Proposed Sutton Block Expansion Groundwater & Surface Water Effects Assessment

Prepared for

Stevenson Aggregates Limited

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Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Stevenson Aggregates Limited and others referred to in the report. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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Executive Summary

Pattle Delamore Partners (PDP) have been commissioned by Stevenson Aggregates Ltd (SAL) to assess the effects of the proposed Sutton Block expansion, north of the existing Drury Quarry, on groundwater and surface water.

The existing Drury Quarry resource consent 40317 (WAT60277068-B) allows the Drury Quarry to be dewatered to RL-45m with a total groundwater take and diversion of 3,700m^3/d. The current pit floor is at RL-39.3m (October 2024) and aggregate resources from the existing pit is expected to be utilised within the next 20 years.

The expansion of the current Drury pit to the east, west and south is restricted by the Hunua and Drury Faults (and the quarry clean fill and managed fill to the east of the Hunua Fault). To continue to provide a local supply of aggregate resource SAL proposes to progressively develop a new standalone pit within the existing site boundary (north of the Drury Quarry), called the "Sutton Block". The proposed new quarry in this report is referred to as the Sutton Block expansion.

The proposed quarry is contained within the head of Northern Tributary (NT1) Catchment. The tributaries within this catchment discharge to the Hingaia Stream after passing through the Upper and Lower Dams along the NT1 Stream.

The proposed lowest dewatering level for the new pit is at RL-60m within a footprint of about 108ha (Figure 1). The deepening and expansion of the new quarry is a gradual process consisting of four quarry dewatering stages (within an estimated 50-year time frame).

The investigations for this report were carried out through a combination of fieldwork and desktop study using the available geological and hydrogeological data based on pumping and field permeability tests, groundwater level monitoring, groundwater and surface water sampling (for chemical analysis) and stream flow gauging.

A significant volume of data on groundwater levels, stream low flows and groundwater inflow have been collected as part of the monitoring conditions for the neighbouring quarries (Hunua Pit, Symonds Hill Pit and Drury Quarry) since 2011. This data has been incorporated in this assessment of effects for the proposed Sutton Block expansion.

Hydrogeological Setting

Groundwater at depth within the greywacke occurs in a fully saturated state and is referred to as the regional groundwater. Groundwater movement in the regional groundwater is irregular, dependent on the intensity and continuity of fractures within and across individual strata. The regional groundwater inflow into the proposed Sutton Block expansion is sourced from the greywacke east and west of the Hunua Fault.

Above the regional groundwater, there are pockets of local saturated zones (perched groundwater) which are not directly connected with the regional groundwater and generally discharge to local streams. These pockets of saturated groundwater are referred to as shallow groundwater. The boundary between the shallow and deep groundwater systems is generally a transitional zone where there is a gradual increase in extent of the saturated zone with depth (PDP 2011 and PDP 2021).

The groundwater and surface water chemical analysis indicates a difference in ionic composition between samples from the sump/groundwater and surface water, indicating minor direct hydraulic connectivity between the streams and the regional groundwater.

Based on the groundwater level monitoring data collected for the past 12 years, the groundwater flow barriers (Drury and Hunua Faults and their branches) have divided the regional groundwater into multiple hydrogeological blocks. These are referred to as the Hunua Greywacke Block, Drury Greywacke Block and Sutton Greywacke Block (the greywacke block east of Hunua Fault). The approximate location of these greywacke blocks is shown in Figure 4. The eastern boundary of the Sutton Greywacke Block is unknown but is likely to be bounded by other flow barrier faults (intervening faults) in adjacent catchments. The groundwater level in the Hunua and Drury Blocks currently is controlled by dewatering in the quarries in these blocks (i.e., former Hunua Pit, Symonds Hill Pit and Drury Pit). The main natural regional groundwater divide is to the east of Hays, Symonds and Maketu Catchment (Figure 3) separating the surface water catchments that discharge to the Tamaki Strait and Firth of Thames and the surface water catchments that discharge to the Manukau Harbour (via Hingaia Stream).

The hydraulic conductivity of the greywacke rocks within the Sutton greywacke block is close to the hydraulic conductivity applied for the assessment of effects for the existing Drury Quarry and Symonds Hill Pit dewatering consents (40317 and WAT60152106-A respectively).

For this study recharge to the regional groundwater is estimated to be about 60mm/year (about 4.6% of rainfall). This is the same recharge rate that was adopted for the recent Symonds Hill Pit and the existing Drury Quarry consent.

Assessment of Effects

The effects of the proposed Sutton Block expansion dewatering on the wider groundwater resource have been assessed using field investigation results and analytical methods.

The pre-quarry groundwater levels beneath the proposed quarry footprint within the Hunua, Drury and Sutton Greywacke Blocks are about RL64m, RL58m and RL170m. As a result of dewatering at the Symonds Hill Pit and Drury Quarry, the groundwater levels in the Hunua and Drury Greywacke Blocks have been lowered and currently are at about RL63.6m and RL-39.3m (October 2024), respectively.

By the time the new quarry reaches RL60m during Stage 3 (30 years from now), the regional groundwater to the west of the Hunua Fault within the Hunua and Drury Greywacke Blocks is likely to reach RL-5m and RL-45m respectively (these are authorised/consented lowest dewatering levels for these quarries assumed for the current assessment).

Using, the hydraulic parameters and the analytical method applied at Hunua and Symonds Hill, the theoretical groundwater inflow is predicted to range from 4,300m^3/d (Stage 2) to 18,243 m^3/d (Stage 5) and the zone of influence extend from 4.4km (Stage 2) to 7.5km (Stage 5). However, it is likely that the intervening faults will reduce the above effects as a result of the compartmental nature of the greywacke. As for other quarries in the greywacke in this region, ongoing monitoring is required to refine the predictions as the quarry floor deepens.

There will be additional shallow groundwater inflow of up to 183m^3/d within the NT1 Catchment and further short-term inflow of 1,000m^3/d is estimated to enter the sump due to the storage release from fractures following each quarry step. Therefore, the maximum groundwater inflow for the proposed quarry expansion (Stage 5) including the above short-term storage contribution is expected to be 19,426m^3/d. This is the maximum groundwater diversion rate sought in the consent application.

The proposed dewatering level at Stage 4 (RL-60m) requires partial removal of the barrier faults between the greywacke blocks (e.g., Hunua Fault). Considering the low hydraulic gradient detected in the Hunua and Drury Greywacke Blocks west of the Hunua Fault, Stage 4 dewatering may cause the groundwater within the Hunua and Drury Greywacke Blocks to drop to RL-60m. However, this is unlikely scenario as the intervening barrier faults are common in the greywacke in this area and this is likely to reduce the predicted drawdowns. In addition, the facts that only 5% of the Hunua Fault (east of the Hunua and Drury Greywacke Blocks) will be breached during the gradual progression of the proposed pit expansion, is likely to cause further reductions in the theoretical drawdowns predicted for the Hunua and Drury Greywacke Blocks. Therefore, the predictions need to be updated (as part of the consent conditions) as more monitoring data during the pit development becomes available.

The farm wells in the greywacke with permitted activity within the zones of influence for each quarry dewatering stage are identified. Based on the Auckland Council groundwater database these bores are significantly deeper than the predicted drawdowns and are likely to accommodate the drawdowns without any reduction in yield. However, as for the existing consent, SAL proposes to mitigate any adverse effects on these farm wells should they be attributed to the proposed quarry development. Mitigation options may include deepening the bores or lowering the pumps. Consent conditions are recommended to address this matter.

Given that the inferred Hunua Fault (flow barrier fault) passes through the proposed new quarry (Figures 2 and 4) it needs to be removed progressively along with the quarry rock as the pit deepens. Although field data currently indicates a significant groundwater head gradient across the Fault, its progressive removal is not expected to give rise to any specific risks for uncontrolled changes in groundwater flows. The barrier effect of the Fault in the ground outside the quarry is not expected to be disturbed significantly by the quarrying. In addition, the fault is likely to remain intact below the new pit floor and the proposed sump is expected to intercept any westward groundwater throughflow before it can recharge the groundwater to the west of Hunua Fault. The higher heads on the eastern side of the fault will gradually reduce as the quarry is deepened and groundwater is captured in the quarry sump.

Similar to other quarries within the greywacke, the proposed dewatering is unlikely to have any adverse effects on the shallow or perched groundwater in shallow sediments, pockets of saturation in the shallow greywacke, coal measures, Waitemata Group or the lava flows (e.g. Kaarearea Paa also referred to as Ballards Cone).

The stream flow augmentation when the quarry intercepts the regional groundwater system is recommended for the Maketu Streams and a NT1 tributary along the southern boundary of the Sutton Block to offset groundwater flow captured by the quarry sump. The proposed augmentation rates may need to be revised based on the long-term stream flow and groundwater level monitoring programmes.

For other streams further away from the proposed Sutton Block (Mangawheau and Hingaia Tributary Streams), augmentation would commence only if shown to be required by actual stream flow monitoring data as the new pit deepens.

The results indicate that no change in the augmentation regime for the Symonds, Hays and Peach Hill Streams according to the consent (WAT60152106-A and 40317) is required. The consented dewatering levels in Symonds Hill and Drury Quarries are well below the Hays, Symonds Streams and any additional drawdowns caused by the proposed Sutton Block is not likely to result in any additional loss of flow in these streams. The Peach Hill Stream is currently being augmented conservatively as part of the Drury Quarry dewatering consent. The conservative current augmentation is likely to accommodate the maximum prediction flow loss as a result of the Sutton Block.

The main objective of any quarry rehabilitation programme after completion of the proposed aggregate extraction and cessation of pumping from the sump (after about 50 years), is to maintain the pre-quarry groundwater levels to the east of Hunua Fault. This can be achieved by restoration of the Fault barrier effect by judicial placement of low permeability materials over fracture zones on the quarry floor and the whole western face of the quarry.

The exact location of the barrier fault between the Hunua and Sutton Greywacke Blocks is not known. Based on the available groundwater level monitoring data, the boundary is more likely to be close to the inferred alignment of the Hunua Fault which passes through the proposed pit (Figure 4). If the recommended monitoring data as the new pit deepens show that the boundary is further to the west and well outside the proposed Sutton Block, the effects on groundwater and baseflow will be less than predicted above and likely to be limited to Sutton Greywacke Block.

Considering the conservative nature of the assessments and the recommended augmentation and mitigation programmes, the proposed Sutton Block expansion is expected to have no more than minor effects on the groundwater environment or streams low flow conditions.

Table of Contents

Table of Figures

Table of Tables

Appendices

1.0 Introduction

SAL operates the existing Drury Quarry, located 40km south of Auckland and 4.5km southeast of Drury. The location of Drury Quarry is shown in Figures 1 and 2. The quarry produces aggregate sourced from greywacke rocks. As part of the ongoing aggregate extraction activities, SAL will complete rock extraction from the existing Drury Quarry within the next 20 years and plan to expand the Drury Quarry into the Sutton Block (Sutton Block expansion), about 500m north of the existing quarry pit.

The existing groundwater consent 40317 for the current Drury Quarry authorise dewatering the regional groundwater down to RL-45m, and abstraction of up to 3,700m^3/d of groundwater. The quarry water use (e.g. dust suppression) forms only a small proportion of this groundwater volume. Most of this groundwater, discharges back to the Hingaia Stream via one of its tributaries (NT1, Figure 2).

The existing quarry footprint comprises about 60ha of the Peach Hill and the NT1 Catchments with the pre-quarry groundwater level at the sump at about RL58m (Namjou 1997). The groundwater dewatering (pumping) in the quarry started in late 2006 and currently the groundwater level is at RL-39.3 (October 2024).

The expansion of the current pit to the east, west and south is restricted by the Hunua and Drury faults (Figure 4). Therefore, SAL are proposing to extend the current greywacke extraction area progressively to an area to the north of the current pit in the Sutton Block.

PDP have been engaged by SAL to provide a groundwater effects assessment of the proposed Sutton Block expansion to support resource consent applications to Auckland Council. The proposal involved quarrying to a pit floor of RL-60m with an area of about 108ha (Figure 2). The lowering and expanding the pit is gradual process consisting of 5 quarry dewatering stages.

The assessment has been based on field site investigations (groundwater level monitoring, aquifer permeability tests (slug tests), water quality sampling and a well survey in the surrounding areas) and a desktop groundwater study using the available geological and hydrogeological data.

1.1 Objectives

The objective of this technical report is to assess the groundwater and surface water effects arising from the proposed Sutton Block expansion.

The main objectives of the report are to:

- Assess the regional and shallow groundwater diversion rate required for dewatering the Sutton Block expansion; and

- Assess the zone of influence from the proposed diversion of groundwater associated with the Sutton Block expansion, including assessing potential effects on the neighbouring wells, stream baseflows and groundwater resources.

1.2 Scope

The assessment has been carried out both through a desktop groundwater study using available geological and hydrogeological data and field investigations. Local and regional groundwater levels and the existing Drury Quarry sump inflow are monitored by SAL and the results have been used by PDP for the effects assessment. In addition, the stream flow data based on regular gauging surveys since 2012 along the existing quarry neighbouring tributaries have been used for the assessment.

PDP has gathered all available borehole and groundwater level data from the registered and unregistered well owners in the surrounding areas of the proposed quarry since 2012. This data has been used for the assessments.

The scope of the Groundwater Effects Assessment is as follows:

- Characterise the conceptual groundwater model;
- Assess the current and future zones of influence;
- Estimate long-term groundwater inflow;
- Assess the effects of the quarry pump out on the groundwater resource;
- Assess the effects of the quarry pump out on groundwater users;
- Assess potential effects on the base flows of streams; and,
- Assess any required changes to the existing and ongoing groundwater monitoring, stream flow monitoring, and stream augmentation plan.

Note that the scope, does not include an assessment of the stream diversion works during the establishment phase.

1.3 Previous Work

The regional geology of the Drury area has been described in the Geological Map, Sheet 3 Auckland (Schofield, 1967, and Kear, 1959). Nixon (1977) undertook some detailed gravity, magnetic and seismic studies across the Drury Fault to determine its nature and lateral extent. The structural features of the Drury Quarry were studied previously by Lornie (1984). Ormerod (1989) studied the structure of the Mesozoic greywacke basement in the south Auckland area using the 3D gravity modelling technique. Yang (1989) used azimuthal and multiple source bipole-quadripole resistivity soundings at Drury Quarry to study the orientation of the dominant fractures.

A hydrogeological study of the Peach Hill Catchment began in 1988 when Murray North Ltd, on behalf of the former Auckland Regional Authority, drilled 12 monitoring boreholes (BH101 to BH112) as part of the regional refuse studies carried out by the ARC between 1988 and 1989.

Following completion of the drilling, standpipe piezometers were installed in some of these bores (BH103 to 109, ARC 1988).

Murray-North Ltd performed in-situ packer tests and falling head tests on these boreholes. They also performed laboratory permeability tests on samples of the coal measures material that was encountered. In 1989, Groundwater and Civil N.Z. Consultants, GCNZ (1989) drilled another borehole (BH113) consisting of multi-level piezometers tapping the greywacke and the coal measures and carried out a water quality study in the Peach Hill Catchment (GCNZ 1989).

Namjou (1997) carried out further hydrogeological investigations to develop a conceptual groundwater model for Drury Quarry and the Peach Hill Catchment (Figure 3). As part of this study, 3D-groundwater flow and transport models were also developed to assess the feasibility of a proposed landfill at Peach Hill Catchment. He also carried out gravity survey across the Hunua Fault to assess its location.

John Ashby & Associates (1999 to 2000) completed a drilling programme in the Sutton Block to assess the aggregate resource in this area. As part of this assessment, they drilled 5 bores (00C1 to 00C5, Figure 4). All bores were equipped with 20mm piezometers.

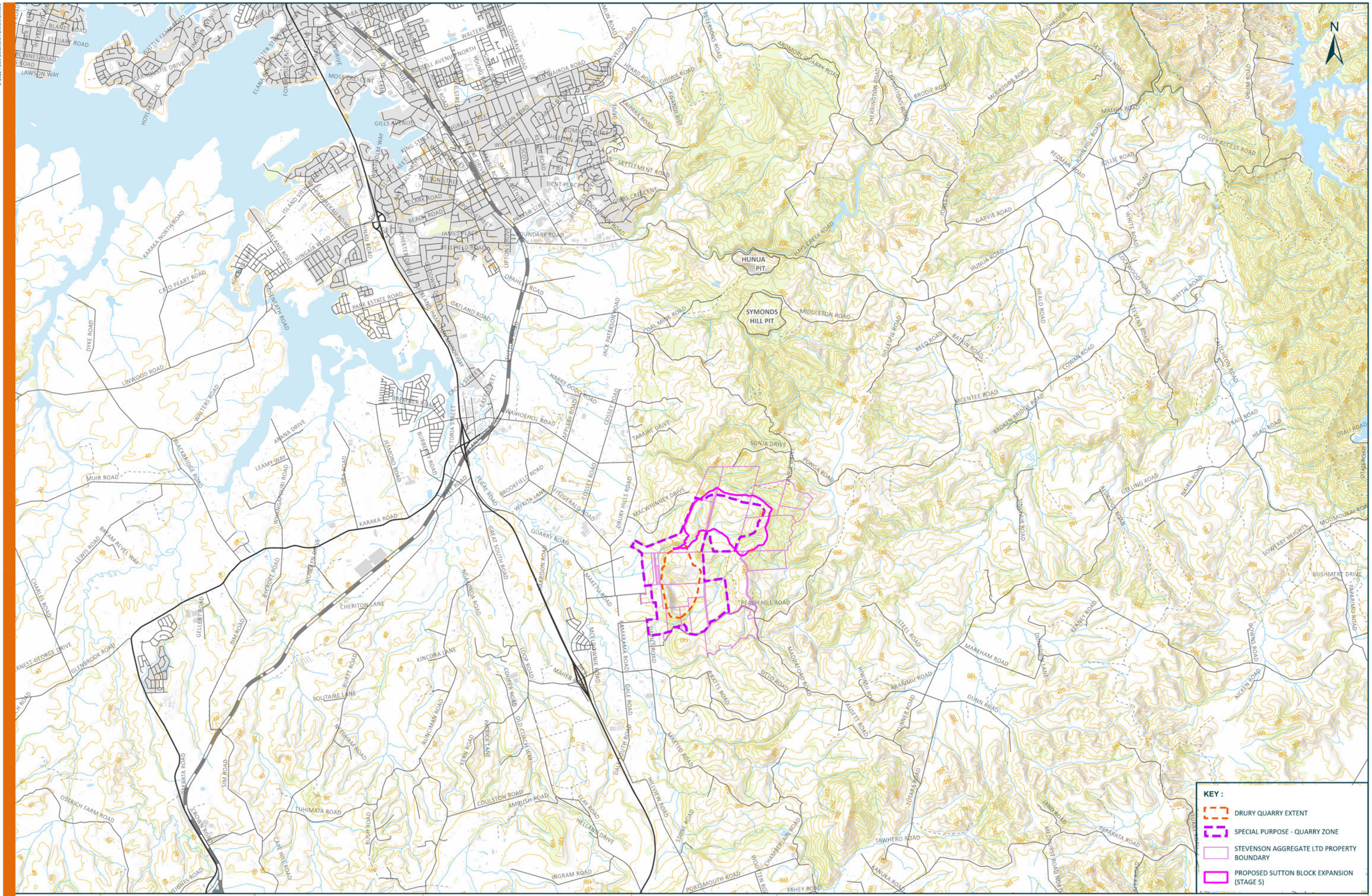
Stevens and Fulton (2005) carried out further greywacke resource evaluation for the Sutton Block. As part of this assessment, they drilled another eight cored bores (SP001 to SP008) for SAL. A piezometer was installed in one of these bores (SP001/21215, Figure 4) which is a 138.8m deep bore equipped with a 32mm PVC casing. Except for SP001/21215 which is reportedly sealed down to 112m depth, there is no information on the specification of the other piezometers (00C1 to 00C5), and it is likely the screen zones for all these historical bores were not sealed. Therefore, the groundwater levels in these bores are likely to represent the shallow groundwater.

