REPORT

Tonkin+Taylor

Grey Lynn Tunnel – Changes to the Tawariki Street Secondary Shaft

S127 application and Assessment of Effects on the Environment

Prepared for
Watercare Services Limited
Prepared by
Tonkin & Taylor Ltd
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Document Control

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1 Introduction

1.1 Watercare and Grey Lynn Tunnel

Watercare Services Limited (Watercare) is responsible for the provision of potable (drinking) water and wastewater services in Auckland. Watercare is a Council-Controlled Organisation (CCO) of the Auckland Council. The company's vision is to be '*trusted by our communities to deliver performance every day'*.

The Grey Lynn Tunnel is a wastewater interceptor that runs from the Central Interceptor (CI) at Western Springs to Tawariki Street, Grey Lynn. This wastewater interceptor provides additional sewer capacity, reduces wet weather wastewater overflow discharges and enables future works to improve freshwater quality in central Auckland waterways. Resource consents for the Grey Lynn Tunnel and associated works were obtained from Auckland Council (AC) and the designation confirmed in 2019[1].

Currently, the Grey Lynn Tunnel terminates at 44 – 48 Tawariki Street (the 'Tawariki Street Shaft Site'). This site is designated for the purpose of '*construction, operation, and maintenance of wastewater infrastructure*' and provides for two shafts, known as the primary and secondary shaft. The primary shaft is the termination site of the Grey Lynn Tunnel and will allow for the retrieval of the tunnel boring machine (TBM) and connections to the Tawariki Local Sewer and Orakei Main Sewer. The secondary shaft to be constructed at the Tawariki Street Shaft Site allows for the connection of future sewers from the Combined Sewers Overflow (CSO) network.

1.2 Overview of proposed change

Since consenting and designating the Tawariki Street shaft site, Watercare has purchased the adjacent property at 42 Tawariki Street. It is now proposed to shift the secondary shaft within this property to allow for more space at the shaft construction site. As such, Watercare seeks to vary resource consent BUN60334952, which includes groundwater consent WAT60334954, to allow for the secondary shaft to be constructed on 42 Tawariki Street rather than 44 Tawariki Street as currently provided for in the consent.

In addition, at the time of consenting and designating the sites, the groundwater and settlement assessments were undertaken on the basis that the two shafts would be constructed at least 2.5 years apart allowing for groundwater levels to recover reducing the effects of groundwater drawdown. Therefore, the assessment of the secondary shaft relied upon the envelope of effects anticipated for the primary shaft given its similar footprint, construction methodology and ground conditions. Since the consenting and designating of the Grey Lynn Tunnel, Watercare has identified the potential to undertake the works concurrently for the two shaft sites and seeks to alter the resource consent (and designation) to allow for this construction programme option.

This Assessment of Effects on the Environment (AEE) report has been prepared on behalf of Watercare Services Limited to support a resource consent application to authorise a change of conditions under section 127 of the Resource Management Act 1991 (RMA), and in fulfilment of the requirements of section 88 of the RMA[2].

[1] Resource consent BUN60334952 and Designation 9468.

[2] A Notice of Requirement for an alteration to designation has also been prepared and lodged with Auckland Council.

1.3 Applicant and property details

Requiring Authority	Watercare Services Limited
Owner of site	42 Tawariki Street: Watercare Services Limited Road reserve: Auckland Transport
Site address / map reference	42 – 48 Tawariki Street, Auckland and Road Reserve
Site area	Existing consented area: Approximately 2,220 m² Total site area with change to conditions: Approximately 2,920 m²
Legal description	Lot 37 Deposited Plan 38075
Records of Title reference	NA44C/1088 and Road Reserve immediately adjacent
Council	Auckland Council
Plans	Auckland Unitary Plan – Operative in Part (AUP)
Designation ID	9468
Existing Consent Reference	BUN60334952 WAT60334954
Address for service during consent processing	Tonkin & Taylor Ltd, PO Box 5271, Victoria Street West, Auckland 1142 Attention: Rachel Signal-Ross Phone: 09 352 2995 Email: rsignal-ross@tonkintaylor.co.nz
Address for service during consent implementation and invoicing	Watercare Services Ltd, 73 Remuera Road, Newmarket, Auckland Attention: Xenia Meier Phone: 021 574 585 Email: Xenia.meier@water.co.nz

We attach copies of the relevant Records of Title in Appendix A and the existing consent in Appendix B.

2 Environmental setting

2.1 Site location and description

This comprises the Tawariki Street shaft site designation area (Designation 9468) and 42 Tawariki Street (collectively referred to as 'the site'). The existing designation partially extends into the road reserve to the south and the neighbouring school to the east (located at 183 Richmond Road).

A mix of land uses surround the site which include:

- Our Lady Perpetual Help Church and carpark to the north;
- School fields associated with Marist School and St Paul's College to the east; and
- Residential properties to the south and west of the site.

As outlined above, 44 – 48 Tawariki Street are currently designated for the purpose of the construction, operation and maintenance of wastewater infrastructure. The dwellings on 44 – 48 Tawariki Street and 42 Tawariki Street have been removed.

Figure 2.1: Site location plan showing Designation 9468 in maroon and proposed extension in purple (Source: Auckland Council AUP Maps)

2.2 AUP zoning and overlays

The planning notations at the site inclusive of zoning are identified in Table 2.1 below. 42 Tawariki St (along with 44-48 Tawariki St) is zoned Residential – Mixed Housing Urban under the AUP.

Table 2.1: Zoning and planning notations

Zoning / planning notations	Comment
Auckland Unitary Plan Mapviewer	
Residential - Mixed Housing Urban Zone	Applies to the entire site
Controls: Macroinvertebrate Community Index – Urban	Applies to the entire site
Designations – 9468: Construction, operation, and maintenance of wastewater infrastructure (Grey Lynn Tunnel), Watercare Services Ltd	Applies to 44 – 48 Tawariki Street, a section of the road reserve and neighbouring school. Watercare proposes to extend the designation to include 42 Tawariki Street and adjacent road reserve.

In addition to the above, the Auckland Council Geomap Viewer identifies a potential flood plain on 42 Tawariki Street. Two minor overland floodpaths are also mapped across 42 Tawariki St.

2.3 Geology and groundwater

The geology and groundwater regime within the project area is described in the Groundwater and Settlement Effects Assessment (Appendix D) and is summarised below.

The subsurface at the Tawariki Street site is interpreted to comprise the following geological units:

1 Fill, comprising a mixture of high plasticity, very soft clay and loose silty sand and sand, and contains occasional organics and manmade objects such as metal; overlying

2 Tauranga Group sediments which site specific investigations identified as high plasticity, very soft silty clay and clay. These sediments, along with fill deposits, are expected to thicken to the west of the site; overlying

3 Weathered ECBF, identified as extremely weak, residually to moderately weathered rock. Rock is interbedded siltstone and sandstone; overlying

4 ECBF rock, identified as extremely to very weak, moderately to slightly weathered rock. Rock is interbedded siltstone and sandstone with occasional shallow to steep angled discontinuity.

The groundwater table (shallow aquifer) generally mimics regional topography, with areas of localised perching likely along ridgelines. There are no consented groundwater takes near the shaft site. The closest consented groundwater take is 1.8km away, which is a bore for providing water to Auckland Zoo animals.

3 Proposed change of conditions

3.1 Tawariki Street shaft site

The Grey Lynn Tunnel including the Tawariki Street site is subject to a suite of existing consents. In addition, Designation 9486 specifically provides for the construction of two shafts and associated infrastructure at 44 – 48 Tawariki Street. As set out in the original application, works at the shaft site will generally comprise:

- Site establishment, including vegetation removal, services relocations, site levelling and drainage works, establishment of erosion and sediment control measures, formation of construction access, establishment of site buildings and services; and construction of site perimeter fencing and noise mitigation barriers;
- Construction of the primary and secondary shafts;
- Dewatering of the shafts;
- Construction of two underground chambers and a grit trap; and
- Reinstatement on completion, including parking areas, landscape planting, an above-ground plant room (approximately 90 m² and 4 m high), and an air vent stack (up to 8 m in height).

The effects associated with construction activities and the long-term operation of infrastructure at the Tawariki Street site were considered through the previous application process. The primary shaft, underground chambers and grit trap as well as the plant room and air vent stack were assessed and consented in the original application. This s127 application and associated assessment of effects is limited to the changes described below.

A Notice of Requirement for an alteration to designation has also been prepared and lodged with Auckland Council.

3.2 Reasons for change of conditions

Since consenting and designating the Tawariki Street site, Watercare has purchased the property at 42 Tawariki Street. Watercare now proposes to relocate the secondary shaft to within this property to allow for more space at the construction site. As such, Watercare seeks to vary the groundwater consent to allow for the construction of the secondary shaft within 42 Tawariki St.

In the original application the secondary shaft was proposed to be constructed at least 2.5 years after the primary shaft. Since consenting and designating of the Grey Lynn Tunnel, Watercare has identified the potential to undertake the works concurrently for the two shafts. This would allow for efficiencies in construction and for future local connections to be made sooner. As the original application was based on the separate construction periods, Watercare now seeks to vary the consent to allow for the option of constructing the two shafts in the one construction period (noting construction may still occur across two separate construction periods as already provided for in the existing consent).

The secondary shaft is located approximately 20m to the west of its currently consented/ designated location. The groundwater and settlement effects of the change in location of the secondary shaft and a potential change to the construction programme are addressed in this AEE. Otherwise, there is no other change in effects associated with the relocation of the secondary shaft and potential change to construction programme beyond those already provided for through the existing consent.

3.3 Changes to conditions sought

3.3.1 Condition 1.1 of BUN60334952

Condition 1.1 of BUN60334952 (which includes groundwater permit WAT60334954) requires that the works be undertaken in accordance with the plans and reports submitted as part of the application. To allow the shafts to potentially be constructed in the one construction period and to allow for the construction of the secondary shaft at 42 Tawariki Street, amendments to Condition 1.1 are proposed to refer to the information provided in this s 127 application.

Watercare's required drafting of Condition 1.1 is as follow (additions underlined, deletions ~~struck-through~~):

Plans and Information

1.1 Except as modified by the conditions below and subject to final design, the works shall be undertaken in accordance with the plans and information submitted with the application, including:

a) Assessment of Effects on the Environment, titled "Grey Lynn Tunnel – Notice of Requirement, Resource Consent Application and Assessment of Environmental Effects" prepared by Jacobs, dated February 2019.

b) S127 and Assessment of Effects on the Environment, titled "Grey Lynn Tunnel – Changes to the Secondary Shaft", prepared by Tonkin + Taylor Ltd, dated October 2022

c) Drawings as detailed below:
Tawariki St – Central Interceptor (DSCN) 00 Site General – Redesigned Site Layout – Concept Layout, dated 6 July 2022.
~~'Grey Lynn Tunnel – Tawariki Street Site Plan', Rev 0, by Boffa Miskell, dated April 2019.~~

...

d) Technical Reports as detailed below:

...

Tawariki St Shaft site relocation: Groundwater and Settlement Effects Assessment, prepared by Tonkin + Taylor Ltd, dated November 2022

e) Section 92 responses dated 18 April and 24 May 2019

3.3.2 Condition 3.12 of groundwater permit WAT60334954

Condition 3.12 requires Watercare to consult with the owners of specified properties, and subject to the owner's approval and on terms acceptable to Watercare, undertake a detailed pre-construction condition survey of these structures. The original condition refers to 42 Tawariki Street, and as such minor amendments are required to remove reference to 42 Tawariki Street which is now owned by Watercare, and instead refer to the new immediate neighbours as a result of the shift in shaft location as follows:

3.12 The Consent Holder shall consult with owners of 160-178 Surrey Crescent, the 490 and 510 Richmond Road and residences at 24, 26 30, 2/20, 32, 34 and 38 Sackville Street and 35, 37, 39, 41 and ~~42~~ 38 and 40 Tawariki Street (refer to Appendix 1, 3 Reference maps), and subject to the owner's approval on terms acceptable to the Consent Holder, undertake a detailed pre-construction condition survey of these structures to confirm their existing condition and enable the sensitivity of the existing buildings and structures to any groundwater and ground settlement changes to be accurately determined. The survey shall

be completed at least three months prior to the Commencement of Dewatering of any Project stage involving shaft sinking or tunnelling. The intent of the survey is to assist in enabling the magnitude of allowable effects from changes in groundwater pressure and ground settlement movements to be reasonably determined. The survey shall include but not necessarily be limited to the following: …

The consent also contains a reference map for Condition 3.12. An updated version of the reference map is required as shown in Figure 3.1 below.

The groundwater permit includes a suite of conditions that address monitoring, reporting and contingency measures, including relevant alert and alarm levels, pre- and post-construction condition survey requirements and repair measures (if required). It is not proposed to change any of these conditions as the proposed works will be able to meet these. This will be addressed through the Groundwater Monitoring and Contingency Plan (M&CP) required by Conditions 3.8 to 3.11 of the existing groundwater permit.

Figure 3.1: Updated reference map

4 Assessment of effects of changing conditions

4.1 Introduction

In accordance with section 127(3)(b) of the RMA, the following assessment identifies and assesses the effects that may arise from the proposed condition changes only, and not the effects of the activity itself.

This assessment also outlines the measures that Watercare proposes to avoid, remedy or mitigate any potential adverse effects on the environment.

The secondary shaft is located approximately 20m to the west of its original location. The groundwater and settlement effects of the change in location of the secondary shaft and the potential option of constructing the shafts in the one construction period rather than across two separate periods, are addressed in this AEE. There is no other change in effects associated with this application beyond those already provided for through the existing consent.

The works authorised by the existing consent will have a range of other actual and potential effects on the environment. These effects, including and erosion and sediment control, have not been reassessed in this s 127 application as no changes are proposed in relation to these matters. This s 127 application does not assess the change in effects relating to district plan issues, as they sit outside of the matters to be considered and will be separately assessed and addressed through a Notice of Requirement to alter the designation.

It is important to note that Watercare already owns 42 Tawariki St and could undertake a number of activities as of right on the site, including demolition of the existing dwelling and construction of a drop shaft[3]. As such, some of the effects on surrounding landowners from this alteration to designation would be generally similar in nature to activities which could occur as of right as a permitted activity.

4.2 Positive effects

The works required within 42 Tawariki St will contribute to the wider CI project. This has significant positive effects which include:

- Providing network capacity for existing development and future growth;
- Reducing overflows to stream and coastal environments in the catchments it serves; and,
- Enabling future works to further improve fresh water quality for the Grey Lynn catchment.

The CI main works will be integral to the ongoing operation of the wastewater network in Auckland over the next 50 years and beyond. The wastewater network enables the communities of Auckland to provide for their ongoing health and wellbeing and for continued economic growth and development across Auckland. The wastewater network is fundamental to the health and operation of Auckland.

Specifically in relation to the s127 application, the change in shaft location will allow for a more manageable site layout and greater efficiency and flexibility for the project's construction activities and programme.

[3] Permitted under AUP rule E26.2.3.1 (A57)

4.3 Groundwater effects

The groundwater effects of constructing the secondary shaft in the new proposed location, potentially in the same construction period as the primary shaft, are assessed in the Groundwater and Settlement Effects Assessment (Appendix D).

Effects on groundwater levels are expected to be localised to within approximately 100 m of the proposed excavation and temporary in nature. Upon completion and sealing of the shafts, groundwater levels are expected to return to pre-construction levels. Ongoing long-term groundwater drawdown is considered to be unlikely as the completed infrastructure is expected to be a closed or watertight system.

No existing groundwater users will be affected as the closest consented groundwater take is 1.8 km away (a bore used for providing drinking water to animals at Auckland Zoo). Overall, groundwater effects associated with the change in location and potential change in construction programme are expected to be less than minor.

4.4 Settlement effects

The construction of the shafts may produce both mechanical settlement (due to soil excavation) and consolidation settlement (due to groundwater drawdown) around the shafts. An assessment of the potential settlement effects of the project as a result of the change in location and potential change in construction programme have been assessed in the Groundwater and Settlement Effects Assessment (Appendix D). The assessment is based on undertaking the works concurrently in one construction window resulting in an upper bound effect. Should the works be undertaken in stages (i.e. over separate construction periods), then the effects will be less and within the bounds of the assessment.

Structures closest to the excavation and immediately to the west are expected to experience the greatest levels of ground settlement due to their distance from the excavation and thickness of compressible material. With distance from the excavation, settlement values diminish. Ground settlement effects arising from construction and operating the Tawariki Shafts on the majority of surrounding structures is assessed to generally be negligible to very slight risk of damage.

Ground settlement effects at 38 and 40 Tawariki Street could result in surficial cosmetic (non-structural) cracking at the location where the buildings are joined (both internal and external) and is expected to be readily repairable. As set out in the Groundwater and Settlement Effects Assessment, the risk of damage can be managed through a baseline survey, visual monitoring of the property during construction, and as part of the consent conditions.

Properties at 29, 33, 39 and 41 Tawariki Street are further away from the proposed works and are assessed to experience comparatively lower levels of differential settlement. Given the analysis undertaken, the ground settlement effects on buildings to be generally negligible to very slight risk of damage. Damage that may occur is assessed to likely be aesthetic related and readily repaired.

Overall, the settlement effects of constructing the two shafts within the one construction period and relocating the secondary shaft from 44 to 42 Tawariki Street, are expected to be potentially minor for 38 & 40 Tawariki St, and less than minor for all other surrounding buildings and structures.

4.5 Conclusion

The groundwater and settlement effects of the change in location of the secondary shaft and potential change to construction programme are addressed in this AEE. There is no other change in effects associated with this s 127 application beyond those already provided for through the existing consent. The methodology for constructing the shaft will be the same as described in the original

application, and no changes are proposed to the primary shaft, Grey Lynn Tunnel alignment or other on-site works.

Existing consent conditions relating to groundwater and settlement will continue to apply. Subject to the minor changes to the conditions, as set out in Section 3, we consider that the change in effects associated with the relocated shaft site and altered construction programme are consistent with those originally assessed, and will be appropriately addressed through the implementation of the existing consent conditions and associated management plans.

The assessment set out above concludes that the effects from the relocated shaft site are within the consented envelope of effects and can be appropriately avoided, remedied and mitigated such that they are no more than minor.

5 Statutory assessment

5.1 RMA assessment

5.1.1 Section 127

Section 127 of the RMA provides for conditions of consent to be changed or cancelled, with the provisions of sections 88 to 121 applying as if:

- The application were an application for a discretionary activity; and
- The references to a resource consent and to the activity were references only to the change or cancellation of a condition and the effects of the change or cancellation.

Section 127(4) provides that, in determining who is adversely affected by the change or cancellation of conditions, the local authority must consider every person who:

- Submitted on the original application; and
- May be affected by the change or cancellation.

As provided in section 127(3)(a), this application to change a condition of consent is a discretionary activity. The assessment in this report addresses the effects of the proposed change of condition only and not the effects of the activity itself, as per section 127(3)(b). An assessment of who is adversely affected by the change is made in Section 7.2 of this report.

The scope of what can be considered under section 127 was confirmed in the High Court decision on *Body Corporate 97010 v Auckland City Council* (2000)[4], which found that an application for a change of conditions may be appropriate where the variation does not result in "*a fundamentally different activity or one having materially different adverse effects*" compared to the activity in its original form.

The current application seeks a change of conditions to allow for the option of constructing the primary and secondary shafts concurrently, and for the secondary shaft to be shifted by 20 m. The change will not have materially different adverse effects or result in a fundamentally different activity to that currently consented. We therefore consider it appropriate for this application to be processed under section 127 of the RMA as a discretionary activity.

5.1.2 Section 104 of the RMA

Section 104 of the RMA sets out the matters to which a consent authority must have regard to, subject to Part 2 of the RMA, when considering an application for resource consent. These are:

- Any actual and potential effects on the environment of allowing the activity (refer Section 4 above);
- Any measure proposed or agreed to by the applicant for the purpose of ensuring positive effects on the environment to offset or compensate for any adverse effects on the environment that will or may result from allowing the activity;
- Any relevant provisions of:
  - a national environmental standard;
  - other regulations;
  - a national policy statement;
  - a New Zealand coastal policy statement;

[4] 6 ELRNZ 183. Confirmed by the Court of Appeal in *Body Corporate 97070 v Auckland City Council* [2000] 3 NZLR 513.

  - a regional policy statement or proposed regional policy statement;
  - a plan or proposed plan; and
- Any other matter the consent authority considers relevant and reasonably necessary to determine the application.

Pursuant to section 127(3), the consideration is limited to the change or cancellation of a condition and the effects of the change/cancellation only. This statutory assessment does not revisit or reassess the original proposal in its entirety.

5.1.3 Part 2 of the RMA

Part 2 of the RMA sets out the purpose and principles of the Act. The purpose of the RMA is to promote the sustainable management of natural and physical resources. Traditionally, an analysis of the consistency of an application with Part 2 of the RMA has been fundamental to the overall assessment of applications for resource consents. Section 104(1) of the RMA requires that consideration of applications for resource consents be 'subject to Part 2'. Until recently this has been considered to require an 'overall broad judgement' approach in the form of a fulsome Part 2 analysis. However, this traditional approach has been called into question through decisions on R J Davidson Family Trust v Marlborough District Council (Davidson)[5].

The AUP has been prepared recently and is considered to contain provisions prepared having regard to Part 2 and a coherent set of policies to achieve clear environmental outcomes. Based on the direction established by the Court of Appeal, an assessment against Part 2 matters is considered to add little if anything to the overall evaluation. Rather, the focus of this assessment is on the relevant AUP provisions.

5.2 National Environmental Standards

5.2.1 Resource Management (National Environmental Standards for Freshwater) Regulations 2020

The Resource Management (National Environmental Standards for Freshwater) Regulations 2020 regulates activities that pose risks to the health of freshwater and freshwater ecosystems. The standards apply to activities in relation to farming activities, natural wetlands, instream structures and the reclamation of rivers. There are no applicable standards relevant to this application.

5.2.2 National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health

The NES Soil applies to land where an activity described in the Hazardous Activities and Industries List (HAIL) is occurring, has occurred or likely to have occurred. The site and surrounding land is residential. A Preliminary Site Investigation prepared as part of the original Grey Lynn Tunnel application concluded it is unlikely that a HAIL activity has been undertaken within the vicinity of the shaft site. Therefore, the NES Soil does not apply.

No other national environmental standards are relevant.

[5] R J Davidson Family Trust v Marlborough District Council [2018] NZCA 316.

5.3 National Policy Statement for Freshwater Management

The National Policy Statement for Freshwater Management 2020 (NPS-FM) provides guidance on how freshwater is to be managed in a manner that gives effect to Te Mana o te Wai. Table 6.1 below provides an assessment against the relevant provisions of the NPS-FM. Overall, the proposed works are considered consistent with the objective of the NPS-FM, in terms of providing firstly for the health of freshwater ecosystems as well as the social, economic and cultural well-being of communities

Table 5.1: NPS-FM assessment

Reference	Comment
Objective (1) – The objective of this National Policy Statement is to ensure that natural and physical resources are managed in a way that priorities: a First, the health and well-being of water bodies and freshwater ecosystems; b Second, the health needs of people (such as drinking water); and c Third, the ability of people and communities to provide for their social, economic and cultural well-being, now and in the future.	The proposed works will be managed in a way that prioritises the health and well-being of water bodies (including groundwater) and freshwater ecosystems. The proposed works will provide an improvement to the wastewater network by reducing the potential for wastewater contamination in freshwater ecosystems as a result of future intensification and development. The proposed works form part of the CI project, which is a piece of regionally important wastewater infrastructure which enables people and communities to provide for their social, economic and cultural well-being, now and in the future.
Policy 1 – Freshwater is managed in a way that gives effect to Te Mana o te Wai.	The proposed works will be undertaken in a manner that protects the health of freshwater and contributes to improved freshwater outcomes by reducing the risk of wastewater contamination as a result of development, thereby making a positive contribution to giving effect to Te Mana o te Wai.
Policy 2 - Tangata whenua are actively involved in freshwater management (including decision making processes), and Māori freshwater values are identified and provided for.	The site itself is not located in an area of significant cultural value or within a statutory acknowledgement area. Watercare continues to engage with mana whenua through their Kaitiaki Forum, providing opportunities for mana whenua involvement in freshwater management.
Policy 3 - Freshwater is managed in an integrated way that considers the effects of the use and development of land on a whole-of-catchment basis, including the effects on receiving environments.	By addressing effects on water quality as a component of land use, the potential effects of the proposed activity are being considered in an integrated way. Policy 3 refers to the use and development of land on a whole-of-catchment basis. This application concerns the development of a wastewater sewer pipeline which will provide network capacity to enable future development to occur while minimising the risk of wastewater overflows to freshwater ecosystems.
Policy 5 - Freshwater is managed through a National Objectives Framework to ensure that the health and well-being of degraded water bodies and freshwater ecosystems is improved, and the health and well-	The CI project and Grey Lynn Tunnel will improve the health and wellbeing of waterbodies and freshwater ecosystems by reducing the risk of wastewater overflows to surface water as a result of

Reference	Comment
being of all other water bodies and freshwater ecosystems is maintained and (if communities choose) improved.	future development. Therefore the works will improve the resilience of the wastewater infrastructure and help maintain and improve the health and well-being of water bodies and freshwater ecosystem.
Policy 12 - The national target (as set out in Appendix 3) for water quality improvement is achieved.	CI will contribute to an improvement in water quality by reducing the risk of wastewater overflows to freshwater ecosystems as future development occurs. The proposed works will help contribute to the achievement of national targets for water quality by improving the resilience of wastewater infrastructure.
Policy 15 – Communities are enabled to provide for their social, economic, and cultural well-being in a way that is consistent with this National Policy Statement.	The designated works (and associated alteration) relate to the construction of a local wastewater sewer pipeline which will reduce the risk of wastewater overflows to freshwater ecosystems as a result of future development. These works form a connecting part of the wider Central Interceptor project, which is a regionally important wastewater infrastructure upgrade that enables communities to provide for their social, economic and cultural wellbeing.

5.4 National Policy Statement on Urban Development 2020

The National Policy Statement on Urban Development 2020 (NPSUD) came into effect on 20 August 2020. The NPSUD is focused on providing sufficient development capacity to meet the different needs of people and communities and integrating land use planning and infrastructure planning.

Plan Change 78 (PC78) was notified on 18 August 2022. PC78 responds to the government's National Policy Statement on Urban Development 2020 (amended in 2022) and requirements of the Resource Management Act.

One of the qualifying matters identified in PC78, which allows Council to reduce building density, is Water and Wastewater Constraints which applies to much of the area surrounding the Tawariki Street shaft site. The lack of capacity in the wastewater system in this area constrains up-zoning.

Once complete, the CI project will allow for added capacity across the wider wastewater network and directly benefits downstream areas, such as the Central Business District and Freemans Bay, allowing for future up-zoning to provide for urban development and intensification.

5.5 Auckland Unitary Plan – Operative in Part

The AUP sets the objective, policies and rules for the sustainable management of natural and physical resources in Auckland. It contains the Regional Policy Statement (RPS), and regional and district objectives, policies and rule. An assessment against the key direction established through the relevant provisions of the AUP is set out in

Table 5.2 below. Generally, the assessment of the project in the original resource consent application is still applicable to the application.

Table 5.2: Auckland Unitary Plan objectives and policies

Reference	Comment
Chapter B3 – Infrastructure, transport and energy	
B3.2.1 Objective (4) – The functional and operational needs of infrastructure are recognised.	There is a functional and operational need for the proposed work to be located where they are in order to align with existing wastewater infrastructure and support future intensification. The change in shaft location provides for more space for the construction of the shafts, enabling a more effective / efficient layout and design.
B3.2.2 Policy (1) – Enable the efficient development, operation, maintenance and upgrading of infrastructure.	The s127 application provides for the efficient development of wastewater infrastructure on the site. The overall consented works will provide for positive benefits by reducing the risk of wastewater overflows to enable future development.
B3.2.2 Policy (8) – Avoid, remedy or mitigate the adverse effects from the construction, operation, maintenance or repair of infrastructure.	The construction methodology is designed to first avoid adverse effects where practicable. Where adverse effects cannot be avoided, the measures set out in the consent conditions and corresponding management plans will appropriately mitigate the adverse effects of the works.
Chapter B6 – Mana Whenua	
Objective B6.3.1 (2) - The mauri of, and the relationship of Mana Whenua with, natural and physical resources including freshwater, geothermal resources, land, air and coastal resources are enhanced overall.	Ongoing engagement is being undertaken with the relevant mana whenua to this project. This is detailed below in Section 6.2. This engagement has ensured that mana whenua values and relationship with the environment has been considered and factored into the Project.
Policy B6.3.2 (3) - Ensure that any assessment of environmental effects for an activity that may affect Mana Whenua values includes an appropriate assessment of adverse effects on those values	
Chapter E1 – Water quality and integrated management	
E1.2 Objective (3) – Stormwater and wastewater networks are managed to protect public health and safety and prevent or minimise adverse effects of contaminants on freshwater and coastal water quality.	The proposed works will be managed to protect public health and safety and minimises adverse effects of contaminants on freshwater by ensuring the risk of wastewater overflows are reduced as future development occurs.
E1.3 Policy (19) – Ensure wastewater networks are designed and operated to minimise wet weather overflows by: d Requiring wastewater networks to be designed and constructed in accordance with recognised industry standards, including being sized to cater for the maximum probably development level of the area to be serviced; e Requiring the management of connections to the wastewater network; f Requiring wastewater networks to be managed in accordance with a network operations plan including an overflow	The proposed works are for the purposes of extending the existing local network connection to CI in order to reduce wastewater overflows entering freshwater ecosystems. The Grey Lynn Tunnel and secondary shaft will be designed and constructed in accordance with recognised industry standards and will be sized to accommodate for future growth in the area. The Grey Lynn Tunnel connection is designed and located to manage overflows to reduce the risk of wastewater overflows.

Reference	Comment
mitigation plan with clear requirements and timeframes; and g Designing and locating overflow points to minimise nuisance, damage, public health risk and adverse ecological effects.	
Chapter E2 – Water Quantity, Allocation and Use	
E2.2 Objective (1) - Water in surface rivers and groundwater aquifers is available for use provided the natural values of water are maintained and established limits are not exceeded.	The potential groundwater effects of the relocated shaft are assessed in detail in the AEE. The natural values of water and availability of water resources will be maintained. No scheduled historic heritage places or sites and places of significance to Mana Whenua will be affected. The groundwater diversion will not cause or exacerbate any flooding. Any settlement effects are anticipated to be minor. Conditions on the consent will appropriately manage and mitigate effects. In particular, the conditions require monitoring prior to, during and after construction of the Project. This will provide information to confirm that the magnitude of impact, if any, is no greater than predicted in the original AEE and this s127 application.
E2.2 Objective (2) - Water resources are managed within limits to meet current and future water needs for social, cultural and economic purposes.	
E2.3 Policy (23) – Require proposals to divert groundwater, in addition to the matters addressed in Policy E2.3(6) and (7) above, to ensure that: (a) the proposal avoids, remedies or mitigates any adverse effects on: (i) scheduled historic heritage places and scheduled sites and places of significance to Mana Whenua; and (ii) people and communities. (b) the groundwater diversion does not cause or exacerbate any flooding; (c) monitoring has been incorporated where appropriate, including: (i) measurement and recording of water levels and pressures; and (ii) measurement and recording of the movement of ground, buildings and other structures. (d) mitigation has been incorporated where appropriate including: (i) minimising the period where the excavation is open/unsealed; (ii) use of low permeability perimeter walls and floors; (iii) use of temporary and permanent systems to retain the excavation; or (iv) re-injection of water to maintain groundwater pressures.	
Chapter E26 – Infrastructure	
E26.2.1 Objective (1) – The benefits of infrastructure are recognised	CI including the Grey Lynn Tunnel will improve the resilience of the wastewater network and increase the capacity of the system to allow for future growth and development in the Auckland region.

Reference	Comment
	Furthermore, the Grey Lynn Tunnel will provide benefits in relation to reducing the risk of wastewater overflows entering freshwater ecosystems.
E26.6.1 Objective (9) – The adverse effects of infrastructure are avoided, remedied or mitigated.	The consent conditions (including the minor amendments set out in Section 3) and the relevant management plans will adequately avoid, remedy or mitigate adverse effects associated with this s 127 application.
E26.2.2 Policy (1) – Recognise the social, economic and cultural and environmental benefits that infrastructure provides, including: ... b Providing for public health and safety; ... e Enabling growth and development; f Protecting and enhancing the environment	Grey Lynn Tunnel and the wider CI project will provide for a reduction in the risk of wastewater overflows, thereby providing social, economic, cultural and environmental benefits. Specifically, public health and safety will be provided for by reducing the risk of wastewater contamination. In addition the proposed works improve wastewater infrastructure, which enables future growth and development in the area. A reduction in wastewater overflows will also protect and enhance freshwater ecosystems.

Summary

Both the Regional Policy Statement and Regional Plan components of the AUP include a suite of objectives and policies that recognise the benefits of infrastructure and explicitly recognise the functional and operational needs of infrastructure. The wider CI and Grey Lynn Tunnel project is considered to be consistent with the RPS given its role in providing efficient and resilient infrastructure services to the community.

This change to consent conditions responds to an operational need for space at the construction site, enabling a more effective and efficient layout and design. The option of constructing the two shafts concurrently allows for efficiencies in construction and for future local connections to be made sooner. Subject to the minor changes to the conditions as set out in Section 3, the effects of the change to conditions will be continue to be appropriately addressed through the implementation of the existing consent conditions and associated management plans.

The objectives and policies set out an approach to managing the adverse effects of infrastructure on the environment, while providing for infrastructure and its associated benefits. This change of conditions is considered to be consistent with the relevant objectives and policies of the Auckland Unitary Plan.

6 Consultation

As part of the wider authorisation process for the Grey Lynn Tunnel including the Tawariki Street shaft site consents and designations, Watercare undertook extensive consultation with a broad range of stakeholders – including Mana Whenua, Local Boards and communities, Auckland Council, Auckland Transport and landowners.

In relation to this s127 application, Watercare has undertaken targeted consultation with the stakeholders identified below. A targeted approach to consultation was considered appropriate given the limited nature of the changes (i.e. moving the secondary shaft 20 m and potential change to construction phasing, with all other components of the proposal remaining unchanged).

6.1 33, 38 and 40 Tawariki St - Owners and Occupiers (Housing New Zealand/Kāinga Ora)

Kāinga Ora owns all three properties which will be the immediate neighbours as a result of shifting the secondary shaft to 42 Tawariki St. A meeting was held on 14 October 2022 to discuss the project and Kāinga Ora indicated there were no concerns with the proposal. Written approval discussions are under way, and a copy of the application is to be sent through.

Kāinga Ora also confirmed that the properties are currently tenanted. Kāinga Ora will facilitate Watercare's discussions with the occupiers of these dwellings.

6.2 Mana whenua

Iwi have been engaged through a subset of Watercare's Mana Whenua Kaitiaki Forum. This group meets with CI representatives as a working group to support the project team in delivering project outcomes with cultural aspects. The group provides specialists advice particularly in the areas of consent compliance, new consent applications and social outcomes, as well as reporting back to the Forum's Managers' Group. The relocation of the secondary shaft was added to the monthly agenda in April 2022. Te Akitai have expressed an interest in the application which will be provided to them once completed. Feedback will be provided to Council either directly or at their request.

6.3 Auckland Transport

Watercare will be designating the road reserve outside 42 Tawariki Street for the Project. Watercare has met with Auckland Transport (AT) to discuss the proposed works and will continue to communicate with both the AT Consenting and Corridor Access Request (CAR) teams. AT will be involved during the preparation and implementation of any required Traffic Management Plan(s) for the Project.

A meeting was held with AT on 27 September 2022, where AT indicated there were no concerns with the proposal. In summary, no changes are proposed to parking, construction traffic routes and trip generation assumptions that are outside the existing consented and designated envelope. Other than the changes set out in Section 3.3, no other changes are proposed and all other conditions of the consent will continue to apply.

7 Notification assessment

7.1 Public notification

Section 95A of the RMA is relevant when a consent authority is considering whether an application under section 127 should be considered with or without public notification. Section 95A identifies a four step process. In relation to these steps we note the following:

- The applicant does not request public notification of the application;
- There is no rule or national environmental standard that precludes or requires public notification of this application;
- This application is made under section 127 and under section 127(4) a consent authority must only consider the effects of the change;
- An assessment of effects on the environment is provided in Section 4 of this AEE report. This assessment concludes that the adverse effects on the environment are likely to be no more than minor;
- The application is not for any of the activities identified in section 95A(5)(b);
- No special circumstances are considered to exist in relation to the application.

Based on this assessment, this application therefore meets the tests of the RMA to be processed without public notification.

