REPORT

Tonkin+Taylor

Herne Bay Connector Project Groundwater and Settlement Monitoring & Contingency Plan

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Watercare Services Limited
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Table of contents

1 Introduction 1
1.1 Project overview 1
1.1.1 Project scope 1
1.1.2 Project alignment 2
1.1.3 Outside of scope – Point Erin Park 3
1.2 Assessment overview 3
2 Proposed construction methodology 4
2.1 Main pipeline 4
2.1.1 Tunnel boring machine 4
2.1.2 Open trenching 4
2.2 Primary tunnel shafts (thrust/receiving) 4
2.3 Interceptor shafts (SE) 5
2.4 Interception pipes 5
2.5 Service relocation 5
3 Monitoring 6
3.1 General 6
3.2 Datums 6
3.3 Operational life 6
3.4 Data management 6
3.5 Data collection 6
3.6 Building and ground settlement monitoring 7
3.6.1 General 7
3.6.2 Settlement monitoring intervals 8
3.6.3 Settlement trigger levels 8
3.7 Groundwater monitoring 9
3.7.1 General 9
3.7.2 Groundwater monitoring intervals 9
3.7.3 Groundwater trigger levels 9
3.8 Underground services condition monitoring 13
3.8.1 General 13
4 Pre and post construction condition surveys of nearby buildings 15
5 Summary of monitoring frequency 18
6 Reporting of monitoring records 1
6.1 Baseline readings 1
6.2 Reporting intervals and requirements 1
7 Alert and Alarm trigger level response procedures 2
7.1 Response procedure if the Alert trigger levels are exceeded 2
7.2 Response procedure if the Alarm trigger levels are exceeded 2
8 Contingency options 3
8.1 General 3
8.2 Ground and building deformation contingency measures 3
8.3 Underground services settlement contingency measures 3
9 Monitoring and contingency plan review 4
10 Applicability 5

Appendix A Figures

Glossary

This glossary defines the specific meaning of certain words and phrases used in this report. Note that some words and phrases used in this report have different definitions and meanings in other literature.

Commencement of dewatering	Excavation/tunnelling below groundwater level and/or commencing taking any groundwater. Excludes piling operations.
Completion of dewatering	When excavation/tunnelling below groundwater level is completed, and ground openings are backfilled above the groundwater level.
Commencement of excavation	Excavations deeper than 1.5 m and greater than 1 m^3 in volume. Excludes excavation of shaft retention piles.
Completion of excavation	When all tunnelling and excavations have been completed, tunnel liner has been installed, and ground openings have been backfilled.
Completion of construction	Means when the Certificate of Completion is issued by AC.
Minor severity	Damage and defects that are typically localised in nature and their effects are typically of low significance and readily repairable (e.g. hairline cracks).
Moderate severity	Damage and defects that are typically spread over a larger area and/or may be of greater significance and impact upon serviceability (e.g. sticking doors and cracked window panes).
Severe	Damage and defects that are typically widespread in nature and/or their effects are typically of high significance (e.g. visible deformation and crack in structural elements).
Damage	Includes aesthetic, serviceability and severe damage.
Aesthetic damage	Superficial damage and defects that do not affect the use, integrity or serviceability of the item. In certain situations, aesthetic damage may develop into serviceability and/or structural damage. Aesthetic damage may include fine cracks easily treated during normal redecoration, cracks in exterior visible upon close inspection, etc.

Serviceability damage	Damage and defects that may impact the use, integrity or serviceability of the item but have not led to (nor are expected to immediately develop in) structural damage. Serviceability damage may include cracked windowpanes, uneven pavements, bowing and/or cupping decking boards, sticking windows and doors etc. Over time, serviceability damage may develop into structural damage.
Structural damage	Damage and defects that affect structural components of an item and have the potential to cause structural failure of the item. This may include bulging concrete block walls, detached structural members, decay in structural timber members, differential settlement in foundations resulting in reduced stability etc.
Alert level	Monitoring reaches a level close to where damage may occur unless movement continues unchecked and requires review of available monitoring information (plus other information) to assess the future trend.
Alarm level	Monitoring reaches a level where damage may occur and requires immediate action including the cessation of ground dewatering and other construction activities that may have an effect on ground deformation.
Council / AC	Auckland Council (Team Leader, Water Allocation, NRSI) or nominated AC staff acting on The Team Leader's behalf.
NRSI	Natural Resources and Specialist Input, Auckland Council.
RL	Reduced Level.
Services	Includes for example fibre optic cables, sanitary drainage, gas and water mains, power and telephone, road infrastructure assets such as footpaths, kerbs, catch-pits, pavements and street furniture.

1 Introduction

Watercare Services Limited (Watercare) has commissioned Tonkin & Taylor Ltd (T+T) to provide a Draft Groundwater and Settlement Monitoring and Contingency Plan (GSMCP) to support a resource consent application for the proposed Herne Bay Connector Project (the Project)[1]. The proposed wastewater pipeline will run from Marine Parade at its south-western end to the proposed Central Interceptor drop shaft in Point Erin Park at its north-eastern end.

The GSMCP is based on the following report prepared for the project:

- Herne Bay Connector Project – Groundwater and Settlement Assessment Report by T+T reference 1090120.v4, dated September 2023.

This GSMCP serves to establish a set of project controls to measure groundwater drawdown and ground settlements, and to address potential geotechnical effects related to the project works. The GSMCP also provides contingency and mitigation measures that may be applied should monitoring results indicate ground settlement and groundwater drawdown to be approaching or likely to exceed established alert and alarm limits. Monitoring plans are shown on Figure 1 to 17 in Appendix A.

This GSMCP has been prepared for approval by Auckland Council. This report, the proposed monitoring locations, and monitoring trigger levels have been established to reflect the design and construction methodologies proposed at the time of writing. We assess that the trigger levels set within this report are within the damage risk classification presented in our Groundwater and Settlement Assessment Report[2].

1.1 Project overview

Watercare is working jointly with Auckland Council to deliver the Western Isthmus Water Quality Improvement Programme (WIWQIP), which will reduce wastewater overflows and improve water quality at local beaches. As part of the WIWQIP, this Project will upgrade the existing Branch 5 Sewer in the Herne Bay area by constructing a new wastewater trunk sewer. Upon completion, the new Herne Bay trunk sewer line will connect to the Central Interceptor (CI) wastewater conveyance and storage tunnel (which is to be extended from Tawariki Street in Grey Lynn to a new drop shaft in Point Erin Park).

1.1.1 Project scope

The proposed alignment will comprise:

- Installation of approximately 1.5 km of 2.1 m internal diameter trunk sewer line between Shaft 1 (at Point Erin Park) and Shaft 7 (on Marine Parade), constructed via a tunnel-boring machine (TBM);
- Installation of approximately 150 m of 600 mm diameter trunk sewer within Marine Parade (between Shaft 7 and 8), constructed via open-cut trenching;
- Construction of eight primary tunnel shafts, ranging in diameter from 3.5 m to 13.5 m, along with four 3.5 m diameter intercepting shafts;
- Installation of four interception pipes and eleven connections to existing engineered overflow points (EOPs); and

[1] Tonkin & Taylor Ltd, May 2023. *Variation Order, Change Request for Herne Bay Technical Assessment Reporting.* T+T Ref. 1090120.1000

[2] Tonkin & Taylor Ltd, September 2023. *Herne Bay Connector Project – Groundwater and Settlement Assessment Report*. T+T Ref. 1090120.v4

- Relocation and reinstatement of utilities as required.

The primary purpose of the Project is to reduce engineered overflow spill frequencies resulting from the aging combined sewer network in the area and to comply with Watercare's Network Discharge Consent (NDC) conditions. This is expected to lead to improvements in bathing water quality conditions at the beaches, reduction of odour from stormwater catchpits and improved overall amenity.

1.1.2 Project alignment

Figure 1.1 and Figure 1.2 below show the proposed alignment and key features of the Project.

Figure 1.1: Eastern portion of the Project

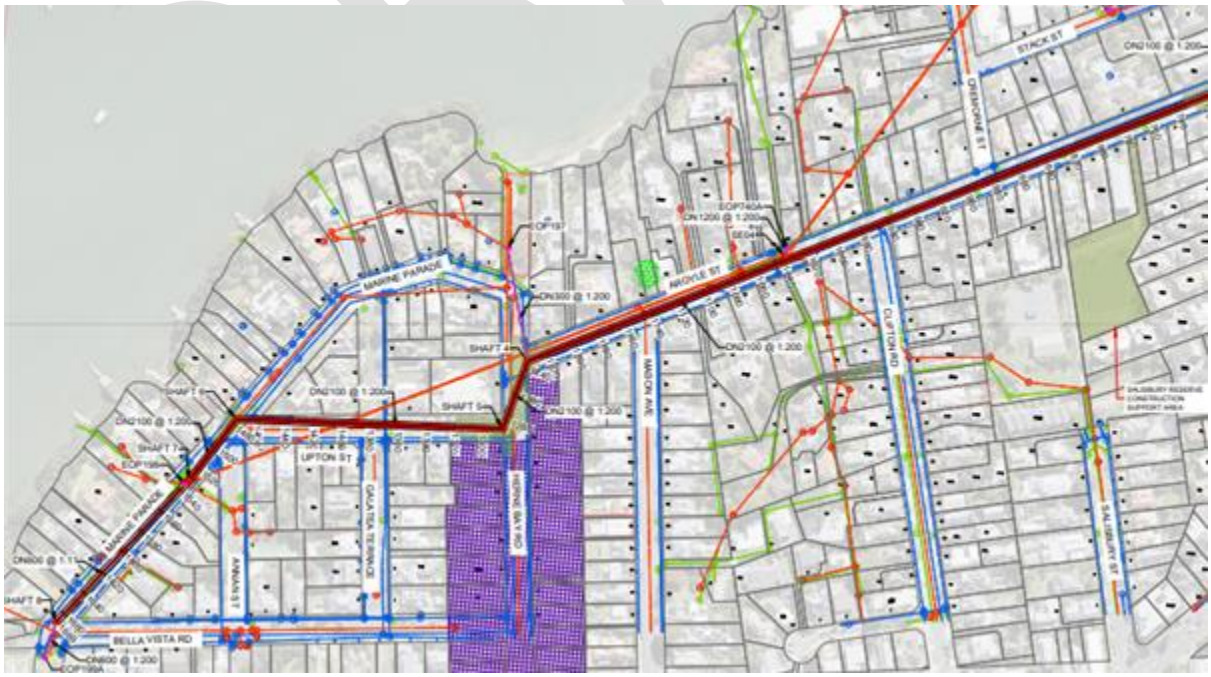

Figure 1.2: Western portion of the Project

1.1.3 Outside of scope – Point Erin Park

The eastern terminus of the Project is at Point Erin Park, where it will connect to the CI extension via a drop chamber, which will be constructed as part of the CI extension project.