Water Resource Consulting Group Ltd (2006) carried out a quarry water supply assessment for the processing plant and dust suppression. They concluded the total quarry water demand is 342m^3/d (56m^3/d for dust suppression and the rest for the processing plant, etc.).

Tonkin and Taylor (2009) carried out a geotechnical feasibility study at Peach Hill Catchment for the expansion of the Thorburn managed fill and overburden disposal. They also carried out another geotechnical study (T&T 2009b) to assess the geotechnical aspects of the proposed expansion of the north face of the quarry. As part of this investigation, they drilled four cored bores next to the northern face of the quarry, but no piezometers were installed in these boreholes.

Riley Consultants Ltd (Riley 2023) have carried out a geotechnical assessment of the long-term and short-term slope stability of the proposed quarry extension. For this assessment, they drilled five cored bores (DH101 to DH105) and installed four shallow piezometers with two nested piezometers in DH104 (screen depths at 4 to 31mbgl) and two in DH105 (screen depths at 10 to 20mbgl).

PDP have been involved in assessment of effects on groundwater and surface water at the existing Drury Quarry since 2012 (PDP 2012). As part of the above assessments and reporting a significant amount of data on the geology, hydrogeology, groundwater levels and stream low flows in the quarry and its surrounding catchments has been analysed and assessed (PDP 2024).



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D	ISSUED FOR RESOURCE CONSENT APPLICATION	OCT 24	MS
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B	ISSUED FOR REVIEW	OCT 23	AS
A	ISSUED FOR DISCUSSION	JAN 23	MS

SOURCE:
1. TOPOGRAPHIC TERRAIN BASE MAP ELEMENTS PROVIDED BY CORAX, LINZ AND KIWIRAIL.
2. STEVENSON AGGREGATE LTD PROPERTY BOUNDARIES SUPPLIED BY TERRA MINING CONSULTANTS, RECEIVED 28/06/12.
3. PROPOSED SUTTON BLOCK EXPANSION (DRAWING SSQ_24_405, ISSUED SEPT 2024), DRURY QUARRY EXTENT, AND SPECIAL PURPOSE – QUARRY ZONE (2021 AND 2022) PROVIDED BY TERRA MINING CONSULTANTS.

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FIGURE
FIGURE 1: LOCATION PLAN

PROJECT
PROPOSED SUTTON BLOCK EXPANSION – GROUNDWATER & SURFACE WATER EFFECTS ASSESSMENT

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SOURCE:
1. AERIAL IMAGERY SOURCED FROM GOOGLE EARTH (FLOWN APRIL 2022) AND PILBROW SURVEYS (FLOWN 2022)
2. CADASTRAL/TOPOGRAPHICAL INFORMATION AND INSET DERIVED FROM LINZ DATA.
3. QUARRY STAGES (DRAWINGS SSQ_24_401, SSQ_24_402, SSQ_24_401, SSQ_24_403, SSQ_24_404, SSQ_24_405, ISSUED SEPT 2024), DRURY QUARRY EXTENT, AND SPECIAL PURPOSE – QUARRY ZONE (2021 AND 2022) PROVIDED BY TERRA MINING CONSULTANTS.
4. SHALLOW GROUNDWATER CATCHMENTS DERIVED BY PDP.
5. FAULT LINES PROVIDED BY GNS SCIENCE (2020) (NZL GNS1:250K GEOLOGY (3rd EDITION)) ACCESSED 20/12/2022, AND, MURRAY, S., GRAEME, F (2005) GEOLOGICAL AND RESOURCE ASSESSMENT OF DRURY QUARRY, PREPARED FOR STEVENSON RESOURCES LTD., SEPTEMBER 2005.

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FIGURE

FIGURE 2: PROPOSED SUTTON BLOCK EXPANSION STAGES

PROJECT

PROPOSED SUTTON BLOCK EXPANSION – GROUNDWATER & SURFACE WATER EFFECTS ASSESSMENT

1.4 Proposed Quarry Sutton Block Expansion

As discussed above, SAL is proposing to expand the Drury Quarry into the Sutton Block approximately 500m to the north of the current pit. The pit is contained within the upstream of NT1 Catchment. The tributaries within this catchment discharge to the Hingaia Stream after passing through the upper and lower dams along NT1 Stream (Figure 3).

The proposed indicative quarry stages are presented in Table 1. The Life of Quarry plan includes the proposed full extent of the Sutton Block pit 108ha with the lowest sump water level at RL-60m.

Table 1: Proposed Sutton Block – Quarry Dewatering Stages

Quarry Stage	Approx. Timeline (years)	Pit Floor (m, RL)	Quarry Stage Area (ha)
Stage 1 (infrastructure establishment)	3	135	11
Stage 2 (operating quarry)	15	90	29.4
Stage 3 (operating quarry)	30	60	54.2
Stage 4 (operating quarry)	40	-60	87.6
Stage 5 (life of quarry)	50		108

1.5 Field Investigation

A significant volume of data on groundwater levels, stream flow data and groundwater inflow have been collected since the consent to dewater the Drury Quarry was granted in 2012 (Consent 40317). Further field investigation has been undertaken as part of the proposed Sutton Block dewatering consent.

The additional site investigation programme consisted of:

- Drilling and installing 5 piezometers;
- Field permeability tests;
- Stream flow gauging; and
- Groundwater and surface water sampling for laboratory analysis.

The following sections describe the investigation programme. The results of the investigations are discussed in relevant sections throughout the report.

1.5.1 Drilling

As part of the current investigation program, five bores were drilled, and piezometers installed by Drillforce east of the Hunua Fault to investigate the barrier properties of the Hunua Fault. The drilling was carried out between January and March 2022 and the geological logs are presented in Appendix A. Table 2 summarised the installed piezometer specifications and the location of the bores is shown in Figure 4.

Table 2: New Groundwater Level Monitoring Bores

Bore	Coordinates (NZTM)	GL (m, RL)	Bore depth (m)	Bore ID (mm)	Screen interval (m)	GW level (m, RL) (4/7/2022)	Geology
SG11L	1777720, 5890561	222.5	230	50	12	170.43	Fractured Greywacke
SG11U	1777717, 5890556	222.5	69	50	15	170.68	Residual Soil and Greywacke
SG12L	1778048, 5890049	277.0	280	50	9	177.97	Fractured Greywacke
SG12U	1778044, 5890046	277.0	65	50	9	223.08	Residual Soil and Greywacke
SG13	1777749, 5889552	249.0	250	50	9	104.43	Fractured Greywacke

1.5.2 Groundwater Level Monitoring

Groundwater levels in 21 piezometers in the vicinity of the Drury Quarry have been monitored monthly as part of the quarry monitoring programme carried out since 2012. The monitoring data and relevant results are discussed in this report. The locations of the groundwater level monitoring bores are shown on Figure 4 and the hydrographs are shown in Appendix B.

Monthly monitoring data from 21 piezometers at the Hunua Quarry (Hunua and Symonds Hill Pits) which are regularly submitted to the Council as part of the monitoring conditions, has also been incorporated in this assessment. The groundwater level in the greywacke, coal measures and basalt were monitored to define the groundwater movement in each formation.

The monitoring programme since February 2022 also includes monthly monitoring of the recent five bores (with piezometers) drilled as part of this investigation (Table 2).

1.5.3 Stream Flow Gauging

As part of the existing monitoring programme for the Drury Quarry, stream flow monitoring has been undertaken two times per year in dry conditions. The monitoring streams (Figure 3) are:

- Waihoihoi Stream;
- NT1 Stream;
- Peach Hill Stream; and
- Maketu Stream.

The location of the gauging sites is also shown in Figure 3.

Monitoring is conducted by physical gauging techniques in accordance with DSIR (1991) 'Hydrologists Field Manual' outlined in GMP (PDP, 2015) using either Global Flow Probe or bucket and stopwatch, or both depending on the stream channel conditions.

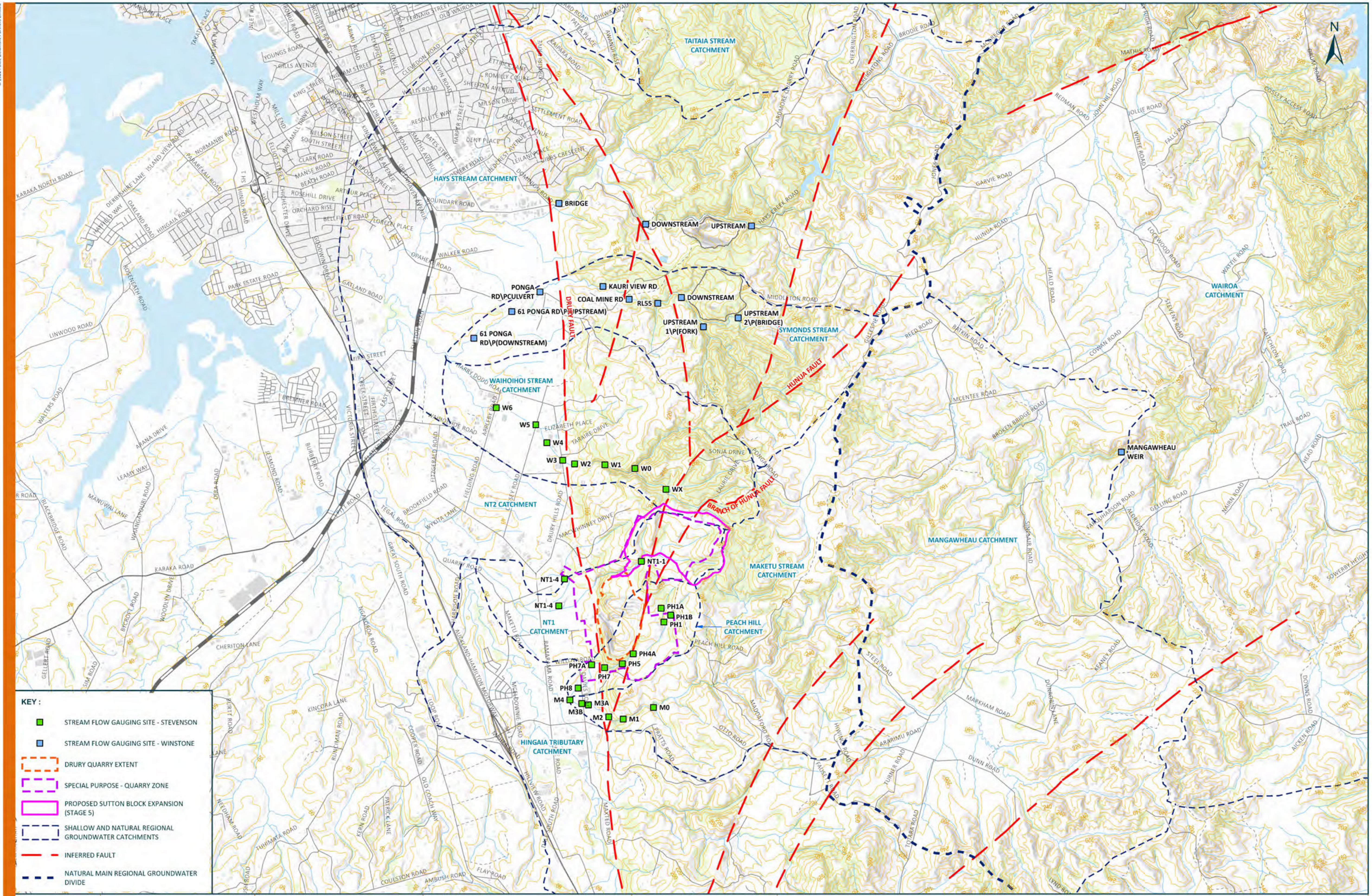
In addition, flows in all tributaries over the Sutton Block expansion area (NT1 Catchment) have been monitored during the dry conditions in 2022. The results are presented in Appendix C.

The monitoring data from a v-notch weir installed at NT1 Stream (NT1-1 gauging station, south of Sutton Block) by SAL between 15/02/2010 and 17/5/2010 and then subsequently till present has also been used for the stream flow correlation and estimation of the mean annual low flow (MALF).

1.5.4 Field Permeability Tests

Field permeability tests including slug tests, and a pumping test were carried out in 2017 as part of a technical assessment to authorise SAL to take groundwater for the Peach Hill Stream augmentation (according to Consent 40317) from a production bore next to the Peach Hill Stream rather than the Drury Quarry sump (PDP 2017).

Slug tests in the new piezometers (SG11, SG12 and SG13) were also undertaken using rising and falling head techniques and based on the methodology recommended by Butler (1998) using solid slugs.



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4. FAULT LINES PROVIDED BY GNS SCIENCE (2020) (NZL GNS1:250K GEOLOGY (3RD EDITION)) AND, MURRAY, S., GRAEME, F., (2005), PDP (2021).

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FIGURE
FIGURE 3: SHALLOW AND REGIONAL GROUNDWATER CATCHMENTS

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PROPOSED SUTTON BLOCK EXPANSION – GROUNDWATER & SURFACE WATER EFFECTS ASSESSMENT

1.5.5 Groundwater and Surface Water Quality Sampling

Groundwater and surface water quality sampling in the area has been undertaken by PDP in 2012, 2015 and 2022. The latest results (2022) are summarised in Appendix D.

The most recent groundwater samples were taken from all new piezometers (Table 2) following the drilling and the quarry sump (in dry conditions) in 2022. Surface water samples were also taken from NT1-1 gauging station (Figure 3).

The samples were sent to Analytica Laboratories in Auckland for analysis. All samples were analysed for a range of parameters relevant to ionic composition and ecological and community use. Parameters were: total ammoniacal nitrogen (NH4-N), nitrate nitrogen (NO3-N), nitrite nitrogen (NO2-N), sulphate, dissolved reactive phosphorus (DRP), boron and other major ions. In addition, all samples were analysed for dissolved metals and reactive silica (SiO2).

1.5.6 Well and Surface Water Take Survey

A desktop well survey was initially undertaken in May 2012 by PDP to identify groundwater users in the surrounding areas. Farm well information was obtained from Auckland Council (AC) on 6 June 2012 and used to identify wells located in the greywacke. A field-based well survey was also undertaken on 19 June 2012 to locate previously unidentified farm wells between Ponga Rd and the Drury Quarry and correlate them with AC data where possible. The above data compared with a more recent council bore search data collected on the 6 December 2022 to identify if there are any new bores or takes within a 10km of the proposed Sutton Block expansion. The location of the farm wells and surface water takes is shown in Figure 4.

In addition, Grant Fisher Industrial Geology LTD, (GFIG, 2010) was carried out an earlier field survey to identify the existing farm wells within the Hunua Quarry surrounding areas. The results are presented in Appendix I.

No farm wells were identified south of the existing Drury Quarry and between the Hunua and Drury Faults. Bore 21302 (next Peach Hill Road, Figure 4) is not being used and belong to SAL.

2.0 Geological Characteristics

The geology of the Drury Quarry and the proposed Sutton Block expansion surrounding areas has been studied previously by Murray North Ltd (1987), Namjou (1997) and Stevens and Fulton (2005).

The geology of the site and surrounding areas is shown in Figure 4 and the regional geology (IGNS 2001) is shown in Figure 5. The Waipapa Group greywacke, Waikato coal measures, Bombay basalts, Pleistocene deposits and fill/overburden materials are the main lithological units of the area.

a) Waipapa Group Greywacke

These greywacke rocks form the basement of the site and consist mainly of jointed Mesozoic (Upper Jurassic) sandstones and siltstones of the Waipapa Group. These rocks have a thickness of up to 10,000m (Schofield, 1967). The basement rocks consist mainly of moderately strong to strong indurated argillites of coarse silt size. Finer and coarser-grained argillites form laminations within these rocks.

The greywacke rocks are exposed at the existing Drury Quarry, which is located at the eastern flank of the NNW-trending Drury Fault (Figure 4).

The rock mass defects in the greywacke basement are bedding, veining, jointing and faulting. Bedding is difficult to determine; however, some interbedded argillite layers are visible north of the Drury Quarry. Veining is well developed in these rocks; the veins contain mainly quartz, prehnite, pyrite, quartz-chlorite/calcite or dark red iron-oxide. The weathered greywacke is overlying these rocks with a variable thickness (2 to 20m).

b) Waikato Coal Measures (Te Kuiti Group)

The basement greywacke is overlain unconformably by the Waikato Coal Measures of the Te Kuiti Group. These rocks are exposed over most of the southern half and some parts of the northern section of the Peach Hill Catchment. They are of Eocene age and consist mainly of mudstones with some thin coal seams interbedded with sandstones and conglomerates. The bedding dip is difficult to distinguish due to the extent of weathering; however, in general, the beds dip gently toward the north-west. The top 2 to 3m of the coal measures are highly weathered to a highly plastic, silty clay. These materials generally form a hummocky ground surface on slopes within the surrounding valleys. Borehole data indicates that the unweathered coal measures extend to depths of up to 54m (BH103, Figure 4).

No Waitemata Group rocks are exposed in the Sutton Block expansion area and its surrounding valleys within the Greywacke Block. The closest mapped Waitemata Group is located within Waihoihoi Catchment about 800m to the north of the proposed Sutton Block expansion.

c) Bombay Basalts

The Peach Hill and Kaarearea Paa volcanic cones located south and north of the Peach Hill Catchment respectively (Figure 4), are both effusive volcanic centres (upper Pliocene) consisting mainly of basaltic lava flows with some scoria and ash layers (BH110, BH111, BH112 and BH113). As Briggs et al. (1994) suggested, the faults in this region may have provided a pathway for magma to reach the surface from underlying feeder dykes.

Other Bombay volcanic cones have been identified along the Drury Fault. Basalt from these volcanic centres is identified within the Tauranga Group west of the quarry (west of the Drury Fault) and above the greywacke east of the Drury Fault.

d) Kaihu Group

The Kaihu Group unconformably overlies the Waitemata Group west of the Drury Fault and includes Pliocene marine sediments, the basal member of which is the Kaawa Formation with a thickness of up to 250m (Zeljko et al 2002). The Kaawa Formation consists of shell beds and dark blue (and green) fine to medium grained sandstone.

e) Tauranga Group (Puketoka Formation)

The Tauranga Group (Late Pliocene to Early Pleistocene) are non-marine sediments consisting predominantly of silt and clays. The thickness of these sediments is variable and can reach 80m (Zeljko et al 2002). These sediments are located west of the Drury Fault. However, at some locations they also cover the Drury Fault trace in low lying areas (next to the stream channels).