7.2 Limited notification

For applications that are not publicly notified, under section 95B the consent authority must determine whether to give limited notification of an application to any affected parties. Section 95B identifies a four step process. In relation to these steps we note the following:

- The application does not need to be notified to any parties under section 95B(4). The proposed change will not affect any customary rights;
- The proposed activity is not on or adjacent to, or does not affect, land that is the subject of a statutory acknowledgement;
- There are no applicable rules or national environmental standards precluding limited notification;
- No special circumstances are considered to exist in relation to the application that warrant notification of the application to any other persons not already determined to be eligible for limited notification.

In terms of section 95E(3), a consent authority must not consider a person affected if they have provided written approval to the activity. Watercare is currently discussing written approvals with Kāinga Ora. If written approvals are provided, Kāinga Ora cannot be considered adversely affected by the application. The same applies to the occupiers of 38 and 40 Tawariki should written approval be obtained.

Section 95E(1) states that a consent authority must consider a person to be an affected person if the activity's adverse effects on the person are minor or more than minor (but not less than minor). As written approvals are currently being sought, it is anticipated that there will be no affected parties. With the exception of 38 & 40 Tawariki Street where settlement as a result of dewatering could potentially cause cosmetic damage, effects are assessed as less than minor and accordingly no other parties will be affected by the change to conditions of consent. Discussions are currently underway for written approval from the owners (Kāinga Ora) and occupiers of 38 & 40 Tawariki St.

In addition, section 127(4) states that for the purposes of determining who is adversely affected by the change to consent conditions, the consent authority must consider, in particular, every person who made a submission on the original application and may be affected by the change.

Five submissions were received on the original application:

- Dolores Sanchez of 511 Richmond Road opposed the application due to concerns about potential effects on property value, potential limitation on future development potential, potential property damage and traffic effects. 511 Richmond Road is a considerable distance from the shaft site and the proposed changes set out in this application will not have any potential or actual effects on the property.
- Vaughn Schwass of 30 Tawariki St opposed the application, primarily due to concerns about construction effects including traffic. No changes are proposed in relation to construction traffic, works methodology, or erosion and sediment control. As such, Mr Schwass is not considered to be affected by the change.
- Housing New Zealand (now Kāinga Ora) made two submissions, one on the NoR and one on the resource consent application. Their submission on the resource consent was in support, primarily due to the additional housing and business capacity enabled by the Grey Lynn Tunnel.
- Auckland Transport's submission was on the NoR, and supportive in part, with issues raised in relation to the potential construction traffic and parking effects of the project. Watercare is in discussion with Auckland Transport regarding the NoR to alter the designation, however AT is not considered to be affected by any of the matters in scope of this s 127 application to change the conditions of the groundwater consent.

7.3 Section 95 conclusions

Following the steps set out in sections 95A and 95B, and considering section 127(4), subject to securing written approvals from the owners and occupiers of 38 and 40 Tawariki St, we consider that this proposal meets the tests of the RMA to be processed without public or limited notification. However, if written approval is not obtained, on the basis that there could potentially be minor adverse effects on the owners and occupiers of 38 and 40 Tawariki St, the application is required to be limited notified to these parties.

8 Conclusion

This report has been prepared on behalf of Watercare Services Limited to seek a s 127 variation to BUN60334952.

The Grey Lynn Tunnel is a wastewater interceptor that runs from the Central Interceptor (CI) at Western Springs to Tawariki Street, Grey Lynn. This wastewater interceptor provides additional sewer capacity, reduces wet weather wastewater overflow discharges and enables future works to improve freshwater quality in central Auckland waterways.

Currently, Watercare holds consents and a designation for the '*construction, operation, and maintenance' of* two shafts, known as the primary and secondary shaft at 44-48 Tawariki Street. Since obtaining consent, Watercare has purchased the adjacent property at 42 Tawariki Street. It is now proposed to shift the secondary shaft approximately 20m to the west within this property to allow for more space at the construction site. As such, Watercare seeks to vary the consent to allow for the relocation of the secondary shaft.

In addition, in the original application the secondary shaft was proposed to be constructed at least 2.5 years after the primary shaft. Watercare has now identified the potential to undertake the works concurrently for the two shaft sites and seeks to vary the consent to allow for this construction programme option. However, Watercare may revert to constructing the secondary shaft after the primary shaft.

The effects associated with construction activities and the long-term operation of infrastructure at the Tawariki Street site were considered through the previous application process. This s 127 application and associated assessment of effects is limited to the two changes described above. In summary:

- The change to conditions will have no more than minor effects on the environment.
- The proposed change is consistent with Part 2 of the RMA;
- Utilising the same conditions and management plans across the site will provide Watercare with greater flexibility and allow it to effectively and efficiently carry out all necessary works at the shaft site.
- The proposed change is consistent with, and finds support from, the relevant provisions of the NPSUD, NPSFW and AUP.

9 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.

We understand Watercare will submit this report as part of a s127 application and that Auckland Council as the consenting authority will use the report for the purpose of assessing that application.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:

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Rachel Signal-Ross
Senior Planner

Authorised for Tonkin & Taylor Ltd by:

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Karen Baverstock
Project Director

11-Nov-22

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Appendix A: Records of Title

RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier	**NA44C/1088**
Land Registration District	**North Auckland**
Date Issued	17 May 1979

Prior References
NA1810/58

Estate	Fee Simple
Area	561 square metres more or less
Legal Description	Lot 37 Deposited Plan 38075

Registered Owners
Watercare Services Limited

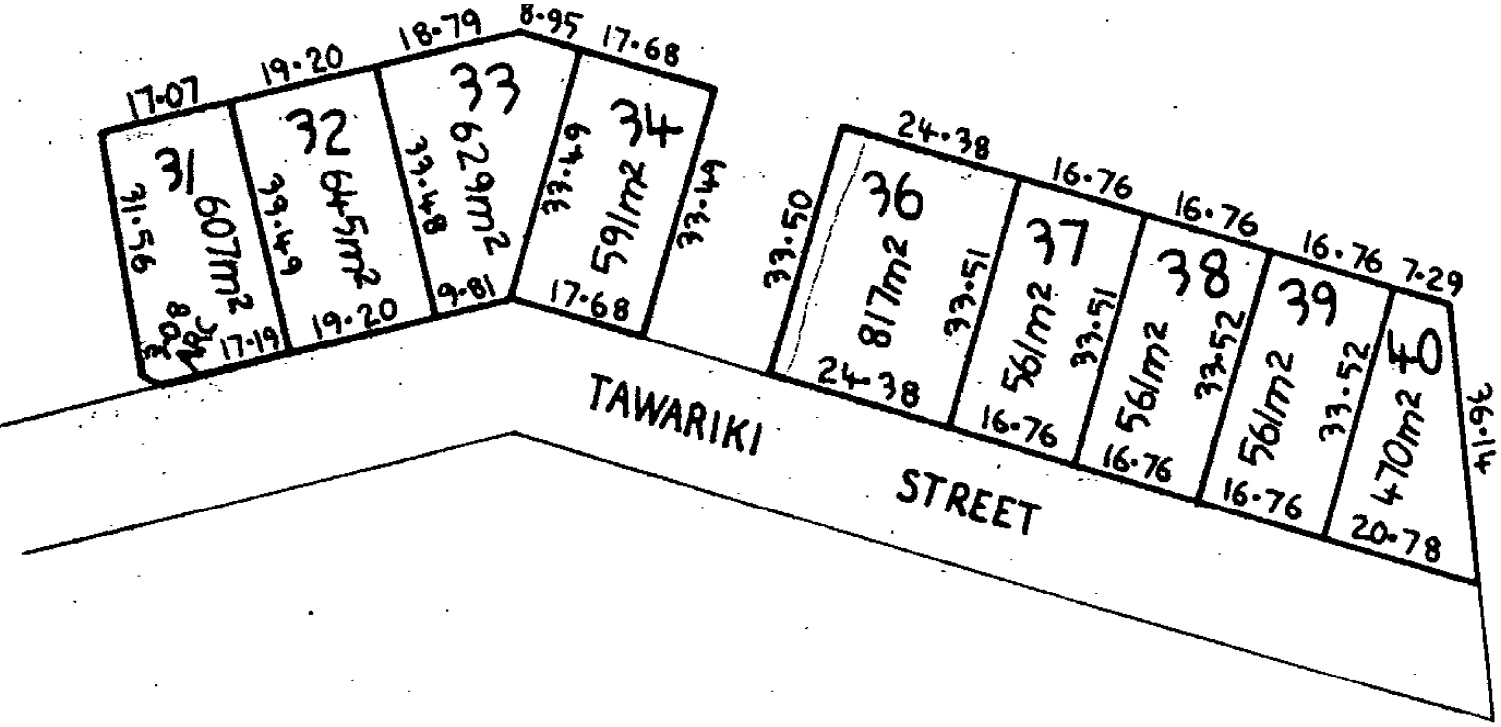
Interests

Subject to Part IV A Conservation Act 1987

Subject to Section 11 Crown Minerals Act 1991

7442 Order in Council imposing Building Line Restriction

Subject to a drainage right over part created by Transfer C244461.2 - 6.3.1991 at 2.44 pm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MRC
TAWARIKI
STREET

RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier	**NA44C/1089**
Land Registration District	**North Auckland**
Date Issued	17 May 1979

Prior References
NA1810/58

Estate	Fee Simple
Area	561 square metres more or less
Legal Description	Lot 38 Deposited Plan 38075

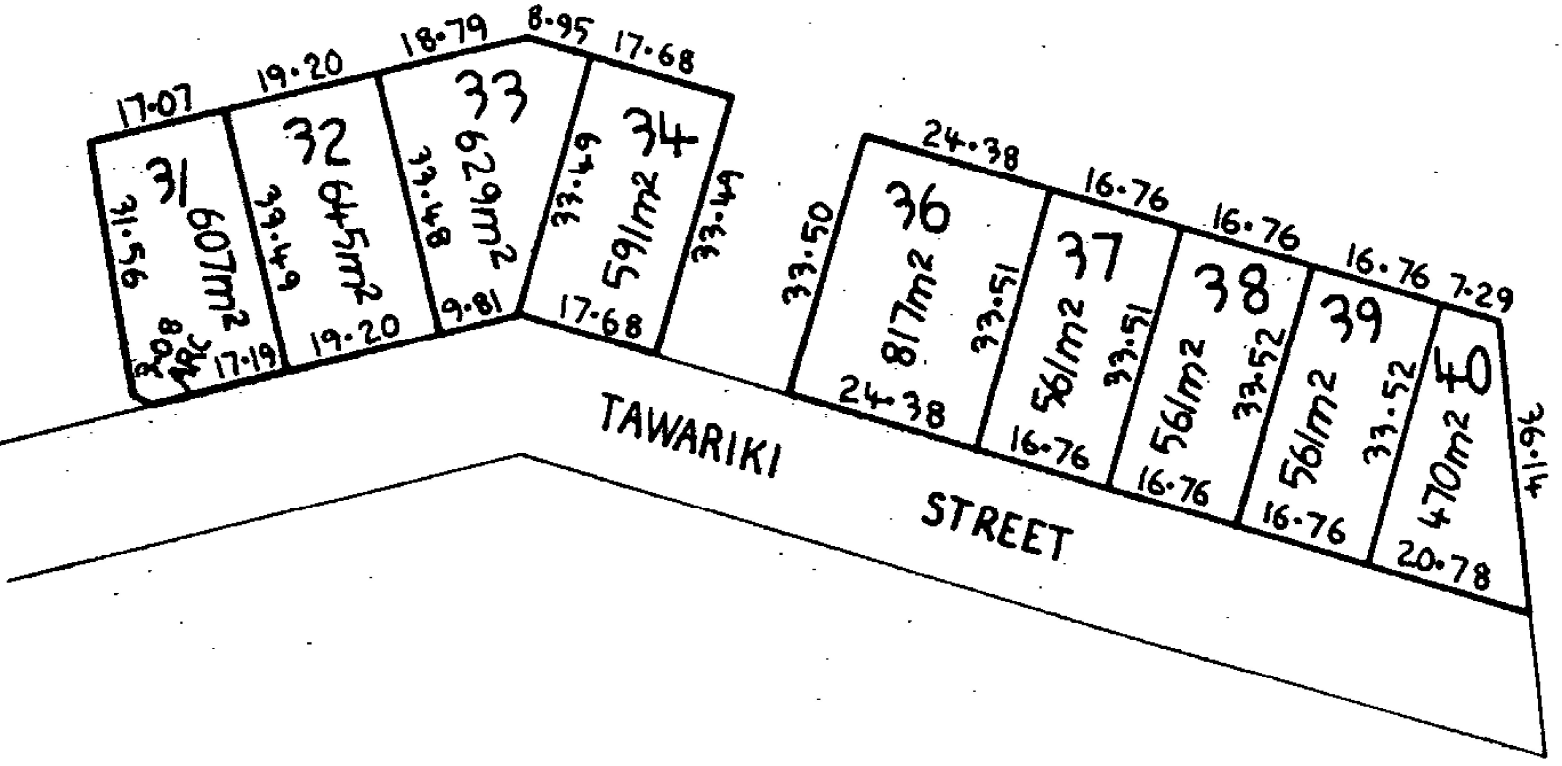
Registered Owners
Watercare Services Limited

Interests

Subject to Part IV A Conservation Act 1987

Subject to Section 11 Crown Minerals Act 1991

7442 Order in Council imposing Building Line Restriction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TAWARIKI
STREET

RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier	**NA44C/1090**
Land Registration District	**North Auckland**
Date Issued	17 May 1979

Prior References
NA1810/58

Estate	Fee Simple
Area	561 square metres more or less
Legal Description	Lot 39 Deposited Plan 38075

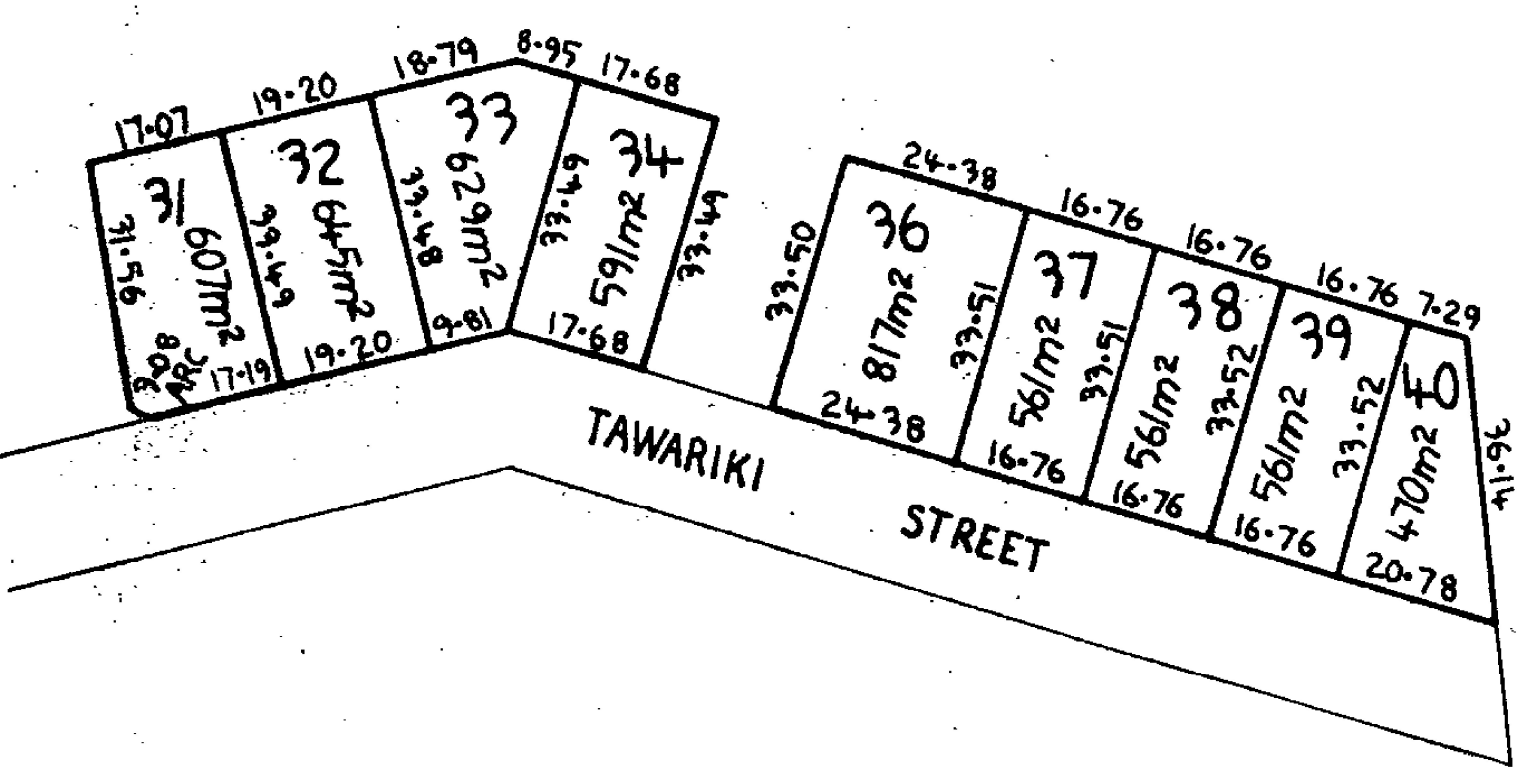
Registered Owners
Watercare Services Limited

Interests

Subject to Part IV A Conservation Act 1987

Subject to Section 11 Crown Minerals Act 1991

7442 Order in Council imposing Building Line Restriction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STREET

RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD
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R.W. Muir
Registrar-General
of Land

Identifier	**NA44C/1091**
Land Registration District	**North Auckland**
Date Issued	17 May 1979

Prior References
NA1810/58

Estate	Fee Simple
Area	470 square metres more or less
Legal Description	Lot 40 Deposited Plan 38075

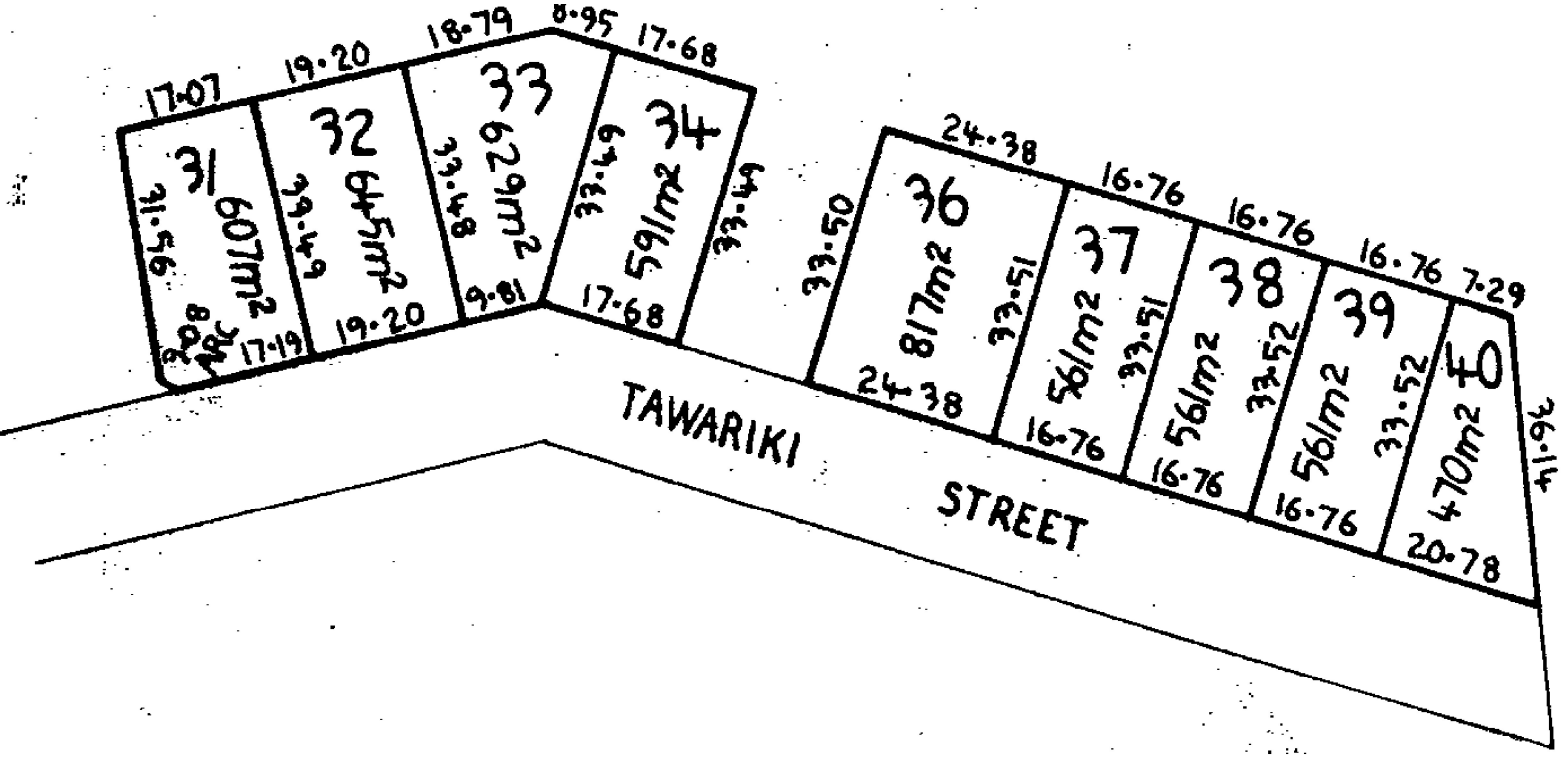
Registered Owners
Watercare Services Limited

Interests

Subject to Part IV A Conservation Act 1987

Subject to Section 11 Crown Minerals Act 1991

7442 Building Line Restriction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STREET

Appendix B: Existing consent

Appendix 1 – Conditions of NOR and RC

1. Definitions

Alarm Level – Specific levels at which actions are required as described in the relevant conditions.

Alert Level – Specific levels at which actions are required as described in the relevant conditions.

Bulk Excavation – Includes all excavation that affects groundwater excluding minor enabling works and piling less than 1.5m in diameter.

Commencement of Dewatering – Means commencement of bulk excavation and/or commencing taking any groundwater from a shaft or tunnel excavation (after construction of the pile walls (if required) and/or dewatering prior to bulk excavation).

Completion of Dewatering – Means when all the permanent shaft lining, base slab and walls are complete and the tunnel lining is complete, and effectively no further groundwater is being taken for the construction of the shaft/tunnel, in accordance with the design.

Commencement of Excavation – Means commencement of Bulk Excavation for shafts, trenches and tunnels.

Completion of Excavation – Means the stage when Bulk Excavations has been completed for shafts, trenches and tunnels.

Condition Survey – Means an external visual inspection or a detailed condition survey (as defined in the relevant conditions).

Damage – Includes Aesthetic, Serviceability, Stability, but does not include Negligible Damage. Damage as described in the table 1.

Monitoring Station – Means any monitoring instrument including a ground or building settlement monitoring mark, inclinometer, groundwater monitoring bore, retaining wall deflection station, or other monitoring device required by this consent.

Seasonal Low Groundwater Level – Means the annual lowest groundwater level – which typically occurs in summer.

2. Building Damage Classification reference table

Category of Damage	Normal Degree of Severity	Description of Typical Damage *(Building Damage Classification after Burland (1995), and Mair et al (1996))*	General Category *(after Burland – 1995)*
0	Negligible	Hairline cracks.	**Aesthetic Damage**
1	Very Slight	Fine cracks easily treated during normal redecoration. Perhaps isolated slight fracture in building. Cracks in exterior visible upon close inspection. Typical crack widths up to 1mm.	
2	Slight	Cracks easily filled. Redecoration probably required. Several slight fractures inside building. Exterior cracks visible, some repainting may be required for weather-tightness. Doors and windows may stick slightly. Typically crack widths up to 5mm.	
3	Moderate	Cracks may require cutting out and patching. Recurrent cracks can be masked by suitable linings. Brick pointing and possible replacement of a small amount of exterior brickwork may be required. Doors and windows sticking. Utility services may be interrupted. Weather tightness often impaired. Typical crack widths are 5mm to 15mm or several greater than 3mm.	**Serviceability Damage**
4	Severe	Extensive repair involving removal and replacement of walls especially over door and windows required. Window and door frames distorted. Floor slopes noticeably. Walls lean or bulge noticeably. Some loss of bearing in beams. Utility services disrupted. Typical crack widths are 15mm to 25mm but also depend on the number of cracks.	
5	Very Severe	Major repair required involving partial or complete reconstruction. Beams lose bearing, walls lean badly and require shoring. Windows broken by distortion. Danger of instability. Typical crack widths are greater than 25mm but depend on the number of cracks.	**Stability Damage**

Table 1: Building Damage Classification

Note: In the table above the column headed "Description of Typical Damage" applies to masonry buildings only and the column headed "General Category" applies to all buildings.

3. Reference maps for Condition 3.6 of the NOR and 3.12 of the RC

160-178 Surrey Crescent

490 and 510 Richmond Road

24, 26, 30, 2/20, 32, 34 and 38 Sackville Street

35, 37, 39, 41, 42 Tawariki Street

Notice of Requirement Conditions

1. General conditions

1.1 Except as modified by the conditions below and subject to final design, the works shall be undertaken in accordance with the information provided by the Requiring Authority in the Notice of Requirement dated February 2019, and supporting documents being:

a) Assessment of Effects on the Environment, titled "Grey Lynn Tunnel – Notice of Requirement, Resource Consent Application and Assessment of Environmental Effects" prepared by Jacobs, dated February 2019.

b) Drawings as detailed below:

- 'Land Requirement Plan Tawariki Street Shaft Site', Rev A by Jacobs, undated.
- 'Grey Lynn Tunnel Western Springs to Tawariki Street Plan and Profile Sheet 1', Rev 0, by Watercare, dated 20 Feb 2019.
- 'Grey Lynn Tunnel Western Springs to Tawariki Street Plan and Profile Sheet 2', Rev 0, by Watercare, dated 20 Feb 2019.
- 'Grey Lynn Tunnel Western Springs to Tawariki Street Plan and Profile Sheet 1', Rev 0, by Watercare, dated 20 Feb 2019.
- 'Grey Lynn Tunnel – Tawariki Street Site Plan', Rev 0, by Boffa Miskell, dated April 2019.
- 'Grey Lynn Tunnel – Tawariki Street Fence Options, Rev 0, by Boffa Miskell, dated April 2019.
- 'Grey Lynn Tunnel – Tawariki Street Section and Elevation Location Plan, Rev 0, by Boffa Miskell, dated April 2019.
- 'Grey Lynn Tunnel – Tawariki Street Cross Sections, Rev 0, by Boffa Miskell, dated April 2019.
- 'Grey Lynn Tunnel – Tawariki Street Retaining Wall Elevations, Rev 0, by Boffa Miskell, dated April 2019.
- 'Grey Lynn Tunnel – Tawariki Street Panorama View from 39 Tawariki Street – Following Site Reinstatement, Rev 0, by Boffa Miskell, dated April 2019.

c) Technical Reports as detailed below:

- Ecological Assessment, prepared by Bioresearches Group Ltd, dated 18 February 2019.
- Archaeological and Historic Heritage Assessment, prepared by Clough & Associates Ltd, dated February 2019.
- Traffic Impact Assessment, prepared by Commute, dated 21 February 2019.
- Noise Assessment, prepared by Marshall Day Acoustics, 13 February 2019.
- Vibration Assessment, prepared by McMillen Jacobs Associates, dated 21 December

2019.

- Settlement Assessment, prepared by McMillen Jacobs Associates, dated 31 January 2018.
- Contamination Report, prepared by AECOM, dated 21 February 2019.
- Visual Impact and Landscape Assessment, prepared by Boffa Miskell Ltd, dated 20 February 2019.
- Arborist Report, prepared by Greenscene NZ, dated 20 February 2019.

d) Section 92 responses dated 18 April and 24 May 2019

1.2 As soon as practicable following completion of commissioning of the Project, the Requiring Authority shall, in consultation with the Council:

a) review the extent of the area designated for the Project;

b) identify any areas of designated land that are no longer necessary for the ongoing operation, maintenance, renewal and protection of the Project and associated structures and activities;

c) identify, in consultation with Auckland Transport any areas of the designation within road reserve that are no longer necessary as the completed infrastructure is otherwise provided for and adequately protected by provisions of the Local Government (Auckland Council) Act 2009 and Utilities Access Act 2010;

d) give notice to the Council in accordance with Section 182 of the RMA for the removal of those parts of the designation identified in (b) and (c) above, which are not required for the long-term operation and maintenance of the Project; and

e) provide as-built plans to the Council's Team Leader, Compliance and Monitoring, Resource Consents.

1.3 A liaison person shall be appointed by the Requiring Authority for the duration of the construction phase of the Project to be the main and readily accessible point of contact for persons affected by the designation and construction work. The liaison person's name and contact details shall be advised to affected parties by the Requiring Authority. This person must be reasonably available for on-going consultation on all matters of concern to affected persons arising from the Project. If a liaison person will not be available for any reason, an alternative contact person shall be nominated to ensure that a Project contact person is available by telephone 24 hours per day seven days per week during the construction phase.

1.4 The designation shall lapse on the expiry of a period of 10 years after the date on which the last of any appeals on all consents and notices of requirement associated with the Project is withdrawn or determined, or, if no appeals are lodged, the date on which the notices of requirement are included in the AUP in accordance with section 184(1)(c) of the RMA, unless:

a) it has been given effect before the end of that period; or

b) the Council determines, on an application made within 3 months before the expiry of that period, that substantial progress or effort has been made towards giving effect to the

designation and is continuing to be made; and fixes a longer period for the purposes of this subsection.

1.5 Except as provided for in Condition 1.6 below, the Requiring Authority shall submit an Outline Plan of Works (OPW) for the Project for each of the relevant Project stages in accordance with section 176A of the RMA.

1.6 An OPW need not be submitted if the Council has waived the requirement for an OPW in accordance with section 176A(2)(c) of the RMA.

1.7 The OPW shall include the following Management Plans, relevant to the stage of works sought for the Project:

a) Construction Management Plan (CMP);

b) Construction Traffic Management Plan;

c) Communications Plan;

d) Construction Noise and Vibration Management Plan (CNVMP); and

e) Site Reinstatement Plan.

1.8 The OPW shall include plans for any proposed new permanent buildings. The design of any buildings shall take into account the following matters:

a) The extent to which the buildings are appropriate to their context and minimise potential adverse effects on the amenity of the surroundings (including neighbouring properties);

b) The use of building materials which are sufficiently robust and minimise the potential for graffiti and vandalism;

c) The extent to which the buildings are visually recessive through use of appropriate colours, textures and modulation.

1.9 The OPW shall include plans for any other permanent at grade and above ground structures. Any permanent at grade and above ground structures shall take into account the following matters:

a) the location, landscape setting and adjoining land uses;

b) the layout, form and detail, and the use of a consistent and appropriate palette of materials, to ensure these elements are visually recessive;

c) the configuration of multiple surface elements to minimise their prominence and visual clutter;

d) the use of materials which are sufficiently robust and minimise the potential for graffiti and vandalism;

e) landscaping to integrate with the Reinstatement Plan required in Condition 12.1; and

f) site configuration that maximises the use of Crime Prevention Through Environmental Design (CPTED) principles;

g) site access that complies with the vehicle crossing standards of the Auckland Unitary Plan;

and

h) consultation with the owners of 39 and 41 Tawariki Street.

2. Construction Management

2.1 The Requiring Authority shall prepare Construction Management Plans (CMP) for each of the relevant Project stages. The purpose of the CMP(s) is to set out the detailed management procedures and construction methods to be undertaken in order to avoid, remedy or mitigate potential adverse effects arising from construction activities and to achieve compliance with the specific conditions of this designation that relate to the matters referred to items (c) to (o) of Condition 2.2 below. The CMP(s) shall be submitted to the Council with the relevant OPW for the stage to which they relate.

2.2 The CMP(s) required by Condition 2.1 above shall include specific details relating to the management of all construction activities associated with the relevant Project stage, including:

a) Details of the site or project manager and the construction liaison person identified in Condition 1.3, including their contact details (phone, postal address, email address);

b) An outline construction programme;

c) The proposed hours of work, including activities that may occur outside the typical working day hours;

d) Measures to be adopted to maintain the land affected by the works in a tidy condition in terms of disposal / storage of rubbish, storage and unloading of construction materials and similar construction activities;

e) Location of site infrastructure including site offices, site amenities, contractors yards site access, equipment unloading and storage areas, contractor car parking, and security;

f) Procedures for controlling sediment run-off, dust and the removal of soil, debris, demolition and construction materials (if any) from public roads and / or other places adjacent to the work site including removal of any unreasonable levels of dust (as determined by the Council's Team Leader Compliance Monitoring Central) deposited on any adjacent dwellings;

g) Procedures for ensuring that residents, road users and businesses in the immediate vicinity of construction areas are given prior notice of the commencement of construction activities and are informed about the expected duration and effects of the works;

h) Means of providing for the health and safety of the general public and for pedestrian management as required by Condition 6.1;

i) Procedures for the management of works which directly affect or are located in close proximity to existing network utility services;

j) Procedures for responding to complaints about construction activities;

k) Procedures for the refuelling of plant and equipment;

l) A Construction Noise and Vibration Management Plan (CNVMP) containing measures to address the management of noise and vibration as identified in Condition 3.1;

m) Measures for the protection and management of trees as identified in Condition 10.1; and

n) Measures to address CPTED issues within and around the site; and

o) In relation to the owners of 39 and 41 Tawariki Street, a parking plan will be developed in consultation with the owners that provides parking for the owners of 39 and 41 Tawariki Street either on the road beside the properties or a reasonable alternative as agreed with the owners prior to the works commencing.

2.3 The CMP shall be implemented and maintained throughout the entire construction period for the Project or relevant Project stage to manage potential adverse effects arising from construction activities. The CMP or any specific component of the CMP shall be updated as necessary and provided to the Council in accordance with Condition 2.1.

3. Construction Noise and Vibration

3.1 A Construction Noise and Vibration Management Plan (CNVMP) either as part of the CMP, or as a standalone plan, shall be prepared by a suitably qualified person, and shall be submitted to and certified by the Council with the OPW to which it relates. The purpose of the CNVMP is to provide a framework for the development and implementation of the Best Practicable Option ('BPO') for management of all construction noise and vibration effects and to define the procedures to be followed when full compliance with the construction noise and vibration standards of Conditions 3.2 to 3.9 are not met following adoption of the BPO.

3.2 Construction noise shall be measured and assessed in accordance with NZS6803:1999 Acoustics – Construction Noise, and shall comply with the following noise limits, unless varied in accordance with Condition 3.5:

Time and Day	Noise Limits	
	L_{Aeq} dB	L_{Amax} dB
Monday to Saturday 0730 – 1800	70	85
At All Other Times and Public Holidays	45	75

3.3 Construction works which exceed a level of LAeq 45dB at the most exposed receiver(s) are restricted to between 0730 to 1800 on weekdays and Saturdays, with no noisy works permitted on Sundays and Public Holidays. Each CNVMP shall define which activities will comply with a limit of LAeq 45dB and can therefore be undertaken outside of these hours in compliance with Condition 8.1.

3.4 Each CNVMP shall, in demonstrating compliance with Condition 3.2, as a minimum, address

the following aspects with regard to construction noise:

a) a description of noise sources, including machinery, equipment and construction techniques to be used;

b) predicted construction noise levels;

c) hours of operation, including times and days when noisy construction work would occur;

d) physical noise mitigation measures, including prohibiting the use of tonal reverse alarms, maintenance of access roads (to ensure they are smooth), acoustic screening around the site, plant selection and maintenance procedures, and site layout;

e) construction noise criteria for any specific areas and sensitive receivers such as schools, child care centres, medical or aged care facilities;

f) the identification of activities and locations that will require the design of specific noise mitigation measures;

g) the consultation undertaken by the Requiring Authority with affected stakeholders to develop the proposed noise management measures and any feedback received from those stakeholders, along with the noise management measures that will be adopted based on this consultation;

h) methods for monitoring and reporting on construction noise;

i) methods for receiving and responding to complaints about construction noise; and

j) construction operator training procedures.

3.5 Where a CNVMP predicts that noise levels from a particular activity will or will likely exceed the noise limits set out in Condition 3.2, or where noise measurements show that compliance is not being achieved, the Requiring Authority shall prepare and submit for the certification of the Council an Activity Specific Construction Noise Management Plan (ASCNMP). The ASCNMP(s) shall be submitted to the Council for review and approval at least 7 working days prior to the proposed works commencing.

