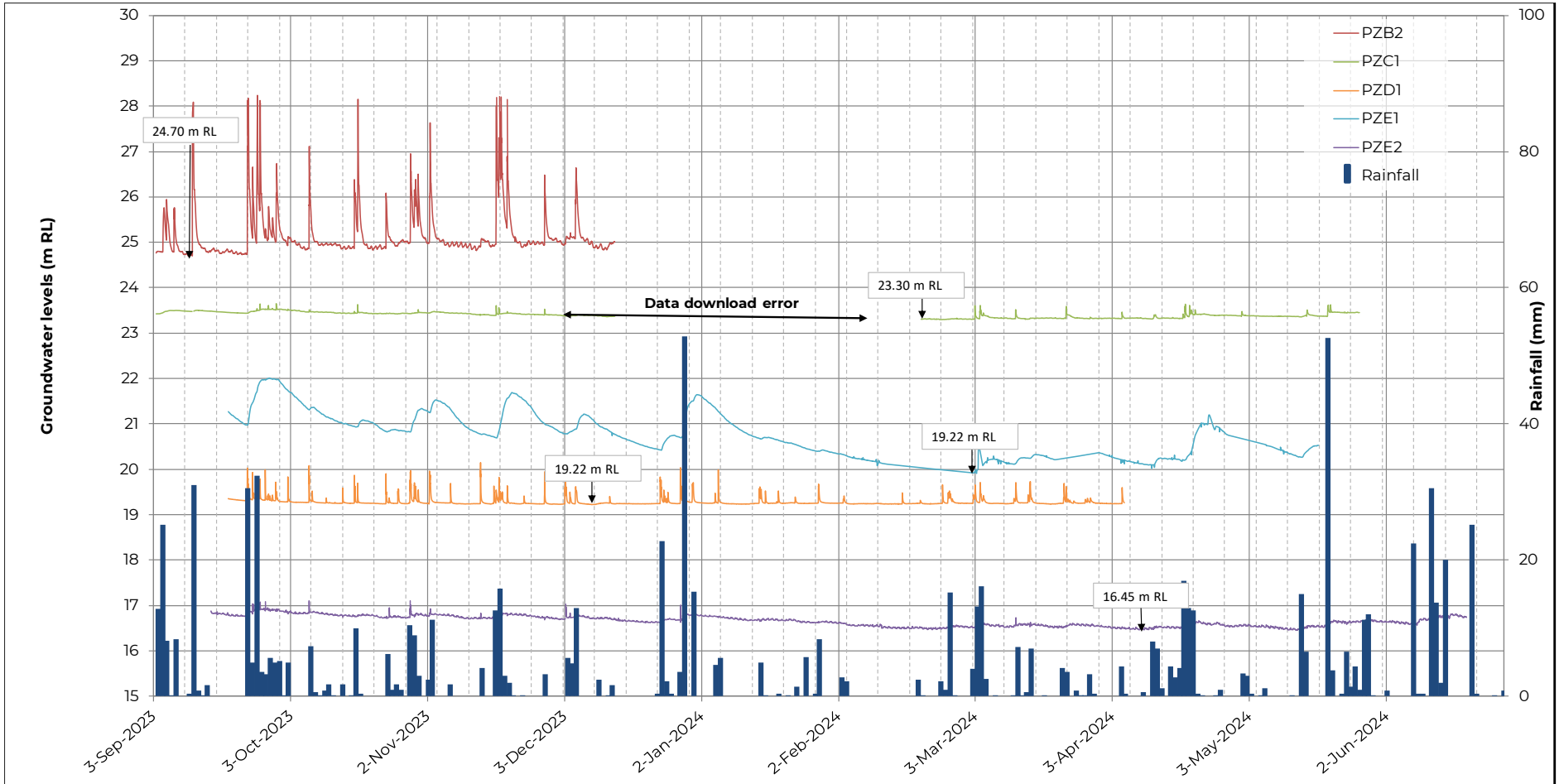


Figure 2-2: Locality map showing piezometer locations for groundwater level monitoring.

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

Piezometer	Bore ID	Easting (m)	Northing (m)	Depth (m bgl)	Initial SWL (m bgl) (Date)	Initial SWL (m RL)	Seasonal Low WL (m RL)	Screen interval (m bgl)	Lithology screened
PZA1	BH23/09	1756960.31	5920074.78	7	5.12 (8 Sept 2023 – measured the day after drilling))	29.76	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	24.70	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	23.30	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	19.22	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	20.93	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	16.47	5.08-8.58	ECBF Sandstone interbedded with mudstone.
PZB1	BH23/08	1757011.9	5920089.59	9	8.175 (28 Aug 2023)	23.49	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

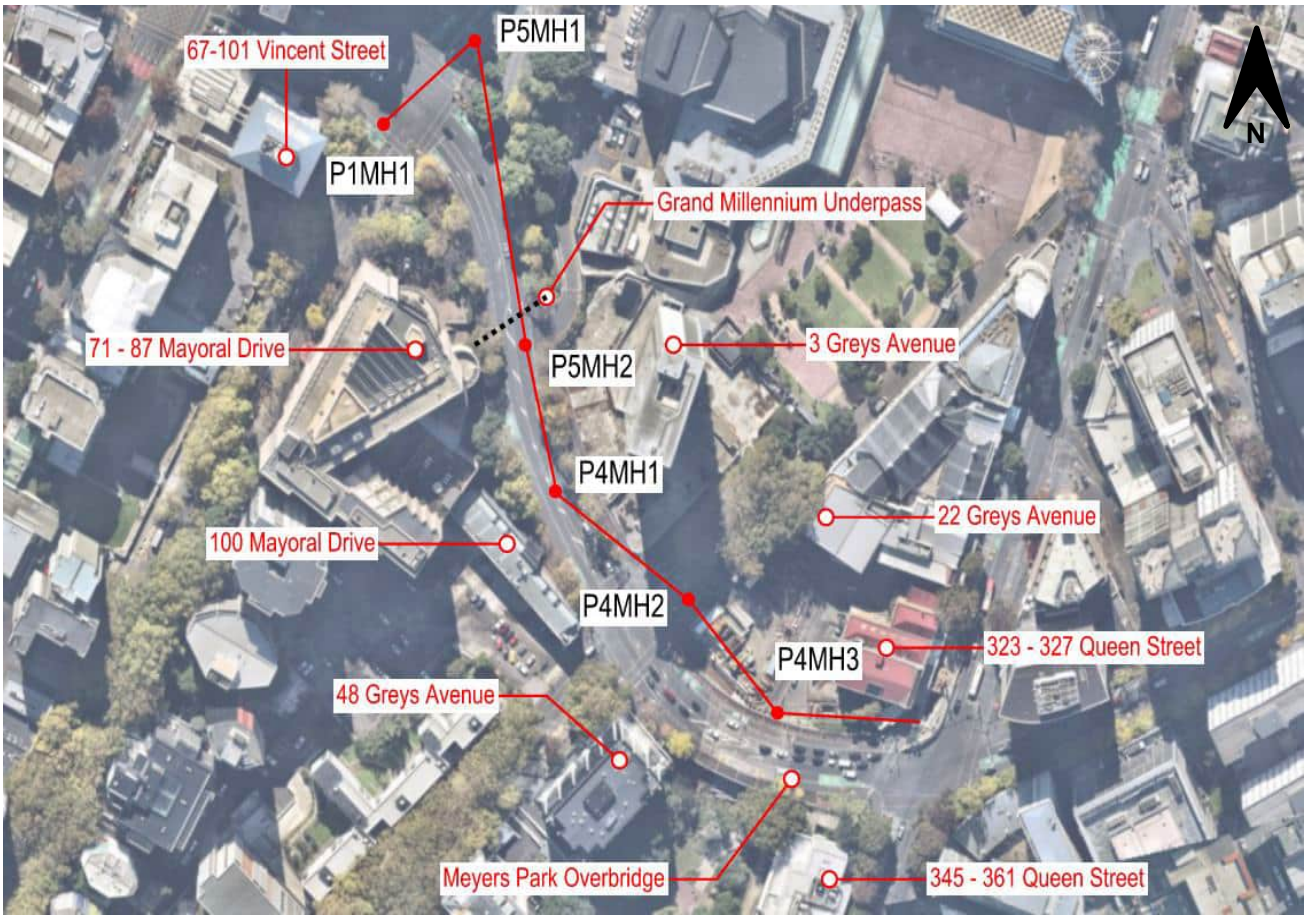


Figure 2-4 Site plan with relevant buildings and structures shown.

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.

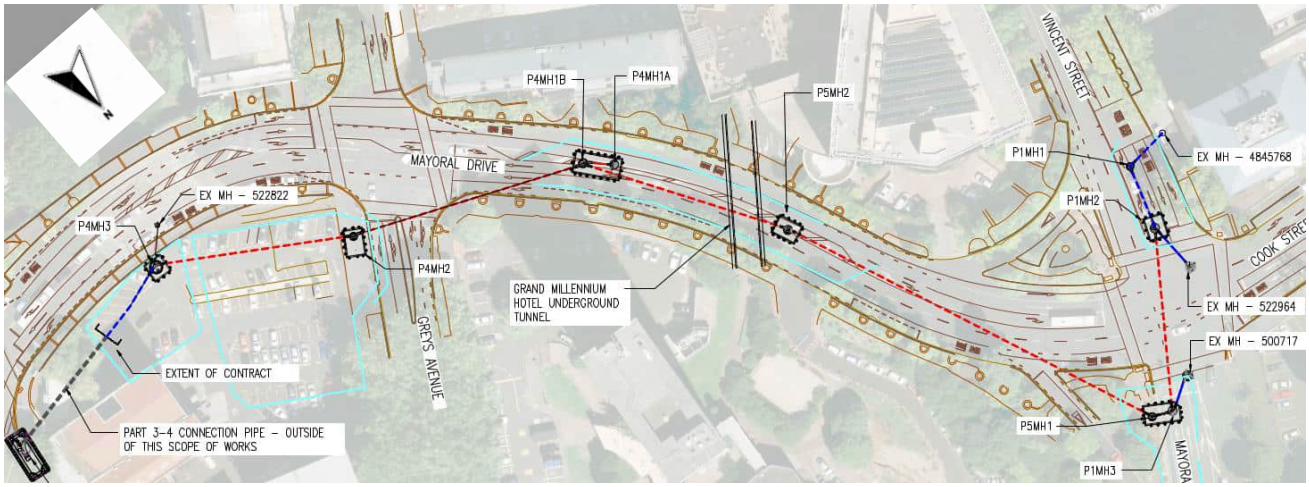


Figure 3-1: Overview of main indicative construction works (red lines are trenchless pipelines, blue are trenched pipelines)

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.

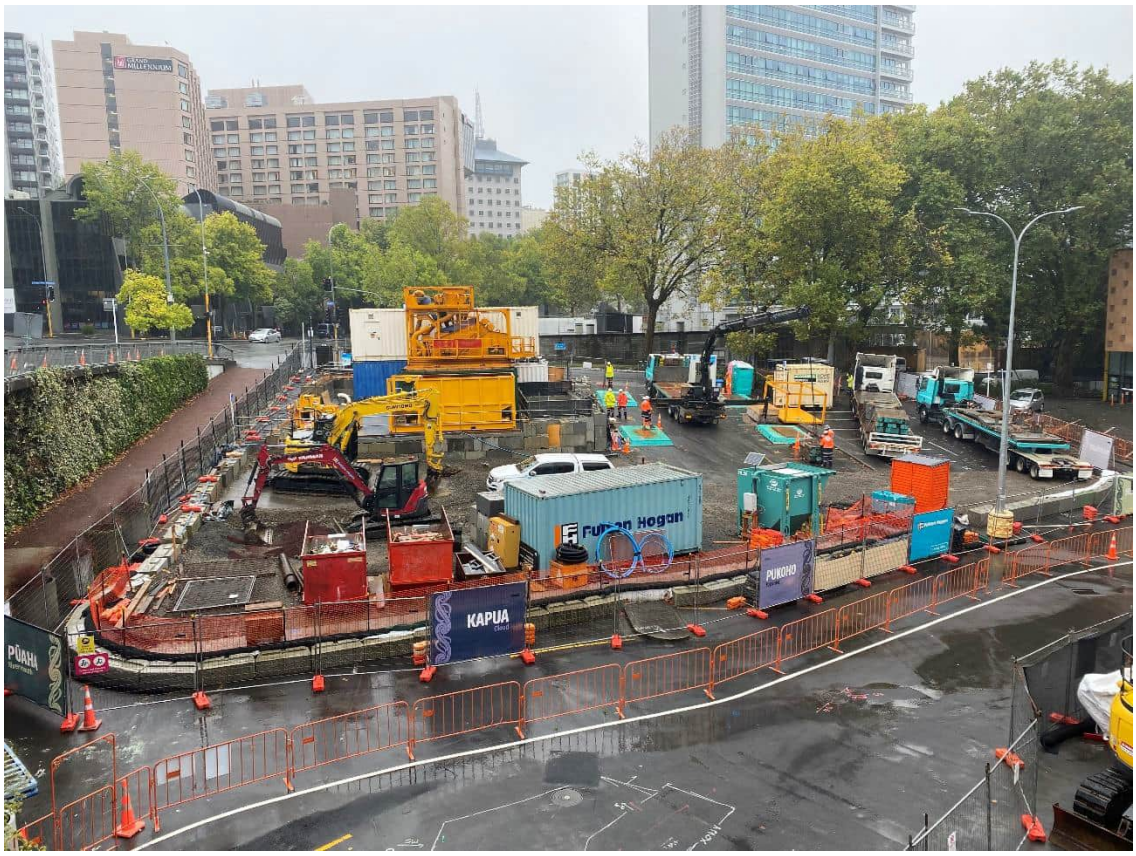


Figure 3-2: Indicative Greys Ave CSA layout (looking north-west towards Greys Ave)

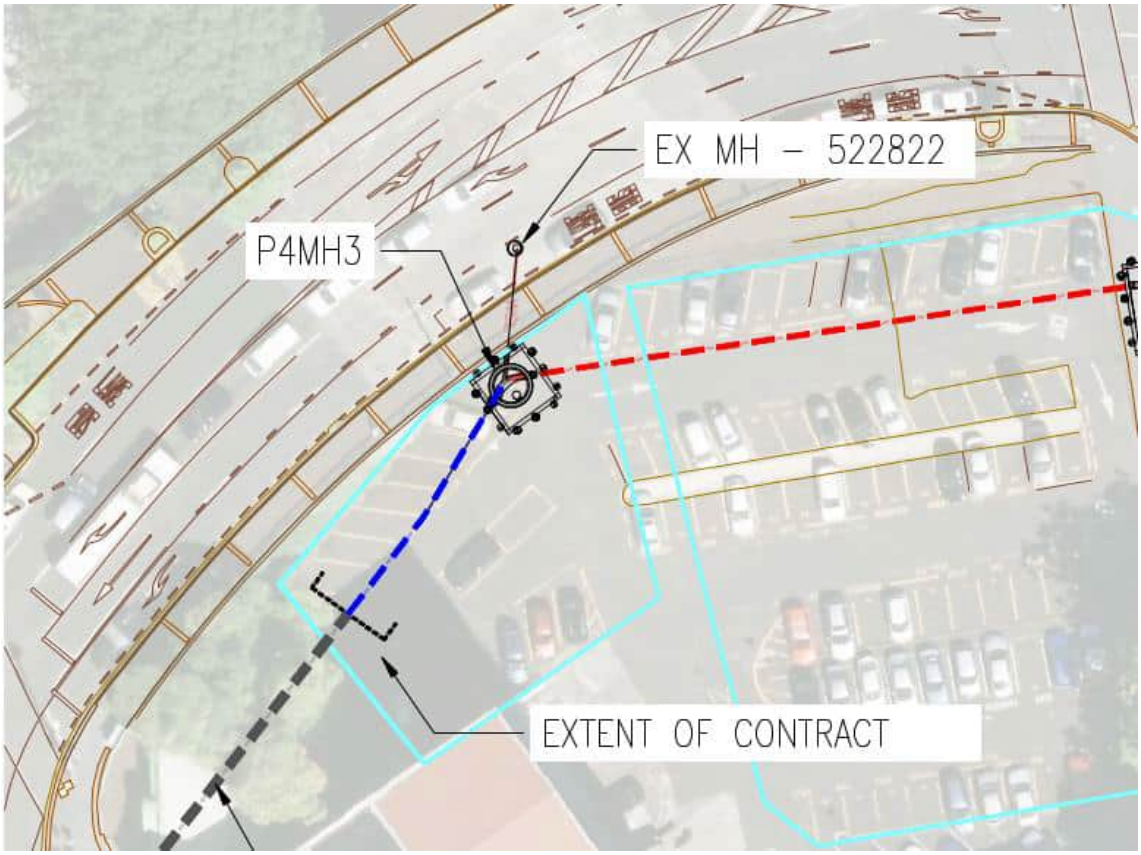


Figure 3-3: Indicative compound around P4MH3 within Greys Ave Carpark (indicative compound extents shown in light blue)

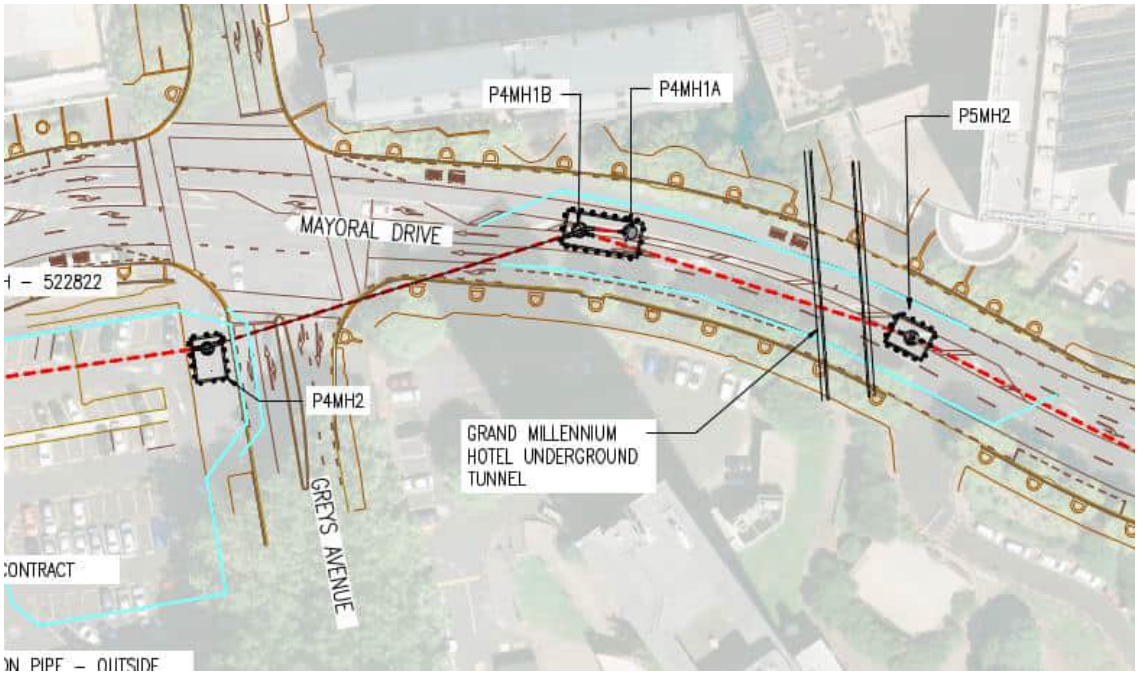


Figure 3-4: Two compounds on Mayoral Drive/Greys Ave outside 299 Queen Street, G05/1 Greys Ave and the CSA in the Greys Ave carpark

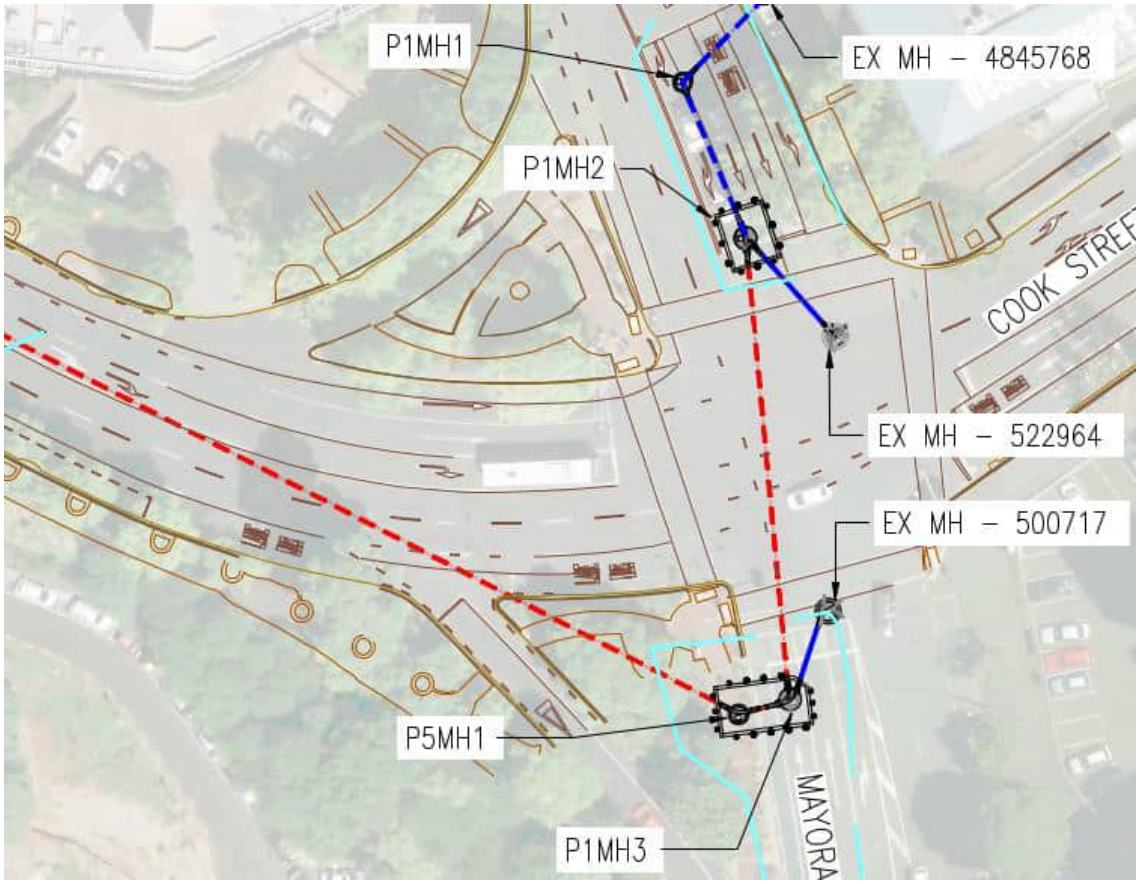


Figure 3-5: Two compounds at Cook St/Mayoral Drive/Vincent St intersection

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 Figure 5-2 to Figure 5-6. 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.

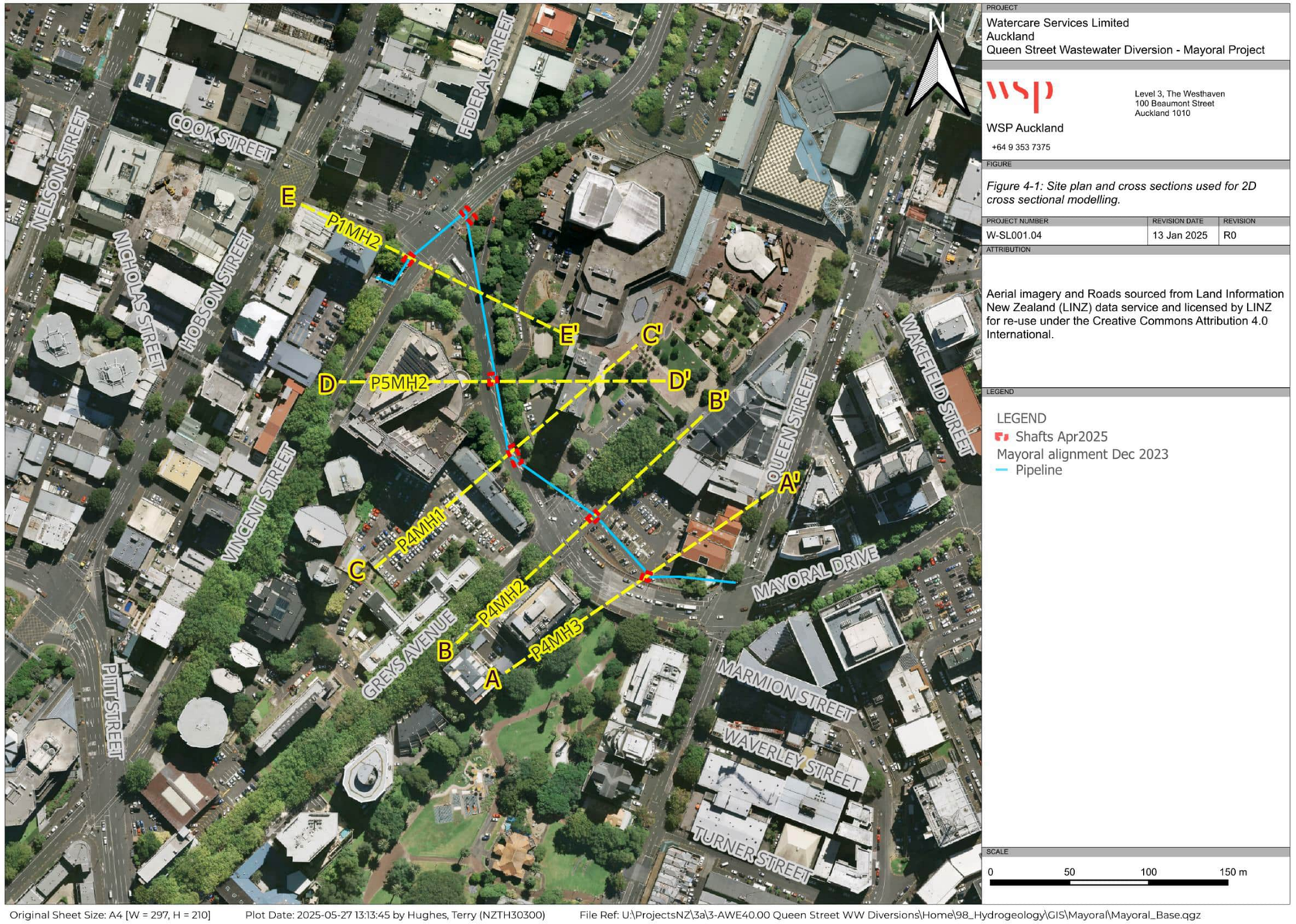


Figure 5-1: Site plan showing location of site investigations and ground model cross sections (yellow dashed line)

Mayoral P4MH3 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

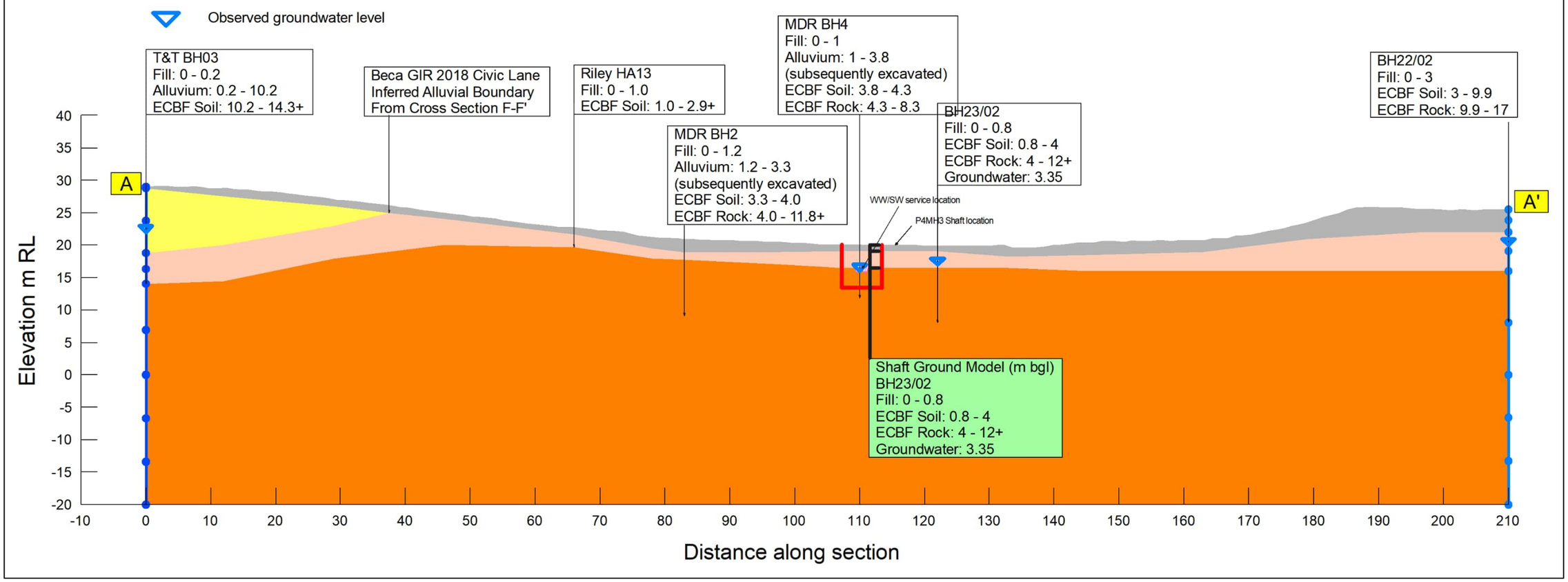


Figure 5-2: P4MH3 ground model cross section (all depths recorded in text boxes are in m bgl).

Mayoral P4MH2 ground model

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function
	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 level

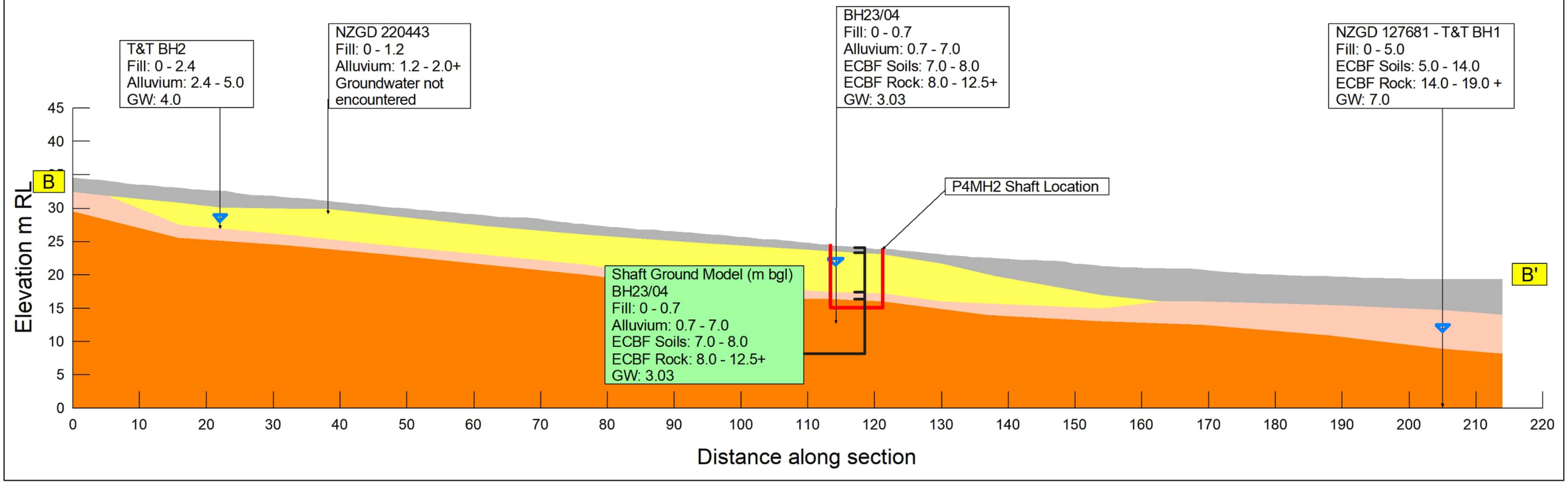


Figure 5-3: P4MH2 ground model cross section (all depths recorded in text boxes are in m bgl).

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

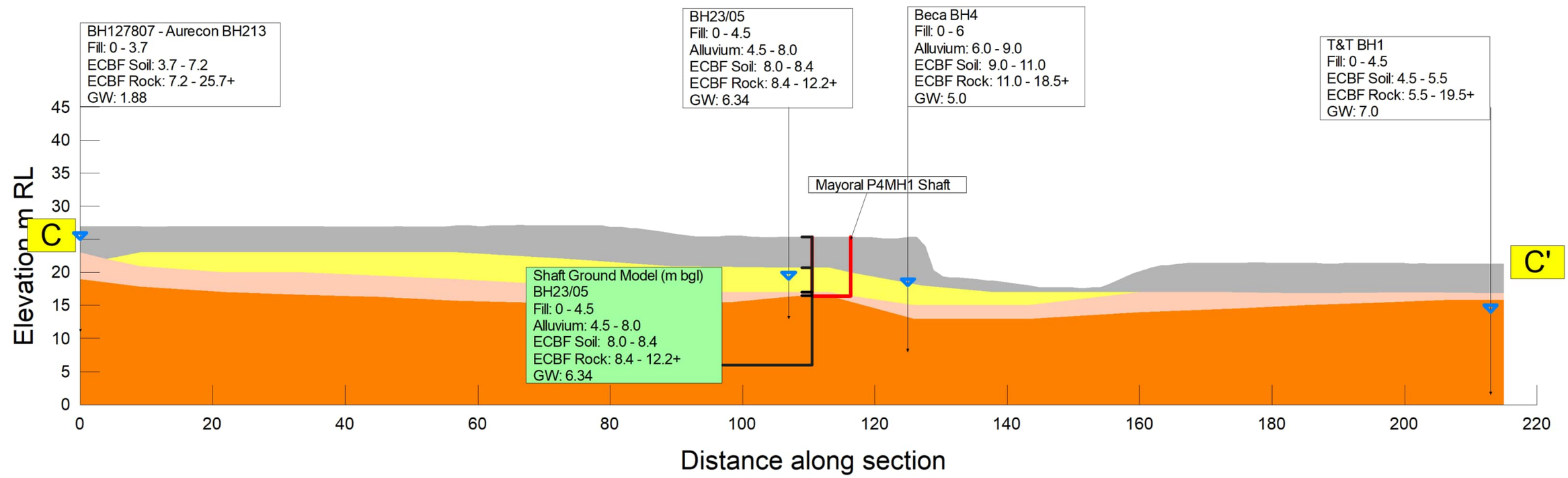


Figure 5-4: P4MH1 ground model cross section (all depths recorded in text boxes are in m bgl).

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

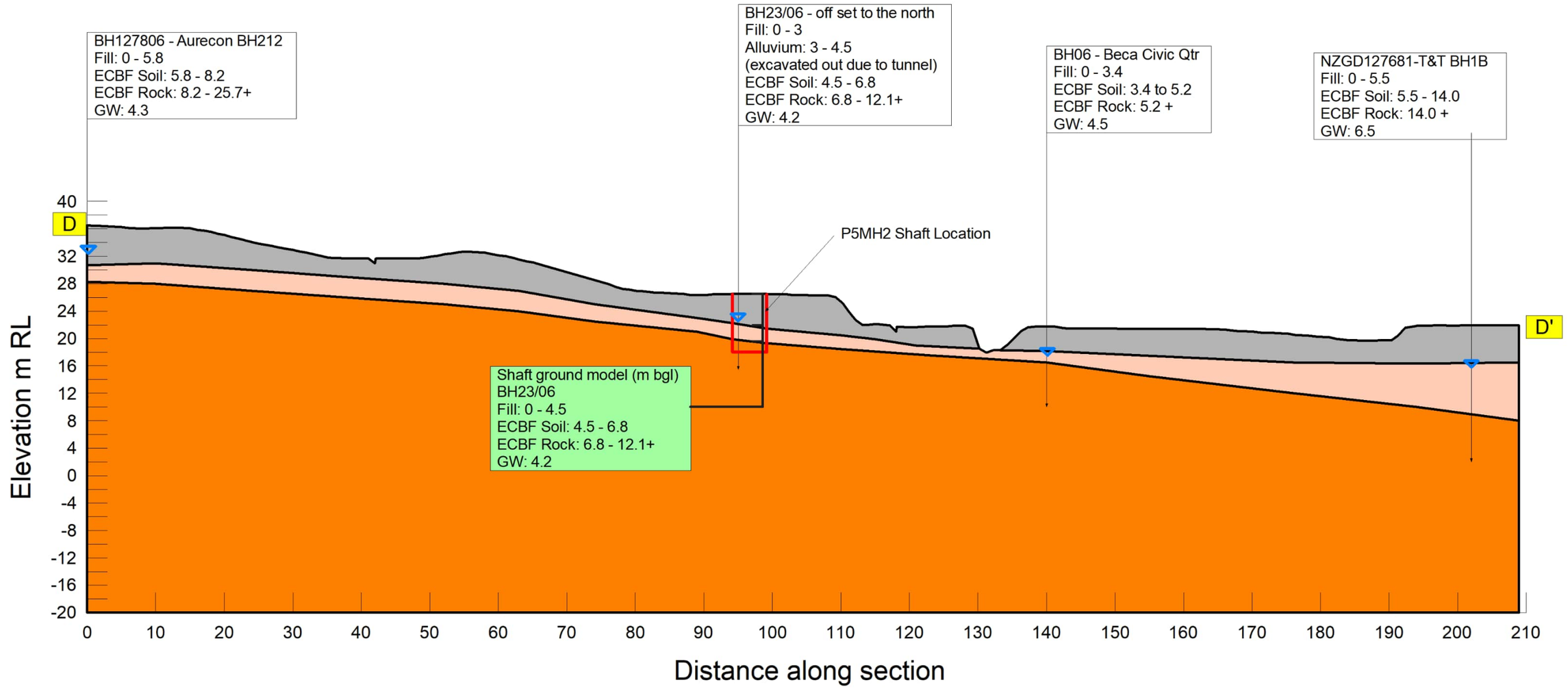


Figure 5-5: P5MH2 ground model cross section (all depths recorded in text boxes are in m bgl).

Mayoral P1MH2 ground model

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function
	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

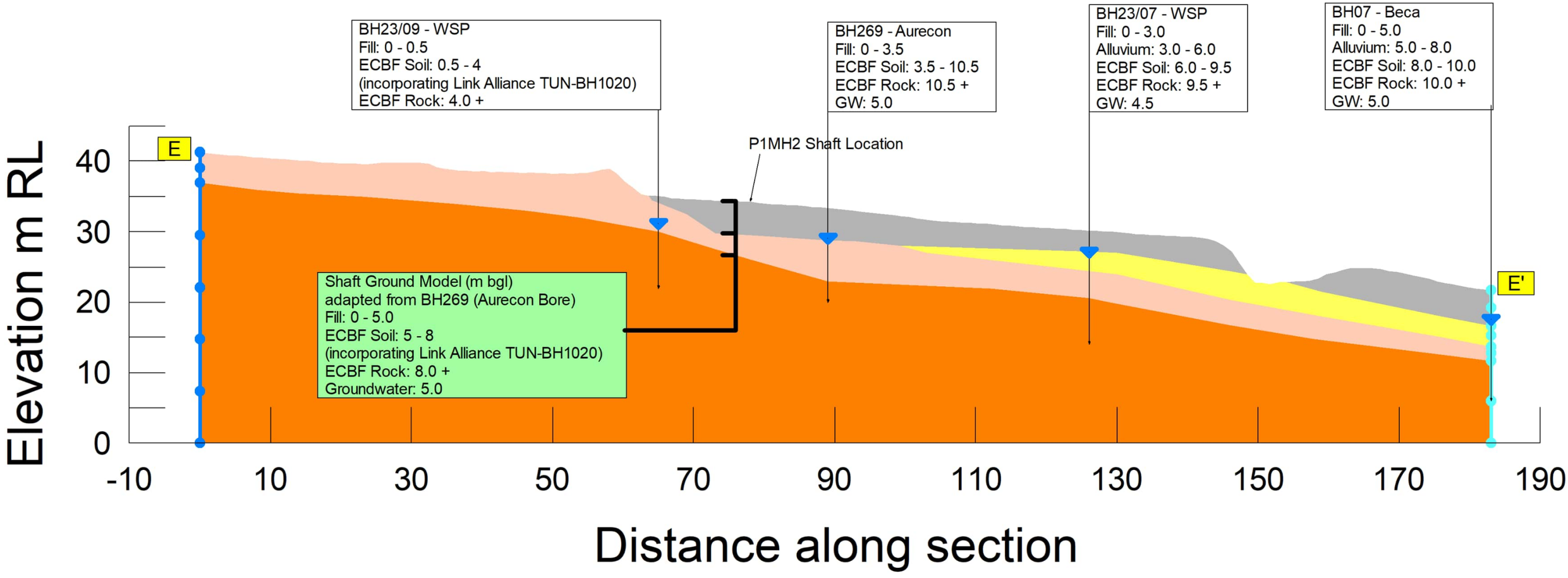


Figure 5-6: P1MH2 ground model cross section (all depths recorded in text boxes are in m bgl).

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 4- 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 4.2 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). Predicted groundwater levels within the shaft footprint are most likely similar to groundwater levels recorded in the nearby site investigation piezometers and the lowest recorded groundwater levels were adopted for settlement estimation, particularly where the groundwater levels showed minimal variation. In P4MH2 a higher water level was modelled due to the difficulty in matching water levels across the model domain. Dewatering in P4MH2 is quite significant within compressible alluvial materials and therefore gave a suitably conservative assessment. Drainage boundaries representing stormwater and wastewater pipes were added to the model where groundwater levels indicate drainage to an unknown feature, particularly within valley floors. The 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)	Pre-dewatering (steady state) water level at shaft (m RL)	Piezometer	Seasonal Low (m RL)
P4MH3	A	20	A'	22	16.44	PZE2	16.47
P4MH2	B	29.5	B'	10	21.51	PZE1	20.93
P4MH1	C	25	C'	14	19.22	PZD1	19.22
P5MH2	D	32	D'	16.5	23.10	PZC1	23.30
P1MH2	E	35	E'	17	30.09	PZA1	30.09

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 (°)**	**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.

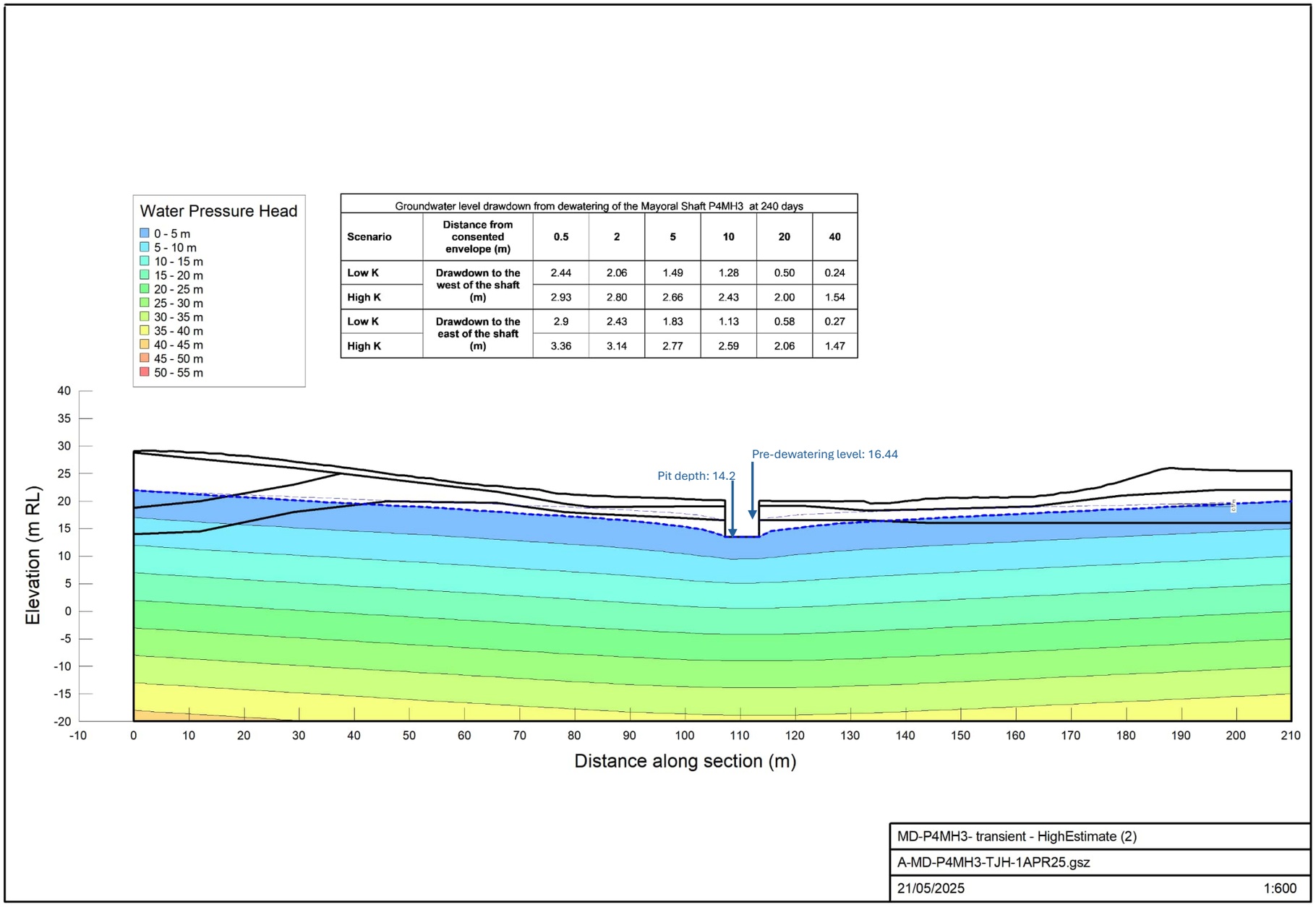
The modelled groundwater level drawdown from dewatering of the Mayoral Shafts along the assessment cross sections are presented in Figure 6-1 to Figure 6-5 for the best estimate case of hydraulic parameter values. A table of drawdowns at selected distances along the section moving out from the sides 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.