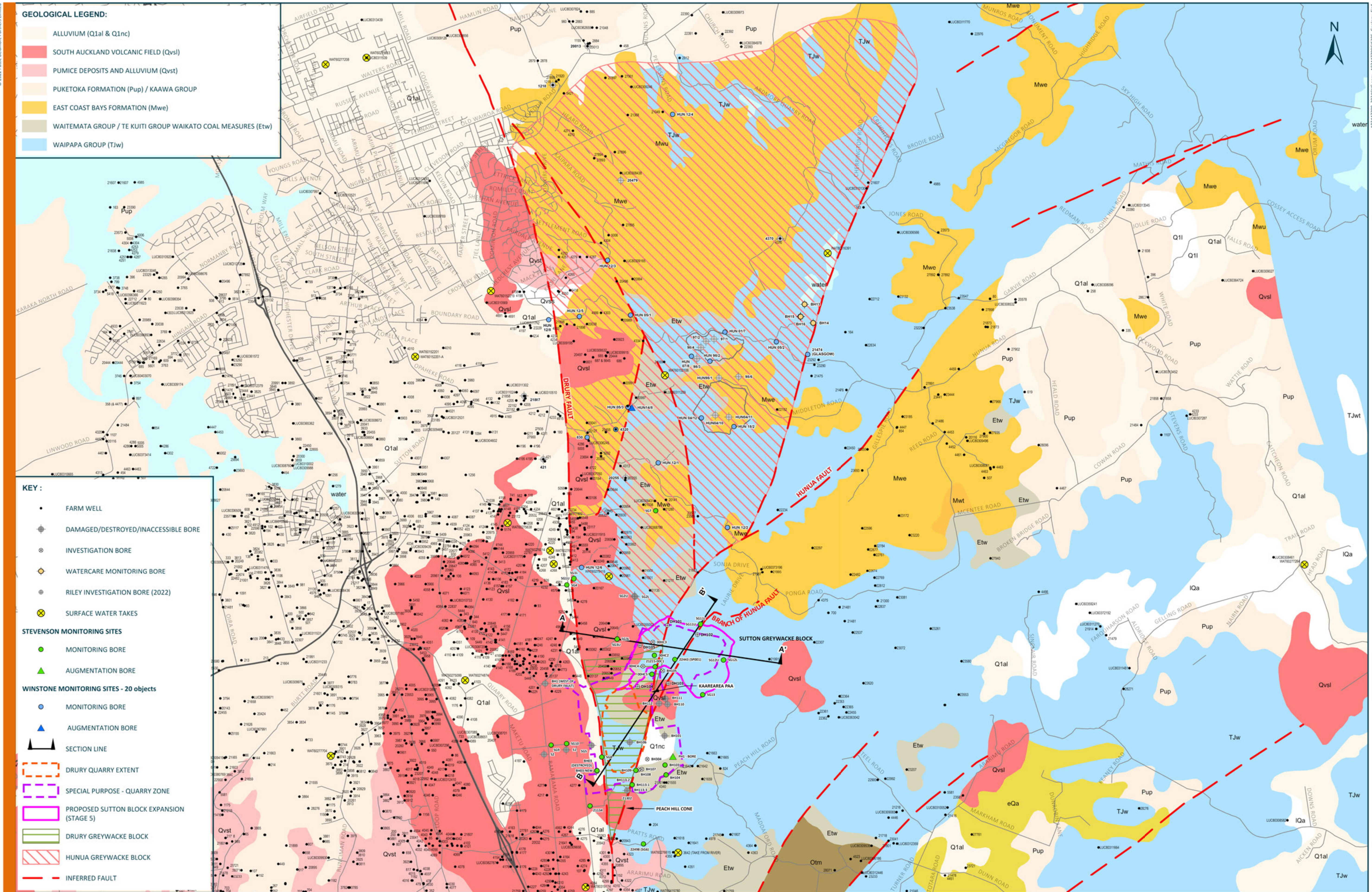
f) Fill Materials

Fill covers mainly the middle of the Peach Hill Catchment and forms the western edge of the Drury Quarry. It is the result of overburden disposal from the quarrying operations (consists of redeposited greywacke and coal measures materials, clay, silt, sand and gravel) as well as placement of the managed fill. Its thickness ranges between 3m and 55m.

g) Hunua and Drury Faults

The dominant structural features at the site are the Hunua and Drury Faults. The NNE-trending Hunua Fault is truncated to the south by the NNW- trending Drury Fault (Figure 4). The Drury Fault forms the boundary between the up-faulted Hunua Ranges and the down-faulted Manuka Lowlands. Nixon (1977) has shown that the Drury Fault is a steeply-dipping (65 to 90 degrees dip) normal fault. The throw of the fault is highly variable ad lies within the range 0.4 to 2.7km (Nixon 1977). The geological mapping carried out by Murray North Ltd (1988) and Namjou (1997) indicates that the greywacke-coal measures contact across the Hunua Fault is offset by approximately 70m. According to data from bore BH109, which lies only a few metres east of the fault scarp, no fault zone was encountered to a depth of 37.2m (bottom of the bore). The available geological and geophysical data indicates that the Hunua Fault is a vertical normal fault.

The Hunua Fault trace is associated with a prominent scarp approximately 40m high across the middle of Peach Hill Catchment. There is a 3m scarp close to Kaarearea Paa which may be related to the Hunua Fault. Rafferty (1977) and Briggs et al. (1994) indicated the age of this basaltic volcanism to be Pleistocene, with activity over the period 0.51 to 1.59 million years ago. Therefore, the Hunua Fault has been inactive for at least the last 0.5 million years. Previous studies (Rafferty, 1977 and Briggs et al. 1994) based on radiometric dating of the lava intrusion along the Drury Fault suggests that the Drury Fault has been active within the last 1.25 million years.



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0 500 1000
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NO.	REVISION	DATE	BY
D	ISSUED FOR RESOURCE CONSENT APPLICATION	OCT 24	MS
C	DRAFT FOR RESOURCE CONSENT APPLICATION	DEC 23	TK
B	ISSUED FOR REVIEW	OCT 23	AS
A	ISSUED FOR DISCUSSION	JAN 23	TK

SOURCE:
1. ROAD CENTRELINES DATA PROVIDED BY LINZ.
2. QUARRY BOUNDARIES SUPPLIED BY TERRA MINING CONSULTANTS, RECEIVED 28/06/12.
3. PROPOSED SUTTON BLOCK EXPANSION (DRAWING SSQ_24_405, ISSUED SEPT 2024), DRURY QUARRY EXTENT, AND SPECIAL PURPOSE – QUARRY ZONE (2021 AND 2022) PROVIDED BY TERRA MINING CONSULTANTS.
4. FAULT LINES PROVIDED BY GNS SCIENCE (2020) (NZL GNS1:250K GEOLOGY (3RD EDITION)) AND, MURRAY, S., GRAEME, F., (2005), PDP (2021).
5. GEOLOGICAL INFORMATION SUPPLIED BY GNS FROM QMAP EDBROOKE, S.W.(COMPILER) 2001. GEOLOGY OF THE AUCKLAND AREA. GNS. 1:250,000 GEOLOGICAL MAP
6. FARM BORE DATA COMPILED BY GRANT FISHER INDUSTRIAL GEOLOGY (14/12/2010) AND AC BORE SEARCH RECEIVED 06/12/2022 AND 08/08/2024

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FIGURE
FIGURE 4: GEOLOGY

PROJECT
PROPOSED SUTTON BLOCK EXPANSION – GROUNDWATER & SURFACE WATER EFFECTS ASSESSMENT

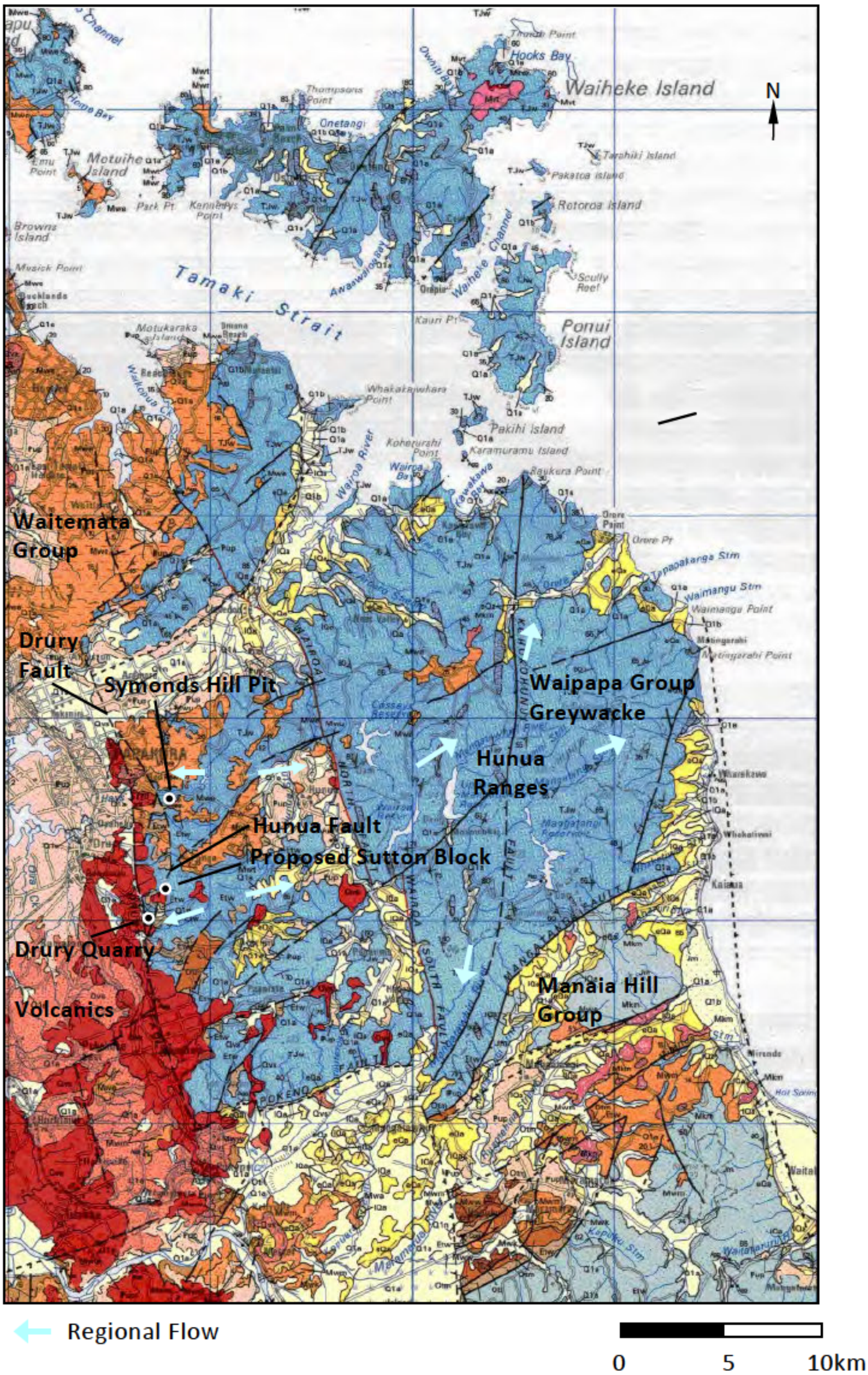


Figure 5: Regional Geology (IGNS 2001) and Regional Groundwater Flow Paths

3.0 Hydrogeological Characteristics

3.1 Groundwater Conceptual Model

The groundwater conceptual model discussed below was developed using the available geological logs, field observations, piezometer data and other available geological and hydrogeological information.

The conceptual model of the current groundwater movement at the site and surrounding areas is shown along two hydrogeological sections (AA' and BB'). The hydrogeological sections are shown in Figures 6 and 7.

3.2 Surface Water Catchments

Based on a previous study (PDP 2011, PDP 2012 and PDP 2021), the boundaries of the groundwater catchments east of the Drury Fault are roughly coincident with the topographic boundaries (i.e. surface water catchments). The configuration of the surface water and groundwater catchments in the area is shown in Figures 2 and 3. The main surface water (and natural regional groundwater) divide is to the east of Hays, Symonds and Maketu Catchments. This divide separates the surface water catchments that discharge to the Tamaki Strait and Firth of Thames and the surface water catchments that discharge to the Manukau Harbour (via Hingaia Stream).

3.3 Groundwater Movement

The natural groundwater movement in the greywacke at the proposed Sutton Block expansion is similar to groundwater movement assessed as part of the existing Drury Quarry (Murray North Ltd (1987), GCNZ (1989) and Namjou (1997).

Shallow/perched groundwater occurs within the highly weathered greywacke, Waikato Coal Measures, and in the upper section of unweathered greywacke with limited or very low interconnected fractures network where saturation is not continuous (Figures 6 and 7).

At depth, groundwater in the greywacke occurs as a zone of continuous saturation that extends to full depth within the greywacke across the region. This is referred to as the deep or regional groundwater. While the deep greywacke extends at depth for several kilometres, the main groundwater movement is thought to occur within its upper sections where rock defect openings are widest.

The shallow groundwater is evident based on the groundwater level data from the multilevel piezometers (BH113) and other bores (e.g. BH305, Figure 4) east of the Drury Fault. In BH113-4, the groundwater level in the shallow coal measures is about 12m above the groundwater level in the deep piezometer BH113-1. Similarly, the groundwater level in shallow piezometer (BH305) in coal measures stands about 30m above the groundwater in greywacke (BH109).

An elevated groundwater level is also reported in BH111 in the basalt (Kaarearea Paa, Figure 4). The groundwater level in this bore based on the geological logs (Murray North Ltd 1988) was at RL177.5m (the bore is no longer exists). This is about 75m higher than the groundwater level in the closest bore in the greywacke (BH101).

A seepage line consisting of springs in the upper Peach Hill Catchment confirms the presence of the shallow/perched groundwater within the cone. These springs discharge to the Peach Hill Stream. This, in addition to the previous groundwater study for the Hunua Quarry AEE (PDP 2011), indicates that the groundwater in the cone and its related lave flows forms a perched or shallow groundwater system separate to the deeper greywacke groundwater system. The shallow/perched groundwater within the cone may not extent across the whole cone and in some areas may be laterally discontinuous, limited to local depression zones within the lava flows.

The boundary between the shallow and deep groundwater systems is generally a transitional zone where there is a gradual increase in the extent of the saturated zone with depth. Dewatering operations can also cause formation of perched conditions within the greywacke as shallow groundwater systems can be developed within the less permeable zones (i.e. zones with minor joints) that remain unaffected by under-drainage due to dewatering activities.

3.4 Groundwater Catchment

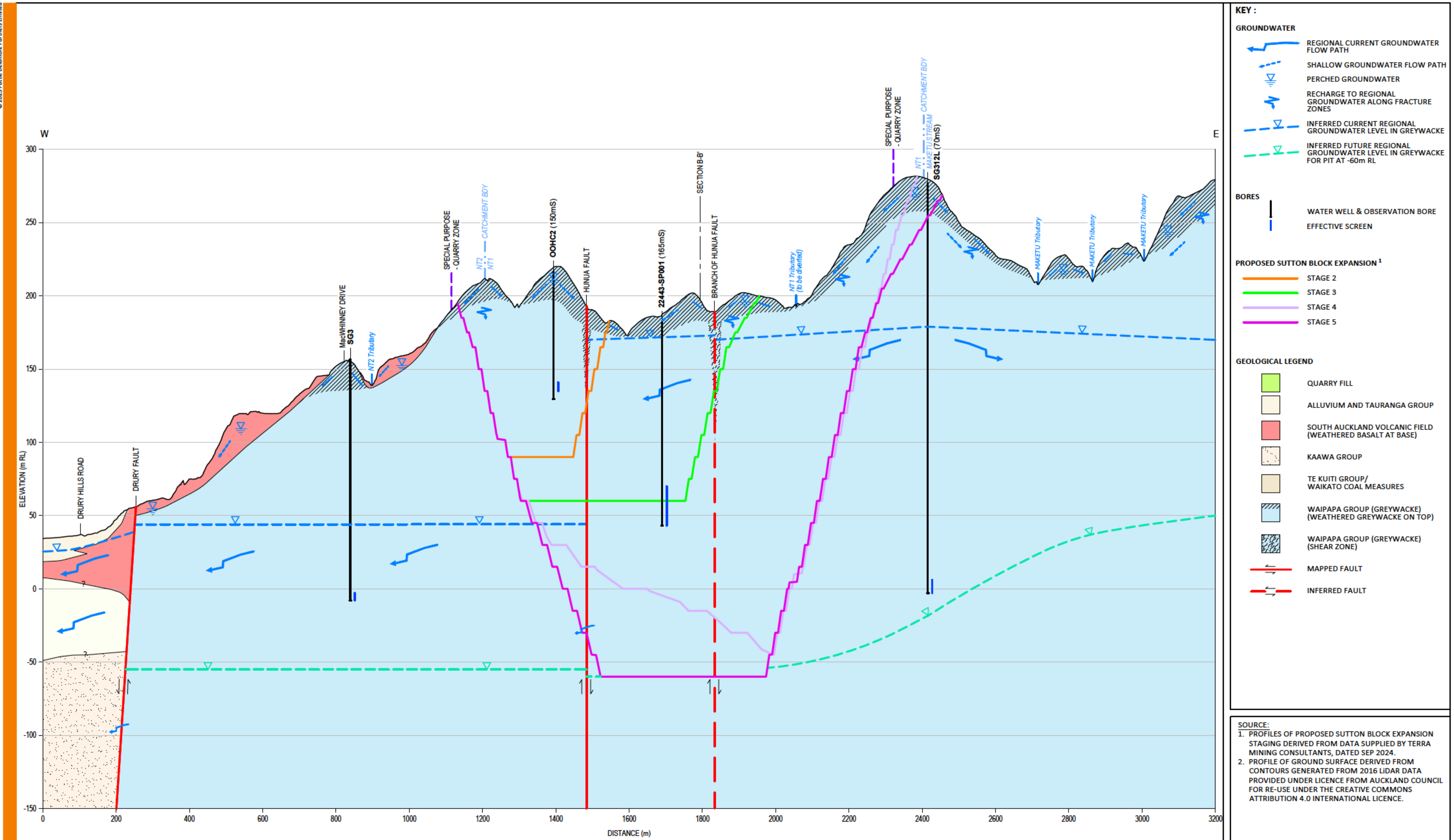
The regional groundwater is recharged by downward percolation from the shallow groundwater or directly through the greywacke outcrops in catchments. The most significant recharge occurs through the exposed fractured greywacke (including exposed fractured greywacke within the existing Drury Quarry and the Symonds Hill Pit).

In the absence of groundwater flow barriers (faults), the boundaries between the neighbouring groundwater catchments (shallow and regional groundwater) are driven by the relative elevations of the streambeds where groundwater discharge occurs. The locations of the greywacke natural groundwater divides (i.e., the boundaries between the shallow and regional groundwater catchments) are expected to be roughly midway between the respective deep system discharge zones. Based on a previous study (PDP 2011), the boundaries of the regional groundwater catchments east of the Drury Fault become roughly coincident with the topographic boundaries. This was also confirmed during previous work at the Drury Quarry (Namjou 1997). As part of the 1997 study, 22 bores were drilled within the quarry floor area, of about 20ha, when the quarry floor was at RL75m. The groundwater levels in these bores were monitored in summer and winter conditions. The study showed that a regional groundwater divide exists between the Peach Hill and NT1 Streams. The divide coincided with a topographic ridge line which existed between these two catchments before quarrying. The configuration of the shallow groundwater catchments in the pit surrounding catchments is shown in Figure 3. The regional groundwater catchment boundaries are likely to coincide with the shallow groundwater boundaries. However, in areas close to the flow barrier faults, the regional groundwater catchment boundaries can deviate from the shallow groundwater catchments depending on the hydraulic properties of these fault zones.