Works subject to the ASCNMP(s) shall not commence until certification is received from the Council. If monitoring shows that levels specified in an ASCNMP are being exceeded, work generating the exceedance shall stop and not recommence until further mitigation is implemented in accordance with an amended ASCNMP certified by the Council.

In addition to the requirements of Condition 3.4, an ASCNMP must:

a) describe the activity (including duration), plant and machinery that is expected not to comply with the noise limits in Condition 3.2;

b) describe the mitigation measures proposed to reduce the noise levels as far as practicable, including any options that have been discounted due to cost or any other reason;

c) provide predicted noise levels for all receivers where the noise levels will not be compliant with the limits in Condition 3.2, including the effect of mitigation specified in 3.5(b);

d) provide a set of noise limits that are Activity – Specific;

e) describe the noise monitoring that will be undertaken to determine compliance with the Activity – Specific noise limits; and

f) describe any additional noise mitigation measures that may be implemented to maintain compliance with Activity Specific noise limits.

3.6 Each CNVMP shall also describe measures adopted to meet the requirements of German Standard DIN4150-3:1999, and as a minimum shall address the following aspects with regard to construction vibration:

a) vibration sources, including machinery, equipment and construction techniques to be used;

b) subject to agreement with the landowner and occupier, preparation of building condition reports on 160-178 Surrey Crescent, the 490 and 510 Richmond Road and residences at 24, 26 30, 2/20, 32, 34 and 38 Sackville Street' and 35, 37, 39, 41 and 42 Tawariki Street prior to, and after completion of works (refer to Appendix 1, 3 Reference maps);

c) use of building condition surveys to determine the sensitivity of the building(s) on the adjacent sites to ground movement in terms of the Line 1-3 criteria of the DIN standard;

d) identification of any particularly sensitive activities in the vicinity of the proposed works (e.g. commercial activity using sensitive equipment such as radiography or mass-spectrometry), along with the details of consultation with the land owners of the sites where the sensitive activities are located and any management measures that will be adopted based on this consultation;

e) the consultation undertaken by the Requiring Authority with affected stakeholders to develop the proposed vibration management measures and any feedback received from those stakeholders, along with the vibration management measures that will be adopted based on this consultation;

f) methods for monitoring and reporting on construction vibration; and

g) methods for receiving and responding to complaints about construction vibration.

3.7 Construction activities shall comply with the Guideline vibration limits set out in DIN 4150-3:1999 unless varied in accordance with Condition 3.8.

3.8 The Guideline vibration limits set out in DIN4150 must not be exceeded except where the Requiring Authority can demonstrate to the satisfaction of the Council:

a) that the receiving building(s) are capable of withstanding higher levels of vibration and what the new vibration limit is. The investigation required to demonstrate this must include an assessment of the building(s) by a suitably experienced and qualified structural engineer and a full pre-condition survey; and

b) that the Requiring Authority has obtained the written agreement of the building owner(s), that a higher limit may be applied.

3.9 Each CNVMP shall be implemented and maintained throughout the entire construction period. Each CNVMP shall be updated when necessary and any updated CNVMP shall be

submitted to the Council in accordance with Condition 3.1.

4. Operational Noise

4.1 The noise arising from any operational activities undertaken on the designated land, shall not exceed the following noise limits when measured at or within the boundary of any site zoned as follows:

Residential	
Time	Noise Limit*
0700-2200 hours	50 dB LAeq
2200-0700 hours	40 dB LAeq 75 dB LAmax
Special Purpose – School	
Time	Noise Limit
Monday to Saturday 0700-2200 hours	55 dB LAeq
Sunday 0900-1800 hours	
All other times	40 dB LAeq 75 dB LAmax
Business	
Time	Noise Limit
At all times	60 dB LAeq

**Notes:*

(1) These noise limits relate to noise generated by the normal operation of permanent works associated with the Project and do not apply to short term maintenance activities.

(2) Noise levels shall be measured and assessed in accordance with New Zealand Standards NZS6801:2008 Acoustics - Measurement of Environmental Sound and NZS6801:2008 Acoustics - Environmental Noise.

5. Traffic Management

5.1 A detailed Construction Traffic Management Plan (CTMP) or plans shall be prepared for the Project or relevant Project stage by a suitably qualified person, in consultation with Auckland Transport and St Pauls College, and submitted as part of the CMP. The purpose of the CTMP is to:

a) Manage the road transport network for the duration of construction to manage congestion

and minimise delays to road users;

b) Inform the public about traffic management on the road transport network for the duration of construction;

c) Protect public safety including the safe passage of pedestrians and cyclists;

d) Maintain pedestrian access to private property at all times;

e) Provide vehicle access to private property to the greatest extent possible; and

f) Manage traffic effects from construction yards on adjacent properties.

5.2 The CTMP(s) shall be submitted to the Council for certification that it achieves the overall purpose of Condition 5.1 and complies with the relevant conditions this designation. No related construction activity shall commence until certification is provided by the Team Leader – Compliance Monitoring Central. If no certification or request for alteration of the CTMP has been received from Council within 20 working days, the CTMP is deemed to be certified. The CTMP(s) shall describe the measures that will be taken to avoid, remedy or mitigate the traffic effects associated with construction of the Project or Project stage. In particular, the TMP(s) shall describe:

a) Traffic management measures to maintain traffic capacity, and safety, or minimise the impact on traffic capacity during weekdays and weekends;

b) Measures to ensure that Parawai Crescent is not used by heavy vehicles travelling to or from the site and that all heavy vehicles travelling to the site utilise a left turn only from Richmond Road into Mokau Street.

c) Any road closures that will be required and the nature and duration of any traffic management measures that will result, including any temporary restrictions, detours or diversions for general traffic and buses;

d) Methods to manage the effects of the delivery of construction material, plant and machinery;

e) Measures to maintain pedestrian access at all times and existing vehicle access to property where practicable, or to provide alternative access arrangements;

f) Measures to maintain pedestrian and cyclist movements and reduce the impact on mobility impaired users on roads and footpaths adjacent to the construction works. Such access shall be safe, clearly identifiable and seek to minimise significant detours;

g) Any proposed monitoring to measure the impact of the works on traffic and the impact of the traffic management measures. If safety or operational issues are evident, measures to be implemented to address these issues;

h) Measures to manage the proposed access to the site should the access be unable to cater for two- way traffic passing at the same time, and in particular to minimise reverse movements and blocking of the road;

i) The availability of on-street and off-street parking if the designated site is unable to accommodate all contractor parking. This shall include an assessment of available parking (if any) for contractors on street and identify measures to meet and/or reduce

contractor parking demand for on-street parking;

j) Means for communicating options to site staff for travel to and from the work site including public transport, walking, cycling and carpooling, for the purpose of minimising demand for on-street parking generated by site staff;

k) Reconstruction of the residential vehicle crossings to Auckland Transport commercial vehicle crossing standards at 33 and 40 Tawariki Street to provide for heavy vehicle manoeuvring; and.

l) Methods to ensure public refuse collection can be maintained for all properties.

5.3 The CTMP(s) shall be consistent with the New Zealand Transport Agency Code of Practice for Temporary Traffic Management, which applies at the time of construction.

5.4 Any damage in the road corridor directly caused by heavy vehicles entering or exiting the site shall be repaired as within two weeks or within an alternative timeframe to be agreed with Auckland Transport.

6. Pedestrian Management

6.1 Any temporary accessways shall be designed as far as practicable in accordance with CPTED (Crime Prevention Through Environmental Design) principles and provide appropriate lighting and signage where necessary.

7. Work within Road Reserve

7.1 The Requiring Authority shall not require Auckland Transport or network utility operators with existing infrastructure within the road reserve to seek written consent under Section 176 of the RMA for on-going access, to enable works associated with the routine construction operation, maintenance, upgrade, replacement, urgent repairs and renewal works of existing assets. Furthermore, this exemption to s176 approval does not alleviate the need for Works Over approval from Watercare.

7.2 Works within transport corridors shall be undertaken in accordance with the National Code of Practice for Utility Operators' Access to Transport Corridors (November 2011), or any approved update of that code, unless otherwise agreed between the Requiring Authority and the Corridor Manager.

8. Construction Hours

8.1 Construction hours shall be as follows, except where work is necessary outside the specified days or hours for the purposes specified in Condition 8.2 below.

a) Tunnelling activities – 24 hours a day, 7 days a week operations for all tunnelling activities, including the main tunnel works and the link tunnels.

b) General site activities – 7am to 6pm, Monday to Friday, 8am to 6pm Saturday.

c) Truck movements – 7am to 6pm, Monday to Friday, 8am to 6pm Saturday. Truck movements shall be managed to avoid, as far as practicable, entering and exiting Mokau Street between 8:15am and 9:15am and 2:45pm and 3:45pm Monday to Friday during school term times for St Paul's College. and Marist School Herne Bay.

8.2 Purposes for which work may occur outside of the specified days or hours are:

a) where, due to unforeseen circumstances, it is necessary to complete an activity that has commenced;

b) where work is specifically required to be planned to be carried out at certain times;

c) for delivery of large equipment or special deliveries required outside of normal hours due to traffic management requirements;

d) in cases of emergency

e) for the securing of the site or the removal of a traffic hazard; and/or

f) for any other reason specified in the CMP or TMP.

Where any work is undertaken pursuant to paragraphs (a) – (f), the Requiring Authority shall, within five working days of the commencement of such work, provide a report to Team Leader Compliance Monitoring Central detailing how the work was authorised under those paragraphs.

9. Community Information and Liaison

9.1 The Requiring Authority shall prepare a Communications Plan (CP) for the construction phase of the Project or for each Project stage and submit the plan in accordance with Condition 1.7. The CP shall set out:

a) the method(s) of consultation and liaison with key stakeholders, including the Catholic Diocese of Auckland, and the owners/occupiers of neighbouring properties regarding the likely timing, duration and effects of works;

b) details of prior consultation or community liaison undertaken with the parties referred to in (a) above, including outlining any measures developed with such persons or groups to manage or to mitigate any adverse effects or inconvenience that may arise;

c) details of the consultation undertaken with the owners of 39 and 41 Tawariki Street in relation to the proposed landscaping of the site at 44 and 46 Tawariki

d) full contact details for the person appointed in accordance with Condition 1.3 to manage the public information system and be the point of contact for related enquiries; and

e) the information required by Conditions 3.4(g) and (i) and 3.6(e) and (g).

10. Tree Management

10.1 The Requiring Authority shall provide details in the CMP as to how the potential impacts of construction on trees and vegetation will be managed. The details shall provide for the:

a) Identification of trees to be protected, pruned, removed, or transplanted and procedures for marking these out on site.

b) Procedures for identifying and protecting trees to be retained where works occur in the dripline of such trees as identified by a suitably qualified person.

11. Archaeology and Heritage

11.1 If any archaeological material, including human remains are exposed during site work then the Accidental Discovery Protocol according to Standard E12.6.1 of the Auckland Unitary Plan shall apply.

12. Site Reinstatement

12.1 Prior to commencement of works at all surface construction sites or an alternative timeframe as agreed in writing with the Team Leader Compliance Monitoring Central, the Requiring Authority shall prepare a Reinstatement Plan for the site, in consultation with the landowner(s). The Reinstatement Plan shall be submitted to the Council in accordance with Condition 1.7. The Reinstatement Plan shall include:

a) Any existing structures or features on the site to be protected during works or reinstated on completion of works.

b) The location and design of permanent wastewater infrastructure to remain at the site including the design of lid structures and chamber covers including the associated contouring of ground.

c) The location and design of permanent access to the wastewater infrastructure. As far as practicable, permanent all-weather access for heavy vehicles shall minimise areas of new impermeable surfaces and, in open space areas, the use of grass cell, or similar, shall be preferred.

d) Details of proposed landscaping and planting, including implementation and maintenance programmes.

e) Details of permanent vehicle crossings to the site and design standards.

12.2 When contractors' yards or other temporary works areas are no longer required for any construction or operational purpose, site works, including site offices, storage and equipment sheds, fencing and hard stand areas shall be removed, and the area reinstated in accordance with Conditions 12.1.

13. Detailed Landscape Design Drawings, Maintenance Requirements and Implementation

13.1 Prior to the commencement of any work on site, the Requiring Authority shall provide to the Council's Team Leader Compliance Monitoring Central for written certification, a finalised set of detailed landscape design drawings and supporting written documentation which have been prepared by a landscape architect. The purpose of the detailed landscape drawings and information is to demonstrate that adverse visual and amenity effects arising from the development of permanent features on the site are appropriately mitigated. Particular regard shall be had to:

a) Adverse visual effects on 35, 37, 39, 41 and 42 Tawariki Street;

b) Adverse effects on the character of the Tawariki Street streetscape; and

c) The quality of replacement planting at the western embankment on St Paul's College land (183 Richmond Road) to screen views from the east of the site

13.2 The submitted information shall be generally consistent with the approved landscape concept plan(s) (prepared by Boffa Miskell dated April 2019) and shall include the design changes certified through consultation with 39 & 41 Tawariki Street; and at a minimum, shall include the following visual mitigation and planting maintenance measures:

a) Reinstatement planting on site, including plant type and size, within Tawariki Street road reserve and St Paul's College grounds;

b) Planting, including plant type and size, along the western and southern boundary to partially screen views from 42, 41, 39 and 37 Tawariki Street and provide a vegetated backdrop (on site) for the above ground elements and buildings - specifically the future-proof-planned height of the air vent (8 metres);

c) Provision of retaining walls, fences, lighting, signage and other structural landscape design elements of a design, material and colour that reflects the treatment of neighbouring residential dwellings.

d) A landscape maintenance plan (report) and related drawings and specifications for all aspects of the finalised landscape design covering a minimum for 3 years, including in relation to the following requirements: soil preparation, irrigation, watering, drainage, staking, mulching, tree pits and garden bed details, weed removal/spraying and pest control, plant replacement for all plants including specimen trees and climbers which are severely damaged or die for a period of, covering a minimum 3 years, inspection timeframes, contractor responsibilities and ongoing maintenance requirements after contractors approved maintenance period.

13.3 The landscape design shall be implemented within the next planting season after completion of works on site, retained and maintained for a minimum three (3) years in accordance with the implementation and maintenance programme, to the satisfaction of Council's Team Leader Monitoring (Central) and shall be retained for the life of the designation.

4. Resource Consent Conditions

1. General conditions applying to all resource consents

Plans and Information

1.1 Except as modified by the conditions below and subject to final design, the works shall be undertaken in accordance with the plans and information submitted with the application including:

a) Assessment of Effects on the Environment, titled "Grey Lynn Tunnel – Notice of Requirement, Resource Consent Application and Assessment of Environmental Effects" prepared by Jacobs, dated February 2019.

b) Drawings as detailed below:

- 'Land Requirement Plan Tawariki Street Shaft Site', Rev A by Jacobs, undated.
- 'Grey Lynn Tunnel Western Springs to Tawariki Street Plan and Profile Sheet 1', Rev 0, by Watercare, dated 20 Feb 2019.

- ‘Grey Lynn Tunnel Western Springs to Tawariki Street Plan and Profile Sheet 2’, Rev 0, by Watercare, dated 20 Feb 2019.
- ‘Grey Lynn Tunnel Western Springs to Tawariki Street Plan and Profile Sheet 1’, Rev 0, by Watercare, dated 20 Feb 2019.
- ‘Grey Lynn Tunnel – Tawariki Street Site Plan’, Rev 0, by Boffa Miskell, dated April 2019.
- ‘Grey Lynn Tunnel – Tawariki Street Fence Options, Rev 0, by Boffa Miskell, dated April 2019.
- ‘Grey Lynn Tunnel – Tawariki Street Section and Elevation Location Plan, Rev 0, by Boffa Miskell, dated April 2019.
- ‘Grey Lynn Tunnel – Tawariki Street Cross Sections, Rev 0, by Boffa Miskell, dated April 2019.
- ‘Grey Lynn Tunnel – Tawariki Street Retaining Wall Elevations, Rev 0, by Boffa Miskell, dated April 2019.
- ‘Grey Lynn Tunnel – Tawariki Street Panorama View from 39 Tawariki Street – Following Site Reinstatement, Rev 0, by Boffa Miskell, dated April 2019.

c) Technical Reports as detailed below:

- Ecological Assessment, prepared by Bioresearches Group Ltd, dated 18 February 2019.
- Vibration Assessment, prepared by McMillen Jacobs Associates, dated 21 December 2018.
- Groundwater Assessment, prepared by Williamson Water & Land Advisory, dated 19 February 2019.
- Settlement Assessment, prepared by McMillen Jacobs Associates, dated 31 January 2019.
- Air Quality Assessment, prepared by AECOM, undated.
- Contamination Report, prepared by AECOM, dated 21 February 2019

d) Section 92 responses dated 18 April and 24 May 2019

Lapse

1.2 These resource consents shall lapse 10 years after the date on which the last of any appeals on all consents and notices of requirement associated with the Project is withdrawn or determined, or, if no appeals are lodged, the date on which the notices of requirement are included in the AUP in accordance with section 184(1)(c) of the RMA, unless:

a) it has been given effect before the end of that period; or

b) the Council determines, on an application made within 3 months before the expiry of that period, that substantial progress or effort has been made towards giving effect to the consent, and continues to be made, and fixes a longer period for the purposes of this subsection.

Monitoring fees

1.3 The Consent Holder shall pay the Council a consent compliance monitoring charge or charges to recover the actual and reasonable costs that have been incurred to ensure compliance with the conditions attached to these consents. Such charges are to cover the cost of inspecting the site, carrying our tests, reviewing conditions, updating files, etc. all being work to ensure compliance with the resource consents and are to be paid within one (1) month of date of invoice.

2. Specific conditions: Land use consent - LUC60334953

Dust Management

2.1 Beyond the boundary of the site, there shall be no dust caused by discharges from the site, which in the opinion of an enforcement officer, is noxious, offensive or objectionable.

2.2 All processes on site shall be operated in accordance with the CMP as required by the designation associated with this consent.

2.3 The Consent Holder shall ensure that dust management during excavation works generally complies with the Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions, MfE (2016).

Earthworks and stability

2.4 All earthworks shall be managed to avoid where possible and minimise any discharge of debris, soil, silt, sediment or sediment-laden water beyond the site to either land, stormwater drainage systems, watercourses or receiving waters. In the event that a discharge occurs, the activity which resulted in the discharge shall cease immediately and the discharge shall be mitigated and/or rectified to the satisfaction of the Team Leader Compliance Monitoring Central.

2.5 Prior to earthworks commencing at any site, a detailed Erosion and Sediment Control Plan ("ESCP") for that area which clearly identifies the type and location of the controls proposed, shall be submitted to the Council for certification. The ESCP(s) shall be in accordance with GD05 and any amendments to that document. If no certification has been received within 20 working days, the ESCP is deemed to be certified.

2.6 Erosion and sediment control measures shall be carried out in accordance with the certified ESCP(s) required by this consent for the duration of the works.

2.7 Any subsequent amendments to the certified ESCP(s) and / or methodology must be certified by the Team Leader Compliance Monitoring Central in writing prior to any such amendment being implemented.

2.8 Prior to earthworks commencing at any site, a certificate signed by a suitably qualified person, confirming that the erosion and sediment controls have been constructed and completed in general accordance with the ESCP(s), shall be provided to the Team Leader Compliance Monitoring Central.

2.9 The Consent Holder or their agent shall arrange and conduct a pre-construction site meeting between representatives of the Council, the Consent Holder and their contractor, prior to any

works commencing on a site. The purpose of the pre-construction site meeting is to discuss the proposed site access arrangements and the ESCP(s). If as a result of that meeting any amendments are required to the erosion and sediment control methodology, those amendments shall be submitted to the Team Leader Compliance Monitoring Central for certification in accordance with Condition 2.5.

2.10 All perimeter controls shall be operational before earthworks begin.

2.11 All cleanwater runoff from stabilised surfaces including catchment areas above the site shall be diverted away from earthwork areas via a stabilised system, so as to prevent surface erosion.

2.12 All sediment laden runoff shall be treated on site by sediment control measures, as described in the consent application or modified under Condition 2.5 and 2.7. These measures are to be constructed or installed in accordance with ESCP, be operational before commencement of works and be maintained to perform at full operational capacity until the site has been adequately secured against erosion.

2.13 Sediment control measures shall be inspected on a weekly basis by the Consent Holder and after a significant storm event to ensure effective operation. Any defects shall be immediately remedied by the Consent Holder.

2.14 The site shall be stabilised in accordance with the ESCP in a progressive manner as earthworks are completed across various areas of the site.

2.15 To prevent discharge of sediment-laden water or other debris into any public stormwater drainage systems or watercourses and therefore into receiving waters, and to prevent nuisance and amenity impacts on users of the road reserve, there shall be no deposition of earth, mud, dirt or other debris on any public road or footpath outside the project footprint resulting from earthworks activity on the site. In the event that such deposition does occur, it shall immediately be removed. In no instance shall roads or footpaths be washed down with water without appropriate erosion and sediment control measures in place to prevent contamination of the stormwater drainage system, watercourses or receiving waters.

2.16 If works on a site are abandoned or will be unused for any reason, adequate preventative and remedial measures shall be taken to control sediment discharge and shall thereafter be maintained for as long as necessary to prevent sediment discharges from the site. All such measures shall be of a type and to a standard which are to the prior satisfaction of the Team Leader Compliance Monitoring Central.

2.17 All earthworks shall be managed to ensure that they do not lead to any uncontrolled instability or collapse affecting either the site or adversely affecting any neighbouring properties. In the event that such collapse or instability does occur, it shall immediately be rectified.

2.18 The Consent Holder shall engage an independent suitably qualified and experienced engineer to design temporary works and supervise all excavations (especially close to boundaries and existing structures), retaining and foundation construction. The supervising engineer's contact details shall be provided in writing to the Team Leader Compliance Monitoring Central at least two weeks prior to earthworks commencing on site. This timeframe may be waived in the event of emergency works due to the failed condition of any

retaining structures.

2.19 A suitably qualified and experienced engineer excavation and retaining work-method statement shall be provided to the Team Leader Compliance Monitoring Central in writing prior to earthworks commencing on site for certification. The work method statement shall include excavation time frames, temporary propping/weatherproofing and/or sequencing of boundary works.

Noise and Vibration from tunnelling works

2.20 Ground-borne noise arising from construction work activities involving tunnelling works must comply as far as practicable with an internal noise level of 35 dB LAeq(15min) in bedrooms and sleeping spaces between 10pm to 7am. Any complaint received about ground-borne noise must be assessed by the Consent Holder and a noise level of 35 dB LAeq shall be used for assessment purposes.

2.21 In the event that noise assessment shows the 35 dB LAeq(15min) level being infringed, the Consent Holder shall submit a report to the Team Leader Compliance Monitoring Central that an adequate assessment has been completed, all practicable mitigation measures have been implemented, and effects assessed by a suitably qualified and experienced acoustic specialist.

2.22 Vibration levels arising from tunnelling activity shall not exceed the limits set out in German Industrial Standard DIN 4150-3 (1999) Structural Vibration – Part 3 Effects of Vibration on Structures when measured in accordance with that Standard on any structure not on the same site.

Advice Note: *Where appropriate, noise levels shall be measured in accordance with the provisions of NZS 6801:2008 Acoustics – Measurement of environmental sound and shall be assessed in accordance with NZS 6802:2008 Acoustics – Environmental noise.*

3. Specific conditions: Groundwater permit conditions – WAT60334954

General Groundwater Conditions

3.1 This consent shall expire 35 years from the granting of the consent (or in October 2054) unless it has lapsed, been surrendered or been cancelled at an earlier date pursuant to the RMA.

3.2 The Consent Holder shall ensure that all excavation, dewatering systems, retaining structures and associated works for the construction of the shafts, tunnels, underground structures and associated works, including all temporary and permanent works, shall be designed, constructed and maintained so as to avoid damage to buildings, structures and services (including road infrastructure assets such as footpaths, kerbs, catch-pits, pavements and street furniture), unless otherwise agreed in writing with the asset owner.

3.3 The Consent Holder shall ensure that all backfilling of temporary shafts is designed and constructed to the required engineering standard, so as to avoid any damage to buildings, structures and services.

3.4 The Consent Holder shall, at least 10 working days prior to the Commencement of

Dewatering, advise the Team Leader Compliance Monitoring Central, in writing, of the date of the proposed commencement of this work.

3.5 The Consent Holder shall, at least 10 working days following Completion of Dewatering, advise the Team Leader Compliance Monitoring Central, in writing, of the date of completion.

3.6 Under section 128 of the RMA the conditions of this consent may be reviewed by the Manager Resource Consents at the Consent Holder's cost:

3.7 Within six months after Completion of Dewatering and subsequently at intervals of not less than five years thereafter in order:

a) To deal with any adverse effects on the environment which may arise or potentially arise from the exercise of this consent and which it is appropriate to deal with at a later stage

b) To vary the monitoring and reporting requirements, and performance standards, in order to take account of information, including the results of previous monitoring and changed environmental knowledge on:

- ground conditions
- aquifer parameters
- groundwater levels; and
- ground surface movement

Monitoring and Contingency Plan

3.8 The Consent Holder shall, before Commencement of Dewatering, prepare a Monitoring and Contingency Plan or Plans ("M&CP") addressing groundwater and settlement monitoring for each of the relevant Project stages. The M&CP shall demonstrate how the conditions of this consent will be implemented and shall include the following:

a) details of the building risk assessment process and building condition surveys;

b) details of the groundwater monitoring programme;

c) details of the ground surface settlement and building movement;

d) a location plan of monitoring marks and the location of existing and proposed groundwater monitoring bores;

e) details of the shaft retaining wall monitoring programme;

f) the groundwater, deformation and settlement Alert and Alarm Levels (Trigger Levels) to be utilised for early warning of settlement with the potential to cause damage to buildings and services and details of the processes used to establish, and if necessary, to review these triggers;

g) if updated under f), Alert and Alarm Levels, shall be provided in the format shown in Schedule A of condition 3.11;

h) details on the procedures for notification of the Team Leader Compliance Monitoring Central in the event that Trigger Levels are exceeded;

i) options for additional investigations and analyses to determine the potential for groundwater effects or settlement and for damage to structures, including additional groundwater or settlement monitoring and building condition surveys;

j) details of the contingency measures to be implemented in the event of trigger levels being exceeded, including details on the practicable methodologies to avoid, remedy, or mitigate surface settlements with the potential to cause damage to buildings; and

k) a methodology to identify trenched sections where there is potential for ground settlement to cause damage to houses or buildings and the measures that will be taken to ensure such damage does not occur.

3.9 The Consent Holder shall submit to the Team Leader Compliance Monitoring Central for certification:

a) a draft M&CP including aspects dealing with pre-construction monitoring and locations of monitoring marks, including the pre-construction monitoring required under the conditions of this consent. This shall be provided at least 7 months prior to the Commencement of Dewatering for shaft sinking or tunnelling of any Project stage; and

b) the final M&CP. This shall be provided at least 20 working days prior to Commencement of Dewatering for shaft sinking or tunnelling of any Project stage.

3.10 The Consent Holder shall comply with the M&CP at all times.

3.11 The Consent Holder may amend the M&CP from time to time, as necessary for the Project or any Project stage, subject to certification by the Team Leader Compliance Monitoring Central prior to any such amendment being implemented.

Schedule A: Alarm and Alert Levels			
Movement		**Trigger Thresholds (+/-)**	
		Alarm	**Alert**
a)	Differential vertical settlement between any two Ground Surface Deformation Stations (the **Differential Ground Surface Settlement Alarm or Alert Level**)	1:1000	1:1500
b)	Total vertical settlement from the pre-excavation baseline level at any Ground Surface Deformation Station (the **Total Ground Surface Settlement Alarm or Alert Level**):	50mm	30mm
c)	Differential vertical settlement between any two adjacent Building Deformation Stations (the **Differential Building Settlement Alarm or Alert Level**)	1:1000	1:1500

d)	Total vertical settlement from the pre-excavation baseline level at any Building Deformation Station (the **Total Building Settlement Alarm or Alert Level**)	50mm	30mm
e)	Total lateral deflection from the pre-excavation baseline level at any retaining wall deflection station (the **Retaining Wall Deflection Alarm or Alert Level**):	TBC	TBC
f)	Total lateral wall deflection from the pre-excavation baseline level and any subsequent reading at any Inclinometer (the **Inclinometer Deformation Alarm or Alert Level**):	TBC	TBC
g)	Distance below the pre-dewatering Seasonal Low Groundwater Level and any subsequent groundwater reading at any groundwater monitoring bore (the **Groundwater Alert Levels 1 & 2**):	N/A	(1) TBC (2) TBC

Pre-construction Condition Survey

3.12 The Consent Holder shall consult with owners of 160-178 Surrey Crescent, the 490 and 510 Richmond Road and residences at 24, 26 30, 2/20, 32, 34 and 38 Sackville Street and 35, 37, 39, 41 and 42 Tawariki Street (refer to Appendix 1, 3 Reference maps), and subject to the owner's approval on terms acceptable to the Consent Holder, undertake a detailed pre-construction condition survey of these structures to confirm their existing condition and enable the sensitivity of the existing buildings and structures to any groundwater and ground settlement changes to be accurately determined. The survey shall be completed at least three months prior to the Commencement of Dewatering of any Project stage involving shaft sinking or tunnelling. The intent of the survey is to assist in enabling the magnitude of allowable effects from changes in groundwater pressure and ground settlement movements to be reasonably determined. The survey shall include but not necessarily be limited to the following:

a) major features of the buildings and site developments, including location, type, construction, age and existing condition;

b) type and capacity of foundations;

c) existing levels of aesthetic damage;

d) existing level of structural distress or damage;

e) assessment of structural ductility; and

f) susceptibility of structure to movement of foundations, including consideration of the local geological conditions;

***Advice note**: 'Commencement of Dewatering' means commencement of bulk excavation and/or commencing taking any groundwater from a shaft or tunnel excavation (after construction of the pile walls (if required) and/or dewatering prior to bulk excavation).*

3.13 Where neighbouring building/property owners indicate, to the satisfaction of the Team Leader Compliance Monitoring Central by way of a recommendation from a qualified and experienced vibration consultant, the presence of particularly sensitive structures (examples include old or brittle structures, vibration sensitive equipment, unusually heavy loads or settlement sensitive machinery) the Consent Holder shall engage a Chartered Professional Engineer to undertake a full engineering assessment to determine what, if any, additional avoidance, design, remedial or monitoring works are required in this vicinity. The Team Leader Compliance Monitoring Central may require an independent review of that assessment by a Chartered Professional Engineer.

3.14 The building condition surveys required by the conditions of this consent shall be undertaken by an independent and suitably qualified person. When requested in writing by the Team Leader Compliance Monitoring Central, the Consent Holder provide the contact details and qualifications of this person within five workings days.

Post-construction Condition Surveys

3.15 Unless otherwise agreed in writing with the building owner that such survey is not required, the Consent Holder shall (subject to the owner(s) approval on terms acceptable to the Consent Holder), within six months of the Completion of Dewatering of any Project stage involving shaft sinking or tunnelling, undertake a postconstruction survey of buildings identified in Condition 3.12 and 3.13. The Consent Holder may, if they are able to provide evidence to show the deformation was not caused by activities related to this consent, seek written approval from the Team Leader Compliance Monitoring Central to waive this condition. If any building damage is identified following completion of the pre-construction survey, the survey shall determine the likely cause of damage.

***Advice note:** 'Completion of Dewatering' means when all the permanent shaft lining, base slab and walls are complete and the tunnel lining is complete, and effectively no further groundwater is being taken for the construction of the shaft/tunnel, in accordance with the design.*

3.16 The Consent Holder shall, at the direction of the Team Leader Compliance Monitoring Central, and subject to the owner's approval on terms acceptable to the Consent Holder, undertake an additional survey on any existing building or structure surveyed in accordance with Condition 3.12 and 3.13, for the purpose of checking for damage and for following up on a report of damage to that building. The requirement for any such survey will cease six months after the Completion of Dewatering of any Project stage involving shaft sinking or tunnelling.

3.17 The Consent Holder shall ensure that a copy of the pre, post-construction and any additional building survey reports are provided to the respective property owner(s) and the Team Leader Compliance Monitoring Central (unless the property owner(s) has instructed the Consent Holder not to do so) within 15 working days of completing the reports.

Repair of Damage

3.18 If the exercise of this consent causes any unforeseen damage to buildings, structures or services not assessed under Conditions 3.12 and 3.13, the Consent Holder shall notify the Team Leader Compliance Monitoring Central as soon as practicable, and provide in writing to the Team Leader Compliance Monitoring Central a methodology for repair of the damage caused that has been certified by a Chartered Professional Engineer, and shall urgently undertake such repairs in accordance with the certified methodology, at its cost, unless written approval for this damage is provided from the owners.

Groundwater Monitoring

3.19 The Consent Holder shall install and maintain groundwater monitoring boreholes at the locations described in the M&CP for the period required by Conditions 3.21, 3.23 and 3.25. Should any of the monitoring bores be damaged and become in-operable or unsuitable for monitoring, then the Consent Holder shall contact the Team Leader Compliance Monitoring Central within three working days and a new monitoring bore shall be installed at a nearby location in consultation with, and to the satisfaction of, the Team Leader Compliance Monitoring Central.

3.20 The Consent Holder shall monitor groundwater levels in the groundwater monitoring boreholes and keep records of the water level measurement and corresponding date. All water level data shall be recorded to an accuracy of at least ± 5mm. These records shall be compiled and submitted to the Team Leader Compliance Monitoring Central at six monthly intervals.

3.21 The Consent Holder shall monitor groundwater levels monthly in boreholes identified in the M&CP and keep records for a period of at least six (6) months before the Commencement of Dewatering of any Project stage involving shaft sinking or tunnelling. The variability in groundwater levels over this period will be utilised to establish the seasonal groundwater level variability. The Consent Holder shall monitor groundwater levels at regular intervals in all proposed monitoring boreholes during the monitored period (three readings indicating steady state) before the Commencement of Dewatering of any Project stage involving shaft sinking or dewatering.

3.22 Prior to the Commencement of Dewatering of any Project stage involving shaft sinking or tunnelling, the Consent Holder shall assess the potential groundwater effects resulting from the exercise of this consent. The output of this assessment shall be used to define the expected groundwater level at each borehole and to establish groundwater Trigger Levels for each borehole that minimise the potential for damage to existing buildings or structures. The process for establishing groundwater Trigger Levels shall be set out in the M&CP and shall be based upon the final tunnel alignment and construction methodology, and any groundwater monitoring required under this consent, and shall be based upon groundwater modelling completed using this data. A factor of natural seasonal variability shall be allowed for in this review based on the survey completed under Condition 3.21.

3.23 From Commencement of Dewatering of any Project stage involving shaft sinking or tunnelling, the Consent Holder shall monitor groundwater levels in each borehole at a minimum of monthly intervals and records shall be kept of each monitoring date, the

corresponding water level in each borehole and the corresponding depth of all excavations. In addition to the above, all boreholes located within 100 metres of the shaft construction site or within 100 metres of the tunnel excavation face shall be monitored for groundwater level at least once in any period of seven consecutive days. These records shall be compiled and submitted to the Team Leader Compliance Monitoring Central at six (6) monthly intervals.

3.24 All monitoring data obtained pursuant to Condition 3.23 shall be compared to the predicted groundwater levels for each borehole. Where Trigger Levels are exceeded the actions as set out in the M&CP shall be undertaken and the Team Leader Compliance Monitoring Central shall be notified within three working days, advising of the trigger exceedance, the risk of settlement causing damage to buildings and details of the actions taken.

3.25 The Consent Holder shall continue to monitor groundwater levels in each borehole at monthly intervals for a period of twelve (12) months following Completion of Dewatering of any Project stage involving shaft sinking or tunnelling, or for a lesser period if groundwater levels in any particular borehole showeither:

a) recovery of the groundwater level to within two (2) metres of the pre-construction groundwater level and is above trigger levels; or

b) a trend of increasing groundwater level in at least three consecutive monthly measurements and is above trigger levels, in which case monitoring at that borehole may cease.

After 12 months following the Completion of Dewatering of any Project stage involving shaft sinking or tunnelling, monitoring of groundwater levels shall continue at the direction of the Team Leader Compliance Monitoring Central if groundwater levels are not recovering from construction effects and there is a risk of adverse effects on neighbouring buildings or properties.