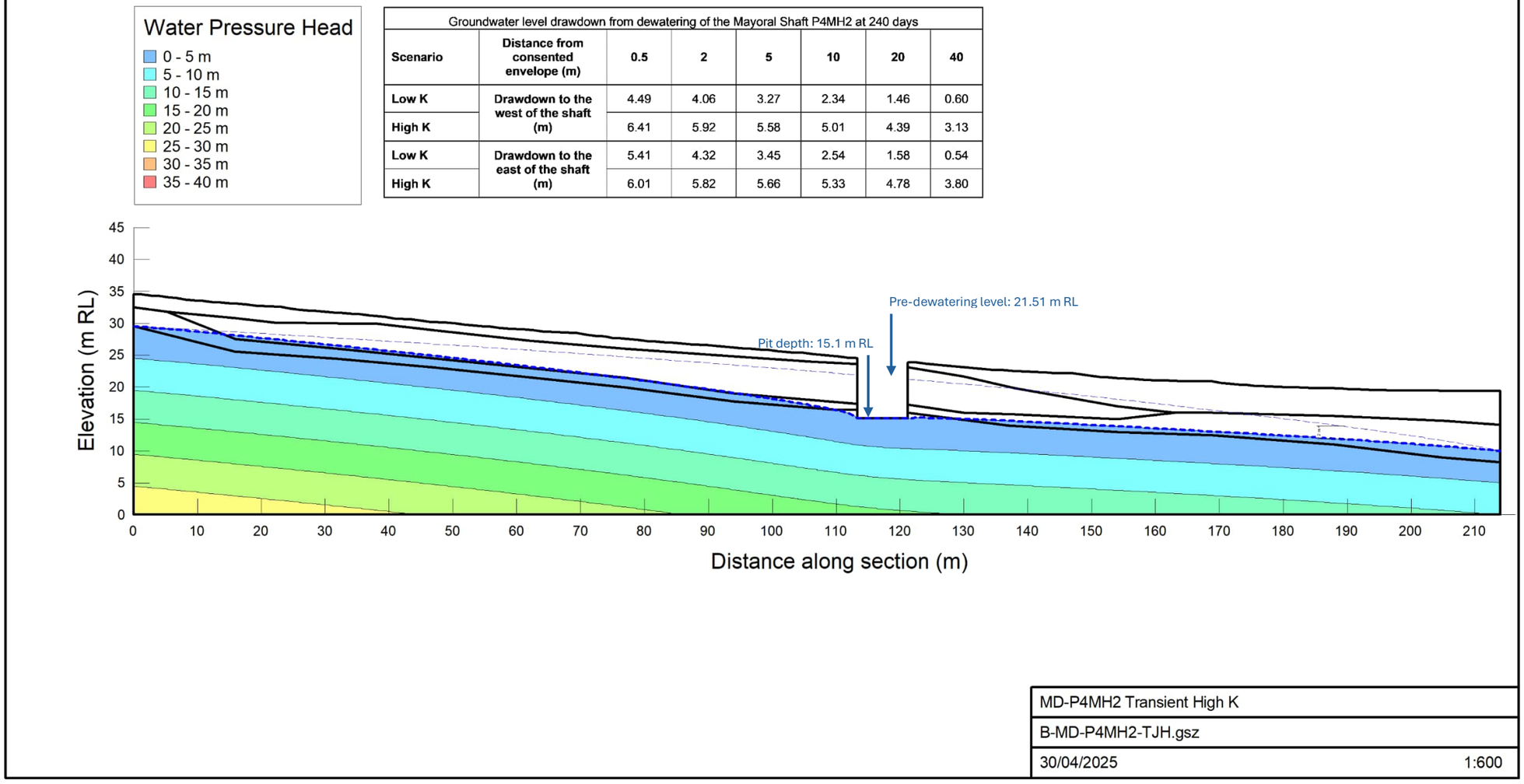
Shaft	Discharge (m^3/day)	
	Day 1	Day 240
P4MH3	56	28
P4MH2	54	18
P4MH1	35	13
P5MH2	63	35
P1MH2	9	4



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 6-1: 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

Figure 6-2: High K estimate case groundwater drawdown for the P4MH2 Shaft.

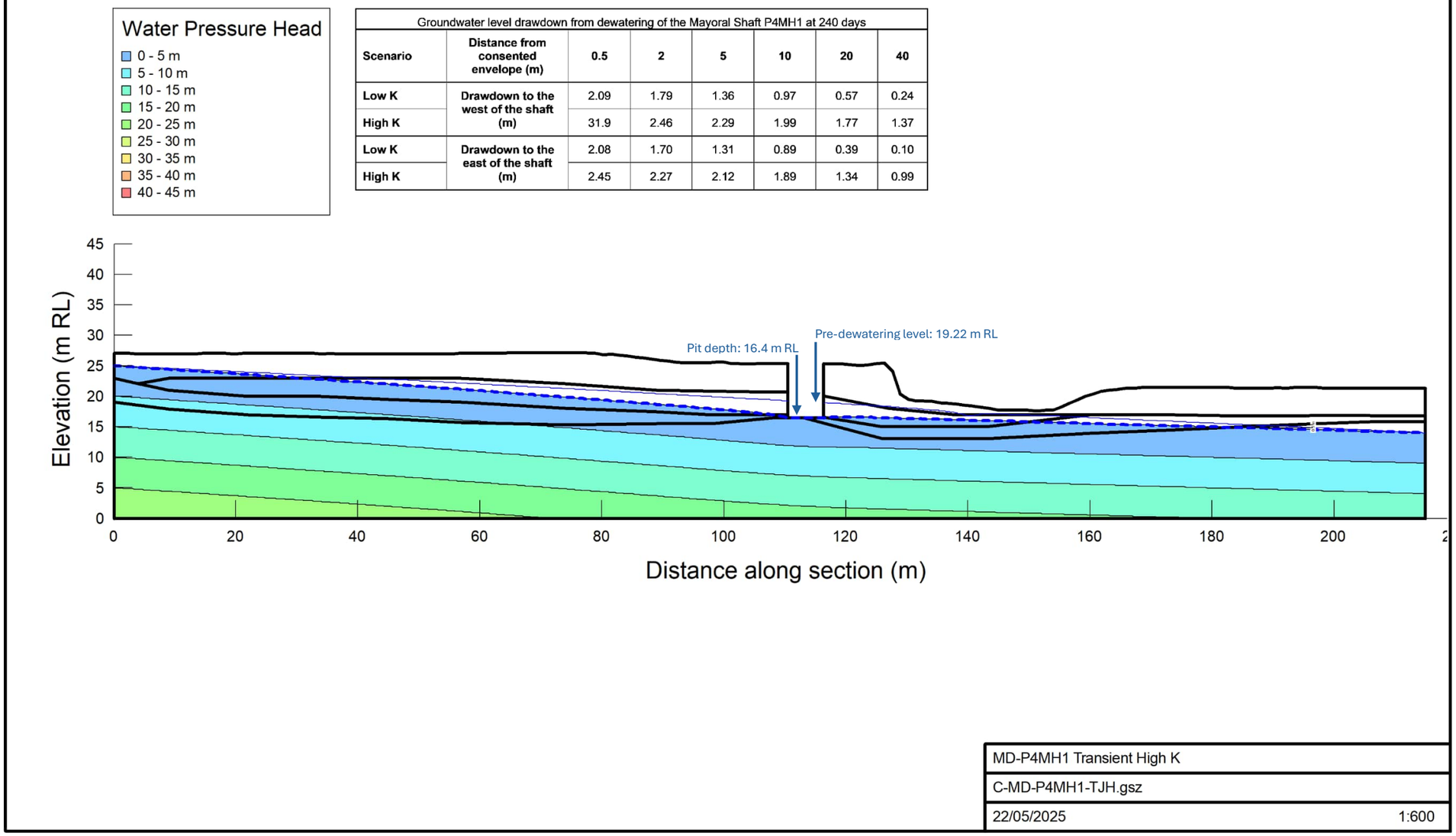


Figure 6-3: High K estimate case groundwater drawdown for the P4MH1 Shaft.

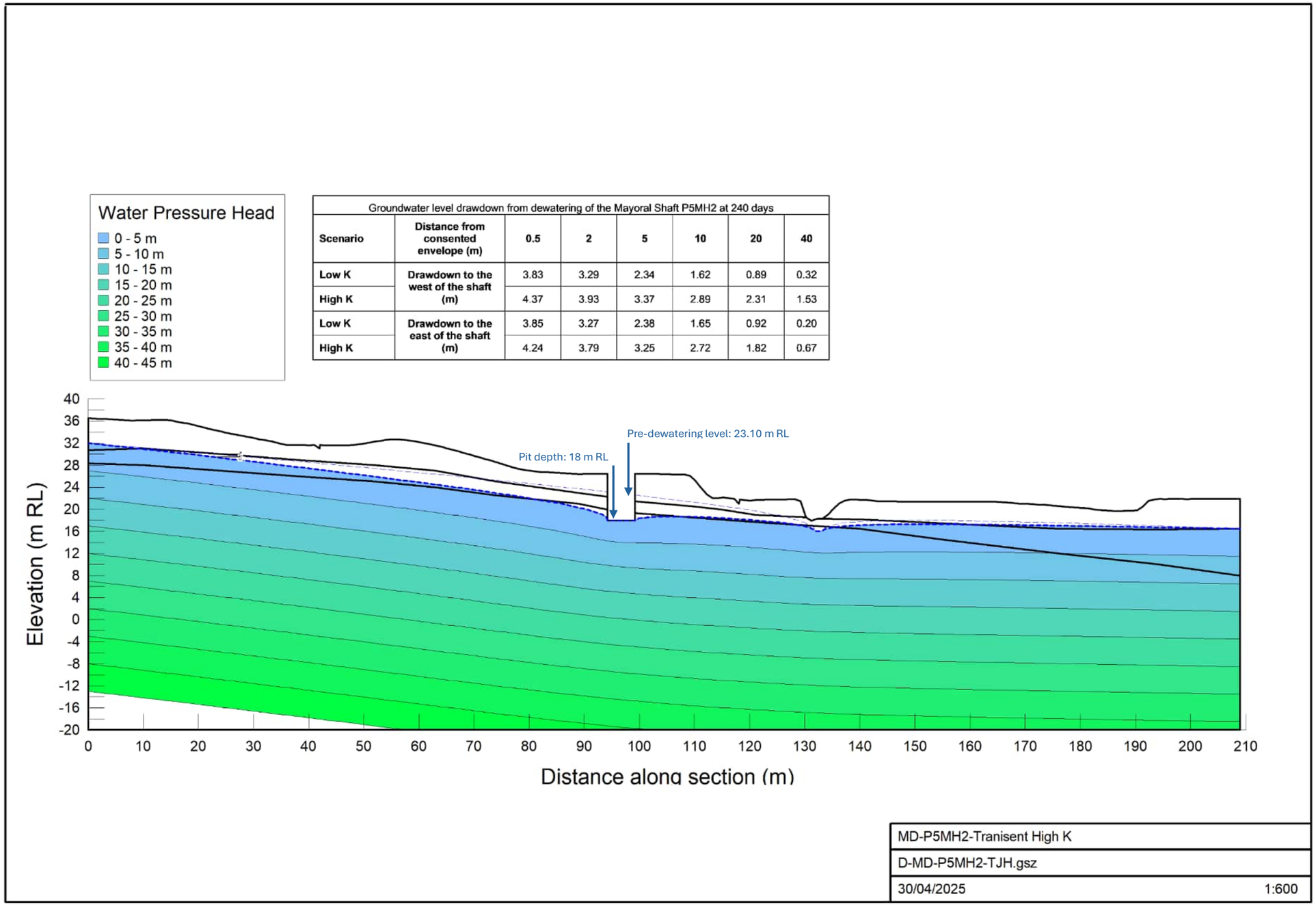
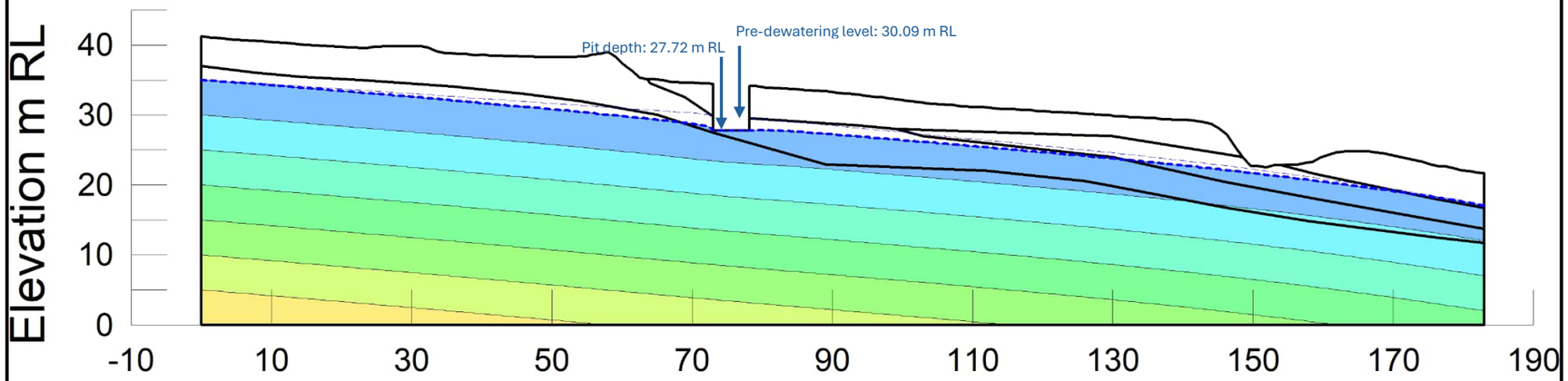


Figure 6-4: High K estimate case groundwater drawdown for the P5MH2 Shaft.

Mayoral P1MH2 ground model

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 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



MD-P4MH1 Transient High K

E-MD-P1MH2-TJH.gsz

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Figure 6-5: 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

Further groundwater drawdown assessment has been conducted for P4MH1 and P4MH2 due to proposed deepening and is presented in the addendum report in Appendix E.

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. It is noted that the distance of 0.5 m from the edge of the shaft was selected as representative of the settlement immediately outside the shaft because anomalies are often observed in the settlement estimates at the edge of the shaft, possibly related to boundary conditions. Settlements so close to the shaft are also unlikely to have significant effects, because there are no buildings or other structures in this zone, any services will have been relocated and any damage to hard surfaces will be repaired at the end of construction as part of the typical reinstatement works.

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.

Further settlement assessment has been conducted for P4MH1 and P4MH2 due to proposed deeper shafts and is presented in the addendum report in Appendix E.

6.2.1 P4MH3

Figure 6-6 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 6-6 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.

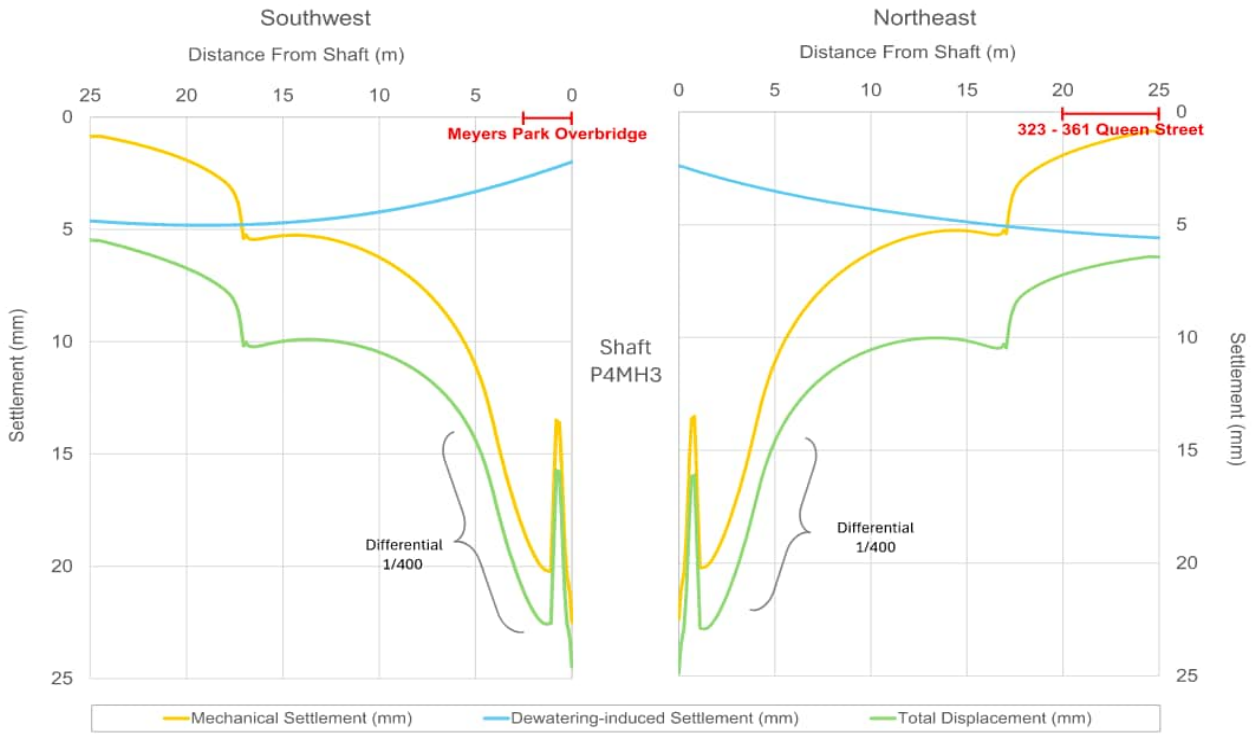

Figure 6-6: Settlement profile across the section for P4MH3.

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*

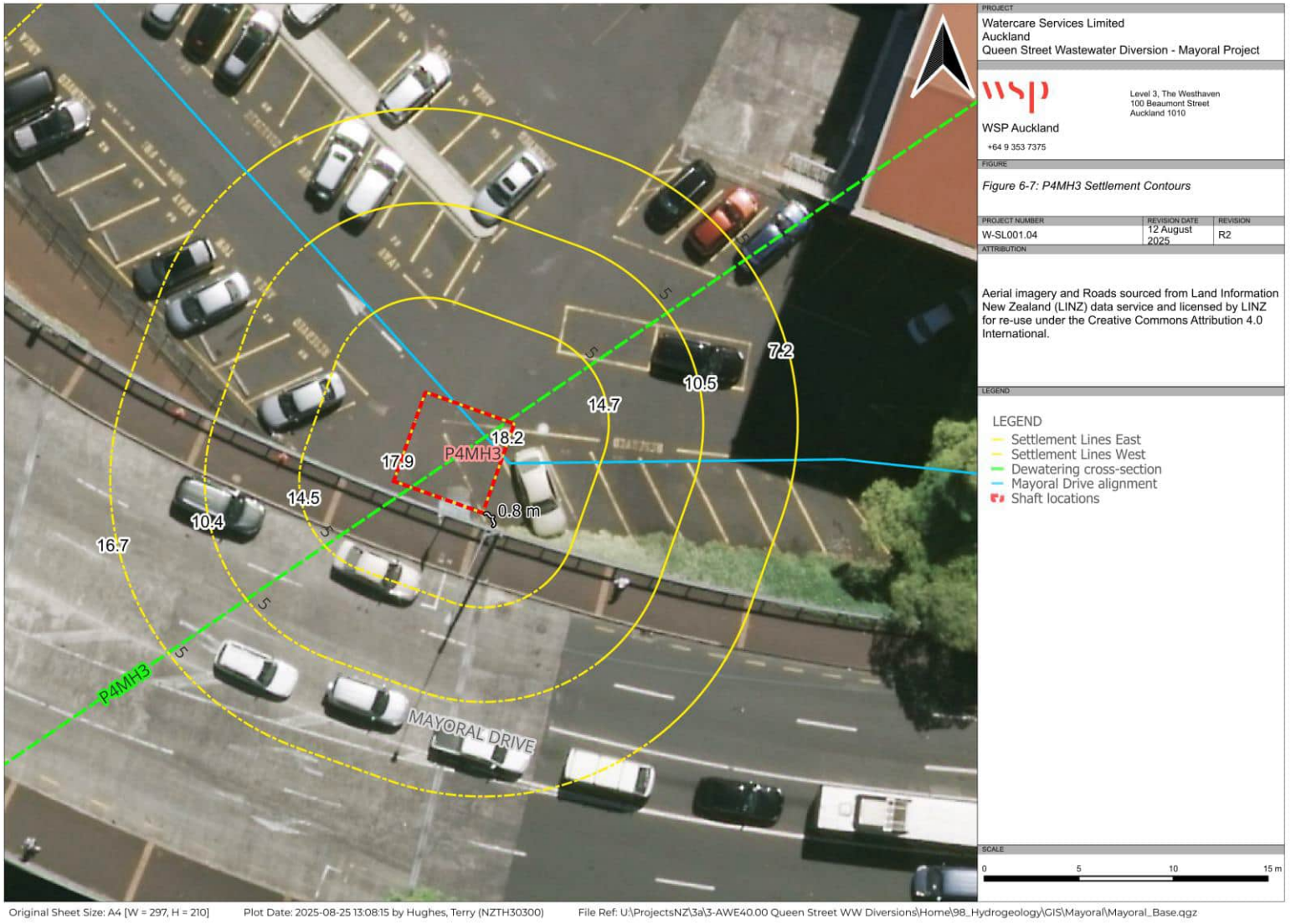

Figure 6-7: P3MH4 Settlement Contours

6.2.2 P4MH2

Figure 6-8 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 Figure 6-8 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.

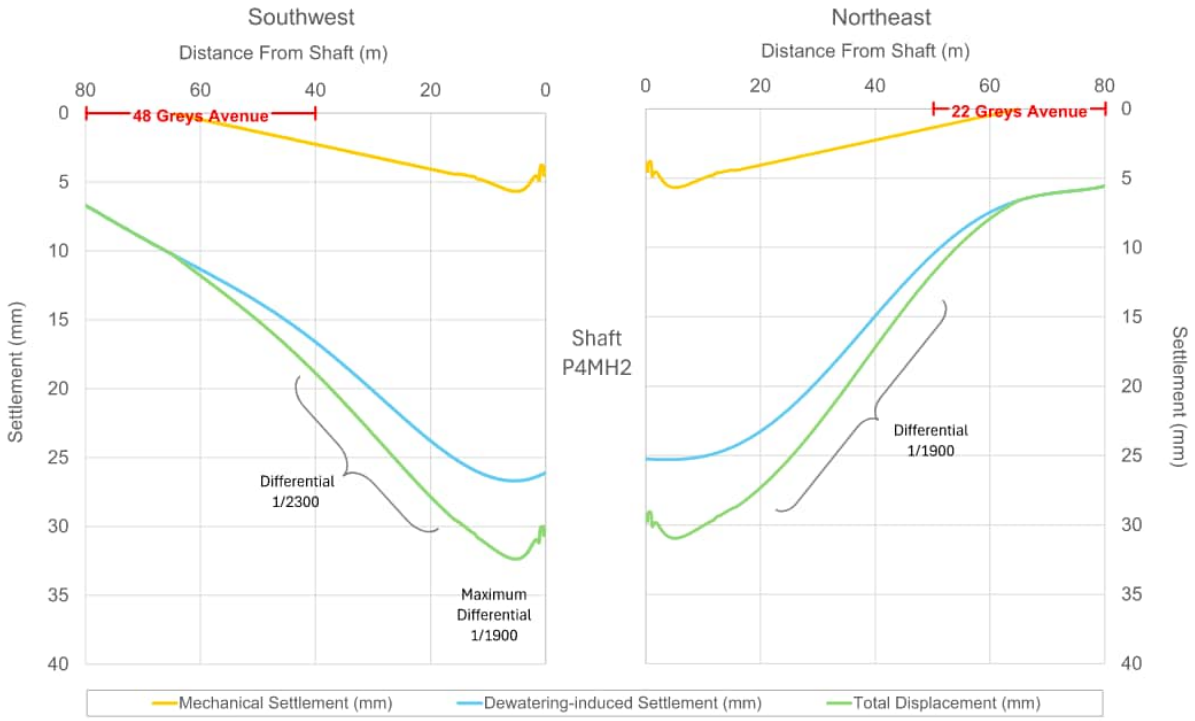

Figure 6-8: Settlement profile of across the section for P4MH2.

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*

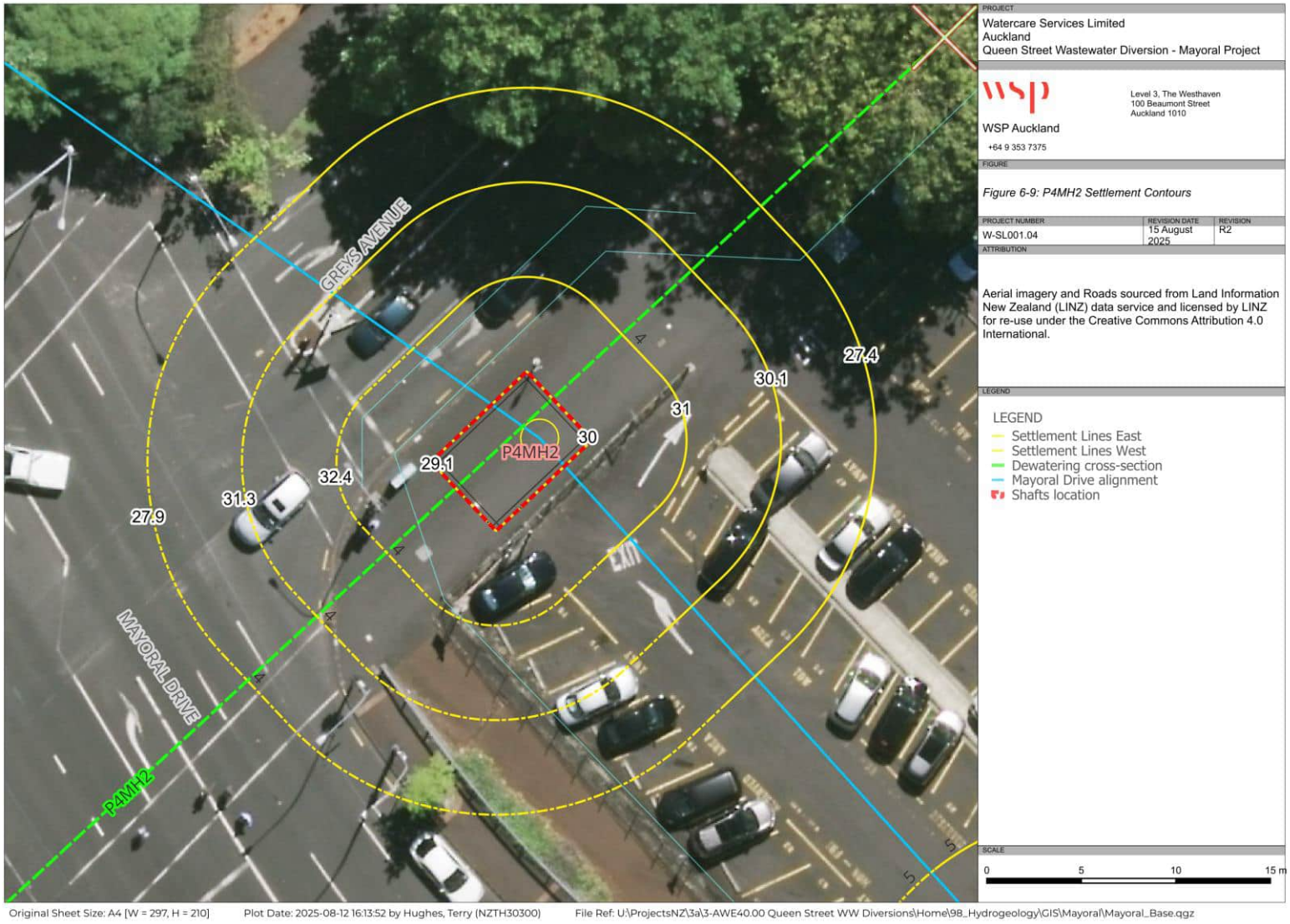

Figure 6-9: P4MH2 Settlement contours

6.2.3 P4MH1

Figure 6-10 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 6-10.

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.

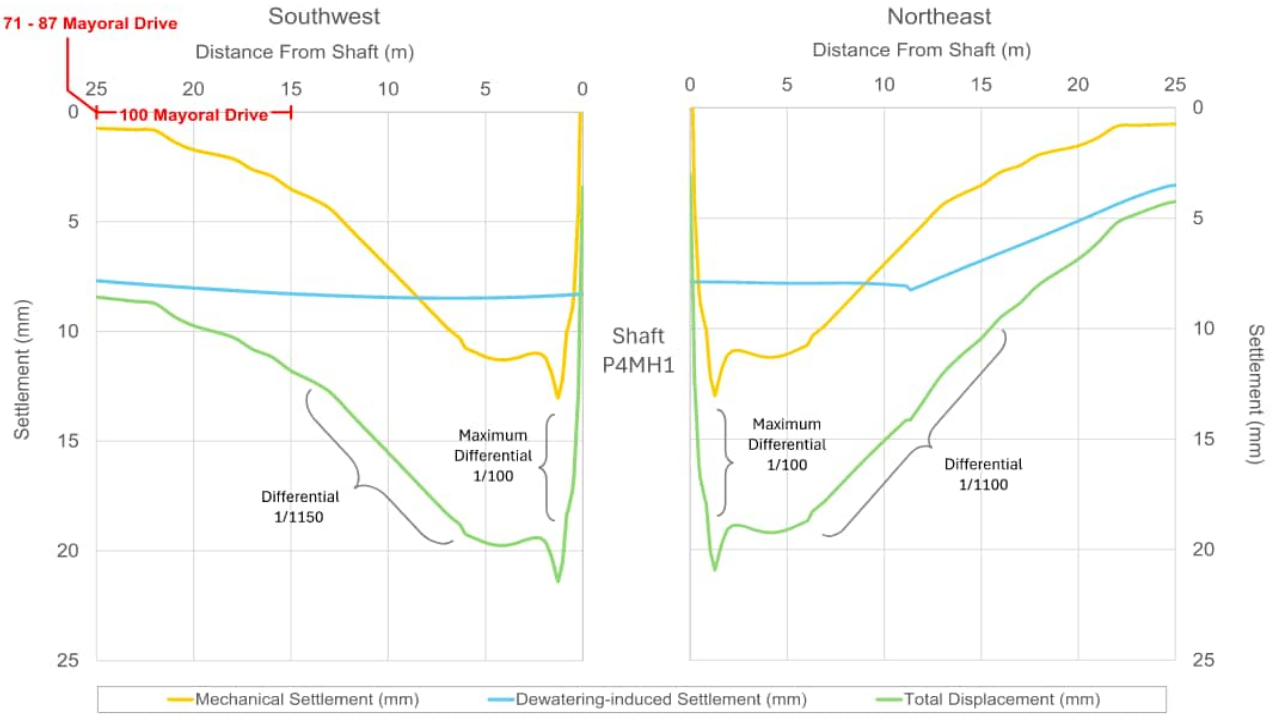

Figure 6-10: Settlement profile of across the section for P4MH1.

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*

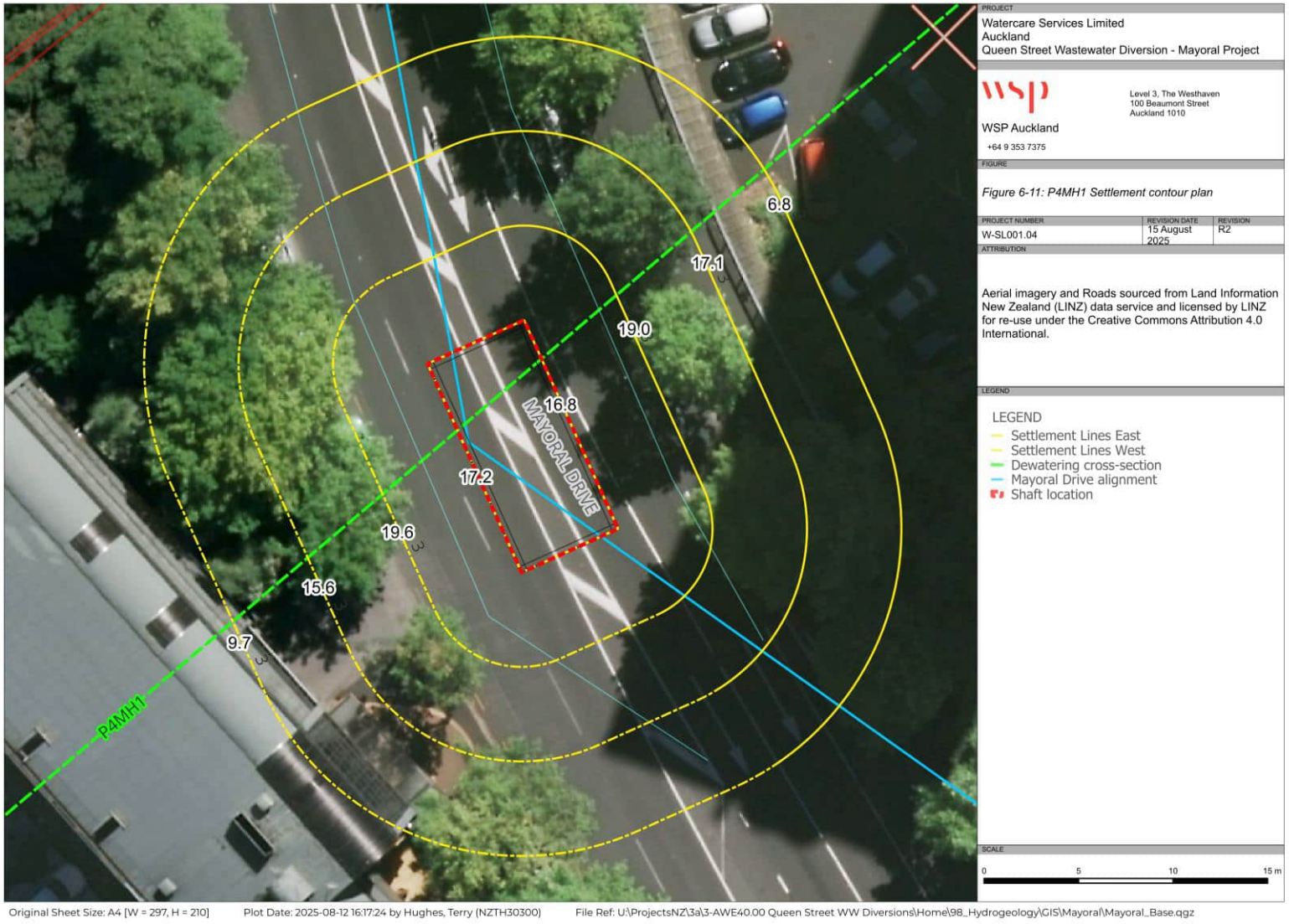

Figure 6-11: P4MH1 Settlement contours

6.2.4 P5MH2

Figure 6-12 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 6-12 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.

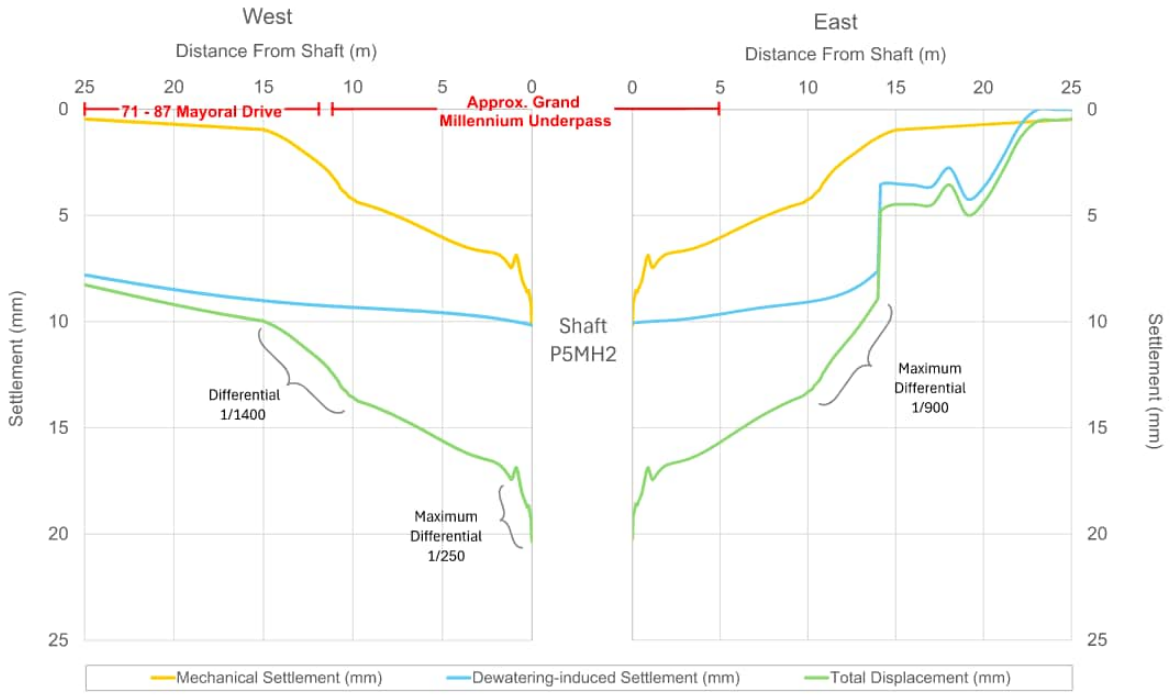

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Figure 6-12: Settlement profile across the section for P5MH2.

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*

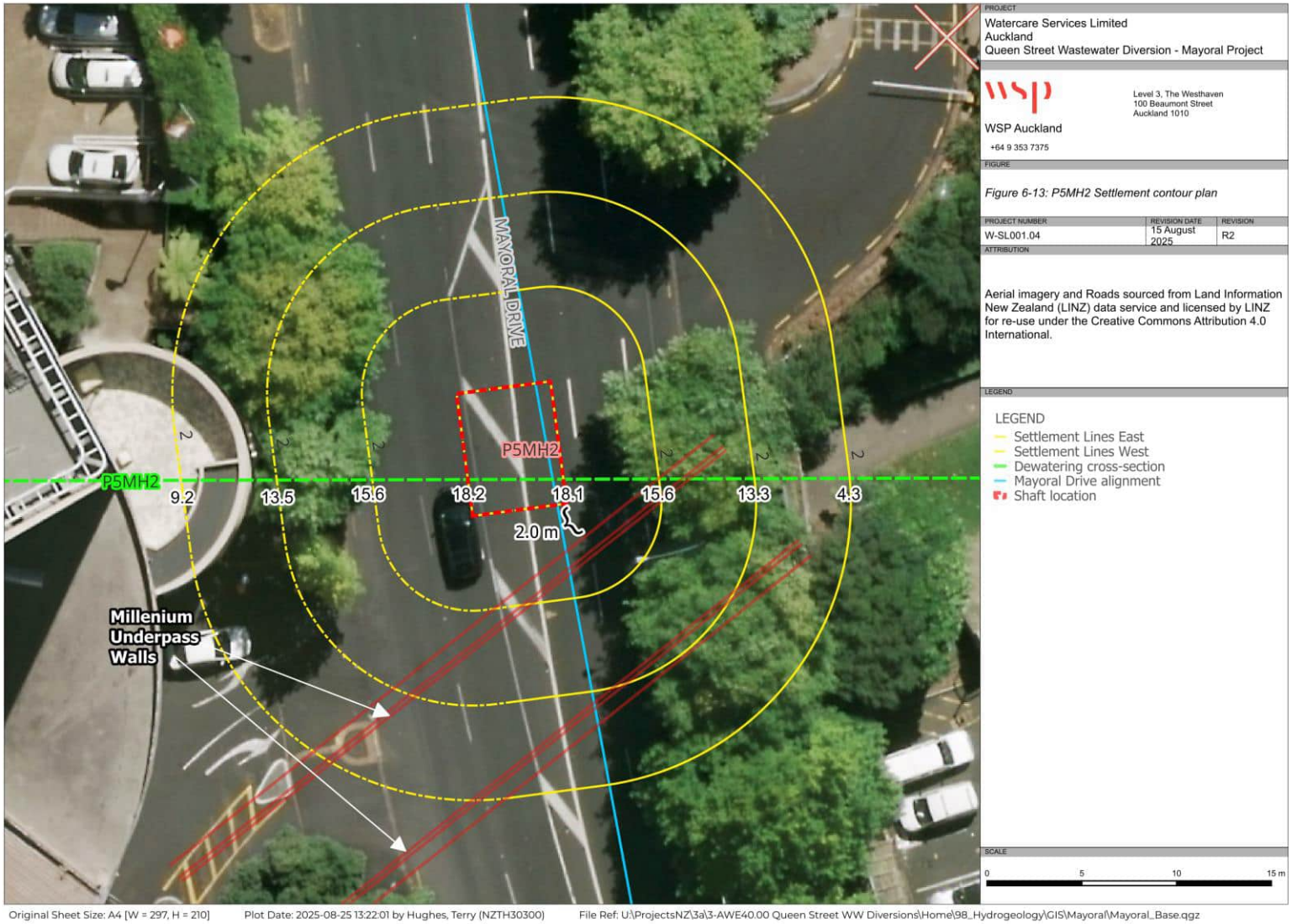

Figure 6-13: P5MH2 Settlement contours.

6.2.5 P1MH2

Figure 6-14 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.

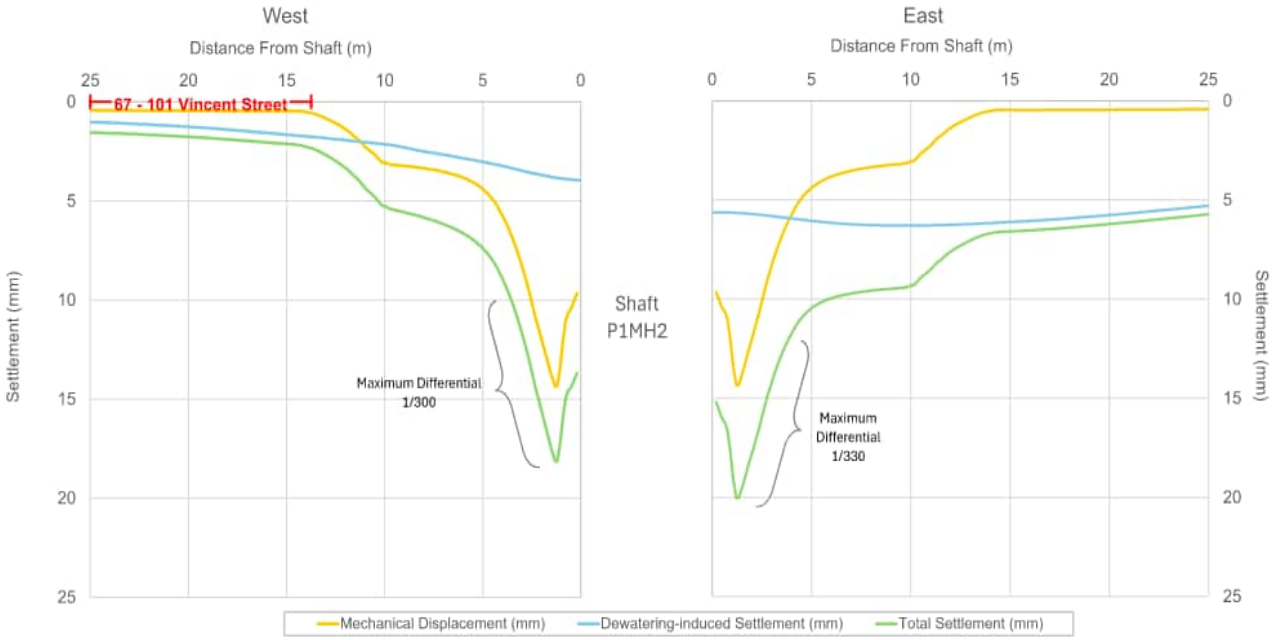

Figure 6-14: Settlement profile of across the section for P1MH2.

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*

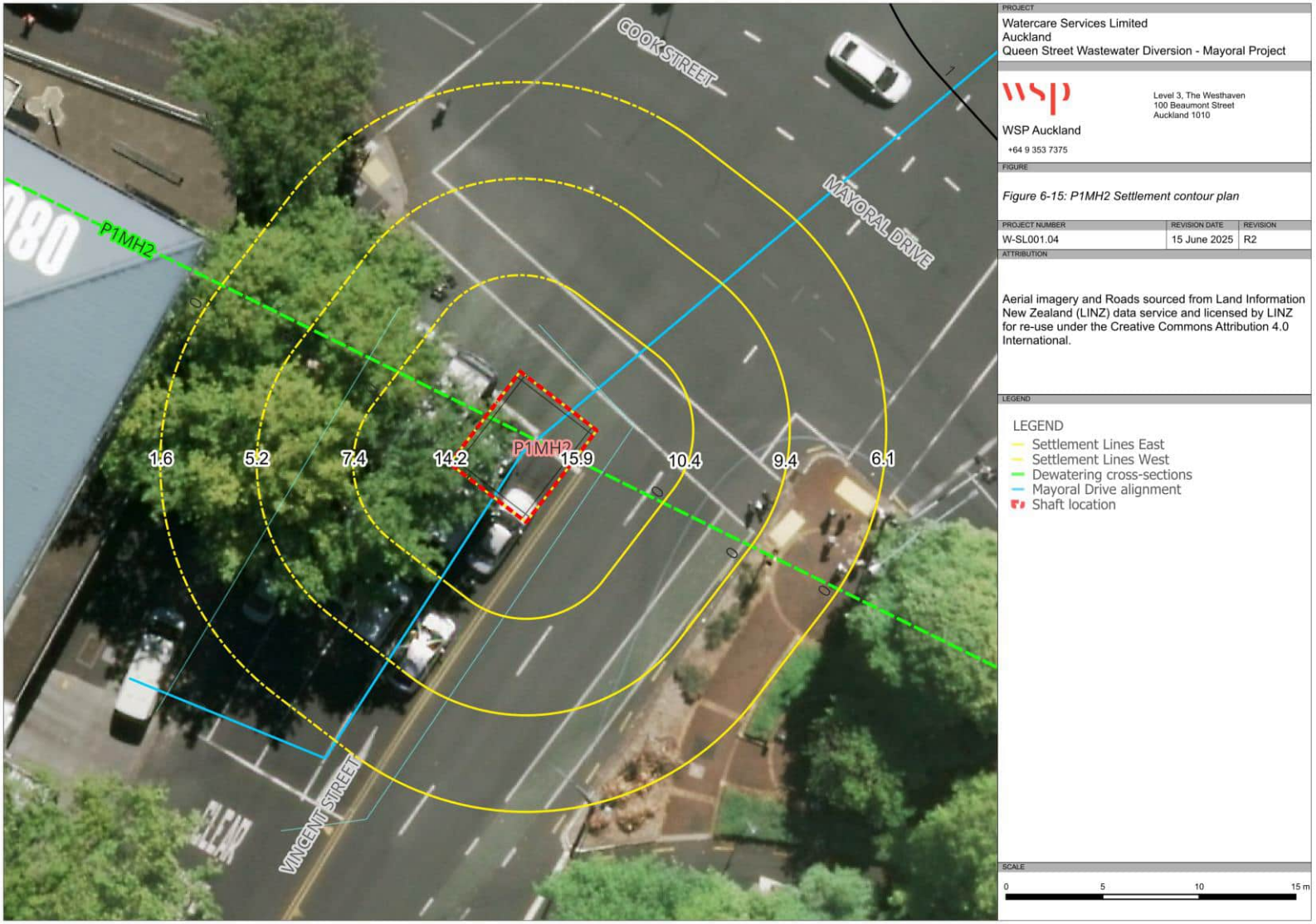

Figure 6-15: P1MH2 Settlement contours

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. Current settlement monitoring and trigger levels will therefore suffice for services monitoring.