The following works within Point Erin Park are covered by the CI extension resource consent application and do not form part of the 'application area' for the Herne Bay Project:

- The construction of the CI tunnel terminal shaft, control chamber, and stub connection to facilitate a potential future connection to the proposed Herne Bay Trunk Sewer tunnel;
- The construction of a plant room to house equipment to control the gates;
- Connections between the terminal shaft, control chamber, vent and plant room; and
- Tree works (pruning, works in the root zone, removal, relocation), and park reinstatement and landscaping following completion of construction works.

1.2 Assessment overview

WSP concept drawings of the scheme[3] include two design options being considered for the final tunnel depth along the main alignment.

The final tunnel elevation is to be determined as part of detailed design, and therefore both potential tunnel depths have been considered in this GSMCP and the T+T Groundwater and Settlement Assessment Report (GSAR). While it is anticipated that some details may change as the Project moves through the detailed design process and as construction methodology is confirmed, this GSMCP assumes that the geotechnical and groundwater effects remain within the envelope outlined in the GSAR. All figures and dimensions provided are approximate and will be confirmed during the detailed design stage.

[3] WSP (16 February 2023). *Herne Bay Trunk Sewer Upgrade, Marine Parade to Pt Erin.* DWG No. W-SL007.001 – W-SL007.008. Ref No. W-SL007.01.

2 Proposed construction methodology

2.1 Main pipeline

2.1.1 Tunnel boring machine

The excavation of the main tunnel alignment between Shaft 1 (at Point Erin Park) and Shaft 7 (on Marine Parade) will be undertaken with an Earth Pressure Balance (EPB) Tunnel Boring Machine (TBM). The TBM will be launched from the thrust shafts and retrieved from the reception shafts, with the concrete liner sections to be placed in behind the TBM as it progresses. Invert levels of the bored tunnel sections are to range between 6.28 m bgl (Option 2 at Shaft 7) and up to 25.24 m bgl (Option 1 at Shaft 5)[3].

The TBM is expected to predominantly operate in closed mode (with hydrostatic pressures balanced) for the bored portion of the alignment. It may be necessary to operate the TBM in open mode over short sections of the tunnel alignment, where hydrostatic pressures will not be (or only partially) pressure balanced. Where open mode is used, some groundwater inflow into the tunnel is expected resulting in some depressurisation of the hydrostratigraphic unit / aquifer immediately outside the tunnel. It is anticipated tunnelling in open mode would only be used where drilling within rock that is at least very weak (UCS greater than 1 MPa).

2.1.2 Open trenching

Between Shaft 7 and Shaft 8, the construction methodology is proposed to comprise open trenching temporarily supported using a slide rail shoring system. The proposed depth of trenching will vary between approximately 2.4 m (Shaft 8) to 5.9 m (Shaft 7) below existing ground levels (begl).

Where trenches extend below groundwater levels, pumping may be required during construction to limit groundwater inflows into the excavation. The Contractor may choose a different temporary support mechanism from that presented above as the design is developed, provided that the chosen support method can be demonstrated to limit the total ground deformations to the values presented in this GSMCP.

2.2 Primary tunnel shafts (thrust/receiving)

The thrust and receiving shafts are located where the direction of the alignment changes to follow the road alignment and allows for the deployment and retrieval of the TBM. The shafts generally have an external diameter of 9 m and 13.5 m for the receiving and launch shafts, respectively, with a finished shaft invert between 2.42 m deep (Shaft 8) and 25.24 m deep (Shaft 5).

Secant piles will form the shaft walls and will be constructed with a bored piling rig and support crane. The secant piles are proposed to extend to full depth of the shafts and extend a minimum of 2 m below the excavation level to provide groundwater cut-off. The piled shaft will then be excavated, and a capping ring beam installed. The shaft is expected to be excavated by conventional mechanical equipment (e.g. 23 t excavator with 2 t excavator within the shaft) through overburden soils and East Coast Bay Formation (ECBF) soil and rock.

On completion of the shaft and tunnel excavations, a permanent manhole will be installed within the shaft, the space between the shaft walls and manhole will be backfilled with hardfill, and holes will be cut into the shaft walls to reduce groundwater impedance by the secant piles and allow for groundwater flow around the manhole in the long term.

Given the depth of the proposed shaft excavations, control groundwater inflow will be required to maintain groundwater levels at or below the base of each shaft during the construction period, by way of:

- Exclusion (secant piling extending to or below the base of the shaft will act as a hydraulic barrier impeding groundwater inflow); and
- Temporary dewatering/pumping to maintain groundwater levels below the base of each shaft during the construction period.

2.3 Interceptor shafts (SE)

Four intercept shafts (SE01 – SE04) will be constructed following the completion of the main tunnel by drilling vertical shafts beside the main tunnel. The interceptor shaft invert levels are proposed to be a minimum of -3.27 m RL (23.89 m bgl) at SE01 and a maximum of 0.89 m RL (12.86 m bgl) at SE04.

A trench box or casing will be installed for the stability of surficial soils prior to drilling of the shaft. This is to extend into competent ground that would maintain stability during excavation. If required, the casing can be extended deeper by welding additional segments as drilling progresses, to maintain stability of the surrounding soils.

The shaft would then be drilled to depth with a 75 t piling rig with a 3.5 m diameter auger following which a temporary steel casing would be installed to full depth. A window will then be cut into the base of the casing and a lateral passage excavated/mined to connect to the main tunnel. Once the lateral passage is lined, the permanent concrete manhole structure will be installed into the shaft and the temporary casing removed. Grout will then be poured or tremmied into the annulus between the permanent manhole and ground.

Due to the depth of excavation, groundwater inflow control will be required to maintain groundwater levels at or below the base of each shaft during the construction period. Inflow rates are anticipated to be low, and pumping/dewatering would only occur when construction is taking place in the base of the shaft. In practice that would mean that groundwater could refill within the shaft overnight, and it is expected that pumping would mainly be required each morning to provide a reasonably dry work environment for constructability and safety purposes.

If required during construction, contingency options to minimise water inflows may be considered such as concrete seal at the base of the bored shaft.

2.4 Interception pipes

The proposed construction methodology for the interception pipes will generally be undertaken using temporary excavations shored with trench boxes (for shallower excavations where possible) or adopting a similar methodology to that of the intercept shafts at deeper locations. The invert levels of the EOPs are between 1.1 m bgl (9.39 m RL) at EOP202 and 14.56 m bgl (10.48 m RL) at EOP197.

The pipe connections between the EOPs and the main tunnel shafts / intercept shafts are expected to be either trenched or directionally drilled. Open trenching will be undertaken for shallower connections using “traditional construction” with 23 t excavators and slide rail shoring systems with multi-level props to support the sides of the excavation. Directional drilling will comprise excavation of drilling and receiving pits which will be shored with trench shields. A directional drill rig will then be mobilised to site and a bore drilled using a recirculating bentonite slurry. A polyethylene pipe (PE) will be pulled through and the grouted into place.

2.5 Service relocation

The pipeline alignment and shaft locations are to be formed within the road corridor. It is expected that some services may be located within construction zones that therefore may need to be relocated or otherwise protected.

3 Monitoring

3.1 General

Ground settlement and groundwater drawdown monitoring during the construction works will be undertaken to assess if the response of the surrounding structures is within design tolerances. This process allows for the geotechnical effects to be monitored and can act as an indication for mitigation or remedial measures to be implemented if required.

Monitoring and surveying of the following shall be undertaken during construction:

- Building and Ground Settlement Monitoring Points via survey markers.
- Groundwater level monitoring via standpipe piezometers.

The monitoring results will be collected by the contractor prior to and during construction and collated by the Geotechnical Engineer for comparison with the specified Alert and Alarm trigger levels. Should any Alert or Alarm levels be breached, the responses detailed in the sections below must be implemented.

Monitoring records will be included in summary reports prepared by the Geotechnical Engineer and issued to AC every two months during the implementation of this GSMCP.

3.2 Datums

A common datum shall be selected for all construction stage monitoring. Unless otherwise agreed in writing, the horizontal coordinates are to be taken in terms of New Zealand Transverse Mercator Projection based on NZGD2000 datum and vertical levels in terms of Auckland Height Datum 1946.

3.3 Operational life

All monitoring locations shall remain operational for a minimum of 3 months post completion of the proposed works. Where possible, monitoring points shall be located in such a manner that construction activities are unlikely to result in damage or inability to access the monitoring point during construction. If a monitoring point is damaged or becomes inoperable during construction, a replacement monitoring point shall be established in the same locations as the damaged point within 1 monitoring round from being identified as damaged.

3.4 Data management

An electronic database of all monitoring locations and their results shall be created and maintained throughout the required monitoring period in Microsoft Excel or similar.

All monitoring locations shall be surveyed (x, y, z coordinates) and presented on a plan that is made available electronically and is compatible with GIS or CAD software (Autodesk, ArcGIS, MicroStation or similar).

3.5 Data collection

A telemetry system should be used where practical to record near real-time data and centralise data collection. This system can be linked to automatic alerts via email and SMS if specified thresholds are reached. Such systems have the advantage of improving Health and Safety on the project by reducing staff exposure to site risks while taking measurements, the carbon footprint associated with travel and risk by providing near live data to proactively respond to observed changes.

3.6 Building and ground settlement monitoring

3.6.1 General

Building and ground settlement monitoring marks shall be established at the approximate locations presented in the Ground settlement monitoring plan (Figure 1 to 17) presented in Appendix A.

The philosophy of the monitoring programme is to monitor that actual settlements are less than the values that can be expected to result in the onset of minor severity damage to structures under worst-case assumptions.

The Alarm Trigger Level has been conservatively estimated as the amount of movement that could potentially cause minor damage. This corresponds to the point at which remedial actions to prevent further settlement are enacted. Alarm Trigger Levels are presented in Section 3.7.3. Required actions are presented in Section 7.

Each monitoring point has an Alert Trigger Level which represents a settlement at 70% of the Alarm Trigger Level. These are defined in Section 3.7.3. The purpose of the Alert Trigger Level is to provide sufficient notice for additional monitoring and assessment of construction operations to be undertaken prior to the Alarm Trigger Level being reached.

Building Monitoring Points have been assigned to any structure that lies within the envelope of potential settlement effects adjacent to the TBM thrust / reception shaft or interception shaft excavations. Buildings that are outside the calculated settlement envelope will not be directly monitored. Ground Monitoring Points will be utilised to assess ground movements within and immediately outside the calculated settlement envelope.

The Alert and Alarm settlement levels are uniform for all Building Monitoring Points, as their purpose is to monitor that settlement of a magnitude sufficient to cause minor damage will not occur. A minimum of three monitoring points arranged in a triangular orientation are proposed on each property dwelling to monitor differential settlements as shown on Figure 1 to 17) (Appendix A).

Ground Monitoring Points have generally been positioned as per the following:

- A minimum of two monitoring points have been placed at the road-side boundary of private properties located adjacent to the main thrust / reception shafts or interception shafts. These monitoring points are intended to check that Alert or Alarm level settlements, should they occur, are limited to the road corridor and provide comparison to building settlement points established on these structures.
- Monitoring points have been placed on buildings and surrounding ground for road-side properties in close proximity to the EOP branch sewer manholes to be constructed.
- Along the tunnel alignment, monitoring points have been established at the road kerbs alternating either side of the road (and tunnel alignment) at the following spacings:
  - 50 m spacings where the tunnel depth is less than 15 m below road level.
  - 100 m spacings where tunnel depth is greater than 15 m below road level.
  - 50 m spacings along open trenched sections of the tunnel and interception pipes.
- Where critical services are located near the proposed works, a ground settlement monitoring point has been located in close proximity the service.