Although on a local scale due to small scale faults, the flow regime is complex, on a regional scale there is a general westerly flow direction from the elevated areas of the catchments to the east. Under current conditions (no quarry operation to the east of the Hunua Fault), the eastern boundary of the Maketu, Hays and Symonds Stream Catchments form a main groundwater divide (Figure 3) between the groundwater in greywacke that flows to the Wairoa River (and upper reaches of the Firth of Thames) and the groundwater that flows toward the Drury Fault.

Before the Drury Quarry dewatering, the deep groundwater within the quarry area and surrounding catchment was flowing in a westerly direction towards the lower parts of the catchments where streams cross the Drury Fault. However, some of this groundwater now flows to the quarry sump as a result of the quarry dewatering operation.

The general westerly groundwater flow in the deep groundwater system in greywacke is disrupted by the occurrence of the flow barrier faults (that is Hunua and Drury Faults). However, the shallow groundwater flow paths are contained within each sub-catchment.



SOURCE:
1. PROFILES OF PROPOSED SUTTON BLOCK EXPANSION STAGING DERIVED FROM DATA SUPPLIED BY TERRA MINING CONSULTANTS, DATED SEP 2024.
2. PROFILE OF GROUND SURFACE DERIVED FROM CONTOURS GENERATED FROM 2016 LIDAR DATA PROVIDED UNDER LICENCE FROM AUCKLAND COUNCIL FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.

SECTION A-A'
HORIZONTAL SCALE 1:10,000
VERTICAL SCALE 1:2,500

SCALE AS SHOWN (A3)

NO.	REVISION	DATE
C	ISSUED FOR RESOURCE CONSENT	OCT 24
B	ISSUED FOR RESOURCE CONSENT	DEC 23
A	ISSUED FOR REVIEW	OCT 23

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FIGURE
FIGURE 6: INDICATIVE HYDROGEOLOGICAL SECTION A-A'

PROJECT
PROPOSED SUTTON BLOCK EXPANSION - GROUNDWATER & SURFACE WATER EFFECTS ASSESSMENT

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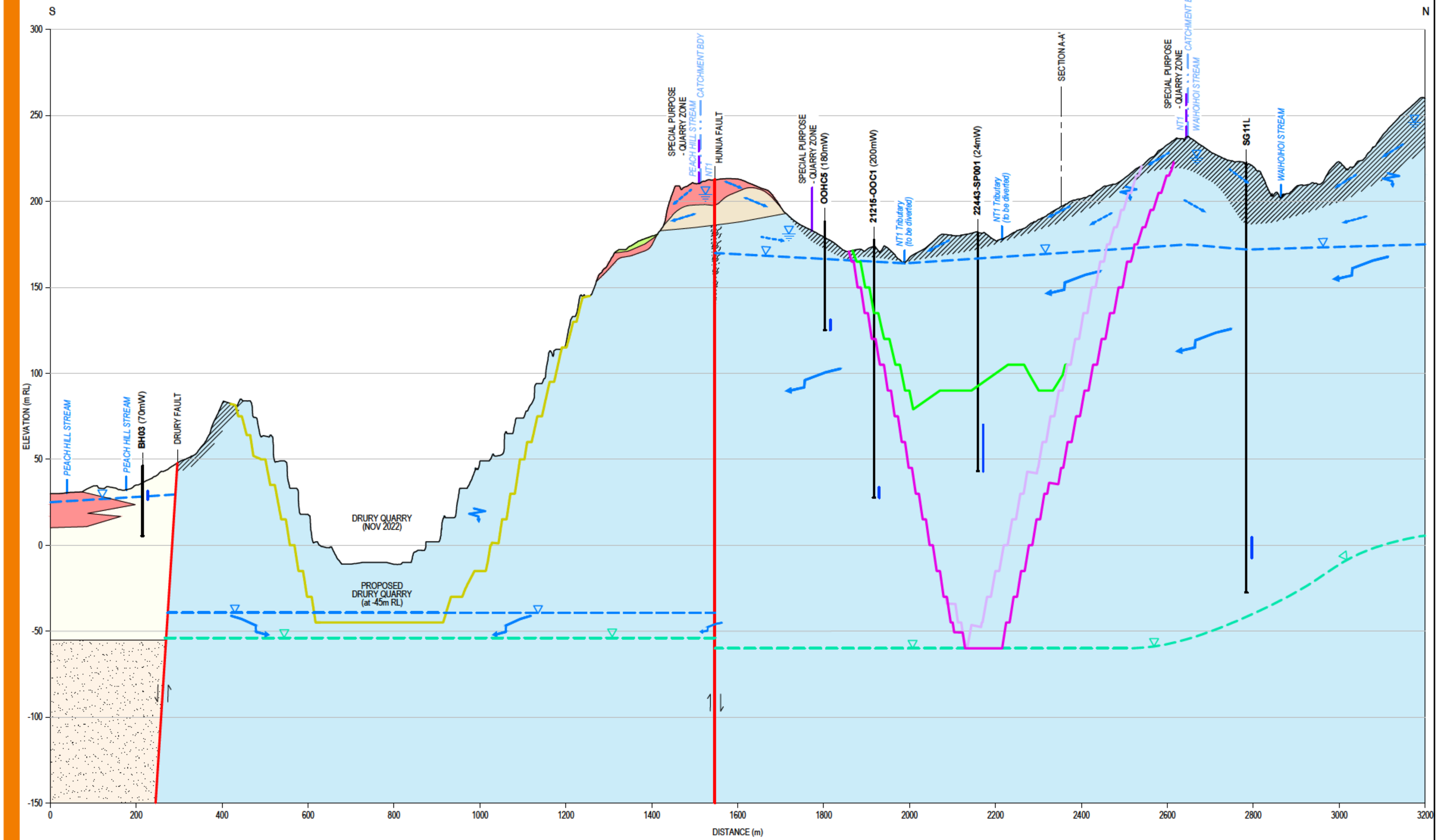

SECTION B-B'

HORIZONTAL SCALE 1:10,000
VERTICAL SCALE 1:2,500

KEY :

GROUNDWATER

- REGIONAL CURRENT GROUNDWATER FLOW PATH
- SHALLOW GROUNDWATER FLOW PATH
- PERCHED GROUNDWATER
- RECHARGE TO REGIONAL GROUNDWATER ALONG FRACTURE ZONES
- INFERRED CURRENT REGIONAL GROUNDWATER LEVEL IN GREYWACKE
- INFERRED FUTURE REGIONAL GROUNDWATER LEVEL IN GREYWACKE FOR PIT AT -60m RL

BORES

- WATER WELL & OBSERVATION BORE
- EFFECTIVE SCREEN

PROPOSED SUTTON BLOCK EXPANSION [1]

- STAGE 2
- STAGE 3
- STAGE 4

GEOLOGICAL LEGEND

- QUARRY FILL
- ALLUVIUM AND TAURANGA GROUP
- SOUTH AUCKLAND VOLCANIC FIELD (WEATHERED BASALT AT BASE)
- KAAWA GROUP
- TE KUITI GROUP/ WAIKATO COAL MEASURES
- WAIPAPA GROUP (GREYWACKE) (WEATHERED GREYWACKE ON TOP)
- WAIPAPA GROUP (GREYWACKE) (SHEAR ZONE)
- MAPPED FAULT
- INFERRED FAULT

SOURCE:
1. PROFILES OF PROPOSED SUTTON BLOCK EXPANSION STAGING DERIVED FROM DATA SUPPLIED BY TERRA MINING CONSULTANTS, DATED SEP 2024.
2. PROFILE OF DRURY QUARRY (AS AT NOV 2022) DERIVED FROM DATA SUPPLIED BY PILBROW SURVEYING LTD.
3. PROFILE OF PROPOSED DRURY QUARRY AT -45m RL DERIVED FROM DATA SUPPLIED BY TERRA MINING CONSULTANTS, DATED APR 2022.
4. PROFILE OF GROUND SURFACE DERIVED FROM CONTOURS GENERATED FROM 2016 LiDAR DATA PROVIDED UNDER LICENCE FROM AUCKLAND COUNCIL FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.

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SCALE AS SHOWN (A3)

NO.	REVISION	DATE
C	ISSUED FOR RESOURCE CONSENT	OCT 24
B	ISSUED FOR RESOURCE CONSENT	DEC 23
A	ISSUED FOR REVIEW	OCT 23

CLIENT
STEVENSON

FIGURE
FIGURE 7: INDICATIVE HYDROGEOLOGICAL SECTION B-B'

PROJECT
PROPOSED SUTTON BLOCK EXPANSION - GROUNDWATER & SURFACE WATER EFFECTS ASSESSMENT

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3.5 Groundwater Flow Barriers

Across the Hunua and Drury Faults there is a significant head difference in groundwater in the greywacke confirming the flow barrier properties of these faults.

3.5.1 Drury Fault

The Drury Fault zone forms a barrier to the natural westerly flow of groundwater (Murray North Ltd, 1987, GCNZ 1989 and Namjou 1997).

In the vicinity of where the Peach Hill and NT1 Streams cut across the Drury Fault, the regional groundwater (before any quarrying) was estimated to have been dammed up behind the Drury Fault to about 33m and 35m, respectively. Under the current dewatering conditions, the head differences between the sump (RL-32m) and the groundwater level in volcanic/alluvium west of the Drury Fault (RL38m at BH03) is about 70m. No seepage is observed on the quarry western wall which is adjacent and along the Drury Fault. Considering the above, the barrier properties of the fault are unlikely to be localised (PDP 2012).

Perched groundwater is also expected within the alluvium and Tauranga Group west of the Drury Fault above the groundwater level in basalt.

3.5.2 Hunua Fault

The Hunua Fault also forms a boundary to the groundwater flow. As shown in the AA' cross sections across the quarry, the deep groundwater level in the greywacke to the east of the Hunua Fault stands above the groundwater just to the west of the fault. The average regional groundwater levels in recently drilled piezometers SG11L and SG12L west of the Hunua Fault is about RL170m. This is about 120m higher than the groundwater level in SG3L (about RL50m) east of the Hunua Fault confirming the flow barrier properties of the Hunua Fault.

Furthermore, the groundwater levels in BH107 and BH108 have retained their artesian heads since they were drilled in 1988. The artesian bores BH107 and BH108 are shown in Photos 1 and 2 and their location in Figure 4. The groundwater level can be measured in BH109 (a non-flowing artesian bore, Figure 4) which was drilled in the greywacke just east of the Hunua Fault (where the greywacke is overlain by about 30m of coal measures). The groundwater level in this bore is at about RL90m or about 120m above the current dewatering level (RL-32m) at the existing Drury Quarry.

A third artesian bore (BH105) was identified along the same Greywacke Block (east of the Hunua Fault within the NT1 Catchment (Figure 4 and Photo 3). The artesian flow at this location (1.4km north of BH108) indicates that the barrier property of the Hunua Fault is widespread and is not limited the east of the existing Drury Quarry.

These data clearly support the previous conclusions made on the groundwater barrier properties of the Hunua Fault (Murray North Ltd, 1987, GCNZ 1989 and Namjou 1997).


Photo 1: BH107 (E1776882, N5888490)


Photo 2: BH108 (E1776835, 5888480)


Photo 3: BH105

Photos 1 to 3: Artesian Bores, BH107 (top left), BH108 (top right) and BH105 (bottom)

Recent groundwater level data indicates that the southern portion of the Hunua Fault (between BH109 and Hunua/Drury Fault intersection, Figure 4) may act as a low permeability zone rather than a flow barrier boundary. The monitoring bore SG6 (Figure 4) which is located 450m east of the Hunua Fault has shown about 6.4m drawdown since last year. Therefore, although Hunua Fault overall act as a flow barrier fault, some local leakage across the fault may be occurring. The low permeability fault zone is likely to cause a significant attenuation of drawdowns across the boundary.

3.5.3 Other Faults

The groundwater level contour map is constructed based on the 2024 monitoring data (Figure 8). The map indicates a sharp increase in groundwater levels between the Peach Hill and NT1 Catchments (which contains the proposed Sutton Block expansion). This may be due to another groundwater flow barrier or a fault with lower permeability north of the Drury Quarry which may have impeded the natural movement of groundwater.

In addition, the groundwater level monitoring data collected since 2011 as part of the Hunua and Drury Quarries monitoring conditions has confirmed another low permeability zone between the Drury Quarry and SG3L (a deep monitoring bore along Macwhinney Rd (Figure 4).

3.6 Greywacke Blocks

The groundwater flow barriers (Drury and Hunua Faults and their branches) have divided the regional groundwater into multiple hydrogeological blocks.

The current identified Greywacke Blocks are:

- Hunua Greywacke Block
- Drury Greywacke Block
- Sutton Block Greywacke Block (East of Hunua Fault)

3.6.1 Hunua Greywacke Block

The current zone of influence for the Symonds Hill Pit (next to the former Hunua Pit) dewatering is constrained in the east, south and westerly directions by geological fault boundaries or low permeability zones.

The current groundwater level contour map is shown in Figure 8. The contour map suggests significant hydraulic connectivity between the Hunua Pit and the rest of the Greywacke Blocks especially to the south and south-west.

A sharp increase in groundwater levels to the east of the Hunua and Symonds Hill Pits (Figure 8) is likely to be due to a groundwater flow barrier or low permeability boundary (Huna Fault or its branch), impeding the natural westward movement of groundwater from the upper catchment areas. The general westerly groundwater flow in the regional groundwater in greywacke is disrupted by the occurrence of the flow barrier faults (e.g. Hunua, Drury Faults and their branches).

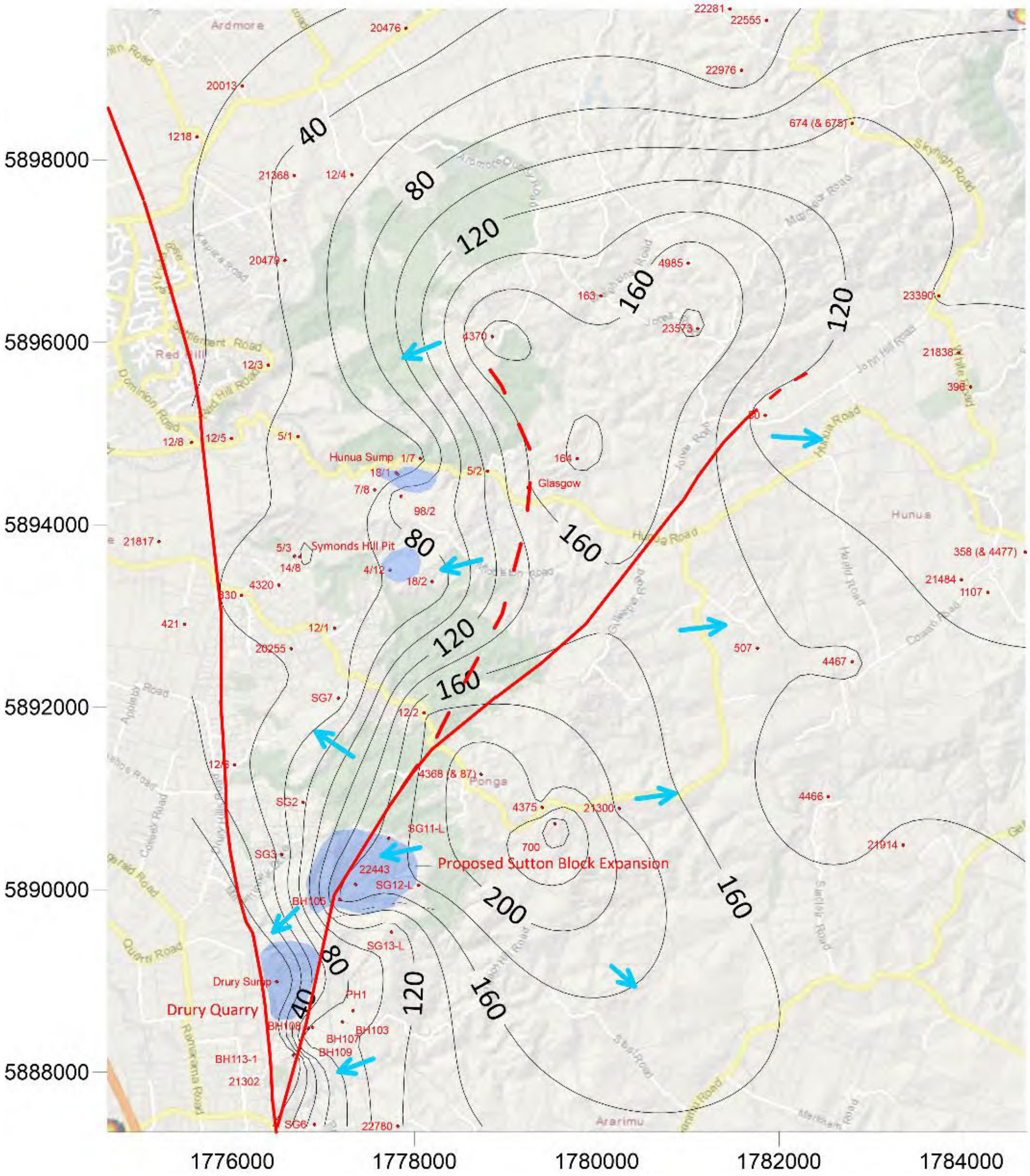


Figure 8: Existing Groundwater Level Contours (Aug 2024) showing the Regional Groundwater Flow Paths (arrows)

The hydrographs for the deep bores in the Hunua Greywacke Block north of the pit (e.g., SG1L, SG2L, SG3L and SG7) between the Hunua Pit and Drury Quarry are shown in Figure 9. The hydrographs for all Stevenson monitoring bores are provided in Appendix B. The location of the monitoring bores is shown in Figure 4.

The hydrographs for the deep bores north of the Drury Quarry and the monitoring bores to the south of the Hunua Quarry (e.g., HUN5/3, HUN12/1L, 20255 and 4320) show a sharp drop between October 2016 and April 2017 (Figure 9) which corresponds to a sudden increase in inflow (storage release) at the Hunua Quarry (PDP 2021). During this period the Drury sump dewatering level remained stable at RL16m.

Following the Hunua Pit sump water level recovery as a result of backfilling (in 2017), the above drawdowns effects are now being reversed while no apparent drawdown has occurred as a result of the drop in the Drury Quarry sump water level from RL16m to RL-26.6m.

Monitoring data indicate a direct relationship between the past Hunua Pit dewatering and drawdown in the deep monitoring bores to the north of Drury Quarry. The results also indicate a potential low permeability zone (4.7km to the south of Hunua Pit), which is likely to form the southern boundary of the Hunua Greywacke Block, just south of SG3L (Figure 4). This agrees with the conceptual model developed as part of the investigations undertaken to support the consent application for the existing Drury Quarry and Symonds Hill Pit dewatering consents (40317 and WAT60152106-A, respectively).

Therefore, the regional groundwater inflow into the former Hunua Pit and Symonds Hill Pit is sourced predominantly from the greywacke bounded by the Hunua and Drury Faults and their branches. This greywacke zone of contribution is referred to as the Hunua Greywacke Block in this report.