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	2	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, investigations within the underpass footing have been undertaken to confirm the construction design and historical drawings. This investigation revealed that the underpass is founded on 2.0 m of engineered scoriaceous gravel which has a high modulus of elasticity and is not prone to dewatering settlement and therefore the settlement numbers listed in Table 7-2 above are overly conservative and only relate to the structure being placed on natural ground. Borehole records (BH25-01) are presented in Appendix D.

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	2	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 founded on 2.0 m of engineered scoriaceous gravel 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 / Heritage Structure	20	7	>1/2000	0	Negligible
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. This value is considered very conservative because of three-dimensional effects:

- The settlement analyses were undertaken assuming a two-dimensional model which overpredicts settlement because it ignores the limited length of the excavation.
- The edge of the Myers Park overbridge is near the corner of the shaft, where settlements will be even less compared to those predicted by a 3D model on a cross section through the mid-point of the shaft.

In addition to the above, the structure affected by this predicted displacement is part of the crib wall which retains the approach embankments to the bridge. The prefabricated concrete elements forming crib walls are not rigidly connected to each other and the finished wall forms an articulated structure that can deform differentially visibly without damage or compromise in performance. An example of a visibly deformed crib wall is shown on **Error! Reference source not found.** which is part of the same crib wall, located approximately 25 m from the shaft.

Despite this, the footpath and road supported by the wall at this location do not exhibit signs of distress, other than negligible cracking on the footpath which may not even be related to the deformations of the crib wall.

Following the above, if a likely damage category of those listed in Table 7-1 was assigned to the crib wall, we consider that a category lower than that corresponding to the expected settlement would be appropriate; in this case 'negligible' to 'very slight'. However, we do not consider that a Burland-based approach in classifying the potential damage to the crib wall is appropriate in this instance, because Burland's data are based on observations on buildings, which are stiffer structures and more vulnerable to differential movement.

The underpass itself is piled into the underlying ECBF bedrock, based on the historic GI findings (one at each of the four corners of the underpass) and the design drawings, dated 1972 (refer to Appendix D 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

*WSL Assets excluded from the assessment for underground assets, as owned by WSL

P1MH2

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID	Expected Displacement	Effect
Wastewater	Gravity	Approx. 5 m	2.7	300	VC	852360	NA	NA
Wastewater	Gravity	< 5 m	2.7	150	AC	852395	NA	NA
Wastewater	Gravity	Approx. 5 m	2.7	150	AC	837687	NA	NA
Wastewater	Manhole	< 5 m	2.7			522964	NA	NA
Stormwater	Gravity	< 5 m	2.8	300	Ceramic	2000612464	total settlement up to 25 mm and differential settlement in the order of 1/300	Negligible
Stormwater	Gravity	Approx. 5 m	Approx. 2.5	525	Concrete	2000666607	total settlement up to 25 mm and differential settlement in the order of 1/300	Negligible
Stormwater	Gravity	< 5 m	Approx. 3	675	Concrete	2000323342	total settlement up to 25 mm and differential settlement in the order of 1/300	Negligible
Water Supply	Pressure	< 5 m	Unknown	150	AC	2798400 / 2804156	NA	NA

P5MH2

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID	Expected Displacement	Effect
Water Supply	Pressure	< 5 m	Unknown	250	CLS	2770075	NA	NA
Water Supply	Pressure	< 5 m	Unknown	50	MS	2768961	NA	NA
Transpower	Transmission line	Approx. 5 m	NA	NA	NA	Hobson Street - Penrose Cable	Not Applicable, not gravity main	Negligible

P4MH1

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID	Expected Displacement	Effect
Transpower	Transmission line	Approx. 5 m	NA	NA	NA	Hobson Street - Penrose Cable	Not Applicable, not a gravity type infrastructure	Negligible

P4MH2

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID	Expected Displacement	Effect
Stormwater	Gravity	< 5 m	3.2	450	Concrete	2000534535	total settlement up to 33 mm and differential settlement <1/500.	Negligible
Water Supply	Pressure	< 5 m	Unknown	20	PE	2044195	NA	NA
Water Supply	Pressure	< 5 m	Unknown	100	MS	2657704	NA	NA
Water Supply	Pressure	< 5 m	Unknown	300 / 375	CLS	2804152 / 2791453	NA	NA
Water Supply	Pressure	Approx. 10 m	Unknown	200	CLS	81024923	NA	NA
Stormwater	Gravity	Approx. 20 m	3.4	450	Concrete	2000079935	No applicable, large offset from shaft	Negligible

P4MH3

Asset	Pressurised / Gravity	Approx. Distance to Shaft (m)	Approx. Depth (m BGL)	Diameter (mm)	Material Type	GIS ID	Expected Displacement	Effect
Stormwater	Gravity	< 5 m	3.2	750	Concrete	2000134745	differential settlements of more than 1/100 and total settlement up to 25 mm	Risks to be managed through GSMCP
Stormwater	Gravity	< 5 m	Approx. 1.5 - 4 m	1050	Concrete	2000022613	differential settlements of less than 1/400 and total settlement of up to 15 mm anticipated	Negligible
Stormwater	Gravity	< 5 m	Approx. 1.4 - 3	900	Concrete	2000811674	differential settlements of less than 1/400 and total settlement of up to 15 mm anticipated	Negligible
Stormwater	Gravity	Approx. 5	Approx. 2.5 - 3	1050	Concrete	2000044962	differential settlements of less than 1/400 and total settlement of up to 15 mm anticipated	Negligible
Stormwater	Gravity	Approx. 5	Approx. 8.3	225	Concrete	2000923017	differential settlements of less than 1/400 and total settlement of up to 15 mm anticipated	Negligible
Stormwater	Gravity	Approx. 5	Approx. 1.2	750	Concrete	2000311777	differential settlements of less than 1/400 and total settlement of up to 15 mm anticipated	Negligible
Wastewater	Gravity	< 5 m	Approx. 3	300	AC	837665	NA	NA
Wastewater	Gravity	Approx. 5 m	Approx. 3	300	AC	832739	NA	NA
Wastewater	Gravity	Approx. 5 m	Approx. 3	300	AC	851940	NA	NA
Water Supply	Pressure	Approx. 5 m	Unknown	250	CLS	2770075	NA	NA

APPENDIX B: CONSTRUCTION METHODOLOGY

Construction Methodology

Queen Street Wastewater Diversion – Package B

Contract No: CT7754

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

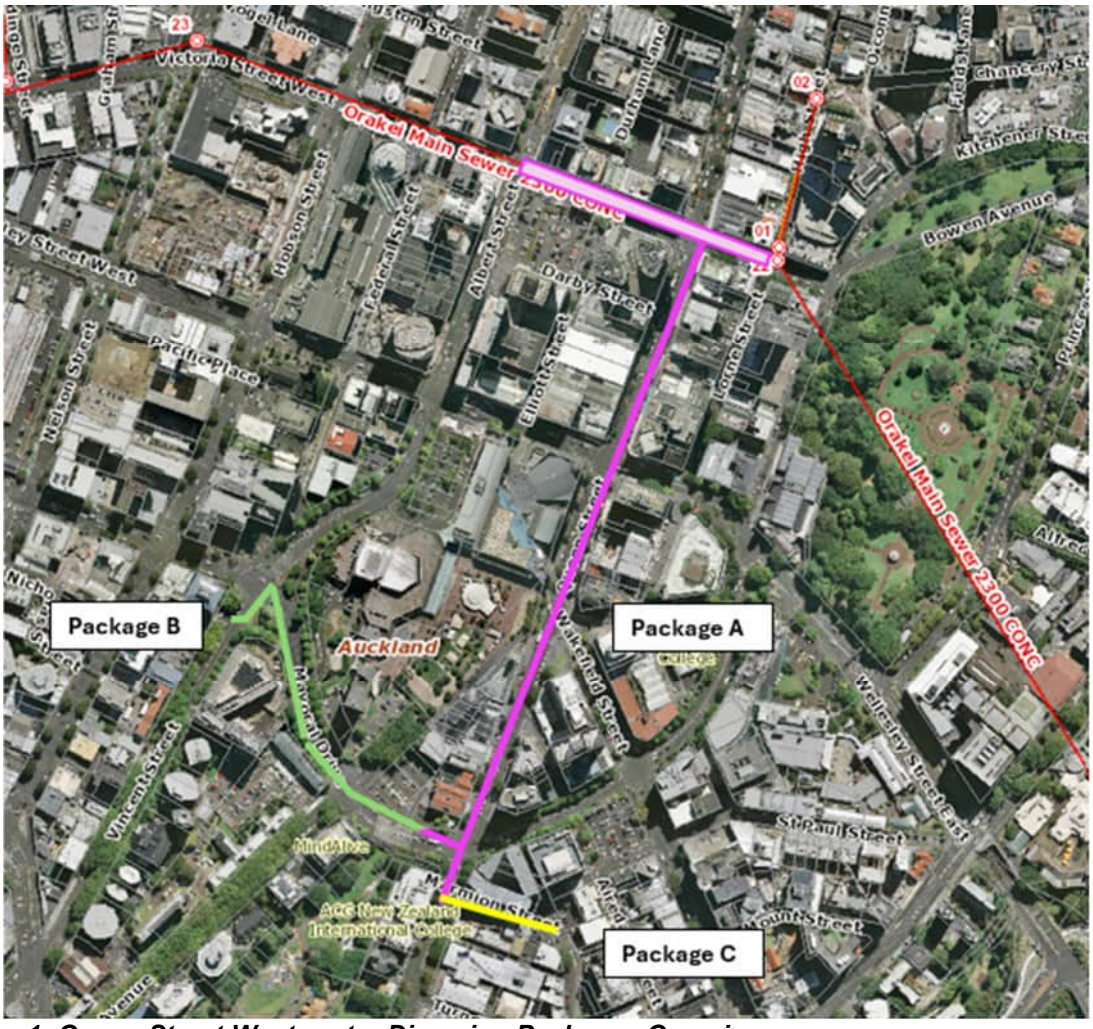


Figure 1: Queen Street Wastewater Diversion Packages Overview

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).

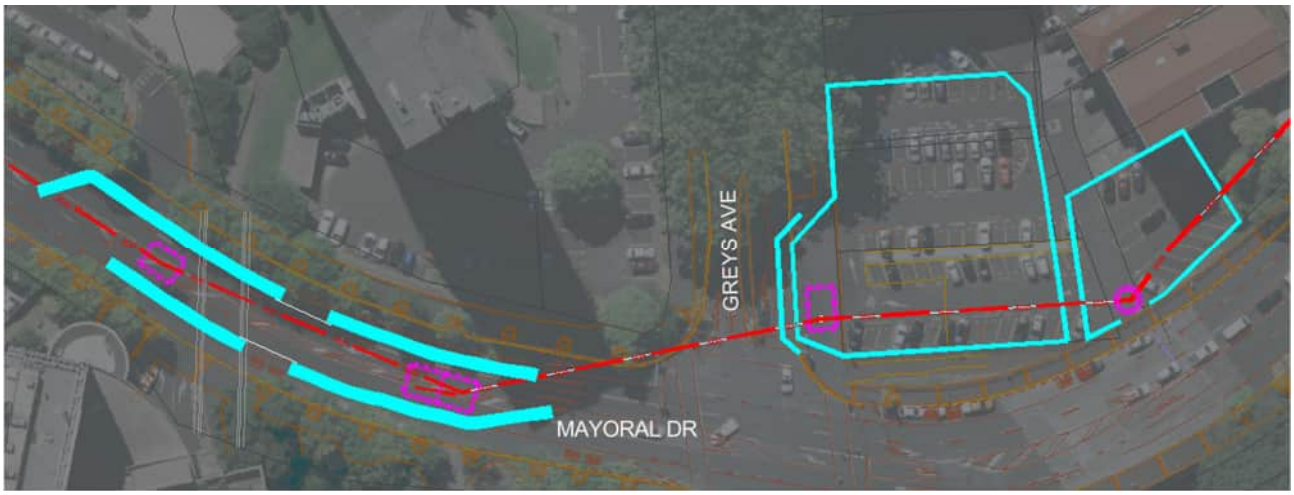


Figure 3: Two long-term compounds on Mayoral Drive/Greys Avenue (compound extents shown with blue line)

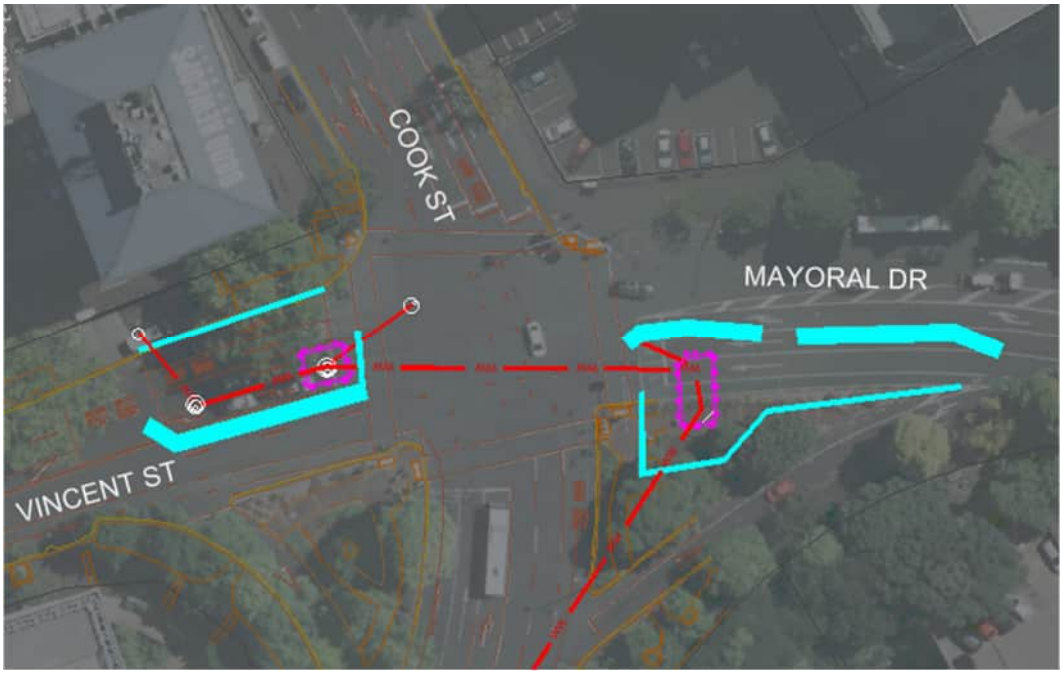


Figure 4: Two long-term compounds at Cook St/Mayoral Drive/Vincent St intersection (compound extents shown with blue lines)

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.

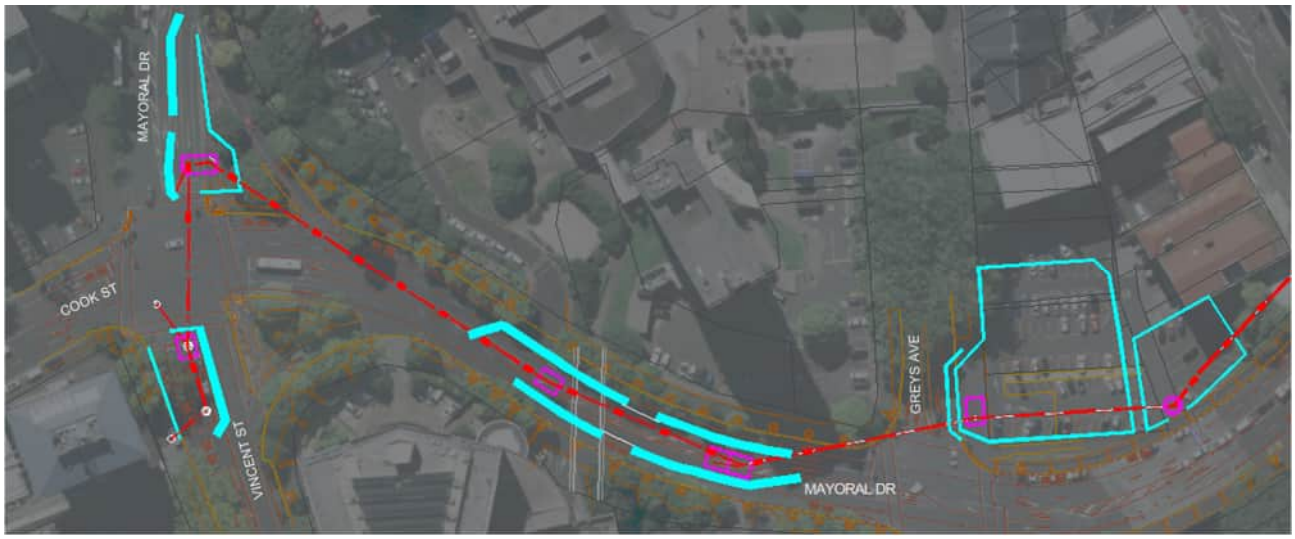


Figure 5: Main Construction Works Overview

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.

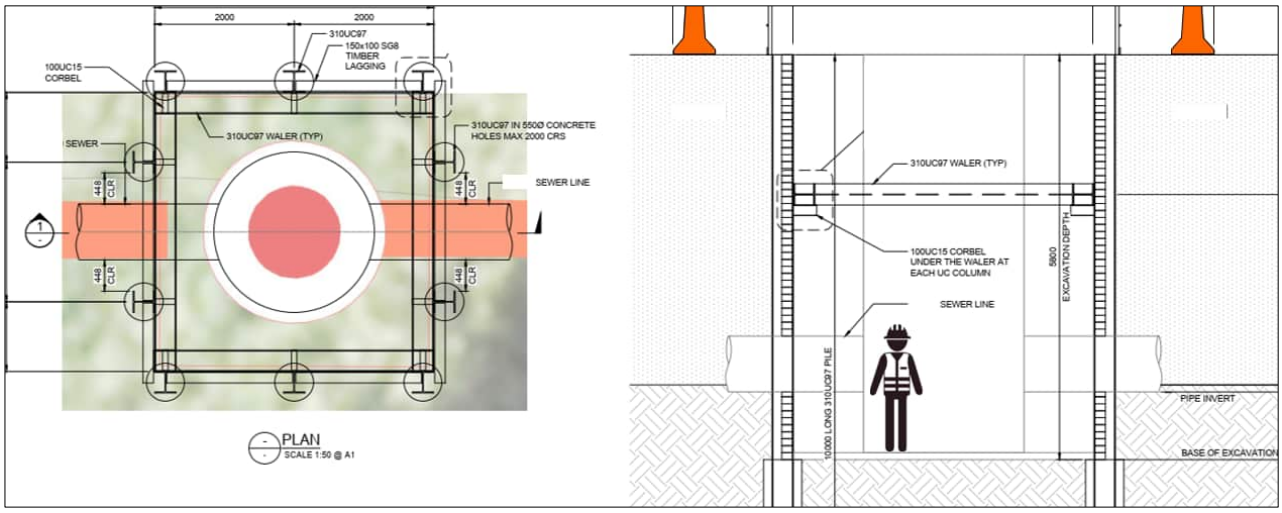


Figure 6 – Typical temporary works detail for shafts (A. O'Sullivan & Associates)

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).

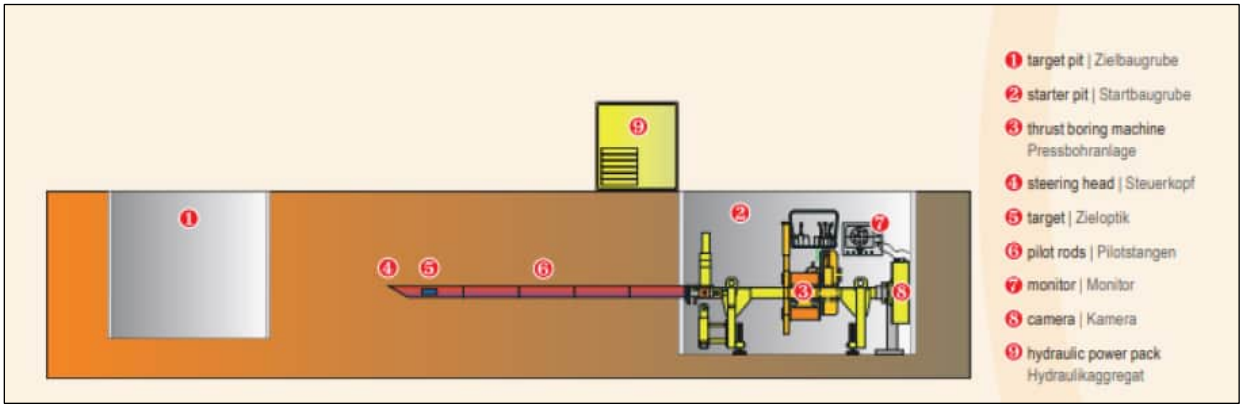


Figure 7 – Typical pilot bore – pilot process

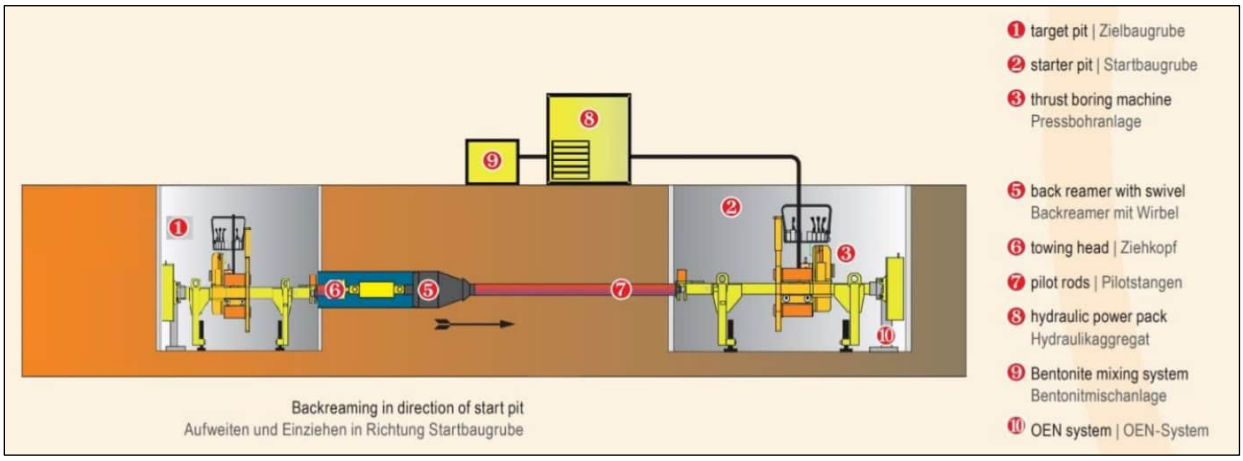


Figure 8 – Typical pilot bore – cutting back

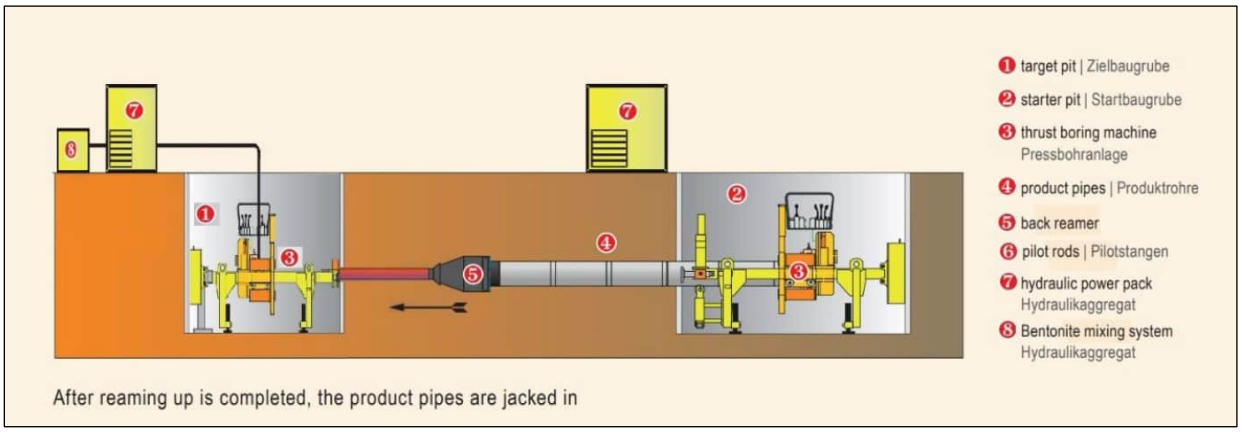


Figure 9 – Typical pilot bore – jacking pipes in

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).

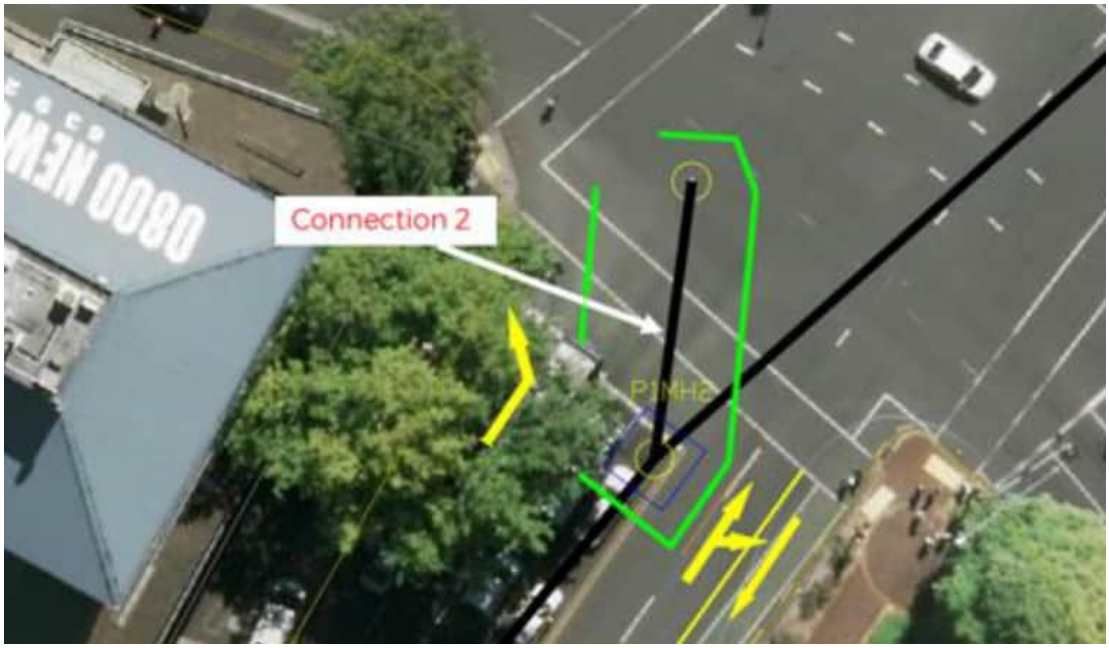


Figure 10 – Plan view of short-term TM for an EOP connection using opencut method

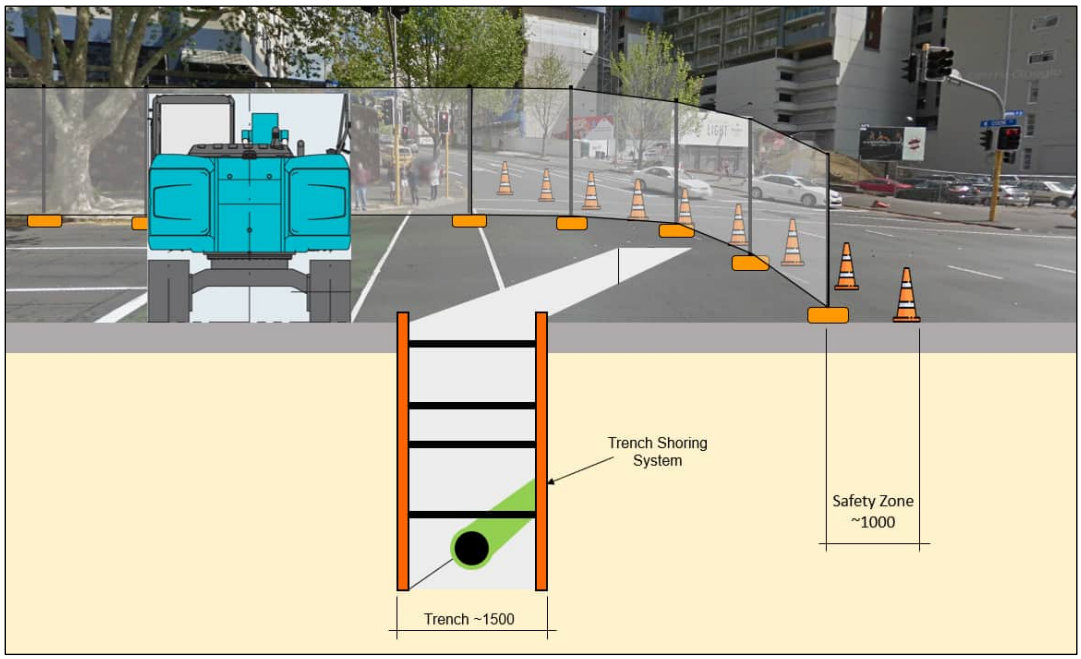


Figure 11 – Trench shoring system for EOP connection using the opencut method

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

Appendix C.1 ENGEO Mechanical Settlement

Appendix C.2 Sigma / w dewatering-induced settlement

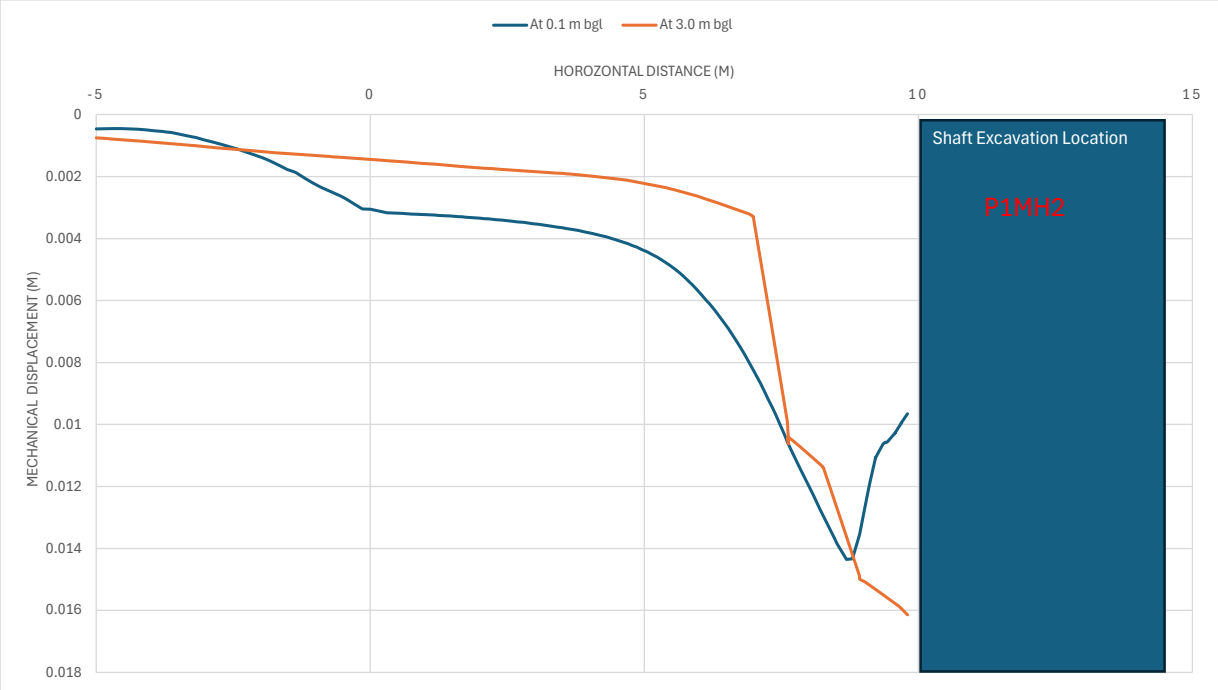
Appendix C.3 Combined settlement plots

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**



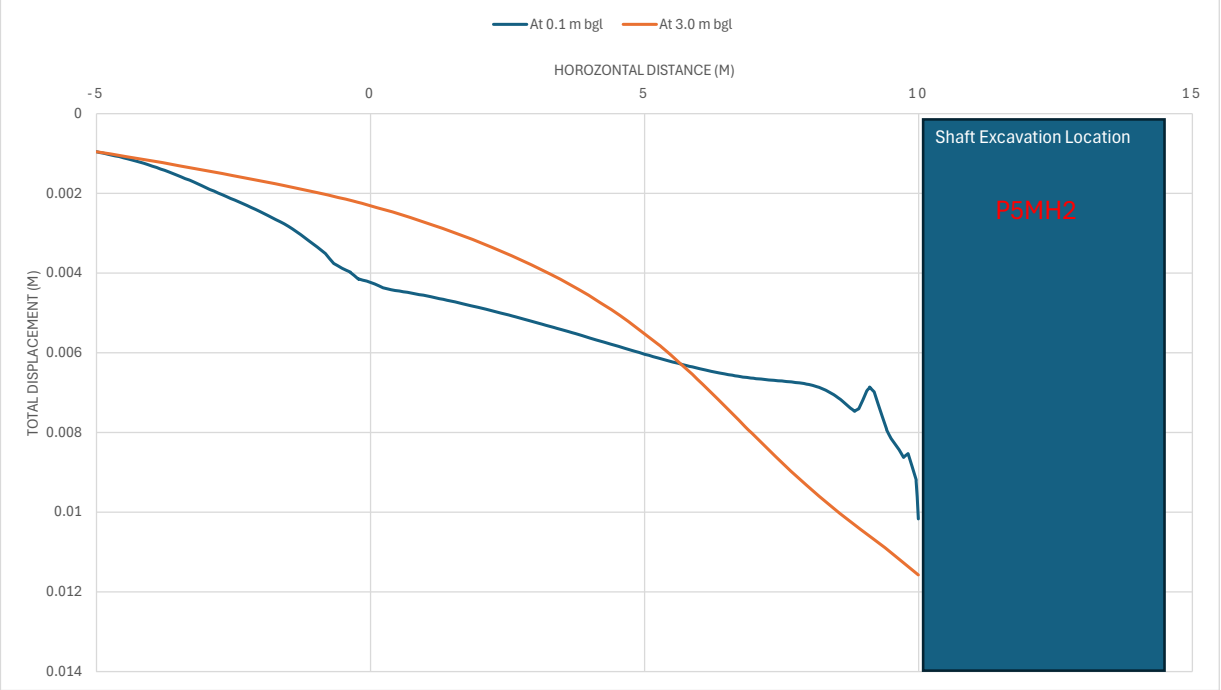
At 0.1 m bgl		At 3.0 m bgl	
X [r	|u| [m]	X [m]	|u| [m]
9.80E+00	9.66E-03	9.80E+00	1.61E-02
9.69E+00	9.94E-03	9.65E+00	1.59E-02
9.69E+00	9.95E-03	9.65E+00	1.59E-02
9.58E+00	1.03E-02	9.62E+00	1.58E-02
9.58E+00	1.03E-02	9.62E+00	1.58E-02
9.43E+00	1.06E-02	9.02E+00	1.51E-02
9.43E+00	1.06E-02	9.02E+00	1.51E-02
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
9.22E+00	1.11E-02	8.25E+00	1.14E-02
9.22E+00	1.11E-02	8.25E+00	1.14E-02
9.10E+00	1.19E-02	7.63E+00	1.04E-02
9.10E+00	1.19E-02	7.63E+00	1.06E-02
9.03E+00	1.26E-02	7.61E+00	9.92E-03
9.03E+00	1.26E-02	7.61E+00	9.92E-03
8.93E+00	1.35E-02	6.99E+00	3.29E-03
8.93E+00	1.35E-02	6.99E+00	3.29E-03
8.79E+00	1.43E-02	6.91E+00	3.21E-03
8.79E+00	1.43E-02	6.91E+00	3.21E-03
8.68E+00	1.44E-02	6.32E+00	2.84E-03
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
8.20E+00	1.27E-02	4.48E+00	2.07E-03
8.20E+00	1.27E-02	4.48E+00	2.07E-03
8.08E+00	1.23E-02	3.65E+00	1.92E-03
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**



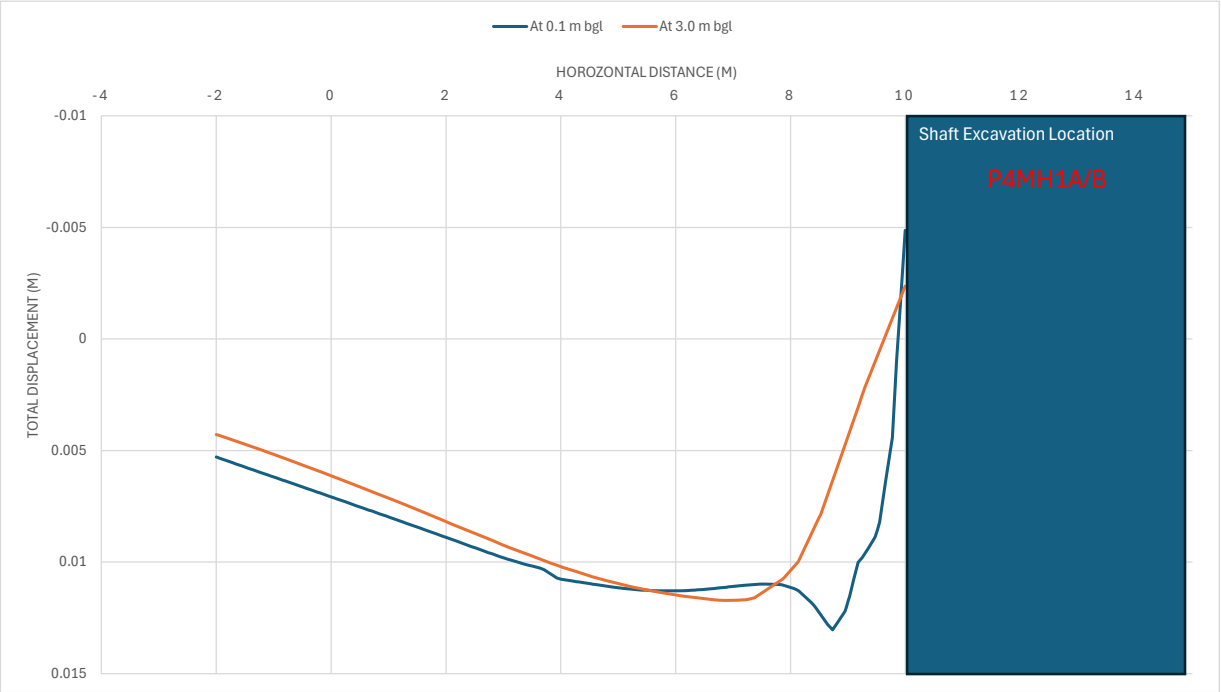
At 0.1 m bgl		At 3.0 m bgl	
X [r	u_x [m]	X [m]	u_x [m]
1.00E+01	1.02E-02	1.00E+01	1.16E-02
9.96E+00	9.22E-03	9.39E+00	1.09E-02
9.96E+00	9.18E-03	9.39E+00	1.09E-02
9.81E+00	8.53E-03	9.18E+00	1.07E-02
9.81E+00	8.53E-03	9.18E+00	1.07E-02
9.73E+00	8.62E-03	8.69E+00	1.02E-02
9.73E+00	8.62E-03	8.69E+00	1.02E-02
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**



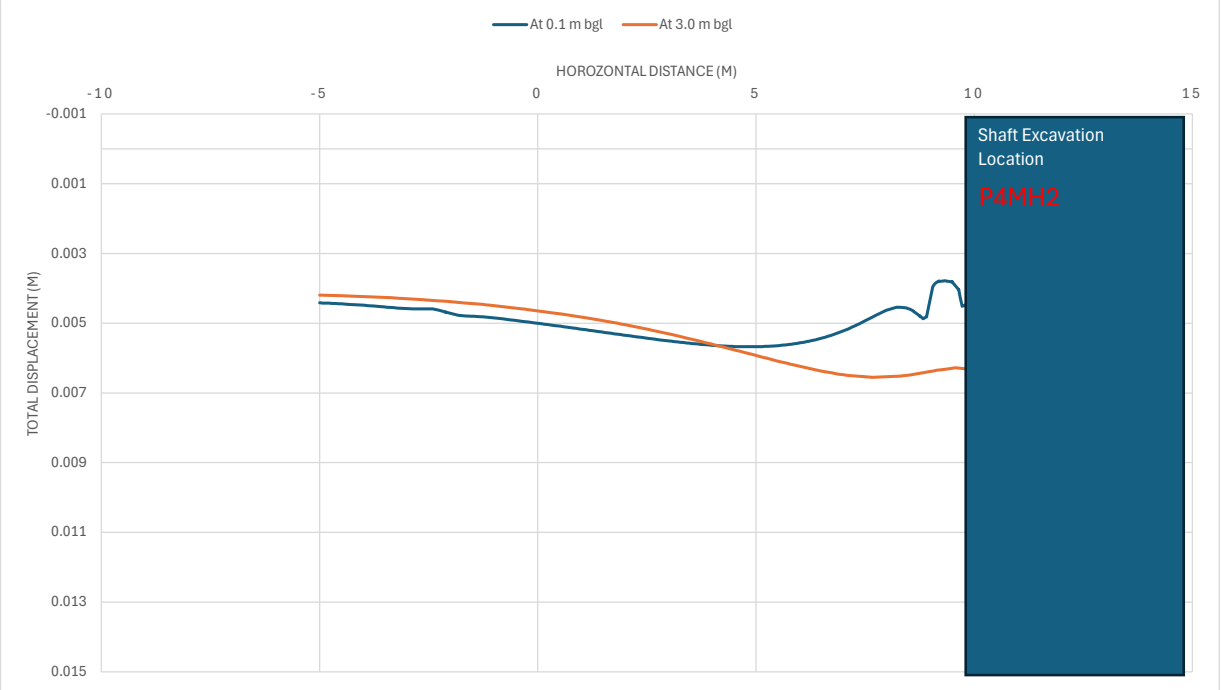
At 0.1 m bgl		At 3.0 m bgl	
X [r	u_x [m]	X [m]	u_x [m]
1.00E+01	-4.87E-03	1.00E+01	-2.37E-03
9.85E+00	9.84E-04	9.30E+00	2.13E-03
9.85E+00	9.84E-04	9.30E+00	2.13E-03
9.78E+00	4.41E-03	9.19E+00	2.95E-03
9.78E+00	4.41E-03	9.19E+00	2.95E-03
9.55E+00	8.21E-03	8.52E+00	7.87E-03
9.55E+00	8.21E-03	8.52E+00	7.87E-03
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**



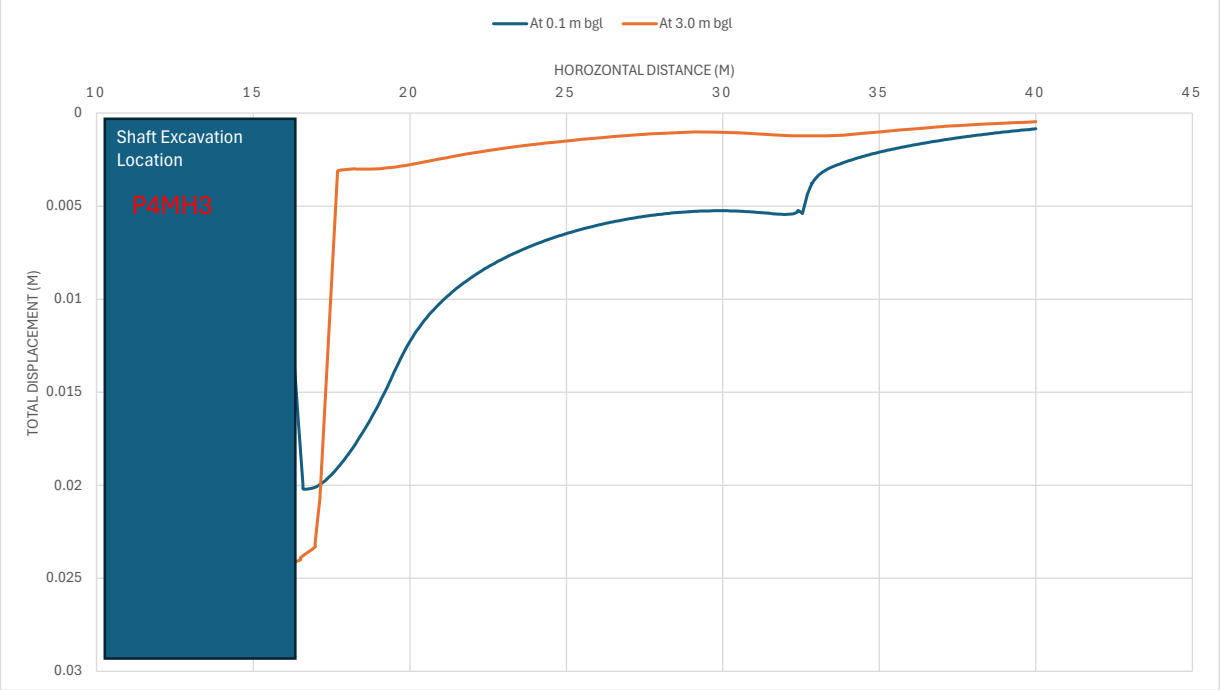
At 0.1 m bgl		At 3.0 m bgl	
X [m]	u_x [m]	X [m]	u_x [m]
10.00	0.0040	1.00E+01	6.33E-03
9.95	0.0041	9.57E+00	6.28E-03
9.95	0.0041	9.57E+00	6.28E-03
9.81	0.0045	9.12E+00	6.36E-03
9.81	0.0045	9.12E+00	6.36E-03
9.72	0.0045	9.01E+00	6.38E-03
9.72	0.0045	9.01E+00	6.38E-03
9.64	0.0040	8.51E+00	6.49E-03
9.64	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