Vertical survey measurements shall be accurate to +/- 2 mm vertically. It is noted that the settlement markers will be subject to landowner approval when placed on private property and may require re-locating.

3.6.2 Settlement monitoring intervals

Surveys shall be carried out by the Contractor or their approved surveyor at the intervals outlined in Table 3.1. Although no settlement effects can reasonably be expected to occur beyond 100 m from the work site, those points located at this distance or greater are to be surveyed once a month as a means of assessing the magnitude of natural ground surface elevation fluctuations (i.e. not as a result of the proposed works).

Table 3.1: Settlement monitoring intervals summary

Phase	Monitoring frequency
Prior to construction	A minimum 2 baseline readings within 1 month prior to commencement of dewatering
During excavation/dewatering	Weekly for: • All monitoring markers within 50 m of TBM tunnel/trench excavations • All monitoring markers within 20 m of a TBM shaft Fortnightly where: • All monitoring markers within 100 m of TBM tunnel/trench excavations • All monitoring markers within 50 m of a TBM shaft Every two months for: All monitoring markers following establishment of baseline readings (to monitor seasonal fluctuations)
After completion of excavation/dewatering	Monthly for three months or until such time following the completion of excavation and dewatering that stable measurements are demonstrated, and written confirmation is provided from AC to cease monitoring.

Monitoring frequency to be increased as advised by the Geotechnical Engineer at any monitoring point where the measured rate of settlement indicates that the alert or alarm level trigger may be approached prior to the next normally scheduled monitoring round.

3.6.3 Settlement trigger levels

Alert and Alarm Trigger Levels are summarised in Table 3.2. Monitoring data shall be compared with the trigger levels within 24 hours of recording. If an Alert or Alarm Trigger Level is breached, the actions identified in Section 7 of this GSMCP shall be undertaken.

Table 3.2: Ground (G) and Building (B) settlement trigger levels

Monitoring item	Description	Settlement Alert level (mm)	Settlement Alarm level (mm)	Differential settlement Alert level	Differential settlement Alarm level
BS1 to B180	Building monitoring point	7	10	1 in 1000 between any two building settlement survey markers	1 in 700 between any two building settlement survey markers

Monitoring item	Description	Settlement Alert level (mm)	Settlement Alarm level (mm)	Differential settlement Alert level	Differential settlement Alarm level
GS1 to GS125	Ground monitoring points	7	10	1 in 700 between any two ground settlement survey markers	1 in 500 between any two ground settlement survey markers

3.7 Groundwater monitoring

3.7.1 General

Groundwater levels shall be monitored during construction with groundwater monitoring wells installed along the pipe alignment. Twenty-five multi-point Vibrating Wire Piezometers (VWPs) were installed during completion of ground investigations for the development mid-2023. It is intended that these would be utilised to undertake groundwater monitoring during construction of the tunnel and shafts.

The as-built locations of these monitoring positions are shown on Figure 1 to 17 in Appendix A, and summary details of the installations are presented in Table 3.3.

Should any of the monitoring bores be damaged and become in-operable during construction works, then AC is to be informed and a new monitoring bore is to be drilled at an appropriate nearby location.

3.7.2 Groundwater monitoring intervals

The groundwater monitoring locations are to be installed within telemetry instrumentation which allows for near-continuous remote monitoring to be undertaken (at 15-minute intervals).

A groundwater monitoring viewing web portal is to be established to view real-time monitoring data across all installations prior to and during construction.

3.7.3 Groundwater trigger levels

Groundwater monitoring is to be undertaken in order to establish the baseline groundwater levels across the site. The baseline reading shall be taken as the summer low groundwater level (GWL) where possible and recorded before the commencement of construction. The baseline readings will be confirmed in a pre-construction report.

Groundwater modelling of the shaft excavations undertaken[2] indicates that negligible to minor groundwater drawdown is likely to occur due to the provision of a groundwater cut-off wall (i.e. secant piles). A localised reduction in pore water pressure may occur near the toe of the secant pile wall, the magnitude of which will be dependent on the depth of the shaft excavation, design of the secant wall cut-off (i.e. 'toe' depth) and permeability of the soil / rock at the base of the wall.

Therefore, appropriate Alert levels may only be established following completion of detailed design for the shafts and confirmation of the adopted design tunnel profile. Alert levels will be established with respect to the design assumptions and final tunnel elevation adopted and confirmed in a pre-construction report.

If the Alert levels are reached, the actions outlined in Section 7 shall be carried out.

Table 3.3: Groundwater monitoring installation details and alert levels

BH ID	Collar RL (m)	Depth of Shaft/Tunnel (m bgl) [m RL]		VWP Tip Depth (m bgl) [m RL]	Geological Unit Screened	Baseline GWL	Alert Level for typical drawdown (m)	
		Design Option 1	Design Option 2				Alert Level No. 1	Alert Level No. 2
HBS1-01	13.0	17 [-4]	11.6 [1.4]	5 [8]	Takanini Formation	TBC	TBC	TBC
		17 [-4]	11.6 [1.4]	10.5 [2.5]	Takanini Formation	TBC	TBC	TBC
		17 [-4]	11.6 [1.4]	15 [-2]	ECBF Rock	TBC	TBC	TBC
		17 [-4]	11.6 [1.4]	21 [-8]	ECBF Rock	TBC	TBC	TBC
HBS1-02	12.8	16.8 [-4]	11.4 [1.4]	6 [6.8]	Takanini Formation	TBC	TBC	TBC
		16.8 [-4]	11.4 [1.4]	11 [1.8]	Weathered ECBF	TBC	TBC	TBC
		16.8 [-4]	11.4 [1.4]	16.5 [-3.7]	ECBF Rock	TBC	TBC	TBC
		16.8 [-4]	11.4 [1.4]	22 [-9.2]	ECBF Rock	TBC	TBC	TBC
HBS2-01	17.7	18.6 [-0.9]	13.1 [4.6]	4.5 [13.2]	Takanini Formation	TBC	TBC	TBC
		18.6 [-0.9]	13.1 [4.6]	15 [2.7]	ECBF Rock	TBC	TBC	TBC
		18.6 [-0.9]	13.1 [4.6]	22 [-4.3]	ECBF Rock	TBC	TBC	TBC
HBS2-02	18.2	19.1 [-0.9]	13.6 [4.6]	4 [14.2]	Takanini Formation	TBC	TBC	TBC
		19.1 [-0.9]	13.6 [4.6]	15 [3.2]	Weathered ECBF	TBC	TBC	TBC
		19.1 [-0.9]	13.6 [4.6]	24 [-5.8]	ECBF Rock	TBC	TBC	TBC
HBS3-01	21.7	22.1 [-0.4]	16.6 [5.1]	7.5 [14.2]	Takanini Formation	TBC	TBC	TBC
		22.1 [-0.4]	16.6 [5.1]	15 [6.7]	Weathered ECBF	TBC	TBC	TBC
		22.1 [-0.4]	16.6 [5.1]	22.7 [-1]	ECBF Rock	TBC	TBC	TBC
HBS3-02	20.5	20.9 [-0.4]	15.4 [5.1]	6 [14.5]	Takanini Formation	TBC	TBC	TBC
		20.9 [-0.4]	15.4 [5.1]	12 [8.5]	Residual ECBF	TBC	TBC	TBC

BH ID	Collar RL (m)	Depth of Shaft/Tunnel (m bgl) [m RL]		VWP Tip Depth (m bgl) [m RL]	Geological Unit Screened	Baseline GWL	Alert Level for typical drawdown (m)	
		Design Option 1	Design Option 2				Alert Level No. 1	Alert Level No. 2
		20.9 [-0.4]	15.4 [5.1]	24 [-3.5]	ECBF Rock	TBC	TBC	TBC
HBS4-02	23.9	21.5 [2.4]	16.1 [7.8]	3.5 [20.4]	Takanini Formation	TBC	TBC	TBC
		21.5 [2.4]	16.1 [7.8]	8 [15.9]	Weathered ECBF	TBC	TBC	TBC
		21.5 [2.4]	16.1 [7.8]	24 [-0.1]	ECBF Rock	TBC	TBC	TBC
HBS5-01	28.2	25.5 [2.7]	20 [8.2]	5 [23.2]	Residual ECBF Soils	TBC	TBC	TBC
		25.5 [2.7]	20 [8.2]	10.5 [17.7]	Weathered ECBF	TBC	TBC	TBC
		25.5 [2.7]	20 [8.2]	27 [1.2]	ECBF Rock	TBC	TBC	TBC
HBS5-02	27.5	24.8 [2.7]	19.3 [8.2]	4 [23.5]	Ardmore Formation	TBC	TBC	TBC
		24.8 [2.7]	19.3 [8.2]	8 [19.5]	Weathered ECBF	TBC	TBC	TBC
		24.8 [2.7]	19.3 [8.2]	26 [1.5]	ECBF Rock	TBC	TBC	TBC
HBS6-01	18.9	15.1 [3.8]	9.6 [9.3]	4.5 [14.4]	Takanini Formation	TBC	TBC	TBC
		15.1 [3.8]	9.6 [9.3]	8 [10.9]	Takanini Formation	TBC	TBC	TBC
		15.1 [3.8]	9.6 [9.3]	16 [2.9]	ECBF Rock	TBC	TBC	TBC
HBS6-02	16.3	12.5 [3.8]	7 [9.3]	3 [13.3]	Fill	TBC	TBC	TBC
		12.5 [3.8]	7 [9.3]	7 [9.3]	Takanini Formation	TBC	TBC	TBC
		12.5 [3.8]	7 [9.3]	16 [0.3]	ECBF Rock	TBC	TBC	TBC
HBT-01	15.9	19.5 [-3.6]	14 [1.9]	5 [10.9]	Weathered ECBF	TBC	TBC	TBC
		19.5 [-3.6]	14 [1.9]	24 [-8.1]	ECBF Rock	TBC	TBC	TBC
HBT-02	19.1	22.2 [-3.1]	16.6 [2.5]	3 [16.1]	Weathered ECBF	TBC	TBC	TBC
		22.2 [-3.1]	16.6 [2.5]	15 [4.1]	ECBF Rock	TBC	TBC	TBC