Settlement and Deflection Monitoring

3.26 The Consent Holder shall establish and maintain a Settlement Monitoring Network of ground settlement monitoring marks and inclinometers to detect any deformation (vertical and/or horizontal movements) at the locations described in the M&CP and for the period required by the conditions of this consent.

a) The locations of the monitoring marks shall be identified on a plan within the draft M&CP, as required under Condition 3.9;

b) The monitoring marks shall be located at least one mark within five (5) metres of each of the groundwater monitoring boreholes described in Condition 3.19;

c) The locations and number of monitoring marks shall be sufficient to provide a reliable basis for assessing, monitoring and responding to settlement risk during shaft and tunnel construction work, and for confirming compliance with the limits set out in Condition 3.33.

3.27 In the event of any of the monitoring marks required under Condition 3.26 being destroyed or becoming inoperable, the Consent Holder shall, unless otherwise agreed in writing by the Team Leader Compliance Monitoring Central, replace the monitoring marks with new monitoring marks.

3.28 The Consent Holder shall survey and record the elevation of each monitoring mark and record the corresponding date. Monitoring marks shall be surveyed at least three times over a 12-month period prior to commencement of any Project stage involving shaft sinking or tunnelling to establish seasonal variability, and the minimum level of these baseline surveys shall be used to establish the pre-construction reference ground level. All surveys are to be completed to an accuracy of at least ± 2mm for level and ± 5mm for plan position, or as otherwise achieved by best practice precise levelling.

3.29 The Consent Holder shall survey and record the readings of each inclinometer as required in Condition 3.26 at an average of each two (2) metres depth of shaft excavation, and at a minimum frequency of fortnightly intervals from the Commencement of Dewatering of any Project stage involving shaft sinking for a period of one month after the Completion of Excavation, then monthly until the Completion of Dewatering for any Project stage involving shaft sinking. At least two baseline surveys shall be completed by the Consent Holder before Commencement of Dewatering.

3.30 Prior to the Commencement of Dewatering of any Project stage involving shaft sinking or tunnelling, the Consent Holder shall assess the potential settlement effects resulting from the exercise of this consent. The output of this assessment shall be used to define the expected settlement levels and to establish settlement Trigger Levels (Alert Levels and Alarm Levels) that minimise the potential for damage to existing buildings or structures. The process for establishing settlement Trigger Levels shall be set out in the M&CP and shall be based upon the final tunnel alignment and construction methodology, any groundwater, deformation or settlement monitoring required under this consent, and groundwater and settlement modelling completed using this data. A factor of natural seasonal variability shall be allowed for in this review based on the survey completed under Condition 3.28.

***Advice Note**: 'Alert Level' is the Differential and Total Settlement Limit set at a threshold less than the Alarm Level, at which the Consent Holder shall implement further investigations and analyses as described in the M&CP to determine the cause of settlement and the likelihood of further settlement.*

'Alarm Level' is the Differential and Total Settlement Limit set in Condition 3.33, or which has the potential to cause damage to buildings, structures and services, at which the Consent Holder shall immediately stop dewatering the site and cease any activity which has the potential to cause deformation to any building or structure or adopt the alternative contingency measures approved by the Team Leader Compliance Monitoring Central.

3.31 During construction in any Project stage involving shaft sinking or tunnelling, the Consent Holder shall survey the settlement monitoring network described in Condition 3.26 at maximum six monthly intervals and keep records of each date and the corresponding ground surface and building level. In addition to the above, all monitoring marks located within 50 metres of the excavated tunnel and within 100 metres of the tunnel excavation face shall be monitored at least once every month, monitoring marks located within 100 metres of an excavated shaft shall be monitored at least once every week. These records shall be compiled and submitted to the Team Leader Compliance Monitoring Central at six monthly intervals.

3.32 The Consent Holder shall compare all settlement monitoring data obtained during shaft

sinking and tunnelling construction work to the pre-construction minimum levels in accordance with the M&CP. Where Trigger Levels are exceeded the appropriate actions as set out in the M&CP shall be undertaken and the Team Leader Compliance Monitoring Central shall be notified within three working days, advising of the trigger exceedance, the risk of settlement causing damage to buildings, and details of the actions taken.

3.33 The Consent Holder shall ensure that the exercise of this consent does not cause building or ground settlement greater than the Alarm Level thresholds specified below.

a) greater (i.e. steeper) than 1:1,000 differential settlement (the Differential Settlement Alarm Level) between any two adjacent settlement monitoring marks required under this consent; or

b) greater than 50mm total settlement (the Total Settlement Alarm Level) at any settlement monitoring mark required under this consent.

3.34 The Consent Holder shall continue to monitor the Monitoring Stations at monthly intervals for a total period of 12 months after Completion of Dewatering of any Project stage involving shaft sinking or tunnelling, or for a shorter period if certified by the Team Leader Compliance Monitoring Central. At 12 months following the Completion of Dewatering of any Project stage involving shaft sinking or tunnelling, monitoring of ground and settlement marks shall continue at the direction of the Team Leader Compliance Monitoring Central if monitoring marks have breached trigger levels and there is risk of adverse effects.

3.35 The Team Leader Compliance Monitoring Central shall be advised in writing within 10 working days of when excavation and dewatering has been completed.

Advice Note: *The Consent Holder is advised that the discharge of pumped groundwater to a stormwater system or waterbody will need to comply with any other regulations, bylaws or discharge rules that may apply.*

4. Specific conditions: Air quality discharge consent - DIS60338392

General Air quality conditions

4.1 This consent shall expire 35 years (or in October 2054) from the date of granting of the consent unless it has lapsed, been surrendered or been cancelled at an earlier date pursuant to the RMA.

4.2 Under section 128 of the RMA, the conditions of this consent may be reviewed by the Manager Resource Consents at the Consent Holder's cost in May 2021 and annually thereafter in order to:

a) Deal with any significant adverse effects on the environment arising from the exercise of the consent which was not foreseen at the time the application was considered and which is appropriate to deal with at the time of the review.

b) Consider the adequacy of conditions which prevent nuisance and adverse effects beyond the boundary of the Site, particularly if regular or frequent complaints have been received and validated by an enforcement officer.

c) Consider developments in control technology and management practices that would enable practical reductions in the discharge of contaminants to air.

d) Alter the monitoring requirements, including requiring further monitoring, or increasing or reducing the frequency of monitoring.

e) Take into account any Act of Parliament, regulation, national policy statement, regional policy statement or relevant regional plan at the time of consent approval that relates to limiting, recording or mitigating emissions by this consent.

Or, the consent may be reviewed by the Team Leader, Central Compliance Monitoring at any time, if it is found that the information made available to the council in the application contained inaccuracies which materially influenced the decision and the effects of the exercise of the consent are such that it is necessary to apply more appropriate conditions.

Operational Air Quality

4.3 The Consent Holder shall, at all times operate, monitor and maintain the Grey Lynn Tunnel so that odour discharges authorised by this consent are maintained at the minimum practicable level.

4.4 Access to the relevant parts of the property shall be maintained and be available at all reasonable times to enable the servants or agents of Auckland Council to carry out inspections, surveys, investigations, tests, measurements or take samples whilst adhering to the Consent Holder's health and safety policy.

4.5 Beyond the boundary of the site there shall be no effect caused by discharges from the normal operation of the Grey Lynn Tunnel which, in the opinion of an enforcement officer, is noxious, offensive or objectionable.

***Advice Note**: the storage and transfer of wastewater within the Grey Lynn Tunnel as well as scheduled maintenance activities, and any discharges into air arising from this, are considered part of the normal operation of the tunnel.*

4.6 Air ventilated from the tunnel shall be discharged via a stack no lower than 5 metres above ground level. In the event that odour discharges are found to result in noxious, dangerous, offensive or objectionable, the Team Leader, Central Compliance Monitoring, may require the Consent Holder increase the vertical stack height by up to further 3 metres to enable greater dispersion.

4.7 Except as authorised by this consent, beyond the boundary of the site, there shall be no hazardous air pollutant, caused by discharges from the site, which is present at a concentration that causes, or is likely to cause adverse effects to human health, the environment or property.

4.8 Except during maintenance, cleaning, or other inspections all access hatches shall be adequately covered to ensure fugitive discharges to atmosphere are kept to a minimum practicable level.

4.9 The Consent Holder shall give consideration to the wind direction, wind strength and weather conditions and the likelihood of neighbours present prior to undertaking any tunnel maintenance activities on site that have the potential to generate odour effects beyond the site boundary.

4.10 All access hatches, fans, ducting and emissions control equipment shall be designed and maintained in good condition and be free from leaks so that fugitive discharges to the atmosphere are kept to a minimum practicable level.

4.11 All relevant fans and ducting to emissions control equipment shall draw sufficient negative pressure so that fugitive discharges to the atmosphere are kept to a minimum practicable level.

4.12 A record of the timing and nature of any maintenance activities undertaken to wastewater infrastructure at the Site that has the potential to discharge odour or dust shall be kept. Details of all inspections and monitoring records relating to the operation and maintenance of the Site shall be kept for a minimum of two years from the date of each entry and shall be provided to the council on request.

4.13 The council shall be notified as soon as practicable in the event of any significant discharge to air, which results or has the potential to result in a breach of air quality conditions or adverse effects on the environment. The following information shall be supplied:

a) Details of the nature of the discharge;

b) An explanation of the cause of the incident; and

c) Details of remediation action taken.

4.14 All air quality complaints that are received shall be recorded. The complaint details shall include:

a) The date, time, location and nature of the complaint;

b) The name, phone number and address of the complainant, unless the complainant elects not to supply these details;

c) Weather conditions, including approximate wind speed and direction, at time of the complaint;

d) Any remedial actions undertaken.

Details of any complaints received shall be provided to the council within one working day of the complaint being received.

Barry Kaye

Duty Commissioner

9 October 2019

Resource Consent Notice of Works Starting

Please email this form to **monitoring@aucklandcouncil.govt.nz at least *5* days prior to work starting** on your development or post it to the address at the bottom of the page.

Site address:				
AREA (please tick the box)	**Auckland CBD☐**	**Auckland Isthmus☐**	**Hauraki Gulf Islands ☐**	**Waitakere ☐**
Manukau ☐	**Rodney ☐**	**North Shore ☐**	**Papakura ☐**	**Franklin ☐**

Resource consent number:	**Associated building consent:**
Expected start date of work:	**Expected duration of work:**

Primary contact	**Name**	**Mobile / Landline**	**Address**	**Email address**
Owner				
Project manager				
Builder				
Earthmover				
Arborist				
Other (specify)				

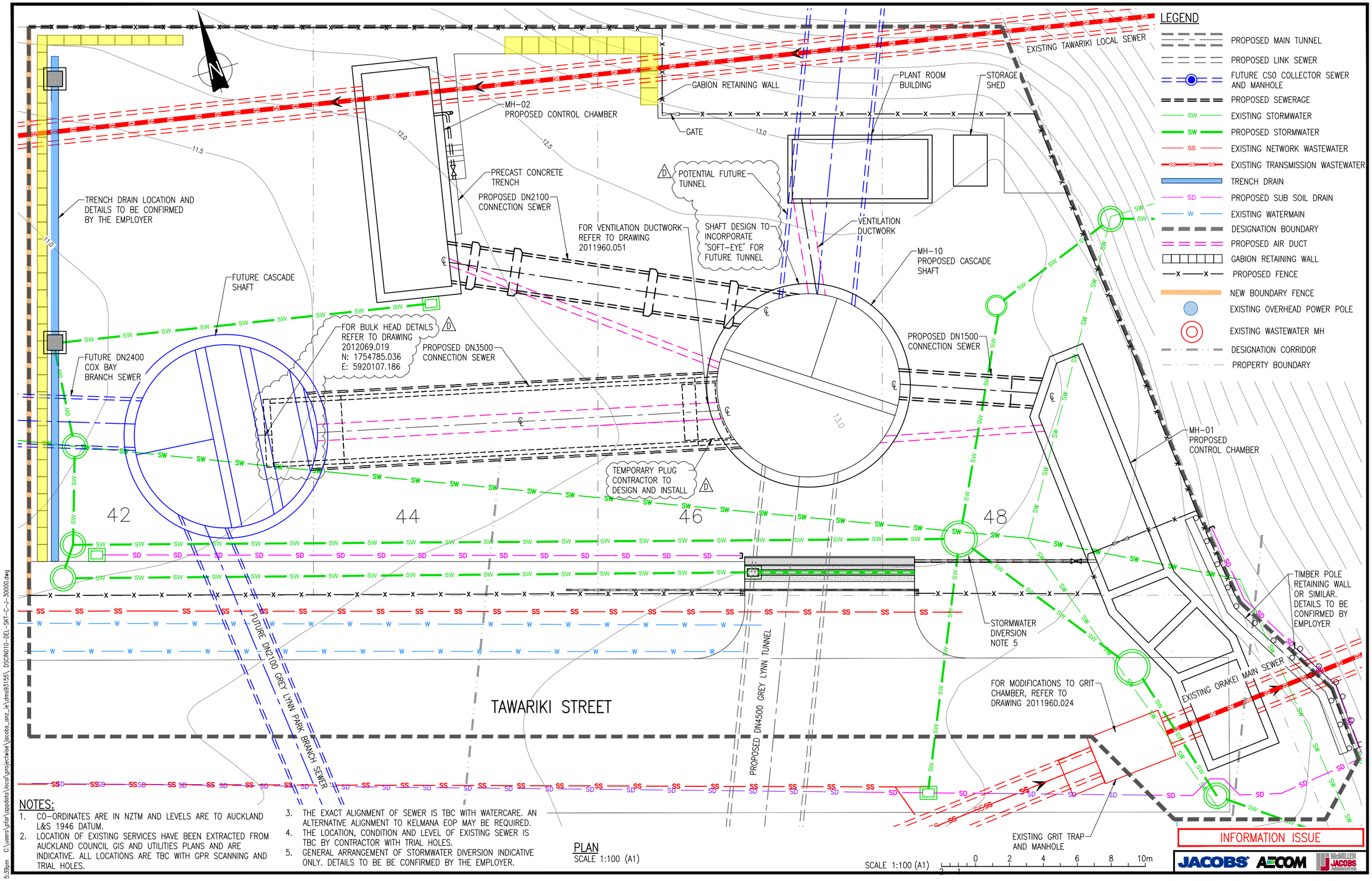
Signature: Owner / Project Manager (indicate which)	**Date:**

Once you have been contacted by the Monitoring Officer, all correspondence should be sent directly to them.

SAVE $$$ minimise monitoring costs!

The council will review your property for start of works every three months from the date of issue of the resource consent and charge for the time spent. You can contact your Resource Consent Monitoring Officer on 09 301 0101 or via monitoring@aucklandcouncil.govt.nz to discuss a likely timetable of works before the inspection is carried out and to avoid incurring this cost.

Appendix C: Drawings



NOTES:

1. CO-ORDINATES ARE IN NZTM AND LEVELS ARE TO AUCKLAND L&S 1946 DATUM.
2. LOCATION OF EXISTING SERVICES HAVE BEEN EXTRACTED FROM AUCKLAND COUNCIL GIS AND UTILITIES PLANS AND ARE INDICATIVE. ALL LOCATIONS ARE TBC WITH GPR SCANNING AND TRIAL HOLES.
3. THE EXACT ALIGNMENT OF SEWER IS TBC WITH WATERCARE. AN ALTERNATIVE ALIGNMENT TO KELMANA EOP MAY BE REQUIRED.
4. THE LOCATION, CONDITION AND LEVEL OF EXISTING SEWER IS TBC BY CONTRACTOR WITH TRIAL HOLES.
5. GENERAL ARRANGEMENT OF STORMWATER DIVERSION INDICATIVE ONLY. DETAILS TO BE BE CONFIRMED BY THE EMPLOYER.

PLAN
SCALE 1:100 (A1)

SCALE 1:100 (A1) 0 2 4 6 8 10m

INFORMATION ISSUE

JACOBS AECOM MWILLEN JACOBS ASSOCIATES

Plot Date: Jul 05, 2022 - 5:39pm C:\users\pfan\appdata\local\projectwise\jacobs_anz_ie\dms93155\ DSCIN010-DEL-SKT-C-J-30000.dwg

ISSUE	DATE	AMENDMENT
D	06.07.22	INFORMATION ISSUE – REVISED AS INDICATED
C	30.06.22	INFORMATION ISSUE – SW AND RETAINING REVISED AS INDICATED
B	29.06.22	INFORMATION ISSUE – SCOPE OF ADIT UPDATED
A	21.06.22	INFORMATION ISSUE – CONCEPT SITE LAYOUT

Watercare

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TAWARIKI ST – CENTRAL INTERCEPTOR (DSCIN)

00 SITE GENERAL

REDESIGNED SITE LAYOUT – CONCEPT LAYOUT

CAD FILE	DSCIN010-DEL-SKT-C-J-30000.DWG
REF No.	2011960.012
ORIGINAL SCALE A1	1:100
SKETCH No.	DSCIN010-DEL-SKT-C-J-30000
ISSUE	D

Appendix D: Groundwater and Settlement Assessment

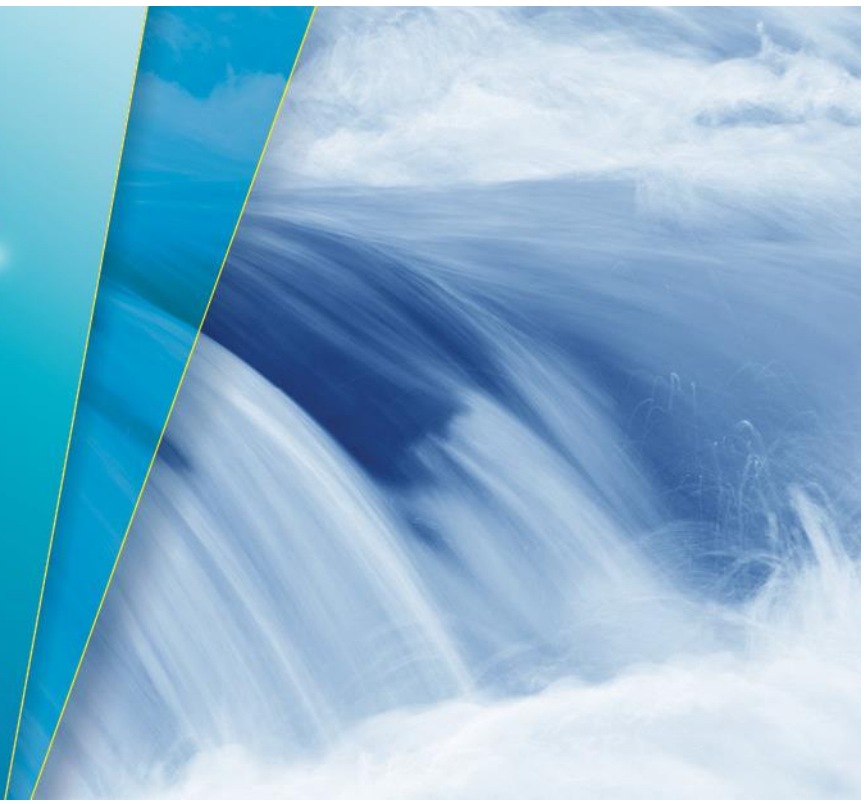
REPORT

Tonkin+Taylor

Tawariki Shafts Groundwater and Settlement Effects Assessment

Grey Lynn Tunnel - Tawariki Shafts

Prepared for
Watercare Services Limited
Prepared by
Tonkin & Taylor Ltd
Date
November 2022
Job Number
30552.9090.v1



Exceptional thinking together
www.tonkintaylor.co.nz

Document Control

Title: Tawariki Shafts Groundwater and Settlement Effects Assessment					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
11/11/22	1	Final Issue	EDMA	SVP	KLB

Distribution:

Watercare Services Limited	1 electronic copy
Tonkin & Taylor Ltd (FILE)	1 electronic copy

Table of contents

1 Introduction

1.1 General

Watercare Services Limited (WSL) has engaged Tonkin and Taylor Limited (T+T) to undertake a groundwater dewatering and excavation induced settlement assessment to support a section 127 application to provide for the option of constructing the Tawariki Connector Sewer shaft concurrently with the main primary shaft as part of the Grey Lynn Tunnel project, and to relocate the secondary shaft approximately 20m to the west from 44 to 42 Tawariki Street. Results of this assessment are presented in this Groundwater and Settlement Effects Report (GWSER), which has been prepared in accordance with T+T's proposal dated 10 February 2022[1].

This assessment presents the results of undertaking the works concurrently in the one construction window, resulting in an upper bound effect. Should the works be undertaken in stages as currently provided for in the existing resource consents and designation, then the effects will be less and within the bounds of this assessment.

This report is based on the factual geotechnical information presented in the Geotechnical Factual Report[2] (GFR) and interpretive information presented in the Jacobs Geotechnical Interpretative Report[3] (GIR).

1.2 Overview

The Grey Lynn Tunnel is a wastewater interceptor pipeline that runs from the Central Interceptor (CI) at Western Springs to Tawariki Street, Grey Lynn. Resource consents were obtained from Auckland Council (AC) and the associated designation confirmed in 2019[4].

The Grey Lynn Tunnel terminates at 44 – 48 Tawariki Street (the 'Tawariki Street Shaft Site'). This site is designated[5] for the purpose of construction, operation, and maintenance of wastewater infrastructure and provides for two shafts, known as the primary and secondary shaft. The primary shaft is the termination site of the Grey Lynn Tunnel and will allow for the retrieval of the tunnel boring machine (TBM) and connections to the Tawariki Local Sewer and Orakei Main Sewer. The secondary shaft to be constructed at the Tawariki Street Shaft Site allows for the connection of future sewers from the Combined Sewer Overflow (CSO) network. This shaft was proposed to be constructed at least 2.5 years after the primary shaft site.

At the time of consenting and designating the sites, the groundwater and settlement assessments were undertaken on the basis that the two shafts would be constructed at least 2.5 years apart allowing for groundwater levels to recover reducing the effects of groundwater drawdown. Therefore, the assessment of the secondary shaft relied upon the envelope of effects anticipated for the primary shaft given its similar footprint, construction methodology and ground conditions.

Since the consenting and designating of the Grey Lynn Tunnel, Watercare has identified the potential to undertake the works for the two shaft sites within the one construction window. This will allow for efficiencies in construction and for future local connections to be made sooner.

[1] Tonkin + Taylor Ltd, Planning and Geotechnical (Groundwater and Settlement), Central Interceptor (Grey Lynn Tunnel) – Tawariki Street Second Shaft, Job No. 30552.9090, dated 10 February 2022
[2] Beca Ltd, *Central Interceptor Variation SCN034 Tawariki Street,* Document Number: GAJV-RPT-00216, Revision: 1.0, November 2020
[3] Jacobs Ltd, Central Interceptor – Addendum No1 to Geotechnical Interpretative Report, Document Number: JNZ-RPT-00009, Revision: 4, May 2021
[4] Resource consent reference BUN60334952
[5] Designation 9468

Watercare has also purchased the property at 42 Tawariki Street and proposes to relocate the secondary shaft to this property.

Details of the works are summarised in Table 1.1 below.

Table 1.1: Summary of consented/designated works at the Tawariki Street Shaft site

Component	Description of Work
Main Shaft	• 25 m deep shaft with an internal diameter of approximately 10.8 m • Diversion of the Tawariki Local sewer to a chamber to the north of the shaft • Diversion of the Orakei Main sewer to a chamber to the south of the shaft • Construction of a stub pipe on the western edge of the shaft to allow for future connections • Construction of a grit trip at 48 Tawariki Street • Permanent retaining of the bank at the end of Tawariki Street • Construction of an above ground plant and ventilation building.
Tawariki Connector Sewer Shaft (Secondary shaft)	• 25 m deep drop shaft with an internal diameter of approximately 10.2 m • A sewer pipe constructed by pipe-jacking to connect the secondary shaft to the main shaft

1.3 Scope of works

Our scope of works for this project includes:

- Undertake a site walkover including to visually assess building type and condition of immediately surrounding buildings (as visible from the road).
- Develop a geotechnical/ hydrogeological conceptual model for the excavation area based on site information obtained from the GFR and excavation methodology information provided by WSL.
- Obtain and examine available underground utilities information and on surrounding groundwater bores information from Auckland Council's database.
- Identify buildings and utilities close to the excavations that are potentially sensitive to ground settlement.
- Excavation-induced mechanical settlement analysis.
- Groundwater numerical modelling to assess groundwater drawdown for the shaft excavations.
- Numerically assess the cumulative groundwater drawdown associated with the addition of the grit chamber excavation to that of the two shafts at the same time.
- Assess the zone of influence associated with mechanical ground settlement for the grit chamber (i.e. retaining wall deflection) utilising empirical methods.
- Use of the geotechnical/ hydrogeological conceptual model, in combination with the modelled drawdown values, to assess drawdown-induced ground settlement.
- Combine the developed settlements (drawdown and mechanical) to derive a total settlement contour plan, including:
  - Excavation-induced mechanical settlement.

  - Groundwater drawdown-induced settlement.
- Compare the derived total settlement values against the location of identified points of interest (buildings and utilities) close to the excavations that are potentially sensitive to ground settlement.
- Prepare this Assessment of Groundwater and Settlement Effects Report to support an Assessment of Effects on the Environment (AEE).

2 Planning considerations

At the time of consenting and designating the Grey Lynn Tunnel, the Groundwater and Settlement Assessment Reports assessed the effects of the works on the basis that the shafts would be constructed a minimum of 2.5 years apart and therefore groundwater would recover in the interim period.

Condition 1.1 of resource consent BUN60334952 (which includes groundwater permit WAT60334954) requires that the works be undertaken in accordance with the plans and reports submitted as part of the application. This condition reads as follows:

> ***Plans and Information***
>
> *1.1 Except as modified by the conditions below and subject to final design, the works shall be undertaken in accordance with the plans and information submitted with the application including:*
> *a) Assessment of Effects on the Environment, titled "Grey Lynn Tunnel – Notice of Requirement, Resource Consent Application and Assessment of Environmental Effects" prepared by Jacobs, dated February 2019.*
> *b) Drawings as detailed below:*
>
> *…*
>
> *c) Technical Reports as detailed below:*
>
> *…*
>
> - *Groundwater Assessment, prepared by Williamson Water & Land Advisory, dated 19 February 2019.*
> - *Settlement Assessment, prepared by McMillen Jacobs Associates, dated 31 January 2019.*
>
> *…*
>
> *d) Section 92 responses dated 18 April and 24 May 2019*

As a result of further design work and construction programme considerations as detailed above, Watercare is considering the option of constructing both shafts in the one construction period rather than separately. The secondary shaft will also be relocated approximately 20m to the east onto 42 Tawariki Street to provide for more space and greater construction efficiencies. Therefore, to provide for the relocated secondary shaft and the option of constructing the shafts in the one construction period, a section 127 application under the Resource Management Act 1991 (RMA) is required to change Condition 1.1 of BUN60334952.

The assessment to support this application is limited to the *change in effects* resulting from the change to conditions. In this case, to support this change to conditions an assessment of the groundwater and settlement effects of constructing the two shafts in the one construction period, and moving the secondary shaft from 44 to 42 Tawariki Street, is required as set out below.

3 Existing groundwater consent

Watercare currently holds a suite of resource consents for the construction of the Grey Lynn tunnel (inclusive of the shaft site at Tawariki Street). Specifically relevant to the proposed change to condition is groundwater permit WAT60334954.

The Settlement Assessment Report submitted as part of this resource consent application, and referenced in Condition 1.1 above, concluded that:

> *"The construction of the Tawariki Street shafts produces mechanical and groundwater settlement, that has been modelled and combined to produce a settlement contour plot. The maximum settlement from this is 14 mm occurring over the playing fields within St Paul's College to the east of the shafts. Settlements of this magnitude are insignificant in a greenfield environment and the potential settlement effects are considered to be less than minor.*
>
> *No buildings or utility services are predicted to be impacted by the construction of both the tunnel and shaft components of the Grey Lynn Tunnel."*

The Groundwater Assessment concluded that at the time of the secondary shaft being constructed (approximately 2.5 years after the primary shaft) groundwater drawdown from the primary shaft would have recovered. It was also considered that due to the slightly smaller size of the secondary shaft, the effects would be less than and within the envelope of effects considered through the assessment of the primary shaft. The assessment of the primary shaft therefore served as the assessment of the secondary shaft and a separate assessment was not required.

The Auckland Council decision report on the resource consent application (and Notice of Requirement) concluded that:

> *l. With regard to groundwater effects, dewatering/diversion and settlement effects that will arise from the proposal will not be felt or experienced by the public or wider environment given the depth of the works, remoteness from water-systems and construction methodology. While there will be adverse effects felt by [properties] surrounding the shaft site and potentially at points along the tunnel alignment that may result in settlement and damage to buildings, these can be mitigated by conditions that have been imposed, which ensure damage to buildings is remedied should this arise, and that a Monitoring and Contingency Plan is prepared to require on-going monitoring during the works.*

The groundwater permit includes a suite of conditions included in section 3: 'Specific conditions: G*roundwater permit conditions – WAT60334954'*. These conditions address monitoring, reporting and contingency measures, including relevant alert and alarm levels, pre- and post-construction condition survey requirements and repair measures (if required). It is not proposed to change any of these conditions as the proposed works will be able to meet these. This will be addressed through the Groundwater Monitoring and Contingency Plan (M&CP) required by Conditions 3.8 to 3.11.

4 Site setting

4.1 Site description

The site is located across 42 to 48 Tawariki Street in Ponsonby, Auckland.

Figure 4.1. Site location

As shown on Figure 4.1, the topography of the site is variable. The site is located within a regional gully feature with ground levels to the north and south rising from approximately 12 m RL to 45 m RL to the north, and 35 m RL to the south.

The site is bounded to the west and south by residential dwellings, by Marist Catholic School and Our Lady of Perpetual Help (a church) to the north, and St Paul's College field to the east.

4.2 Neighbouring bores

A review of the Auckland Council borehole database[6] shows that the closest recorded bore authorised for the take of groundwater to the proposed shaft locations is bore ID 31342, located approximately 1.8 km away. Further details of this bore are provided in Table 4.1.

Table 4.1: Auckland Council bore search results

Consent Reference	Consent Description	Easting NZTM	Northing NZTM	Activity Description	Distance to proposed excavation
31342	To authorise the taking of groundwater	1753464	5918870	Zoo animal watering	1.8 km

[6] Received via email from Auckland Council 11/11/2021

5 Proposed construction methodology

The underground structures at the Tawariki Street Shaft site that are part of this assessment include the following:

- Main shaft: 25 m deep with an internal diameter of 10.8 m.
- Secondary shaft: 25 m deep with an internal diameter of 10.2 m.
- A grit chamber approximately 13.5 m deep (varied due to topography change), 26 m long and 4.5 m wide.

For purposes of this assessment, the excavations required for the above structures are assumed to occur concurrently and therefore this assessment very much provides an upper bound effect. In practise, while there may be some cross-over in the construction of the three 'deeper' structures on site, they are likely to be constructed sequentially through the one construction window, or in separate construction windows as already provided for in the existing consents/designation.

The proposed concept construction methodology for the shafts and ancillary structures include the following temporary excavation supports:

- Secant piles within overburden soils (Tauranga Group Alluvium and ECBF soils). Lateral stiffening support may be provided by the use of ring beams.
- Rock bolts, shotcrete and/or rock mesh within weathered and/or fresh ECBF bedrock.
- The proposed concept construction methodology for the grit chamber may include sheet pile trench supports.

The temporary shaft excavation supports have been specified to impede groundwater flow into the shafts during construction, and therefore limit groundwater drawdown. Groundwater modelling undertaken to support the consent application incorporates a low permeability liner through the soils at the site.

It is expected that dewatering of the two shafts and grit chamber will occur over approximately 24 months and up to 36 months in total. This may be completed within the one construction window (as provided for in the s127 application) or across two construction periods as already provided for in the existing consents / designation.

Following construction, a permanent water-tight concrete lining will be installed around the shaft walls and base.

As part of preparing for the work, dwellings located at 42[7], 44, 46 and 48 Tawariki Street have been removed.

[7] Watercare now owns this property.

6 Ground model

6.1 Geological setting

6.1.1 Published geology

The 1:250,000 published geology for the Auckland Urban area[8] indicates that the area is generally underlain by East Coast Bays Formation (ECBF). Materials of ECBF are described as interbedded greenish grey siltstone and sandstone with occasional inclusions of volcanic grit.

The ECBF deposits are indicated in orange on Figure 6.1 and were deposit in large submarine fan environments during the Miocene period. Cycles of erosion, along with sea level rise and fall have varied the material type from siltstone to sandstone. Intermittent volcanism within the area deposited volcanic grit within sediments.

The subsurface materials encountered during borehole investigation were generally consistent with the published geological map. The ground model is further discussed in subsequent sections.

Figure 6.1: Geological map of the area. Image retrieved from T+T Mapviewer derived from Edbrooke, 2001, on 13 April 2022.

[8] Edbrooke, S.W. 2001. Geology of the Auckland area: Scale 1:250,000. Institute of Geological & Nuclear Sciences Limited.

6.1.2 Site investigations

Beca Ltd, on behalf of Jacobs Ltd, carried out a geotechnical ground investigation of the Tawariki Street site on two occasions between 2018 and 2020. This information is provided in their Geotechnical Factual Report[9] and in Jacobs Geotechnical Interpretative Report[10]. This report considers information supplied by these reports with considerable focus on boreholes BH03, BH04 and BH05 which are attached in Appendix A.

6.1.3 Geological interpretation

T+T's assessment of the subsurface geological conditions outlines how the factual data from the site investigations has been interpreted to develop a simplified geological model that we consider suitable for the purpose of this assessment. The model is based on the geomorphology, published geology and previously collected site specific investigations.

The subsurface at the Tawariki Street site is interpreted to comprise the following geological units:

1 Fill; overlying

2 Tauranga Group sediments; overlying

3 Weathered ECBF, overlying

4 ECBF rock.

Material descriptions can be generalised as:

- **Fill (made ground)** deposits comprise a mixture of high plasticity, very soft clay and loose silty sand and sand. Soils are expected to have derived from the Tauranga Group sediments in the area and placed from cut slopes. The fill material contains occasional organics and manmade objects such as metal.
- **Tauranga Group** sediments has been broken down into two units by Jacobs[10] as cohesive and granular soils. However, only cohesive materials are identified in site specific investigations of BH03-05. These cohesive materials are described as high plasticity, very soft silty clay and clay.
- It should be noted that a thickening of the Tauranga Group sediments to the west of the shaft locations (down slope) is expected. This prediction is based on geomorphology of the valley and the stream (Cox's Creek) which flows in the western direction. It is also expected that fill deposits will thicken in the western direction due to the presence of reclaimed land in this area.
- **Weathered ECBF** materials are identified as extremely weak, residually to moderately weathered rock. Rock is interbedded siltstone and sandstone.
- **ECBF rock** deposits are identified as extremely to very weak, moderately to slightly weathered rock. Rock is interbedded siltstone and sandstone with occasional shallow to steep angled discontinuity.

The ground model presented in Table 6.1 has been used for geotechnical assessment and geological cross sections are provided in Appendix B.

The ground model adopted by the hydrogeological and mechanical settlement assessments is consistent with this model.

[9] Beca Ltd, *Central Interceptor Variation SCN034 Tawariki Street,* Document Number: GAJV-RPT-00216, Revision: 1.0, November 2020

[10] Jacobs Ltd, *Central Interceptor – Addendum No1 to Geotechnical Interpretative Report,* Document Number: JNZ-RPT-00009, Revision: 4, May 2021

Table 6.1: Tawariki Street shafts ground model summary.

Unit		Depth to top of unit (m)	Unit thickness (m)	Peak shear vane reading range [average] (kPa)	SPT n values (average)
1	Fill	0	0.5 – 2.2	Not recorded	1 – 4 (2)
2	Tauranga Group	0.5 – 2.2	2.3 – 3.0		1 – 20 (12)
3	Weathered ECBF	3.5 – 4.5	1.0 – 8.0		20 – 50+ (35)
4	ECBF rock	5.3 – 11.5	>20	N/a	50+ (50)

6.2 Geotechnical parameters

Geotechnical parameters have been collated from the Jacobs' Geotechnical Interpretative Report[10] and reviewed against the interpretation of geology described above. The values used for the Tawariki Street ground settlement assessment are given in the table below.

Table 6.2: Geotechnical analysis parameters for ground settlement.

Geological Unit	Fill	Tauranga Group	Weathered ECBF	ECBF rock
Unit weight, kN/m^3	15	16	19	20
Secant stiffness at 50% of ultimate deviatoric stress at reference pressure, ε_{50} (MPa)	15	20	30	540
Unloading-reloading stiffness, ε_{ur} (MPa)	45	60	90	1090
Normally consolidation coefficient, K_{nc} Note(1)	0.47	0.67	0.67	0.46
Elastic modulus exponent, m	0.5	0.5	0.5	0
Poisson's ratio, v	0.3	0.4	0.4	0.2
Reference pressure, p_{ref} (kPa)	100	100	100	100
Friction angle, Φ	32	28	32	33
Cohesion, c (kPa)	1	7	6	75
K0	0.5	0.5	0.5	1.2

Note (1): Calculated based on the larger of 1-sin(Φ) and v/(1-v).