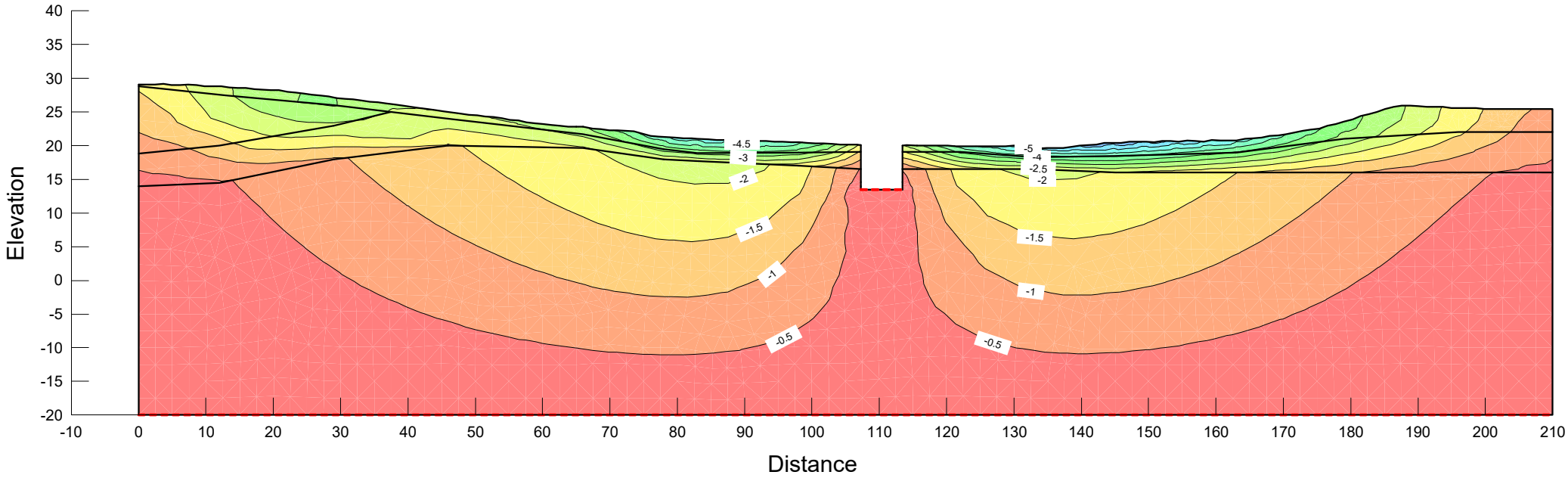
Date of issue: **5/03/2025**



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

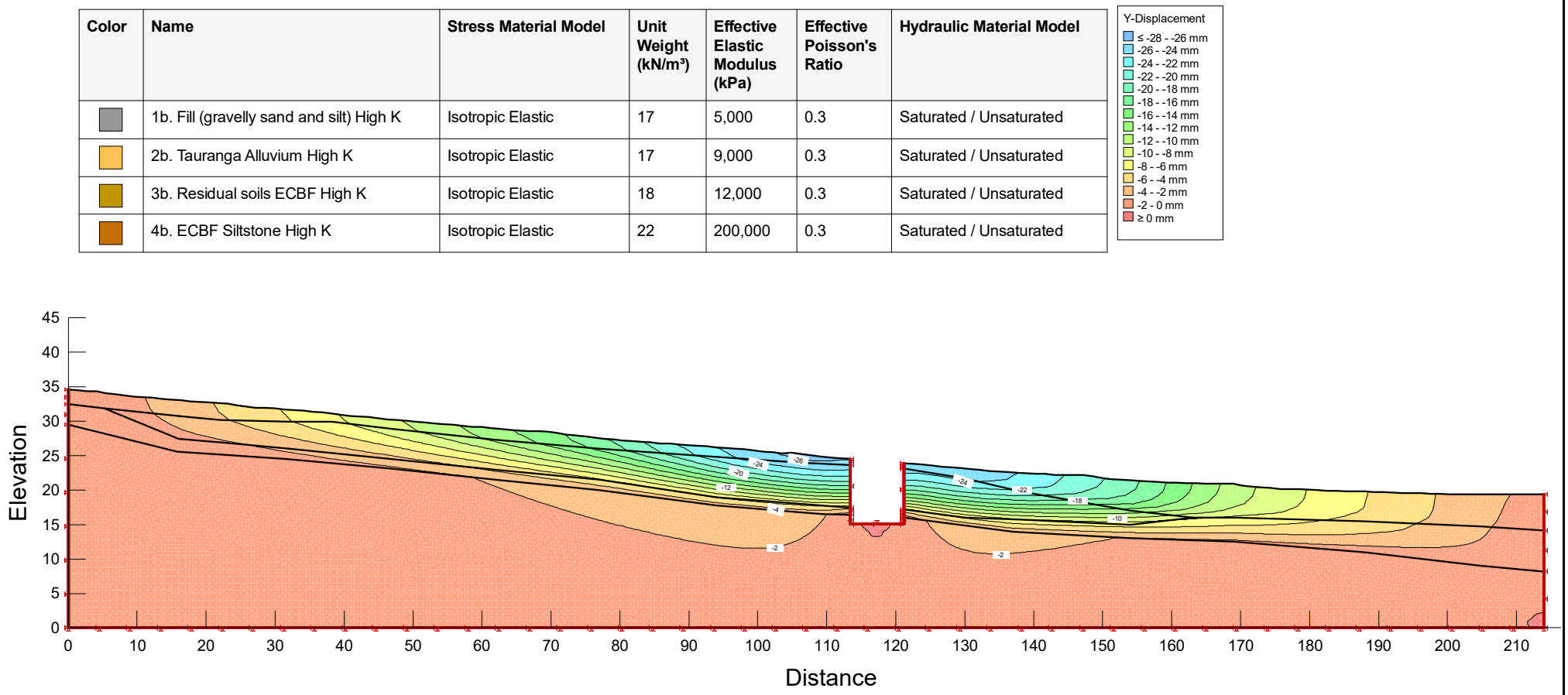
Color	Name	Stress Material Model	Unit Weight (kN/m³)	Effective Elastic Modulus (kPa)	Effective Poisson's Ratio	Hydraulic Material Model
	1b. Fill (gravelly sand and silt) High K	Isotropic Elastic	17	5,000	0.3	Saturated / Unsaturated
	2b. Tauranga Alluvium High K	Isotropic Elastic	17	9,000	0.3	Saturated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

Y-Displacement
- ≤ -6 - -5.5 mm
- -5.5 - -5 mm
- -5 - -4.5 mm
- -4.5 - -4 mm
- -4 - -3.5 mm
- -3.5 - -3 mm
- -3 - -2.5 mm
- -2.5 - -2 mm
- -2 - -1.5 mm
- -1.5 - -1 mm
- -1 - -0.5 mm
- ≥ -0.5 mm



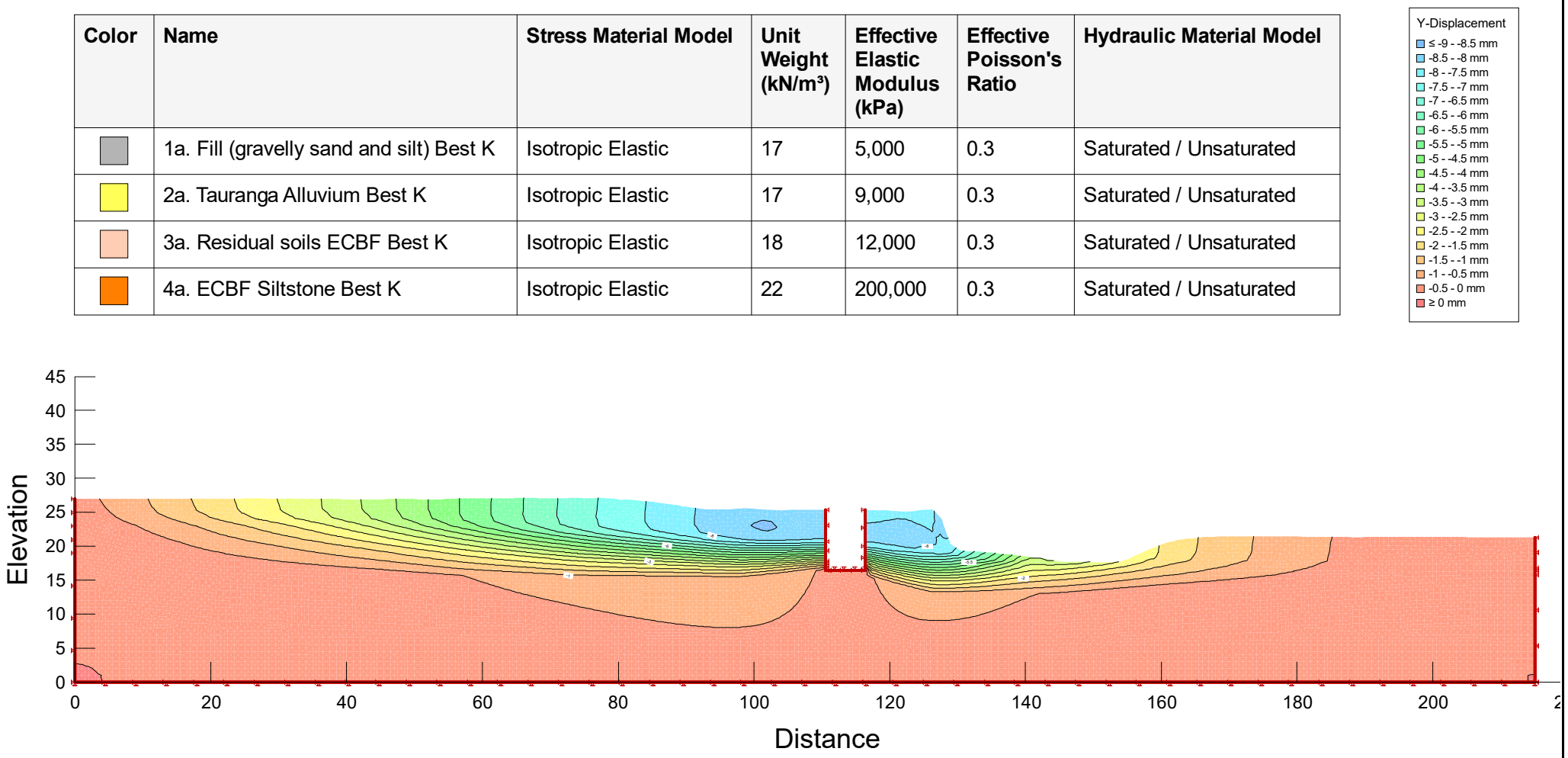
Load/Deformation [0 - 240d]
A-MD-P4MH3-TJH-1APR25.gsz
30/04/2025

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

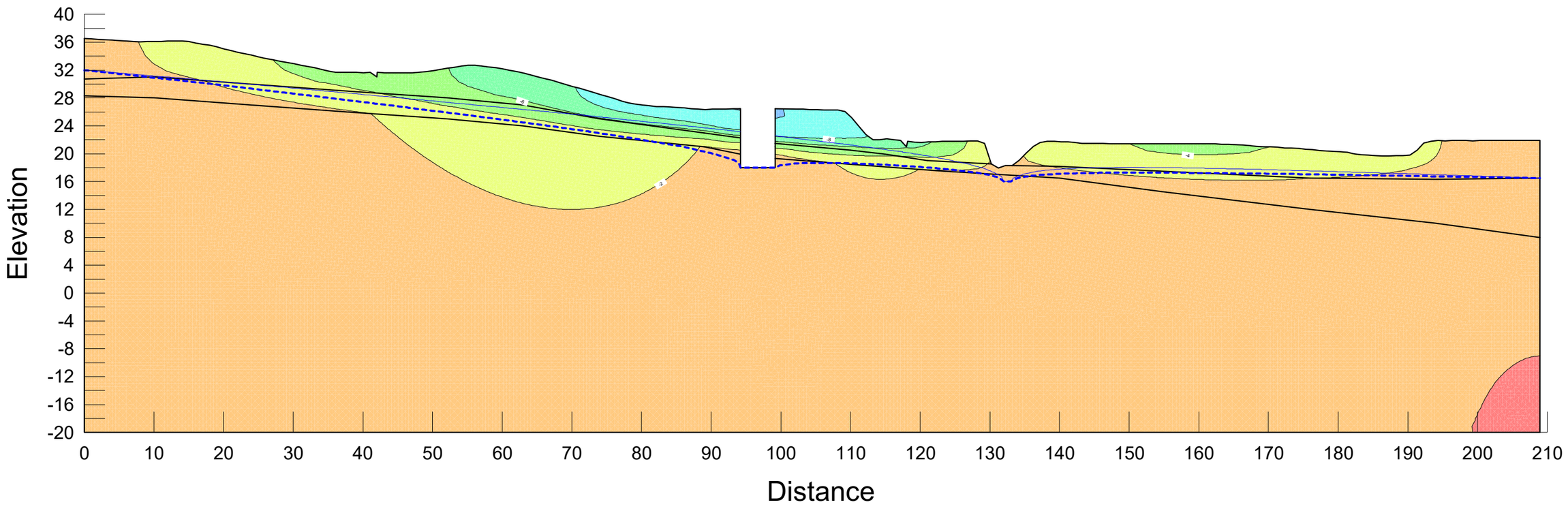
Color	Name	Stress Material Model	Unit Weight (kN/m³)	Effective Elastic Modulus (kPa)	Effective Poisson's Ratio	Hydraulic Material Model
	1a. Fill (gravelly sand and silt) Best K	Isotropic Elastic	17	5,000	0.3	Saturated / Unsaturated
	2a. Tauranga Alluvium Best K	Isotropic Elastic	17	9,000	0.3	Saturated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

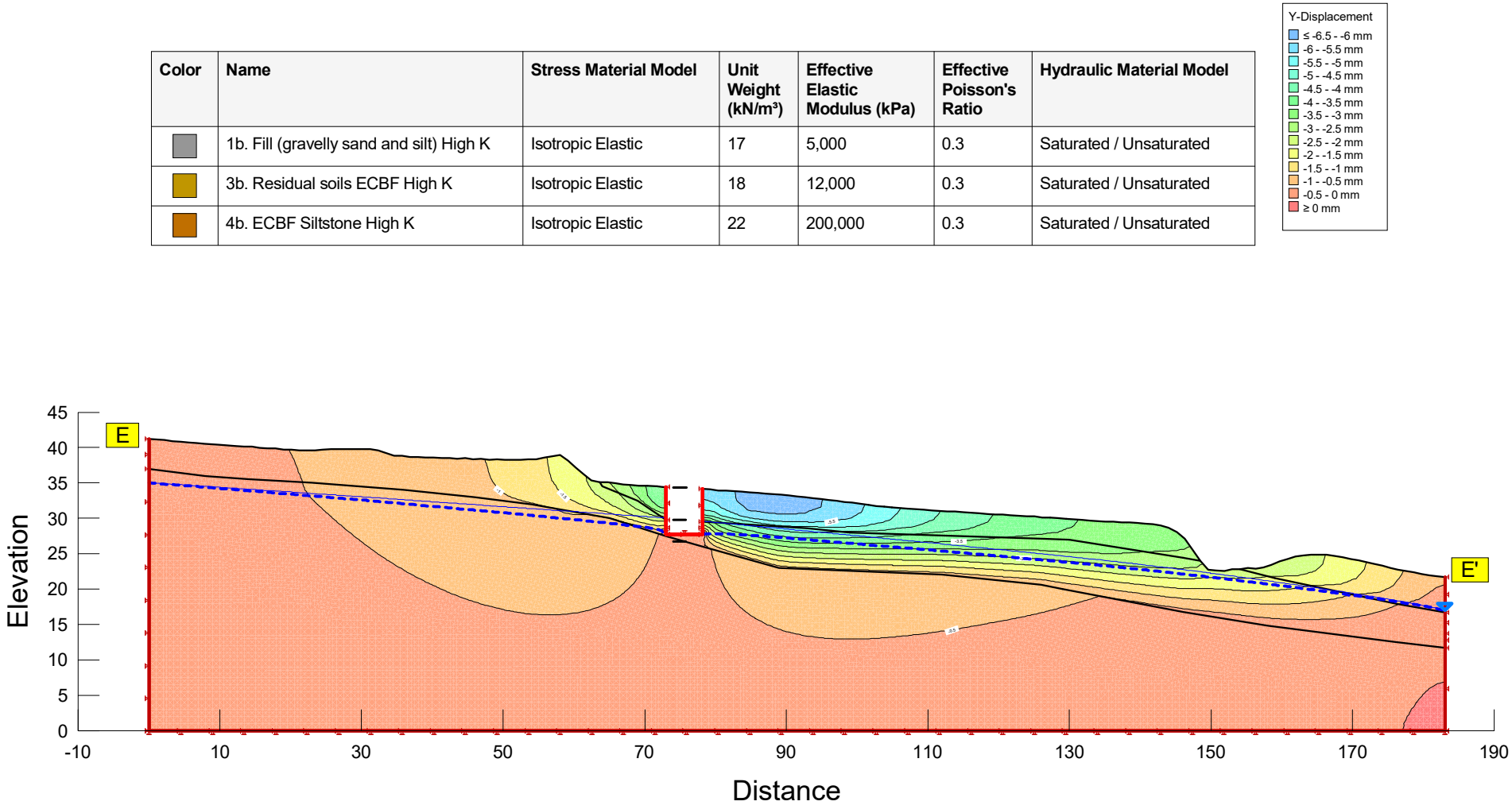
Color	Name	Stress Material Model	Unit Weight (kN/m³)	Effective Elastic Modulus (kPa)	Effective Poisson's Ratio	Hydraulic Material Model
	1b. Fill (gravelly sand and silt) High K	Isotropic Elastic	17	5,000	0.3	Saturated / Unsaturated
	3b. Residual soils ECBF High K	Isotropic Elastic	18	12,000	0.3	Saturated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

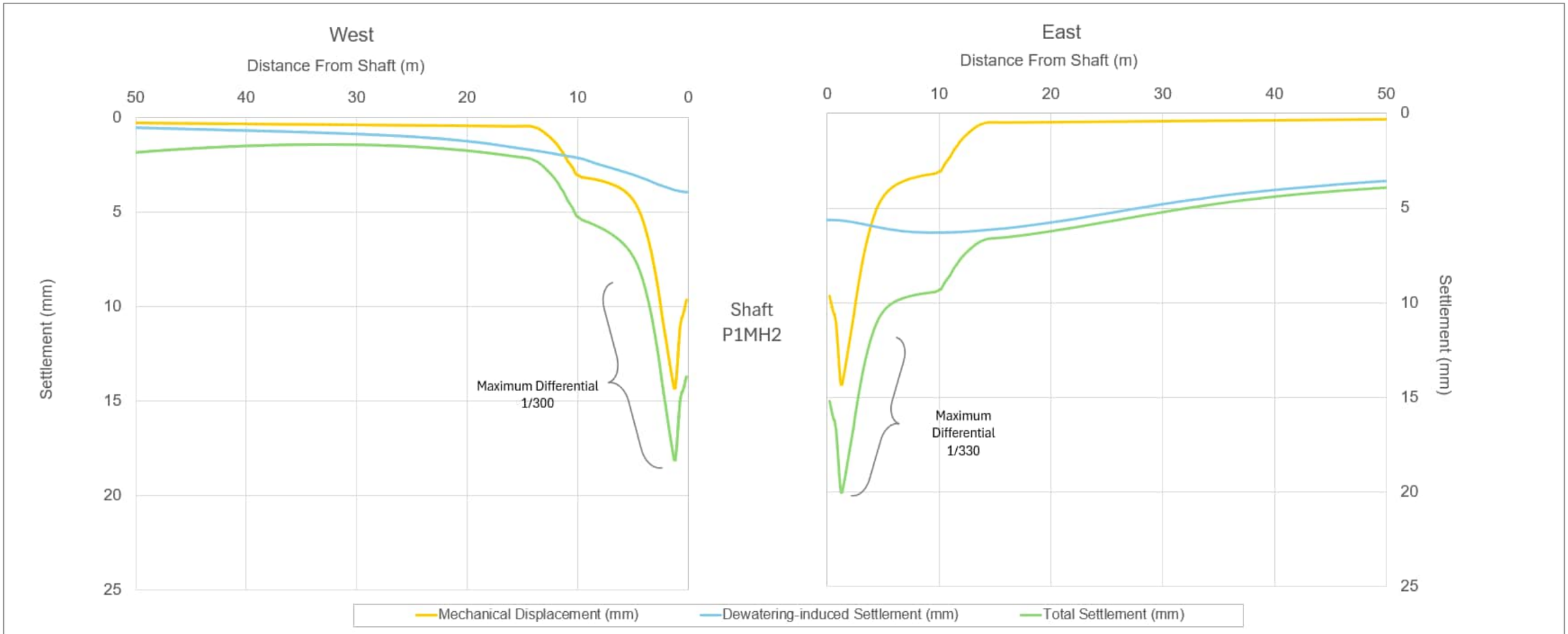


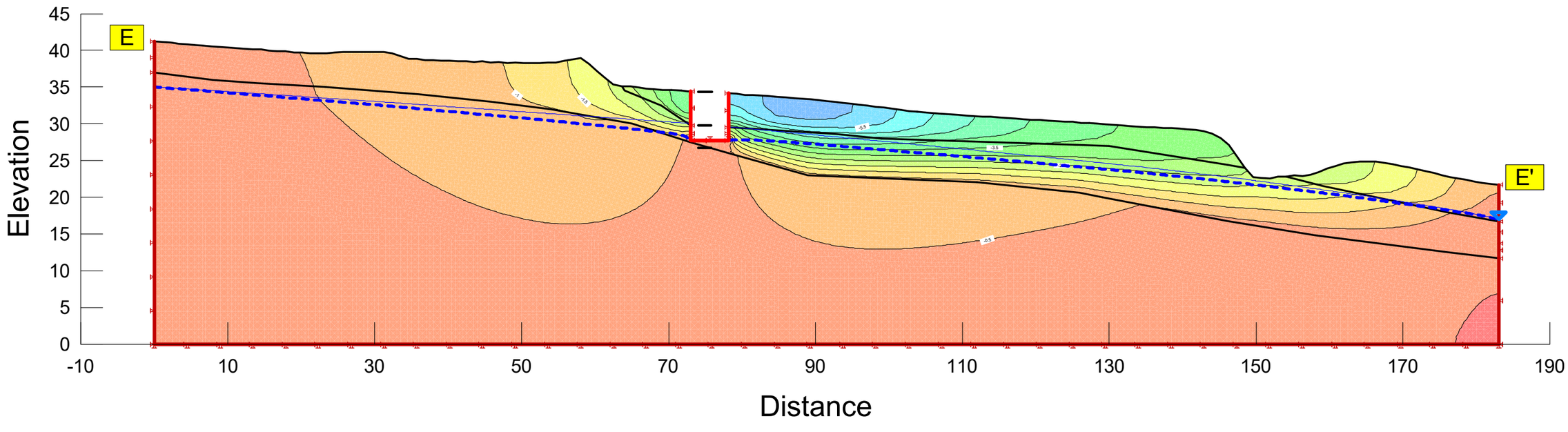
02_Load/Deformation High [0-240d]
D-MD-P5MH2-TJH.gsz
30/04/2025

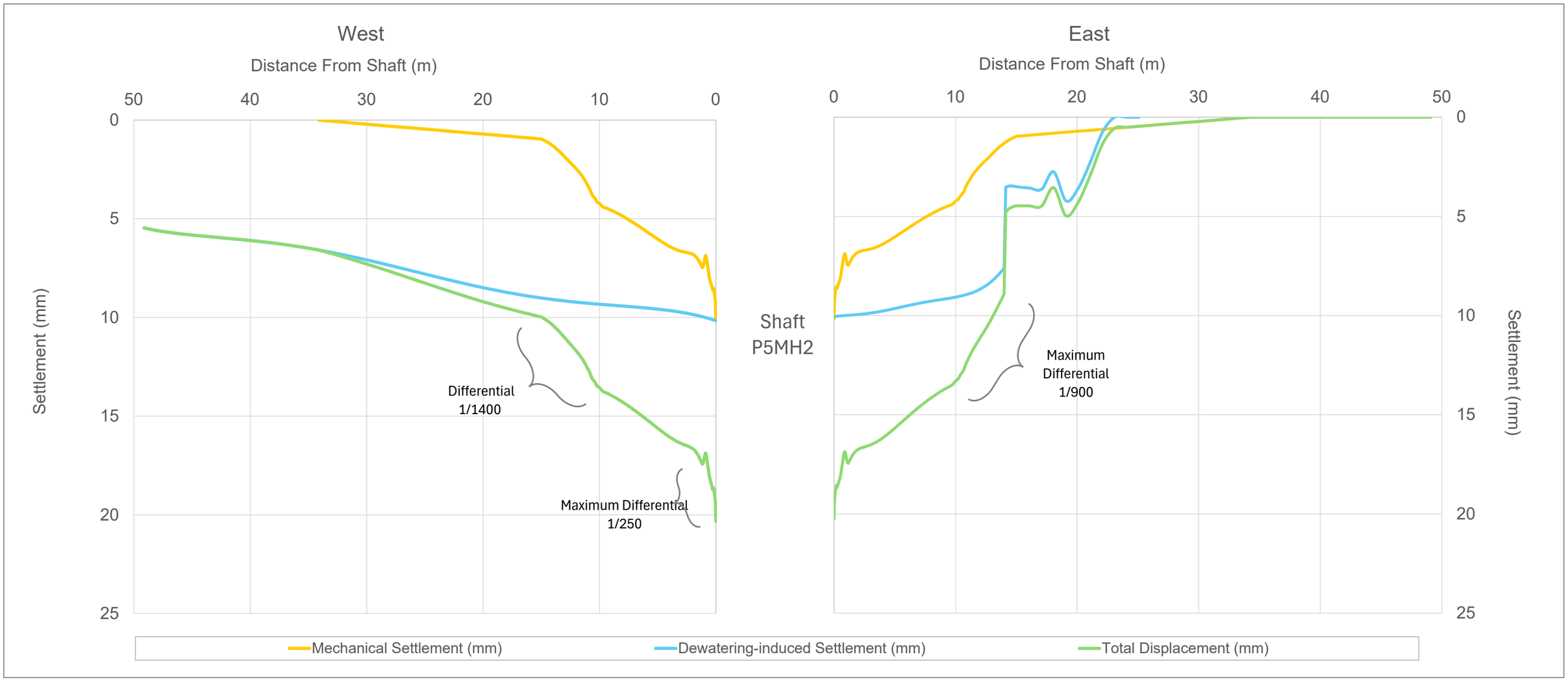
Color	Name	Stress Material Model	Unit Weight (kN/m³)	Effective Elastic Modulus (kPa)	Effective Poisson's Ratio	Hydraulic Material Model
	1b. Fill (gravelly sand and silt) High K	Isotropic Elastic	17	5,000	0.3	Saturated / Unsaturated
	3b. Residual soils ECBF High K	Isotropic Elastic	18	12,000	0.3	Saturated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

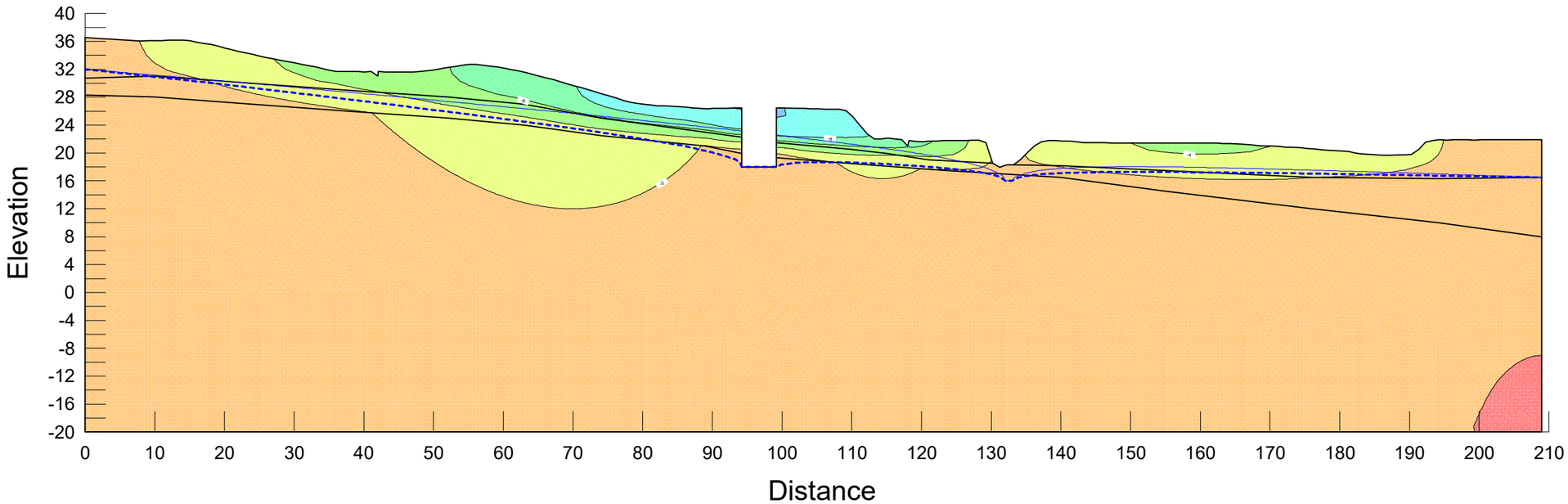


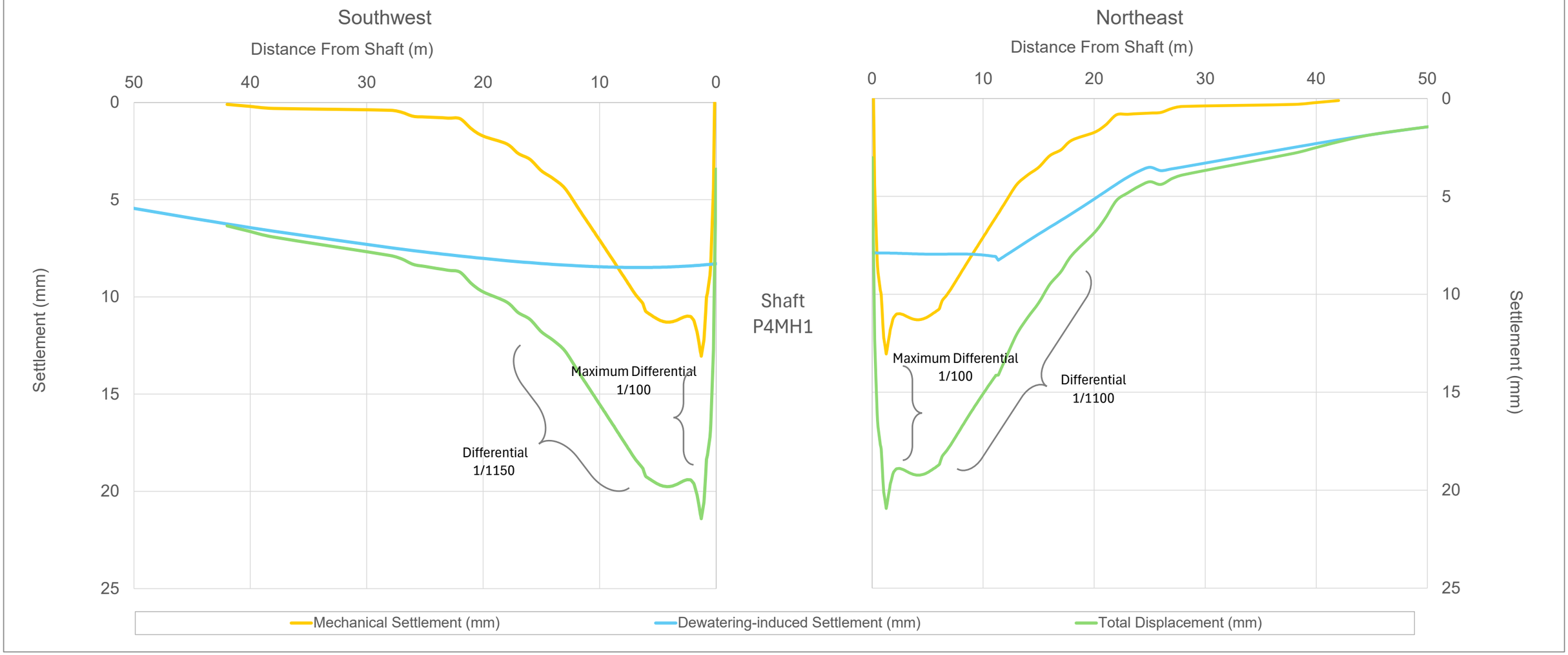
02_Load/Deformation High [0-240]`
E-MD-P1MH2-TJH.gsz
30/04/2025

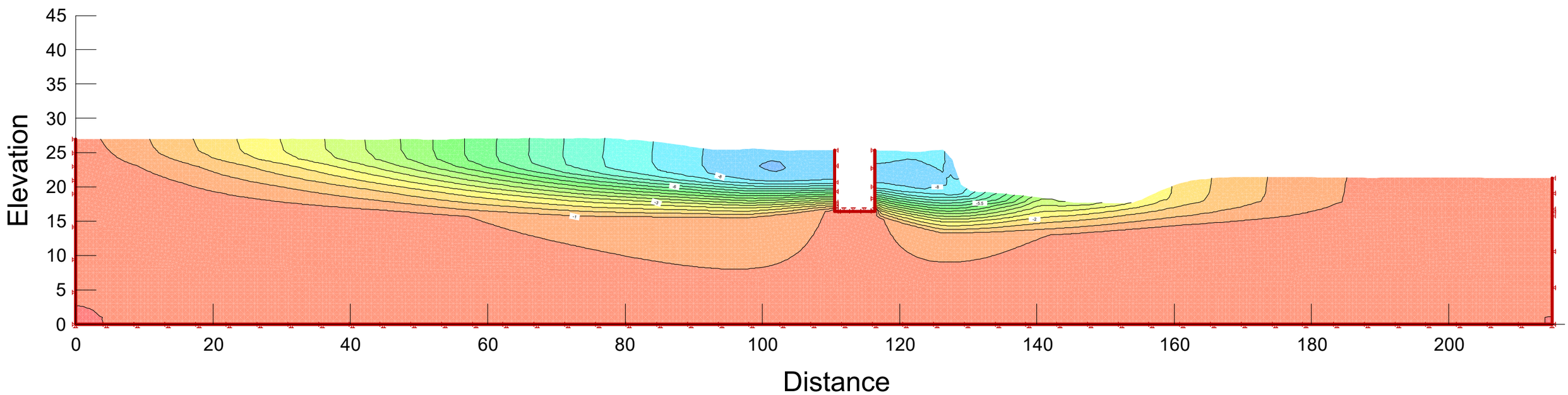

West
Distance From Shaft (m)
50
40
30
20
10
0
Settlement (mm)
0
5
10
15
20
25
Maximum Differential
1/300
Shaft
P1MH2
East
Distance From Shaft (m)
0
10
20
30
40
50
Settlement (mm)
Maximum
Differential
1/330
Mechanical Displacement (mm)
Dewatering-induced Settlement (mm)
Total Settlement (mm)

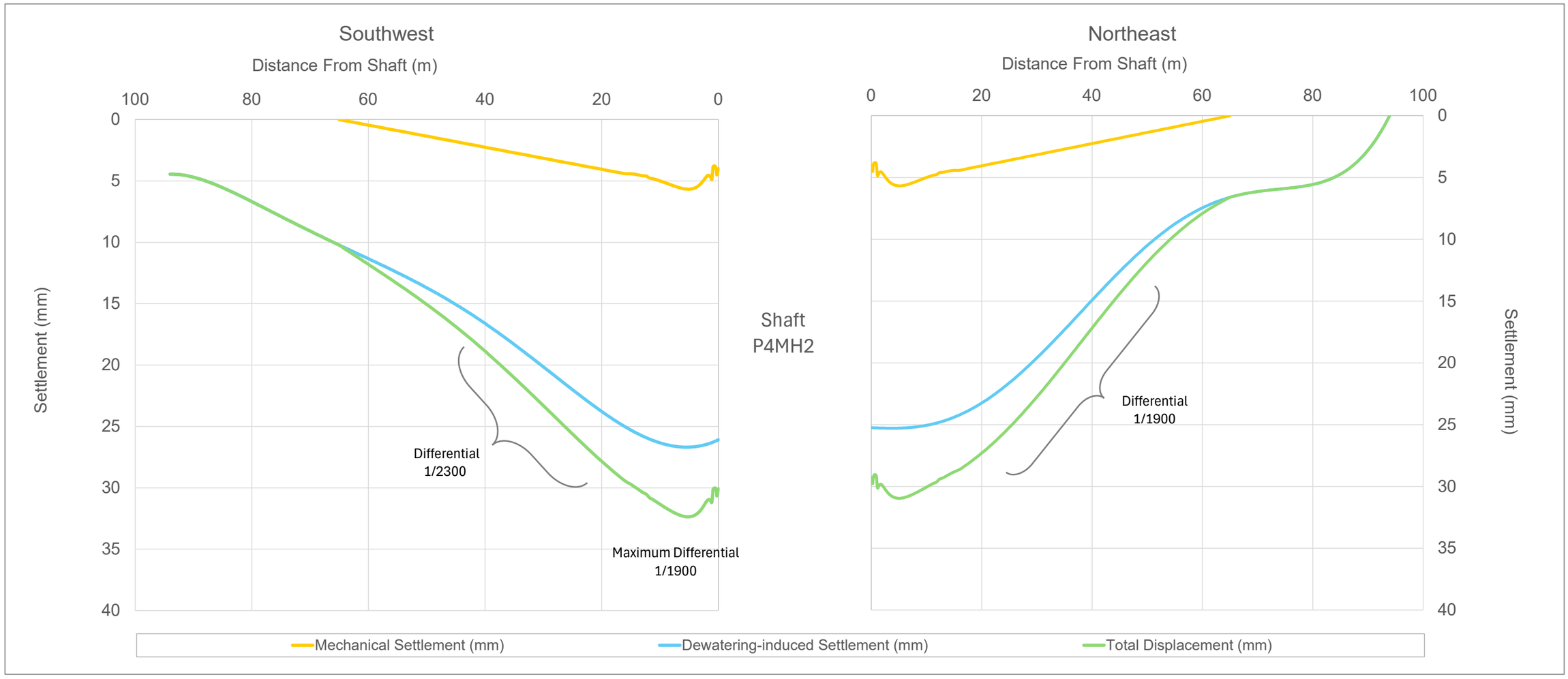

E
E'
Elevation
45
40
35
30
25
20
15
10
5
0
-10
10
30
50
70
90
110
130
150
170
190
Distance

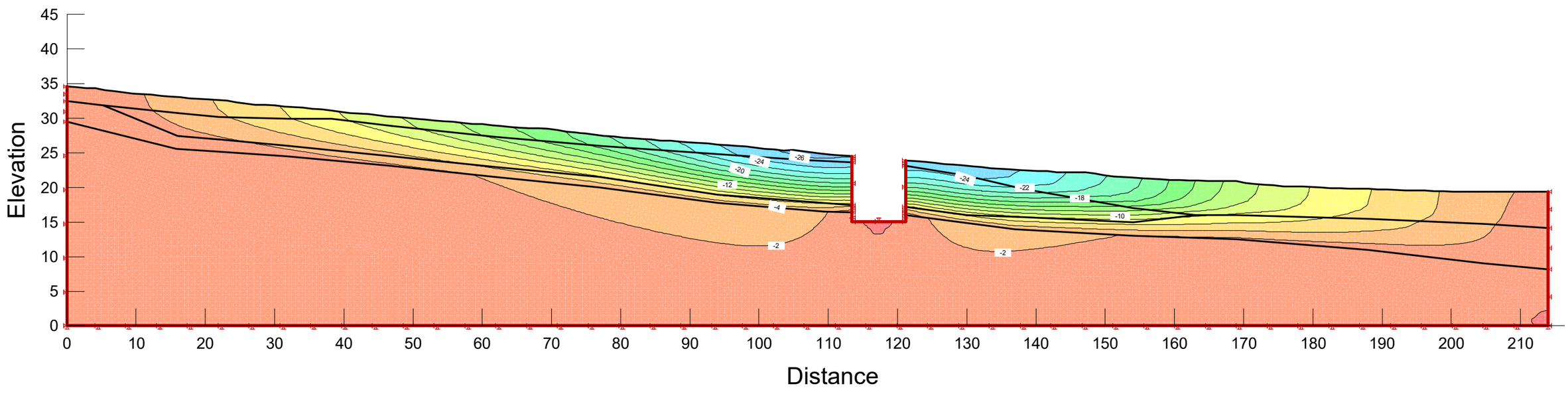

West
Distance From Shaft (m)
50
40
30
20
10
0
Settlement (mm)
0
5
10
15
20
25
Differential
1/1400
Maximum Differential
1/250
Shaft
P5MH2
East
Distance From Shaft (m)
0
10
20
30
40
50
Settlement (mm)
Maximum
Differential
1/900
Mechanical Settlement (mm)
Dewatering-induced Settlement (mm)
Total Displacement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

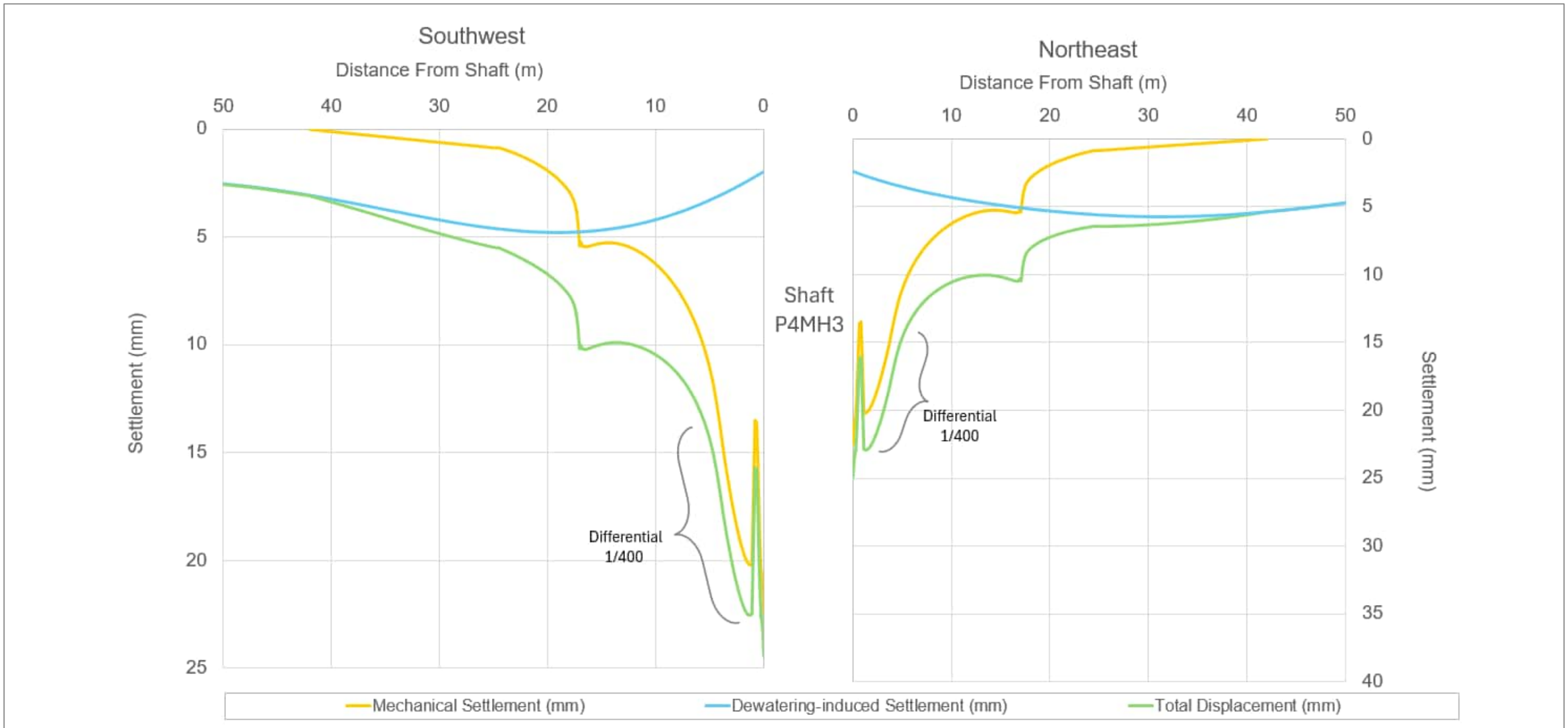

Elevation
40
36
32
28
24
20
16
12
8
4
0
-4
-8
-12
-16
-20
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Distance

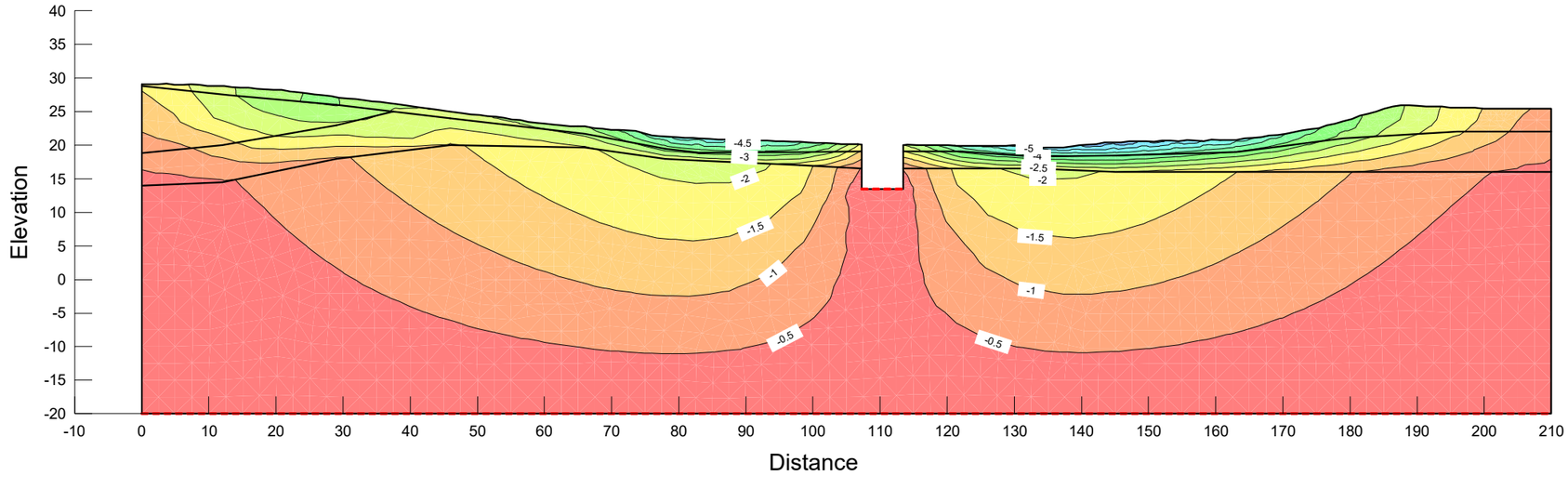

Southwest
Distance From Shaft (m)
50
40
30
20
10
0
Settlement (mm)
0
5
10
15
20
25
Maximum Differential
1/100
Differential
1/1150
Shaft
P4MH1
Northeast
Distance From Shaft (m)
0
10
20
30
40
50
Maximum Differential
1/100
Differential
1/1100
Settlement (mm)
Mechanical Settlement (mm)
Dewatering-induced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