BH ID	Collar RL (m)	Depth of Shaft/Tunnel (m bgl) [m RL]		VWP Tip Depth (m bgl) [m RL]	Geological Unit Screened	Baseline GWL	Alert Level for typical drawdown (m)	
		Design Option 1	Design Option 2				Alert Level No. 1	Alert Level No. 2
		22.2 [-3.1]	16.6 [2.5]	21 [-1.9]	ECBF Rock	TBC	TBC	TBC
HBT-03	20.6	23.2 [-2.6]	17.7 [2.9]	5 [15.6]	Takanini Formation	TBC	TBC	TBC
		23.2 [-2.6]	17.7 [2.9]	26 [-5.4]	ECBF Rock	TBC	TBC	TBC
HBT-04	19.9	22 [-2.1]	16.8 [3.1]	6.45 [13.5]	Residual ECBF	TBC	TBC	TBC
		22 [-2.1]	16.8 [3.1]	26 [-6.1]	ECBF Rock	TBC	TBC	TBC
HBT-05	18.6	20.2 [-1.6]	14.9 [3.7]	4.5 [14.1]	Takanini Formation	TBC	TBC	TBC
		20.2 [-1.6]	14.9 [3.7]	20.5 [-1.9]	ECBF Rock	TBC	TBC	TBC
HBT-07	13.3	14.5 [-1.2]	8.9 [4.4]	7.5 [5.8]	Takanini Formation	TBC	TBC	TBC
		14.5 [-1.2]	8.9 [4.4]	14.5 [-1.2]	ECBF Rock	TBC	TBC	TBC
HBT-09	21.7	20.8 [0.9]	15.4 [6.3]	4.1 [17.6]	Takanini Formation	TBC	TBC	TBC
		20.8 [0.9]	15.4 [6.3]	19.1 [2.6]	ECBF Rock	TBC	TBC	TBC
HBT-10	16.8	15.6 [1.2]	10.3 [6.5]	4 [12.8]	Residual ECBF	TBC	TBC	TBC
		15.6 [1.2]	10.3 [6.5]	16.5 [0.3]	ECBF Rock	TBC	TBC	TBC
HBT-10a	13.8	12.2 [1.6]	7 [6.8]	7.5 [6.3]	ECBF Rock	TBC	TBC	TBC
		12.2 [1.6]	7 [6.8]	15 [-1.2]	ECBF Rock	TBC	TBC	TBC
HBT-11	15.8	14.1 [1.7]	8.5 [7.3]	3.5 [12.3]	Takanini Formation	TBC	TBC	TBC
		14.1 [1.7]	8.5 [7.3]	7 [8.8]	Ardmore Formation	TBC	TBC	TBC
		14.1 [1.7]	8.5 [7.3]	15 [0.8]	Takanini Formation	TBC	TBC	TBC
HBT-12	25.9	22.5 [3.4]	17 [8.9]	5 [20.9]	Residual ECBF	TBC	TBC	TBC
		22.5 [3.4]	17 [8.9]	20 [5.9]	ECBF Rock	TBC	TBC	TBC

BH ID	Collar RL (m)	Depth of Shaft/Tunnel (m bgl) [m RL]		VWP Tip Depth (m bgl) [m RL]	Geological Unit Screened	Baseline GWL	Alert Level for typical drawdown (m)	
		Design Option 1	Design Option 2				Alert Level No. 1	Alert Level No. 2
HBT-13	18.6	8.8 [9.8]	5.1 [13.5]	4.5 [14.1]	Residual ECBF	TBC	TBC	TBC
		8.8 [9.8]	5.1 [13.5]	12.5 [6.1]	ECBF Rock	TBC	TBC	TBC
HBT-14	24.1	5 [19.1]	4.1 [20]	4.5 [19.6]	Residual ECBF	TBC	TBC	TBC
		5 [19.1]	4.1 [20]	14 [10.1]	ECBF Rock	TBC	TBC	TBC

3.8 Underground services condition monitoring

3.8.1 General

Excavations (trenches, shafts and tunnels) are expected to be undertaken in proximity to various existing underground services including wastewater, stormwater, water, electricity, telecommunications, and gas. These services are constructed of different materials to various standards, and as such have varying tolerances to deformation.

The assessment of effects undertaken[2] indicates differential settlements are estimated well outside of published tolerances across the majority of the alignment, generally in excess of 1(v):2,000(h). Settlements closer to tolerances, between 1(v):250(h) and 1(v):500(h), have been estimated at the topographic low points of the alignment where the Option 2 (upper) tunnel profile is adopted. These services are listed below:

- 86-88 Sarsfield Street (SE03):
  - 675 CI and 750 CONC (rising) local wastewater line.
  - 450 CONC and 125 PYTH stormwater line.
- 46-50 Argyle Street (SE04):
  - 900 CONC and 225/300 VC local wastewater line.
  - 229 / 300 VC transmission wastewater line.
  - 300, 900 and 1050CONC stormwater line.
  - 100AC local water line.
- 37-39 Marine Parade (Shaft 7)
  - 150 CI and 300-375 VC local wastewater line.
  - 299 VC transmission wastewater line.
  - 600 ERWR stormwater line.
  - 40 MS local water line.

The alignment of these services is presented on Figure 1 to 17 in Appendix A, which shows that the majority of the services in these areas intersect the proposed intercept shafts. It is expected that some services may need to be relocated as part of the works, or otherwise abandoned, replaced, or upgraded. The requirement to undertake condition surveys on the above should therefore be

confirmed following detailed design and prior to commencement of construction once the methodology around these services is finalised.

Prior to construction a pre-condition survey shall be undertaken on assets that are able to be accessed. The survey may comprise a CCTV condition assessment carried out by adequately qualified personnel, and shall include the following but 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 RL (GPS).
5 Photographic/video evidence of (1), (2), and (3) above.

If the total or differential Alarm limits are reached during construction in close proximity of the pipe (less than 20 m), a post-construction survey will be done within six months of completion of construction 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 Chartered Surveyor or Chartered Professional Engineer 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 monitoring programme and the vertical Alert and Alarm Trigger Levels for the Ground Monitoring Pins for monitoring underground services is the same as the Ground Monitoring Points presented in Section 3.6.1 unless otherwise agreed upon with the asset owner. If the trigger levels are exceeded, the actions outlined in Section 7 shall be carried out.

4 Pre and post construction condition surveys of nearby buildings

A pre-construction condition survey of the properties listed in Table 4.1 shall be carried out a maximum of 3 months prior to the commencement of construction and/or dewatering (whichever occurs first). An external survey should be undertaken as a minimum.

Table 4.1: Summary of properties to be surveyed

Building Address	Legal Title	Building Type
28 Sarsfield Street	LOT 1 DP 335655	Residential
30 Sarsfield Street	PART ALLOTMENT 9-10 SECTION 8 SUBURBS OF AUCKLAND	Residential
32 Sarsfield Street	PART ALLOTMENT 9 SECTION 8 SUBURBS OF AUCKLAND	Residential
37 Sarsfield Street	LOT 5 DP 499	Residential
59 Hamilton Road	PART ALLOTMENT 8-9 SECTION 8 SUBURBS OF AUCKLAND	Residential
54 Sarsfield Street	LOT 1 DP 509905	Residential
61 Sarsfield Street	LOT 1 DP 1228	Residential
UNIT 1-6, 65 Sarsfield Street	UNIT 1A AND ACCESSORY UNIT 2 DP 120066	Residential
80 Sarsfield Street	LOT 1 DP 176793	Residential
81 Sarsfield Street*	LOT 1 DP 375454	Residential
56 Sentinel Road	LOT 1 DP 6560	Residential
83B Sarsfield Street	LOT 2 DP 470317	Residential
85 Sarsfield Street	LOT 1 DP 470317	Residential
86 Sarsfield Street	LOT 1 DP 498806	Residential
88 Sarsfield Street	LOT 11 DP 11193	Residential
91 Sarsfield Street	LOT 5 DP 441	Residential
99 Sarsfield Street	LOT 1 DP 202223	Residential
UNIT 1-3, 105 Sarsfield Street	UNIT 1A AND ACCESSORY UNIT 1 DP 107274	Residential
92 Sarsfield Street	FLAT 1 DP 87128, PT LOT 3 DP 7639	Residential
94 Sarsfield Street	FLAT 2 DP 87128, PT LOT 3 DP 7639	Residential
96 Sarsfield Street	FLAT 3 DP 99775, PT LOT 3 DP 7639	Residential
98 Sarsfield Street	FLAT 4 DP 87128, PT LOT 3 DP 7639	Residential
51 Wallace Street	FLAT 5 DP 87128, PT LOT 3 DP 7639	Residential
2 Stack Street	LOT 1 DP 338779	Residential
58 Wallace Street	PART LOT 2-3 ALLOTMENT 5 OF SECTION 8 SUBURBS OF AUCKLAND	Residential

Building Address	Legal Title	Building Type
43 Wallace Street	LOT 2 DP 7639	Residential
41 Wallace Street	PART LOT 1 DP 7639	Residential
39 Wallace Street	LOT 1 DP 454071	Residential
48 Wallace Street	PART ALLOTMENT 5 SECTION 8 SUBURBS OF AUCKLAND AND DP 21470	Residential
50A Wallace Street	PART ALLOTMENT 5 SECTION 8 SUBURBS OF AUCKLAND AND DP 3212	Residential
46 Argyle Street	LOT 1 DP 147	Residential
50A & 50B Argyle Street	LOT 4 DP 31540, LEASEHOLD, FLAT 1 DP 89770	Residential
49A Argyle Street	LOT 1 DP 42614	Residential
45 Argyle Street	LOT 1 DP 448279	Residential
79 Argyle Street	LOT 1 DP 350150	Residential
42 Herne Bay Road	PT LOT 3 ALLOTMENT 1 SECTION 2&8 SUBURBS OF AUCKLAND	Residential
36 Herne Bay Road	DP 11631	Residential
34 Herne Bay Road	PART ALLOTMENT 1 SECTION 8 SUBURBS OF AUCKLAND	Residential
32 Herne Bay Road	Lot 1 DP 145282	Residential
27 Herne Bay Road	Lot 37 DP 2477	Residential
72 Argyle Street	LOT 1 DP 308160	Residential
31 Herne Bay Road	LOT 2 DP 308160	Residential
29 Herne Bay Road	LOT 2 DP 327185	Residential
20 Marine Parade	LOT 1 DP 76835	Residential
16 Upton Street	LOT 1 DP 1214	Residential
31 Marine Parade	LOT 1 DP 510896	Residential
33A Marine Parade	LOT 1 DP 149545, LEASEHOLD, FLAT 1 DP 149545	Residential
35 Marine Parade	LOT 1 DP 29583	Residential
37 Marine Parade	LOT 2 DP 29583	Residential
39 Marine Parade	LOT 3 DP 29583	Residential
22 Marine Parade	PART ALLOTMENT 1 SECTION 8 SUBURBS OF AUCKLAND	Residential
24 Marine Parade	Lot 1 DP 46328	Residential
51-53 Marine Parade	ALLOTMENT 77 SUBURBS OF AUCKLAND AND LOT 2 DP 90153	Residential
32 Marine Parade & 13 & 17 Bella Vista Road	LOT 3 DP 182886	Residential
5 Stack Street	Lot 1 DP 458791	Residential
15 Cremorne Street	Lot 2 DP 212064, Lot 1 DP212064, Lot 1 DP 208893	Residential

Building Address	Legal Title	Building Type
6 River Terrace	Section 2 SO 409229, Lot 1 DP 402794	Residential
8 Wairangi Street	Lot 2 DP 39761	Residential
1 Marine Parade	Lot 4 DP 21439	Residential

* Set out of Building monitoring pins to be co-ordinated as building is currently under construction.