6.3 Hydrogeological setting

6.3.1 Method

The hydrogeological setting was characterised by combination of:

- Identification of hydrostratigraphic units, based on T+T's geological interpretation presented in section 6.1.3.
- Review of previous documents provided to T+T. The focus of the review was to establish the following key groundwater assessment components adopted previously:

- Aquifer properties for each identified hydrostratigraphic unit.
- Pre-construction groundwater levels and flow direction in the immediate vicinity (i.e. 200 m radius) of the site.

6.3.2 Previous reporting

As described in section 1 and section 2, the previous groundwater assessment[11] was based on construction of one shaft only (i.e. assumed that groundwater would recover prior to construction of the secondary shaft).

Following the applicant's resource consent submission, Auckland Council engaged ENGEO Ltd and WGANZ Pty Ltd (ENGEO/WGA) to undertake a regulatory review of the dewatering and groundwater diversion application (WAT60334954) lodged by Watercare Services Ltd (WSL). The regulatory review[12] focused on the construction of two shafts proposed at 44-48 Tawariki Street, the magnitudes of mechanical settlement (settlement caused by ground relaxation due to excavations) and consolidation settlement (ground settlement due to lowering of groundwater levels) due to the construction, and the effect of these settlements on adjacent buildings and structures.

During the Section 92 review process, further information was provided by WSL, listed below as follows:

- Report titled *"Grey Lynn Interceptor Resource Consent Application: RMA Section 92 Responses Pertaining to Groundwater Assessments",* prepared by Williamson Water & Land Advisory Ltd, Ref. WWA0047, dated 17 April 2019.
- Report titled *"Grey Lynn Interceptor Resource Consent Application: RMA Section 92 Responses Pertaining to Groundwater Assessments",* prepared by Williamson Water & Land Advisory Ltd, Ref. WWA0047, dated 21 May 2019.
- Memorandum titled *"Grey Lynn Tunnel Resource Consent Application: RMA Section 92 Review Reponses"*, prepared by Jacobs/AECOM/McMillen Jacobs Associates, dated 27 May 2019. The list of Section 92 queries raised by ENGEO/WGA and responses from WSL are outlined in the following document:
  - Report titled *"44-48 Tawariki Street, Grey Lynn (Grey Lynn Tunnel and Tawariki Street Shafts) – S92 Review"*, prepared by ENGEO/WGA, Rev. 4, dated 8 August 2019.

6.3.3 Results

The hydrostratigraphic units identified include:

- Fill; overlying
- Tauranga Group sediments (TGA); overlying
- Weathered ECBF, overlying
- ECBF rock.

The previous assessment[11] reported:

- *The shaft will be situated primarily within the ECBF formation with thin Weathered ECBF or TGA deposits overlaying at the land surface. These deposits are considered to have negligible*

[11] Grey Lynn Tunnel - Groundwater Effects Assessment, prepared by Williamson Water & Land Advisory Ltd, dated Feb 2019.
[12] "Auckland Council Technical Memo - Specialist Unit", prepared by Jeffrey Peng. Geotechnical Engineer, ENGEO Ltd and Brett Sinclair. Principal Hydrogeologist, WGANZ Pty Ltd, dated 2 October 2019.

influence on groundwater impacts from shaft construction because they are hydraulically similar to the ECBF (i.e. both of low permeability) and only occur near the land surface. Therefore, only the ECBF was considered for groundwater dewatering modelling purposes.

The regulatory review[12] completed in 2019 summarised the following key groundwater components presented in the previous groundwater assessment, and included:

- Aquifer properties:
  - *Slug tests performed in piezometers installed into the ECBF at the site indicated horizontal hydraulic conductivity for the unweathered to slightly weathered ECBF of between 1 x 10^{-6} m/s and 1 x 10^{-7} m/s.*
  - *Packer tests performed on the highly weathered to slightly weathered ECBF during drilling investigations returned horizontal hydraulic conductivity results of between 2.8 x 10^{-8} m/s and 2.6 x 10^{-7} m/s, although these results are of lower reliability than the slug test results. The vertical hydraulic conductivity of ECBF rocks is commonly accepted as being approximately one order of magnitude less than the horizontal hydraulic conductivity.*
- Hydrostratigraphic units:
  - *The TGA and the highly weathered ECBF are considered to form a hydraulic confining layer above the slightly to unweathered ECBF. Furthermore, the highly weathered ECBF forms an aquitard between the unweathered rock mass and the TGA.*
- Groundwater levels:
  - *Groundwater measurements in three piezometers installed on site indicated the groundwater pressure in the ECBF ranges from 10.91 m RL to 15.04 m RL. These pressures equate to a range from 1.04 m below ground level to 2.77 m above ground level (artesian pressure).*

The previous assessment documents the groundwater model developed to investigate the effects of the proposed shaft dewatering. The model was developed using the MODFLOW finite difference modelling code within the GMS10.2 modelling platform. Nine layers were defined in the model, with hydraulic parameters applied to the simulated layers within the model. The calibrated hydraulic parameters presented in the previous assessment are shown on Table 6.3.

Table 6.3: Calibrated hydraulic parameters presented in the previous assessment

Material	Hydraulic Conductivity (m/s)	Vertical Anisotropy	Storage (Layers 2-9)	Specific Yield (Layer 1)
ECBF	3 x 10^{-7}	30	0.0005	0.25

The hydraulic head distribution representative of the calibrated hydraulic parameters and initial (pre-construction dewatering) conditions are presented in the previous groundwater assessment undertaken, an extract is shown on Figure 6.2. These initial heads represent results obtained from the steady-state model simulation from Layer 1 (the unconfined groundwater system).

T+T completed a visual review of the hydraulic head contours which indicates the direction of groundwater flow in the immediate vicinity of the site (i.e. 200 m radius) is relatively uniform and is generally from east to west. The hydraulic gradient is also relatively uniform. The change in head between 200 m upgradient of the site and 200 m downgradient of the site is approximately 10 m, resulting in a hydraulic gradient of approximately 0.025 (or 2.5%).

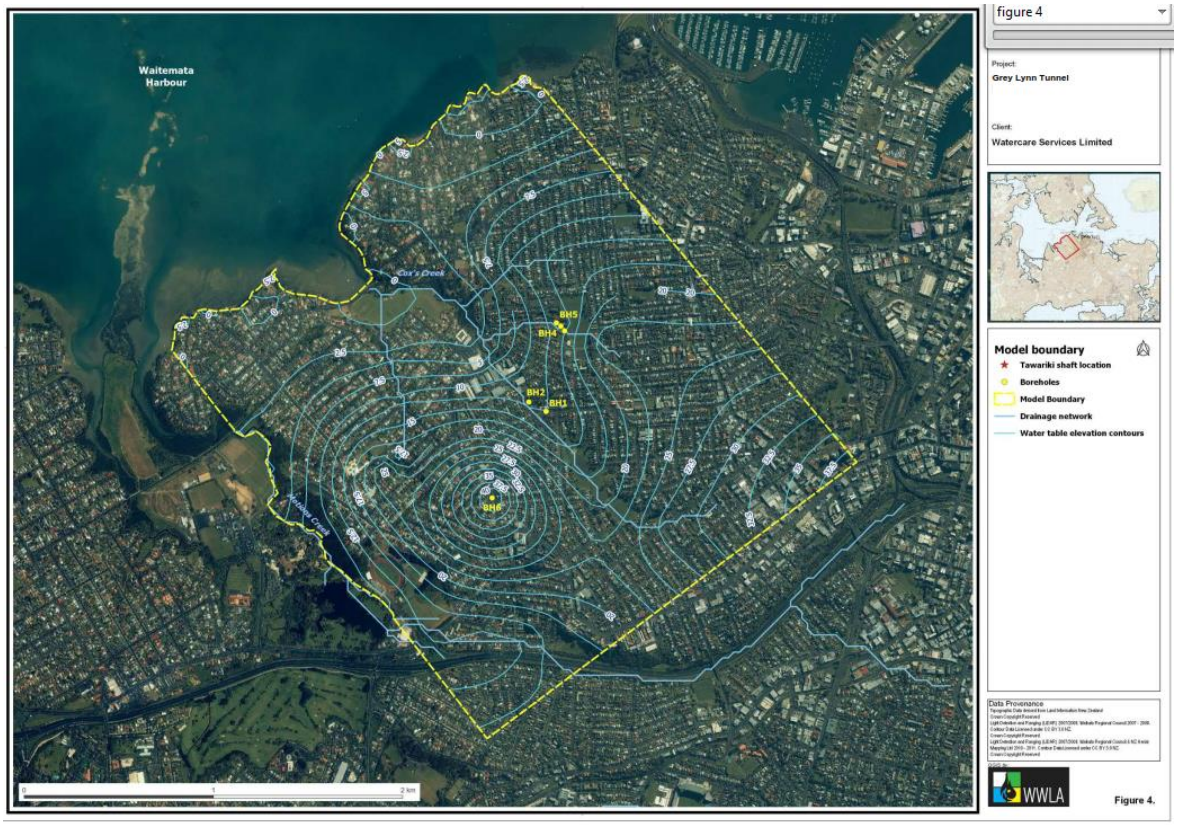


Figure 6.2: An extract of the hydraulic head distribution representative of initial (pre-construction dewatering) conditions from the previous groundwater assessment undertaken[11]

7 Hydrogeological assessment

7.1 Method

Analytical Element Method (AEM) groundwater flow modelling software Analytical Aquifer Simulator (AnAqSim[13]) was used to estimate time dependent (transient) groundwater drawdown during the construction period. AnAqSim is capable of modelling groundwater flow in three dimensions.

The following method was used to assess the potential impact of dewatering at the site:

- A steady-state model was developed to represent initial groundwater conditions prior to construction of the two shafts and grit chamber.
- The hydraulic heads produced by the steady-state model were used as initial conditions for subsequent transient simulations. The transient model represents the aquifer under conditions resulting from dewatering pumping and includes the proposed retention around the perimeter of the shafts and the grit chamber. The retention acts to impede groundwater flow.
- Drawdown-induced settlement was calculated using an incremental layer summation method using python programming (refer Appendix C). This approach calculated the decrease in pore water pressure and corresponding increase in effective stress at the centre of each incremental layer caused by the groundwater drawdown in the unconfined units. This method assumed that the competent ECBF unit was incompressible.
- A sensitivity analysis was undertaken to assess how sensitive the drawdown and settlement model outputs were to changes in input values selected for the retention system conductance (leakiness).

The adopted modelling approach made the following assumptions:

- Infiltration recharge does not occur (resulting in a more conservative drawdown assessment).
- The initial groundwater level at the site centre was approximately 15 m RL.
- The initial groundwater surface was applied was planar enforcing a uniform hydraulic gradient of 2.5% and uniform flow direction of east to west.
- Groundwater drawdown associated with the construction of the tunnel connecting the shafts is considered to have a negligible contribution based on its size and depth. While a detailed assessment has not been undertaken, the contribution of the connecting tunnel upon groundwater drawdown is assessed to be within the bounds of the assessment below.

7.2 Steady state model

The outer boundary conditions used in the steady-state model comprised ‘head specified external line boundaries’ extending 1 km radius from the site centre. The groundwater flow direction was set to flow from east to west, and a uniform gradient of 0.025 was applied.

The input parameters used to setup the steady-state model are shown on Table 7.1.

The resulting groundwater levels from the steady-state simulation (m RL) are shown with respect to ground level (m RL) and shaft location on Figure 7.1.

[13] www.fittsgeosolutions.com

Table 7.1. Steady-state model setup

Model layer	Top elevation (m RL)	Bottom elevation (m RL)	Hydraulic head at site centre	Kh (m/s)	Kv (m/s)	Aquifer type
1	50[1]	5	15 m RL	1×10^{-6}	1×10^{-7}	Confined[2]
2	5	-25	15 m RL	1×10^{-6}	1×10^{-7}	Confined

1-Arbitrary, not used for any calculation when subsequent transient model is set to unconfined (calculation based on saturated conditions only).

2-Set to confined for the steady-state model only, to enforce a uniform hydraulic gradient.

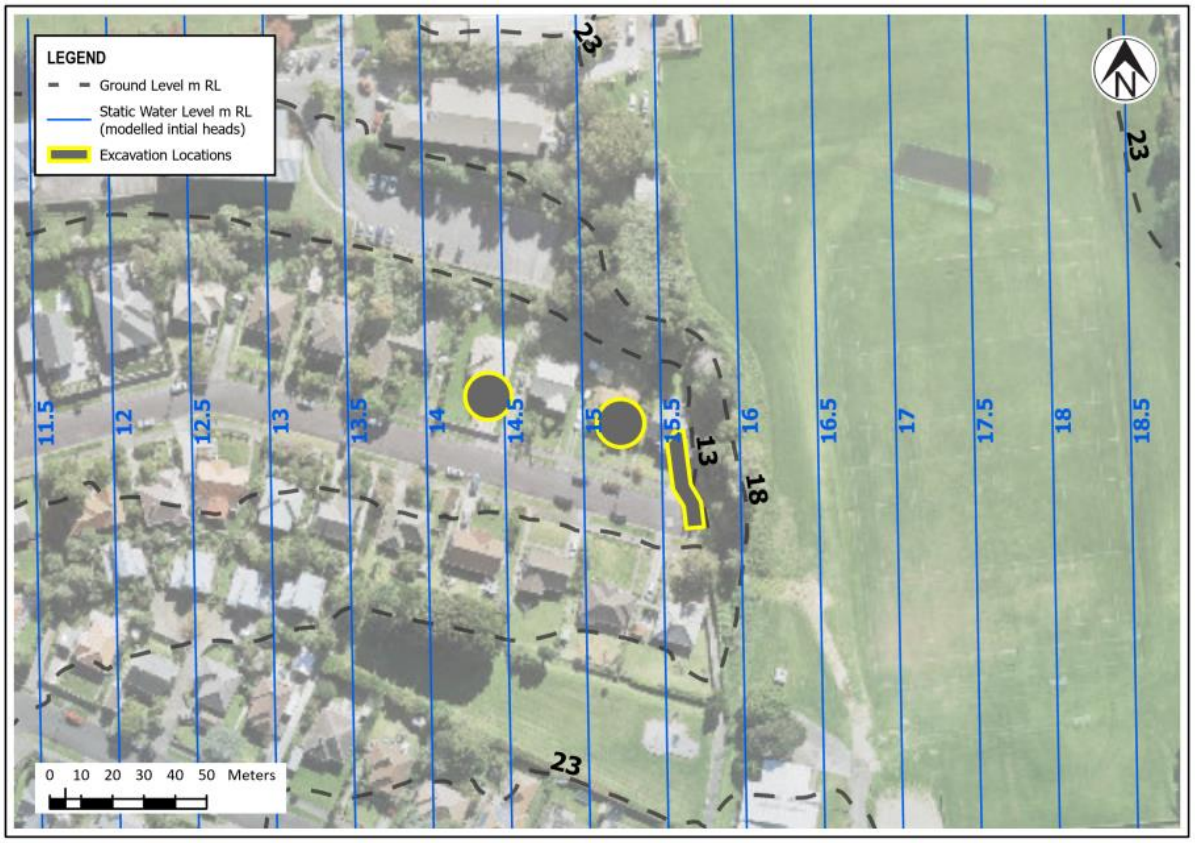


Figure 7.1. Static water level (m RL) and initial (steady-state) heads adopted for modelling purposes. Planar surface / uniform gradient and flow direction applied. Relative to ground level contours (m RL, coarse 5 m resolution).

7.3 Transient model

The hydraulic heads produced by the steady-state model (described above) were used as initial conditions for subsequent transient simulations.

The setup of the transient model was the same model as the steady-state model, with the following updates:

- Excavation retention added to the numerical model, along the perimeter of the proposed shafts and grit chamber footprint to a level of 5 m RL (approx. 7 m bgl). This was achieved using a leaky barrier boundary condition (refer Table 7.3).
- Groundwater levels within the shaft(s) footprint lowered from the initial head to the base of the shaft at -13 m RL (approx. 25 m bgl) refer Table 7.4.
- Groundwater levels within the grit chamber footprint lowered from the initial head to the base of the excavation at 0 m RL (approx. 13.5 m bgl) refer Table 7.4.
- Layer 1 set to unconfined with a specific yield value of 0.25 (refer Table 7.2)
- Layer 1 set to confined with a storativity value of 1 x 10^{-4}.

Table 7.2. Transient model setup

Model layer	Top elevation (m RL)	Bottom elevation (m RL)	Kh (m/s)	Kv (m/s)	Sy	S	Aquifer type setting
1	50[1]	5	1 x 10^{-6}	1 x 10^{-7}	0.25	-	Unconfined
2	5	-25	1 x 10^{-6}	1 x 10^{-7}	-	1 x 10^{-4}	Confined

1-Arbitrary, not used for any calculation when transient model is set to unconfined (calculation based on saturated conditions only).

Performance of the retention system is uncertain due to various contributing factors such as the type and the sequence of activities undertaken by the construction contractor. To assess the impact of this uncertainty, a parameter sensitivity analysis on the retention conductance (leakiness) was completed (refer Table 7.3).

Table 7.3. Leaky barrier boundary condition and retention conductance applied

Run ID	Retention conductance / leaky barrier boundary condition (day$^{-1)}$	Retention conductance interpretation
Run0	1 x10^{-2} Applied to model layer 1	**<u>Potential short-term scenario:</u>** • Allows for temporary hydraulic defects in the retention system and associated leakage during the construction/ dewatering period. • In this event, we expect that the contractor would use practical measures to control these (e.g. by grouting or plugging gaps) to reduce groundwater leakage into the shaft. • Adopted conservative value for the purpose of assessing potential effects.
Run1	1 x10^{-3} Applied to model layer 1	**<u>Expected long-term / average scenario:</u>** • Retention system performs as designed / intended. • Largely impermeable medium, but accounts for some groundwater leakage through the retention system.

Notes: Conductance C = K*/b*, where K* = hydraulic conductivity of the retention, and b* = thickness of the retention system (b* = 0.5 m for the secant piles at the shaft locations, and 13 mm for the sheet pile at the grit chamber location).

Table 7.4. Internal boundary conditions applied

Type	Setting	Value (m RL)
Head specified line boundaries (HSLB)	NA	-13 m RL for shafts 0 m RL for grit chamber
Spatially variable area sinks (SVAS)	Head dependent flux	-13 m RL for shafts 0 m RL for grit chamber

7.3.1 Output format

The transient model outputs are provided at a single 365 day timestep, selected to represent pseudo steady-state (long-term) conditions.

The model outputs are presented at drawdown observation points along four lines of section (north: N, south: S, east: E, west: W) as shown on Figure 7.2.

The drawdown and settlement results are also presented as contour plots in Figure 7.5. The method applied includes:

- Drawdown contours were generated directly from AnAqSim software.
- Drawdown-induced settlement contours were generated using Surfer software applying the Kriging interpolation method to the observation points shown on Figure 7.2.

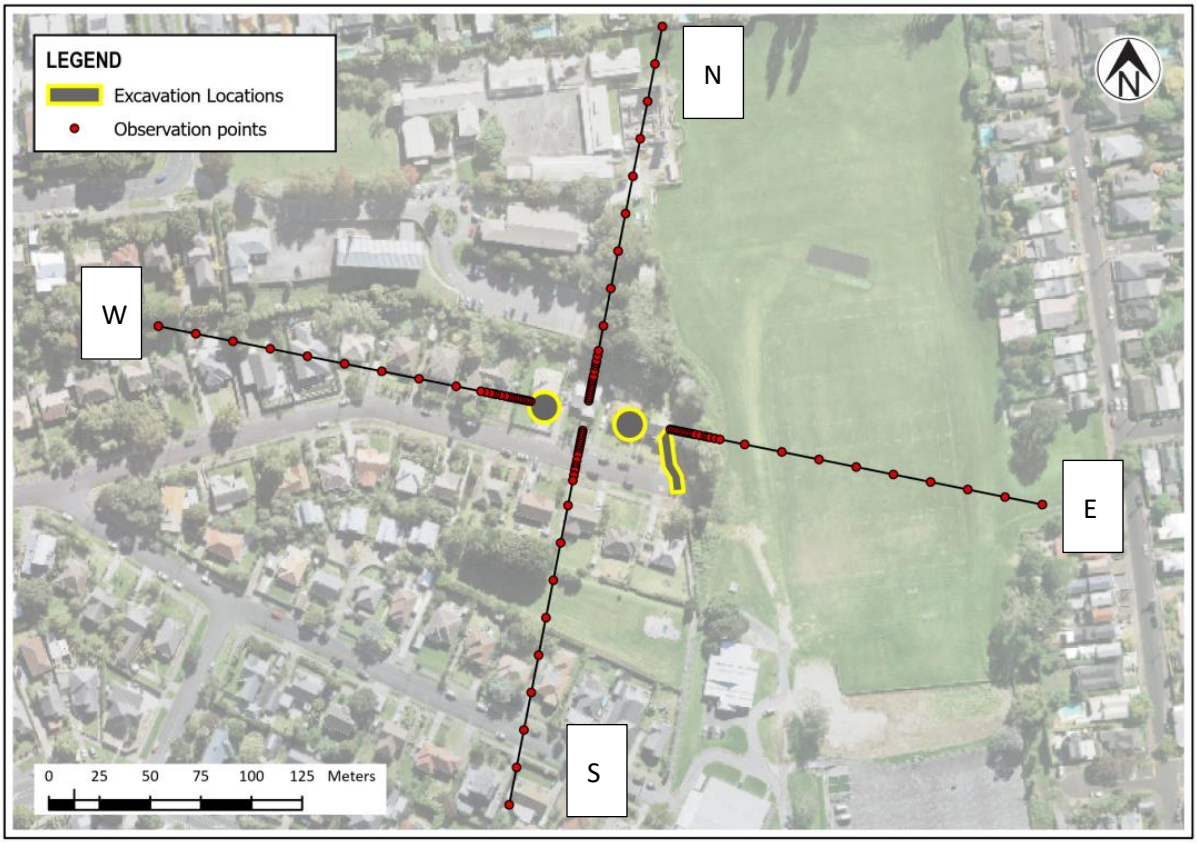
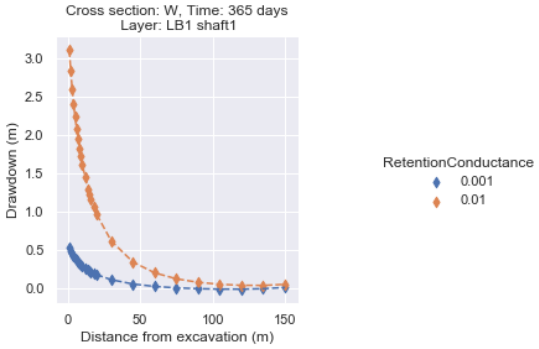


Figure 7.2. Modelled shaft locations, and position of drawdown and settlement observation points along lines of section (north: N, south: S, east: E, west: W).

7.3.2 Results

The groundwater model drawdown and drawdown induced settlement results along the four lines of section are presented on



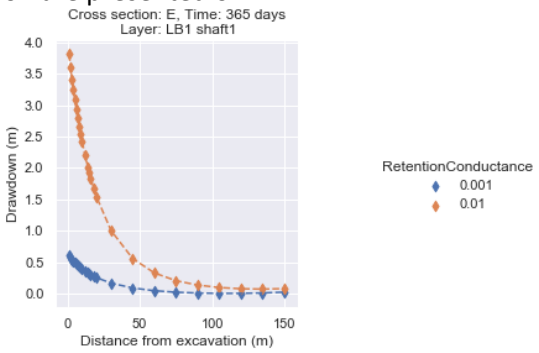


Figure 7.3 and Figure 7.4 respectively. Adopting a conservatively leaky retention condition (Run0), these results show that the modelled drawdown is generally even in all directions around the proposed excavations with a slight ellipsoidal shape immediately around the excavations, becoming radial with distance away. Maximum groundwater drawdown levels up to **4.0 m** are predicted next to the excavations, reducing to less than **0.5 m at approximately 50 m distance**, and **near zero to within generally 100 m** distance.

Modelled groundwater induced ground settlement immediately outside the excavation ranges from approximately **14 mm** to **25 mm**, with the larger settlements observed on the western side due to the greater thickness of compressible soils. Surface ground settlement reduces with increasing distance from the excavation, decreasing to less than 12 mm at adjacent dwellings.

Figure 7.5 shows the Run0 drawdown results exported from AnAqSim software. This is the upper bound (worst) case from an effects perspective. An interpolated settlement contour plot is presented on Figure 7.5 which was derived using our settlement analysis results along the lines of section specified and engineering judgement. For illustrative purposes, contours extending from the shaft edge to the 14 mm settlement contour line have been excluded. For assets where settlements are larger than 14 mm our analysis relies on the interpretation of results from Figure 7.4.

A summary of the drawdown-induced settlements at assessed structures is presented in Section 10.

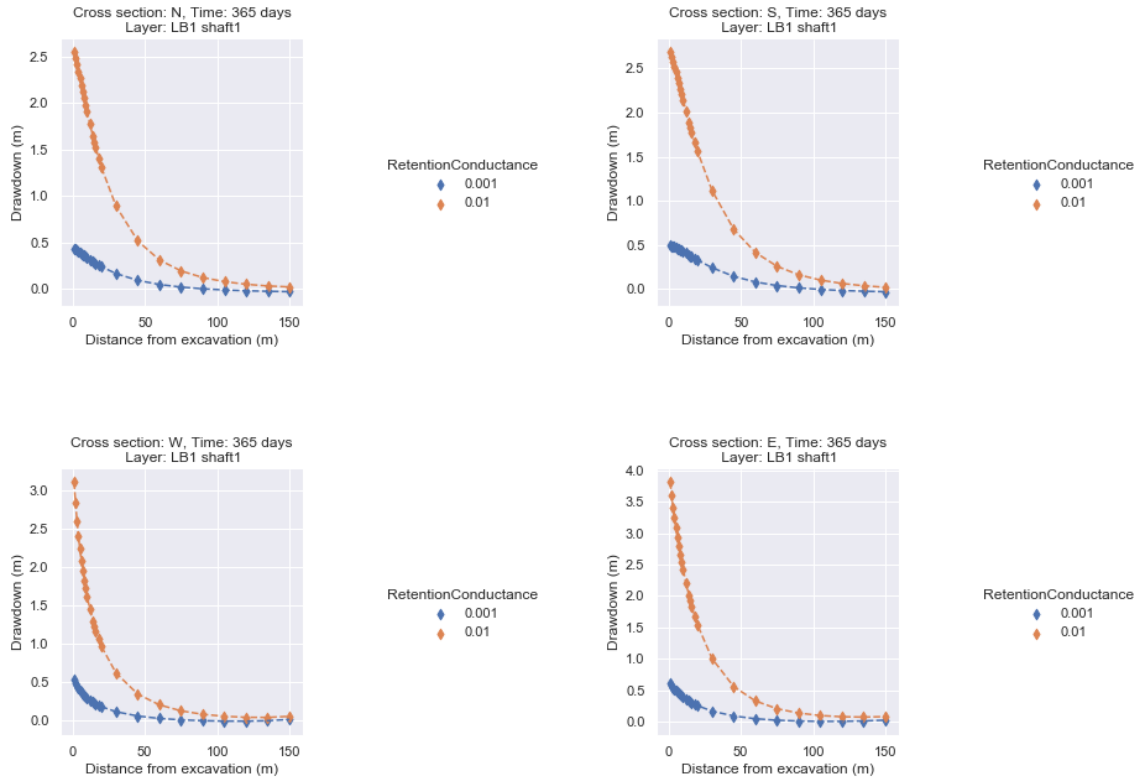


Figure 7.3. Drawdown results along lines of section (north: N, south: S, east: E, west: W)

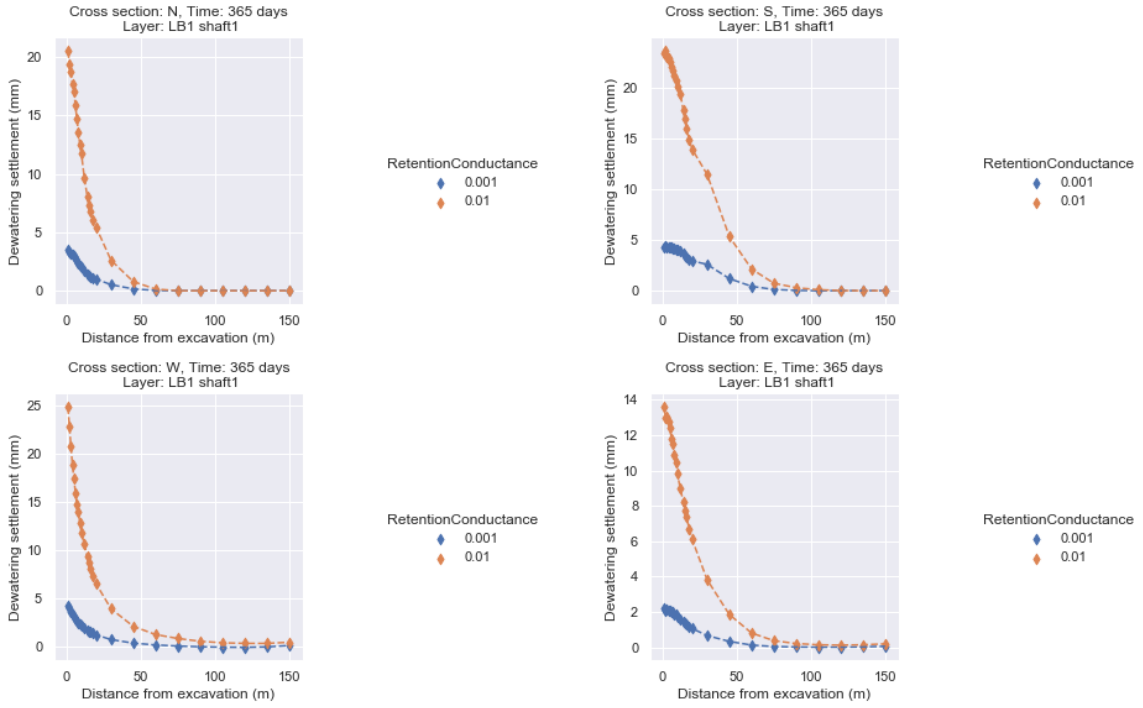


Figure 7.4. Drawdown-induced settlement results along lines of section (north: N, south: S, east: E, west: W)

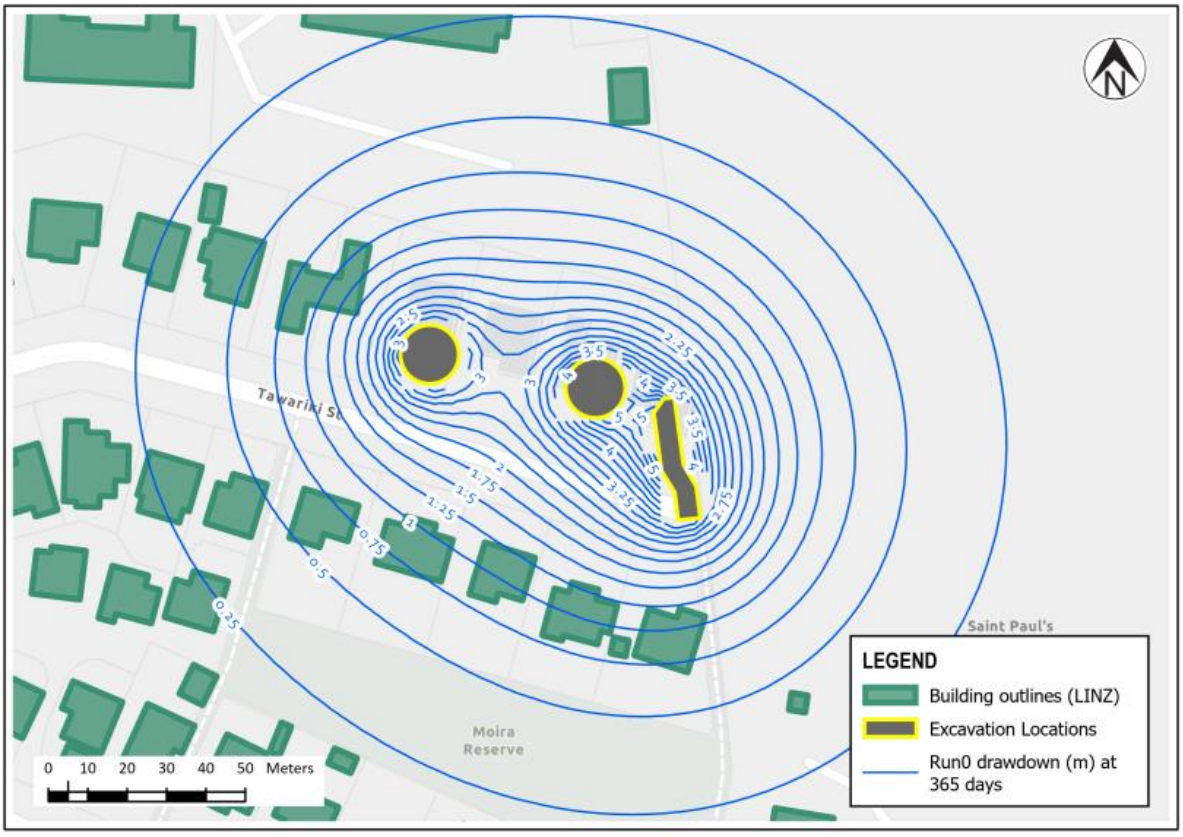


Figure 7.5. Drawdown (m) contours relative to adjacent buildings. Results from model Run0 (retention conductance set to 0.01 day^{-1}) at 365 days.

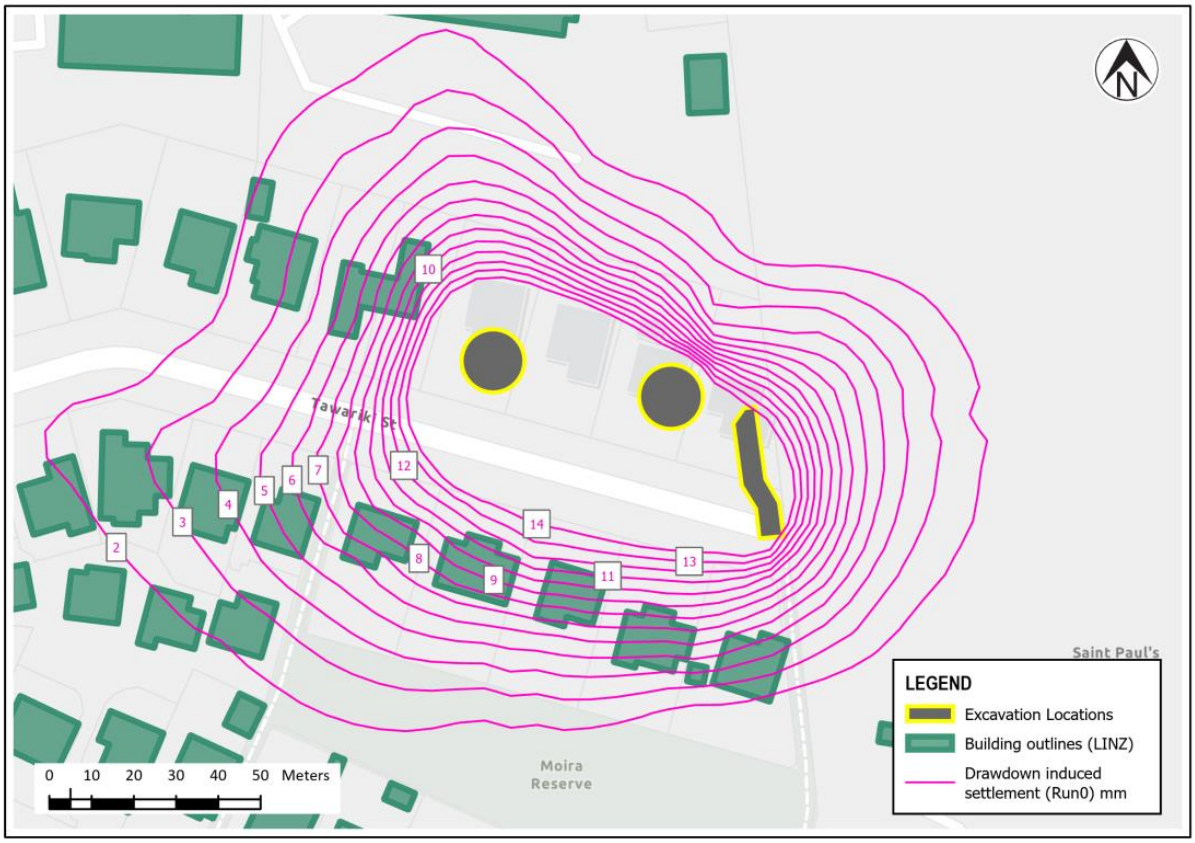


Figure 7.6. Drawdown-induced settlement (mm) contours relative to adjacent buildings. Results from model Run0 (retention conductance set to 0.01 day^{-1}) at 365 days.