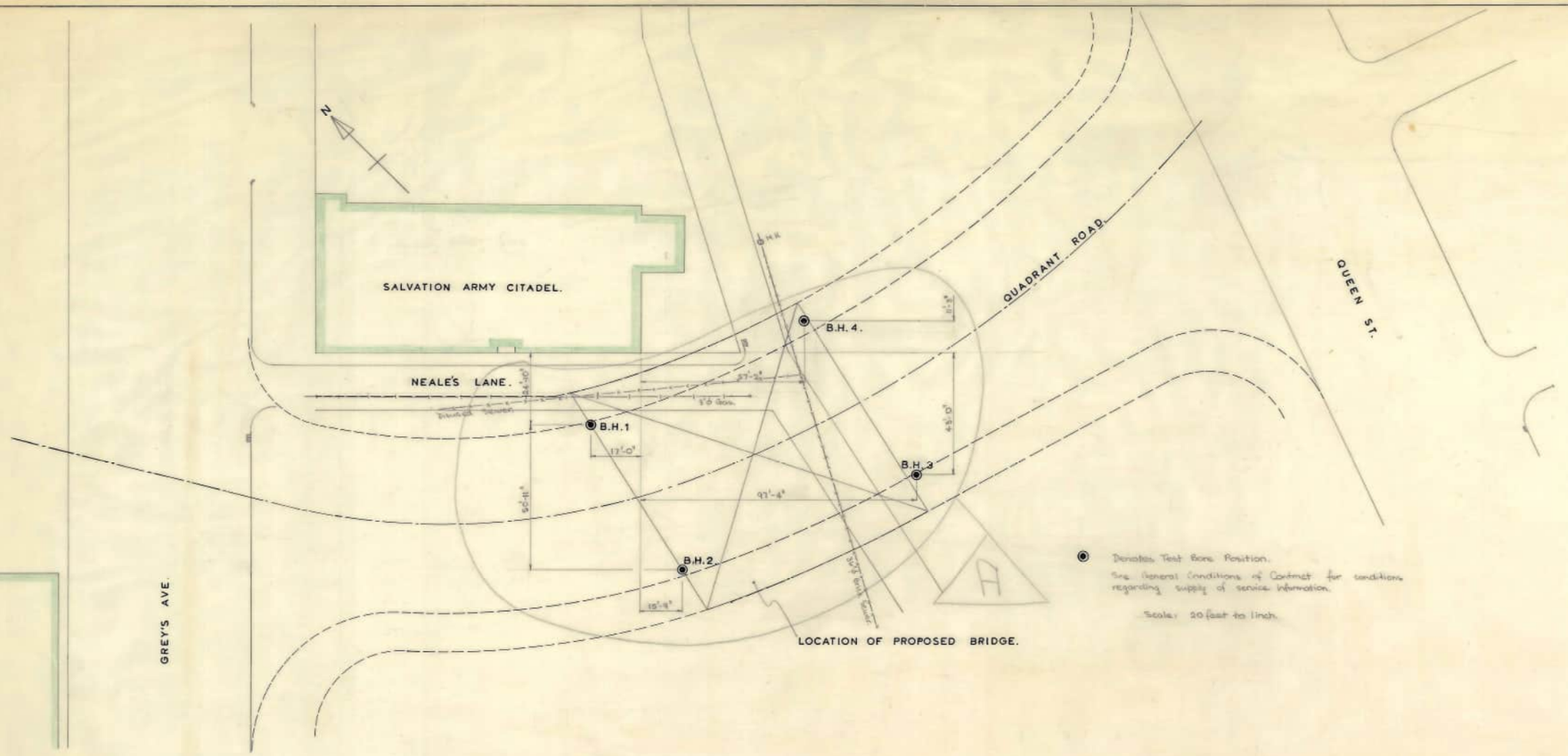

Southwest
Distance From Shaft (m)
100
80
60
40
20
0
Settlement (mm)
0
5
10
15
20
25
30
35
40
Differential
1/2300
Maximum Differential
1/1900
Shaft
P4MH2
Northeast
Distance From Shaft (m)
0
20
40
60
80
100
Settlement (mm)
Differential
1/1900
Mechanical Settlement (mm)
Dewatering-induced Settlement (mm)
Total Displacement (mm)

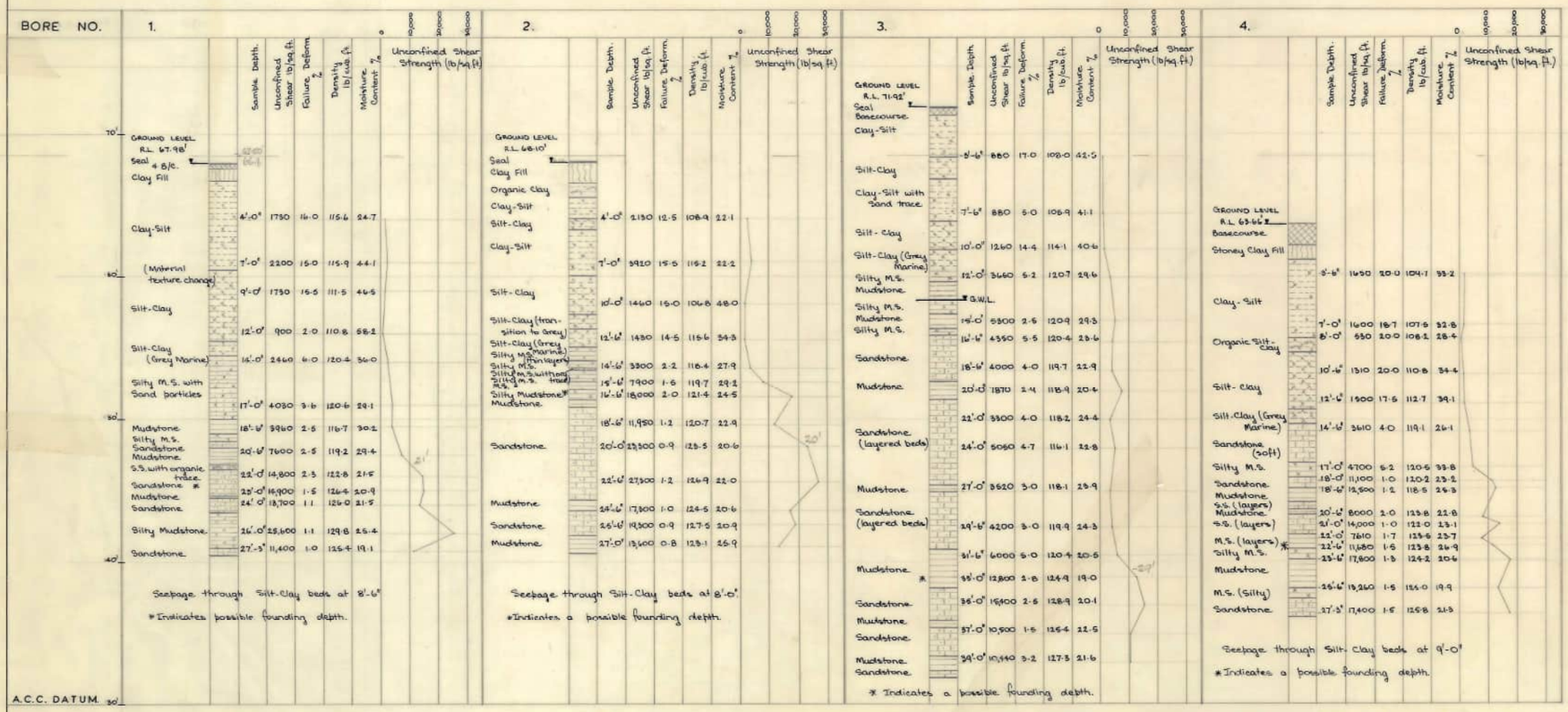

Elevation
45
40
35
30
25
20
15
10
5
0
-26
-24
-20
-12
-4
-2
-24
-22
-18
-10
-2
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Distance


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


Elevation
Distance
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
-4.5
-3
-2
-1.5
-1
-0.5
-5
-4
-2.5
-2
-1.5
-1
-0.5

APPENDIX D: MAYORAL OVERBRIDGE AND MILLENNIUM UNDERPASS PROPERTY FILE DRAWINGS AND INVESTIGATIONS





Scale: ½ inch to 1 foot Vertical.

SURVEY			
DESIGN			
CHECKED			
DRAWN	T.B. Headbeater	3.2.72.	
TRACED			
CHECKED			
APPROVED	R. Kelly	4.2.72.	
APPROVED			

V. Cochran
B.E. Civ. AMICE FNZIE
DESIGN ENGINEER

DIRECTOR OF WORKS & CITY ENGINEER

AUCKLAND CITY COUNCIL — DEPARTMENT OF WORKS & SERVICES

QUADRANT ROAD - GREY'S AVENUE TO QUEEN STREET - PROPOSED BRIDGE.

TEST BORE POSITIONS.

REF. PLANS

AMENDMENTS

REF.		DATE
A	Bore logs added. Remarks, positions amended.	4/4/72

CODE No.

SCALES: AS NOTED.

FILE No.

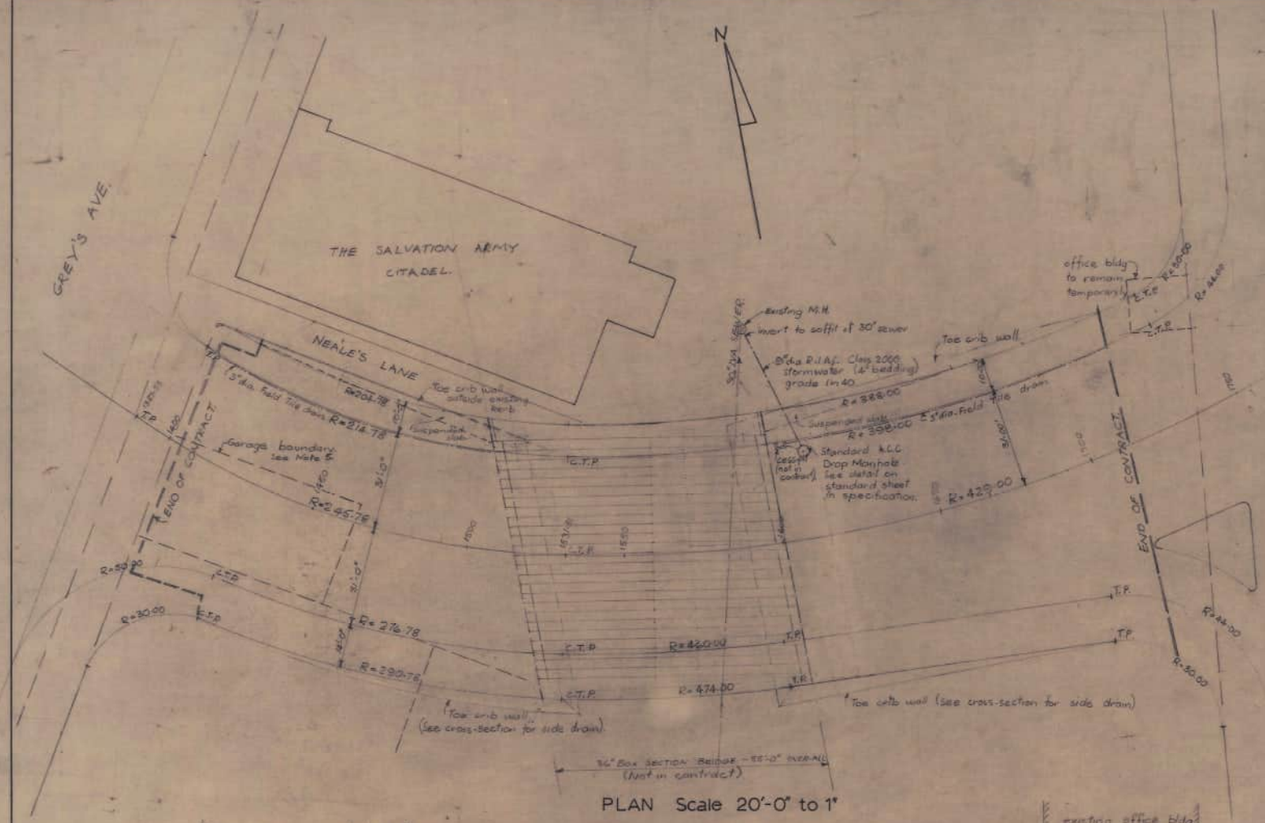
No. OF SHEETS

SHEET No.

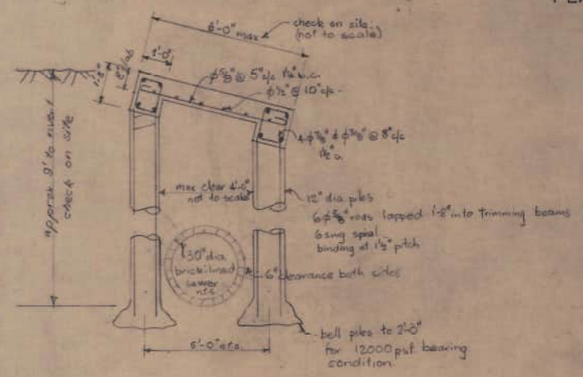
PLAN No. 12099/25 ~~Q17/202~~ A

WORK COMPLETED & AMENDMENTS ENDORSED _____ DATE

_____ CONTRACTS SUPERVISOR

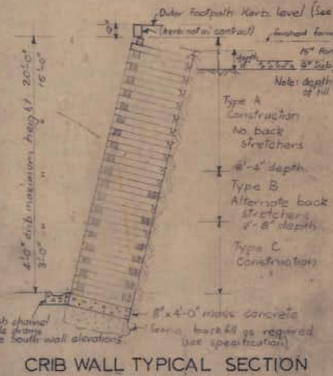


PLAN Scale 20'-0" to 1"



CRIB WALL SUPPORT OVER SEWER

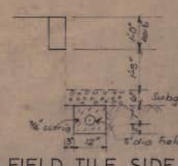
Note. All concrete in sewer support to have 28 day cylinder strength of 3000 lb/in². Similar support (one bay only) required over stormwater sewer (see North-East wall elevation).



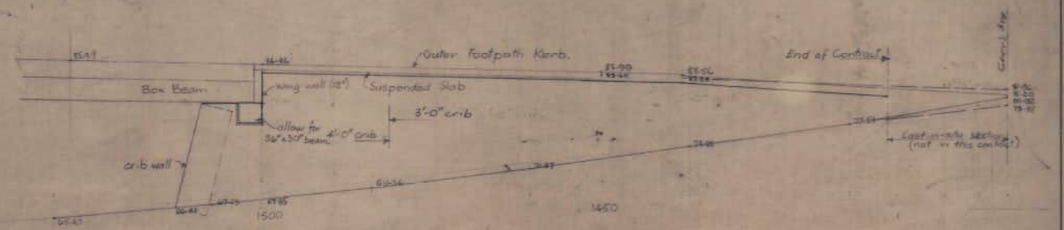
CRIB WALL TYPICAL SECTION

NOTE

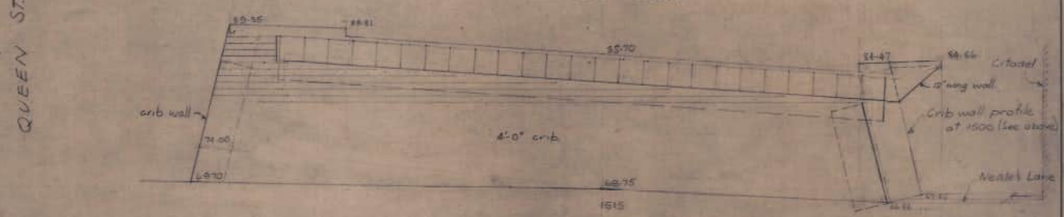
1. All crib walling to be laid according to typical cross-section. (See note 2). Footings to be stepped to Engineer's approval
2. Footing for crib wall placed over sewer shall be suitably reinforced to enable footing pressures to be carried over sewer - confirm on site (See detail above)
3. Mass concrete to have 28 day cylinder strength not less than 2500 psi.
4. Back-fill to be placed and compacted according to specification.
5. Available working area for placing fill and laying crib-wall in western embankment is restricted by existing building lines and property boundaries.
6. All fill to be approved by the Engineer and adequate check kept of compacted density and shear value.



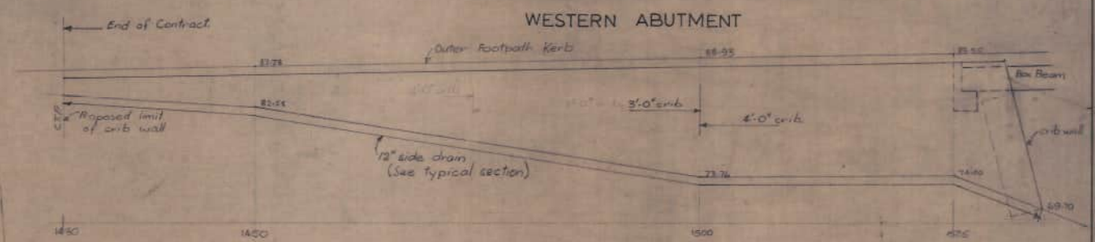
FIELD TILE SIDE DRAIN



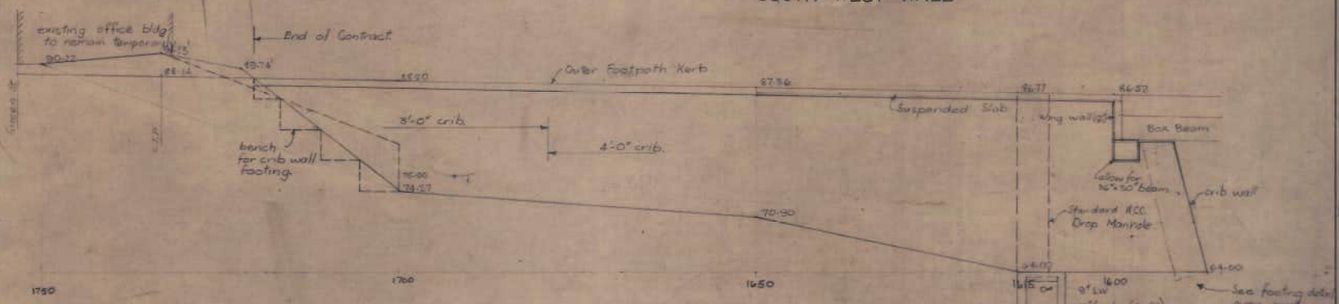
NORTH-WEST WALL



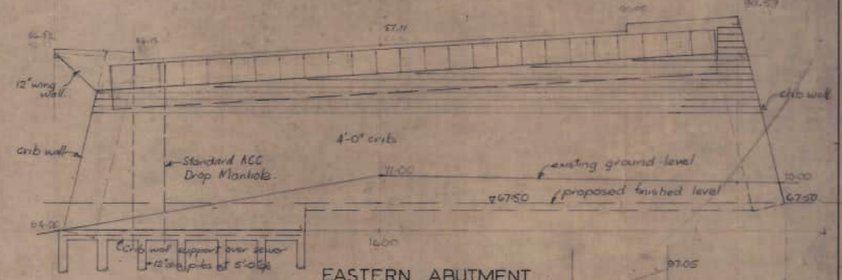
WESTERN ABUTMENT



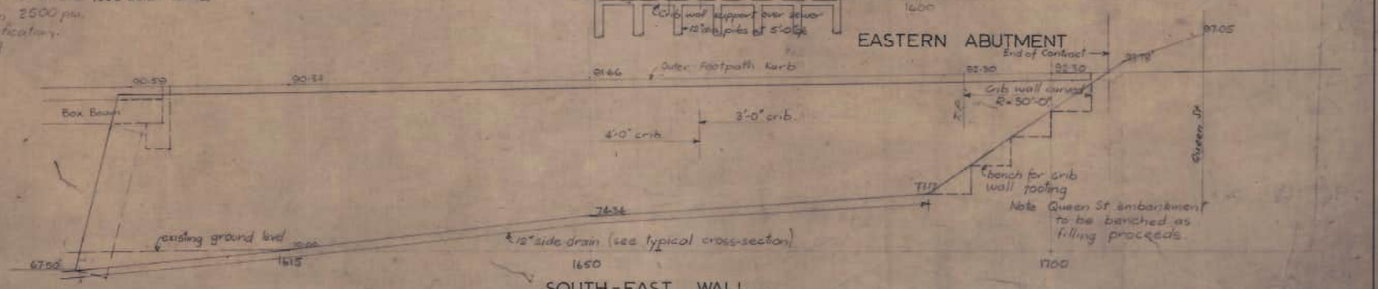
SOUTH-WEST WALL



NORTH-EAST WALL



EASTERN ABUTMENT



SOUTH-EAST WALL

RECORD COPY

SURVEY			
DESIGN	H. MEAN	JAN '72	V. Cochrane
CHECKED			DESIGN ENGINEER
DRAWN	H. MEAN	JAN '72	
TRACED			
CHECKED			
APPROVED		Feb '72	for [illegible]
APPROVED			DIRECTOR OF WORKS & CITY ENGINEER

AUCKLAND CITY COUNCIL — DEPARTMENT OF WORKS & SERVICES

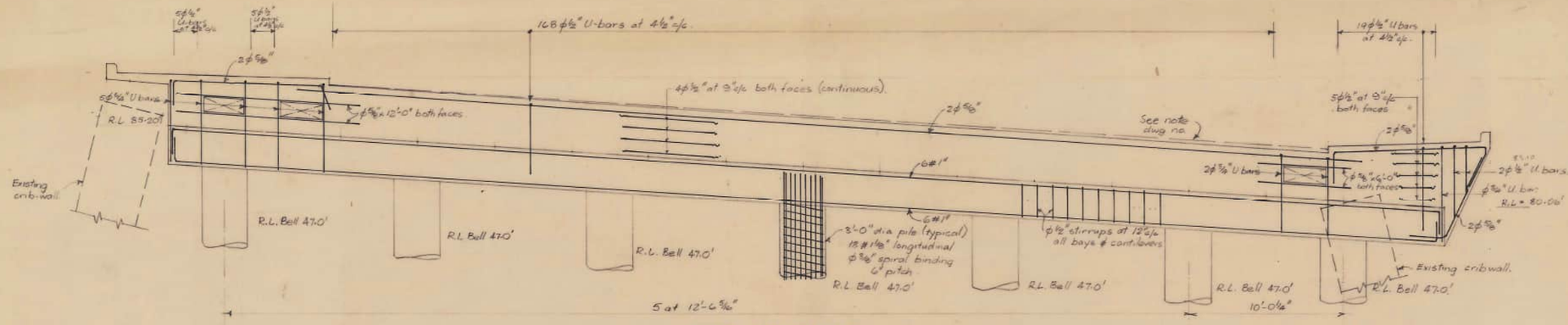
QUADRANT ROAD CAUSEWAY AND CRIB WALLS

REF. PLANS

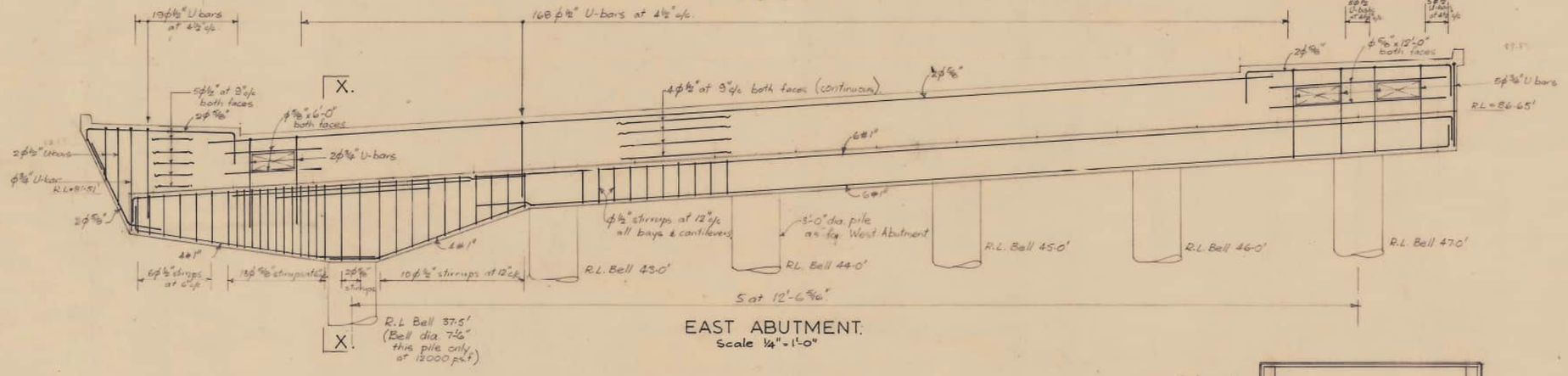
AMENDMENTS

REF.		DATE
	12099/51 to 55	
	12098/56 to 58 working	TSA
	12099/56 57 & 62	
	12099/60 typical pile detail	

CODE No.	SCALES		PLAN No.
226-01-01	1"=20' & ⅛", ¼" = 1'-0"		12099/34 047/271
FILE No.	No. OF SHEETS	SHEET No.	WORK COMPLETED & AMENDMENTS ENDORSED DATE
65/123	1	1	CONTRACTS SUPERVISOR



WEST ABUTMENT.
Scale ¼" = 1'-0"



EAST ABUTMENT.
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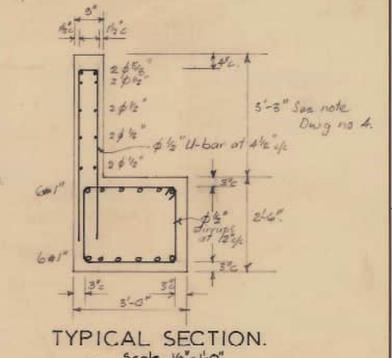

TYPICAL SECTION.
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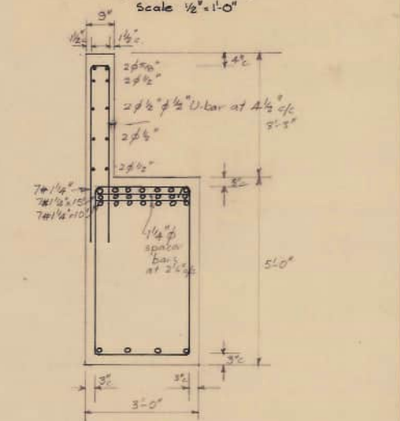

SECTION X-X.
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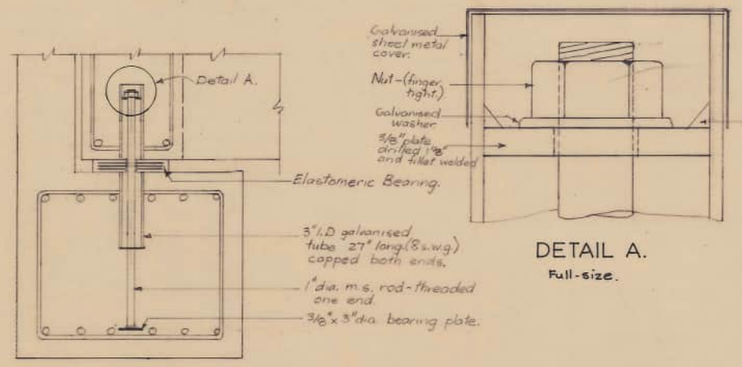
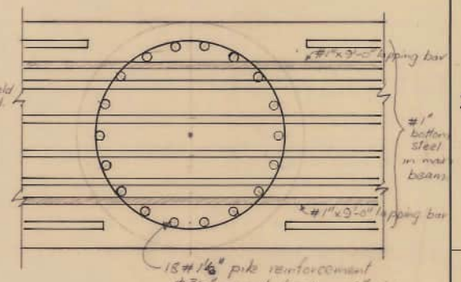
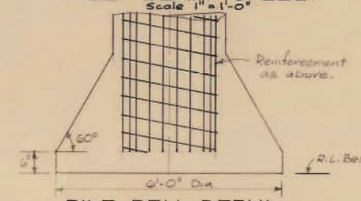


SEISMIC SHEAR KEY DETAILS.
Scale 1" = 1'-0"
see dwg No 5 for shear key locations.

DETAIL A.
Full-size.



PILE BEAM STEEL.
Scale 1" = 1'-0"



PILE BELL DETAIL.
Scale ½" = 1'-0"

NOTES
1. Reinforcement grades shown thus :- # HY60 (deformed) ϕ HY40 (deformed) or Round Mild steel (Stirrups only)
2. Reinforcement cover shown thus ½"c, 3"c etc.
3. Reinforcement laps (longitudinal only) not less than (i) 32 bar diameters for HY40 grade (ii) 48 " " " HY60 grade
4. Reinforcement located in 9" wing wall to allow stressing of 12/0.5 wire cables.
5. Balustrade not shown - see dwg. no 1.
6. Bell dia based on bearing capacity 7000 p.s.f.
7. All abutment concrete Type E - 4000 psi.

AMENDMENTS	BY	APP'd	DATE
1. Revise steel in abutment - see 12099/46 B4/4 1171			Nov'72
2. " " " " " 12099/46 B4/4 1173			" "
3. Revise seismic & reinforcement details - see dwg no 12099/43 B4/4 1177			JAN'73

	NAME	DATE
Design	H.M.McN	Sept'72
Drawn	H.M.McN	Sept.'72
Checked		

RECOMMENDED: F. Reddy

APPROVED: B Anderson 13/9/72

CITY of AUCKLAND
DEPARTMENT OF WORKS

QUADRANT ROAD BRIDGE.

ABUTMENT DETAILS.

ORIGINAL SCALES 1/4", 1/2", 1"=1'-0" ± F.S.

REF. PLANS

CODE No. 926·11

FILE No. 65/123/3.

PLAN No. 12099/42, B4/45.

SHEET No. 2.

No. of SHEETS 5.

ORIGINAL SCALE OF INCHES

GRAPHIC SCALES

RECORD COPY

UM A1

Borehole No. BH25/01

Project: Queen Street Wastewater Diversions - Parts 1, 4 a
Client: Watercare Services Limited
Project No.: W-SL001.04
Location: Opposite No. 71 Mayoral Drive, Auckland CBD.

Coordinates: 1757039mE, 5919990mN
Ref. Grid: NZTM2000
R.L.: 25.72m
Datum: NZVD2016
Location Method: GPSH

Depth: 7.3m
Inclination: Vertical
Azimuth: 0 deg

FORMATION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	MAIN DESCRIPTION / DETAIL DESCRIPTION	STRENGTH|DENSITY	MOISTURE	DEFECTS / NOTES / OTHER TESTS	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CORE: METHOD SAMPLE	CORE: TCR	INSTALLATION DETAILS
Fill	25 / 1	N/R	Hydrovac, no recovery.								Bituminous Material 0.3m
	24 / 2	N/R									Gravel backfill
	23 / 3		Medium to coarse GRAVEL; dark brown and dark reddish brown. Loosely packed, moist, poorly graded, subrounded to subangular, moderately to slightly weathered, moderately strong, scoriaceous basalt. [Drainage material].								
	22 / 4										
	21		Concrete footing.								

Started: 03/06/2025 Logged by: H.Qiao
Finished: 03/06/2025 Checked By: B.Shakes

Method: Rotary cored
Hammer Energy Ratio: 0%
Drilling Co.: Prodrill
Drilling Rig: SLG1

Hole Depth	Date / Time	Casing	Casing Dia mm	Water Level

Notes:
1. The log was prepared by WSP Engineering Geology team based on the core samples and drill records provided by Prodrill Ltd.
2. SPT tests not carried out.
3. TCR (%) was not recorded by the driller.

Borehole No. BH25/01

Project: Queen Street Wastewater Diversions - Parts 1, 4 a
Client: Watercare Services Limited
Project No.: W-SL001.04
Location: Opposite No. 71 Mayoral Drive, Auckland CBD.

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FORMATION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	MAIN DESCRIPTION / DETAIL DESCRIPTION	STRENGTH|DENSITY	MOISTURE	DEFECTS / NOTES / OTHER TESTS	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CORE: METHOD SAMPLE	CORE: TCR	INSTALLATION DETAILS
Fill	20 / 6		[CONT] Concrete footing. Medium to coarse GRAVEL; dark brown and dark reddish brown. Loosely packed, moist, poorly graded, subrounded to subangular, moderately to slightly weathered, moderately strong, vesicular and scoriaceous basalt. [Basement fill].								Gravel backfill
Fill	19 / 7										
Coast Bays Formation			Clayey SILT; grey. Stiff, moist, low plasticity. [Completely Weathered].								7.3m
	18 / 8		End Of Hole: 7.30m Target depth								
	17 / 9										
	16										

Started: 03/06/2025 Logged by: H.Qiao
Finished: 03/06/2025 Checked By: B.Shakes

Method: Rotary cored
Hammer Energy Ratio: 0%
Drilling Co.: Prodrill
Drilling Rig: SLG1

Hole Depth	Date / Time	Casing	Casing Dia mm	Water Level
7.3m	6/06/2025	7.3m	-	3.65mbgl

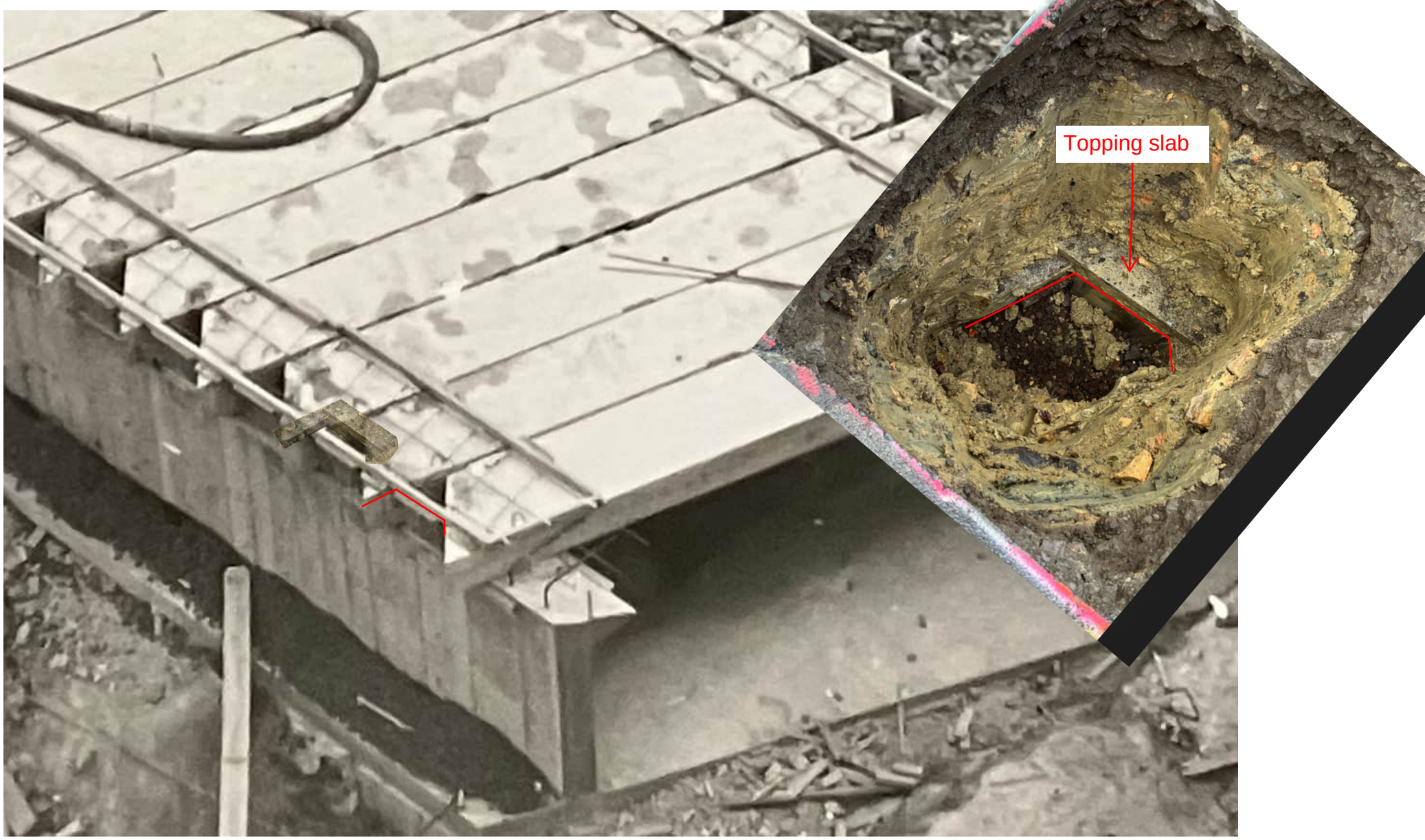
Notes:
1. The log was prepared by WSP Engineering Geology team based on the core samples and drill records provided by Prodrill Ltd.
2. SPT tests not carried out.
3. TCR (%) was not recorded by the driller.

Borehole No. BH25/01

Project: Queen Street Wastewater Diversions - Parts 1, 4 a
Client: Watercare Services Limited

Project No.: W-SL001.04
Location:
Opposite No. 71 Mayoral Drive, Auckland CBD.

0.00 - 7.30m


Topping slab

APPENDIX E: DEWATERING AND SETTLEMENT ASSESSMENT – ADDENDUM DETAILING FURTHER ASSESSMENT

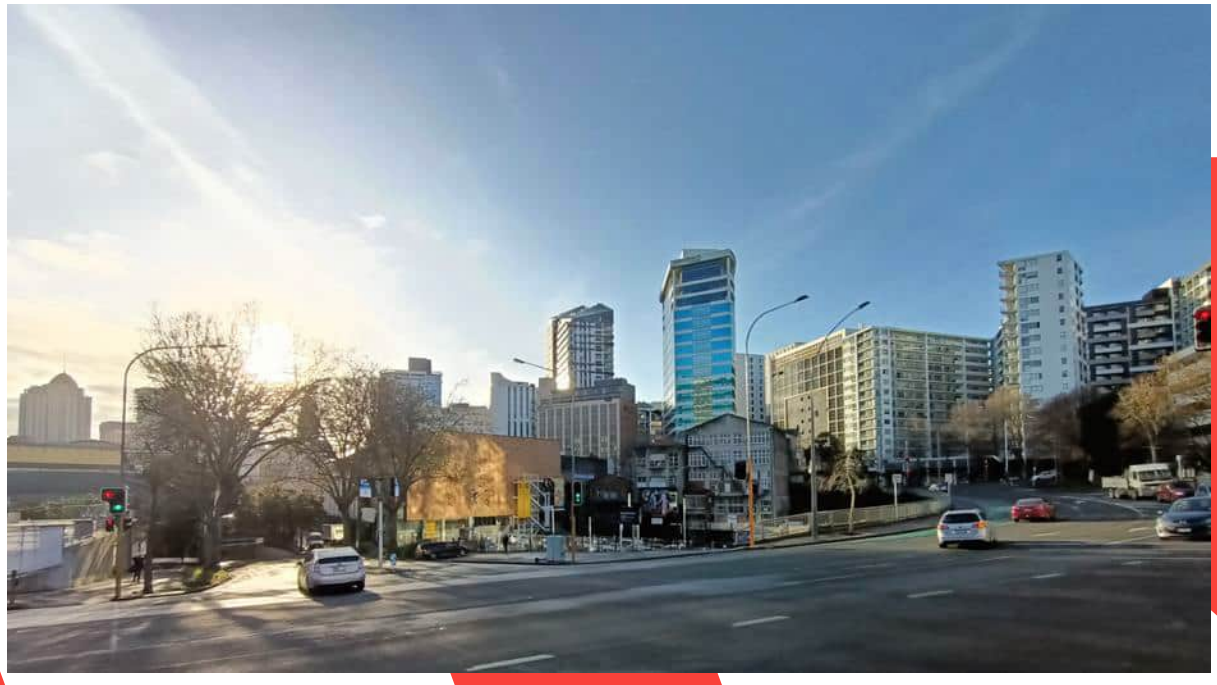
Public

Watercare Services Limited
DEWATERING AND SETTLEMENT ASSESSMENT – ADDENDUM DETAILING FURTHER ASSESSMENT

QUEEN STREET WASTEWATER DIVERSION PROGRAMME: MAYORAL DRIVE ALIGNMENT PROJECT

5 September 2025

W-SL001.04



DEWATERING AND SETTLEMENT ASSESSMENT – ADDENDUM DETAILING FURTHER ASSESSMENT

QUEEN STREET WASTEWATER DIVERSION PROGRAMME: MAYORAL DRIVE ALIGNMENT PROJECT

Watercare Services Limited

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Auckland
Level 3 The Westhaven
100 Beaumont St
Auckland 1010, New Zealand
+64 9 355 9500
wsp.com/nz

REV	DATE	DETAILS
R0	5 September 2025	Addendum to Dewatering and Settlement Assessment Report (June 2025) detailing an assessment of depth increase of shafts P4MH1 and P4MH2

	NAME	DATE
Prepared by:	Terry Hughes and Ada Ng	5 September 2025
Reviewed by:	Louise Soltau and Alireza Mohammadinia	9 September 2025
Approved by:	Philip McFarlane	9 September 2025

TABLE OF CONTENTS

1 INTRODUCTION

The Mayoral Drive Alignment Project assessment of dewatering effects report Revision 1 (R1) was submitted to Auckland Council on 21 July 2025 and a section 92 request for further information from council was returned to the client on the 28th July 2025. In addition, it was discovered that existing stormwater services underlying the alignment between Mayoral Shafts P4MH1 and P4MH2 were deeper than originally assumed and the depth of these shafts may need to be increased by 1.0 m. These shafts require further assessment due to the likely increase in depth and are addressed in this addendum report.

Specifically, the shaft depth changes are:

Shaft ID	R1 assessment depth (m bgl)	Addendum assessment depth (m bgl)	R1 assessment depth (m RL)	Addendum assessment depth (m RL)
P4MH1	9	10.1	16.4	15.3
P4MH2	9	9.8	15.1	14.3

This addendum report provides assessments based on a new shaft design depth, specifically centred on the increased amount of groundwater drawdown and the potential for increased settlement surrounding these two shafts.

This updated assessment indicates that the change in effect of deepening P4MH1 and P4MH2 is slight and therefore there is no change in damage classification for settlement as specified in Section 7 of the R2 Dewatering Specialist report (parent report). A minor increase in settlement amounts (approximately 2.0 mm) has been estimated and these values are reflected in the accompanying Groundwater Settlement Monitoring and Contingency Plan (Appendix F).

2 ASSESSMENT METHODOLOGY

The assessment methodology for groundwater drawdown and settlement for the 1.0 m deeper shafts, P4MH1 and P4MH2, is unchanged from the R1 assessment. SEEP/W and SIGMA/W were used to estimate drawdown and settlement for the increased shaft depths.

Refer Section 5 of the R1 Dewatering and Settlement Assessment Report (WSP, 2025) for the detailed assessment methodology.

3 TECHNICAL ANALYSIS

3.1 DEWATERING ANALYSIS

The dewatering analysis has been adopted from the previous R1 reported assessment based on the methodology cited in Section 2 above.

The cross-sections of the modelled groundwater level drawdown from dewatering of the updated (deeper) P4MH1 and P4MH2 shafts are presented in Figure 3-1 and Figure 3-2 for the best estimate case of hydraulic parameter values. The drawdown at selected distances from the edge of the shaft along each of the cross-sections is specified in the table in Figure 3-1 and Figure 3-2. These tables include the sensitivity analysis, showing the range of drawdowns between the high and low hydraulic conductivity scenarios. Generally, the higher hydraulic conductivity scenarios are used for assessment because the drawdown is more extensive, hence allowing for a more conservative assessment.

Dewatering rates for the increased depth shafts are presented in Table 3-1. The dewatering rate for P4MH2 is higher than that of P4MH2, with the maximum dewatering rate of 60 m^3/day for the high-K case after 1 day The dewatering rate reduces to 19 m^3/day after 240 days of dewatering. Similarly for shaft P4 MH1, the dewatering rate of 40 m^3/day on day 1 reduces to 14 m^3/day after 240 days.

Table 3-1: Groundwater dewatering rates.

Shaft	**Discharge (m^3/day)**			
	Day 1 – R1	**Day 1- Addendum**	**Day 240 – R1**	**Day 240 – Addendum**
P4MH1	35	40	13	14
P4MH2	54	60	18	19

The modelled groundwater drawdown from dewatering is used for the dewatering effects assessment (Section 4 of this report) and as input into settlement modelling and assessment. The assessment of ground settlement caused by dewatering is described in detail in the Dewatering and Settlement Assessment Report (WSP, 2025).

Settlement effects on structures near the shafts are typically considered negligible to minimal where drawdowns are less than 2.0 m (as per standard E7.6.1.6(3) of the Auckland Unitary Plan (AUP)). The distance of the 2 m drawdown contours from the conservative shaft extents are listed in Table 3-2. Some properties are located within this 2 m drawdown contour and further assessment of land settlement effects is warranted and included in Section 4 of this report.