The survey report shall confirm the existing condition of these properties (including dwelling, garage and sheds where applicable). Major features of the buildings and site developments shall be recorded including location, type of construction, age and present conditions including defects.

The survey shall include, but not limited to the following:

1 Type of foundations (where observable or otherwise inferred).

2 Condition of existing asset including existing level of damage.

3 Susceptibility of structure to further movement and damage.

4 Review of proposed Alert and Alarm levels to confirm they are appropriately set based on the building type and condition.

5 Photographic evidence of (1), (2), and (3) above.

During construction, visual observations of the structure and surrounding ground of the assets identified in the pre-construction property survey shall be performed on a fortnightly basis where properties are within 25 m of active works. Additional observations may be required if requested by the building or asset owner.

Within six months of completion of construction, a post-construction survey covering the items detailed above shall be completed for any building that had a pre-construction survey carried out. The survey report shall include a determination of the cause of damage identified (if any) since the pre-construction or previous survey and steps to repair it.

A copy of the pre and post-construction survey reports shall be forwarded to AC within 15 working days of completing the reports. Reports should be reviewed and signed by a Chartered Professional Engineer who has certified that the survey has been completed in a professional manner and is an accurate assessment of the condition of the buildings concerned.

5 Summary of monitoring frequency

The monitoring frequency requirements detailed in the previous sections are summarised in Table 5.1 below.

Table 5.1: Summary of monitoring frequency requirements

Monitoring system	Monitoring Locations	Prior to commencement excavation	During excavation and dewatering	After completion of excavation and dewatering	After completion of construction
Settlement monitoring points	BS1 – BS180 GS1 – GS125	A minimum of 2 baseline readings, 1 month prior to construction	Weekly for: • All monitoring points within 50 m of TBM tunnel/trench excavations • All monitoring points within 20 m of a TBM shaft Fortnightly where: • All monitoring points within 100 m of TBM tunnel/trench excavations • All monitoring points within 50 m of a TBM shaft Every two months where: • All monitoring points within 100 m of a TBM shaft	Monthly for three months or until such time following the completion of excavation and dewatering that stable measurements are demonstrated, and written confirmation is provided from AC to cease monitoring.	Post-construction condition survey of dwellings
Vibrating-wire piezometer	Refer to Table 3.3	Baseline readings are currently being undertaken prior to work commencing to establish seasonal fluctuation	'Continuous' monitoring at 15-minute intervals to be undertaken using telemetry instrumentation. Monitoring records to be available via online monitoring portal. Automatic warning system to be established for Alert / Alarm trigger levels.	Monitoring portal to be available for three months or until such time following the completion of excavation and dewatering that stable measurements are demonstrated, and written confirmation is provided from AC to cease monitoring.	N/A

6 Reporting of monitoring records

6.1 Baseline readings

Baseline readings for ground and building deformation shall be established before the commencement of excavation, including piling works.

These baseline readings shall be compiled and submitted to AC's representative prior to commencement of dewatering.

Groundwater monitoring shall be undertaken throughout the summer period when possible. The lowest recorded groundwater level during monitoring will season will be taken as the baseline level.

6.2 Reporting intervals and requirements

All monitoring records as detailed in this report shall be compiled and submitted to AC's representative every two months, from the commencement of excavation until three months after the completion of excavation and dewatering (or at such time following the completion of excavation that stable measurements are demonstrated and written conformation is provided from AC).

Each report shall include the following:

1 Monitoring records presented in a tabulated format as well as on a timeline plot with rainfall data.
2 Comparison of monitoring data with trigger levels.
3 Previous results set out with an explanation of any trends.
4 A construction progress summary.
5 Results of fortnightly visual observations of the structure and surrounding ground of the assets identified in the relevant pre-construction property survey.
6 Any other information relevant to the reporting period (i.e. exceedance of trigger levels and contingency measures being undertaken).

7 Alert and Alarm trigger level response procedures

7.1 Response procedure if the Alert trigger levels are exceeded

If any of the monitoring Alert trigger levels are reached, then one or more of the contingency options described in Section 8 of this plan shall be carried out together with the following:

1 Notify the Project Manager.

2 Notify AC, in writing within one working day of the trigger level being exceeded, with details of any actions being undertaken.

3 Survey all survey monitoring marks within 25 m of the affected monitoring marks to confirm the extent of deformation and exceedance of the Alert trigger.

4 Review the monitoring data, as-built details and geology, and compare against the assumptions made in the design analyses.

5 Submit a written report by a Chartered Professional Engineer to AC for approval, within one week of trigger level exceedance, which provides analyses of all monitoring data relating to the exceedance of any of the trigger levels and any recommendations for remedial actions and time frames for implementing these actions.

6 If considered necessary:

- Increase monitoring frequency.
- Develop a detailed contingency plan and submit to AC.

7.2 Response procedure if the Alarm trigger levels are exceeded

If the monitoring Alarm trigger levels are reached for any ground, building, or service deformation, then the following shall be carried out for the different works in addition to the actions outlined in Section 7.1:

1 Cease further excavation (including tunnelling) or any other activity such as dewatering which has the potential to cause further deformations. Dewatering will not cease where this may result in the potential loss of the TBM or cause instability in an excavation.

2 Submit a written report by a Chartered Professional Engineer to AC for approval, within one week of Alarm trigger level exceedance, which provides analyses of all monitoring data and any recommendations for remedial action.

3 Once approved by AC the recommendations shall be implemented.

Dewatering and/or construction may be resumed once AC's representative gives written approval for construction to continue.

8 Contingency options

8.1 General

If any of the monitoring trigger levels are exceeded the general response will be as detailed in Section 7. Specific actions will be selected depending on the exact nature of the problem. Possible contingency actions are detailed in the following sections.

8.2 Ground and building deformation contingency measures

In the event of ground or building deformation exceeding the monitoring trigger levels, one or more of the following actions shall be taken:

1 Review pre-construction condition surveys of the affected building, followed up by discussions on the situation with the property/service owner that may be affected.

2 If deformations are due to groundwater drawdown, groundwater injection to commence.

3 Monitor the rate of settlement (assuming that other steps have been undertaken to address the cause).

4 If groundwater inflows to excavations are excessive, grout injection behind the excavation retention system should be considered.

5 Check public safety is maintained.

8.3 Underground services settlement contingency measures

Contingency measures for the settlement of underground services shall be established with the asset owner.

9 Monitoring and contingency plan review

The GSCMP shall be reviewed as required during construction to reflect on any changes that relate to implementation of the GSCMP. Reviews shall take into consideration the following:

- Changes in ground conditions and or site conditions.
- Changes in existing structures.
- Changes in analysis, design or construction methods.
- Changes in legal requirements, consent conditions, guidance notes, industry best practices standards, etc.
- Unresolved comments and/or complaints and responses to the complaints and remedial action (if taken) to the address.

10 Applicability

This report has been prepared for the exclusive use of our client Watercare Services Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

During excavation and construction, the site should be examined by an engineer or engineering geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which this report and the geotechnical assessment of effects report have been based. We would be pleased to provide this service to you and believe your project would benefit from such continuity. However, it is important that we be contacted if there is any variation in subsoil conditions from those described in the report.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
.....	.....
Kishan Ranchhod Geotechnical Engineer	Shannon Richardson Project Director

Report has been reviewed by Mark Thomas, Senior Geotechnical Engineer

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

26-Oct-23
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Appendix A Figures

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LEGEND

- Trench
- Building Settlement Monitoring
- Ground Settlement Monitoring
- Groundwater Level Monitoring
- TBM Tunnel Centreline
- Stormwater Pipe
- Wastewater Pipe Local
- Water Pipe Local
- 20mm Settlement
- 15mm Settlement
- 10mm Settlement
- 5mm Settlement
- EOP
- Tunnel Width
- SE Shafts
- Main Shafts
- Property Address — Pre- and post-construction condition survey

37 SARSFIELD STREET
LOT 5 DP 499

32 SARSFIELD STREET
PART ALLOTMENT 9 SECTION 8 SUBURBS OF AUCKLAND

30 SARSFIELD STREET
PART ALLOTMENT 9-10 SECTION 8 SUBURBS OF AUCKLAND

28 SARSFIELD STREET
LOT 1 DP 335655

Shaft 1

Sarsfield St

Curran St

A3 SCALE 1:300
0 3 6 9 12 15 Meters

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NOTES:
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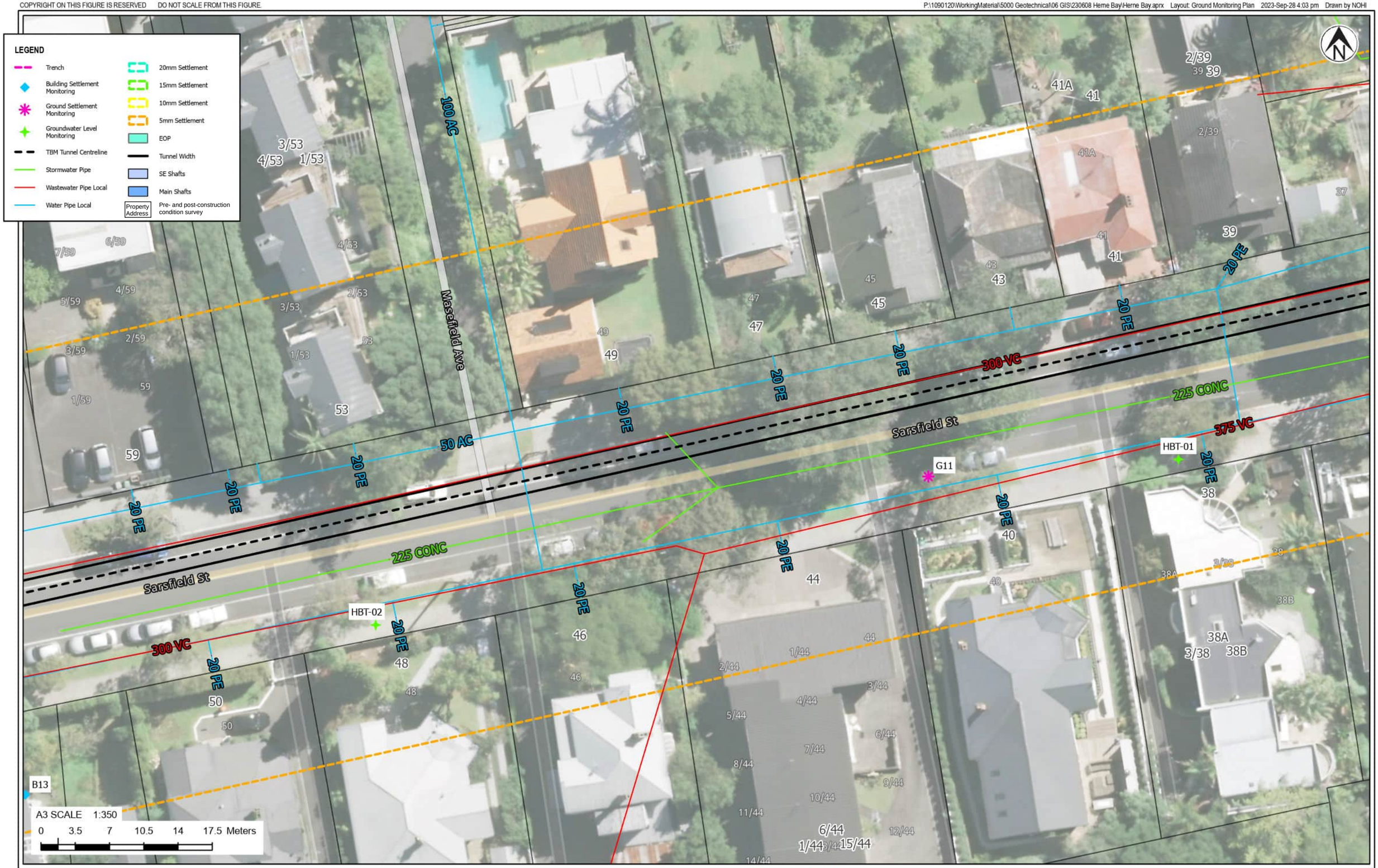
REV	DESCRIPTION	GIS	CHK	DATE
0	First version	NOHI	RSXW	4/09/2023