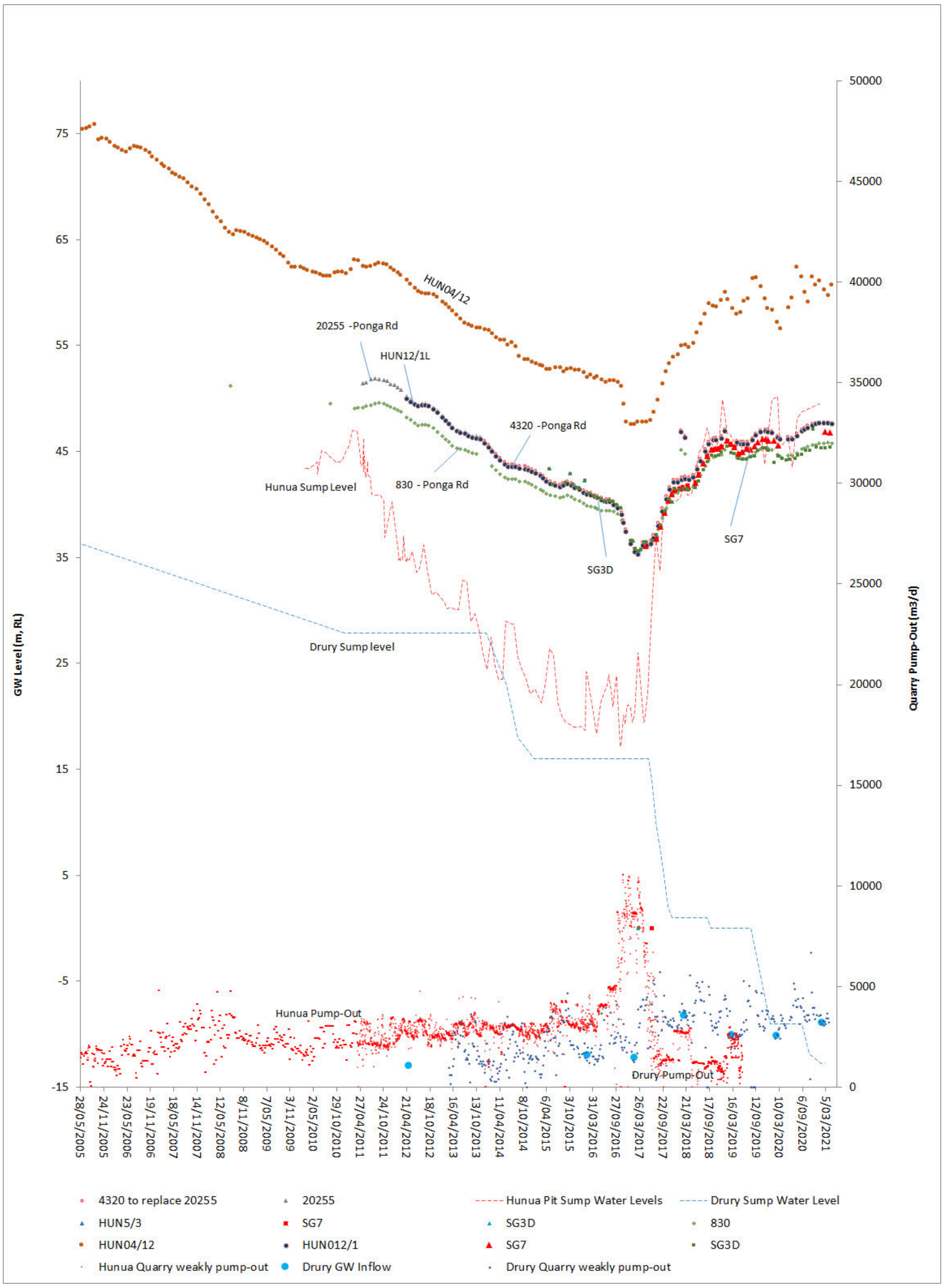


Figure 9: Deep Greywacke Bores Hydrographs between Drury and Hunua Quarries (including Pump-Out)

3.6.2 Drury Greywacke Block

As discussed above, the groundwater level monitoring data indicates no relationship between the Drury Quarry sump water level and drawdowns effects within the Hunua Greywacke Block but a direct relationship between the past Hunua Pit dewatering and drawdowns in the deep bores (including SG3L) north of the Drury Quarry.

The groundwater level contour map (Figure 8) shows two relatively flat groundwater level zones. One zone is located between the Hunua Pit and Drury Quarry (i.e. Hunua Greywacke Block), which includes SG3, SG2 and SG7 together with a number of other private bores. As mentioned above, this zone is predominantly controlled by the Hunua Pit dewatering. The second zone (Drury Greywacke Block) is located south of SG3L and bounded by the Hunua and Drury Faults and extend to the south where the Drury and Hunua Faults intersect (Figure 4). The groundwater in this smaller southern zone is controlled by the Drury pit dewatering. No private bores are located in the Drury Greywacke Block except Bore 21302. This bore is screened in the greywacke and was drilled down to 103mbgl in 2000, about 300m south of the Drury Quarry sump. The bore intake zone (open hole in greywacke) is from RL35m to RL16m (or 84m to 103mbgl). The groundwater level in this bore was similar to the sump water level and the bore is now dry as the groundwater level in the sump has dropped below the bottom of the bore. The above hydraulic connectivity between 21302 and the sump is in agreement with the conceptual model presented as part of the exiting consent (PDP 2012).

The above results indicate a low permeability zone is likely between the Drury Quarry and a deep monitoring bore, SG3L. There is not sufficient data to demonstrate that the boundary between the Hunua and Drury Greywacke Blocks is completely impermeable and some leakage from this boundary (and potentially in local areas across the Hunua Fault) may be occurring (PDP 2012). For example, observed 6m drawdowns in SG6 (22498) since 2023 may have been caused by local leakage across the southern end of Hunua Fault (i.e. south of BH109, Figure 4).

The groundwater level telemetry data for SG11L and SG13 shows a sharp rise between June 2022 to June 2023 (unlike other deep greywacke bores), followed by a drop in groundwater levels (Appendix B). However, no similar pattern in groundwater level is observed in SG12L (located between SG11L and SG13) and the above fluctuation pattern does not match with the sump water level (Appendix B). Therefore, additional monitoring data is required to confirm the above trend. Even if groundwater levels in SG11L and SG13 are affected by localised leakage, as mentioned above, the low permeability fault zone is likely to cause a significant attenuation of drawdowns across the boundary. Any potential long-term drawdown effects in other areas across the Hunua Fault may take a significant amount of time to expand beyond the above low permeability zone.

3.6.3 Sutton Block Greywacke Block (East of Hunua Fault)

The extent of the greywacke block to the east of the Hunua Fault is unknown. This block which is referred to as the Sutton Block Greywacke Block in this report, contains almost half of the final proposed Sutton Block expansion footprint (Stage 5). The groundwater in this block may also be bounded by other flow barrier faults. For example, based on the groundwater level monitoring data (Figure 8) a potential flow barrier fault may be located between SG12L and SG13. The groundwater level in SG12L is at about RL170m, while the groundwater level in SG13 (only 500m away) is at about RL100m. The 70m head difference may indicate a potential flow barrier fault, separating the Sutton Block expansion from the Peach Hill Catchment, east of the Hunua Fault. However, further monitoring as the new pit deepens is required to confirm the extent of such a barrier.

Note that the exact location of the barrier fault between the Hunua and Sutton Greywacke Blocks is not known but based on the available groundwater level monitoring data, the boundary is more likely to be close to the inferred alignment of the Hunua Fault which passes through the proposed pit (Figure 4). The ongoing and recommended monitoring programme will be used to confirm the location of the boundary as the new pit deepens.

3.7 Groundwater Discharge Mechanisms

The mechanism by which groundwater in the deep system discharges at the Hunua or Drury Faults is uncertain, but it can be inferred from the hydraulic heads and available hydrogeological information.

A direct seepage across these faults is limited, due to barrier (or low permeability) properties of the faults. However, general upward seepage along the fault planes is likely. This is evident from springs (Figure 2) observed next to BH109 (Figure 4) in the Peach Hill Catchment behind the Hunua Fault, where the stream crosses the fault. A similar discharge was also evident under pre-quarry conditions to the east of Drury Fault (close to PH7 gauging station, Figure 3).

It should be noted that the stream across the inferred position of the Drury Fault flows over alluvium deposits. Therefore, some contribution from the deep system to the stream via springs (or alluvium beneath the stream channel) across the fault may be lost back to the alluvium before it can be registered in the streams.

3.8 Groundwater and Surface Water Interaction

The average groundwater level in the Drury Greywacke Block prior to the development of the existing Drury Quarry was RL58m (Namjou, 1997). However, the groundwater level in the Greywacke Block east of the Hunua Fault which contains the majority of the Sutton Block expansion footprint is significantly higher at RL170m. This high groundwater level drops to the south towards the Peach Hill Catchment (i.e., ranging from RL100m in SG13 to RL79.5m in BH109).

Therefore, the regional groundwater intercepts the surface water at different elevations to the east and west of the Hunua Fault. In the Hunua Greywacke Block the regional groundwater intercepts the stream at about RL60m (PDP 2021) and in the Drury Greywacke Block the interception occurs at elevation below RL58m. The surface water groundwater interaction in the Sutton Greywacke Block varies from RL170m in the vicinity of the proposed Sutton Block expansion to RL79.5m in the Peach Hill Catchment.

Above these elevations, it is likely that the streams are fed by groundwater in the shallow system (e.g. coal measures, basalt or shallow groundwater in weathered greywacke).

3.9 Hydraulic Conductivity

The hydraulic conductivity (k) is a parameter used to define the ease with which groundwater moves through the aquifer and transmissivity (T) is product of hydraulic conductivity and the aquifer thickness. The hydraulic conductivity of the greywacke rocks is controlled by fracturing and interconnection between fracture zones.

The hydraulic conductivity of the greywacke used in this study is based on previous field permeability tests (Murray North Ltd 1987, GCNZ 1989, Namjou 1997, PDP 2012, PDP 2017 and PDP 2022).

A long-term (28 days) constant head test was undertaken on HUN5/3 as part of an earlier investigation to support resource consent applications for the Hunua Quarry (PDP 2011). The results indicate a hydraulic conductivity value of 1×10^{-5}m/s.

The second 7-day pumping test was carried out in HUN14/8 (Figure 4) in 2021 (PDP 2022). The results indicated a hydraulic conductivity value of 1.5×10^{-5}m/s (in agreement with the earlier test in 2006).

The most recent investigation on the hydraulic conductivity of the greywacke east of the Hunua Fault was carried out in PH1 (the augmentation bore at Peach Hill Catchment) (PDP 2017). The pumping test programme consisted of a step discharge test and a 24-hour constant discharge and recovery tests. A step-drawdown test was undertaken at the site on the 28 September 2017 followed by a 24-hour constant rate test from 28 to 29 September 2017. The monitoring bores for the test are given in Table 3 and shown in Figure 4.

Table 3: Pumping Test Monitoring Bore Details (PDP 2017)					
Monitoring Bore ID	**Location (NZTM)**	**GL (m, RL)**	**Screen Formation**	**Distance to Pumping Bore**	**Bore depth (mbgl)**
BH103	1777212/ 5888550	128.12	Greywacke/ Coal Measures	162	53.6
BH104	1777227/ 5888410	135.97	Coal Measures	276	35
BH109	1776798/ 5888474	81.53	Greywacke	562	34.2

3.9.1 Step Discharge Test

The step discharge test was carried out to assess the pumping well performance and well losses. The test consisted of three steps, with pumping rates of 720, 840 and 960m^3/d. The Eden and Hazel method was used for the analysis (Appendix E) to determine well losses and aquifer transmissivity.

3.9.2 Constant Rate Discharge Test

The constant rate pump test followed the step test (after the bore was allowed to recover) to assess the aquifer properties. The 24-hour test began on 28th September 2017, at a constant pumping rate of 960m^3/d. The pumped water was discharged down-gradient to the neighbouring Peach Hill Stream, approximately 100m from the production bore. Water levels were monitored at 3 monitoring bore locations; BH103, BH104 and BH109, situated 162m, 276m and 562m from the pumping bore respectively (Figure 4).

The drawdown plots during the pumping test are shown in Appendix E.

The maximum recorded drawdown in the pumping bore was 48m. The observed drawdown approximately stabilised after approximately 6 hrs pumping. The drawdown plots for the test duration do not indicate any boundary effects and no drawdown was recorded in any of the monitoring bores.

Field permeability tests (slug test) were also carried out in all recently drilled deep bores (SG11L, SG12L and SG13) in the greywacke at the Sutton Block expansion area and the results are presented in Appendix F.

Tables 4 to 6 summarise the aquifer properties identified based on the aquifer test results.

Table 4: Slug Test Results for Greywacke

Bore	Coordinates (E/N)		GL Elevation (m, RL)	Piezo ID (mm)	Bore ID (mm)	Bore Depth (m, bgl)	screen (m)	SWL (m, bgl)	Tests[1]	Calculated Initial Displacement (m)	Analysis Method	K (m/s)	Average
SG11L	1777717	5890563	222.5	50	150	230	12	52.08	F-1	2.02	Bouwer-Rice (1976)	1.1×10^{-5}	1.12×10^{-5}
									R-1	1.89		1.1×10^{-5}	
									F-2	1.98		1.1×10^{-5}	
									R-2	2.03		1.1×10^{-5}	
									F-3	2.05		1.2×10^{-5}	
									R-3	1.94		1.1×10^{-5}	
SG12L	1778045	5890048	277	50	150	280	9	98.66	F-1	1.99		1.9×10^{-6}	1.98×10^{-6}
									R-1	1.83		1.7×10^{-6}	
									F-2	2.12		1.7×10^{-6}	
									R-2	1.18		2.6×10^{-6}	
SG13	1777748	5889534	249	50	150	250	9	144.17	F-1	2.04		1.4×10^{-6}	1.35×10^{-6}
									R-1	1.84		1.3×10^{-6}	
SG2L	1776785	5890949	192	50	150	199	8	7.4	F	1.96		4.86×10^{-6}	4.65×10^{-6}
									R			4.44×10^{-6}	
SG3L	1776534	5890343	157	50	150	165	8	5.26	F	1.1		1.7×10^{-5}	2.17×10^{-5}
									R			2.63×10^{-5}	
BH3[2]	1776629	5888701	50	25	150	74	54.48	19.52	F	0.72	Springer-Gelhar (1991)	6.76×10^{-6}	6.57 x 10-6
									R			6.38×10^{-6}	
BH2[2]	1776629	5888701	50	25	150	84.5	64.71	19.79	F	0.72		6.40×10^{-6}	6.61×10^{-6}
									R			6.81×10^{-6}	
22443/Test 1	1777352	5890055	182	32	96	138.8	27.00	7.18	F	0.33	Bouwer-Rice (1976)	4.01×10^{-6}	5.19×10^{-6}
									R			6.29×10^{-6}	
22443/Test 2	1776897	5889959	182	32	96	138.8	27.00	7.18	F	0.33		5.04×10^{-6}	
									R			5.42×10^{-6}	
21302	1776672	5888186	119	100	100	103.0	18.80	88.26	F	2.55		4.84×10^{-6}	4.84×10^{-6}

Notes:

1. *"F" indicates falling head test and "R" rising head test*
2. *Bores at the Drury Quarry (PDP 2012)*

Table 5: Pumping Test Result (PH1)

Bore	Aquifer Test	Method	Transmissivity (m^2/d)	K (m/s)[1]
PH1	Constant Discharge	Copper and Jacobs	103	5.96×10^{-6}
	Recovery	Theis Recovery	188	1.09×10^{-5}
	Average		145.5	8.42×10^{-6}

Notes

1. *Aquifer thickness assumed to be 200m*

Table 6: Aquifer Hydraulic Parameters (Hunua Bores)

Bores	Aquifer Test	Method	T (m^2/d)	Average T (m^2/d)	Storage Coefficient	K (m/s)
HUN14/8	Step Test	Eden & Hazel	274	274	-	1.6×10^{-5}
	Constant Discharge	Cooper & Jacob	259	262	-	1.5×10^{-5}
	Recovery	Theis	264		-	1.5×10^{-5}
HUN5/3	Constant Discharge	Cooper & Jacob	260	254	0.0004	1.5×10^{-5}
	Recovery	Theis	248		-	1.4×10^{-5}
Geomean				258[(1)]		1.47×10^{-5}

Notes:

1. *Excluding the transmissivity value based on the step test*

The geometric mean value of the above hydraulic conductivity in the greywacke incorporating the recent pumping test and the slug tests in the new bores (SG11L, SG12L and SG13) is approximately 5.6×10^{-6}m/s (T = 97m^3/d for 200m thick saturated greywacke). This is close to the hydraulic conductivity used for the existing Drury Quarry consent application (i.e., 6.5×10^{-6}m/s) based on slug tests (PDP 2012).

The recent pump test results (PDP 2017 and PDP 2022) indicate there is no significant difference between the hydraulic conductivity, east and west of the Hunua Fault. However, the hydraulic conductivity increases close to the Hunua Fault (shear zone) as is evident from the slug test result in SG11L (next to a branch of the Hunua Fault).

The permeability of the coal measures has been estimated previously (Murray North Ltd, 1988) as part of the investigations in Peach Hill Catchment. The geometric mean hydraulic conductivity of the unweathered coal measures formations was about 5 x 10^{-7}m/s. However, weathering can significantly reduce the permeability of these materials (by one to two orders of magnitude).

3.10 Groundwater Throughflow and Recharge

3.10.1 Groundwater Recharge

The regional groundwater is recharged by downward percolation from the shallow groundwater or directly through greywacke outcrops in catchments. Locally, significant recharge may occur through the exposed fractured greywacke (including exposed fractured greywacke within the Drury quarry pit area).

A portion of the recharge is intercepted by the perched shallow groundwater while the remainder permeates downwards to recharge the regional groundwater. The recharge intercepted by the perched layers is sufficient to sustain the baseflow of the streams in the upstream areas.

3.10.2 Shallow Groundwater

Groundwater recharge to the shallow groundwater has been quantified by assuming it is close to the long-term low-flow specific discharge value (baseflow) for the surface water catchments. The specific discharge based on Q5 (1 in 5 years low flow) was used for recharge estimation.

For this study the MALF is estimated based on the NT1-1 (upstream of the Upper Dam at about RL158m, Figure 3) low flow data and its correlation with the flow data from the closest catchment to the site with long-term stream flow data and a similar geology. The Auckland Council operates a stream flow monitoring station (8529) at the Mangawheau Catchment which has an area of 30.4km^2. This station has been monitored since 1988 and has been used for the stream flow correlations. Based on the Auckland Council stream flow data, the MALF for the Mangawheau Stream is 2.03L/s/km^2.

The NT1 tributaries low flows within the upper catchment areas were measured in dry conditions in 2022 (Appendix C). However, ongoing monitoring of these tributaries is required for any flow correlation and determination of MALF. A v-notch weir was established at NT1-1 and recorded the stream flow for a three-month period between 15/02/2010 and 17/5/2010 in dry conditions. In addition, annual stream flow gauging between 2012 - 2022 is incorporated in the dataset (PDP 2022) and results were correlated against Mangawheau Station and the correlation results are shown in Figure 10. Using the correlation equation, the Q5 and MALF at NT1-1 were 1.39 and 1.79L/s/km^2, respectively. The results are summarised in Table 7.

The correlation accuracy (R^2) and the resulting Q5 estimates for the above gauging stations are given in Table 7. The R^2 is above 0.86, indicating a good correlation between the data sets.

The MALF of 1.79L/s/km^2 equates to a recharge rate of about 56mm/year, or about 4% of annual rainfall (i.e. 1,300mm/year). This is the recharge to the shallow groundwater within the NT1 Catchment. The contribution to the regional groundwater discussed in Section 3.10.2.