8 Mechanical settlement assessment

8.1 Grit chamber

8.1.1 Method

Empirical methods from CIRIA C760 have been adopted to assess the zone of influence behind the grit chamber excavation subject to mechanical settlement.

To compute the zone of influence (ZOI) corresponding to the associated ground movements behind the wall, it has been assumed that:

- ground movement will only occur within the soil material and not within the ECBF rock.
- soils conservatively extend up to 11.5 m depth.
- The excavation retention will be laterally restrained.
- Corner and edge effects are conservatively ignored.

8.1.2 Results

Adopting the method outlined in Figure 6.17 of CIRIA C760, the ZOI subject to ground deformation behind the grit chamber excavations is assessed to be 11.5 m (this is equivalent to a 45 degrees line back from the top of the ECBF rock).

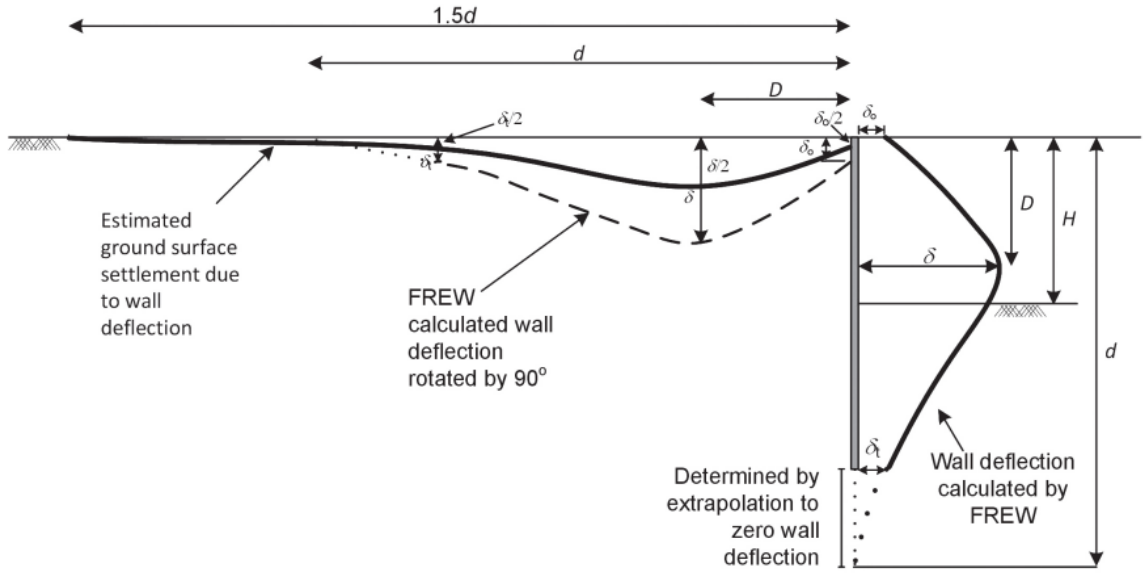


Figure 7: Relationship between assessed wall deflections and predicted ground surface settlements utilising CIRIA C760 Figure 6.17

Within the ZOI, there are no existing structures which may be impacted by ground deformation which already do not need to be relocated as a result of the proposed excavations. The only structures within the ZOI are a series of public underground services which are expected to be relocated as they currently reside within the proposed excavation footprint, and the road pavement which will need to be reinstated post excavation and construction works.

On this basis, a detailed assessment to estimate ground settlement magnitudes within the ZOI has not been undertaken. We also note that other than a potential change to the construction

sequence, there is no change to the grit chamber from that originally considered and addressed in the resource consents and designation.

8.2 Drop shaft

8.2.1 Method

Two dimensional Fast Lagrangian Analysis of Continua (FLAC Version 7.0, Itasca Consulting Group) was used to model soil-structure interaction and estimate a settlement profile for both Tawariki Street shafts. Figure 8.8 shows the model generated in FLAC.

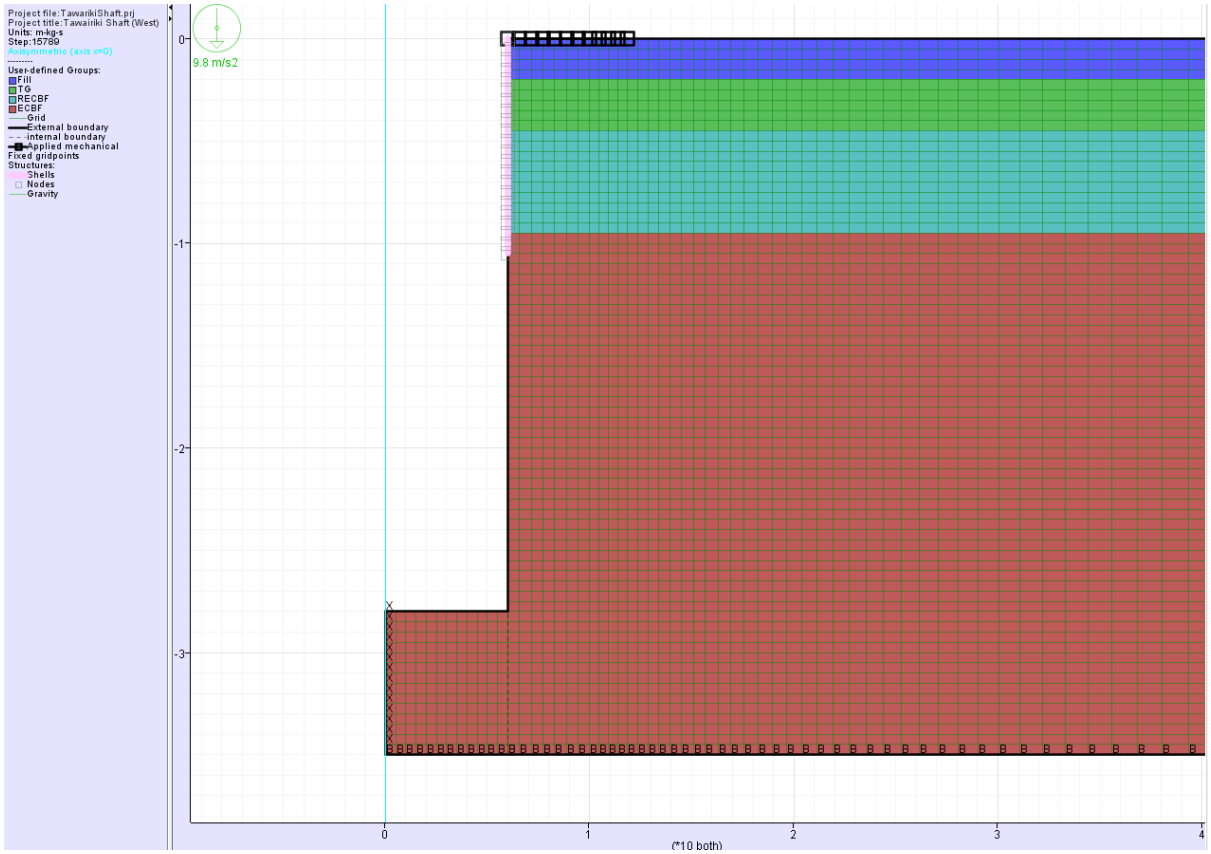


Figure 8.8: Cross section of FLAC model.

The ground conditions are conservatively based on the western section of the west Tawariki secondary shaft, where the alluvium soil is the thickest. The ground model has been simplified by using horizontal layers as summarised in Table 8.1 below.

Table 8.1 Geological model used for modelling

Depth (m)	Geological model
0 to 2.0	Fill
2.0 to 4.5	Tauranga Group
4.5 to 9.5	Residual ECBF
9.5 to 35	ECBF rock

The secant piles are assumed to be constructed with 1.0 m of minimum embedment into ECBF rock. The top of ECBF rock is likely to vary across the circumference of the shaft, and therefore the depth of piles could vary with ECBF rock level.

Table 8.2 Dimensions of shaft

Shaft depth (m)	Diameter (m)	Support
0 to 10.5	12.0m	Secant pile (extends 1.0m into ECBF rock)
10.5 to 28		Unlined (not supported)

Note: Shotcrete has not been modelled as the ECBF rock mass is self-supporting. However, the designer or contractor would likely need to shotcrete to prevent localised failure of the ECBF rock face. Any reduction in settlement estimates due to a shotcrete layer are expected to be negligible.

The modelled groundwater level has been conservatively assumed to be at the ground surface outside of the shaft throughout the construction. The shaft will be excavated "dry", and therefore the groundwater level inside the shaft is assumed to be at the base of the excavation. This is considered appropriately conservative for the assessment of mechanical settlement as the secant piles will be subject to higher retention pressures compared to if groundwater drawdown was modelled.

A 35kPa surcharge has been modelled over a 7m wide area directly behind the shaft opening to account for construction machinery. This is based on a 120tonne crane on a 7m x 5m wide pad.

8.2.2 Structural properties of ring beam installation

The properties in Table 8.3 have been adopted in our model.

Table 8.3 Structural properties used for modelling

Structural member	Modelled structure element	Average Young's Modulus, E (GPa)	Poisson's ratio	Thickness (m)
Secant pile	Axisymetric shell element	13*	0.2	0.55**

*Average of pile young's modulus based on contribution from hard piles only (30MPa compressive strength concrete). The contribution of soft piles are conservatively ignored.

**Based on the overlap thickness of a 750mm diameter piles at 500mm centre-to-centre spacing.

8.2.3 Construction sequence

The following sequence has been assumed for the construction of the Tawariki Shafts:

1 Construct secant pile in a hard and soft sequence with min 1.0m embedment into ECBF rock.

2 Excavate down to final depth (28m below ground surface modelled)

8.2.4 Assumptions and analysis limitations

The modelling results are based on the following assumptions:

1 An axisymmetric model has been used, which does not allow for the explicit modelling of unbalanced loading (variation in ground conditions, groundwater conditions or ground surcharges). However, we expect the effect on settlement is negligible.

2 The secant piles are interconnected and behave as a compression ring. Any adverse effect from loss of contact between secant piles has not been analysed.

3 Mechanical settlement associated with the construction of the tunnel connecting the shafts is considered to have a negligible contribution based on its size and depth. A detailed assessment has not been undertaken. The contribution of the connecting tunnel upon surface ground settlement is assessed to be within the bounds of the assessment below.

8.2.5 Results

8.2.5.1 Settlement profile

Figure 8.9 below presents the settlement predicted on the ground surface due to the shaft excavation.

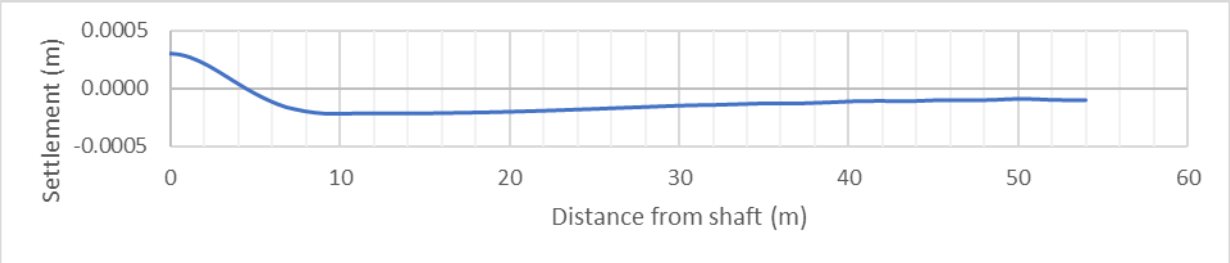


Figure 8.9 Ground surface settlement prediction

The results indicate that mechanical induced settlement from the construction of Tawairiki Shaft is less than 1 mm (that the scale for the y-axis only covers 1 mm).

8.2.5.2 Retaining wall deflection

Figure 8.10 below presents the deflection predicted for the secant pile wall after the completion of shaft excavation.

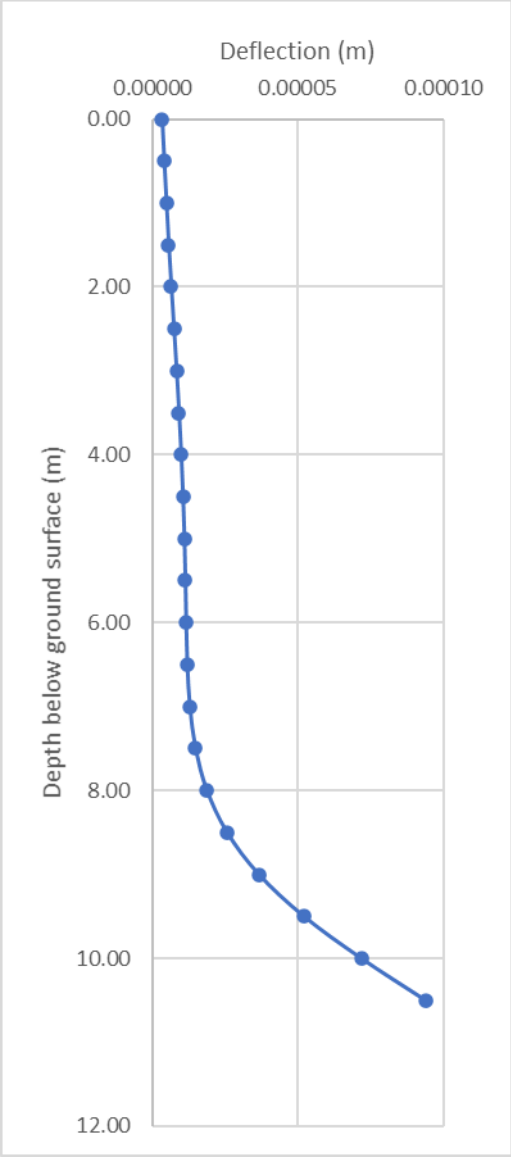


Figure 8.10 Retaining wall deflection prediction (positive deflection values indicate movement into the excavation)

The modelling results indicate that the deflection of the secant pile wall is minimal (less than 1 mm).

9 Effects assessment methodology

9.1 Geotechnical effects

9.1.1 Overview and objective

Ground settlement associated with the project construction methodologies are expected to be derived from two sources, these being:

- Mechanical settlement – settlement due to the physical movement of the ground, as a result of lateral movement at the boundary of trenches and/or excavations. This type of settlement typically occurs within a short period of time and can be controlled by good construction practices and engineering solutions.
- Consolidation settlement – settlement due to an increase in effective stress associated with the lowering of groundwater levels. This settlement is dependent on the rate and extent of groundwater level lowering and the susceptibility of the soils to consolidation. This type of settlement typically occurs more slowly than mechanical settlement and can be controlled by specific pipeline and structure design, and by good construction methodologies, practices, and reduced programme durations.

The construction of the project has the potential to induce vertical and lateral ground movements that can affect the condition of structures within the zone of influence. For purpose of this assessment, we have considered the zone of influence as the area where total ground settlements associated with the projects may be equal to or greater than 5 mm. Settlement guidelines are presented below for the potentially affected structures.

9.1.2 Settlement tolerance

9.1.2.1 Buildings

The proposed works are expected to be constructed near existing structures, principally private dwellings. In general, a building structure's tolerance to total and differential settlement depends upon the materials used in construction as well as type of foundation system adopted (shallow versus piled), the quality of the structure, and the existing condition of the structure.

The limiting values of total settlement and angular distortion along with damage classification as presented in CIRIA PR30 1996 have been used as guidance for assessment of potential effects on buildings. In addition, the New Zealand Building Code states that designers should limit the probable maximum differential settlement of a building to 1V:240H (25 mm over a 6 m horizontal distance) under serviceability limit state loading, or total settlement to 50 mm unless the structure is specifically designed to resist damage under a greater settlement. While the NZ Building Code applies to these structures, the residential house dwellings are likely to have been designed using acceptable solutions outlined in NZS 3604 which is appropriate for ground with movements less than 25mm. The ground deformation limits outlined in NZS 3604 are approximately equivalent to Risk Category 2 in CIRIA PR30.

A review of aerial photographs and Google Street View identifies buildings to the west and south of the proposed works to comprise single level residential dwelling that are expected to be supported on shallow foundations. Cladding was observed to comprise timber weather board, brick and plaster render. These structures are summarised in Table 9.1 below. We assess these buildings as having some tolerance to ground settlement.

Table 9.1: Summary of buildings within the 5mm contour line

Property Address	Property Type	Dwelling Levels	Cladding Type	Foundation Type
29 Tawariki Street	Single Family Residential	1 level	Timber clad, crawl space is concrete or concrete block with plaster render	Shallow - suspended floor foundation with concrete perimeter foundation
33 Tawariki Street	Single Family Residential	1 level	Timber clad, crawl space is concrete or concrete block with plaster render	Shallow - suspended floor foundation with concrete perimeter foundation
35 Tawariki Street	Single Family Residential	1 level	Brick clad, crawl space is concrete or concrete block with plaster render	Shallow - suspended floor foundation with concrete perimeter foundation
37 Tawariki Street	Single Family Residential	1 level	Brick clad, crawl space is concrete or concrete block with plaster render	Shallow - suspended floor foundation with concrete perimeter foundation
38 and 40 Tawariki Street	Single Family Residential (two dwellings)	1 level	Brick clad, crawl space is concrete or concrete block with plaster render	Shallow - suspended floor foundation with concrete perimeter foundation
39 Tawariki Street	Single Family Residential	1 level	Timber and plaster render, crawl space is concrete or concrete block with plaster render	Shallow - suspended floor foundation with concrete perimeter foundation
41 Tawariki Street	Single Family Residential	1 level	Brick clad, crawl space is concrete or concrete block with plaster render	Shallow - suspended floor foundation with concrete perimeter foundation

It is important to note that the values presented in in the New Zealand Building Code are total amounts of movement over the life of a building. The buildings in the vicinity of the project are existing, with unknown histories; and therefore, may have already been subjected to some movement. To account for historical movement, buildings that are subjected to less than 5 mm vertical settlement and differential settlement slopes no greater than 1:1000, have been assessed to have a negligible risk to damage and would not need to be further assessed.

For the purposes of this assessment, the settlement criteria in Table 9.2 (which is generally based on the Burland (1995), and Mair et al (1996) classification) has been adopted for our assessment:

Table 9.2: Settlement criteria for properties and buildings along the proposed project alignment

Risk Category	Maximum settlement of building (mm)	Maximum differential settlement	Description of risk	General Category
0	-	-	Negligible: superficial damage unlikely	Aesthetic Damage
1	<10	< 1 in 500	Very Slight: Fine cracks easily treated during normal redecoration. Perhaps isolated slight fracture in building. Cracks in exterior visible upon close inspection. Typical crack widths up to 1mm.	
2	10 to 50	1 in 500 to 1 in 200	Slight: Cracks easily filled. Redecoration probably required. Several slight fractures inside building. Exterior cracks visible, some repainting may be required for weather-tightness. Doors and windows may stick slightly. Typical crack widths up to 5 mm.	
3	50-75	1 in 200 to 1 in 50	Moderate: Cracks may require cutting out and patching. Recurrent cracks can be masked by suitable linings. Brick pointing and possible replacement of a small amount of exterior brickwork may be required. Doors and windows sticking. Utility services may be interrupted. Weather tightness often impaired. Typical crack widths are 5 to 15 mm or several greater than 3 mm	Serviceability Damage
4	> 75	1 in 200 to 1 in 50	Severe: Extensive repair involving removal and replacement of walls especially over door and windows required. Window and door frames distorted. Floor slopes noticeably. Walls lean or bulge noticeably. Some loss of bearing in beams. Utility services disrupted. Typical crack widths are 15 to 25 mm but also depend on the number of cracks.	
5	> 75	> 1 in 50	Major repair required involving partial or complete reconstruction. Beams lose bearing walls lean badly and required shoring. Windows broken by distortion. Danger of instability. Typical crack widths are greater than 25 mm but depend on the number of cracks	Structural Damage

9.1.2.2 Underground services

Published literature[14] indicates that the maximum differential settlement for cast iron pipes and brittle services with a diameter of 200 mm or greater is in the order of 1:250. Most of the major services near the proposed works appear to be more flexible materials such as concrete pipe, polyethylene pipes, electrical cables etc. Services running perpendicular to the excavation works are considered to be at the highest risk of damage. In general, where a service is parallel to the excavation works, it may experience horizontal displacement associated with ground loss at the excavation face, as well as similar total settlement but with a gentler settlement slope, i.e., differential settlement.

Settlement tolerance of a service will be dependent on the condition of the current asset and its tolerance to deformation. An allowable differential ground settlement of 1:500 has been conservatively adopted for the services along the proposed excavation works to assess the potential for adverse effects. For any services passing within a zone of potential settlement, the service will need to be checked during detailed design for its tolerance to the predicted settlement magnitude and shape, with specific mitigation measures developed in the instance where tolerances may be approached or exceeded. Each service may differ in its acceptable movement tolerance (to be defined by the respective asset owner), so each shall be assessed individually during the detailed design stage.

A review of publicly available information retrieved from BeforeUdig and Auckland Council Geomaps indicates a series of public services within the zone of influence. These are shown on Figure 1 in Appendix D.

9.1.3 Combination of mechanical and consolidation settlement effects

The total settlement that occurs at the ground surface is a combination of consolidation settlement induced by groundwater drawdown and mechanically induced settlement. The mechanically induced settlement is expected to occur relatively quickly, compared to the consolidation settlement resulting from groundwater drawdown.

We have adopted a method to combine the calculated settlements and report the total estimated settlement a set horizontal distances from the excavations.

9.2 Groundwater effects

9.2.1 Overview

These potential groundwater effects have been assessed:

- Effect of diversion – groundwater flow is diverted into and/or around structures which are installed in the ground such as temporary sheet piling and final permanent works
- Effect on neighbouring bores – upstream groundwater levels may be increased by the damming effect of installed structures and reduced by the dewatering required to keep the excavation dry, which affects the ability of bores to provide a water supply.

[14] O'Rourke, T D, and C H Trautmann. 1982. Buried pipeline response to tunnel ground movements. In Europipe 82 Conf., Basel, Switzerland, paper 1.

9.2.2 Groundwater diversion

The effect of diversion is to alter the path of existing groundwater flow. This assessment method considers whether the groundwater flow is permanently diverted by the installed structures and causes increases or decreases in groundwater levels such that these affect lawful groundwater users.

9.2.3 Neighbouring bores

Neighbouring bores may be affected by groundwater level changes, occurring during dewatering activities. These effects are significant if the groundwater supply can no longer be obtained from these neighbouring bores.

10 Effects assessment

This section presents the general range of effects that might arise from the project's construction activities, provides guidance on acceptable settlement amounts, and summarises the specific effects that are estimated for the areas considered to be of particular interest or critical to the project.

10.1 Geotechnical settlement effects

This section presents the general range of geotechnical effects that we have estimated that could occur from the project's construction activities and summarises the specific effects that are estimated for the areas considered to be of particular interest or critical to the project.

The estimated total ground settlements are summarised in the following sections and presented as a contour plan in Appendix D.

10.1.1 Assessment of effects on buildings

Total and differential settlement have been estimated for existing buildings near the proposed excavation works. Table 9.1 presents buildings that have been assessed for potential damage induced by ground settlement associated with the proposed excavation works.

Properties at 35, 37, 38 and 40 Tawariki Street are closest to the proposed excavations works. Subsequently, they are assessed to experience the greatest total and differential surface ground settlements. However, even at these properties, differential settlements are not expected to be steeper than 1V:1500H. Strictly applying the damage categories presented in Table 9.2, dwellings at 35 and 37 Tawariki Street would classify as damage category 2 based on total settlement, but as damage categories 0-1 based on differential settlement. Based on the building type and condition visually observed from the road, we assess that these buildings are more sensitive to differential settle rather than total settlement, and as such, have assessed a damage category of 1. The dwellings at 38 and 40 Tawariki Street are structurally connected and are likely to have a greater vulnerability, particularly in the area where they are connected and hence they have been assessed as a damage category 2. The type of damage that could occur is surficial cosmetic (non-structural) cracking at the location where the buildings are joined (both internal and external) and is readily repairable. We expect that the risk of damage can be managed through a baseline survey, visual monitoring of the property during construction, and as part of the consent conditions.

Properties 29, 33, 39 and 41 Tawariki Street are further away from the proposed works and are assessed to experience comparatively lower levels of differential settlement. Adopting the damage categories presented in Table 9.2, we assess these properties to be within the 0 to 1 damage categories.

Relevant settlement contours for the assessed buildings are presented in Appendix D.

Table 10.1: Summary of total settlements from excavation works at assessed structures

Location	Approximate Horizontal distance from edge of nearest excavation to dwelling[1]: (m)	Estimated Horizontal distance from edge of excavation to 5 mm or less settlement contour (m)	Estimated total maximum surface ground settlement (mm)	Estimated approximate maximum differential surface ground settlement across building	Damage category and description to existing structures[2]
29 Tawariki Street	44	60	6	<1V:4000H	0-1
33 Tawariki Street	34	60	10	1V:3000H	0-1
35 Tawariki Street	34	60	12	1V:2500H	1[3]
37 Tawariki Street	37	60	12	1V:2500H	1[3]
39 Tawariki Street	27	35	9	1V:2500H	1
38 Tawariki Street	23	35	7	1V:3000H	2
40 Tawariki Street	14	30	12	1V:1500H	2
41 Tawariki Street	22	24	6	1V:3000H	0-1

1. Horizontal distances are approximate and calculated using aerial imagery. Horizontal distances should be confirmed during detailed design.

2. Damage category and description as described in Table 9.2.

3. Damage category assessed using engineering judgement and descriptions in Table 9.2 taking into account the very low differential settlement predictions.

Given the analysis undertaken, we assess that the ground settlement effects on buildings to be generally negligible to very slight risk of damage. Damage that may occur is assessed to likely be aesthetic related and readily repaired.

We recommend that building condition surveys are undertaken for 35, 37, 38, 39 and 40 Tawariki Street. We understand that the building conditions surveys for 38 and 40 Tawariki Street will be in addition to the conditions of the Resource Consent. The other properties are already addressed through the existing consent conditions.

10.1.2 Assessment of effects on underground services

Maximum total and differential settlements are assessed to be 25 mm and 1V:1000H respectively. At this level of total and differential settlement, we assess that the risk of damage to underground services is negligible to very slight.

10.2 Groundwater effects

10.2.1 Groundwater diversion

The proposed shafts will be constructed within the groundwater table. The groundwater flow direction of the shallow aquifer is expected to be a muted reflection of the site topography, i.e., flowing from higher to lower ground in a generally westward direction. Groundwater at depth is assumed to flow towards the north west and discharging into Cox's creek.

Groundwater that is not intercepted by the dewatering associated with shaft construction take will be diverted around the proposed secant piled structures. However, the diverted groundwater is still expected to continue to discharge to Cox's Creek. Given the relatively sealed construction method proposed, and fixed dewatering period, the effect of dewatering on the regional groundwater levels is expected to be inconsequential.

10.2.2 Neighbouring bores

The nearest groundwater take bore is approximately 1.8 km away from the proposed shaft excavation works which is outside the zone of expected groundwater drawdown influence. We therefore assess that there are no groundwater take bores in the area impacted by the proposed shaft construction.

10.3 Long-term effects

Ongoing long-term groundwater drawdown is considered to be unlikely as the completed infrastructure should be a closed or watertight system. Groundwater levels are expected to return back to similar levels as prior to construction. Settlements associated with construction are likely to occur in a relatively short period of time and stop once the excavations are complete and backfilled. Nevertheless, settlements that occur during construction are considered to generally not fully recover and are therefore permanent, even when groundwater levels recover.

10.4 Monitoring programme

A groundwater and settlement monitoring programme during construction is required by existing consent conditions. The requirements of the monitoring programme, including Alert and Alarm levels, will be set out in the Groundwater and Surface Monitoring Contingency Plan (GSMCP). The plan includes groundwater drawdown, surface settlement, building settlement monitoring and visual observation monitoring.

Given the low levels of expected ground deformation associated with the proposed works, baseline monitoring of ground surface settlement and building settlement points is recommended to be undertaken prior to commencement of construction to establish seasonal variability. While we would recommend this is undertaken for at least 12 months prior to commencement of construction, we understand this is not practical given a construction start date of March 2023. As such, monitoring should commence as soon as practically possible.

In addition, groundwater monitoring bores located within the boreholes BH03, BH04 and BH05 (referenced in this assessment) should be monitoring for a minimum period of 6 months prior to commencement of construction to establish baseline levels.

We understand that our baseline monitoring recommendations are already a condition of the Resource Consent.

11 Conclusion

This technical Assessment of Groundwater and Settlement Effects Report has been prepared by T+T to support an Assessment of Effects on the Environment (AEE) and S127 to the existing resource consent.

Our assessment presents the results of undertaking the works concurrently in one construction window, resulting in an upper bound effect. Should the works be undertaken in stages (i.e. in separate construction seasons), then the effects will be less and within the bounds of this assessment.

Structures closest to the excavation and immediately to the west are expected to experience the greatest levels of ground settlement due to their distance from the excavation and thickness of compressible material. With distance from the excavation, settlement values diminish. Total surface ground settlements at adjacent dwellings is assessed to be 12 mm or less with differential settlements no steeper than 1V:1500H. At adjacent services, settlements are limited to less than 25 mm with differential settlements no steeper than 1V:1000H.

Based on our technical assessment, we assess:

- Ground settlement effects arising from construction and operating the Tawariki Shafts on surrounding structures is assessed to generally be negligible (0) to very slight risk (1) of damage.
- Ground settlement effects at 38 and 40 Tawariki Street are assessed to be at the lower bound of Slight (2) particularly where they are connected due to the form of the building. The type of damage that could occur is surficial cosmetic (non-structural) cracking at the location where the buildings are joined (both internal and external) and is readily repairable.
- This can be managed by a baseline survey and as part of consent conditions any damage caused will need to be repaired. As it is limited to cosmetic damage, it will be relatively easy to repair (internal decorating) and external whether tightness
- Effects upon groundwater levels are expected to localised to within generally 100 m distance of the proposed excavation and temporary in nature. Upon completion and sealing of the shafts, groundwater levels are expected to return to levels prior to construction.
- Based on the assessment of groundwater and settlement effects set out above, the effects of constructing the two shafts and associated grit chamber within the one construction period, and relocating the secondary shaft from 44 to 42 Tawariki Street, are within the consented envelope of effects.

12 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.

Recommendations and opinions in this report are based on data from discrete investigation locations. The nature and continuity of subsoil away from these locations are inferred but it must be appreciated that actual conditions could vary from the assumed model.

Tonkin & Taylor Ltd

Report prepared by:	Report prepared by::
	
.....	.....
Eduard Mandru Geotechnical Engineer	Troy McAlister Engineering Geologist
Technical review by:	Authorised for Tonkin & Taylor Ltd by:
	
.....	.....
Sjoerd Van Ballegooy Technical Director	Karen Baverstock Project Director

11-Nov-22
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Appendix A: Ground Investigation Data

- **Figure 1 – Site Plan**
- **Borehole Logs (BH03, BH04 and BH05)**

COPYRIGHT ON THIS FIGURE IS RESERVED DO NOT SCALE FROM THIS FIGURE.

C:\Troy\GIS\CI Shafts\Tawariki Shafts\Tawariki Shafts.aprx Layout: T+T A3 Landscape Map Template 2022-Apr-29 10:03 AM Drawn by TRMC

Tonkin+Taylor

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NOTES:

Basemap NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.. Google Satellite: © OpenStreetMap (and) contributors, CC-BY-SA

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	TRMC	EDMA	29/4/22

LOCATION PLAN

PROJECT No.	30552.9090	
DESIGNED	TRMC	MAY.22
DRAWN	TRMC	MAY.22
CHECKED		
APPROVED		DATE

CLIENT **WATERCARE SERVICES LTD**

PROJECT **CENTRAL INTERCEPTOR - TAWARIKI STREET SHAFTS**

TITLE GEOLOGICAL CROSS SECTION LOCATIONS

SCALE (A3) 1:1,000 FIG No. FIGURE 1. REV 0

Jacobs in association with AECOM and McMillen Jacobs Associates		Preliminary Log of Investigation
Project: **Central Interceptor CIGI5**		**Borehole**
Location: **41 Tawariki Street, Grey Lynn**	Project No: **AE04725**	Hole ID: **CIE-BH03**
Client: **Watercare**		Date: **23/03/2018**

Started:	23/03/2018	Remarks Packer Test at 20.00-24.50 m Artesian piezometer, low pressure gauge installed.. Pressure reading on 25/05/2018 was 21 kPa. Hole location determined by Survey.	Co-ordinates: 5920068.77mN 1754833.35mE Elevation: 13.34mRL Inclination: -90°
Finished:	27/03/2018		
Driller:	McMillan		
Plant:	Rig N101 (McMillan)		
Logged:	A. Coutts		
Checked:	CS		Log cover page

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: BH COVER SHEET Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

Borehole

Location: **41 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH03**

Client: **Watercare**

Date: **23/03/2018**

R.L. (m)	Depth (m)	Shift Details & Standing Water Level	Drilling Method	Drilling Flush Return (%)	TCR (SCR) [RQD] %	Spacing of Natural Defects (mm)	Relative Strength	Weathering Grade	Sampling	In-Situ Testing	Geology Legend	GroundWater	Description of Strata	Comments	Geological Unit	Backfill / Installation
13	1		VAC EX	255075	0								Vacuum Excavation.		MG	
12	2	Flush Type: Water Flush Colour: Grey	HQ3		100								Silty CLAY with minor rootlets; light grey mottled orange and dark brown. Very soft, saturated, high plasticity. *1.70m: Becomes minor sand. Sand is fine.* *1.90m: Becomes dark grey.*			
11	3	23/03/2018 8:00:00 AM	TBX		70				TW				PUSH TUBE: Material at top and bottom comprises: CLAY with minor silt and trace fine sand; dark grey mottled light brownish grey. Soft, saturated, low plasticity.		Tp	
													CORE LOSS.			
			HQ3		100					SPT$_s$ 3,7,13 N=20			CLAY with some silt; dark grey mottled light brownish grey. Soft, wet, high plasticity.	2.7m: Rods sinking under own weight.		
10	4		SPT		100				TW				SILT with minor clay and trace sand and rootlets; dark grey mottled orange. Very stiff, moist, low plasticity. Sand is fine.		Wwc	
9	5		TBX		100				TW				PUSH TUBE: Material at top is too deep in tube to obtain sample. Material at base is: Sandy SILT; dark grey. Hard, moist. Sand is fine.	3.45m: Push tube could only be pushed 250mm, too hard.		
			HQ3		100								Highly weathered, dark grey, massive, fine grained SANDSTONE. Extremely weak. Recovered as fine SAND with some silt; Dense, moist.		Wwnc	
8	6		SPT		78					SPT$_s$ 13,14,33 N=47			*4.48m to 4.50m: Becomes silty CLAY. Hard, moist, low plasticity.* *4.70m to 4.77m: Becomes SILT. Hard, moist, low plasticity.*			
													CORE LOSS.			
			HQ3		81 (74) [74]								Highly weathered, dark grey, massive, fine grained SANDSTONE. Extremely weak. Recovered as fine SAND with some silt; Dense, wet.		Wuw	
7	7		SPT		100					SPT$_c$ 19,40 N>50 40/150 bouncing			Moderately weathered, interbedded, grey MUDSTONE and grey speckled white, green with trace red flecks SANDSTONE. Very weak. Mudstone beds are laminated to thin, sandstone beds are thin to moderately thin, sub-horizontal. With minor laminated to thin carbonaceous beds. *5.15m to 5.00m: Thin, sub-horizontal, grey speckled black, discontinuous carbonaceous bed.*		Wpvc Wuw	
			HQ3		92 (92) [92]								Moderately weathered, grey speckled white, green with trace red flecks, massive, medium grained SANDSTONE. Very weak. With trace coarse sand and fine gravel, subrounded, mudstone.	6.3m: Core biscuiting with drilling.	Wpvc	
													CORE LOSS.			
6	8		SPT		0					SPT$_c$ 34,33 N>50 33/75 bouncing			Moderately weathered, grey speckled white, green with trace red flecks, massive, medium grained SANDSTONE. Very weak. With trace coarse sand and fine gravel, subrounded, mudstone. *6.30m: Becomes slightly weathered.* *6.40m to 6.50m: Very thin, moderately inclined carbonaceous bed.*		Wuv	
5	9		HQ3		75 (75) [75]								Slightly weathered, grey, massive, fine grained SANDSTONE. Very weak. Slightly weathered, grey, medium grained SANDSTONE. Extremely weak. Recovered as fine to medium SAND with some silt; Very dense. CORE LOSS. Slightly weathered, grey speckled white, green with trace red flecks, massive, medium grained SANDSTONE. Very weak. With minor coarse sand grains and trace fine gravel, subrounded, mudstone.		Wpvc	
4	10	23/03/2018 3:00:00 PM 26/03/2018 9:00:00 AM (Water depth 1.8m)	SPT		0					SPT$_c$ 44 N>50 44/150 bouncing			CORE LOSS.			
			HQ3		100 (100)								Slightly weathered, grey speckled white, green with trace red flecks, medium grained SANDSTONE. Very weak. With minor coarse sand grains and trace fine gravel, subrounded, mudstone. Slightly weathered, grey speckled white and green with red flecks, massive, fine to coarse volcaniclastic SANDSTONE, very weak. With trace fine gravel sized, subrounded to subangular mudstone and			

Defect Description

TYPE: CS Clay seam; C Cleavage; CR Crushed zone; DZ Decomposed zone; DB Drilling induced fracture; FL Foliation; FZ Fracture zone; IF Incipient fracture; JT Joint; SC Schistosity; SH Shear; SZ Shear Zone; SL Sill; VN Vein; VO Void

SURFACE: C Clean; Mc Mineral coat; Si Soil infill; Sn Surface stain; V Veneer

PLANARITY: P Planar; St Stepped; U Undulating

ROUGHNESS: R Rough; Ss Slickensided; Sm Smooth

APERTURE: T 0mm; Vn 0-2mm; N 2-6mm; Mn 6-20mm; Mw 20-60mm; W 60-200mm; Vw >200mm

Started:	23/03/2018
Finished:	27/03/2018
Driller:	McMillan
Plant:	Rig N101 (McMillan)
Logged:	A. Coutts
Checked:	CS

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations

Remarks

Packer Test at 20.00-24.50 m
Artesian piezometer, low pressure gauge installed..
Pressure reading on 25/05/2018 was 21 kPa.
Hole location determined by Survey.