LOCATION PLAN

PROJECT No.	1090120	
DESIGNED	NOHI	SEP.23
DRAWN	NOHI	SEP.23
CHECKED	RSXW	SEP.23
APPROVED		DATE

CLIENT **WATERCARE SERVICES LIMITED**
PROJECT **HERNE BAY CONNECTOR**
TITLE GROUND SETTLEMENT MONITORING PLAN
SCALE (A3) 1:300 FIG No. Figure 1 of 17 REV 0

P:\1090120\WorkingMaterial\5000 Geotechnical\06 GIS\230608 Herne Bay\Herne Bay.aprx Layout: Ground Monitoring Plan 2023-Sep-28 4:03 pm Drawn by NOHI



NOTES:

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PROJECT HERNE BAY CONNECTOR

TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:350 FIG No. Figure 2 of 17 REV 0

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LEGEND

- Trench
- Building Settlement Monitoring
- Ground Settlement Monitoring
- Groundwater Level Monitoring
- TBM Tunnel Centreline
- Stormwater Pipe
- Wastewater Pipe Local
- Water Pipe Local
- 20mm Settlement
- 15mm Settlement
- 10mm Settlement
- 5mm Settlement
- EOP
- Tunnel Width
- SE Shafts
- Main Shafts
- Property Address — Pre- and post-construction condition survey

UNIT 1-6, 65 SARSFIELD STREET
UNIT 1A AND ACCESSORY UNIT 2
DP 120066

61 SARSFIELD STREET
LOT 1 DP 1228

54 SARSFIELD STREET
LOT 1 DP 509905

59 HAMILTON ROAD
PART ALLOTMENT 8-9
SECTION 8 SUBURBS OF
AUCKLAND

Hamilton Rd

Sarsfield St

A3 SCALE 1:350
0 3.5 7 10.5 14 17.5 Meters

NOTES:
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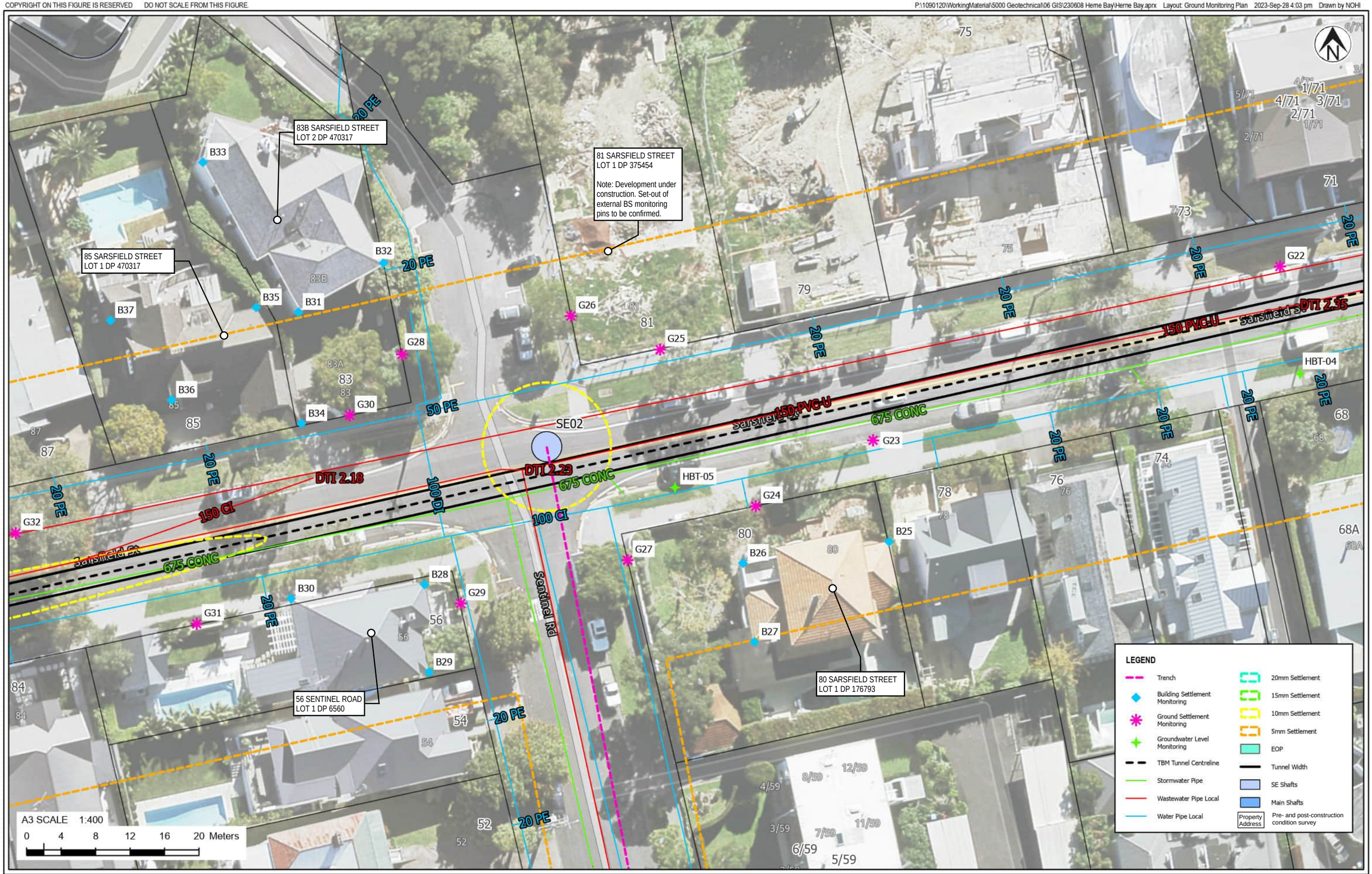
PROJECT HERNE BAY CONNECTOR
TITLE GROUND SETTLEMENT MONITORING PLAN
SCALE (A3) 1:350 FIG No. Figure 3 of 17 REV 0



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APPROVED		DATE

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PROJECT **HERNE BAY CONNECTOR**

TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:400 FIG No. Figure 4 of 17 REV 0

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APPROVED		DATE

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PROJECT **HERNE BAY CONNECTOR**

TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:400 FIG No. Figure 5 of 17 REV 0

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0	First version	NOHI	RSXW	4/09/2023

LOCATION PLAN

PROJECT No.	1090120	
DESIGNED	NOHI	SEP.23
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PROJECT HERNE BAY CONNECTOR

TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:400 FIG No. Figure 6 of 17 REV 0

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UNIT 1-3, 105 SARSFIELD STREET
UNIT 1A AND ACCESSORY UNIT 1 DP 107274

99 SARSFIELD STREET
LOT 1 DP 202223

91 SARSFIELD STREET
LOT 5 DP 441

51 WALLACE STREET
FLAT 5 DP 87128, PT LOT 3 DP 7639

92 - 98 SARSFIELD STREET
FLAT 1 - 4 DP 87128/99775, PT LOT 3 DP 7639

88 SARSFIELD STREET
LOT 11 DP 11193

86 SARSFIELD STREET
LOT 1 DP 498806

B55 B54 B53 B52 B51 B50 B49 B48 B47 B46 B45 B44 B43 B42 B41 B40 B39 B38 B37 B36 B35 B34 B31 B30 B28

G38 G37 G36 G35 G34 G33 G32 G31 G30 G28

HBS2-02

EOP201 SE03 HBT-07

1050 CONC 450 CONC 750 CONC (Rising) 675 CONC 375 PVC-U 300 VC 525 CONC 450 PVC-U 675 CI 150 CI 100 CI 50 MS

DTI 2.18 DTI 3.62 DTI 3.12

20 PE

Sarsfield St Lawrence St

A3 SCALE 1:400
0 4 8 12 16 20 Meters

LEGEND

- Trench
- Building Settlement Monitoring
- Ground Settlement Monitoring
- Groundwater Level Monitoring
- TBM Tunnel Centreline
- Stormwater Pipe
- Wastewater Pipe Local
- Water Pipe Local
- 20mm Settlement
- 15mm Settlement
- 10mm Settlement
- 5mm Settlement
- EOP
- Tunnel Width
- SE Shafts
- Main Shafts
- Property Address
- Pre- and post-construction condition survey

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PROJECT HERNE BAY CONNECTOR
TITLE GROUND SETTLEMENT MONITORING PLAN
SCALE (A3) 1:400 FIG No. Figure 7 of 17 REV 0

UNIT 1-3, 105 SARSFIELD STREET
UNIT 1A AND ACCESSORY UNIT 1 DP 107274

58 WALLACE STREET
PART ALLOTMENT 2-3 ALLOTMENT 5 OF SECTION 8 SUBURBS OF AUCKLAND

51 WALLACE STREET
FLAT 5 DP 87128, PT LOT 3 DP 7639

92 - 98 SARSFIELD STREET
FLAT 1 - 4 DP 87128/99775, PT LOT 3 DP 7639

2 STACK STREET
LOT 1 DP 338779

50A WALLACE STREET
PART ALLOTMENT 5 SECTION 8 SUBURBS OF AUCKLAND AND DP 3212

43 WALLACE STREET
LOT 2 DP 7639

Shaft 2

EOP1019_WWMH01

HBS2-01
HBS2-02
HBS3-02

B54 B56 B58 B60 B59 B61 B62 B63 B64 B65 B52 B53 B50 B51 B69 B72

G37 G38 G39 G40 G41 G42 G43 G44 G45 G46 G47 G48 G49 G50 G111 G112 G114 G115

150 CI
100 CI
305 VC
300 VC
225 VC
150 PVC-U
450 CONC
525 CONC
450 PVC-U
50 MS
20 PE
DTI 3.35
DTI 3.11
DTI 2.15
DTI 3.62

Wallace St
Stack St
Sarsfield St
Wairangi St

A3 SCALE 1:400
0 4 8 12 16 20 Meters

LEGEND
- Trench
- Building Settlement Monitoring
- Ground Settlement Monitoring
- Groundwater Level Monitoring
- TBM Tunnel Centreline
- Stormwater Pipe
- Wastewater Pipe Local
- Water Pipe Local
- 20mm Settlement
- 15mm Settlement
- 10mm Settlement
- 5mm Settlement
- EOP
- Tunnel Width
- SE Shafts
- Main Shafts
- Property Address — Pre- and post-construction condition survey