Table 7: Specific Discharge Q5 and MSALF for Selected Gauging Stations

Gauging Station	R^2	Q5 Low Flow L/s/km^2	MALF (L/s/km^2)	Catchment Area (km^2)
Mangawheau Stream	-	2.03	2.51	30.4
NT1-1	0.86	1.39	1.79	1.02

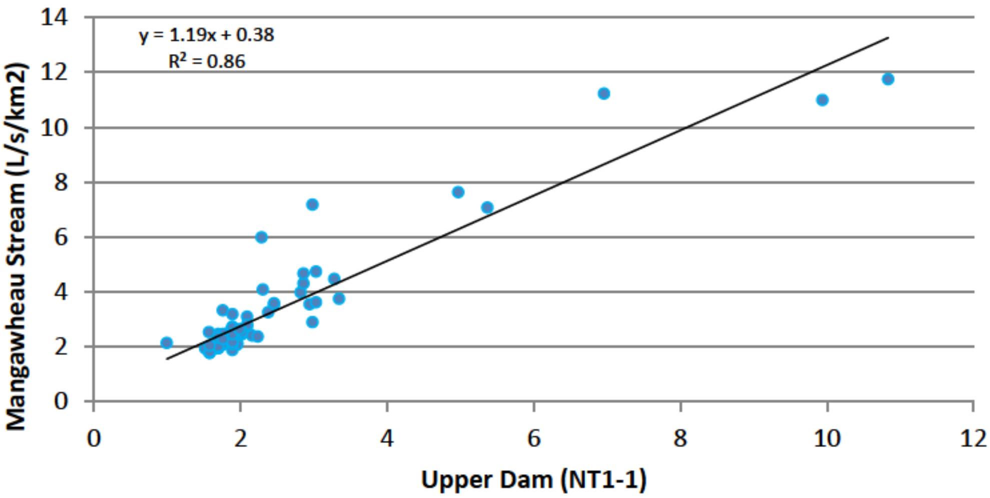


Figure 10: Correlations of Flows Between NT1-1 and Mangawheau Stream

3.10.3 Regional Groundwater

The regional groundwater throughflow has been calculated previously (PDP 2011 and 2012). Using Darcy flow analysis (Q per unit length = Transmissivity x Hydraulic gradient), transmissivity of 86m^2/d and hydraulic gradient of 0.007, the average throughflow was calculated to be about 645m^3/d/km (PDP 2011). This is indicative of the rate of flow across the Drury Fault via either discharge to the shallow groundwater/surface water or minor seepage directly into the alluvium in the Manukau lowlands.

Using the above throughflow (645m^3/d/km), the groundwater resource within the maximum zone of influence for the Hunua Greywacke Block is calculated to be about 4,900m^3/d (645m^3/d/km x 7.6km). Expressed as a percentage of the rainfall at the surface (1,300mm per year) the above throughflow over the Hunua Greywacke Block of 30km^2 (Figure 4) corresponds to a regional groundwater recharge rate of about 4.6% of the annual rainfall (or about 60mm per year).

For Drury Greywacke Block, using the same method, the natural throughflow was calculated to be lower, at about 337m^3/d/km with the estimated recharge of 188mm/year or 14% of the annual rainfall (PDP 2012). The higher estimated recharge is due to smaller recharge area within the Drury Greywacke Block. The above estimated throughflow is likely to be less accurate than the throughflow estimated for the Hunua Greywacke Block due to lack of sufficient pre-quarry groundwater levels along the flow paths towards the Drury Fault. Therefore, for this study the recharge is estimated based on the throughflow calculations for the Hunua Greywacke Block (i.e. 60mm per year or about 4.6% of the annual rainfall). This is the recharge adopted for the technical investigations supporting the resource consent applications for the Symonds Hill Pit and existing Drury Quarry.

This recharge is not equally distributed within the greywacke. As mentioned above, a higher recharge rate is expected over the exposed greywacke in the quarries and also within the exposed fractures zone along the faults. Similarly, more throughflow is expected along the shear zone next to the fault zones.

3.11 Available Groundwater Resources East of Hunua Fault

The resource in the greywacke extends across the region. Abstractions from this aquifer therefore need to be considered in this context. The natural groundwater catchments boundaries are no barriers to resource availability as they are simply defined by flow paths within a regional aquifer that are changeable when new abstractions occur. Considering the greywacke thickness is more than 10km (Schofield, 1967) and form the basement of rocks, there is significant resource available within these rocks. For example, assuming the groundwater resource is only limited to the exposed greywacke east of the Drury Fault with an area of 665km^2 (based on the geological map) and there is no flow barrier fault to the east of the Hunua Fault, the regional groundwater resource in the exposed greywacke is estimated to be more than 109,000m^3/d (based on recharge rate of 60mm/year or about 4.6% of rainfall). Excluding the Hunua and Drury Greywacke Blocks the above resource east of the Hunua Fault is about 104,000m^3/d. Note that in reality, the actual resource availability can be limited by flow barrier faults (not the groundwater catchment divides). For example, the resource availability within the Hunua Greywacke Block was assessed to be about 4,740m^3/d (PDP 2021). For the current study, there is no information on other flow barrier faults to the east of the Hunua Fault that could limit the availability of the groundwater resource within the greywacke.

3.12 Groundwater and Surface Water Quality

The following results are based on the groundwater and surface water sampling rounds carried out in May 2012, August 2012, November 2015 and August 2022. The investigation of groundwater and surface water quality was carried out to assess the ionic composition of the groundwater and surface water and water quality in the area surrounding the proposed Sutton Block expansion. The laboratory results (2022) from the ground and surface water samples are presented in Appendix D.

3.12.1 Major Ions

Piper diagrams were used to differentiate the water samples into water types according to their respective ionic compositions. Figure 11 shows the Piper diagram prepared for the groundwater, sump and two surface water samples based on the results of the five sampling rounds between May 2012 and August 2022. The water types are summarised in Table 8 (see Figures 3 and 4 for location of the sampling sites).

The regional groundwater in the greywacke bores can generally be classified as 'Magnesium bicarbonate type' with the exception of BH SG3L and SG12U which is classified as sodium chloride. The Drury Quarry sump has a higher proportion of sulphate and is classified as calcium sulphate.

The stream sampling site, downstream of the proposed Sutton Block expansion (NT1-1, Figure 3) has the lowest concentrations of analytes and is classified as 'sodium chloride type'. Downstream of the quarry (NT1-4) the stream appears to have water chemistry similar to the Quarry Sump and can be classified as 'calcium-sulphate type'. This may be due to regional groundwater discharge the NT1 Stream at lower elevations.

The water chemistry analysis confirms a difference in ionic composition between samples from the groundwater and surface water which is caused by minor hydraulic interaction between the regional groundwater and the shallow groundwater that discharges to the streams.

Table 8: Sample Water Types 2012 - 2022				
Station ID	**Water Type May 2012**	**August 2012**	**November 2015**	**August 2022**
Surface Water:				
NT1-1	Na-Cl	Na-Cl	Na-Cl	Na-Cl
NT1-4	Ca-SO_4	Ca-SO_4	Ca-SO_4	-
Groundwater:				
Quarry Sump	Ca-SO_4	Ca-SO_4	Ca-SO_4	Ca-SO_4
SG11U	-	-	-	Mg-H/CO_3
SG11L	-	-	-	Na-Cl
SG12U	-	-	-	Mg-H/CO_3
SG12L	-	-	-	Mg-H/CO_3
SG13	-	-	-	Mg-H/CO_3
SG1L	-	-	Mg-H/CO_3	-
SG1U	-	-	Mg-H/CO_3	-
SG2U	-	-	Mg-H/CO_3	-
SG2L	-	-	Mg-H/CO_3	-
SG3U	-	-	Mg-H/CO_3	-
SG3L	-	-	Na-Cl	-
SG4	-	-	Mg-H/CO_3	-
SG5	-	-	Mg-H/CO_3	-

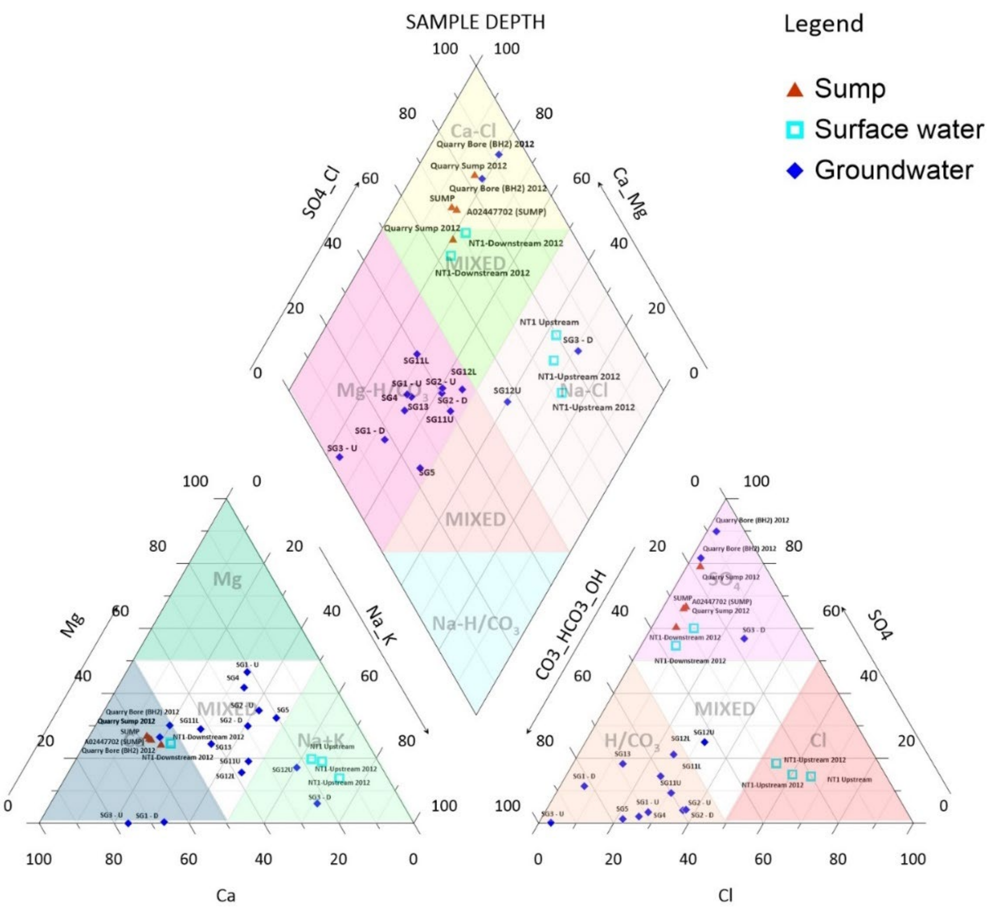


Figure 11: Piper Diagram for Groundwater and Surface Water Samples (May 2012-August 2022)

3.12.2 Concentration Levels and Guidelines

The water quality results were also compared against the following guidelines:

- ANZECC (2000) trigger values for 95% protection of Freshwater Aquatic Ecosystems),
- ANZG (2018) guideline for 80% ecosystem protection,
- ANZECC (2000) trigger values for irrigation and general water use,
- ANZECC (2000) trigger values for livestock drinking water quality,
- NZ DWS (2022) Drinking Water Standards for New Zealand.

Samples that exceed the relevant guidelines are presented in Table 9. All other concentrations were below the relevant guideline values.

Table 9: Samples that Exceeded Water Quality Guidelines (2015 and 2022)					
Sample	**ANZECC 95% Ecosystem Protection**	**ANZG (2018)**	**ANZECC Irrigation and General Use**	**ANZECC Livestock drinking water**	**NZ DWS (2022)**
NT1-1[1]	-	Total Ammoniacal-N / Nitrate	-	E-coli	E-coli
NT1-4[1]	-	Total Ammoniacal-N / Nitrate	Iron	E-coli	E-coli
Drury Sump[1]	-	pH/Nitrate/EC	-	-	E-coli, Arsenic
SG1U[2]	Aluminium	Nitrate	-	-	-
SG1L[2]	Aluminium	EC/pH/ Ammoniacal-N	Iron	-	Aluminium,
SG2U[2]	-	Nitrate	-	-	
SG2L[2]	-		Iron, Manganese	-	Manganese
SG3U[2]	Ammoniacal-N Aluminium, Zinc	EC/pH/ Ammoniacal-N / Nitrate	-	-	Aluminium
SG3L[2]	-	pH	-	-	-
SG11U[1]	Nitrate, Aluminium, Cadmium, Lead, Arsenic	EC, DPR, Nitrate Ammoniacal-N	Dissolved Reactive Phosphorus (DRP) Aluminium, Arsenic Cadmium, Manganese	Aluminium Arsenic, Cadmium	Aluminium, Manganese, Arsenic, Cadmium, Lead
SG11L[1]	Nitrate, Aluminium, Cadmium, Manganese, Copper, Lead, Arsenic, Zinc	EC, DPR, Nitrate, Ammoniacal-N, Zinc	DRP, Aluminium, Arsenic, Cadmium, Manganese	Aluminium Arsenic, Cadmium, Lead	Aluminium, Arsenic, Cadmium, Mercury, Manganese, Lead
SG12U[1]	Aluminium, Chromium, Copper, Zinc	EC, DPR, Nitrate, Zinc	DRP, Iron	-	Aluminium, E-coli
SG12L[1]	Aluminium, Copper, Lead Zinc	EC, DPR, Nitrate, Zinc	DRP, Iron	-	E-coli
SG13[1]	Aluminium, Chromium, Copper, Nickel, Zinc	EC, DPR, Nitrate, Ammoniacal-N, Zinc	Manganese, Iron, Zinc	-	Manganese, E-coli

Notes:

1. *2022 sampling round*
2. *2015 sampling round*
3. *Assume warm-wet conditions and 80% ecosystem protection (ANZG 2018)*

Nitrogen Species

Four different nitrogen species were measured as part of this investigation. These were ammoniacal-N, nitrite-N, nitrate-N and total Kjeldahl nitrogen (TKN). The most recent sampling carried out in July 2022 recorded nutrient concentrations within the current guidelines, New Zealand Drinking Water Standards (NZDWS-2022).

The concentration of all the tested nitrogen species for all sampling sites were well below the ANZECC 95% ecosystem protection.

Dissolved Reactive Phosphorous

Dissolved reactive phosphorous was found in very low concentrations in both the groundwater and surface water. The concentrations exceed ANZECC Primary industries: irrigation/general use in all recently drilled piezometers except SG13. The highest measured concentration of 24.4mg/L was detected in the recently drilled SG11L. This may be due to drilling mud contamination, but the elevated concentration needs to be confirmed through the proposed baseline water quality monitoring programme.

Sulphate

The concentration of sulphate in the groundwater and surface water is below the drinking water guideline except in the sump (331mg/L). The sulphate concentration in groundwater ranges between 5 to 197mg/L. The sulphate in groundwater is more likely to be due to natural sources. The mineral pyrite which is an iron sulphide ($FeS2$) has been detected on the joint surfaces in the bores at the quarry.

Metals

The 2022 results indicated that a number of metal concentrations were in exceedance of all guidelines including drinking water standards in recently drilled boreholes in the Sutton Block (Table 9). The elevated arsenic concentration in SG11 exceeds all guidelines.

Considering there is no quarrying operation and no known managed fill in the Sutton Block and the bores are located upgradient to the existing Drury Quarry in the upper areas of NT1 Catchment, these elevated concentrations are unrelated to the existing Drury Quarry operation or any managed fill in the area. No Fill is detected during the drilling which may suggest a local contamination source and the bores were drilled with air-hammer which minimises the risk of any groundwater contamination from any external water source.

No metal contamination is detected in the stream within the Sutton Block (NT1) downstream of the bores. Therefore, it is not likely that there is a widespread contamination source in the area.

The existing Drury Quarry sump water which is sourced from both groundwater and surface water from the quarry surrounding catchments (including NT1 Catchment) complies with all guidelines except for the drinking water standards (DWS).

The source of elevated aluminium in boreholes may be due to fertilisers (e.g. superphosphate) commonly applied in the surrounding catchments. However, the source of other metals including arsenic is unknown and requires confirmation based on further water quality monitoring.

As part of the recommended conditions further groundwater and surface water sampling (for water quality analysis) is proposed to establish the water quality baseline before the new quarry intercepts the groundwater.

4.0 Assessment of Effects on Groundwater and Surface Water

The following environmental effects as a result of the proposed Sutton Block expansion on the groundwater and surface water are assessed:

- Regional groundwater inflow and effects on groundwater resources;
- Effects on groundwater users;
- Effects on shallow/perched groundwater resource (including shallow groundwater resource in Kaarearea Paa); and
- Effects on the base flows of streams.

The above dewatering effects have been assessed for the following quarry stages:

- Dewatering Effects for Stage 1 (3 years);
- Dewatering Effects for Stage 2 (15 years);
- Dewatering Effects for Stage 3 (30 years);
- Dewatering Effects for Stage 4 (40 years); and
- Dewatering Effects for Stage 5 (50 years).

The plan for the above quarry stages is shown in Figure 2.

4.1 Methodology and Assumptions for Assessing the Zone of Influence

The zone of influence as a result of the proposed Sutton Block expansion dewatering has been assessed using field investigation results and analytical methods (Dupuit–Forchheimer method). The analytical method is presented in Appendix G.

The prediction of zone of influence using the above method assumes isotropic and homogeneous aquifer characteristics under steady state conditions. Aquifer heterogeneity and sub-surface flow barrier boundaries (flow barrier faults) are likely to reduce the predicted theoretical zone of influence. Therefore, the conservative predictions need to be updated as part of the consent conditions based on the actual monitoring data as the new pit develops.

The estimation of the pre-dewatering groundwater level (initial saturated thickness before dewatering) is required in the analytical method. The regional groundwater level at the proposed Sutton Block to the east of Hunua Fault was estimated based on the average regional groundwater levels in SG11L and SG12L (RL170m).

The regional groundwater level to the west of the Hunua Fault and within the Hunua Greywacke Block is estimated based on the data from the closest deep bore to the proposed quarry, that is SG3L (Figure 4). The groundwater level in SG3L is currently at about RL50m but continues to recover as a result of the cessation of dewatering at the Hunua Pit in 2017 and subsequent backfilling of the pit.

Based on the previous investigation (PDP 2011 and 2020) the pre-Hunua Quarry dewatering groundwater level within the Hunua Greywacke Block is estimated to be at about RL64m. This means the required maximum drawdown for dewatering to the west of the Hunua Fault is likely to be less than the east of the fault (less stress on the groundwater). However, considering partial removal of Hunua Fault (i.e. the aquifer boundary) in the vicinity of the proposed pit, the methodology conservatively uses the maximum groundwater head observed to the east of the fault for the prediction of the zone of influence. This results in higher predicted drawdowns as a result of the proposed dewatering.

Based on the groundwater conceptualisation discussed in Section 3, the Hunua Fault forms a barrier (or low permeability zone) to groundwater throughflow. However, a higher transmissivity zones along fractured and sheared zones next to the fault may act as a recharge boundary parallel to the barrier, considering some of these shear zones have been intercepted the surface (e.g. along the Hunua Fault). A high permeability shear and fractured zone was detected during the drilling in SG11L located next to a branch of Hunua Fault (Figure 4).

Other unknown barrier faults which are common in the greywacke (referred to as intervening faults) may further reduce the theoretical extent of the zone of influence towards the east of the Hunua Fault and hence minimise the predicted effects on farm wells. One such barrier fault may be located between SG12L and SG13 (Figure 4) causing about 70m head difference between these two bores. This suggests a flow barrier fault may also exist south of the proposed Sutton Block expansion (east of the Hunua Fault) separating the regional groundwater between the Peach Hill and NT1 Catchments and reducing the extent of predicted zone of influence towards the south of the proposed quarry.