Table 3-2: Distance of the 2 m drawdown contour from shaft edge

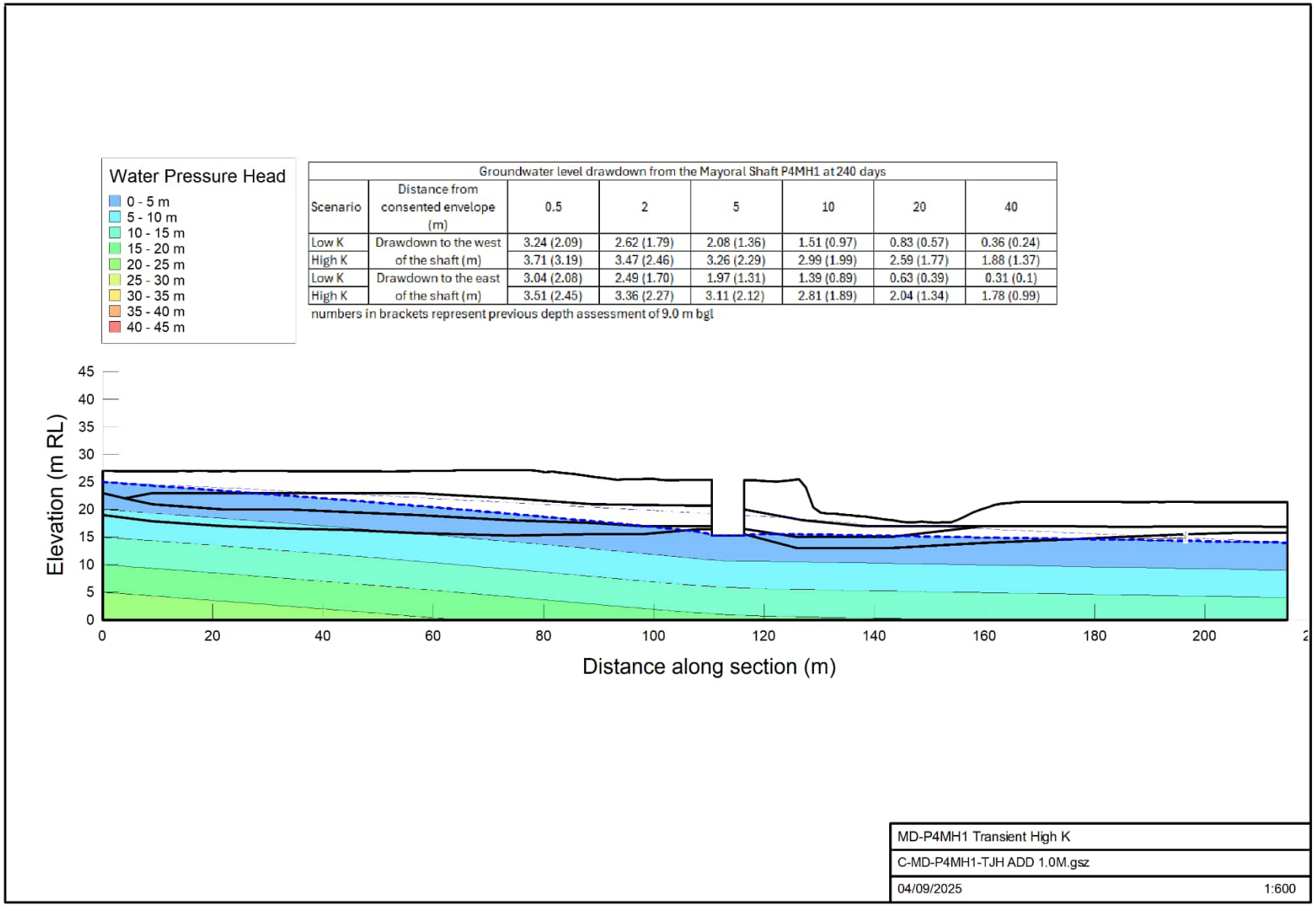
Shaft	**West side (m) – R1**	**West side (m) – Addendum**	**East Side (m) – R1**	**East Side (m) – Addendum**
P4MH1	11	34	8	21
P4MH2	63	67	69	71

Other effects on the environment (neighbouring water takes, 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 are not measurable above seasonal variations. The distance to the 0.5 m drawdown contour from the conservative shaft extent is listed in Table 3-3. The assessment of effects on the environment is described in Section 4.

Table 3-3: Distance of the 0.5 m drawdown contour from the shaft edge.

Shaft	West side (m) – R1	West side (m) – Addendum	East Side (m) – R1	East Side (m) – Addendum
P4MH1	83	91	70	82
P4MH2	100	101	90	91

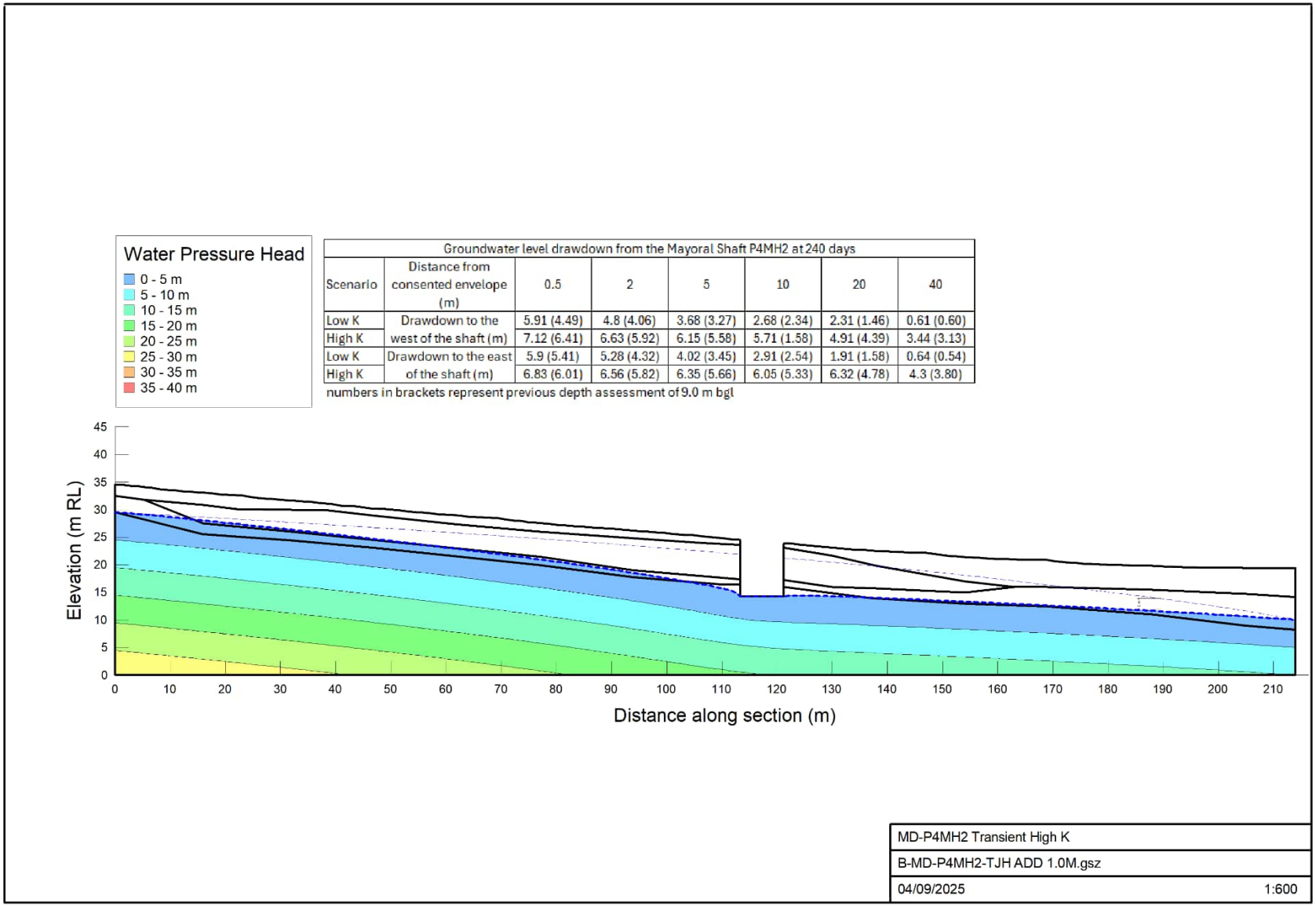


Groundwater level drawdown from the Mayoral Shaft P4MH1 at 240 days

Scenario	Distance from consented envelope (m)	0.5	2	5	10	20	40
Low K	Drawdown to the west of the shaft (m)	3.24 (2.09)	2.62 (1.79)	2.08 (1.36)	1.51 (0.97)	0.83 (0.57)	0.36 (0.24)
High K		3.71 (3.19)	3.47 (2.46)	3.26 (2.29)	2.99 (1.99)	2.59 (1.77)	1.88 (1.37)
Low K	Drawdown to the east of the shaft (m)	3.04 (2.08)	2.49 (1.70)	1.97 (1.31)	1.39 (0.89)	0.63 (0.39)	0.31 (0.1)
High K		3.51 (2.45)	3.36 (2.27)	3.11 (2.12)	2.81 (1.89)	2.04 (1.34)	1.78 (0.99)

numbers in brackets represent previous depth assessment of 9.0 m bgl

Figure 3-1: High K estimate case groundwater drawdown for the P4MH1 shaft.



Groundwater level drawdown from 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)	5.91 (4.49)	4.8 (4.06)	3.68 (3.27)	2.68 (2.34)	2.31 (1.46)	0.61 (0.60)
High K		7.12 (6.41)	6.63 (5.92)	6.15 (5.58)	5.71 (1.58)	4.91 (4.39)	3.44 (3.13)
Low K	Drawdown to the east of the shaft (m)	5.9 (5.41)	5.28 (4.32)	4.02 (3.45)	2.91 (2.54)	1.91 (1.58)	0.64 (0.54)
High K		6.83 (6.01)	6.56 (5.82)	6.35 (5.66)	6.05 (5.33)	6.32 (4.78)	4.3 (3.80)

numbers in brackets represent previous depth assessment of 9.0 m bgl

Figure 3-2: High K estimate case groundwater drawdown for the P4MH2 shaft.

3.2 SETTLEMENT ANALYSIS

The settlement resulting from dewatering was updated for the deeper shafts. The settlement for P4MH1 and P4MH2 has been updated in comparison to the R1 dewatering assessment in the following sections. Note that the mechanical settlements have not been revised, and we will advise that the temporary works designers modify their proposed temporary works with additional struts or props as necessary to limit displacements to those previously provided.

3.2.1 P4MH1

The revised settlement plot for P4MH1 is presented in Figure 3-3 and in Table 3-4. Structures near P4MH1 include the buildings at 71 – 87 Mayoral Drive, 3 Greys Avenue and 100 Mayoral Drive. Note that the building at 3 Greys Avenue is located approximately 36 m from Shaft P4MH1, and the building is not shown in Figure 3-3.

Based on the revised assessment, the maximum settlement is approximately 23 mm, and a maximum differential of 1/60 occurs within 2 m of the shaft. This was assessed disregarding the anomalous dip at approximately 1.2 m from the mechanical settlement. Compared to the original assessment, the difference is less than 5 mm.

Settlement effects on structures and infrastructure are further discussed for P4MH1 in Section 4.3.

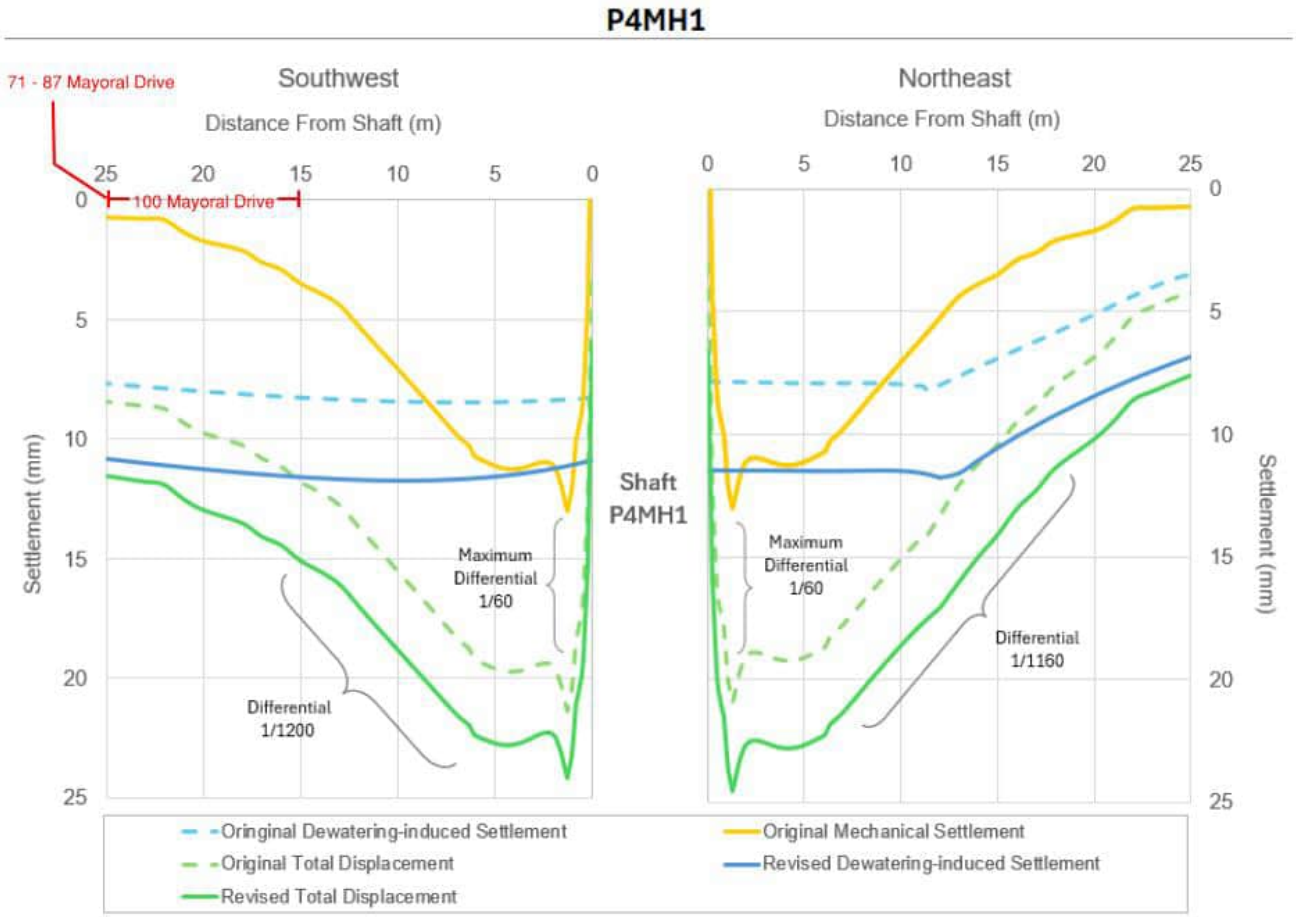


Figure 3-3: Settlement profile for P4MH1 cross-section.

Table 3-4 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)	*10.9*	*11.6*	*11.7*	*11.2*
Mechanical Settlement (ENGEO)	*8.9*	*11.1*	*7.1*	*1.7*
Total Settlement	*19.8*	*22.7*	*18.8*	*12.9*
Settlement (mm)	**Distance from Shaft *Northeast* (m)**			
	0.5	**5**	**10**	**20**
Dewatering-induced Settlement (High-K)	*11.5*	*11.5*	*11.5*	*8.5*
Mechanical Settlement (ENGEO)	*8.9*	*11.1*	*7.1*	*1.7*
Total Settlement	*20.4*	*22.6*	*18.6*	*10.2*

3.2.2 P4MH2

The revised settlement plot for P4MH2 is presented in Figure 3-4 and Table 3-5. Structures near P4MH2 are the buildings at 48 and 22 Greys Avenue as indicated in Figure 3-4.

Based on the assessment, the maximum settlement is approximately 33 mm, and a maximum differential of 1/1800. Compared to the original assessment there is a difference of less than 5 mm in settlement. Compared to the original assessment, the difference is less than 2 mm.

Settlement effects on structures and infrastructure are further discussed for P4MH2 in Section 4.3.

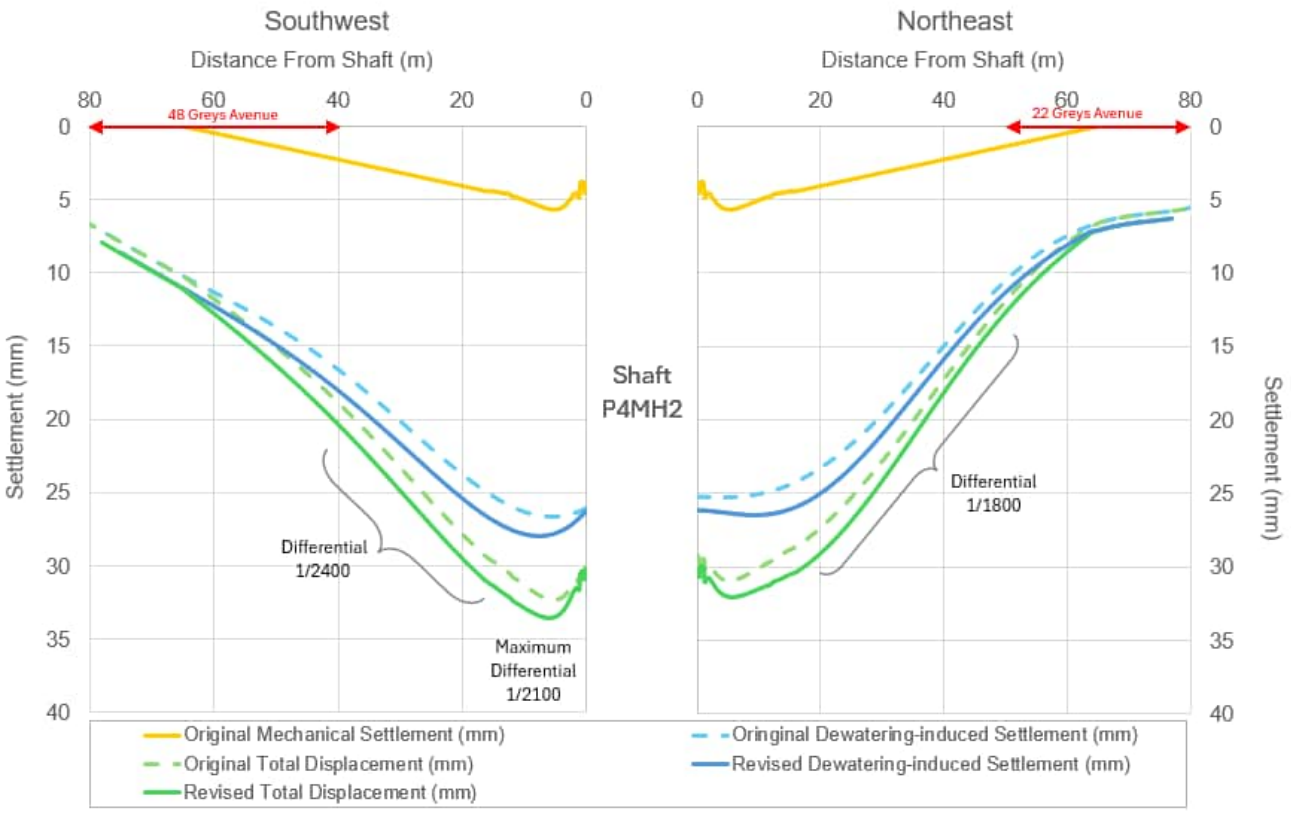


Figure 3-4: Settlement profile of across the section for P4MH2.

Table 3-5 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)	*26.6*	*27.8*	*27.9*	*25.4*
Mechanical Settlement (ENGEO)	*3.8*	*5.7*	*5.0*	*4.1*
Total Settlement	*30.4*	*33.5*	*32.9*	*29.5*
Settlement (mm)	**Distance from Shaft *Northeast* (m)**			
	0.5	**5**	**10**	**20**
Dewatering-induced Settlement (High-K)	*26.1*	*26.3*	*26.4*	*24.9*
Mechanical Settlement (ENGEO)	*3.8*	*5.7*	*5.0*	*4.1*
Total Settlement	*29.9*	*32.0*	*31.4*	*29.0*

4 EFFECTS ASSESSMENT

4.1 EFFECTS ON NEARBY WATER TAKES

Effects on nearby water takes are unchanged and negligible as a result of P4MH1 and P4MH2 being deepened by approximately 1.0 m. This is because there are no existing water takes within the 0.5 m drawdown contour.

Cumulative effects have been addressed in the R1 report.

4.2 EFFECTS ON GROUNDWATER LEVELS, PRESSURES, FLOWPATHS AND SALINE INTRUSION

Effects on groundwater levels, pressures, flowpaths and saline intrusion are unchanged and negligible as a result of P4MH1 and P4MH2 being deepened by approximately 1.0 m. This is because the there are no surface water bodies within the 0.5 m drawdown contour.

4.3 SETTLEMENT EFFECTS

4.3.1 BUILDINGS

This section should be read in conjunction with the Mayoral Drive Dewatering Specialist Report, Revision 1, dated 24th June 2025, which outlines the criteria for which structures, underground services and pavement surfaces are assessed.

The updated settlements impacted by the revised assessment are presented in Table 4-1, with an increase in the maximum total settlement of approximately 2 – 3 mm, and a marginal difference in the differential settlement. The damage category and degree of severity remain as concluded in the R1 assessment.

Table 4-1 Revised summary for structures impacted by the updated dewatering-induced settlement for P4MH1 and P4MH2.

Property Address	Nearby Shaft	Minimum Distance from the Shaft (m)	Maximum Estimated Settlement (mm)	Maximum differential Settlement	Damage Category	Degree of Severity
100 Mayoral Drive	P4MH1	15	15	1/1200	1	Very slight
48 Greys Avenue	P4MH2	40	21	1/2500	1	Very slight
22 Greys Avenue	P4MH2	48	14	1/1300	1	Very slight
The above settlement values show slight increases in total settlement due to deepening these shafts by approximately 1.0 m but does not change the damage classification from the R2 Dewatering Specialist report (Section 7) and no change in adverse effects have been determined.						

4.3.2 SERVICES

For P4MH1, there are stormwater assets within 5 m of the shaft at an approximate depth of 3.2 m. From the revised settlement assessment, infrastructure within 5 m of the shaft may experience total settlement up to 23 mm and differential settlement <1/1,160, which is acceptable based on the service criteria.

For P4MH2, there is no buried gravity infrastructure within 5 m of the shaft. For gravity infrastructure beyond 5 m, the revised total settlement is less than 34 mm with a differential of 1/1,800, which is acceptable based on the service criteria.

5 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 Project of the Queen Street Wastewater Diversion, for consenting purposes (‘Purpose’) and in accordance with TO-WSP-65 signed 3 December 2024 (‘Agreement’). 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.

APPENDIX F: GROUNDWATER, SETTLEMENT MONITORING AND CONTIGENCY PLAN (GSMCP)

Public

Watercare Services Limited
Groundwater and Settlement Monitoring and Contingency Plan

Queen Street Wastewater Diversion Programme: Mayoral Drive Alignment Project

10 September 2025

W-SL001.04

Groundwater and Settlement Monitoring and Contingency Plan

Queen Street Wastewater Diversion Programme: Mayoral Drive Alignment Project

Watercare Services Limited

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REV	DATE	DETAILS
1	10 September 2025	Draft for client review

	NAME	DATE
Prepared by:	Terry Hughes, Vassilis Houssiadas	26 August 2025
Reviewed by:	Louise Soltau, Alireza Mohammadinia	9 September 2025
Approved by:	Philip McFarlane	10 September 2025

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ABBREVIATIONS AND DEFINITIONS

AC	Auckland Council
AEE	Assessment of Environmental Effects
Alarm Level	Specific monitoring levels where predicted drawdown and settlement levels are reached or exceeded and immediate action is required, as described in the relevant conditions.
Alert Level	Specific monitoring levels that approach the predicted drawdown or settlement levels and requires action as described in the relevant conditions.
AUP	Auckland Unitary Plan
Damage	Includes aesthetic, serviceability and structural damage based on the Burland (1995) building damage classification. No actions are required for negligible and very slight aesthetic damage.
Deep Excavation	Typically, a man-made cavity that exceeds 4.5 m in depth.
Dewatering	Removing (taking or diversion of) water from an excavation to allow for a dry work surface.
GSMCP	Groundwater and Settlement Monitoring and Contingency Plan
Monitoring piezometer	A vertical pipe in the ground with a slotted screen that is used to measure the groundwater level

1 INTRODUCTION

1.1 PROPOSED DEVELOPMENT

Watercare are proposing to upgrade the existing wastewater network of the upper (southern) catchment of Auckland City Centre. The current network has insufficient capacity to meet the 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. This Groundwater and Settlement Monitoring and Contingency Plan (GSMCP) applies to the Mayoral Drive Alignment Project of the Queen Street Wastewater Diversion.

The Mayoral Drive Alignment Project involves the construction of a wastewater pipeline from the Part 3 - Part 4 Connector Shaft to a new shaft at the intersection of Vincent Street and Mayoral Street. The Project will be constructed using a combination of trenchless pilot bore to construct the wastewater pipeline tunnel, and panel and post temporary shafts to allow access for the pilot bore drilling machine. Along the Mayoral Drive alignment, six shafts are required for construction of the new wastewater pipeline. Dewatering will be required during the excavation in five of these shafts to maintain workable and stable conditions. Only these five shafts are discussed further in this report.

1.2 PURPOSE

The purpose of this document is to support the resource consent application to dewater during the construction of the Mayoral Drive alignment of the Queen Street Wastewater Diversion. This GSMCP is based on, and must therefore be read in conjunction with, the following technical reports prepared by WSP for the project:

- Dewatering and Settlement Assessment: Queen Street Wastewater Diversion Programme: Mayoral Drive Alignment Project – submitted to council on the 30th June 2025.
- Fulton Hogan, 2025, Construction Methodology, Queen Street Diversion – Package B (Appendix A)

The GSMCP provides a guide to managing potential settlement generated by groundwater drawdown and deflections caused by temporary excavations on buildings and services adjacent to the Mayoral Drive Alignment Project works and provides proposed groundwater level and settlement trigger levels.

This GSMCP is not valid if the temporary works design and construction methodology differs from that assumed in this plan. Changes to the temporary works design or construction methodology may warrant a change of conditions of the resource consent, and as a consequence the GSMCP is required to be updated accordingly. It is the Contractor's responsibility to confirm if changes to the temporary works design or construction methodology are within scope of the resource consent and of the GSMCP, and if changes in either or both are required.

The Contractor is responsible for implementation of this GSMCP, including undertaking the monitoring works and implementing any mitigation measures. If there are any changes to temporary design and/or construction methodology, the Contractor will notify WSP so the plan can be updated and resubmitted to AC for recertification.

1.3 SCOPE OF QUEEN STREET WASTEWATER DIVERSION PROGRAMME COVERED BY THIS GSMCP

This GSMCP sets out:

- The at-risk buildings and other infrastructure as a result of the dewatering and excavation activities.
- Recommended maximum levels for groundwater drawdown and trigger levels for settlement of buildings and other infrastructure associated with the Mayoral Drive Project works.
- Recommended measures to mitigate adverse effects as a result of the dewatering and excavation activities involved in the early works.
- Proposes contingency measures to be implemented should the alert or alarm levels be exceeded.

1.4 LIMITATIONS

This plan ('Plan') has been prepared by WSP New Zealand Limited ('WSP') exclusively for Watercare Services Limited ('Client') in relation to the monitoring of dewatering effects along the Mayoral Drive Alignment Project of the Queen Street Wastewater Diversion Programme, for consenting purposes ('Purpose') and in accordance with TO-WSP-65 signed 3 December 2024 ('Agreement'). This plan is provided to support a resource consent application only. WSP accepts no liability whatsoever for any use or reliance on this Plan, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Plan by any third party.

2 PROPOSED CONSTRUCTION METHODOLOGY

The temporary shafts along the Mayoral Drive alignment will be used as both launch and reception pits for the Pilot Guided Boring Machine. All shafts are rectangular in shape and are proposed to be supported with a post and panel construction. A list of shaft numbers and their details are provided in Table 2-1, and their locations are presented in Figure 2-1.

Table 2-1: Mayoral Drive Alignment Project Shaft Details.

Shaft (Manhole) ID	Width (m)	Length (m)	Depth (m)	Duration Shaft 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

Similar construction methodologies are proposed for all the shafts and are presented in a Fulton Hogan high level construction methodology presented in Appendix A. Construction methodologies generally comprise the installation of steel H piles to complete a post and panel construction with the panels being timber lagging installed as the shaft is excavated. The shafts will also be lined with a concrete base and any groundwater encountered will be managed by sump pumping, given the low volumes of inflows estimated and experienced within nearby shafts of other parts of the Queen Street project works.

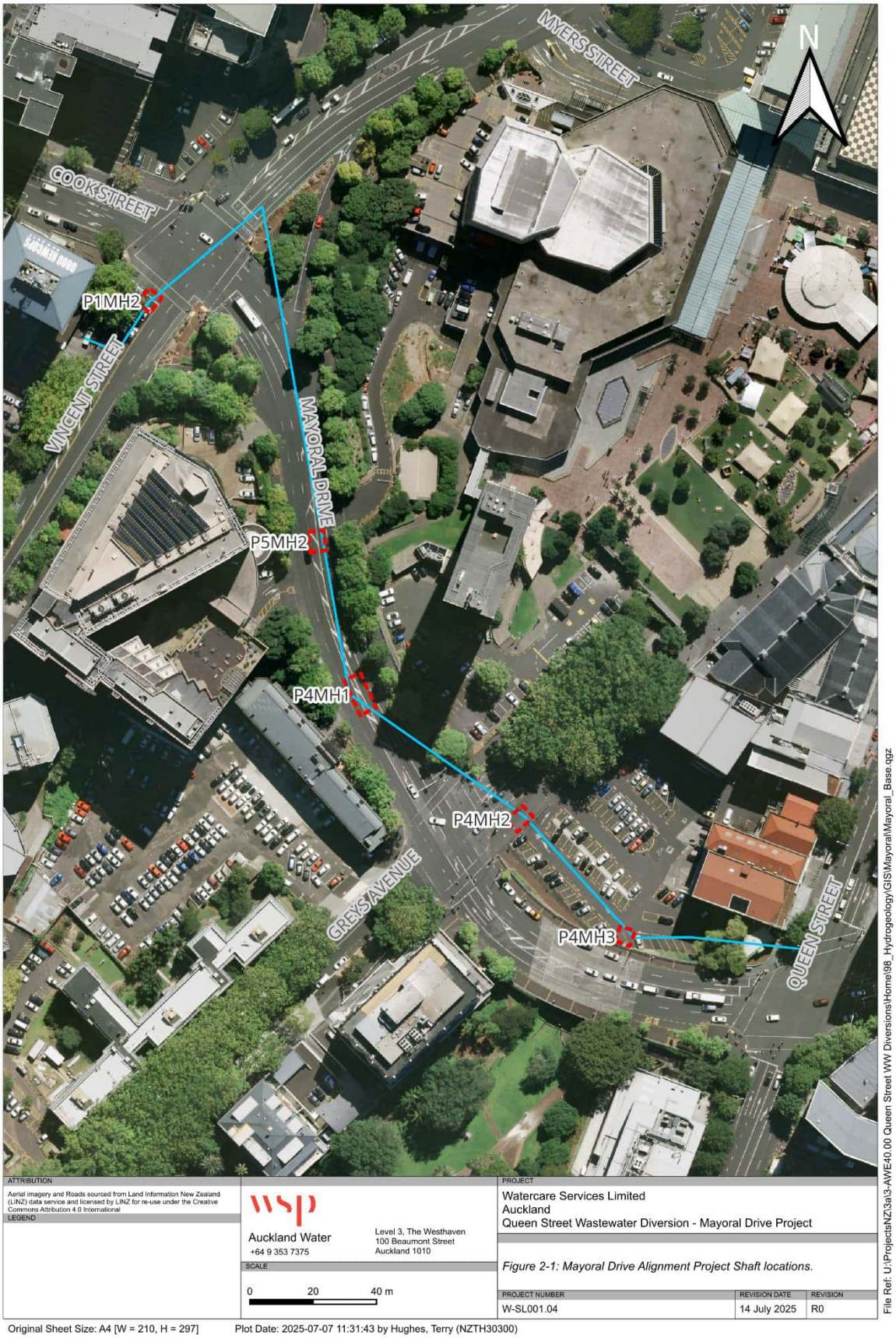


Figure 2-1: Mayoral Drive Alignment Project Shaft Locations

3 OVERVIEW OF MONITORING REQUIREMENTS

This section provides an overview of the monitoring and reporting required for the excavation and construction works in accordance with the conditions that are likely included in the consent to dewater.

Temporary works, ground settlement, building and structure deflections, and groundwater drawdown monitoring during the construction works will be undertaken to monitor whether the response of the surrounding buildings and structures remain within design tolerances and estimated range of settlement effects. This process allows for the geotechnical effects to be monitored and are to be used as an indication if mitigation measures are required.

3.1 MONITORING AND REPORTING REQUIREMENTS

In general, monitoring is subdivided into three separate stages reflecting the separate periods of construction works. These are summarised in Table 3-1.

Table 3-1: Summary of Monitoring Stages

Pre-construction monitoring	This monitoring phase will provide baseline data against which effects resulting from the construction works can be assessed. The outcomes will form part of the input for the construction phase assessments. Pre-construction monitoring is to include: • Condition surveys and visual inspections of selected nearby buildings (refer to section 5.3.1), including photographs of nearby buildings, to define existing condition of the buildings. • CCTV surveys of stormwater assets • Building and ground monitoring survey points to establish a settlement baseline. • Groundwater level monitoring to establish baseline levels.
During construction monitoring	Monitoring during the construction phase is carried out to compare settlements against the set Alert and Alarm levels and enable the implementation of countermeasures in advance of potential adverse effects occurring. Mitigation options set out in Section 6 of this GSMCP, may also be required to be implemented.
Post-construction monitoring	• Where specified in the Consent, monitoring will occur until the various stages of works are completed (excavation, dewatering and construction). Post-construction measurements will be undertaken, if required, for up to six months after completion of dewatering or until the position markers are found to have stabilised and approval is given in writing by AC. • Condition surveys and visual inspections of selected nearby buildings and structures will be undertaken, to note whether any damage or other type of deterioration has occurred as a result of the construction works.

The monitoring required during each stage is summarised in Table 3-2.

Table 3-2: Summary of Monitoring Requirements.

Monitoring Type	Construction Stage	Minimum Measurement Frequency	Measurement Accuracy	Reporting Requirement to AC, unless otherwise stated	Relevant GSMCP Sections
Groundwater monitoring	Baseline (pre-construction)	Twice weekly for a four-week period before commencing dewatering in the relevant monitoring piezometer near the shaft.	±10 mm	Every two months for routine monitoring. Within 2 working days of any alert trigger level exceedances.	Section 4
	Excavation dewatering (during construction)	At least twice weekly until completion of dewatering.			
	Post-construction dewatering	Once a month for three months after the completion of dewatering. Monitoring can cease earlier if monitoring levels are stable (groundwater levels are within pre-construction range and seasonal variation), or until stable measurements are demonstrated and written approval is provided by AC for certification.			
Building Condition Surveys (BCS)	Baseline (pre-construction)	A pre-construction condition survey is to be carried out on all buildings identified relevant to this GSMCP (subject to approval of the property owner), no more than six months prior to the commencement of dewatering.	Not applicable	Prior to commencement of construction.	Section 5.3.1
	Excavation dewatering (during construction)	Monthly visual inspections with photographic evidence of the surrounding ground and external facades of buildings identified, from the commencement of dewatering, or within one week of the completion of works for shorter duration activities[1]. This is to record any deterioration or further cracking after pre-construction conditions. Additionally, visual inspections with photographic evidence will be undertaken at intermediate intervals		A record is to be maintained of the time, date and any observations for each inspection. This record is to be maintained and submitted to AC every two months or upon reasonable request from the AC Representative. Results are to be	

Monitoring Type	Construction Stage	Minimum Measurement Frequency	Measurement Accuracy	Reporting Requirement to AC, unless otherwise stated	Relevant GSMCP Sections
		during construction if requested by the building or structure owner, following observation of cracking.		included in the monitoring report to AC every two months.	
	Post-construction dewatering	A post-construction condition survey shall be carried out six-twelve months after completion of dewatering.			
Ground Surface and Building Monitoring	Baseline (pre-construction)	Each ground settlement and building deflection monitoring mark shall be surveyed and recorded at least three times prior to the commencement of dewatering within 1 month prior to commencement of dewatering to establish baseline coordinates and elevation.	Horizontal and vertical accuracy of at least ±2 mm, or as otherwise achieved by precise levelling during baseline phase.	To be compiled and submitted to AC prior to the commencement of dewatering.	Section 5.3.2
	Excavation dewatering (during construction)	Weekly		A record is to be maintained of the time, date and any observations for each survey, and submitted to AC every two months.	
	Post-construction dewatering	Monthly for six months			
Retaining wall (excavation support) monitoring	Baseline (pre-excavation)	Twice within 1 month prior to the commencement of dewatering	Horizontal and vertical accuracy of at least ±2 mm, or as otherwise achieved by precise levelling during baseline phase.	To be compiled and submitted to AC prior to the commencement of excavation.	Section 5.3.3

Monitoring Type	Construction Stage	Minimum Measurement Frequency	Measurement Accuracy	Reporting Requirement to AC, unless otherwise stated	Relevant GSMCP Sections
	Excavation dewatering (during construction)	Retaining wall survey markers shall be surveyed and recorded at: • An average of each 2 metres depth excavation, at a minimum of once weekly; or • When changes to the propping system are being carried out; and • At a minimum frequency of weekly intervals from the commencement of dewatering.		A record is to be maintained of the time, date and any observations for each survey, and submitted to AC every two months.	
	Post-construction dewatering	Every two weeks, until construction is completed.			

[1] An activity of less than one month duration

3.2 ROLES AND RESPONSIBILITIES

The key management roles for each organisation in relation to groundwater and settlement management during the construction of the project are outlined in Table 3-3. Monitoring details and records shall be submitted to AC by those indicated as responsible.

Table 3-3: Specific roles and responsibilities.

Organisation	Role	Responsibilities
Watercare Services Limited (Watercare)	Consent Holder and Project Manager	• Overall responsibility for project compliance and performance in relation to environment, quality assurance and incident management. • Managing new or altered consents required during construction (if any).
Construction Contractor	Project Manager	• Overall responsibility for site management. • Accountable for the implementation of all Management Plans. • Review and implementation of this GSMCP.
	Environment and Sustainability Manager	• Prepare, review and update this GSMCP. • On-site compliance with consent conditions and other requirements and tracking compliance information. • Reviewing and reporting on environmental performance. • Monitoring and inspection of works to assess compliance with the GSMCP. • Implementation of the GSMCP including monitoring, interpretation and reporting. • Inspections, auditing and checking of environmental management practices and procedures. • Obtaining any new or varied consents required due to construction techniques or design changes. • Facilitate and oversee environmental monitoring. Update and maintain the environmental portion of the Project Risk Register. • Training of all staff including subcontractors.
Subcontractors	Project and Site Engineers	• Review and interpret monitoring observations and trends and communicate to the relevant members of the construction team. • Identify and respond to alert levels and manage contingency measures. • Overseeing subcontractors.
	Site Managers	• Adherence to the GSMCP
Independent	Asset Condition Engineer	• Undertake asset dilapidation surveys where exposed, by a suitably qualified and experienced professional (SQEP).

4 PROPOSED GROUNDWATER MONITORING PLAN

4.1 INTRODUCTION

Groundwater levels will be monitored in the existing piezometer network that was utilised for the Mayoral Drive consent application assessment. The purpose of the groundwater monitoring is to confirm where the groundwater level is in relation to the set Alert and Alarm Levels.

The proposed groundwater monitoring requirements are the minimum to be implemented, and the Contractor is expected to adapt the groundwater monitoring plan to align it with their method of working. This means that the Contractor is expected to update the settlement monitoring plan as the works progress. Refer to the GSMCP purpose in Section 1.2.

4.2 PROPOSED MONITORING PLAN

It is proposed that groundwater levels are monitored before any excavations to establish the initial baseline conditions, throughout the earthworks and dewatering and beyond the end of the construction process. It is proposed that monitoring comprises a piezometer for each of the Mayoral Drive Alignment Shafts. The monitoring network will incorporate the existing investigation piezometers installed for the consent application assessment which have been located near or at the proposed shafts, but where piezometers are not within proximity, a new piezometer will be required. Should the monitoring piezometer be damaged and become inoperable during construction works, then AC is to be informed, and a new monitoring piezometer is to be drilled at an appropriate nearby location, if required. Monitoring in these piezometers will be to assess whether the dewatering effects are within the estimated range of groundwater drawdown levels and signal whether the Alert and Alarm levels have been exceeded. The piezometer details are listed in Table 4-1 and the location shown on the monitoring plan in Appendix A. The modelling data at this location are used to define trigger levels.

Table 4-1: Monitoring well details.

Monitoring well ID	Dewatered shaft	Depth (m bgl)	Screened interval (m bgl)	Distance to shaft edge (m)
PZE2	P4MH3	8.58	5.08 – 8.58	12.9
PZE1*	P4MH2	TBC	TBC	TBC
PZD1	P4MH1	7.93	4.93 – 7.93	8.4
PZC1	P5MH2	7.7	4.70 – 7.70	5.6
PZ-P1MH2 (near PZA1)**	P1MH2	TBC	TBC	TBC

* Piezometer within the proposed excavation and will need to be redrilled in a suitable location approximately 5 m from the edge of the excavation

**PZA1 was temporarily constructed as a piezometer to allow for accurate groundwater level measurements. A suitable replacement piezometer will need to be redrilled approximately 5 m from the edge of the excavation.

4.3 PROPOSED MONITORING METHODOLOGY

It is proposed that groundwater levels are monitored using automatic pressure transducers set at 15-minute intervals. The specified monitoring frequency in Table 3-2 is considered the minimum frequency at which the data is retrieved and processed. The transducers should have a minimum accuracy of ± 10 mm.

4.4 GROUNDWATER TRIGGER LEVELS

Groundwater drawdown as a result of the project works has been modelled by WSP and modelled drawdowns have been used to set the groundwater trigger levels. Two alert levels, as opposed to a single alert and alarm level, is set because the settlement itself will be measured, and any mitigation or contingency will be based on those settlement responses. The alert trigger levels will provide notification that groundwater responses to the construction works are nearing those estimated and that such groundwater responses may be close to having implications for surface settlement. Management actions following exceedance of these alert levels are described in Section 6.

The first alert level will be set as the lowest groundwater level considering seasonal variation, plus a dewatering drawdown as per Table 4-2. The second alert level will be set as an additional 0.5 m of drawdown. A schematic diagram of monitoring sites and groundwater alert levels is shown in Figure 4-1.

Confirmation of the exact groundwater trigger levels requires completion of the baseline readings and identification of the lowest seasonal groundwater level.

If the Alert levels are reached, the actions outlined in Section 6 shall be carried out.

Table 4-2: Proposed alert groundwater levels for monitoring piezometer.

Piezometer	**Seasonal low groundwater level**	**Alert level 1** (expected drawn down groundwater level)		**Alert level 2** (0.5 m below expected drawn down groundwater level)	
	Level (m RL)	*Level (m RL)*	*Depth (m bgl)*	*Level (m RL)*	*Depth (m bgl)*
PZE2	*16.75*	14.75 m	5.25 m	14.25 m	5.75 m
PZE1 (is within the excavation footprint and must be replaced)	TBC	TBC	TBC	TBC	TBC
PZD1	19.25	18.00	7.50	17.50	8.00
PZC1	23.30	20.30	6.00	19.80	6.5
PZ-P1MH2	TBC	TBC	TBC	TBC	TBC

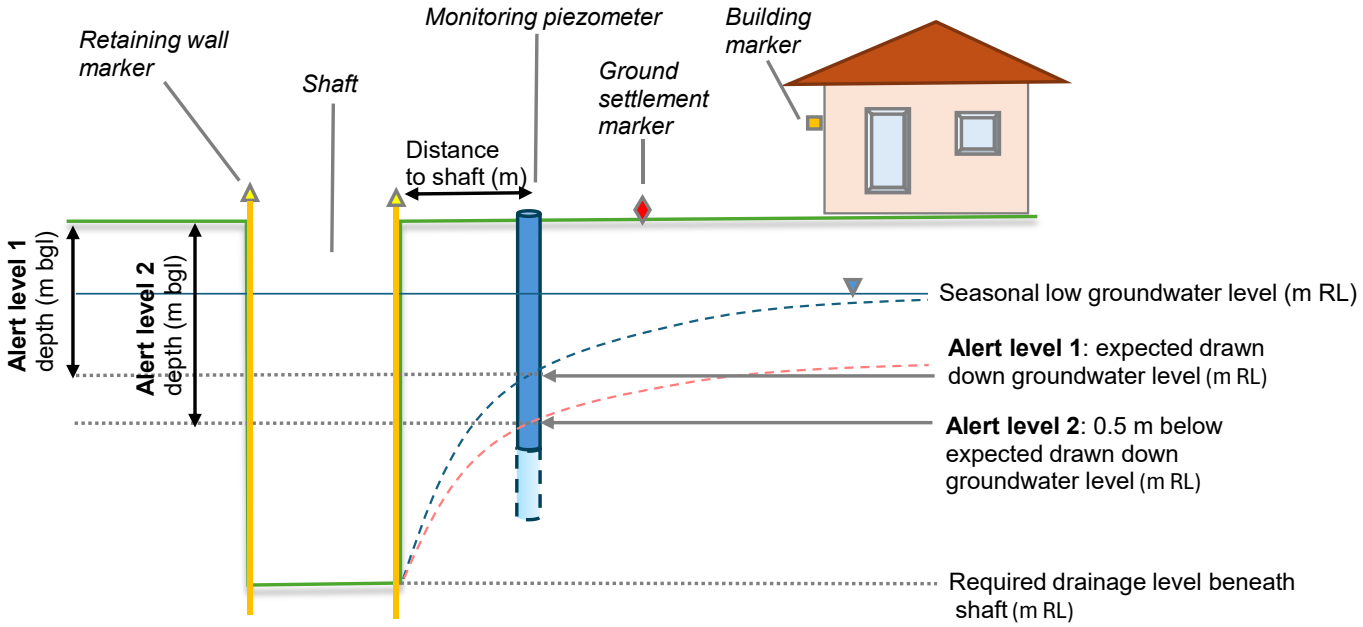


Figure 4-1: Schematic diagram showing monitoring sites and groundwater alert levels (not to scale).

5 PROPOSED SETTLEMENT AND DEFLECTION MONITORING PLAN

5.1 INTRODUCTION

The settlement monitoring plan provides advance warning if the ground is settling more than estimated. This provides time for mitigation or rectification works to be identified and implemented.

5.2 PROPOSED MONITORING PLAN

The settlement monitoring will use visual inspections, ground settlement markers, building markers, and retaining wall markers for monitoring the area around the shaft excavations. The proposed methodology is detailed below.

A preliminary plan showing the proposed location of monitoring points is included in Appendix B. This plan will be updated by the Contractor with as-built locations following installation of the monitoring points and their pre-construction survey.

5.3 PROPOSED MONITORING METHODOLOGY

5.3.1 CONDITION SURVEYS AND VISUAL INSPECTIONS

Pre- and post-construction condition surveys will be undertaken on all assets (buildings and services) assessed to be susceptible to settlement. During construction additional visual inspections shall be undertaken with additional condition surveys performed as required by this plan.

The inspections and subsequent evaluations will be undertaken and reported on by a SQEP and shall include:

- For all inspections, approval from the asset owner shall be acquired.
- Type and arrangement of foundations.
- Condition of the existing asset including any pre-existing damage and the type of damage (e.g., aesthetic, serviceability impact).
- Photographic evidence of the above.