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0	First version	NOHI	RSXW	4/09/2023

LOCATION PLAN

PROJECT No.	1090120	
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TITLE GROUND SETTLEMENT MONITORING PLAN
SCALE (A3) 1:400 FIG No. Figure 8 of 17 REV 0

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8 WAIRANGI STREET, LOT 2 DP 39761

15 CREMORNE STREET, LOT 2 DP 212064, LOT 1 DP 212064, LOT 1 DP 208893

6 RIVER TERRACE, SECTION 2 SO 409229, LOT 1 DP 402794

5 STACK STREET, LOT 1 DP 182886

58 WALLACE STREET PART ALLOTMENT 2-3 ALLOTMENT 5 OF SECTION 8 SUBURBS OF AUCKLAND

B166 B168 B165 B167 B170 B169 B172 B171 B174 B173 B175 B176 B164 B163 B162 B58 B60 B59 B61 B65

G116 G117 G120 G118 G119 G114 G113 G111 G115 G112 G40 G41 G42 G44 G43 G47

EOP1019_WWMH02 EOP1019 EOP1019_WWMH01

River Tce Wairangi St Stack St Wallace St

25 PE 20 PE 20 PE 20 PE 20 PE 20 PE 20 PE

DTI 1.94 DTI 1.31 DTI 1.3 DTI 1.78 DTI 3.35 DTI 2.15 DTI 2.28

150 CI 100 CI 100 CI 100 CI 150 CI

305 VC 375 VC 150 VC 300 VC 300 VC 225 VC

50 MS 50 MS

HBS2-01 Shaft 2

A3 SCALE 1:500

0 5.5 11 16.5 22 27.5 Meters

LEGEND

- Trench
- Building Settlement Monitoring
- Ground Settlement Monitoring
- Groundwater Level Monitoring
- TBM Tunnel Centreline
- Stormwater Pipe
- Wastewater Pipe Local
- Water Pipe Local
- 20mm Settlement
- 15mm Settlement
- 10mm Settlement
- 5mm Settlement
- EOP
- Tunnel Width
- SE Shafts
- Main Shafts
- Property Address
- Pre- and post-construction condition survey

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TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:500 FIG No. Figure 9 of 17 REV 0

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LEGEND

- Trench
- Building Settlement Monitoring
- Ground Settlement Monitoring
- Groundwater Level Monitoring
- TBM Tunnel Centreline
- Stormwater Pipe
- Wastewater Pipe Local
- Water Pipe Local
- 20mm Settlement
- 15mm Settlement
- 10mm Settlement
- 5mm Settlement
- EOP
- Tunnel Width
- SE Shafts
- Main Shafts
- Property Address — Pre- and post-construction condition survey

2 STACK STREET LOT 1 DP 338779

50A WALLACE STREET PART ALLOTMENT 5 SECTION 8 SUBURBS OF AUCKLAND AND DP 3212

43 WALLACE STREET LOT 2 DP 7639

41 WALLACE STREET PART LOT 1 DP 7639

39 WALLACE STREET, LOT 1 DP 454071

48 WALLACE STREET PART ALLOTMENT 5 SECTION 8 SUBURBS OF AUCKLAND AND DP 21470

B62 B63 B64 B65 B66 B67 B68 B69 B70 B71 B72 B73 B74 B75 B76 B77 B78 B79 B80 B81 B82 B83 B84

G46 G47 G48 G49 G50 G51 G52 G53 G54 G55 G56 G57 G58 G59

HBS3-01 HBS3-02

Shaft 3

Wallace St Argyle St

20 PE 100 CI 300 CONC 375 CONC 450 CONC

A3 SCALE 1:400

0 4 8 12 16 20 Meters

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TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:400 FIG No. Figure 10 of 17 REV 0

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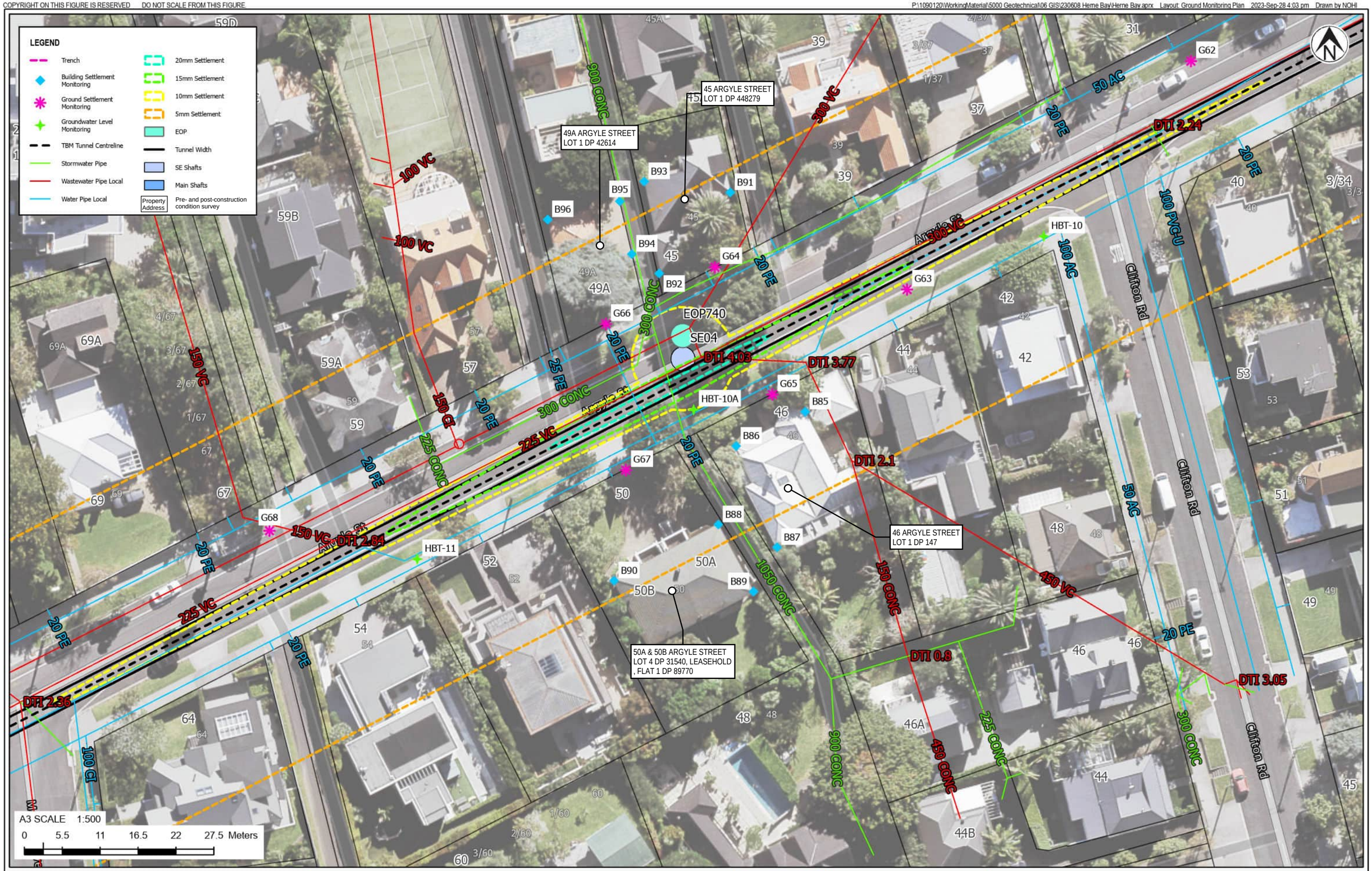
TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:400 FIG No. Figure 11 of 17 REV 0



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TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:500 FIG No. Figure 12 of 17 REV 0

LEGEND

- Trench
- Building Settlement Monitoring
- Ground Settlement Monitoring
- Groundwater Level Monitoring
- TBM Tunnel Centreline
- Stormwater Pipe
- Wastewater Pipe Local
- Water Pipe Local
- 20mm Settlement
- 15mm Settlement
- 10mm Settlement
- 5mm Settlement
- EOP
- Tunnel Width
- SE Shafts
- Main Shafts
- Property Address — Pre- and post-construction condition survey

B99, B100, B97, B98, B101, B103, B102, B104, B105, B106, B107, B108, B109, B110, B111, B113, B112, B114, B115, B117

G69, G70, G71, G73, G74, G75, G76, G72, G77, G78, G79, G84

HBS4-02, HBS5-02

79 ARGYLE STREET LOT 1 DP 350150

42 HERNE BAY ROAD PT LOT 3 ALLOTMENT 1 SECTION 2&8 SUBURBS OF AUCKLAND

36 HERNE BAY ROAD DP 11631

72 ARGYLE STREET LOT 1 DP 308160

31 HERNE BAY ROAD LOT 2 DP 308160

29 HERNE BAY ROAD LOT 2 DP 327185

Shaft 4

Shaft 5

Herne Bay Rd

Argyle St

Masons Ave

DTI 1.88

DTI 2.07

DTI 2.36

40 MS (Abandoned)

40 UNDEF (Abandoned)

50 PE (Abandoned)

20 PE

150 VC

225 CI

225 VC

100 AC

50 AC

100 PE

150 CI

A3 SCALE 1:400

0 4 8 12 16 20 Meters

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TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:400 FIG No. Figure 13 of 17 REV 0