Considering such unmapped intervening faults are likely to occur to the east of the Hunua Fault in the greywacke, the actual drawdown and inflow is likely to be less than predicted.

Removal of a portion of the Hunua Fault next to the proposed new sump is not likely to cause any additional westward throughflow across the fault or rise in groundwater levels to the west of the Hunua Fault. This is because the fault remains intact below the new pit floor and the proposed sump is likely to intercept any westward groundwater throughflow before it can recharge the groundwater to the west of the fault.

The pit floor at the Symonds Hill Pit is at about RL75m and close to the regional groundwater in the greywacke. This is about 100m lower than the current ground level at the proposed new pit (Sutton Block).

The pre-quarry groundwater levels beneath the proposed quarry footprint within the Hunua, Drury and Sutton Greywacke Blocks are about RL64m, RL58m and RL170m. As a result of dewatering at the Symonds Hill Pit and Drury Quarry, the groundwater levels in the Hunua and Drury Greywacke Blocks have been lowered and currently are at about RL63.6m and RL-39.3m (October 2024).

4.2 Dewatering Effects for Stage 1 (up to 3 years)

This quarry stage is primarily for the establishment of supporting infrastructure and construction of the new pit access road and is limited to the excavation of overburden south of the proposed pit above the regional groundwater. The shallow excavation is to the west of the Hunua Fault and does not intercept the regional groundwater at RL64m. The shallow groundwater continues to flow to the NT1 Stream above the Upper Dam and remains unaffected by Stage 1.

4.3 Dewatering Effects for Stage 2 (approximately 15 years)

4.3.1 Regional Groundwater Inflow

The dewatering level for stage 2 is at about RL90m. Stage 2 is about 29.4ha with the bottom of the pit above the regional groundwater to the west of the Hunua Fault (i.e. RL64m) and therefore, it has no effects on the regional groundwater within the Hunua or Drury Greywacke Blocks. The shallow groundwater contribution to the pit for Stage 2 is presented in Section 4.3.3.

For the Sutton Greywacke Block, the pit may intercept the regional groundwater at RL170m, east of the Hunua Fault. An estimate of the drawdowns and regional groundwater inflow associated with the quarry sump for Stage 2 with the dewatering level at RL90m was made using the analytical method discussed above (Appendix G) and the parameters (i.e., hydraulic conductivity and recharge) presented as part of the conceptual model (Sections 3.9 and 3.10). Using the above method, the theoretical groundwater inflow for Stag 2 is calculated for the whole zone of influence including the area to the west of the Drury Fault which will not be affected by this quarry stage. Using the recharge applied in the analytical model (60mm/year) and the contributing zone of influence to the east of the Hunua Fault, the inflow for these stages is estimated to be about 4,300m^3/d.

4.3.2 Effect of Quarry Pump out on Groundwater Users

Using the above analytical method, the maximum zone of influence for Stage 2 is estimated to be about 4,416m. Any existing water bores within the above zone of influence have the potential to be affected by the lowering of the water table in the quarried area. The distance drawdown plot for Stages 2 and 3 is shown in Figure 12. The maximum zone of influence is shown in Figure 16.

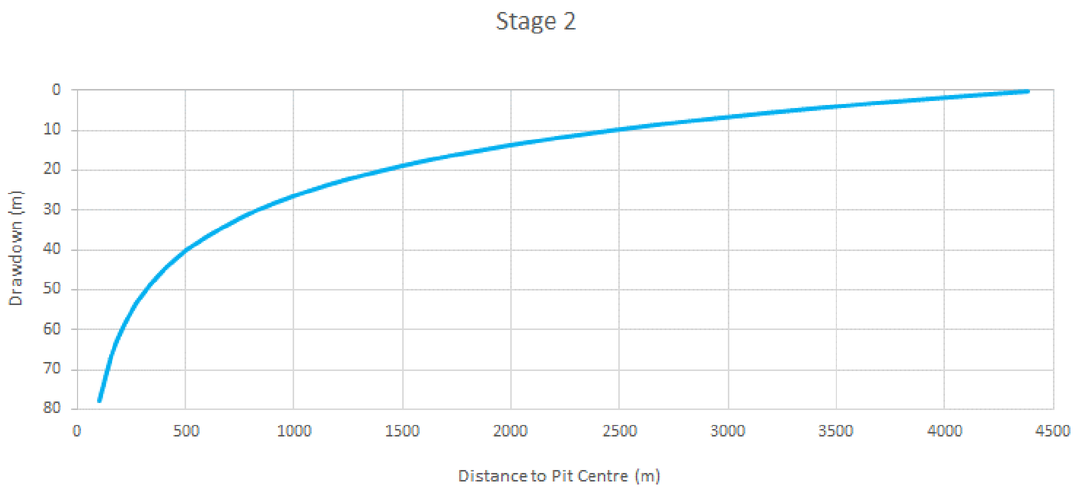


Figure 12: Distance Drawdown Plot for Stage 2

The wells withing the predicted zone of influence for Stage 2 were identified based on the results of the well surveys and AC bore and take database (2012 and 2022) and is presented in Appendix H. The bore details are available only for some of the bores identified in the database. It is likely that many of these wells are investigation bores, not exist, or not in the greywacke. The drawdown effects in these wells based on the analytical method discussed above, range from 0.1m to 17.2m (Appendix H). The location of these bore within the Stage 2 zone of influence is shown in Figure 16.

There is no data on the pump depths for the above bores. However, the bore survey results (Appendix I) and available data on the AC bores (Appendix H) indicate that the bores in the greywacke are generally deep and may accommodate the predicted drawdowns. The bores drilled in shallow sediments (e.g. overlying Waitemata Group) will remain unaffected by the proposed dewatering in the regional groundwater in the greywacke.

If any adverse effects on the above farm wells are detected as a result of the proposed dewatering, mitigation options are available. These mitigation options are outlined as part of the recommended monitoring conditions.

4.3.3 Effects of the Pit Excavation on Shallow Groundwater Resources

Shallow groundwater within, and in the vicinity of, the Sutton Block expansion area is expected to be affected by the proposed quarry. Perched zones of groundwater will be intercepted by quarrying and zones adjacent to the pit walls may drain into the pit where the orientation of structural features or layers promotes lateral drainage. The discontinuous nature of the shallow zones will limit the drainage effects to relatively short distances from the pit wall.

The width of the drainage zone outside the pit will depend on topography as well as geology due to the competing drainage attraction of the natural slopes surrounding the quarry. For the purposes of assessing the amount of resource potentially affected, the ridgelines of adjacent gullies have been taken as flow divides in the shallow groundwater resource.

The total area of the proposed pit at Stage 2 plus the related narrow drainage zone is about 41 ha. Applying the recharge to the shallow groundwater for the NT1 Catchment (56mm, Section 3.10). The shallow groundwater zone would have contributed about 62m^3/d to the quarry pit.

Note that it is not possible to separate these shallow minor inflows (e.g. 62m^3/d for Stage 2) from the regional groundwater inflows (e.g. 4,300m^3/d for Stage 2). The shallow inflows from the shallow groundwater to the pit will be collected by the pit water management system and discharged to the sediment control ponds. The groundwater then will be discharged to Hingaia Stream via NT1 Stream.

The effects on the site stream and neighbouring streams assessed separately as part of Section 4.8.

4.4 Dewatering Effects for Stage 3 (approximately up to 30 years)

4.4.1 Regional Groundwater Inflow

The dewatering level for the above quarry stage is at about RL60m. An estimate of the drawdowns and regional groundwater inflow associated with the quarry sump for Stage 3 was made using the analytical method (Appendix G) and parameters discussed above.

Using the maximum sump drawdown of 110m (RL170m - RL60m), the theoretical groundwater inflow for Stage 3 is calculated for the whole calculated radial zone of influence including the areas to the west of the Drury Fault. Using the recharge applied in the analytical model (60mm/year) and the contributing zone of influence to the east of the Drury Fault (66km^2), the inflow for this stage is calculated to be about 10,800m^3/d.

4.4.2 Effect of Quarry Pump out on Groundwater Users

East of Hunua Fault

Using the analytical method (Appendix G) the maximum zone of influence for the proposed Stage 3 quarry with the maximum drawdown of 110m at the sump is estimated to be about 5,800m. Any existing water bores within the above zone of influence have the potential to be affected by the lowering of the water table in the quarried area. The distance drawdown plot and the maximum zone of influence for Stage 3 is shown in Figures 13 and 16 respectively.

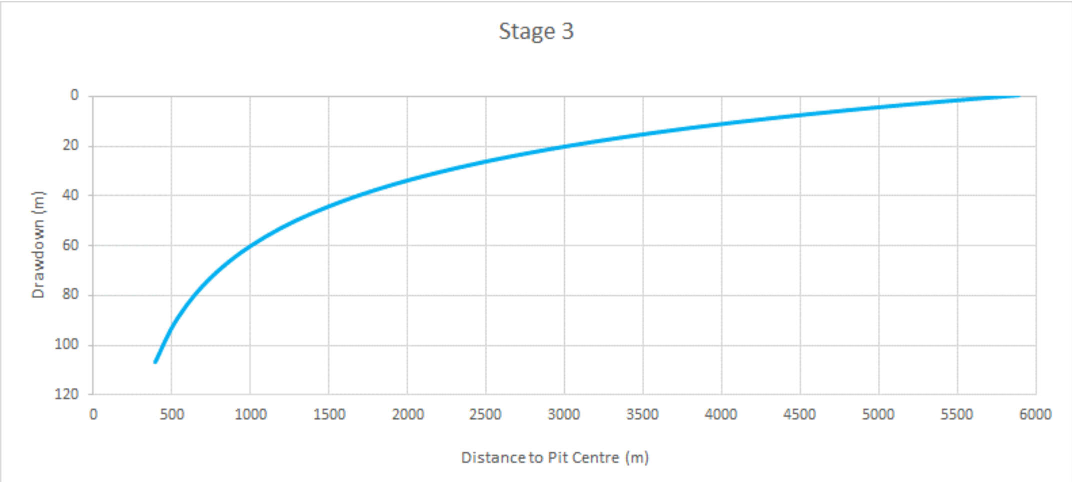


Figure 13: Distance Drawdown Plot for Stage 3

The wells within the predicted zone of influence for Stage 3 were identified based on the results of the well surveys and AC bore and take database (2012 and 2022) and is presented in Appendix H. The drawdown effects in these wells based on the analytical method discussed above, range from 0.02m to 87m (Appendix H). The location of these bore within the Stage 3 zone of influence is shown in Figure 16.

As mentioned above, there is no data on the pump depths. However, the bore survey results indicate that the bores are generally deep and can accommodate the predicted drawdowns in the regional groundwater in the greywacke. Mitigation measures are available to address any adverse drawdown effects on the farm wells.

West of Hunua Fault

The pit floor at the Symonds Hill Pit (west of the Hunua Fault) is likely to be always lower than the pit floor at the proposed Sutton Block expansion until it reaches the minimum authorised dewatering level of RL-5m. This is about 65m below the dewatering level at the Sutton Block expansion at Stage 3 (i.e., RL60m). Considering the low hydraulic gradient detected within the Hunua Greywacke Block, it is likely that Symonds Hill Quarry sump (west of the Hunua Fault) controls the drawdowns within the Hunua Greywacke Block for Stage 3.

Similarly, the existing Drury Quarry will reach RL-45m soon (currently at RL-39.3m, October 2024). This is 105m below the proposed quarry floor at RL60m for Stage 3. Considering the barrier faults, below the Sutton Block pit floor at Stage 3 (RL60m), will remain intact, no interference drawdown effects between the Sutton Block expansion and the Drury Quarry is likely and lowering of the Drury Quarry down to RL-45m is not likely to increase the drawdown effects predicted for the proposed Sutton Block expansion.

4.4.3 Effects of the Pit Excavation on Shallow Groundwater Resources

Using the same method as discussed for Stage 2, the total shallow groundwater zone for Stage 3 is about 92 ha. Using the estimated recharge for NT1 Catchment (56mm, Section 3.10), the shallow groundwater zone contribution to the proposed pit is about 142m^3/d.

As for the previous quarry stages the above inflow will be discharged to the NT1 Stream. Therefore, the proposed development will have no more than minor net effect on the shallow groundwater resources within the NT1 Catchment. The effects on the site stream and neighbouring streams assessed separately as part of Section 4.8.

4.5 Dewatering Effects for Stage 4 (approximately up to 40 years)

4.5.1 Regional Groundwater Inflow

The dewatering level for Stage 4 is at about RL-60m. Using the same method and hydraulic properties discussed above, the theoretical groundwater inflow for Stage 4 is calculated for the whole radial zone of influence including the areas to the west of the Drury Fault. Using the recharge applied in the analytical model (60mm/year) and the contributing zone of influence to the east of the Drury Fault, the inflow for the final stage is calculated to be about 18,000m^3/d.

In terms of the groundwater availability within the zone of influence itself, the quarry take is not a requirement for the operation of the quarry but rather a by-product of it (except for a small portion of the inflow which will be used for the quarry use (e.g. dust suppression). The proposed quarry water use for the Sutton Block is expected to be similar to the existing quarry (Drury Quarry) water use or about 342m^3/d. This is less than 2% of the predicted inflow.

Considering the above, the water is available for other users to access with appropriate well designs. This simply requires their wells to be below the drawdown surface caused by the proposed Sutton Block (See Section 4.5.2). Outside the envelop of effects, considering the extent of the greywacke aquifer and availability of the groundwater resource, it is unlikely that there will be any adverse effects on the farm wells yield.

4.5.2 Effect of Quarry Pump out on Groundwater Users

East of Hunua Fault

Using the analytical method discussed above, the maximum zone of influence for the proposed Stage 4 quarry with the maximum drawdown of about 230m at the sump is about 7,489m. Any existing water bores within the above zone of influence have the potential to be affected by the lowering of the water table in the quarried area.

The distance drawdown plot and maximum zone of influence for Stage 4 is shown in Figures 14 and 16 respectively.

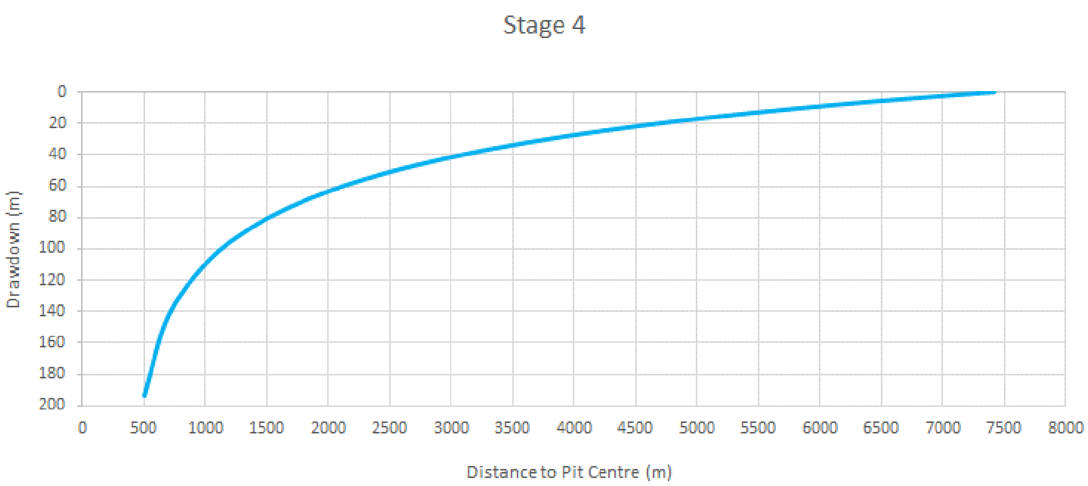


Figure 14: Distance Drawdown Plot for Stage 4

The farm wells within the Stage 4 zone of influence (based on AC database) are presented in Appendix H and shown in Figure 16. The drawdown effects in these wells range between 0.4m and 117m (Appendix H). As mentioned before, the bore details are available only for some of the bores identified in the database. It is likely that many of these wells are investigation bores, not exist, or not in the greywacke.

As mentioned above, based on the AC database it is likely that the farm wells can accommodate the predicted drawdown. However, if required, remedial measures are available to mitigate any adverse effects on the farm wells and these are presented as part of the recommended monitoring conditions.

West of Hunua Fault (Hunua Greywacke Block)

The proposed dewatering level at Stage 4 (RL-60m) requires partial removal of the barrier faults between the greywacke blocks (e.g., Hunua Fault). Considering the low hydraulic gradient detected in the Hunua and Drury Greywacke Blocks west of the Hunua Fault, Stage 4 dewatering may cause the groundwater within the Hunua and Drury Greywacke Blocks to drop to RL-60m.

However, this is a less likely scenario as the intervening barrier faults are common in the greywacke in this area and this is likely to reduce the predicted drawdowns. In addition, the facts that only 5% of the Hunua Fault (east of the Hunua and Drury Greywacke Blocks) will be breached during the gradual progression of the proposed pit expansion, is likely to cause further reductions in theoretical drawdowns predicted for the Hunua and Drury Greywacke Blocks. Therefore, the above predicted drawdowns need to be updated (as part of the consent conditions as more monitoring data during the pit development becomes available.

4.5.3 Effects of Pit Excavation on Shallow Groundwater Resources

Using the same method discussed in Section 4.3.3, the shallow groundwater zone for Stage 4 Pit is 119ha with the estimated shallow groundwater contribution of about 183m^3/d which together with groundwater inflow will be pumped back to NT1 Stream.

4.6 Dewatering Effects for Stage 5 (approximately up to 50 years)

4.6.1 Regional Groundwater Inflow

Similar to Stage 4, the dewatering level for Stage 5 remains unchanged at about RL-60m. Therefore, the dewatering effects for Stage 5 are not expected to be significantly different than Stage 4.

Using the same method and hydraulic properties discussed above, the theoretical groundwater inflow for Stage 5 is calculated for the whole radial zone of influence including the areas to the west of the Drury Fault. Using the recharge applied in the analytical model (60mm/year), and the contributing zone of influence to the east of the Drury Fault, the inflow for the final stage is calculated to be about 18,243m^3/d.

The effects on the groundwater resource availability and the groundwater users are similar to Stage 4 as outlined in Section 4.5. In addition, the quarry use is expected to remain unchanged (less than 2% of the above inflow or about 342m^3/d).

4.6.2 Effect of Quarry Pump out on Groundwater Users

East of Hunua Fault

Using the analytical method discussed above, the maximum zone of influence for the proposed Stage 5 quarry extends only 50m more than Stage 4, totalling approximately 7,543m.

The distance drawdown plot and maximum zone of influence for Stage 5 is shown in Figures 15 and 16 respectively.