Co-ordinates:
5920068.77mN
1754833.35mE
Elevation: 13.34mRL
Inclination: -90°

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: COMPILATION BOREHOLE Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

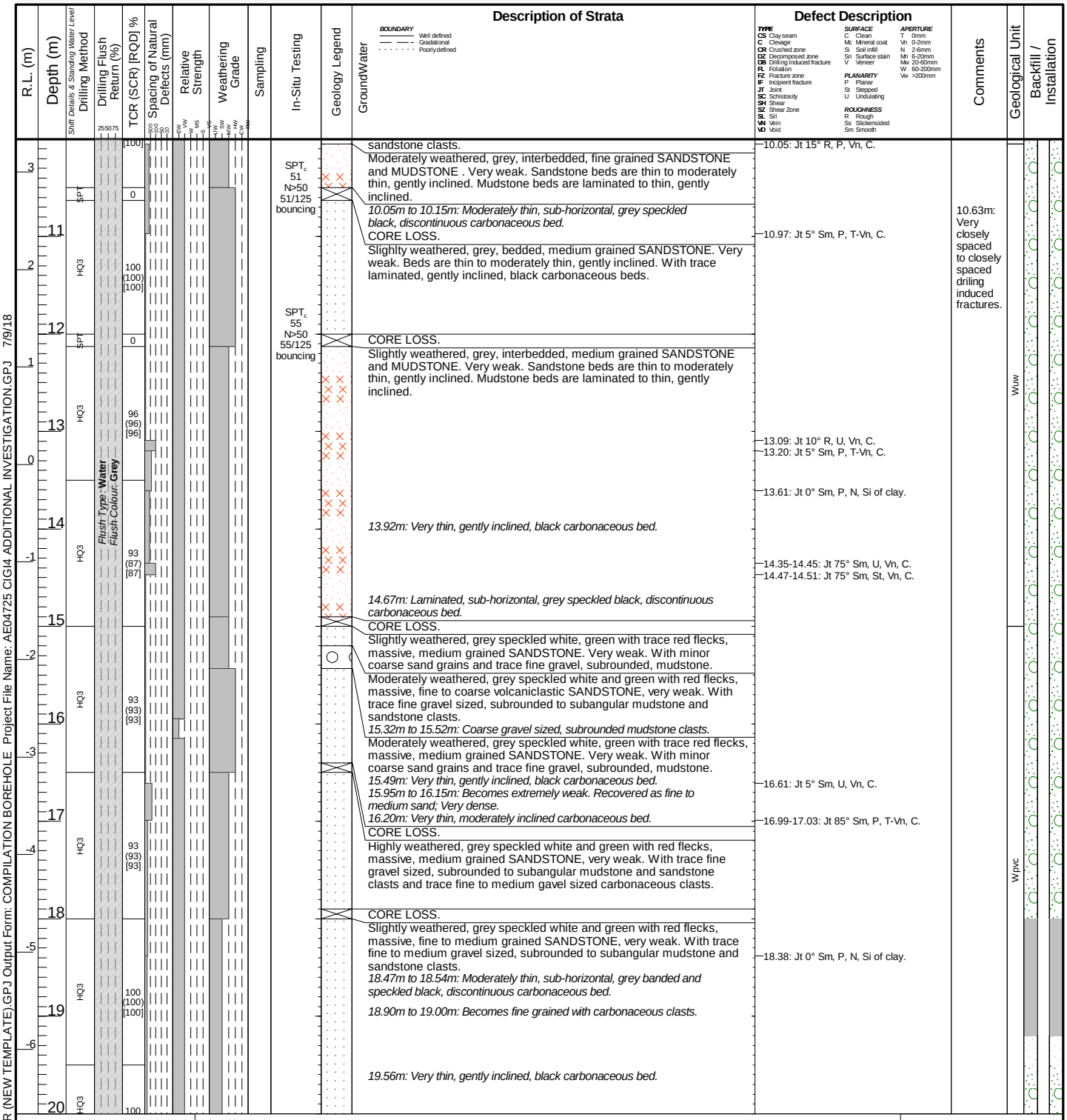
Borehole

Location: **41 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH03**

Client: **Watercare**

Date: **23/03/2018**



Started: 23/03/2018

Finished: 27/03/2018

Driller: McMillan

Plant: Rig N101 (McMillan)

Logged: A. Coutts

Checked: CS

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations

Remarks

Packer Test at 20.00-24.50 m
Artesian piezometer, low pressure gauge installed..
Pressure reading on 25/05/2018 was 21 kPa.
Hole location determined by Survey.

Co-ordinates:
5920068.77mN
1754833.35mE
Elevation: 13.34mRL
Inclination: -90°

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

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Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

Borehole

Location: **41 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH03**

Client: **Watercare**

Date: **23/03/2018**

R.L. (m)	Depth (m)	Shaft Details & Standing Water Level / Drilling Method	Drilling Flush Return (%)	TCR (SCR) [RQD] %	Spacing of Natural Defects (mm)	Relative Strength	Weathering Grade	Sampling	In-Situ Testing	Geology Legend	GroundWater	Description of Strata	Defect Description	Comments	Geological Unit	Backfill / Installation
-7	21	HQ3	255075	(100) [100]	600 200 60	EW VW W MS S SS	CW SW MW HW CW RW						20.08: Jt 0° R, P, Vn, C.			
				90 (70) [70]									20.43-20.53: Jt 85° R, P, Vn, C. 20.55-20.61: Jt 85° R, P, Vn, C.			
-8	22	HQ3		94 (94) [94]								CORE LOSS. Slightly weathered, grey speckled white and green with red flecks, massive, fine to medium grained SANDSTONE, very weak. With trace fine to medium gravel sized, subrounded to subangular mudstone and sandstone clasts.	21.14-21.19: Jt 0° R, P, Mw, Si of rock fragments. 21.22: Jt 0° R, P, Mn, Si of clay.			
-9	23	HQ3		100 (53) [53]								CORE LOSS. Slightly weathered, grey speckled white and green with red flecks, massive, medium grained SANDSTONE, very weak. With trace fine to medium gravel sized, subrounded to subangular mudstone and sandstone clasts. *23.30m to 24.00m: Becomes extremely weak. Recovered as fine to medium SAND with minor silt; Very dense.*			Wpvc(Contd)	
-10	24	HQ3 26/03/2018 4:00:00 PM (Water depth 0.9m)	*Flush Type:* **Water** *Flush Colour:* **Clear, slightly cloudy**	42 (26) [26]								CORE LOSS. Infer sandstone broke and washed away while trying to recover run. Slightly weathered, grey speckled white and green with red flecks, massive, fine to coarse grained SANDSTONE, very weak. With trace fine gravel sized, subrounded mudstone and sandstone clasts.		24m: Difficulty recovering run. Third attempted recovered with fingered catcher. 24.47m: Dipped hole for packer test. Replaced mud pit with fresh water.		
-11	25	HQ3 27/03/2018 8:00:00 AM (Water depth 0.9m)		92 (92) [92]								Slightly weathered, interbedded, medium grey speckled white, green and flecks of red, medium grained SANDSTONE and dark grey MUDSTONE . Very weak. Sandstone beds are thin to moderately thin, mudstone beds are laminated to thin, gently inclined. *25.30m: Very thin, sub-horizontal, black carbonaceous bed.* *25.63m to 25.88m: Beds become steeply inclined.*				
-12	26	HQ3	*Flush Type:* **Water** *Flush Colour:* **Grey**									CORE LOSS. Slightly weathered, grey, massive, medium grained SANDSTONE. Very weak.			Wuw	
-13	27	HQ3		100 (100) [100]								Slightly weathered, grey speckled white, green and flecks of red, massive, medium grained SANDSTONE. Very weak.			Wpvc	
-14		27/03/2018 2:00:00 PM (Water depth 0.9m) 28/03/2018 9:15:00 AM (Water depth 0.7m)										CIE-BH03 terminated at 27.50m. Target Depth				

Description of Strata

BOUNDARY: Well defined; Gradational; Poorly defined

Defect Description

TYPE: CS Clay seam; C Cleavage; CR Crushed zone; DZ Decomposed zone; DB Drilling induced fracture; FL Foliation; FZ Fracture zone; IF Incipient fracture; JT Joint; SC Schistosity; SH Shear; SZ Shear Zone; SL Sill; VN Vein; VD Void

SURFACE: C Clean; Mc Mineral coat; Si Soil infill; Sn Surface stain; V Veneer

PLANARITY: P Planar; St Stepped; U Undulating

ROUGHNESS: R Rough; Ss Slickensided; Sm Smooth

APERTURE: T 0mm; Vn 0-2mm; N 2-6mm; Mn 6-20mm; Mw 20-60mm; W 60-200mm; Vw >200mm

Started: 23/03/2018
Finished: 27/03/2018
Driller: McMillan
Plant: Rig N101 (McMillan)
Logged: A. Coutts
Checked: CS

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations

Remarks
Packer Test at 20.00-24.50 m
Artesian piezometer, low pressure gauge installed..
Pressure reading on 25/05/2018 was 21 kPa.
Hole location determined by Survey.

Co-ordinates:
5920068.77mN
1754833.35mE
Elevation: 13.34mRL
Inclination: -90°

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: COMPILATION BOREHOLE Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with AECOM and McMillen Jacobs Associates		Preliminary Log of Investigation
Project: **Central Interceptor CIGI5**		**Borehole**
Location: **46 Tawariki Street, Grey Lynn**	Project No: **AE04725**	Hole ID: **CIE-BH04**
Client: **Watercare**		Date: **5/07/2018**

Started:	5/07/2018	Remarks Packer Test 1 at 9.75-12.00 m, Packer Test 2 at 19.25-22.50 m, Packer Test 3 at 28.50-31.50 m. Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.1 m RL. Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0. Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946 Hole location determined by Survey.	Co-ordinates: 5920092.60mN 1754813.92mE Elevation: 12.29mRL Inclination: -90°
Finished:	10/07/2018		
Driller:	McMillan		
Plant:	Rig N111 (McMillan)		
Logged:	S. Burgess		
Checked:	LD		Log cover page

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: BH COVER SHEET Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

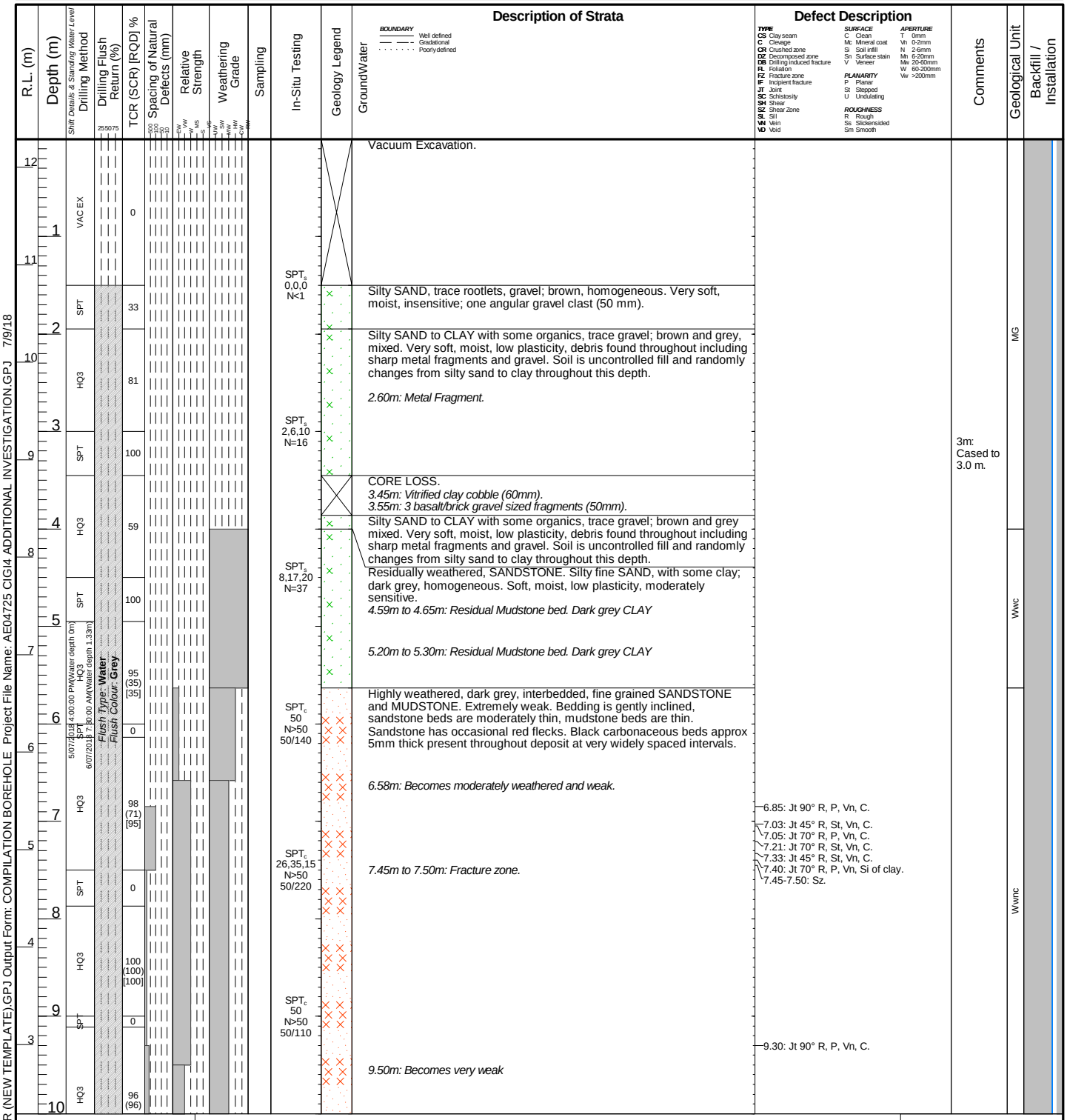
Borehole

Location: **46 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH04**

Client: **Watercare**

Date: **5/07/2018**



Started:	5/07/2018
Finished:	10/07/2018
Driller:	McMillan
Plant:	Rig N111 (McMillan)
Logged:	S. Burgess
Checked:	LD

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations
1	-3.78	14/09/2018		Midday WL

Remarks

Packer Test 1 at 9.75-12.00 m, Packer Test 2 at 19.25-22.50 m, Packer Test 3 at 28.50-31.50 m. Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.1 m RL.
Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0.
Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946
Hole location determined by Survey.

Co-ordinates:
5920092.60mN
1754813.92mE
Elevation: 12.29mRL
Inclination: -90°

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: COMPILATION BOREHOLE Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

Borehole

Location: **46 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH04**

Client: **Watercare**

Date: **5/07/2018**

R.L. (m) | Depth (m) | Shift Details & Standing Water Level | Drilling Method | Drilling Flush Return (%) | TCR (SCR) (RQD) % | Spacing of Natural Defects (mm) | Relative Strength | Weathering Grade | Sampling | In-Situ Testing | Geology Legend | GroundWater

Flush Type: Water
Flush Colour: Grey

6/07/2018 4:00:00 PM HQ3
9/07/2018 7:30:00 AM Water depth 2m

Description of Strata

CORE LOSS.

Moderately weathered, dark grey, interbedded, fine grained SANDSTONE and MUDSTONE. Extremely weak. Bedding is sub-horizontal, sandstone beds are moderately thin, mudstone beds are thin. Sandstone has occasional red flecks. Black carbonaceous beds approx 5mm thick present throughout deposit at very widely spaced intervals.

Highly weathered, dark grey, homogeneous, fine grained SANDSTONE. Extremely weak.

Highly weathered, dark grey, homogeneous, medium grained SANDSTONE. Extremely weak.
11.83m to 11.85m: Very thin, sub-horizontal, black carbonaceous bed.

CORE LOSS.

Completely weathered, dark grey, homogeneous, fine grained SANDSTONE. Recovered as fine silty SAND, trace clay.Tightly packed, moist.

CORE LOSS.

Completely weathered, dark grey, homogeneous, fine grained SANDSTONE. Recovered as fine silty SAND, trace clay.Tightly packed, moist.

Highly weathered, dark grey, homogeneous, fine grained SANDSTONE. Extremely weak. Minor white clasts present throughout matrix (1mm). Silty SAND. Loosely packed, moist.

15.05m to 15.55m: Trace green clasts (1-3 mm)
15.10m: Becomes moderately weathered

15.45m to 15.50m: Thin, sub-horizontal, black carbonaceous bed.

Highly weathered, dark grey, homogeneous, fine to medium grained SANDSTONE. Extremely weak. Minor white clasts present throughout matrix (1mm). Silty SAND. Loosely packed, moist.

CORE LOSS.

Moderately weathered, dark grey, interbedded, fine to coarse grained SANDSTONE and MUDSTONE. Very weak. Bedding is sub-horizontal, sandstone beds are moderately thin, mudstone beds are thin. Black carbonaceous beds, laminated to thin, present throughout deposit at widely spaced intervals.

18.13m to 18.15m: Thin, sub-horizontal, black carbonaceous bed.

18.70m to 19.30m: Laminated to thin, sub-horizontal, black carbonaceous beds.

Defect Description

10.17: Jt 70° R, P, Vn, C.
10.68: Jt 85° R, U, Vn, C.
10.75: Jt 85° R, U, Vn, C.
10.77: Jt 85° R, U, Vn, C.
17.45: Jt 85° R, P, Vn, C.
18.00: Jt 85° R, St, Vn, C.
18.72: Jt 85° R, P, Vn, C.
18.94: Jt 85° R, P, Vn, C.
19.30: Jt 85° R, St, Vn, C.
19.43: Jt 85° R, St, Vn, C.

Comments | Geological Unit | Backfill / Installation

Started: 5/07/2018
Finished: 10/07/2018
Driller: McMillan
Plant: Rig N111 (McMillan)
Logged: S. Burgess
Checked: LD

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations
1	-3.78	14/09/2018		Midday WL

Remarks
Packer Test 1 at 9.75-12.00 m, Packer Test 2 at 19.25-22.50 m, Packer Test 3 at 28.50-31.50 m. Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.1 m RL.
Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0.
Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946
Hole location determined by Survey.

Co-ordinates:
5920092.60mN
1754813.92mE
Elevation: 12.29mRL
Inclination: -90°

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: COMPILATION BOREHOLE Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

Borehole

Location: **46 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH04**

Client: **Watercare**

Date: **5/07/2018**

Description of Strata

BOUNDARY: Well defined; Gradational; Poorly defined

Defect Description

TYPE: CS Clay seam; C Cleavage; CR Crushed zone; DZ Decomposed zone; DB Drilling induced fracture; FL Foliation; FZ Fracture zone; IF Incipient fracture; JT Joint; SC Schistosity; SH Shear; SZ Shear Zone; SL Sill; VN Vein; VD Void

SURFACE: C Clean; Mc Mineral coat; Si Soil infill; Sn Surface stain; V Veneer

APERTURE: T 0mm; Vh 0-2mm; N 2-6mm; Mn 6-20mm; Mw 20-60mm; W 60-200mm; Vw >200mm

PLANARITY: P Planar; St Stepped; U Undulating

ROUGHNESS: R Rough; Ss Slickensided; Sm Smooth

R.L. (m)	Depth (m)	Drilling Method	Drilling Flush Return (%)	TCR (SCR) [RQD] %	Spacing of Natural Defects (mm)	Relative Strength	Weathering Grade	Sampling	In-Situ Testing	Geology Legend	GroundWater	Description of Strata	Defect Description	Comments	Geological Unit	Backfill / Installation
-8	21	HQ3		93 (93) [93]								CORE LOSS. Moderately weathered, dark grey, interbedded, fine grained SANDSTONE and MUDSTONE. Very weak. Bedding is gently inclined, sandstone beds are moderately thin, mudstone beds are thin. Black carbonaceous beds, laminated to thin, present throughout deposit at widely spaced intervals. *21.45m to 21.48m: Fracture zone. Coal.*	20.30: Jt 75° R, P, Vn, C.		Wuw(Contd.)	
-9	22	HQ3		100 (96) [96]									21.20: Jt 75° R, P, Vn, C. 21.39: Jt 75° R, P, Vn, C. 21.45-21.48: Sz Vn, C, Highly fractured coal. 21.58: Jt 50° R, U, Vn, C. 21.97: Jt 75° R, P, T, C. 22.14: Jt 75° R, U, Vn, C.			
-10	23	HQ3		100 (100) [100]								Moderately weathered, dark grey, homogeneous, medium grained SANDSTONE. Very weak. Minor white clasts present throughout matrix (1mm), trace dark brownish green mudstone clasts (2-6 mm). Local, very thin mudstone beds are present.			Wpvc	
-11	24	HQ3		100 (100) [100]								Moderately weathered, dark grey, homogeneous, fine grained SANDSTONE. Very weak. Minor white clasts present throughout matrix (1mm). Local, very thin mudstone beds are present. *24.30m: Becomes medium grained.* *24.68m: Becomes fine grained.* *24.82m: Thin, gently inclined, grey speckled black, discontinuous carbonaceous bed.* *24.92m: Becomes medium grained.* *25.11m to 25.22m: Mudstone bed.* *25.68m to 25.71m: Mudstone bed.*	24.82: Jt 75° R, P, Vn, C.		Wuw	
-12	25	HQ3														
-13	26	HQ3														
-14	27	HQ3		93 (93) [93]								CORE LOSS. Moderately weathered, dark grey, homogeneous, medium grained SANDSTONE. Very weak. Minor white clasts present throughout matrix (1mm), trace dark brownish green mudstone clasts (2-6 mm). *27.16m to 27.18m: Mudstone bed.*				
-15	28	HQ3		96 (96) [96]								Moderately weathered, dark grey, homogeneous, medium grained SANDSTONE. Very weak. Minor white clasts present throughout matrix (1mm), trace dark brownish green mudstone clasts (2-6 mm). *28.05m to 28.25m: Becomes coarse grained.*			Wpvc	
-16	29	HQ3										CORE LOSS. Moderately weathered, dark grey, homogeneous, medium grained SANDSTONE. Very weak. Minor white clasts present throughout matrix (1mm), trace dark brownish green mudstone clasts (2-6 mm). *28.90m: Becomes extremely weak.* *29.27m: Becomes slightly weathered and strong.* *29.47m: Becomes moderately weathered and very weak.*	29.37: Jt 30° R, P, T, C.			
-17	30	HQ3		95 (95) [95]												

Flush Type: Water
Flush Colour: Grey

9/07/2018 1:45:00 PM(Water depth 0.97m)

9/07/2018 4:00:00 PM

10/07/2018 7:30:00 AM(Water depth 0.6m)

Started: 5/07/2018

Finished: 10/07/2018

Driller: McMillan

Plant: Rig N111 (McMillan)

Logged: S. Burgess

Checked: LD

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations
1	-3.78	14/09/2018		Midday WL

Remarks

Packer Test 1 at 9.75-12.00 m, Packer Test 2 at 19.25-22.50 m, Packer Test 3 at 28.50-31.50 m. Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.1 m RL.
Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0.
Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946
Hole location determined by Survey.

Co-ordinates:
5920092.60mN
1754813.92mE
Elevation: 12.29mRL
Inclination: -90°

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

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Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

Borehole

Location: **46 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH04**

Client: **Watercare**

Date: **5/07/2018**

R.L. (m)	Depth (m)	Drilling Method	Drilling Flush Return (%)	TCR (SCR) [RQD] %	Spacing of Natural Defects (mm)	Relative Strength	Weathering Grade	Sampling	In-Situ Testing	Geology Legend	GroundWater	Description of Strata	Defect Description	Comments	Geological Unit	Backfill / Installation
-18	31	HQ3	Flush Type: Water Flush Colour: Grey 255075	94 (94) [94]	600 200 60	EW VW W MS S VS	FW SW MW HW CW XW					CORE LOSS. Moderately weathered, dark grey, homogeneous, medium grained SANDSTONE. Very weak. Minor white clasts present throughout matrix (1mm), trace dark brownish green mudstone clasts (2-6 mm). *31.06m to 31.11m: Mudstone bed.* CIE-BH04 terminated at 31.50m. Target Depth	30.47: Jt 30° P, T, C. 30.54: Jt 30° P, T, C. 30.61: Jt 30° P, T, C. 30.68: Jt 30° P, T, C. 30.75: Jt 30° P, T, C.		WW	
-19																

Shift Details & Standing Water Level
10/07/2018 4:00:00 PM
11/07/2018 7:30:00 AM(Water depth 0.8m)

Description of Strata
BOUNDARY: Well defined; Gradational; Poorly defined

Defect Description
TYPE: CS Clay seam; C Cleavage; CR Crushed zone; DZ Decomposed zone; DB Drilling induced fracture; FL Foliation; FZ Fracture zone; IF Incipient fracture; JT Joint; SC Schistosity; SH Shear; SZ Shear Zone; SL Sill; VN Vein; VD Void
SURFACE: C Clean; Mc Mineral coat; Si Soil infill; Sn Surface stain; V Veneer
PLANARITY: P Planar; St Stepped; U Undulating
ROUGHNESS: R Rough; Ss Slickensided; Sm Smooth
APERTURE: T 0mm; Vn 0-2mm; N 2-6mm; Mn 6-20mm; Mw 20-60mm; W 60-200mm; Vw >200mm

Started:	5/07/2018
Finished:	10/07/2018
Driller:	McMillan
Plant:	Rig N111 (McMillan)
Logged:	S. Burgess
Checked:	LD

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations
1	-3.78	14/09/2018		Midday WL

Remarks
Packer Test 1 at 9.75-12.00 m, Packer Test 2 at 19.25-22.50 m, Packer Test 3 at 28.50-31.50 m. Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.1 m RL.
Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0.
Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946
Hole location determined by Survey.

Co-ordinates:
5920092.60mN
1754813.92mE
Elevation: 12.29mRL
Inclination: -90°

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: COMPILATION BOREHOLE Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with AECOM and McMillen Jacobs Associates		Preliminary Log of Investigation
Project: **Central Interceptor CIGI5**		**Borehole**
Location: **44 Tawariki Street, Grey Lynn**	Project No: **AE04725**	Hole ID: **CIE-BH05**
Client: **Watercare**		Date: **11/07/2018**

Started:	11/07/2018	Remarks Packer Test 1: 11.00 - 13.50 m, Packer Test 2: 19.00 - 21.00 m, Packer Test 3: 28.50 - 31.50 m. Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.0 m. Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0. Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946 Hole location determined by Survey.	Co-ordinates: 5920115.28mN 1754793.05mE Elevation: 11.59mRL Inclination: -90°
Finished:	13/07/2018		
Driller:	McMillan		
Plant:	Rig N111 (McMillan)		
Logged:	S. Burgess		
Checked:	LD		Log cover page

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: BH COVER SHEET Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18

Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

Borehole

Location: **44 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH05**

Client: **Watercare**

Date: **11/07/2018**

R.L. (m)	Depth (m)	Drilling Method	Drilling Flush Return (%)	TCR (SCR) [RQD] %	Spacing of Natural Defects (mm)	Relative Strength	Weathering Grade	Sampling	In-Situ Testing	Geology Legend	GroundWater	Description of Strata	Comments	Geological Unit	Backfill / Installation
11	1	VAC EX		0								Vacuum Excavation			
10	2	SPT		100					SPT 1,2,2 N=4			Silty CLAY; light grey mottled orange. Very soft, moist, high plasticity, not dilatant.			
		HQ3 11/07/2018 7:30:00 AM Water depth 0.3m		100								*2.25m: Becomes brown grey with some wood fragments. Soft.*			
9	3											*2.70m: Becomes firm.*		MG	
		TBX		100								Push Tube. Material change at 3.1m from silty CLAY to silty clayey SAND.	3m: Cased to 3.0 m.		
8	4	SPT		100					SPT 0,0,1 N=1			Residually weathered, SANDSTONE. Clayey silty fine SAND; dark grey, homogeneous. Soft, moist, low plasticity, low dilatancy.			
		HQ3		100										T	
7	5	TBX		100								Push Tube. *4.50m: Becomes firm.*			
		SPT		100					SPT 6,11,12 N=23			Residually weathered, SANDSTONE. Clayey silty fine SAND; dark grey, homogeneous. Firm, moist, low plasticity, Insensitive			
6	6	HQ3	*Flush Type:* **Water** *Flush Colour:* **Grey**	77 (77) [77]								CORE LOSS. Highly weathered, fine grained SANDSTONE. Extremely weak. Clayey silty fine SAND; dark grey, homogeneous. Dense, moist.			
		SPT		100					SPT 5,9,11 N=20			*6.45m to 6.80m: Recovered as Silty fine SAND*		Wwc	
5	7	HQ3		67 (33) [33]								CORE LOSS.			
4		SPT		100					SPT 8,12,19 N=31			Highly weathered, fine grained SANDSTONE. Extremely weak. Silty fine SAND, some clay; dark grey, homogeneous. Dense, moist.			
	8	HQ3 11/07/2018 4:00:00 PM Water depth 0.2m		71 (65) [65]								Highly weathered, dark grey, BRECCIA with fine to medium gravel sized, angular to sub-rounded mudstone clasts in a well cemented fine sandstone matrix. Extremely weak. Core loss. Infer BRECCIA and a mudstone clast blocked catcher.			
3		SPT 12/07/2018 7:30:00 AM		100					SPT 12,20,30 N>50 50/290			Highly weathered, dark grey, BRECCIA with fine to medium gravel sized, angular to sub-rounded mudstone clasts in a well cemented fine sandstone matrix. Extremely weak. Highly weathered, fine grained SANDSTONE. Extremely weak. Silty fine SAND, some clay; dark grey, homogeneous. Very dense, moist.		Wwnc	
2	9														
10												Highly weathered, dark grey, BRECCIA, fine to medium gravel sized, sub- rounded mudstone and fine grained sandstone clasts in a fine		Wwc	

Defect Description

TYPE: CS Clay seam; C Cleavage; CR Crushed zone; DZ Decomposed zone; DB Drilling induced fracture; FL Foliation; FZ Fracture zone; IF Incipient fracture; JT Joint; SC Schistosity; SH Shear; SZ Shear Zone; SL Sill; VN Vein; VD Void

SURFACE: C Clean; Mc Mineral coat; SI Soil infill; Sn Surface stain; V Veneer

PLANARITY: P Planar; St Stepped; U Undulating

ROUGHNESS: R Rough; Ss Slickensided; Sm Smooth

APERTURE: T 0mm; Vn 0-2mm; N 2-6mm; Mn 6-20mm; Mw 20-60mm; W 60-200mm; Vw >200mm

Boundary: Well defined; Gradational; Poorly defined

Started: 11/07/2018

Finished: 13/07/2018

Driller: McMillan

Plant: Rig N111 (McMillan)

Logged: S. Burgess

Checked: LD

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations
1	-4.39	13/09/2018		End of Day WL

Remarks

Packer Test 1: 11.00 - 13.50 m, Packer Test 2: 19.00 - 21.00 m, Packer Test 3: 28.50 - 31.50 m.
Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.0 m RL.
Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0.
Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946 Hole location determined by Survey.

Co-ordinates:
5920115.28mN
1754793.05mE
Elevation: 11.59mRL
Inclination: -90°

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: COMPILATION BOREHOLE Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

Borehole

Location: **44 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH05**

Client: **Watercare**

Date: **11/07/2018**

R.L. (m)	Depth (m)	Shaft Details & Standing Water Level / Drilling Method	Drilling Flush Return (%)	TCR (SCR) [RQD] %	Spacing of Natural Defects (mm)	Relative Strength	Weathering Grade	Sampling	In-Situ Testing	Geology Legend	GroundWater	Description of Strata	Defect Description	Comments	Geological Unit	Backfill / Installation
1	11	HQ3	255075	58 (25) [25]								grained sandstone matrix. Recovered as clasts with silty fine SAND; dense.				
		SPT		100					SPT_a 10,16,25 N=41			Highly weathered, dark grey, interbedded, moderately thinly bedded fine grained SANDSTONE and thinly bedded MUDSTONE. Sub-horizontal bedding. Extremely weak. Mudstone has trace black carbonaceous material.			Wwc(Contd.)	
0		HQ3		76 (48) [48]								CORE LOSS. Infer residual BRECCIA from 10.2m. Clast blocked catcher.				
	12	SPT		100					SPT_a 13,24,26 N>50 50/280			Completely weathered, dark grey, BRECCIA recovered as a silty CLAY with subangular mudstone clasts (5-10mm). Soft, moist, low plasticity.			Wwnc	
-1		HQ3		89 (89) [87]								Highly weathered, dark grey, BRECCIA with fine to coarse gravel sized, sub-angular to sub-rounded mudstone clasts and some wood fragments in a fine grained sandstone matrix. Very weak. *11.57m: Recovered as clasts only; infer matrix washed out.*				
	13	SPT		0					SPT_c 50 N>50 50/120			CORE LOSS.	12.43: Jt 90° Sm, P, Vn, C. 12.45: Jt 90° Sm, P, Vn, C. 12.67: Jt 90° R, St, Vn, C.			
-2		HQ3		91 (91) [91]								Highly weathered, dark grey, interbedded, fine grained SANDSTONE and MUDSTONE. Sandstone beds are moderately thin, moderately inclined. Mudstone beds are thin to moderately thin, moderately inclined. Very weak.	13.37: Jt 70° R, P, Vn, C. 13.65: Jt 70° Sm, U, Vn, Si of sandy clay. 13.95: Jt 70° R, P, Vn, C.		Wwc	
	14	SPT		0								CORE LOSS.				
-3		HQ3		92 (92) [92]					SPT_c 50 N>50 50/82			Highly weathered, dark grey, interbedded, fine grained SANDSTONE and MUDSTONE. Sandstone beds are moderately thin, moderately inclined. Mudstone beds are thin to moderately thin, moderately inclined. Very weak. *14.70m to 15.00m: Becomes interbedded with laminated carbonaceous beds (black).* *14.77m: Becomes weak.* *15.12m to 15.33m: Moderately weathered, moderately thick SANDSTONE bed. Moderately strong.*	14.90: Jt 70° R, St, Vn, C. 15.34: Jt 70° R, P, Vn, C.			
	15	SPT										Moderately weathered, dark grey, homogeneous fine grained SANDSTONE.Weak, moderately inclined. *15.83m: Becomes medium grained with white and cream fine gravel sized clasts and black speckles inferred as trace carbonaceous material.*	16.15: Jt 70° R, P, Vn, C.		Wuw	
-4		HQ3										CORE LOSS.				
	16											Moderately weathered, dark grey, homogeneous, fine grained SANDSTONE. Weak, moderately inclined. Minor white clasts present throughout matrix (1mm).				
-5		HQ3		83 (83) [83]								Moderately weathered, dark grey, homogeneous, fine to medium grained SANDSTONE. Weak. Minor white clasts present throughout matrix (1mm). *17.10m to 17.45m: Extremely weak.*				
	17											CORE LOSS.				
-6												Slightly weathered, dark grey, fine to medium grained SANDSTONE. Strong. Matrix has some sand to fine gravel sized white and cream clasts and discontinous black carbonaceous beds.			Wpvc	
	18											Moderately weathered, dark grey, fine to medium grained SANDSTONE. Very weak. Minor white clasts present throughout matrix (1mm). *18.26m: Becomes extremely weak* *18.50m: Becomes very weak.*	18.55: Jt 10° Sm, P, T, C, joint is displaced by 10mm.			
-7		HQ3		97 (97) [97]												
	19															
-8												Moderately weathered, dark grey, medium to coarse grained SANDSTONE. Extremly weak. Minor white clasts present throughout matrix (1mm).				
	20															

Flush Type: **Water**
Flush Colour: **Grey**

12/07/2018 4:00:00 PM
13/07/2018 7:30:00 AM(Water depth 0m)

Description of Strata
BOUNDARY: Well defined; Gradational; Poorly defined

Defect Description
TYPE: CS Clay seam; C Cleavage; CR Crushed zone; DZ Decomposed zone; DB Drilling induced fracture; FL Foliation; FZ Fracture zone; IF Incipient fracture; JT Joint; SC Schistosity; SH Shear; SZ Shear Zone; SL Sill; VN Vein; VO Void
SURFACE: C Clean; Mc Mineral coat; Si Soil infill; Sn Surface stain; V Veneer
PLANARITY: P Planar; St Stepped; U Undulating
ROUGHNESS: R Rough; Ss Slickensided; Sm Smooth
APERTURE: T 0mm; Vn 0-2mm; N 2-6mm; Mn 6-20mm; Mw 20-60mm; W 60-200mm; Vw >200mm

Started: 11/07/2018
Finished: 13/07/2018
Driller: McMillan
Plant: Rig N111 (McMillan)
Logged: S. Burgess
Checked: LD

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations
1	-4.39	13/09/2018		End of Day WL

Remarks
Packer Test 1: 11.00 - 13.50 m, Packer Test 2: 19.00 - 21.00 m, Packer Test 3: 28.50 - 31.50 m.
Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.0 m RL.
Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0.
Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946 Hole location determined by Survey.