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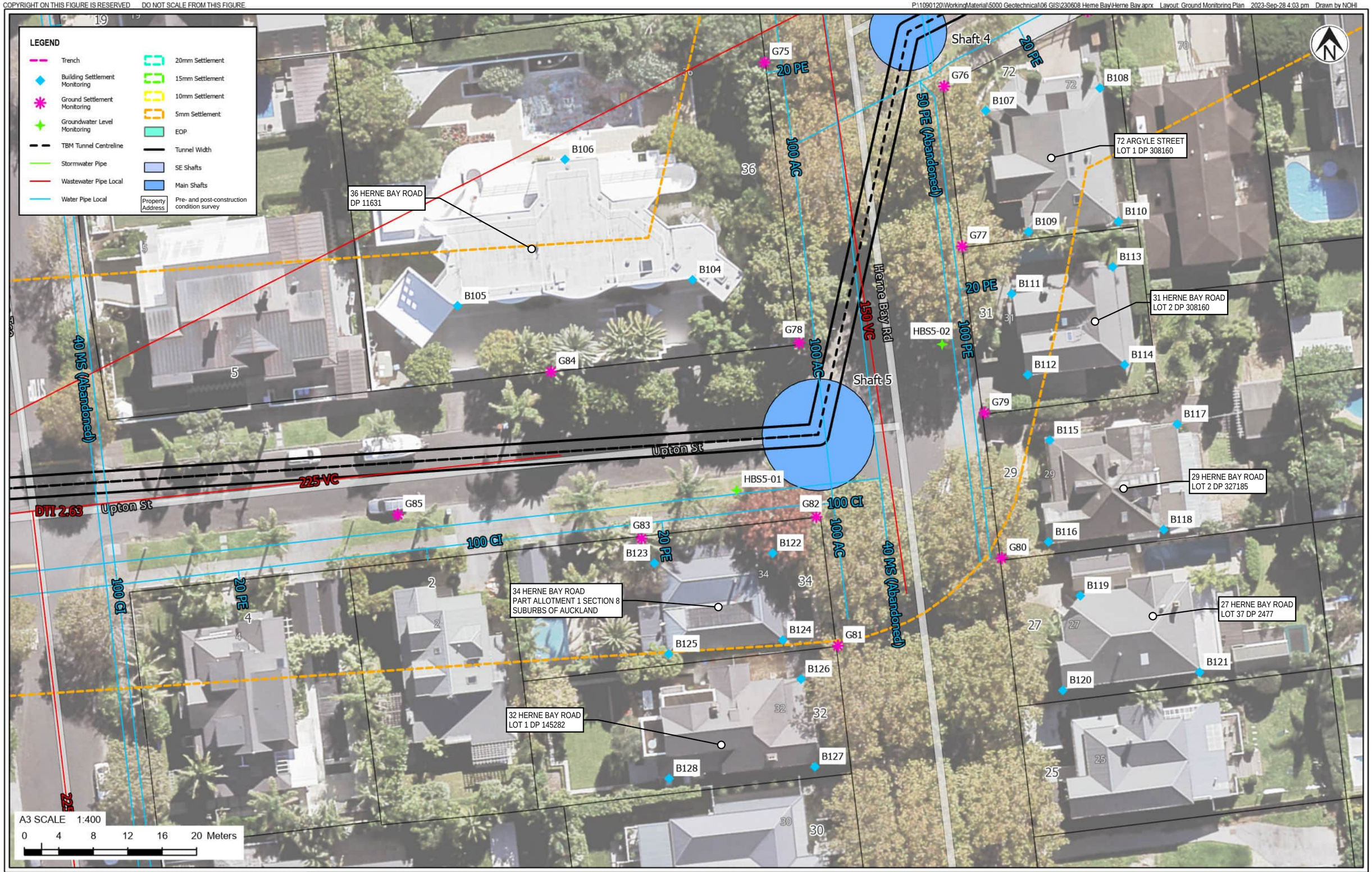
TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:400 FIG No. Figure 14 of 17 REV 0



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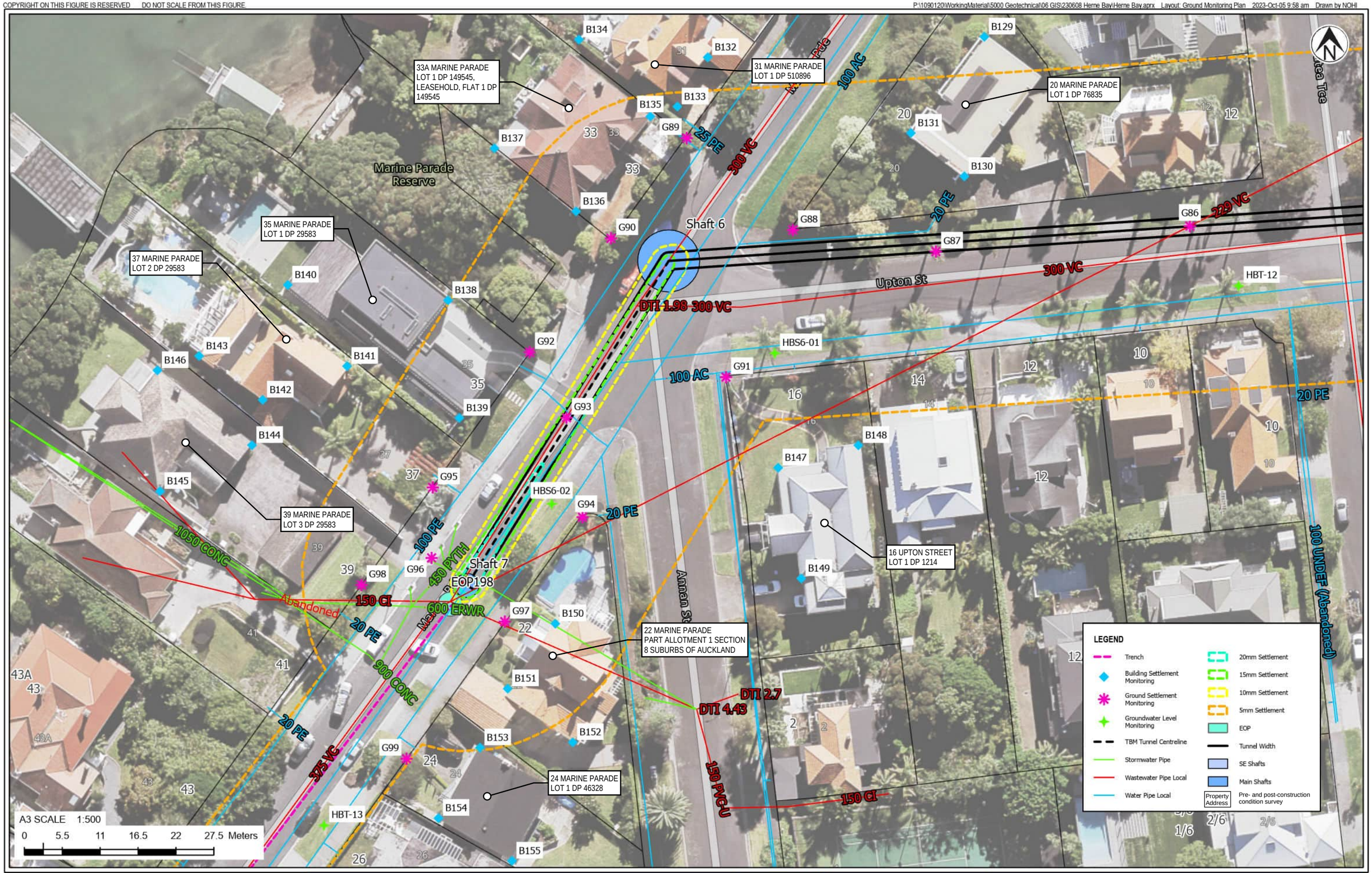
PROJECT **HERNE BAY CONNECTOR**

TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:400 FIG No. Figure 15 of 17 REV 0



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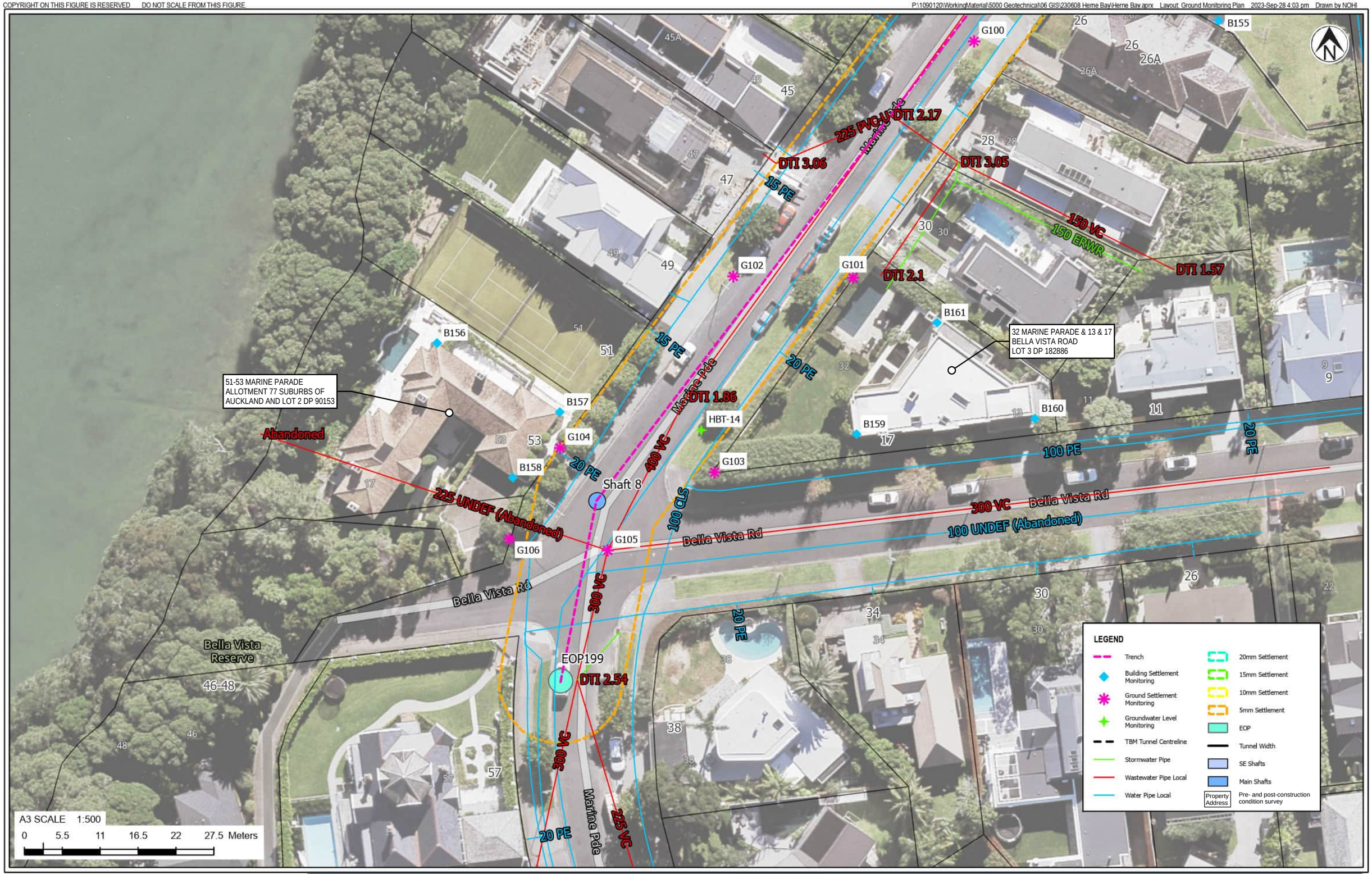
PROJECT **HERNE BAY CONNECTOR**

TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:500 FIG No. Figure 16 of 17 REV 0



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TITLE GROUND SETTLEMENT MONITORING PLAN

SCALE (A3) 1:500 FIG No. Figure 17 of 17 REV 0

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