Visual inspections of the external building fronts facing the excavation, up to 20 m on either side of the excavation, must be undertaken for the purpose of detecting any existing external damage or new external damage or deterioration of building fronts. The sites to be surveyed are the buildings and structures at:

- Condition surveys along 323 – 327 Queen Street
- Conditions surveys along 67 – 101 Vincent Street (Specifically the stone wall that encloses the basement carpark).
- Visual inspections for the crib wall underneath the Myers Park overpass.
- Visual inspections for the small retaining wall at 100 Mayoral Drive.
- Visual inspections for the Millennium Hotel underpass.

Pre-construction

The details and photographs of the pre-construction condition surveys, as outlined above, shall be recorded and submitted to AC before the commencement of dewatering. Although not currently required, if internal access to the property is required and cannot be reasonably obtained, this shall be reported to AC and an alternative monitoring option implemented for the duration of the project or until access can be obtained. As a minimum, high resolution photographs of the exterior of the building or asset should be taken from publicly accessible locations.

During construction

Visual inspections of the structure and surrounding ground of the assets identified in the pre-construction survey shall be performed at monthly intervals or if requested by the building or structure owner. Additional inspections may be required as part of the contingency measures associated with the ground settlement trigger levels.

A record shall be kept of the visual inspections, including time and date, asset inspected, and any observations made. The result of the inspection shall be compared against the pre-construction condition surveys to determine if any damage has occurred.

Post-construction

A post-construction inspection will be completed for each asset six months after completion of the dewatering or as otherwise agreed with the owner. In addition to the details recorded in the pre-construction inspection, the survey should note whether any additional damage has occurred to the structure and the probable cause of such damage. If damage or other type of deterioration has occurred to any building or structure as a result of the construction works, remedial actions must be taken as soon as practicable and in accordance with the GSMCP.

5.3.2 GROUND SURFACE, STRUCTURES AND BUILDING MONITORING

The purpose of the ground surface and building monitoring is to confirm that actual settlements are within the estimated settlement range, as a precautionary measure. The maximum total and differential settlements based on the modelling described in the specialist report (WSP, 2025) are estimated to be low and are therefore expected to be within the negligible to very slight damage category. Trigger levels are based on these estimated settlements.

Ground settlement, structures and building markers will be installed at selected locations around the shaft excavations, at the approximate locations indicated on the plans in Appendix B. The locations were selected as follows:

- The markers should be placed to allow for ease of access for pre and post construction monitoring.
- A set of markers should be placed at the toe of the crib wall that covers the fill underneath the Myers Park overbridge abutments. These markers have been given the descriptor ID of “CW”. These markers are to monitor settlement during the dewatering of P4MH2 and P4MH3.

- A set of markers have been placed on the Myers Park overbridge approaches, within the footpath next to Mayoral drive. Their locations have been paired with the crib wall markers to understand overall effects on the overbridge if P4MH3 requires dewatering. These markers have been given the descriptor ID of “OB”.
- Two markers have been placed at the headwall ends of the Millennium Hotel underpass that is adjacent to the proposed P5MH2 access shaft. Ground markers have been placed near the underpass markers to assess the potential overall effect on the underpass structure. These markers have been given the descriptor ID of “MU”.
- Building markers have been placed in association with construction at the P4MH3, P5MH2 and P1MH2 shafts. 323-327 requires two building markers at its southwest and northwest corners. Three building markers are to be placed on the building at 71-87 Mayoral Drive, one at the circular wall near the fire hydrant and two at the small retaining wall structures that sit next to the footpath.

Pre-construction

Existing levels will be determined for each marker by at least three baseline surveys taken prior to any dewatering commencing. The surveys shall record both the coordinates and elevation of the markers. Additional pre-construction monitoring may be required if any pre-existing evidence of ground movement is identified by the initial surveys. The existing levels will be recorded and submitted to AC before beginning dewatering.

During construction

Markers at the shaft location shall be surveyed once a week.

The results of the surveys shall be recorded in a database and compared against the baseline levels. During dewatering, and until settlements have stabilised, AC shall be provided with the results of the weekly monitoring and a summary report of the ground settlement, with interpretation, in a report every two months.

Post-construction

Following completion of the dewatering, surveying of the markers shall be continued monthly for six months or until the position of the markers is found to have stabilised and approval is given in writing by AC.

5.3.3 SHAFT RETAINING STRUCTURE MONITORING

The purpose of the retaining structure monitoring is to confirm that actual deflections remain within the estimated range. Trigger levels are based on the estimated deflections, as provided by ENGEO (contained within WSP, 2025).

Four retaining wall markers will be installed at the mid-point at the top of each the shaft’s perimeter walls. These markers are presented on each of the 5 location plans presented in Appendix B.

Monitoring can only be conducted once the relevant construction parts of the retaining structure, i.e. the secant piles, have been completed and as excavation commences.

Pre-construction

Existing levels will be determined for each marker by at least two baseline surveys taken prior to any of the dewatering commencing. The surveys shall record both the vertical and horizontal positions of the marker. Additional pre-construction monitoring may be required if any pre-existing ground settlements are identified by the initial surveys. The existing levels will be recorded and submitted to AC before beginning shaft excavation works.

During construction

Markers at the shaft location shall be surveyed once for every two metres depth (on average) of excavation, and, in any case, at a minimum of once a week.

The results of the surveys shall be recorded in a database and compared against the baseline levels. The database should include the depth of the excavation at the time of the survey. During excavation, and until settlements have stabilised, AC shall be provided with the results of the weekly monitoring and a summary report of the ground settlement, with interpretation, in the monitoring report to AC every two months.

The results of the surveys shall be recorded in a database and compared against the estimated levels. AC shall be provided with the results of the monitoring and a summary report of the ground settlement, with interpretation, in the monitoring report to AC every two months.

5.3.4 MONITORING OF UTILITIES AND INFRASTRUCTURE

The shaft excavation will be undertaken in proximity to various existing underground services including water, wastewater, stormwater and electricity. These services are constructed of different materials to various standards, at different depths and locations, and as such are likely to have varying tolerances to deformation. Therefore, settlement trigger levels based on conservative assessment of damage to typical services (refer WSP, 2025[1]) are applied. The asset owners shall be consulted to confirm deformation tolerances of the given assets, and the associated proposed monitoring is suitable.

Prior to construction a pre-condition survey shall be undertaken on services that are accessed for relocation. The survey may comprise a CCTV condition assessment of services accessed for relocation for up to 20 m from the excavation, carried out by a SQEP, and shall include the following but are not limited to:

1. Existing levels of aesthetic damage.
2. Existing levels of serviceability damage.
3. Existing levels of structural damage.
4. Existing top of pipe/invert RL (GPS).
5. Photographic/video evidence of (1), (2), and (3) above.

If the total or differential Alarm limits are reached during construction close to the shaft (less than 20 m), a post-construction survey will be done within six months of completion of the dewatering activity covering the items detailed above.

A copy of the pre- and post-construction survey report shall be forwarded to AC within 15 working days of completing the reports along with a certificate from the SQEP who has certified that the survey has been completed in a professional manner and is an accurate assessment of the condition of the structure concerned.

The proposed ground settlement markers will be used for monitoring for the underground services as well.

If the trigger levels are exceeded, the actions outlined in Section 6 shall be carried out.

5.4 SETTLEMENT TRIGGER LEVELS

Two trigger levels are set for all settlement monitoring points:

- Alert: Measured settlements are still within normal levels but are approaching those predicted (≥ 70%) in the settlement assessment. Alert levels have been set to 70% of estimated settlement levels at the markers, or, for estimated settlement less than very slight damage levels (10 mm), alert levels have been set to 70% of damage levels (i.e., 7 mm).

[1] WSP, 2025. Queen Street Wastewater Diversion Programme: Mayoral Drive Alignment Project. Dewatering and Settlement Assessment.

— Alarm: Measured settlements have reached those predicted. Alarm levels have been set to 100% of estimated settlement levels at the markers, or, for estimated settlement less than damage levels (10 mm), alert levels have been set to very slight damage levels (i.e. 10 mm).

Details of the trigger levels for all monitoring points are provided in Table 5-1 to Table 5-5.

Trigger levels are based on the settlements estimated in the design and do not necessarily imply potential for damage to occur if they are exceeded. These trigger levels are based on an initial estimate of effects, and the Contractor may adopt more rigorous levels if needed for services condition surveys or because of further developments or changes in the design. At least 10 working days prior to adopting any change in trigger levels the Contractor will submit to AC the change in trigger levels for review.

Table 5-1: Estimated settlement and trigger levels for monitoring locations near P4MH3.

P4MH3								
Marker ID	**Distance to shaft edge (m)**	**Maximum estimated settlement (mm)**	**Trigger level (mm) - Ground**		**Trigger levels – differential settlement**			**Justification for marker locations**
			Alert	**Alarm**	**Pairing Marker**	**Alert**	**Alarm**	
Ground settlement markers								
G1	7.7	15	11	15	B1	1/1,500	1/1,000	Related to heritage building at 323-327 Queen Str.
Crib wall markers								
CW1	1.2	18	13	18	CW2/CW3	1/700	1/400	Proximity to shaft and magnitude of predicted settlement at ground level.
CW2	6.1	15	11	15	CW1			
CW3	3.8	18	13	18	CW1			
CW4	17.3	17	12	17	-	1/700	1/400	
CW6	1.2	18	13	18	-	1/700	1/400	To measure effects at the crib wall mid-height
CW7	6.1	15	11	15	-	1/700	1/400	
CW8	3.8	18	13	18	-	1/700	1/400	
CW9	17.3	17	12	17	-	1/700	1/400	
Overbridge markers – Mayoral Drive overbridge approach embankment								
OB1	1.8	18	13	18	OB2/OB3	1/700	1/400	Relate CW readings to surface settlement and observations.
OB2	6.9	15	11	15	OB1			
OB3	4.0	18	13	18	OB1			
OB4	11.9	10	7	10	-	1/700	1/400	To measure effects at the crib wall mid-height
OB5	16.6	7	5	7	-	1/700	1/400	
Building markers								
B1	21.5	7	5	7	B2	1/1,000	1/700	Direct readings on heritage building at 323-327 Queen Str.
B2	33.1	7	5	7	B1	1/1,000	1/700	
Retaining wall markers								
RW1	0	18	13	18				Stability of support, contribution of mechanical movements to settlement outside shaft.
RW2	0	18	13	18				
RW3	0	18	13	18				
RW4	0	18	13	18				

Table 5-2: Estimated settlement and trigger levels for monitoring locations near P4MH2.

P4MH2								
Marker ID	**Distance to shaft edge (m)**	**Maximum estimated settlement (mm)**	**Trigger level (mm) - Ground**		**Trigger levels – differential settlement**			**Justification for marker locations**
			Alert	**Alarm**	**Pairing Marker**	**Alert**	**Alarm**	
Ground settlement markers								
G2	6.9	33	23	33	CW5	1/500	1/200	Effects away from shaft due to extensive cone of predicted dewatering.
G3	33.5	30	21	30	G2/G5	1/2,000	1/1,000	
G4	45.5	29	20	29	G2	1/2,000	1/1,000	
G5	36.0	30	21	30	G2	1/2,000	1/1,000	
G5a	25.0	30	21	30	G2	1/2,000	1/1,000	
Crib wall markers								
CW5	17.5	29	20	29	CW4	1/700	1/400	Total and differential settlement along crib wall
CW10	17.5	29	20	29	CW4	1/700	1/400	Total and differential settlement along top of crib wall
Retaining wall markers								
RW5	0	31	22	31	-	-	-	Stability of support, contribution of mechanical movements to settlement outside shaft.
RW6	0	31	22	31	-	-	-	
RW7	0	30	21	30	-	-	-	
RW8	0	30	21	30	-	-	-	

Table 5-3: Estimated settlement and trigger levels for monitoring locations near P4MH1.

P4MH1								
Marker ID	**Distance to shaft edge (m)**	**Maximum estimated settlement (mm)**	**Trigger level (mm) - Ground**		**Trigger levels – differential settlement**			**Justification for marker locations**
			Alert	**Alarm**	**Pairing Marker**	**Alert**	**Alarm**	
Ground settlement markers								
G6	6.7	22	15	22	-	-	-	Assess magnitude and extent of settlement
G7	9.1	23	16	23	-	-	-	
Building markers								
B2a	12.7	19	13	19	-	-	-	Effects on retaining wall
Retaining wall markers								
RW9	0	20	14	20	-	-	-	Stability of support, contribution of mechanical movements to settlement outside shaft.
RW10	0	20	14	20	-	-	-	
RW11	0	20	14	20	-	-	-	
RW12	0	20	14	20	-	-	-	

Table 5-4: Estimated settlement and trigger levels for monitoring locations near P5MH2.

P5MH2								
Marker ID	**Distance to shaft edge (m)**	**Maximum estimated settlement (mm)**	**Trigger level (mm) - Ground**		**Trigger levels – differential settlement**			**Justification for marker locations**
			Alert	**Alarm**	**Pairing Marker**	**Alert**	**Alarm**	
Ground settlement markers								
G8	10.0	13	9	13	-	-	-	Assess magnitude and extent of settlement
G9	17.2	9	7	9	-	-	-	
G10	9.2	14	10	14	-	-	-	
G11	13.9	9	7	9	-	-	-	
G12	17.7	4	3	4	-	-	-	
Millennium underpass markers								
MU1	12.4	13	9	13	-	-	-	Assess structure settlement.
MU2	23.3	4	3	4	-	-	-	
Building markers								
B3	11.0	14	10	14	G10	1/1000	1/500	
Millennium retaining wall markers								
MRW1	15.0	14	10	14	-	-	-	Effects on retaining walls.
MRW2	17.2	14	10	14				
Retaining wall markers								
RW13	0	18	13	18	-	-	-	Stability of support, contribution of mechanical movements to settlement outside shaft.
RW14	0	18	13	18	-	-	-	
RW15	0	18	13	18	-	-	-	
RW16	0	18	13	18	-	-	-	

Table 5-5: Estimated settlement and trigger levels for monitoring locations near P1MH2

P1MH2								
Marker ID	**Distance to shaft edge (m)**	**Maximum estimated settlement (mm)**	**Trigger level (mm) - Ground**		**Trigger levels – differential settlement**			**Justification for marker locations**
			Alert	**Alarm**	**Pairing Marker**	**Alert**	**Alarm**	
Ground settlement markers								
G13	11.9	9	7	9	-	-	-	Assess magnitude and extent of settlement
G14	11.7	5	4	5	-	-	-	
Building markers								
B4	13.5	5	4	5	G14	1/700	1/400	Effects on retaining wall
Retaining Wall Markers								
RW17	0	16	11	16	-	-	-	Stability of support, contribution of mechanical movements to settlement outside shaft.
RW18	0	16	11	16	-	-	-	
RW19	0	14	10	14	-	-	-	
RW20	0	14	10	14	-	-	-	

The following trigger levels are set for monitoring of services:

- Alert – total ground settlement measured at any ground marker exceeding 30 mm.
- Alarm – total ground settlement measured at any ground marker exceeding 50 mm.
- Alert – differential settlement calculated between two adjacent markers exceeding 1:300
- Alarm – calculated differential settlement between two adjacent markers exceeding 1:200.

6 PROPOSED RESPONSE, MITIGATION AND CONTINGENCY PLAN

6.1 GROUNDWATER LEVELS

Dewatering of the excavations is expected and planned for as a part of the construction works. Groundwater monitoring will be used to confirm the groundwater levels are responding as estimated in the modelling.

Two alert levels for groundwater level monitoring have been set, as described in Section 4, with each alert level requiring specific management actions as follows:

Alert level 1 exceedance:

- The Contractor will notify and advise AC of the alert level exceedance within 24 hours.

Alert level 2 exceedance:

- The Contractor will notify and advise AC of the alert level exceedance within 24 hours.
- The Contractor will increase the groundwater level, ground settlement and building deflection monitoring frequency at the location of exceedances to daily. This monitoring frequency will continue if a ground settlement or building deflection trigger level has been exceeded as well. If no further settlement or building deflection occurs, the frequency reverts back to weekly.
- Monitoring results are to be submitted to AC.

If ground settlement and/or building deflection trigger levels are exceeded as well, further actions are required as outlined in Section 6.2 below.

6.2 GROUND SETTLEMENT AND BUILDING DEFLECTION

The settlement and deflection monitoring will be used to confirm if ground and building settlements are within the estimated range (WSP, 2025). Responses and mitigation measures, as outlined below, are required in the unlikely event that alert or alarm trigger levels (described in Section 5) are exceeded:

Alert level exceedance:

“Alert” exceedance level means the ground settlement is still less than expected but approaching the estimated settlement. In the event of an alert exceedance the following steps shall be taken:

- The Contractor will notify and advise AC of the alert level exceedance within 24 hours.
- The Contractor will re-measure all monitoring stations within 20 m of the affected monitoring location to confirm the extent of apparent settlement and/or deflection. Re-measurements are undertaken for all these monitoring stations every two days until the written report has been submitted to AC.
- Prepare to institute mitigation measures in consultation with the consultants. These may include measures to reduce dewatering, increase the stiffness of the support measures etc.
- A written report, prepared by a SQEP, is to be submitted to the Council within five working days of the Alert Level exceedance.

Alarm level exceedance:

“Alarm” exceedance means the ground settlement has reached or exceeds the estimated settlement, and any further settlement and/or deflection may cause damage to nearby buildings or structures. Note that asset damage is still not expected at this level. In the event of an alarm exceedance the Contractor will take the following steps:

- Initiate a “stop work” and implementation of mitigation measures as outlined following the Alert level exceedance, or as otherwise required to minimise risks of damage to nearby buildings and structures.
- Notify AC within 24 hours of the Alarm Level exceedance and provide details of measurements taken.
- The works will be assessed by a SQEP to identify the reasons for the ground settlements and reconsider the design assumptions.
- Undertake a condition survey by a SQEP on any building or structure located adjacent to any monitoring station where the Alarm Level has been exceeded.
- The SQEP will recommend and oversee the implementation of mitigation measures such as additional ground support (e.g., additional struts or anchors and / or recharge wells) to reduce further settlement and/or deflection and prevent asset damage. The SQEP may also propose additional monitoring instrumentation be installed at the affected area.
- Within five working days of recommencement of works, a report will be prepared by the SQEP and submitted to AC of the alarm exceedance being identified. The report will an analysis of all relevant monitoring data and comparison with the initial design, details of the mitigation measures implemented and the estimated risk of further ground settlement. The report will also include the results of the condition surveys and of asset damage, as well as any remedial works and/or agreements with affected parties.

6.3 RESPONSE TO DAMAGE

6.3.1 BUILDING DAMAGE

Building monitoring is proposed to establish early warning systems against significant damage. Thus, if a building is found to have been damaged as a result of the construction works, either from a post-construction survey or one requested during construction, AC will be immediately notified as per the above. Should repairs be required, these will be undertaken at the cost of the Contractor as soon as practicable. The timing and extent of repairs may vary depending on the building owner’s requirements.

6.3.2 UTILITY AND INFRASTRUCTURE DAMAGE

If trigger levels, in particular differential settlement trigger levels are exceeded at monitoring points related to utilities or infrastructure, the Contractor will immediately notify AC and the utility provider. A condition survey will be undertaken to determine the level and extent of any damage. Should the survey find that damage has occurred as a result of the construction works, the Contractor will notify AC and propose a methodology to repair the damage and prevent further damage.

7 GSMCP REVIEW

The Contractor will review the current plan at least quarterly or to reflect any material changes that occur throughout the course of the project in regard to site conditions, ground conditions or construction methodology. The Contractor's plan and any reviews will be approved in accordance with the Contractor's internal governance process. The reviews must take into consideration:

- Compliance with resource consent conditions, the GSMCP and material changes to these plans.
- Any changes to construction methodology.
- Key changes to roles and responsibilities within the project.
- Changes in industry best practice standards.
- Results of monitoring and reporting procedures associated with the management of adverse effects during construction.
- Any comments or recommendations received from AC regarding the GSMCP.
- Any unresolved complaints and any response to the complaints and remedial action taken to address the complaint as required by the relevant resource consent conditions.
- All affected parties will be notified of the review and any material changes proposed. Any material change proposed shall also be subject to an independent peer review and will be submitted to AC for review.

A copy of the Contractor's operative GSMCP document and subsequent revisions will be kept for the Project Records. Each new/updated revision of the GSMCP documentation will be issued with a revision number and date, and previous will be marked as superseded.

APPENDIX A:

FULTON HOGAN HIGH-LEVEL CONSTRUCTION METHODOLOGY

Construction Methodology

Queen Street Wastewater Diversion – Package B

Contract No: CT7754

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

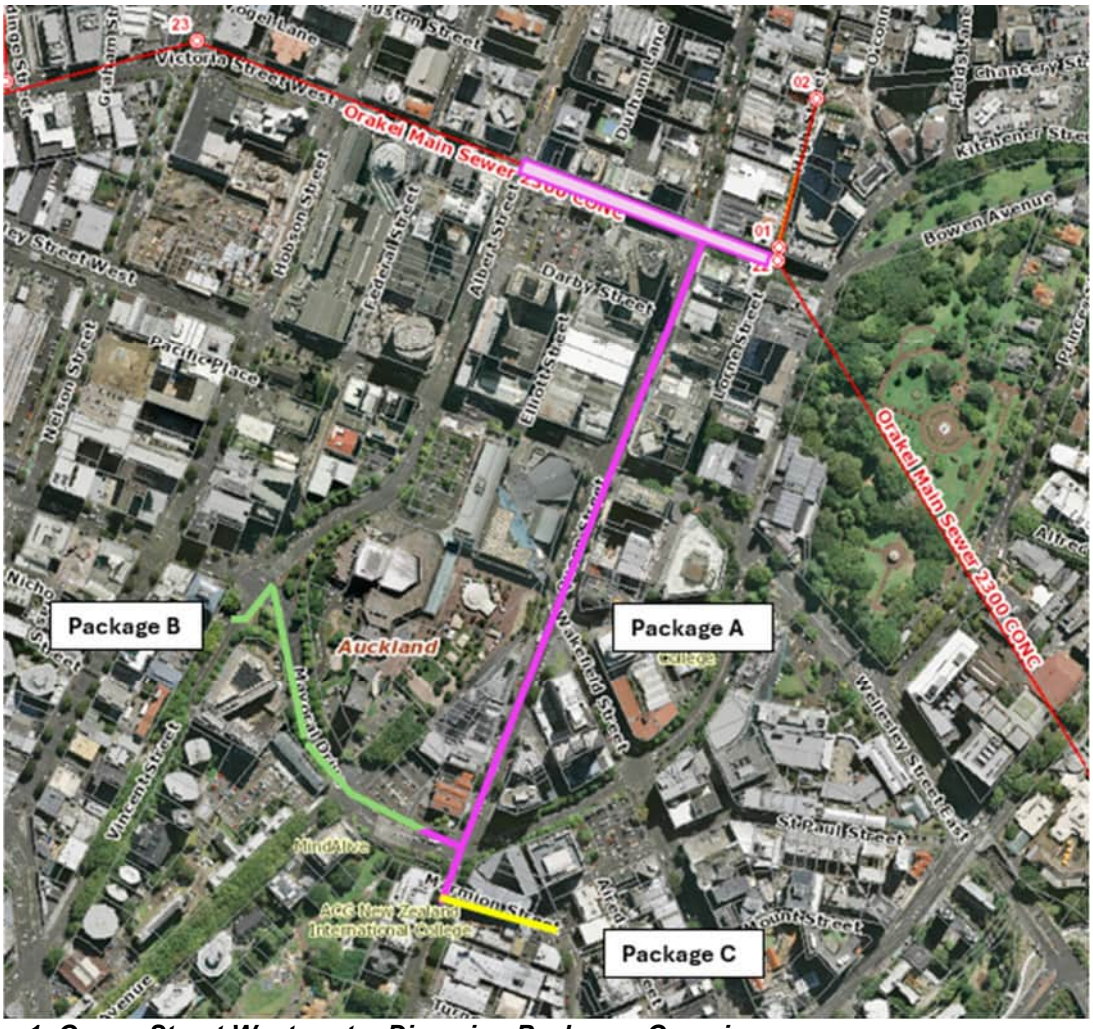


Figure 1: Queen Street Wastewater Diversion Packages Overview

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).

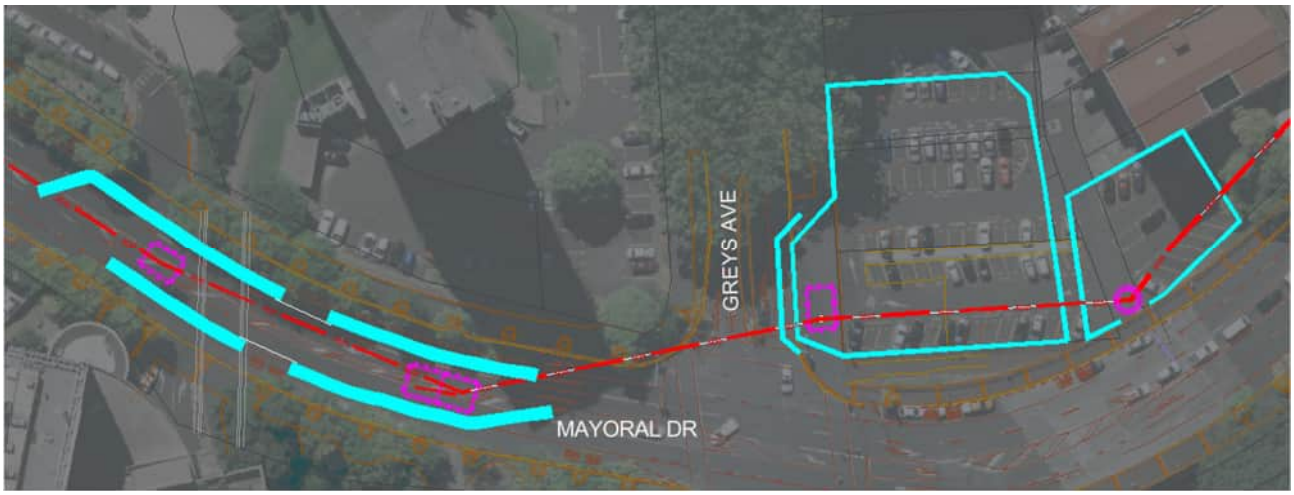


Figure 3: Two long-term compounds on Mayoral Drive/Greys Avenue (compound extents shown with blue line)

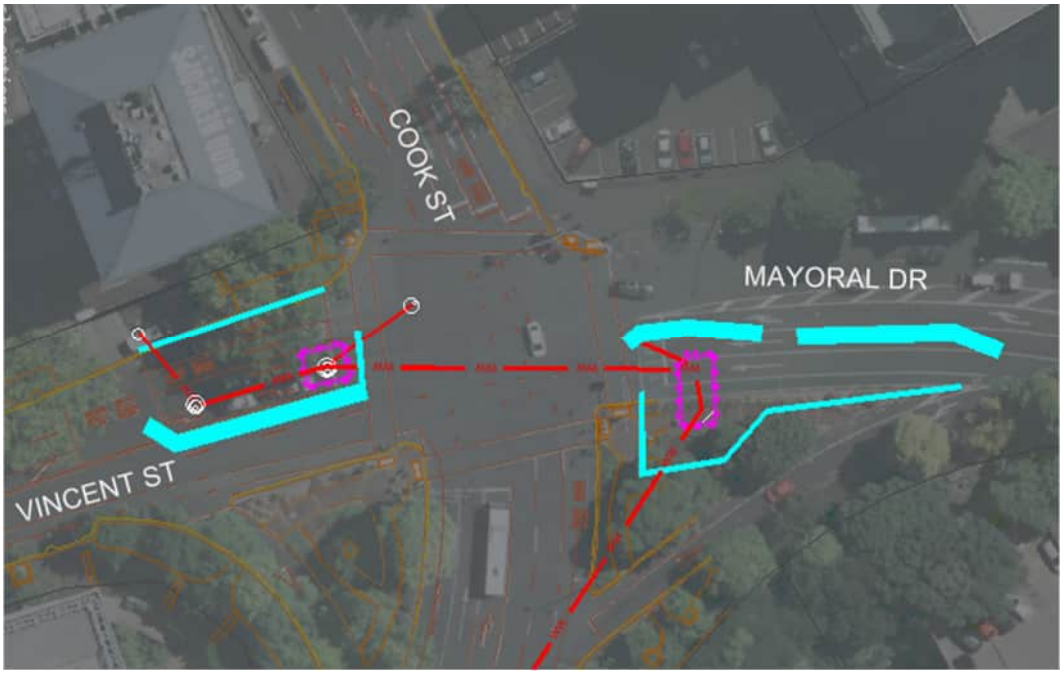


Figure 4: Two long-term compounds at Cook St/Mayoral Drive/Vincent St intersection (compound extents shown with blue lines)

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.

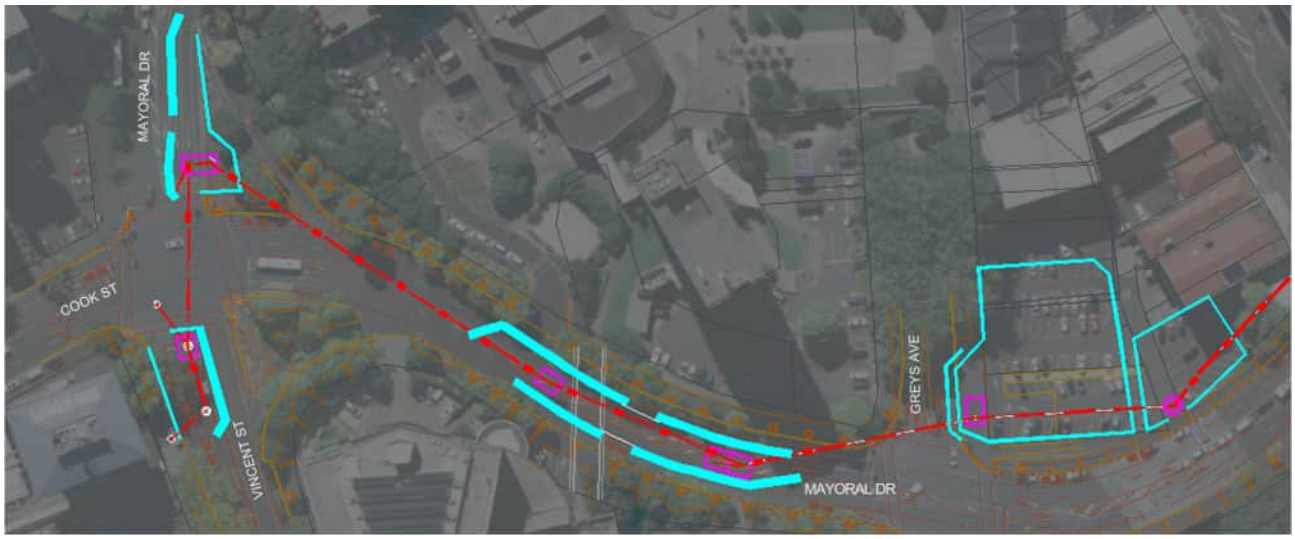


Figure 5: Main Construction Works Overview

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.

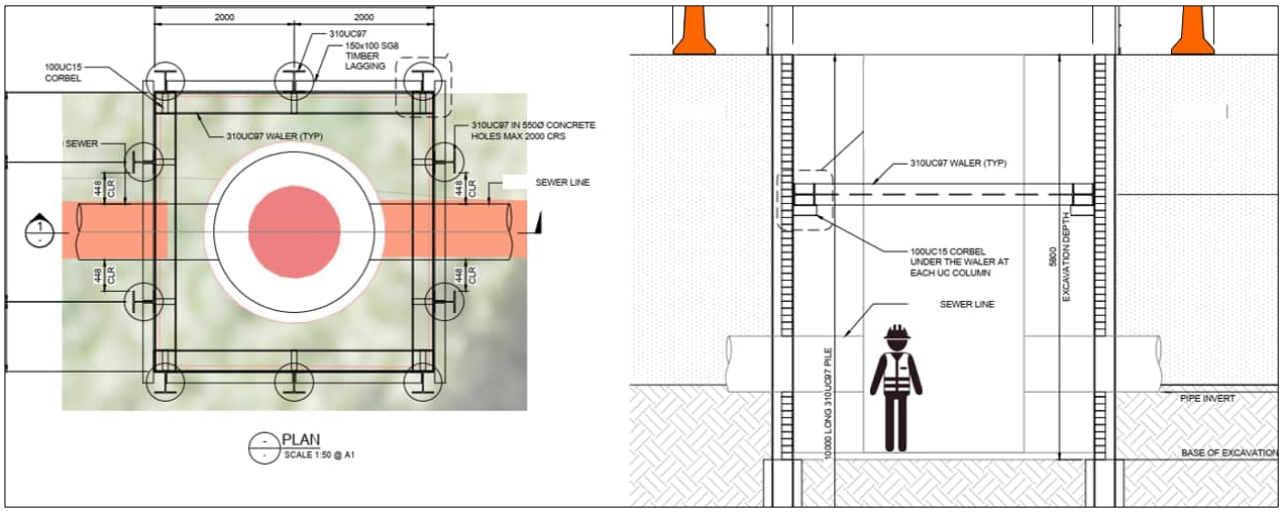


Figure 6 – Typical temporary works detail for shafts (A. O'Sullivan & Associates)

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).

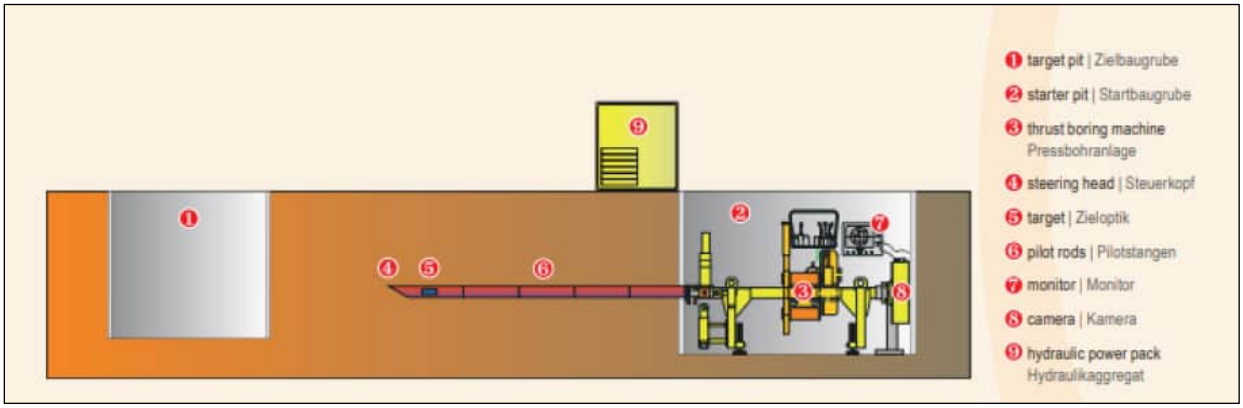


Figure 7 – Typical pilot bore – pilot process

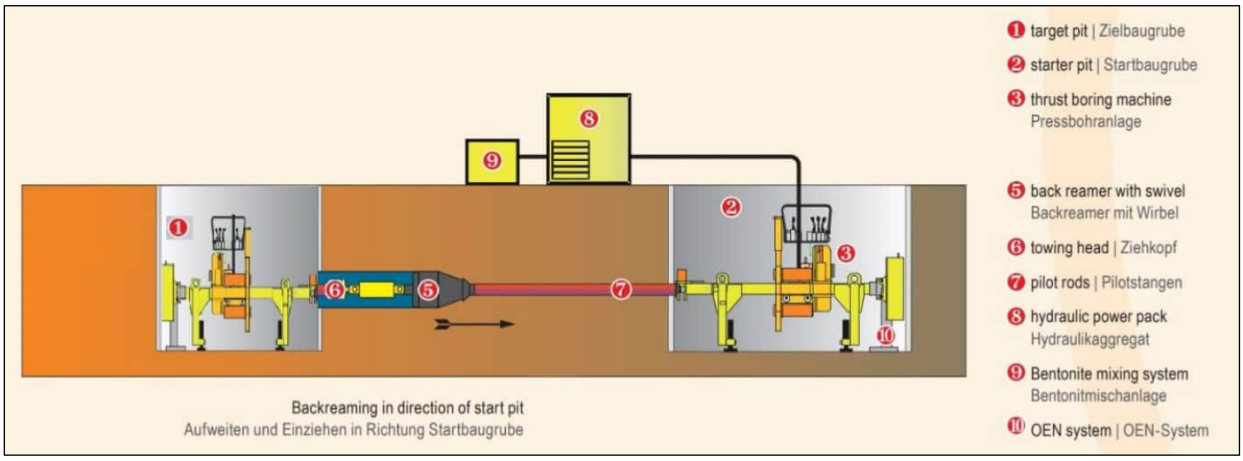


Figure 8 – Typical pilot bore – cutting back

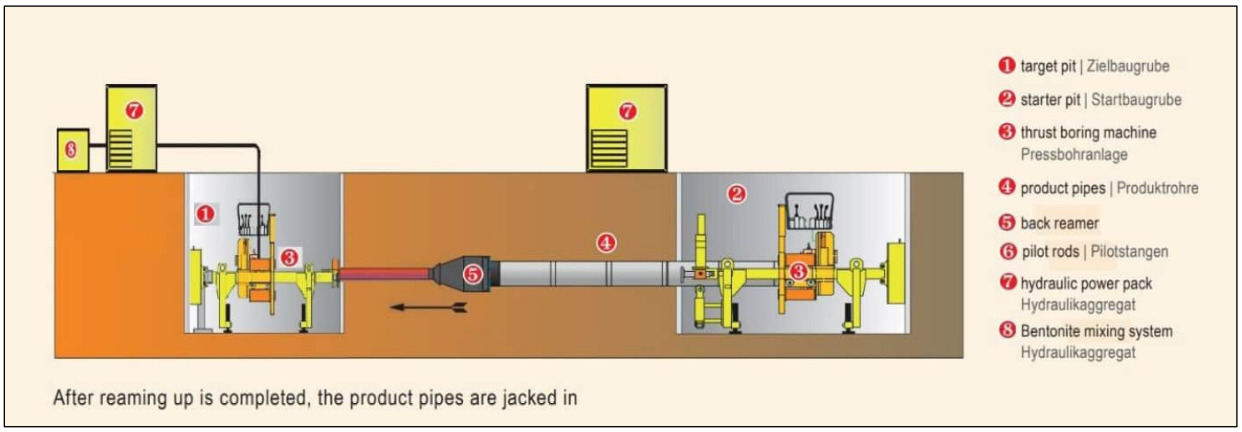


Figure 9 – Typical pilot bore – jacking pipes in

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).

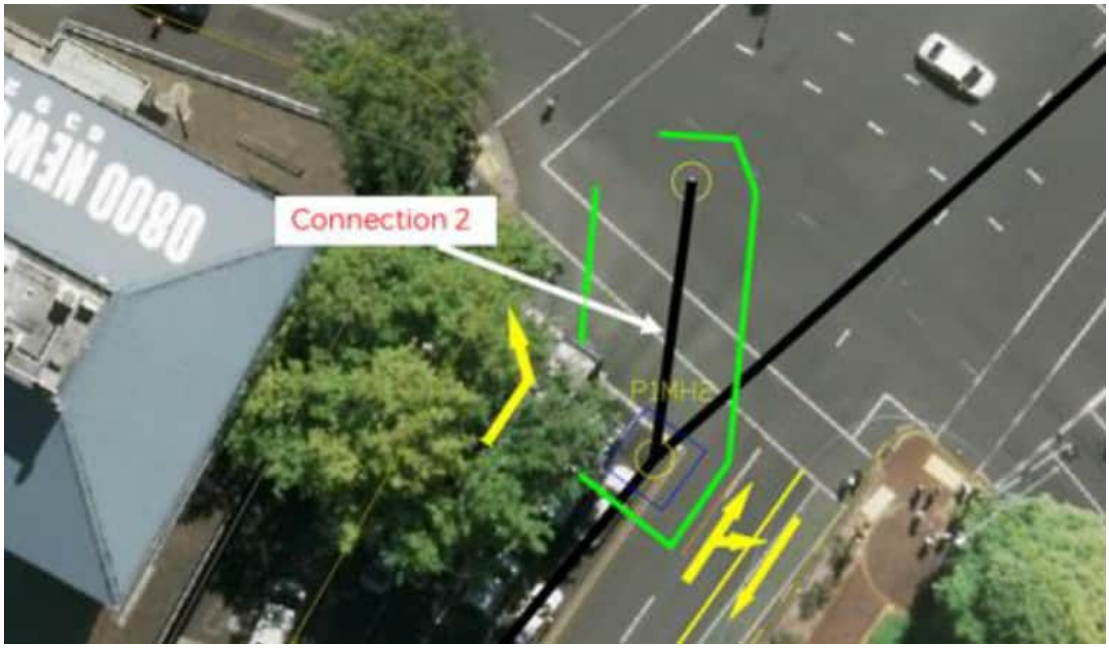


Figure 10 – Plan view of short-term TM for an EOP connection using opencut method

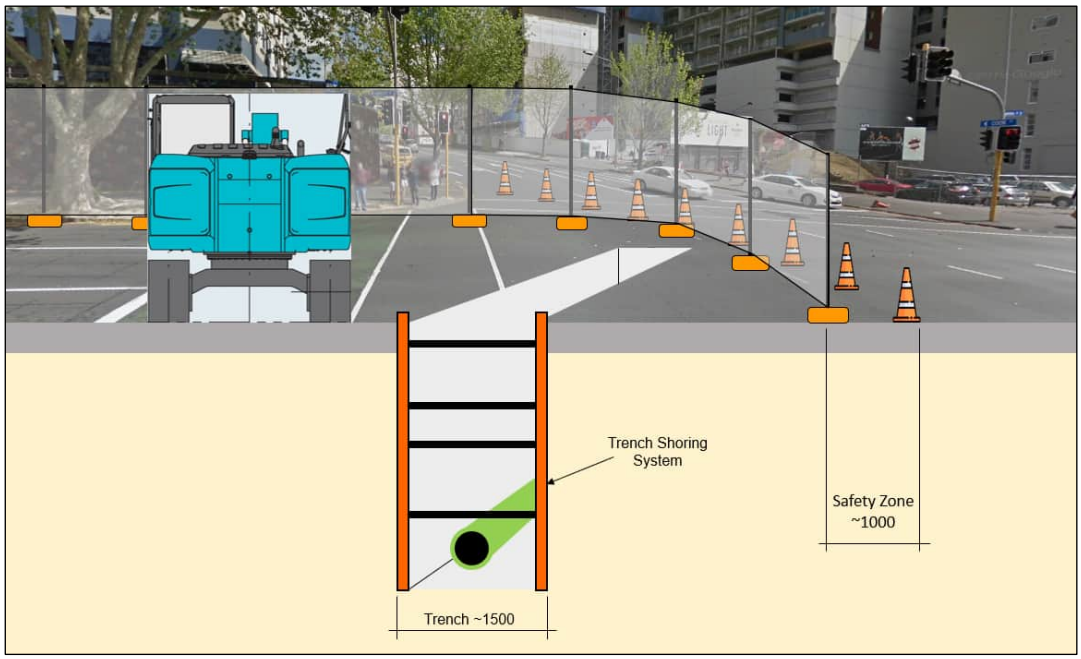


Figure 11 – Trench shoring system for EOP connection using the opencut method

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

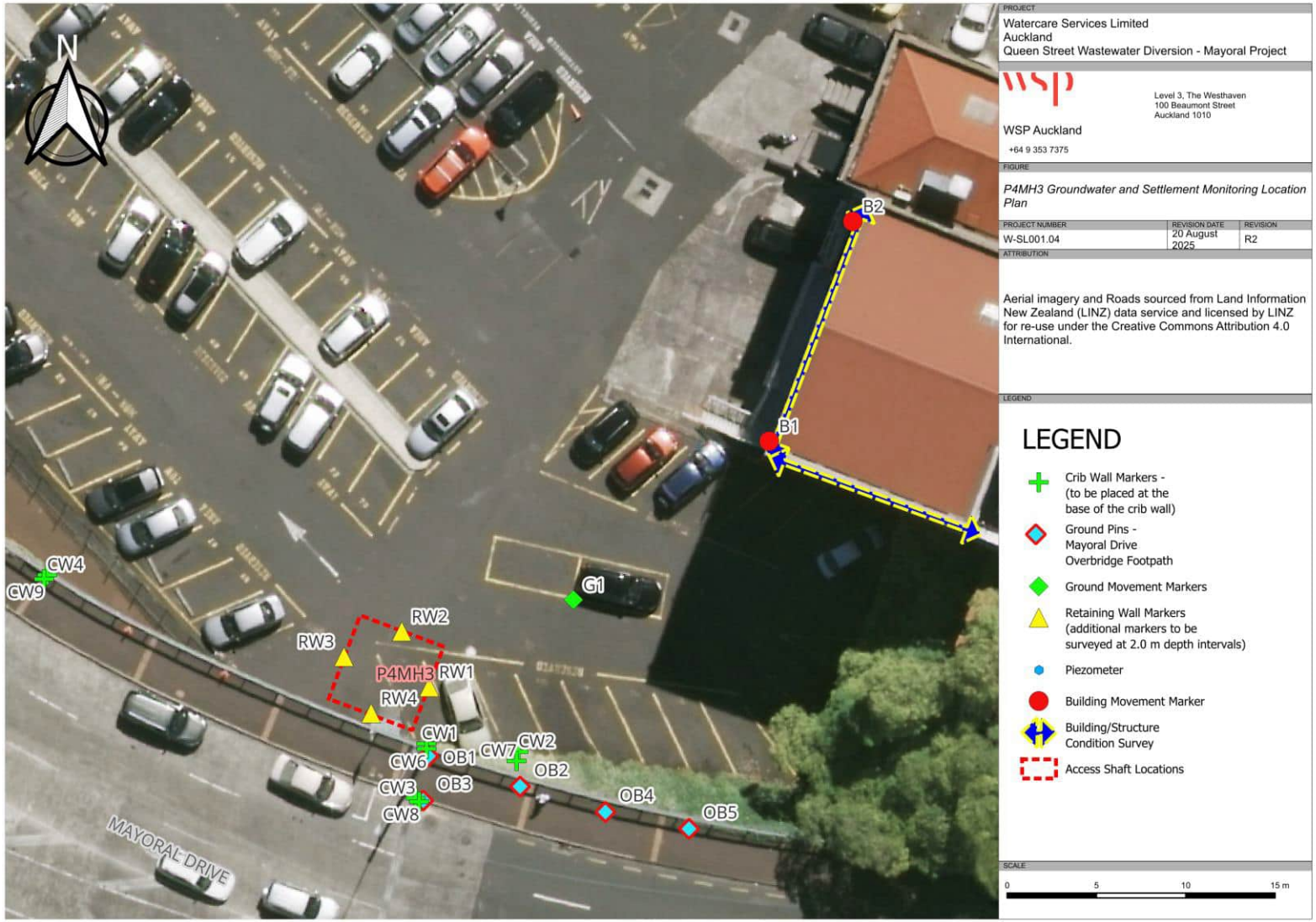
Activity	Plant List
Manholes	14 – 35t excavator
	Trench shoring/H-Piles
	Excavator Movax/Vibro
	Six-wheeler trucks
	HIAB crane
	Concrete truck
	Concrete pump truck
Road Pavement Reinstatement	14 – 35t excavator
	Plate compactor
	Vibratory roller
	Pilot boring machine
	Tool truck

6. Sequence of work & Programme Durations

Refer Appendix 1 for high level construction programme.