Co-ordinates:
5920115.28mN
1754793.05mE
Elevation: 11.59mRL
Inclination: -90°

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: COMPILATION BOREHOLE Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

Borehole

Location: **44 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH05**

Client: **Watercare**

Date: **11/07/2018**

R.L. (m)	Depth (m)	Drilling Method	Drilling Flush Return (%)	TCR (SCR) [RQD] %	Spacing of Natural Defects (mm)	Relative Strength	Weathering Grade	Sampling	In-Situ Testing	Geology Legend	GroundWater	Description of Strata	Defect Description	Comments	Geological Unit	Backfill / Installation
-9	21	HQ3	255075	93 (93) [93]								Moderately weathered, dark grey, interbedded, fine grained SANDSTONE and MUDSTONE. Very weak, moderately inclined. Sandstone beds are moderately thick, mudstone beds are thin. With trace laminated to thin carbonaceous beds.	20.75: Jt 70° R, P, Vn, C.	20m: Borehole becomes artesian.		
												CORE LOSS.				
-10	22	HQ3		87 (87) [87]								Moderately weathered, dark grey, interbedded, fine grained SANDSTONE and MUDSTONE. Very weak, moderately inclined. Sandstone beds are moderately thick, mudstone beds are thin. With trace laminated to thin carbonaceous beds. *21.23m to 21.53m: Moderately thick sandstone bed.* *22.01m to 22.65m: Thick sandstone bed.*	21.08: Jt 70° R, P, Vn, C. 21.30: Jt 70° R, P, Vn, C. 21.45: Jt 70° R, P, Vn, C. 21.69: Jt 70° R, P, Vn, C.			
												CORE LOSS.				
-11	23	HQ3		96 (96) [96]								Moderately weathered, dark grey, interbedded, fine grained SANDSTONE and MUDSTONE. Very weak, moderately inclined. Sandstone beds are moderately thick, mudstone beds are thin. With trace laminated to thin carbonaceous beds. *23.24m to 23.41m: Slightly weathered, moderately thick, fine grained sandstone bed. Strong.* *23.41m to 24.20m: Moderately thick medium grained sandstone bed.*	22.79: Jt 70° R, U, Vn, C. 23.15: Jt 70° R, P, Vn, C. 23.48: Jt 70° R, P, Vn, C.		Wuw(Contd.)	
-12	24	HQ3											24.00: Jt 70° R, P, Vn, C. 24.25-24.30: Fz R, St, Mw, Si of rock fragments and sandy clay.			
-13	25	HQ3	Flush Type: Water Flush Colour: Clear	87 (76) [76]								Moderately weathered, grey with trace white speckles, fine grained to coarse SANDSTONE. Very weak. With trace fine gravel sized mudstone clasts. Moderately weathered, dark grey, BRECCIA with fine to medium gravel sized, angular to sub-rounded mudstone clasts in a fine sandstone matrix. Extremely weak.	24.27: Jt 70° R, P, Vn, C. 25.13: Jt 70° R, U, Vn, C.			
-14												CORE LOSS.				
-15	26	HQ3		93 (93) [93]								Moderately weathered, dark grey speckled white, coarse grained SANDSTONE. Very weak. With trace fine to medium gravel sized, sub-angular mudstone clasts. *25.82m: Becomes weak.* *26.20m to 26.35m: Moderately thick medium grained sandstone bed.*	26.39: Jt 70° R, U, Vn, C.			
	27											CORE LOSS.				
-16		HQ3		83 (83) [83]								Moderately weathered, dark grey speckled white, coarse grained SANDSTONE. Very weak. With trace fine to medium gravel sized, sub-angular mudstone clasts.	27.20: Jt 50° R, P, Vn, C. 27.34: Jt 70° R, P, Vn, C. 27.86: Jt 70° R, P, Vn, C.		Wpvc	
-17	28											CORE LOSS.				
	29	HQ3		100 (100) [100]								Moderately weathered, dark grey speckled white, coarse grained SANDSTONE. Very weak. With trace fine to medium gravel sized, sub-angular mudstone clasts. *29.48m to 29.54m: Moderately thin bed of discontinuous carbonaceous material.*	29.42: Jt 70° R, P, Vn, C.			
-18	30															

Defect Description

TYPE: CS Clay seam; C Cleavage; CR Crushed zone; DZ Decomposed zone; DB Drilling induced fracture; FL Foliation; FZ Fracture zone; F Incipient fracture; JT Joint; SC Schistosity; SH Shear; SZ Shear Zone; SL Sill; VN Vein; VO Void

SURFACE: C Clean; Mc Mineral coat; Si Soil infill; Sn Surface stain; V Veneer

PLANARITY: P Planar; St Stepped; U Undulating

ROUGHNESS: R Rough; Ss Slickensided; Sm Smooth

APERTURE: T 0mm; Vn 0-2mm; N 2-6mm; Mn 6-20mm; Mw 20-60mm; W 60-200mm; Vw >200mm

Started: 11/07/2018

Finished: 13/07/2018

Driller: McMillan

Plant: Rig N111 (McMillan)

Logged: S. Burgess

Checked: LD

Groundwater Observations

No.	Struck (m)	Date	Standing (m)	Observations
1	-4.39	13/09/2018		End of Day WL

Remarks

Packer Test 1: 11.00 - 13.50 m, Packer Test 2: 19.00 - 21.00 m, Packer Test 3: 28.50 - 31.50 m.
Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.0 m RL.
Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0.
Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946 Hole location determined by Survey.

Co-ordinates:
5920115.28mN
1754793.05mE
Elevation: 11.59mRL
Inclination: -90°

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: COMPILATION BOREHOLE Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18
Version CI 1.10 09/07/2015 - R.Roberts

Jacobs in association with
AECOM and McMillen Jacobs Associates

Preliminary Log of Investigation

Project: **Central Interceptor CIGI5**

Borehole

Location: **44 Tawariki Street, Grey Lynn** Project No: **AE04725**

Hole ID: **CIE-BH05**

Client: **Watercare**

Date: **11/07/2018**

R.L. (m)	Depth (m)	Drilling Method	Drilling Flush Return (%)	TCR (SCR) [RQD] %	Spacing of Natural Defects (mm)	Relative Strength	Weathering Grade	Sampling	In-Situ Testing	Geology Legend	GroundWater	Description of Strata	Comments	Geological Unit	Backfill / Installation
-19	31	HQ3	Flush Type: Water Flush Colour: Clear 255075	93 (93) [93]	600 200 60	EW VW W MS S VS	FW SW MW HW CW XW					Moderately weathered, dark grey speckled white, coarse grained SANDSTONE. Very weak. With trace fine to medium gravel sized, sub-angular mudstone clasts. *30.78m to 30.96m: Strong bed.* CORE LOSS. Moderately weathered, dark grey speckled white, coarse grained SANDSTONE. Very weak. With trace fine to medium gravel sized, sub-angular mudstone clasts. CIE-BH05 terminated at 31.50m. Target Depth		Wpwq (Contd.)	

BOUNDARY: Well defined; Gradational; Poorly defined

Defect Description

TYPE: CS Clay seam; C Cleavage; CR Crushed zone; DZ Decomposed zone; DB Drilling induced fracture; FL Foliation; FZ Fracture zone; IF Incipient fracture; JT Joint; SC Schistosity; SH Shear; SZ Shear Zone; SL Sill; VN Vein; VD Void

SURFACE: C Clean; Mc Mineral coat; Si Soil infill; Sn Surface stain; V Veneer

PLANARITY: P Planar; St Stepped; U Undulating

ROUGHNESS: R Rough; Ss Slickensided; Sm Smooth

APERTURE: T 0mm; Vn 0-2mm; N 2-6mm; Mn 6-20mm; Mw 20-60mm; W 60-200mm; Vw >200mm

Shift Details & Standing Water Level: 13/07/2018 4:00:00 PM; 18/07/2018 7:30:00 AM(Water depth - 2.9m)

Started:	11/07/2018	Groundwater Observations	Co-ordinates:
Finished:	13/07/2018	No. Struck (m) Date Standing (m) Observations 1 -4.39 13/09/2018 End of Day WL	5920115.28mN 1754793.05mE
Driller:	McMillan	Remarks Packer Test 1: 11.00 - 13.50 m, Packer Test 2: 19.00 - 21.00 m, Packer Test 3: 28.50 - 31.50 m. Vibrating wire piezometer installed with sensor at 26.0m. Water level = 16.0 m RL. Joint angles are relative to the core axis. If a borehole is true vertical; horizontal=90, vertical=0. Hole location is in NZTM projection. Elevation is relative to Auckland Vertical Datum 1946 Hole location determined by Survey.	Elevation: 11.59mRL
Plant:	Rig N111 (McMillan)		Inclination: -90°
Logged:	S. Burgess		
Checked:	LD		Page 4 of 4

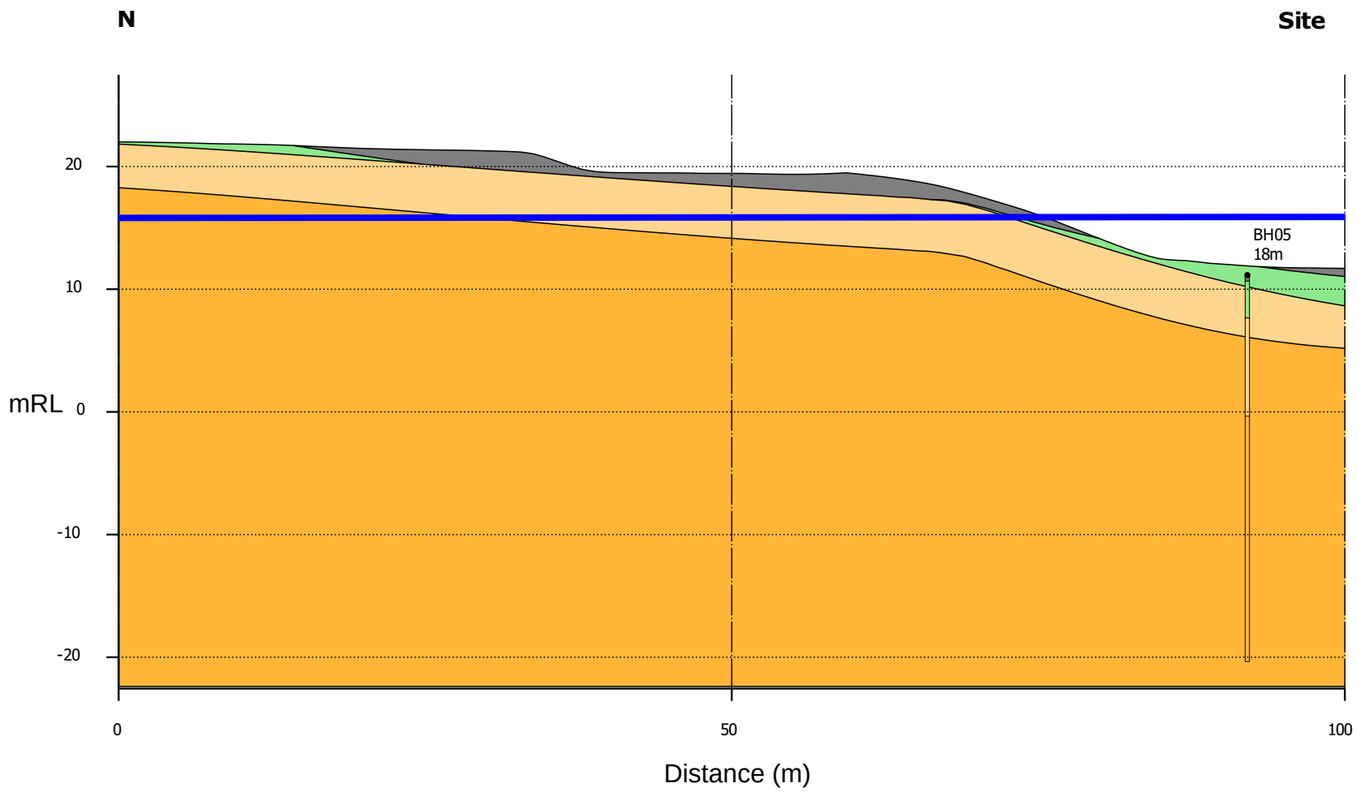
See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Data Template: AE04725 CI MASTER (NEW TEMPLATE).GPJ Output Form: COMPILATION BOREHOLE Project File Name: AE04725 CIGI4 ADDITIONAL INVESTIGATION.GPJ 7/9/18

Version CI 1.10 09/07/2015 - R.Roberts

Appendix B: Geological Cross Section and Site Plan

Central Interceptor Tawariki Shafts - Cross Section North



Responsible dept.	Technical reference	Creator	Approved by	
Geotechnical	Section North	TRMC		
Legal owner		Document type: Cross Section	Document status: Draft	
		Title: Central Interceptor Tawariki Shafts	Identification number: 30552.9090	
			Rev. 1 / Date of issue / Sheet 1	

Legend

Ground Model

- Fill
- Rock ECBF
- Tauranga Group
- Weathered ECBF

Location

N: 1754830, 5920202

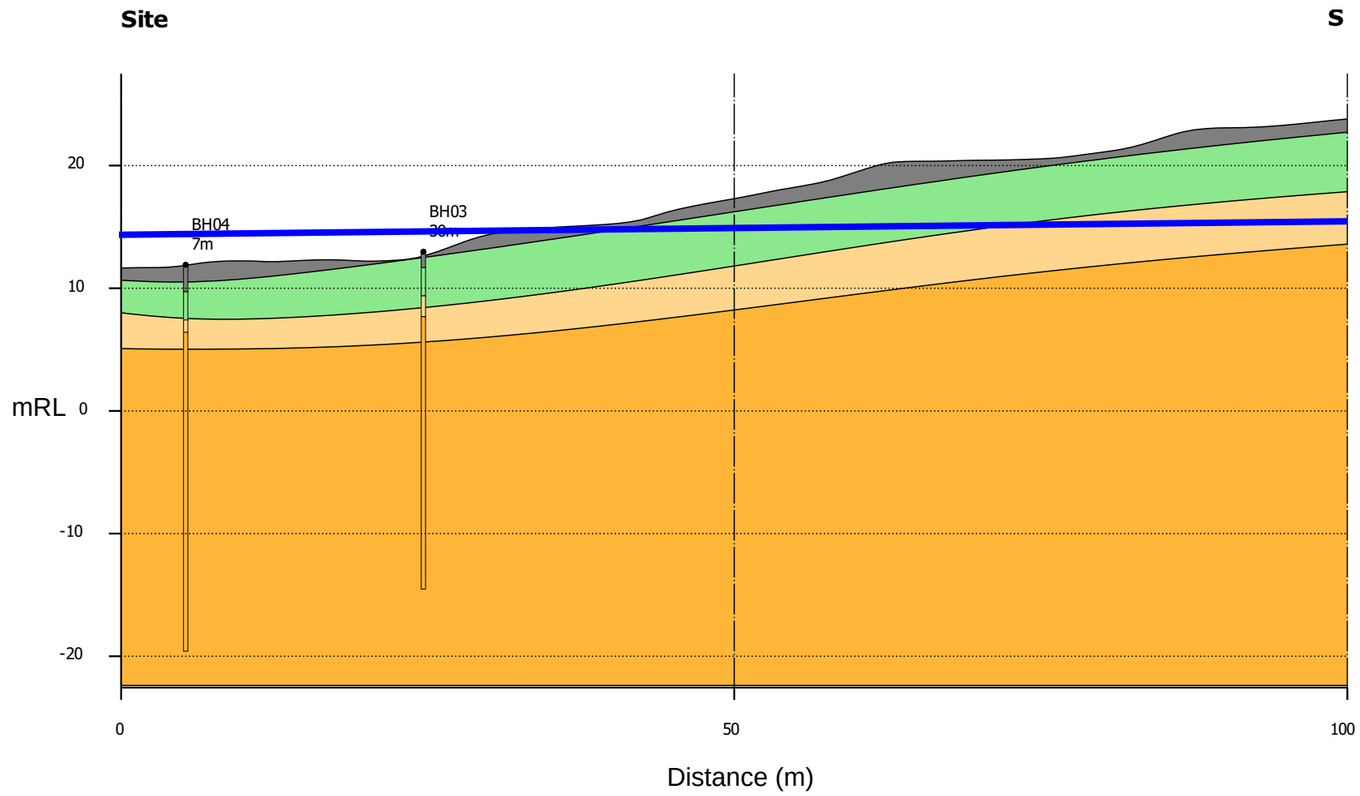
Site: 1754809, 5920104

Scale: 1:500

Vertical exaggeration: 1x

0m 50m

Central Interceptor Tawariki Shafts - Cross Section South



Responsible dept.	Technical reference	Creator	Approved by	
Geotechnical	Section South	TRMC		

Legal owner	Document type: Cross Section	Document status: Draft	
	Title: Central Interceptor Tawariki Shafts	Identification number: 30552.9090	
		Rev.: 1	Date of issue:	Sheet: 1

Legend

Ground Model

- Fill
- Rock ECBF
- Tauranga Group
- Weathered ECBF

Location

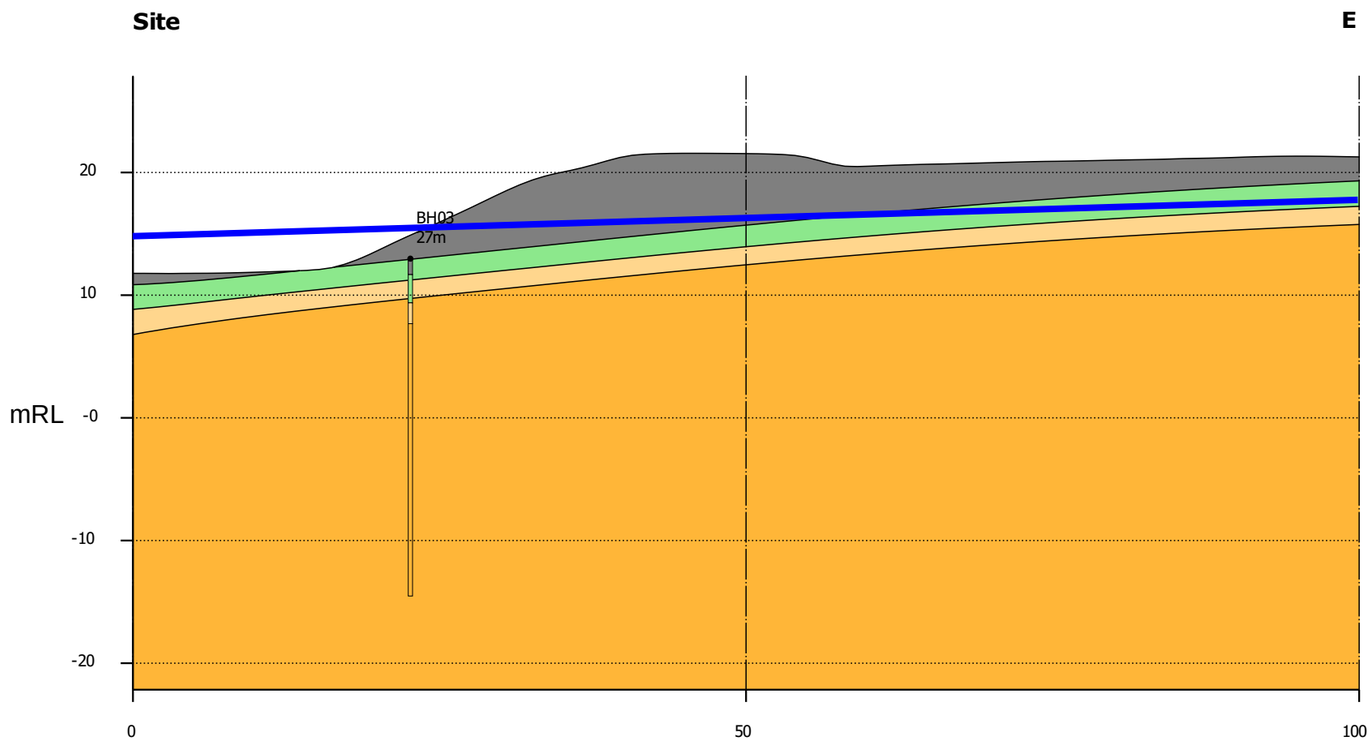
Site: 1754809, 5920099
S: 1754788, 5920001

Scale: 1:500

Vertical exaggeration: 1x

0m 50m

Central Interceptor Tawariki Shafts - Cross Section East



Responsible dept.	Technical reference	Creator	Approved by	
Geotechnical	Section East	TRMC		

Legal owner	Document type: Cross Section	Document status: Draft	
	Title: Central Interceptor Tawariki Shafts	Identification number: 30552.9090	
		Rev.: 1	Date of issue:	Sheet: 1

Legend

Ground Model

- Fill
- Rock ECBF
- Tauranga Group
- Weathered ECBF

Location

Site: 1754817, 5920100

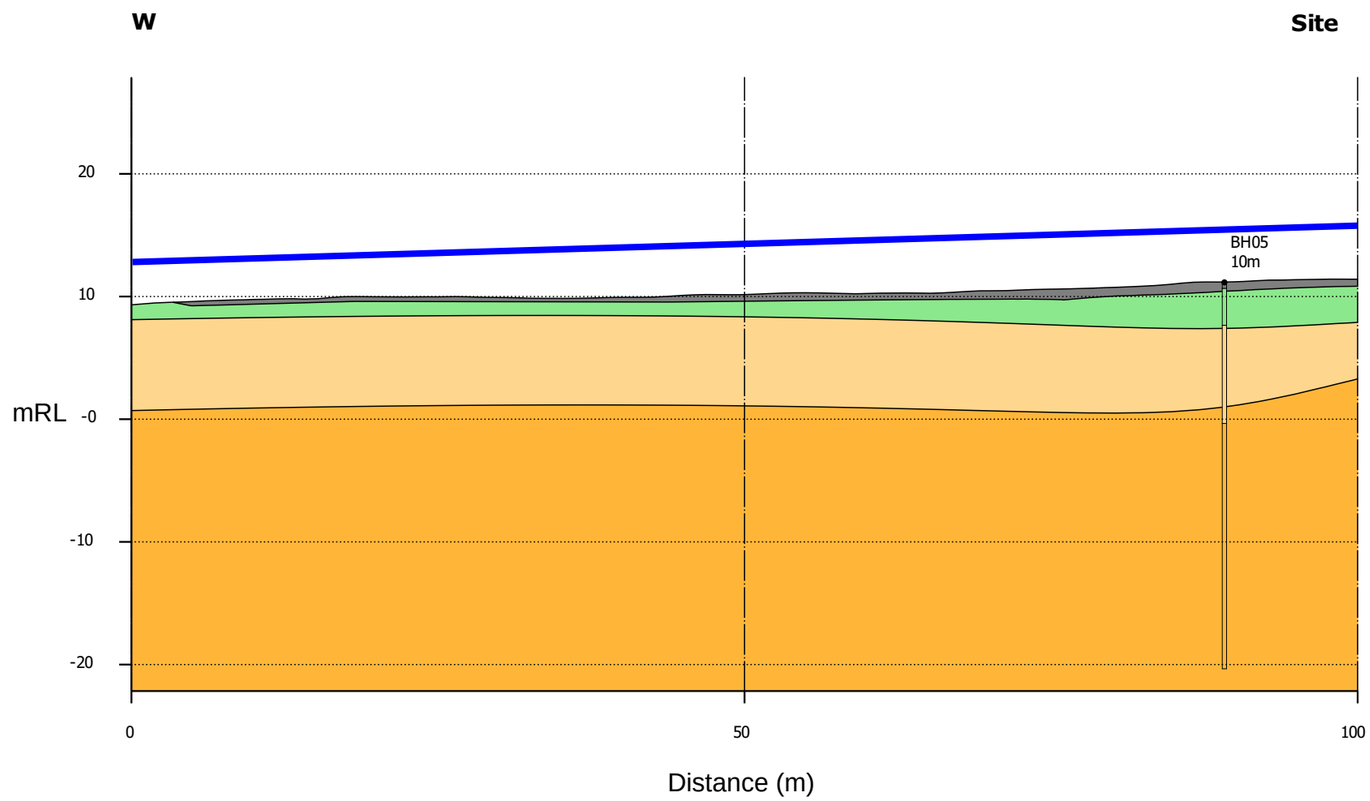
E: 1754915, 5920080

Scale: 1:500

Vertical exaggeration: 1x

0m 50m

Central Interceptor Tawariki Shafts - Cross Section West



Responsible dept.	Technical reference	Creator	Approved by	
Geotechnical	Section West	TRMC		

Legal owner	Document type: Cross Section	Document status: Draft	
	Title: Central Interceptor Tawariki Shafts	Identification number: 30552.9090	
		Rev.: 1	Date of issue:	Sheet: 1

Legend

Ground Model

- Fill
- Rock ECBF
- Tauranga Group
- Weathered ECBF

Location

W: 1754704, 5920123

Site: 1754802, 5920103

Scale: 1:500

Vertical exaggeration: 1x

0m — 50m

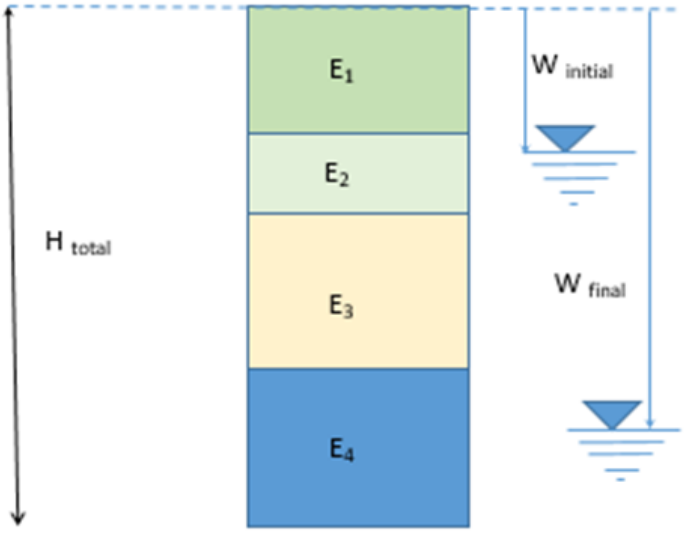
Appendix C: Drawdown induced settlement method

Drawdown-induced settlement method

Observation points were used for assessing groundwater drawdown due to dewatering. These observation points were positioned along four (4) lines of section labelled north: N, south: S, east: E, west: W as shown below.

Drawdown-induced settlement was estimated for each observation point using the following approach:

- Observation points (X,Y) obtained from lines of section N, S, E, W.
- Geological contact elevation (Z) values (m RL) obtained from LeapFrog model.
- Static water level ($W_{initial}$) adopted from the initial heads from the dewatering assessment.
- Final groundwater level (W_{final}) obtained from the AnAqSim model results.
- 1D settlement assessment using an incremental layer-wise summation method calculated in a Python[1] script.
  - Divided the geological profile (H_{total}) into incremental units for calculation, in this case 0.1 m thick.
  - Assigned assumed constrained modulus to each unit.
  - Calculated the change in pore water pressure at the centre of each incremental layer caused by the groundwater drawdown (refer Equation 1).
  - Estimated the settlement of each incremental unit layer and sum the incremental settlement (refer Equation 2).
- The following assumptions were made for the settlement assessment:
  - Initial static water levels were considered hydrostatic.
  - ECBF unit was considered incompressible.



Example soil column and initial/final water level for calculating settlement using layer-wise summation method.

[1] www.python.org

Draft

Equation 2: Change in pore water pressure:

$$\Delta P = \gamma_w(Water_{initial} - Water_{final})$$

$\Delta P = change\ in\ pore\ water\ pressure\ (kPa)$

$\gamma_w = unit\ weight\ of\ water\ (kPa)$

$Water_{initial} = Piezomteric\ head\ before\ dewatering\ (m)$

$Water_{final} = Piezomteric\ head\ after\ dewatering\ (m)$

Equation 1: Layer wise summation method:

$$S = \sum_{i=1}^{n} \left(\varphi \frac{\Delta P_i}{E_i} H_i \right)$$

$S = total\ settlement\ caused\ by\ dewatering\ (m)$

$\Delta P = change\ in\ pore\ water\ pressure$ *(Equation 2)*

$\Delta P_i = additional\ load\ of\ the\ calculated\ soil\ layer\ caused\ by\ dewatering\ (kPa)$

$\varphi =$ empirical coefficient, defined as 1 in this calculation

$E_i = compression\ modulus\ of\ the\ calculated\ soil\ layer\ (kPa)$

$H_i = thickness\ of\ the\ calculated\ soil\ layer\ (m)$

Draft

Appendix D: Ground Settlement Contour Plan

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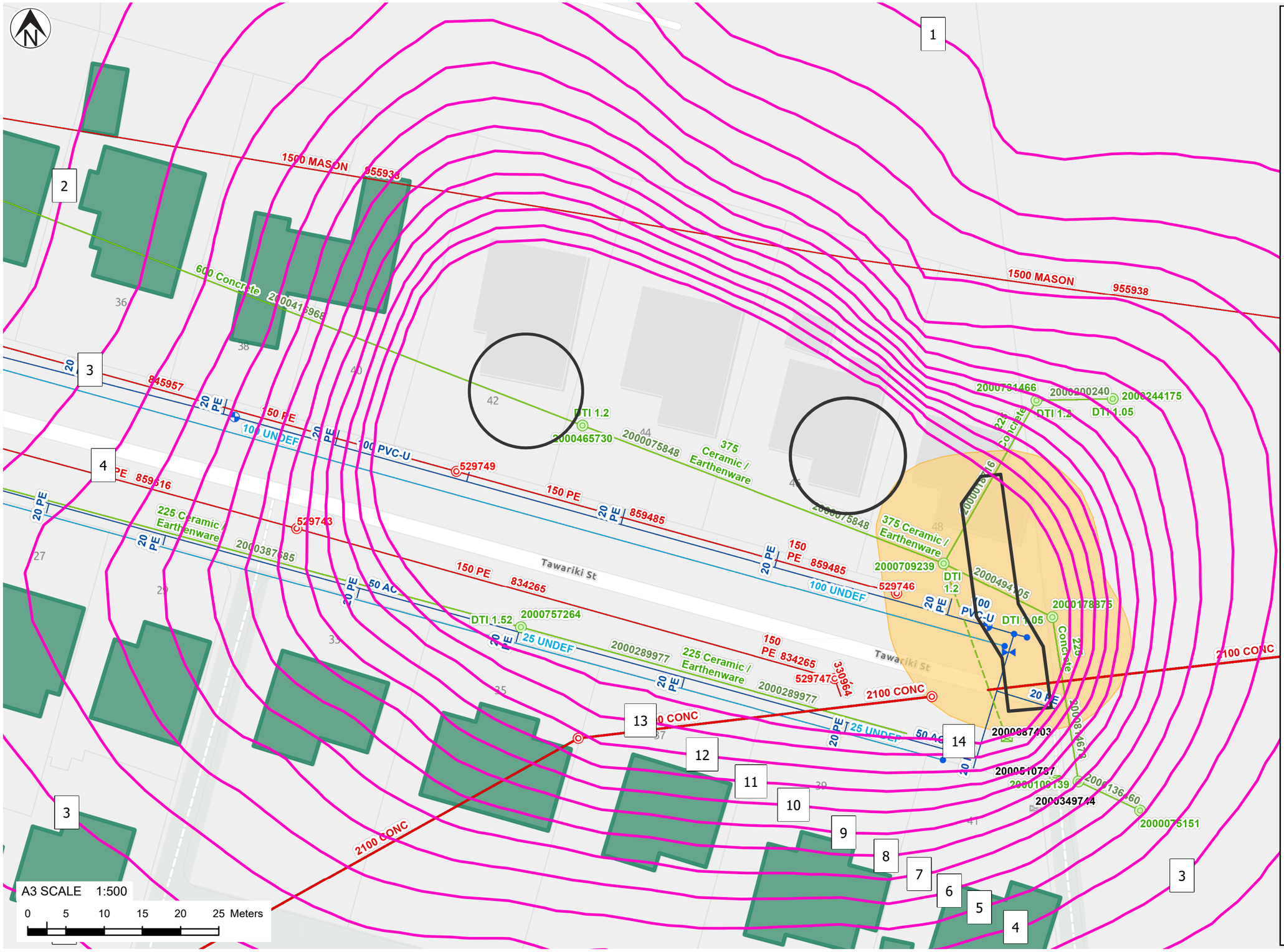
C:\Users\trmc\Desktop\Tawariki GIS\gis_Aug22.aprx Layout: Map1 2022-Sep-12 9:44 am Drawn by TRMC



LEGEND

- Run0_Drawdown-induced settlement (mm)
- Excavation Locations
- Building outlines (LINZ)
- Mechanical Settlement Zone of Influence

Wastewater Pipe (Local)

- Operational
- Wastewater Manhole (Local)

Wastewater Pipe (Transmission)

- Operational
- Wastewater Manhole (Transmission)

Stormwater Manhole And Chamber

- Public - Standard/ Custom

Stormwater Catchpit

- Public
- Private

Stormwater Pipe

- Public - Gravity Mains

Stormwater Connection

- Public

Water Pipe (Local)

- Operational (Potable)
- Abandoned / Not Operational
- Water Valve (Local)
- Water Hydrant (Local)
- Water Other Fitting (Local)

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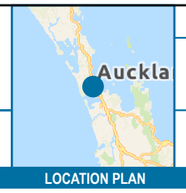
NOTES:

Basemap UndergroundServices: public. NZ Light Grey Canvas (Vector): Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.
Underground services (AC database), Building outlines (LINZ)

REV	DESCRIPTION	GIS	CHK	DATE
0	First version			



PROJECT No.	30552.9090		
DESIGNED	TRMC	SEP.22	
DRAWN	TRMC	SEP.22	
CHECKED	SVB	SEP.22	
APPROVED		DATE	

CLIENT **WATERCARE SERVICES LTD**

PROJECT **CENTRAL INTERCEPTOR TAWARIKI ST. SHAFTS**

TITLE DRAWDOWN-INDUCED SETTLEMENT RESULTS RELATIVE TO UNDERGROUND SERVICES AND RESIDENTIAL DWELLINGS NEARBY

SCALE (A3) 1:500 FIG No. FIGURE 1. REV 0

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