APPENDIX B:

MONITORING SITE PLANS


N
B2
B1
G1
CW4
CW9
RW2
RW3
P4MH3
RW1
RW4
CW1
CW6
OB1
CW7
CW2
OB2
CW3
OB3
CW8
OB4
OB5
MAYORAL DRIVE
PROJECT
Watercare Services Limited
Auckland
Queen Street Wastewater Diversion - Mayoral Project
Level 3, The Westhaven
100 Beaumont Street
Auckland 1010
WSP Auckland
+64 9 353 7375
FIGURE
P4MH3 Groundwater and Settlement Monitoring Location Plan
PROJECT NUMBER
W-SL001.04
REVISION DATE
20 August 2025
REVISION
R2
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
Crib Wall Markers - (to be placed at the base of the crib wall)
Ground Pins - Mayoral Drive Overbridge Footpath
Ground Movement Markers
Retaining Wall Markers (additional markers to be surveyed at 2.0 m depth intervals)
Piezometer
Building Movement Marker
Building/Structure Condition Survey
Access Shaft Locations
SCALE
0
5
10
15 m
Original Sheet Size: A4 [W = 297, H = 210]
Plot Date: 2025-08-24 09:59:10 by Hughes, Terry (NZTH30300)
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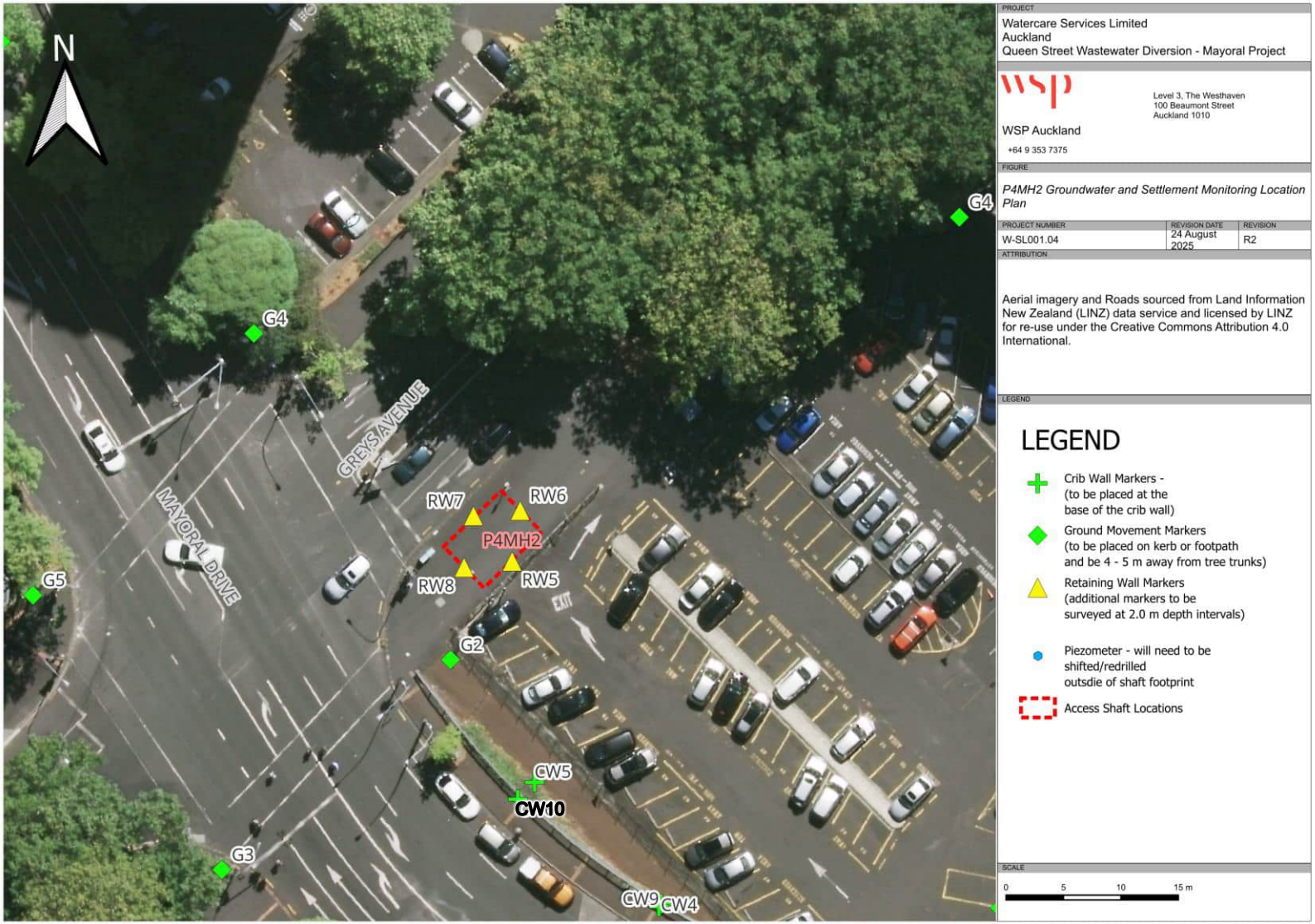

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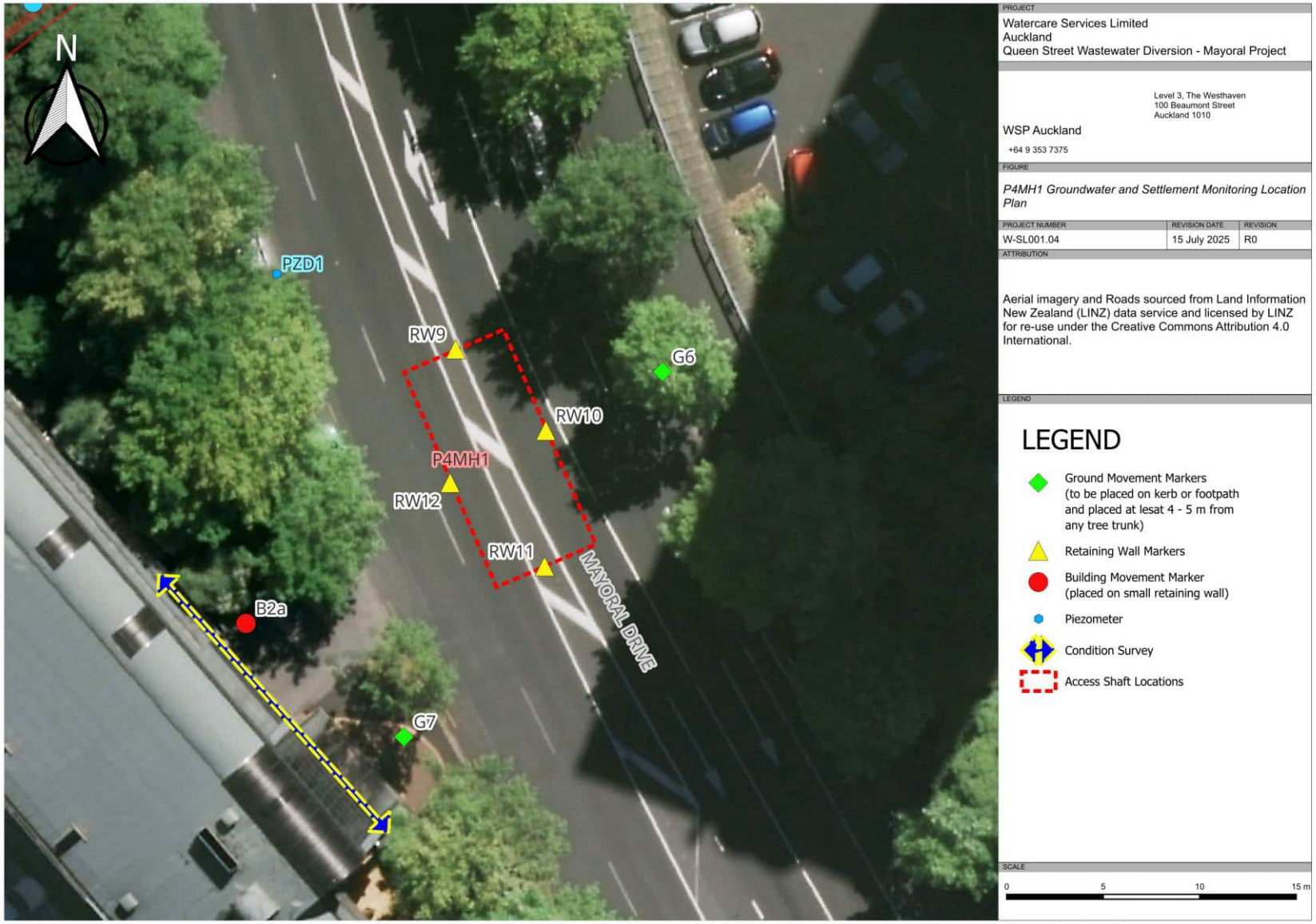
N
PZD1
RW9
G6
RW10
P4MH1
RW12
RW11
MAYORAL DRIVE
B2a
G7
PROJECT
Watercare Services Limited
Auckland
Queen Street Wastewater Diversion - Mayoral Project
Level 3, The Westhaven
100 Beaumont Street
Auckland 1010
WSP Auckland
+64 9 353 7375
FIGURE
P4MH1 Groundwater and Settlement Monitoring Location Plan
PROJECT NUMBER
REVISION DATE
REVISION
W-SL001.04
15 July 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
Ground Movement Markers (to be placed on kerb or footpath and placed at lesat 4 - 5 m from any tree trunk)
Retaining Wall Markers
Building Movement Marker (placed on small retaining wall)
Piezometer
Condition Survey
Access Shaft Locations
SCALE
0
5
10
15 m
Original Sheet Size: A4 [W = 297, H = 210]
Plot Date: 2025-07-16 16:29:10 by Hughes, Terry (NZTH30300)
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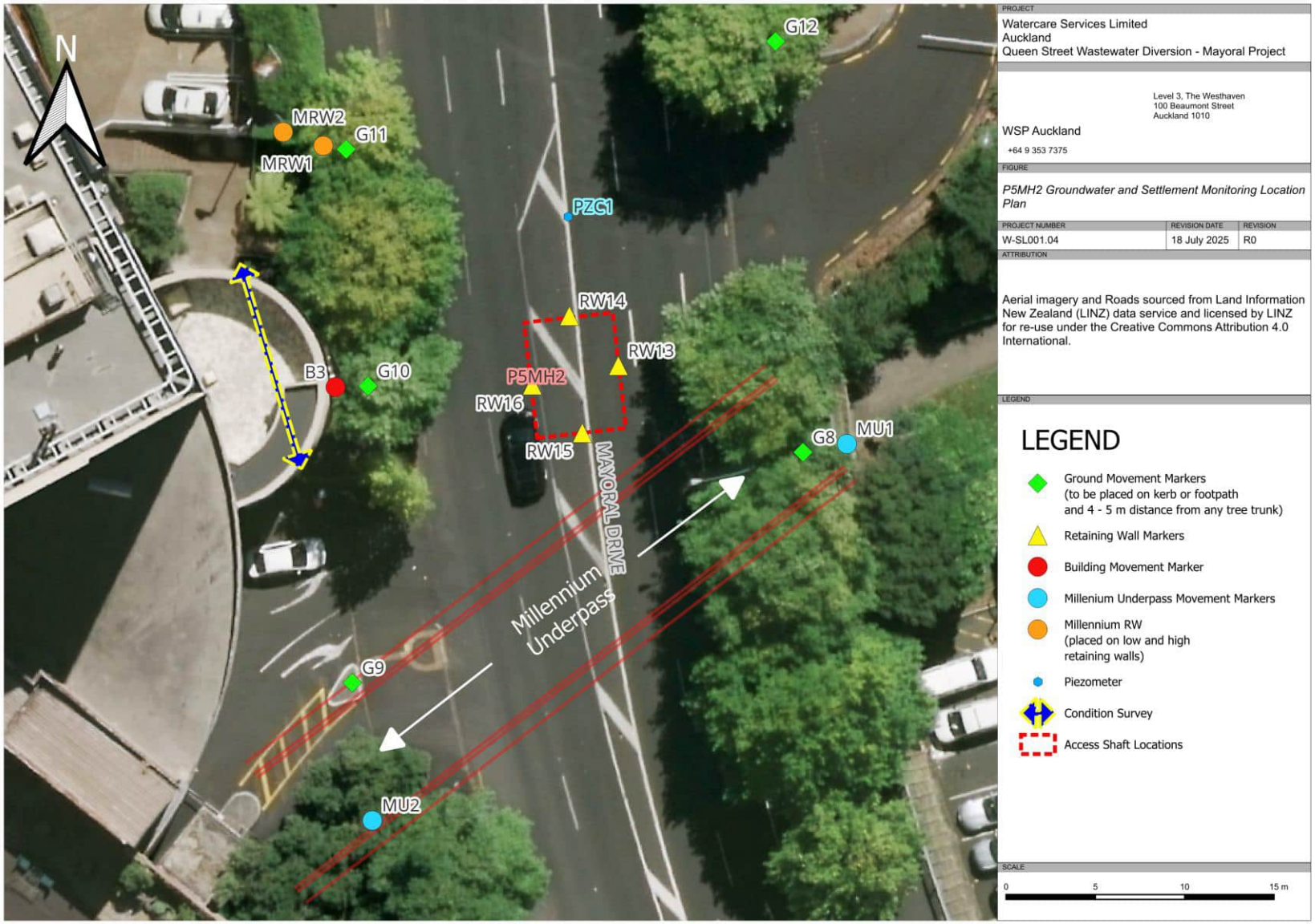
N
MRW2
G11
MRW1
G12
PZC1
RW14
RW13
B3
G10
P5MH2
RW16
RW15
MAYORAL DRIVE
G8
MU1
Millennium Underpass
G9
MU2
PROJECT
Watercare Services Limited
Auckland
Queen Street Wastewater Diversion - Mayoral Project
Level 3, The Westhaven
100 Beaumont Street
Auckland 1010
WSP Auckland
+64 9 353 7375
FIGURE
P5MH2 Groundwater and Settlement Monitoring Location Plan
PROJECT NUMBER
REVISION DATE
REVISION
W-SL001.04
18 July 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
Ground Movement Markers
(to be placed on kerb or footpath
and 4 - 5 m distance from any tree trunk)
Retaining Wall Markers
Building Movement Marker
Millenium Underpass Movement Markers
Millennium RW
(placed on low and high
retaining walls)
Piezometer
Condition Survey
Access Shaft Locations
SCALE
0
5
10
15 m
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File Ref: U:\ProjectsNZ\3a\3-AWE40.00 Queen Street WW Diversions\Home\98_Hydrogeology\GIS\Mayoral\Mayoral_Base.qgz


N
COOK STREET
MAYORAL DRIVE
VINCENT STREET
B4
G14
RW19
RW18
P1MH2
RW17
RW20
G13
PZA1
PROJECT
Watercare Services Limited
Auckland
Queen Street Wastewater Diversion - Mayoral Project
Level 3, The Westhaven
100 Beaumont Street
Auckland 1010
WSP Auckland
+64 9 353 7375
FIGURE
P1MH2 Groundwater and Settlement Monitoring Location Plan
PROJECT NUMBER
REVISION DATE
REVISION
W-SL001.04
15 July 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
Ground Movement Markers (on kerb or footpath markers must be at lesat 4 - 5 m distant from tree trunk)
Retaining Wall Markers
Building Movement Marker (fixed to stone wall, any height that provides line of sight and protection from vandalism)
Piezometer
Access Shaft Locations
SCALE
0
5
10
15 m
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Plot Date: 2025-07-16 12:27:17 by Hughes, Terry (NZTH30300)
File Ref: U:\ProjectsNZ\3a\3-AWE40.00 Queen Street WW Diversions\Home\98_Hydrogeology\GIS\Mayoral\Mayoral_Base.qgz

Attachment D: ENGEO Interim Summary of Static Settlement and Deflection Analysis

1 August 2025

Fulton Hogan
Attn: Jagoda Lipczynska
38 Greys Avenue
Auckland City Centre

Dear Jagoda,

Interim Summary of Static Settlement and Deflection Analysis – Queen Street Wastewater Upgrade ECI Package B, Mayoral Drive, Auckland

(Our Reference: 27865.000.001_03)

1 Introduction

ENGEO Limited was engaged by Fulton Hogan Limited to provide temporary and permanent works design for several proposed excavations along Mayoral Drive. The excavations are required to facilitate installation of new wastewater infrastructure understood to be part of the Queen Street Wastewater Upgrade ECI Package B (FH Contract No. CT7754).

Our work has been carried out in accordance with the Fulton Hogan Consultancy Services Agreement dated 30 January 2025. Our initial scope was for the design of five temporary shafts, however the scope subsequently changed to four temporary shafts, referred to as P4MH2; P4MH1A & P4MHB1; P5MH2; P5MH1 & P1MH3; and P1MH2, and one permanent shaft, referred to as P4MH3.

ENGEO is currently preparing design reports specific to each of the above shaft locations. These reports will include the results of mechanical settlement and horizontal deflection analysis for the ground surface and at 3 m depth due to these works, except for P5MH1 / P1MH3 due to there being no nearby structures requiring this assessment.

We understand that WSP has requested an intermediate report from ENGEO summarising mechanical settlements and horizontal deflections for the above-referenced shaft locations (excluding P5MH1 / P1MH3) and a proposed open trench between P4MH4 to P4MH3, which is summarised in this letter.

This letter may be used as one of the documents to support a Resource Consent or Building Consent application to Auckland Council.

2 Design Philosophy

The following is summarised from the design reports being prepared and is intended to provide some context on the assumptions, Plaxis analysis and results.

2.1 Ground Conditions

ENGEO has relied upon existing investigations provided by the following WSP reports to develop ground models and representative ground parameters:

- WSP report titled Queen Street Wastewater Diversion – Parts 1-4-5 Geotechnical Factual Report dated 27 November 2023 (ref. W-SL001.03 Rev R2).
- WSP report titled Queen Street Wastewater Diversion Parts 1-5-4: Mayoral Drive Alignment Geotechnical Interpretative Report dated 20 December 2024 (ref. W-SL001.00 Rev 1).

These were supplemented with our local knowledge and experience in these ground conditions.

2.2 Design Parameters

Geotechnical design parameters adopted for design are summarised in Table 1. Mohr-Coulomb model was used in PLAXIS.

Table 1: Assumed Soil Parameters

Unit	Effective Unit Weight γ' (kN/m3)	Effective Friction Angle ϕ (deg.)	Effective Cohesion c' (kPa)	Undrained Shear Strength Su (kPa)	Youngs Modulus E (MPa)
Uncontrolled Fill	17 - 18	28	2	20	3
Tauranga Alluvium	18	26 - 30	2 - 3	20 - 30	3 - 9
Soft Residual ECBF Soils	18	28	2	30	10
Transitional ECBF Soils / Residual ECBF	18	32	5	80	12
ECBF Rock	22	35	50	N/A	200

Notes: 1. ECBF is East Coast Bays Formation

Based on our review of the WSP report conclusions and recommendations, and our local knowledge and experience, we are satisfied that these parameters are generally representative and appropriately conservative for the temporary works design.

In addition to this, we have reduced the cohesion of the ECBF rock from 100 kPa, as proposed by WSP, to 50 kPa to allow for extremely weak rock near the base of the shaft.

2.3 Design Groundwater & Dewatering

Design groundwater levels were initially based on those provided in the above referenced WSP reports; however, these were subsequently lowered as excavation progressed.

Consideration of dewatering and its effects (such as risk to adjacent structures and / or infrastructure as a result of dewatering-related settlement) is outside ENGEO's scope. It is understood this is being completed by WSP for the temporary works.

With sufficient dewatering the occurrence of base heave is not considered to be a high risk.

2.4 Surcharge Loads

Fulton Hogan have advised that a maximum widespread surcharge of 20 kPa with a minimum of 1.0 m offset from the shaft excavations and open trench may be assumed at the existing ground surface during the temporary works.

A 12 kPa surcharge was adopted for more confined areas around the excavations, such as adjacent to existing crib walls to allow for a lightweight excavator (i.e. up to 5 tons).

2.5 Seismic Loads

For the seismic case, a design horizontal peak ground acceleration was calculated in accordance with NZGS / MBIE Module 6 (2021), the following was adopted:

- For temporary shafts, an Ultimate Limit State (ULS) 100-year earthquake return period was considered with design horizontal acceleration of 0.09 g.
- For the permanent shaft, a ULS 1000-year earthquake return period was considered with design horizontal acceleration of 0.19 g.

A Topographic Amplification Factor (Atopo) of 1 was considered, and Wall Displacement Factor (wd) ignored due to the relatively stiff or temporary nature of the propped walls.

2.6 Assumed Construction Sequencing

The following is a simplified and generalised summary of the location specific construction methodologies provided in the upcoming design reports.

1. Install vertical elements (sheet piles, secant piles or UC steel sections). If adopting UC steel sections, then this would include augered holes drilled at a maximum of 2.2 m c/c spacing.
2. Excavations are progressively undertaken with waler box props installed where required.
3. Install the permanent infrastructure.
4. For temporary shaft locations, backfill the excavation and remove props as this progresses.
5. For temporary shaft locations, cut off steel sections and lagging and then backfill to underside of road / footpath subgrade.
6. Reinstate subgrade.

3 Assessment of Mechanical Settlements

ENGEO assessed vertical ground settlements adjacent to the proposed excavation, and with respect to the ground surface and at 3 metres depth. This assessment was undertaken as a part of the PLAXIS analysis with plots of cumulative settlement (considering all excavation phases excluding the low probability earthquake phase) versus offset from excavation. Outputs of cumulative static settlement vs offset in a perpendicular orientation to excavation were generated from PLAXIS, with copies attached.

Assessment of ground settlement effects with respect to nearby structures and infrastructure is being undertaken by WSP and is therefore beyond the scope of this report.

4 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Fulton Hogan, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground conditions indicated from published sources, site assessments and subsurface investigations as described in the WSP reports referenced in the above Section 2.1. No additional ground information has been collected in addition to the above-referenced WSP reports.

iii. This report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.

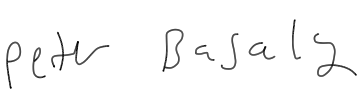
iv. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

v. This Limitation should be read in conjunction with the Engineering NZ / ACENZ Standard Terms of Engagement.

vi. This report is not to be reproduced either wholly or in part without our prior written permission.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on (09) 972 2205 if you require any further information.

Report prepared by



Peter Basaly, CMEngNZ (CPEng)

Senior Geotechnical Engineer

Report reviewed by

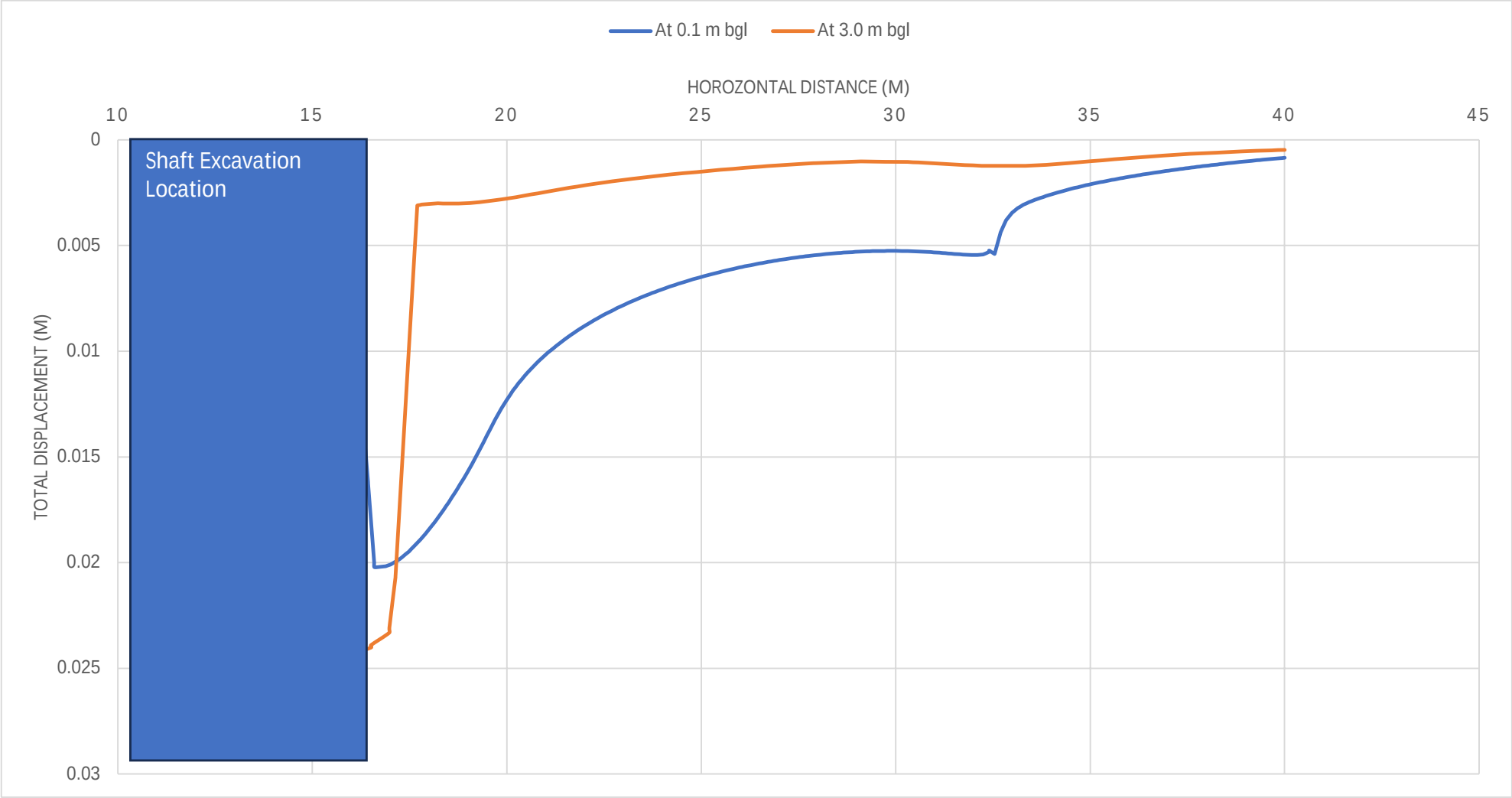
Matt Packard, CMEngNZ (CPEng)

Associate Geotechnical Engineer

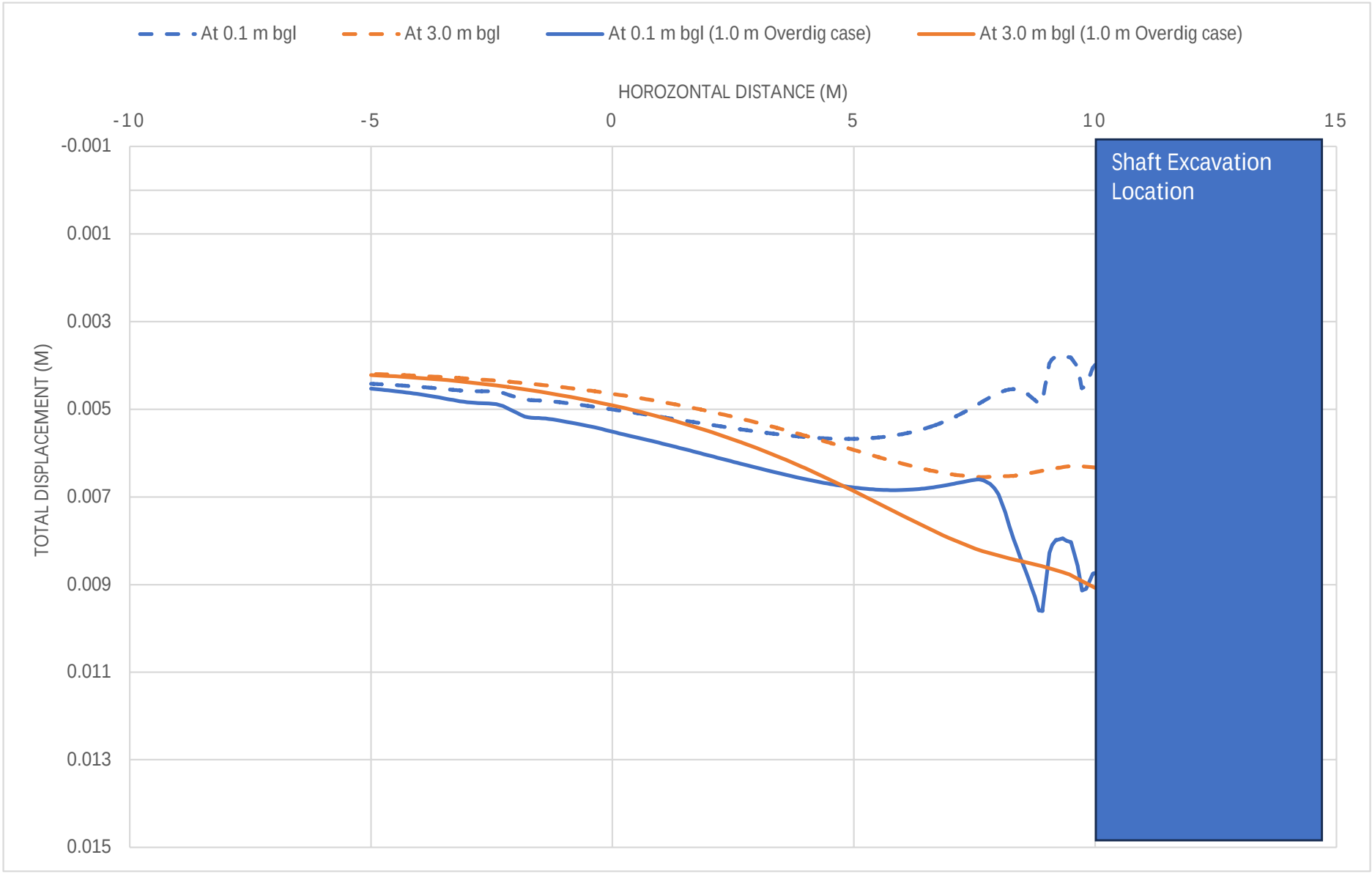
Attachments:

Selected Plaxis Outputs

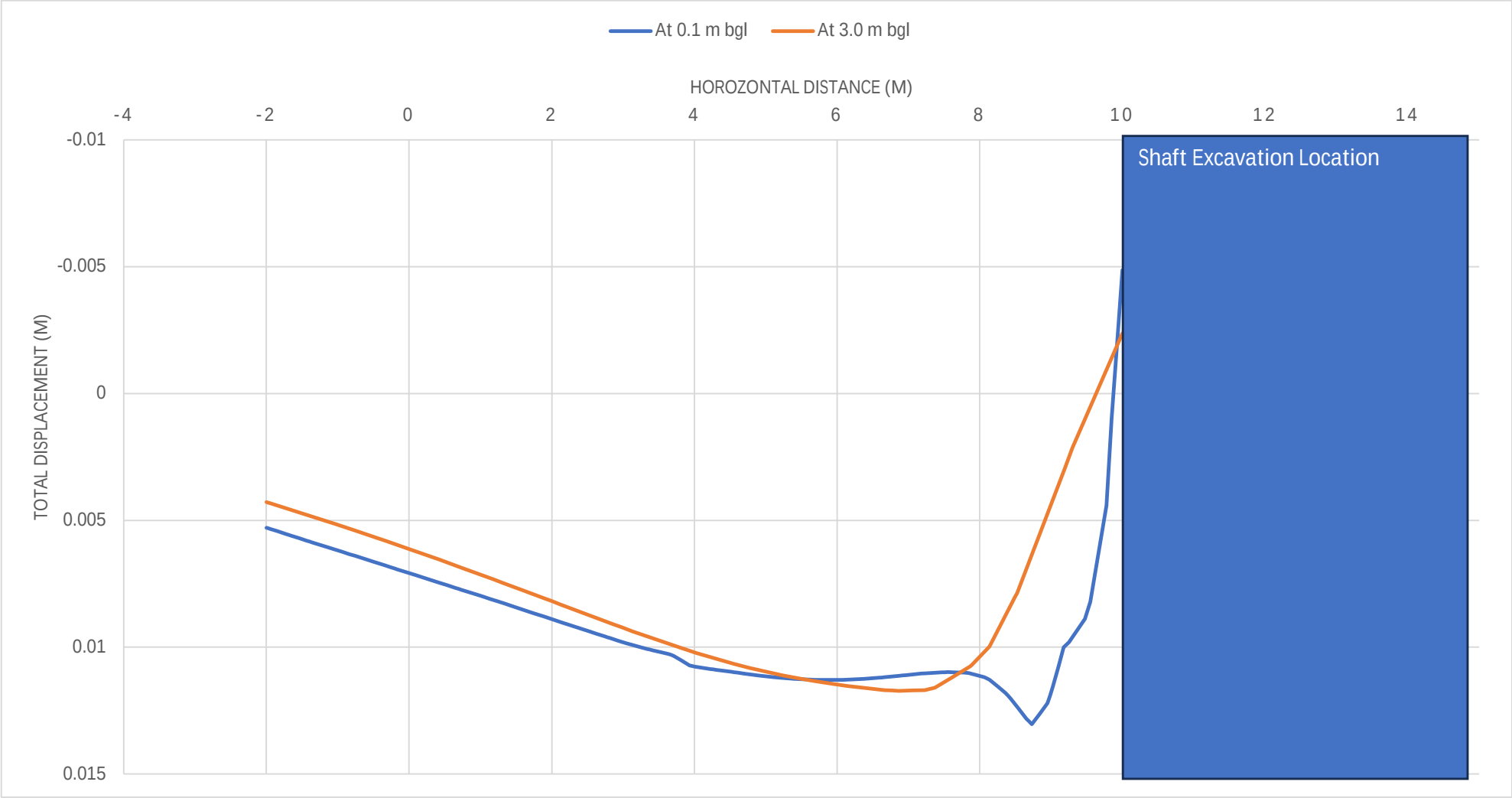
Project: Queen Street Wastewater Diversion - P4MH3
Title: Settlement vs Offset
Client: Fulton Hogan
Date: 25 July 2025



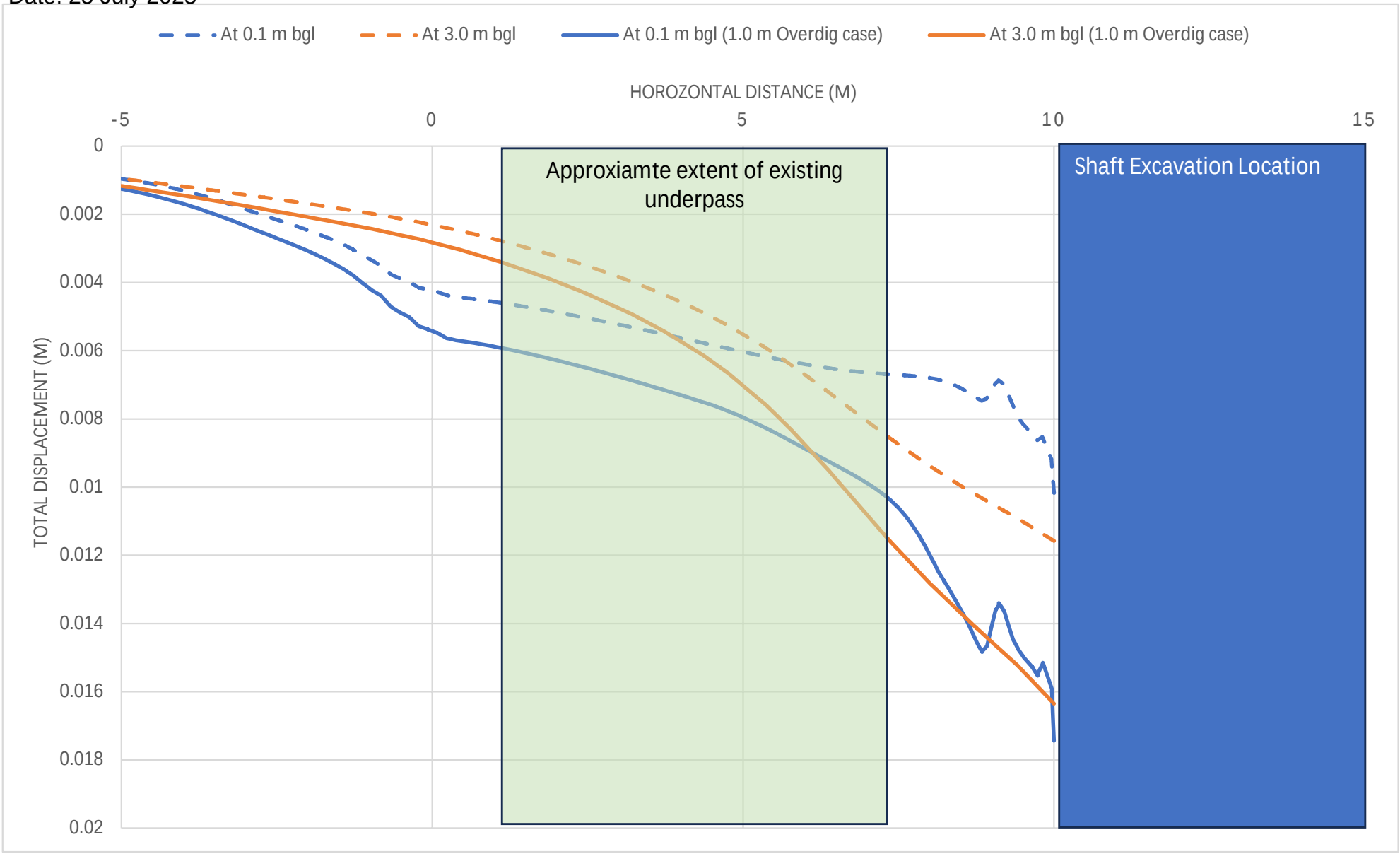
Project: Queen Street Wastewater Diversion - P4MH2
Title: Settlement vs Offset
Client: Fulton Hogan
Date: 25 July 2025



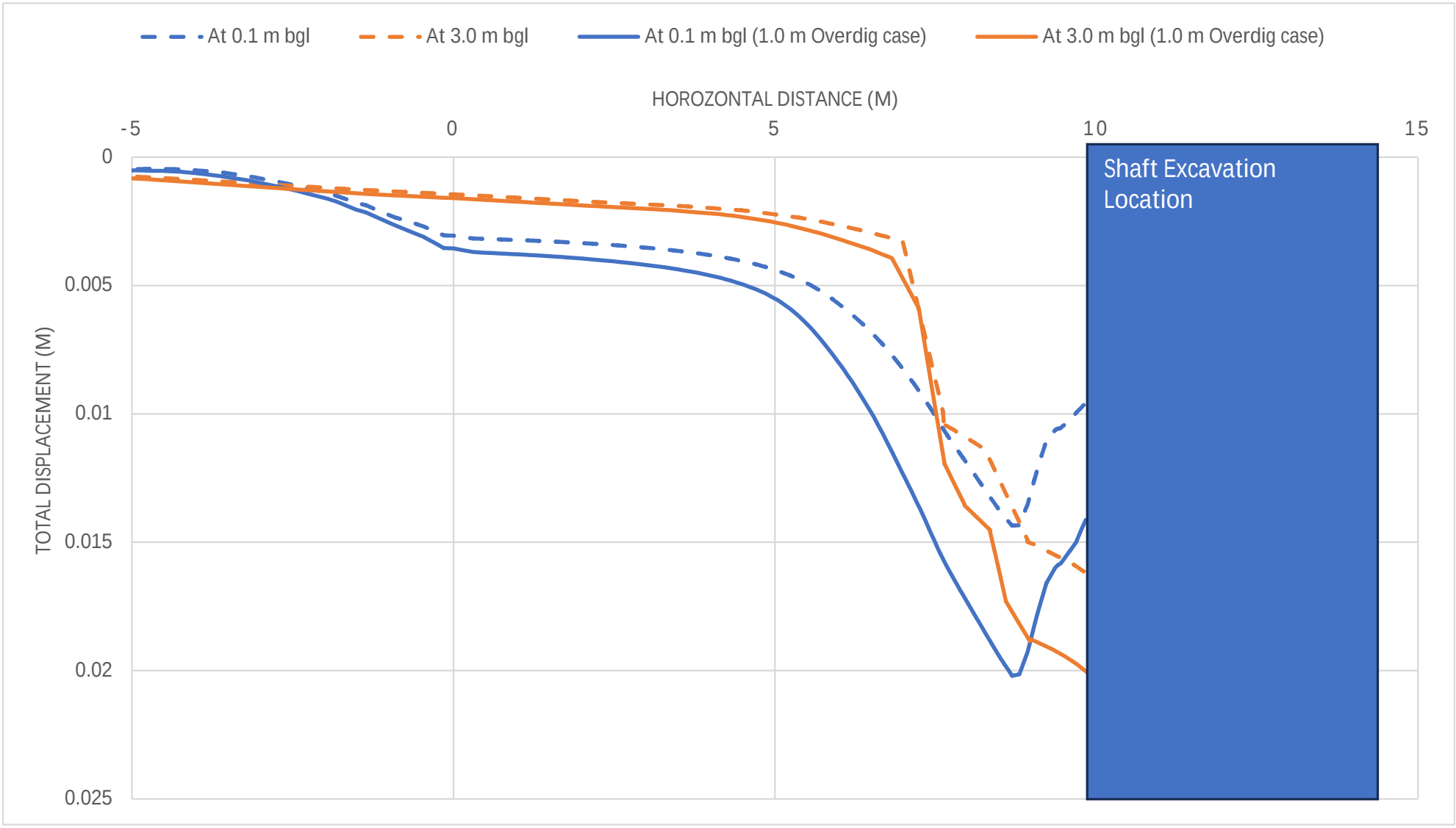
Project: Queen Street Wastewater Diversion - P4MH1A&B
Title: Settlement vs Offset
Client: Fulton Hogan
Date: 25 July 2025



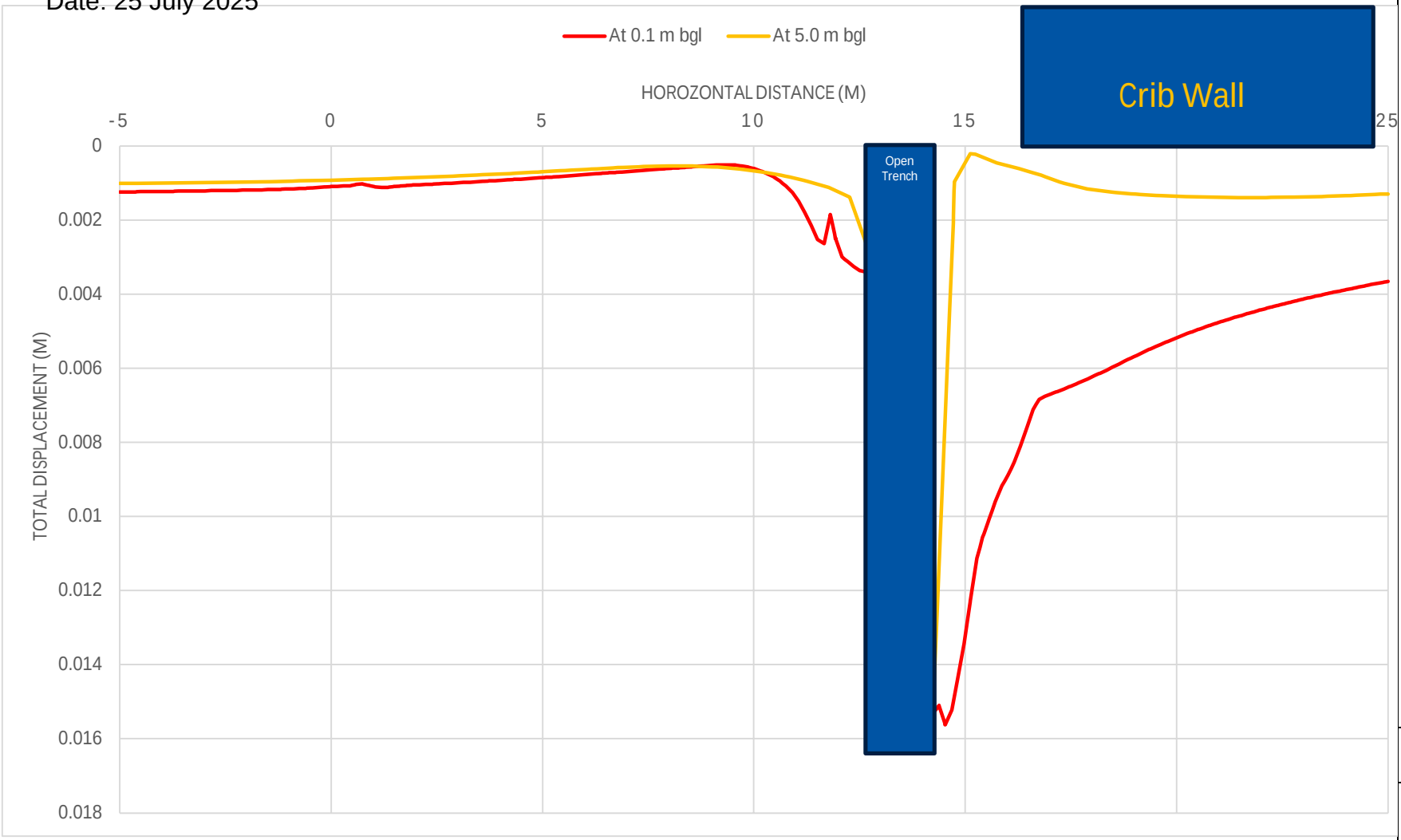
Project: Queen Street Wastewater Diversion - P5MH2
Title: Settlement vs Offset
Client: Fulton Hogan
Date: 25 July 2025



Project: Queen Street Wastewater Diversion - P1MH2
Title: Settlement vs Offset
Client: Fulton Hogan
Date: 25 July 2025



Project: Queen Street Wastewater Diversion - Open Trench between P4MH4 to P4MH3
Title: Settlement vs Offset
Client: Fulton Hogan
Date: 25 July 2025



Note:

ENGEO

Title: Queen Street Wastewater Diversion – Open Trench		
Client: Fulton Hogan		Appendix No.: 2 Size: A4
Project:	Drawn: MZ	
Date: 16.04.25	Checked: MJP	
Proj No.:	Scale: N/A	Version: A