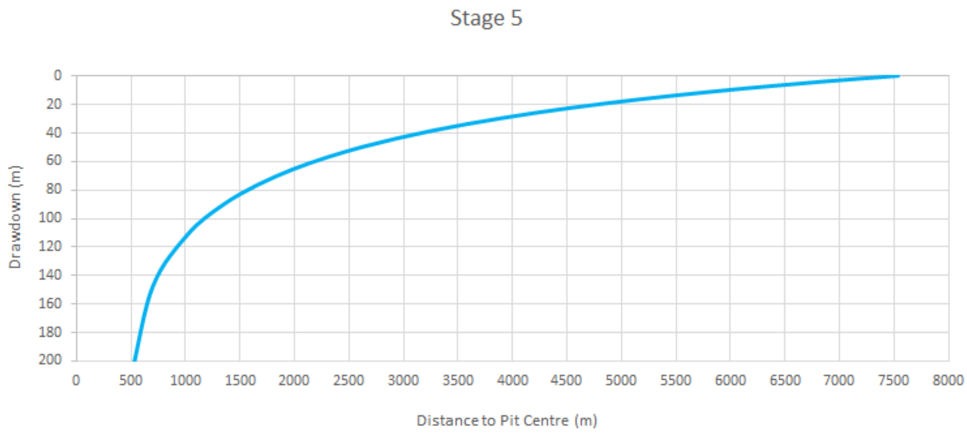


Figure 15: Distance Drawdown Plot for Stage 5

Only one additional farm well (4449) is located within the Stage 5 zone of influence (compared with Stage 4). The drawdown effects in farm wells for Stage 5 are very similar to Stage 4 as the dewatering level remains identical for these Stages (i.e. RL-60m). The predicted drawdown effects in farm wells for Stage 5 range between 0.3m and 120m (i.e. similar to Stage 4) and are presented in Appendix H.

As for Stage 4 bores, the bore details are only available for some of the bores identified in the database. It is likely that many of these wells are investigation bores, do not exist, or are not located in the greywacke.

As mentioned previously, considering the availability of drawdowns in deep greywacke bores, it is likely that the farm wells within Stage 5 can accommodate the predicted drawdown. However, if required, as for Stage 4, remedial measures are available to mitigate any adverse effects on the farm wells.

West of Hunua Fault (Hunua Greywacke Block

Similar to Stage 4, the proposed dewatering level at Stage 5 (RL-60m) requires partial removal of the barrier faults between the greywacke blocks (e.g., Hunua Fault). Therefore, assuming there are no other flow barrier faults, the proposed Sutton Block expansion for Stage 5 controls the regional groundwater levels in the Hunua and Drury Greywacke Blocks.

The drawdown effects to the west of the Hunua Fault for Stage 5 mirror those discussed for Stage 4 (Section 4.5.2), as the dewatering levels are identical for both stages (i.e. RL-60m).

4.6.3 Effects of Pit Excavation on Shallow Groundwater Resources

The shallow groundwater zone for Stage 4 is extended to the boundary of the pit catchment and contains the shallow groundwater zone for Stage 5. Therefore, the shallow groundwater contribution for Stages 5 is predicted to be same as Stage 4 (i.e. 183m^3/d).

4.7 Effects of Pit on Kaarearea Paa

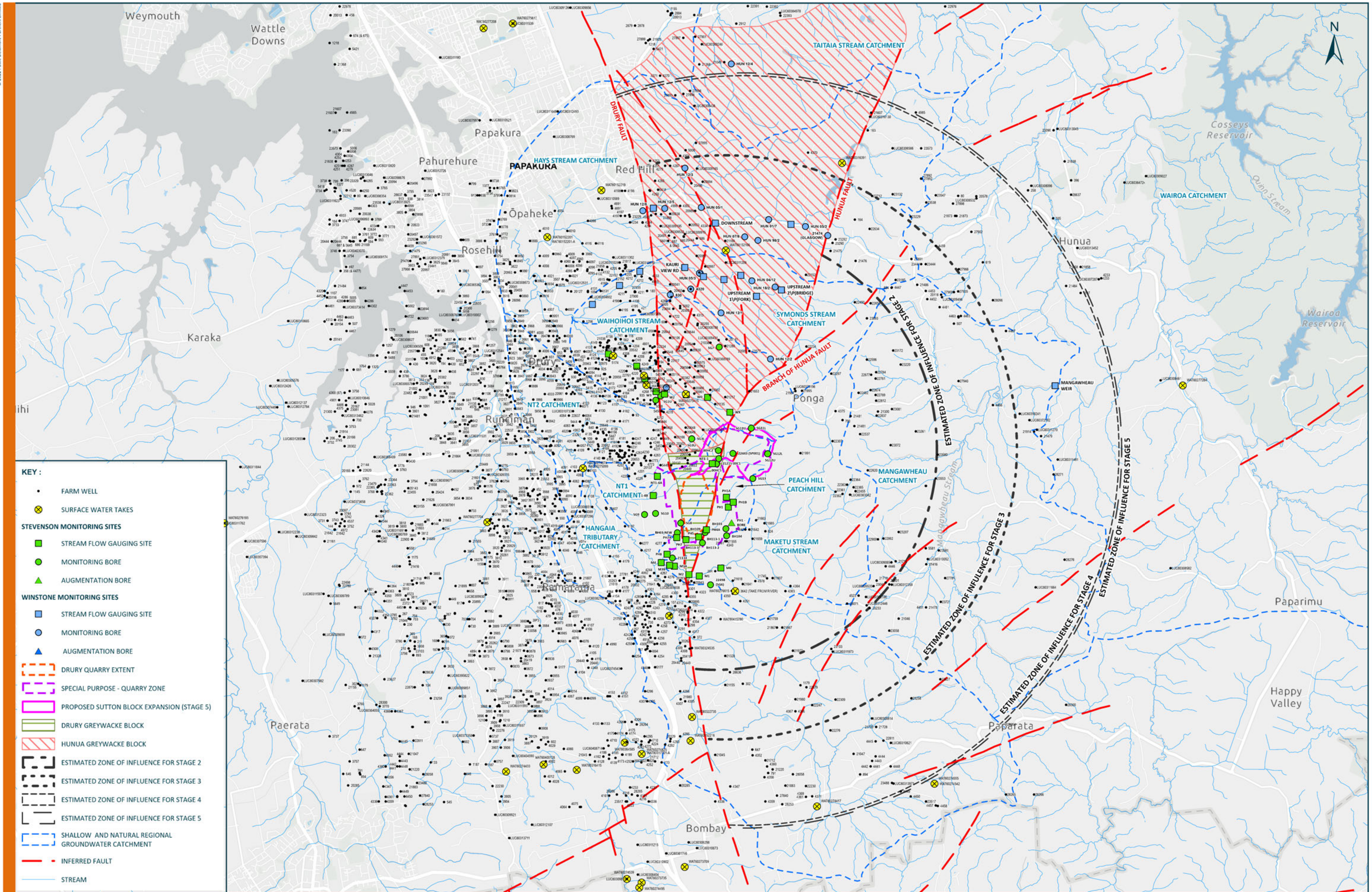
The Sutton Block expansion is well outside the Kaarearea Paa (Figure 4) and no adverse effects on the groundwater within this cone is likely. As mentioned in Section 3.2, springs (Figure 2) are identified next to the Kaarearea Paa. The elevation of the springs is in agreement with the elevated groundwater level (RL177.5m) detected in BH111 (in the basalt, Figure 4). The elevated groundwater level in BH111 is about 75m higher than the groundwater level detected in the closest bore to the cone in the greywacke (BH101). This is indicative of perched groundwater in the basalt.

The fact that the springs continue to discharge, indicates that the 80m drop in groundwater level in the greywacke as a result of the current Drury Quarry dewatering has had no effects on the shallow groundwater within the cone. This is consistent with the shallow groundwater conditions in similar volcanic cones in the Hunua area. Based on the groundwater level monitoring data for bores within the volcanic rocks along the Drury Fault (i.e. downstream of the Waihoihoi Catchment), the deep groundwater dewatering at the Hunua Quarry in greywacke has had no effects on the shallow groundwater in volcanic cones along the Drury Fault.

The lack of shallow groundwater response in the Kaarearea Paa to dewatering is likely to be due to interbedded volcanic tephra/tuff (silts and clays) within the volcanic cone observed in BH110, BH111 and BH112 (Figure 4) and the lava flows underlying low permeability mudstones layers within the coal measures.

The above perched groundwater is discontinuous and, in some areas, lava flows overlying greywacke may be completely dry. This is evident from the recent interception of the lava flows to the north of the existing pit. The field observations to date show no seepage from the lave flows to the existing pit.

The proposed Sutton Block expansion is designed to be excavated within the greywacke rocks and outside the above mapped boundary of the Kaarearea Paa and related lava flows (protected zone). Therefore, no effects as a result of the proposed dewatering on the shallow and perched groundwater in the cone is expected.



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NO.	REVISION	DATE	BY
D	ISSUED FOR RESOURCE CONSENT APPLICATION	NOV 24	BR
C	DRAFT FOR RESOURCE CONSENT APPLICATION	DEC 23	AS
B	ISSUED FOR REVIEW	OCT 23	TK
A	ISSUED FOR DISCUSSION	JAN 23	MS

SOURCE:
1. CADASTRAL/TOPOGRAPHICAL INFORMATION AND INSET DERIVED FROM LINZ DATA.
2. PROPOSED SUTTON BLOCK EXPANSION (DRAWING SSQ_24_405, ISSUED SEPT 2024), DRURY QUARRY EXTENT, AND SPECIAL PURPOSE – QUARRY ZONE (2021 AND 2022) PROVIDED BY TERRA MINING CONSULTANTS.
3. SHALLOW GROUNDWATER CATCHMENTS DERIVED BY PDP.
4. FAULT LINES PROVIDED BY GNS SCIENCE (2020) (NZL GNS1:250K GEOLOGY (3rd EDITION)) AND, MURRAY, S., GRAEME, F., (2005), PDP (2021).
5. FARM BORE DATA COMPILED BY GRANT FISHER INDUSTRIAL GEOLOGY (14/12/2010) AND AC BORE SEARCH RECEIVED 06/12/2022 AND 08/08/2024

CLIENT
STEVENSON

FIGURE
FIGURE 16 : INFERRED DRAWDOWN ZONES OF INFLUENCE

PROJECT
PROPOSED SUTTON BLOCK EXPANSION – GROUNDWATER & SURFACE WATER EFFECTS ASSESSMENT

4.8 Short-Term Groundwater Storage Release

The groundwater inflow monitoring data for the Hunua Pit and Drury Quarry (PDP 2020 and 2012) has shown that that the storage release from the aquifer after each dewatering step should be taken into consideration.

The response shows that the storage release (short-term ground water inflow) from the aquifer after each dewatering step is significant at first, but it is gradually depleted with time (within about two years) if no deepening of the pit or blasting of a local aquifer boundary occurs.

Considering irregular blasting and quarry deepening, it has been difficult to separate the groundwater inflow contribution from storage release from the long-term groundwater inflow for the existing Drury Quarry. However, based on the comprehensive monitoring data (pit floor and groundwater pump-out) collected as part of the Hunua Pit deepening (PDP 2020), the storage release following each quarry step (deepening) is estimated to be about 1,000m^3/d. This short-term storage contribution is considered to be a reasonable estimate for the proposed Sutton Block expansion but may need to be refined as the quarry deepens based on the monitoring data.

The above estimated storage contribution has no effect on the calculated maximum zone of influence, groundwater resource availability (allocation) and assessments presented in this study. The groundwater effects are based on the long-term groundwater inflow rather than short-term storage release.

4.9 Effects on Streams Low Flows

The predicted effects on the stream low flows (baseflow) from the dewatering of the Sutton Block expansion are assessed using a water budget model. The water budget model is based on the same methodology applied as part of the Symonds Hill Pit and existing Drury Quarry consents (PDP 2020 and 2012). The reduction in the streams baseflow occurs in downstream areas where the regional groundwater intercepts the streams.

The existing hydrogeological information indicates that currently the regional groundwater in the greywacke rock-mass to the east of the Hunua Fault discharges into the shallow sediments and the streams at elevations below RL170m. The estimated interaction between the shallow groundwater and the regional ground water, west of the Hunua Fault occurs at RL60m (PDP 2021).

The maximum probable effect of the proposed dewatering on the regional groundwater contribution to the streams has been assessed based on a simplified water budget analysis of existing data. For streams that intercept the Drury Fault, the assessments are for the loss in the vicinity of the Drury Fault before the streams receive any recharge from the alluvium (or basalt) aquifer west of the fault. This is considered to represent a worse-case scenario.

4.9.1 Assumptions

The analysis has been based on the conceptual model and the following assumptions:

- The boundaries of the groundwater catchments are assumed to coincide with the topographic boundaries of the surface water catchments.
- All of the diverted deep flow to the proposed sump, whether otherwise would flow to shallow aquifers or directly to streams, manifests as an equivalent amount in reduced stream flows.
- Under pre-quarry conditions, the amount of regional groundwater discharge to the streams is assumed proportional to the areas of the respective groundwater catchments.
- Not all available groundwater in each catchment discharges to streams within the greywacke blocks. A portion of the groundwater may discharge to the streams in the vicinity of the Drury Fault or alluvium beneath the stream channels across the fault.
- The estimated contribution of regional groundwater throughflow diverted away from the streams is assumed to be controlled by the predicted drawdowns in each catchment.
- The maximum percentage contribution is assumed for the catchment with maximum drawdowns and for other catchments, the contribution percentages are reduced proportional to reduction in predicted drawdowns. The maximum percentage contribution is assigned so the total groundwater inflow, matches with the estimated total regional groundwater inflow for each proposed quarry dewatering stages.
- No regional groundwater dewatering occurs during Stage 1 to the west of the Hunua greywacke Block as the dewatering level for Stage 1 (i.e., RL135m) is above the pre-quarry groundwater level in this block (RL64m).
- A low hydraulic gradient has been identified within the Hunua Greywacke Block for the Hays, Symonds and Waihoihoi catchments (PDP 2021). As discussed in Section 4.4.2, for Stage 3, Symonds Hill Pit with dewatering level at RL-5m controls the drawdowns within the Hunua Greywacke Block, with a maximum drawdown of 80m (PDP 2021). Following Stage 4, as the dewatering level drops below RL-5m and reaches the minimum of RL-60m, as a result of the partial removal of the Hunua Fault, the proposed Sutton Block expansion controls the drawdowns within the Hays, Symonds and Waihoihoi Catchments with a conservative maximum drawdown of 135m (RL75m to RL-60m).
- The drawdowns for other catchments surrounding the proposed pit are based on the analytical method discussed in Appendix G.

- The shallow groundwater contribution to the baseflow for each catchment has been estimated based on the average MALF for streams. In catchments where there are no low flow data available, the MALF for the nearest catchment is applied.
- Considering the compartmental nature of the greywacke, the predicted stream flow losses may not be materialised. Therefore, for the purpose of flow augmentation the predicted losses should be refined through a stream flow monitoring programme. The results of the water budget analysis for each quarry stage are summarised in Tables 10, 11, 12and 13.
- The effects on streams for Stages 4 and 5 are almost identical as the zone of influence for these stages remain approximately the same (Figure 16).

4.9.2 Predicted Flow Loss and Augmentation Requirements

1. Maketu Stream

The Maketu stream is one of the main tributaries east of the proposed quarry. The predicted loss of flow in this tributary ranges between 457m^3/d (Stage 2) to 1,116m^3/d (Stage 5, Tables 10 to 13).

Considering proximity of this catchment to the proposed Sutton Block, the flow augmentation is recommended for this stream (Section 7). The source of this augmentation flow (for Maketu Stream) shall be either from the Sutton Block sump or via an abstraction bore within the SAL property (E1778418/N5889315).

2. Hays and Symonds Stream

The estimated loss of baseflow for the Hays Stream as a result of the proposed Sutton Block expansion for all quarry stages ranges from 6m^3/d (Stage 2) to 1,747m^3/d (Stage 5).

The estimated loss of flow for the Symonds Stream ranges between 171m^3/d (Stage 2) to 708m^3/d (Stage 5). The predicted flow loss for this stream as a result of the Symonds Hill Pit dewatering was slightly higher, about 1,000m^3/d (PDP 2021). The difference in predictions is caused by a difference in number of contributing groundwater catchments to the zone of influence for the proposed new pit.

Note that the groundwater level along the stream as a result of the Symonds Hill Pit dewatering at RL-5m is expected to drop below the stream channel so the additional drawdowns as a result of the new proposed Sutton Block for Stages 3 to 5 is not likely to cause any additional flow loss.

3. Waihoihoi Stream

The groundwater level in the greywacke within the Waihoihoi Catchment is below the stream level east of the Drury Fault (the elevation of the stream before it crosses the Drury Fault at about RL36.5m). No greywacke has been encountered in SG1U, SG1D and HUN12/6 (all screened in basalt) in the vicinity of Waihoihoi downstream catchment areas, where the stream crosses the Drury Fault. The shallow groundwater level in basalt (SG1U) next to the stream at the downstream areas (east of the Drury Fault) has remained relatively stable above the stream at about RL38m, unaffected by the dewatering at the Hunua Pit. Therefore, as assessed as part of the previous consent for the Symonds Hill Pit dewatering, the Waihoihoi Stream flow is expected to be maintained by the surrounding basalt aquifer downstream and the shallow/perched groundwater in the greywacke and Waitemata Group upstream.

In addition, no reduction in baseflow at any stream flow gauging sites along the Waihoihoi Stream since 2012 has been detected as a result of the past Hunua Quarry dewatering (PDP 2021). Considering the above, no reduction in the baseflow of the Waihoihoi Stream as a result of the proposed Sutton Block expansion is expected.

4. NT1 Stream

NT1 is the only catchment where partial excavation will occur as part of the Sutton Block development. As shown in Figure 2, the majority of NT1 tributaries in the upper catchment area are located within the quarry footprint and consequently will be lost.

The maximum flow loss at NT1 downstream areas (below RL170m) east of the Drury Fault is 291m^3/d (Table 13). This is caused by the reduction in the regional groundwater contribution to the NT1 stream. The low flow in NT1 tributaries in the upper catchment areas within the proposed Sutton Block is sourced primarily from the shallow groundwater. Loss of the upper NT1 tributaries will result in the shallow groundwater contributing to these existing NT1 tributaries to be diverted to the future sump.

The total loss (or diversion) of shallow groundwater within these affected tributaries to the future Sutton Block sump for Stage 5 is calculated to be about 183 m^3/d or 2 L/s (Section 4.6.3). Therefore, the total loss of shallow groundwater and the regional groundwater for the whole NT1 catchment (east of the Drury Fault) is calculated to be about 474m^3/d (291m^3/d + 183 m^3/d).

Following treatment, the sump water which will consist of both shallow and deep groundwater will be discharged back to the NT1 tributaries south of the Stage 5 pit boundary. Considering the sump is also receiving regional groundwater inflow from the neighbouring catchments within the zone of influence, no flow loss in the NT1 stream, downstream of the Sutton Block is expected and a gain in the existing NT1 low flows downstream of the quarry is likely.

The applicant proposes to maintain the flow in one of the NT1 tributaries in the upper catchment area referred to as the Southern Tributary (at NT1-8 Station shown in Appendix C and Figures 17 and 18). The catchment area for this tributary will be reduced from 310,370m^2 to 61,919m^2 (Stage 5). Using the calculated MALF for this tributary (1.8L/s/km^2) or 56mm/year, the stream low flow in the Southern Tributary will be reduced from 48m^3/d (existing conditions) to 9.5 m^3/d (Stage 5). Note that no loss of flow for this tributary is expected before Stage 3 as the first two stages are outside the NT1-8 catchment.

The maximum required augmentation flow (Stage 5) to this tributary, after treatment, is about 38m^3/d or 0.44L/s. Using the same method the loss for Stage 4 for this tributary is only slightly lower (i.e., 37.5m^3/d or about 0.43L/s).

The source of this augmentation flow will be the future sump (after treatment) and the discharge point will be upstream of NT1-8 station along the Southern Tributary. The low permeability of highly weathered greywacke and coal measures at shallow depths is likely to prevent any loss of the augmentation flow in this tributary back to the sump.

5. NT2

The NT2 Stream east of the Drury Fault flows predominantly over the basalt, which is underlain by weathered greywacke, above the regional groundwater level. Therefore, as assessed for the previous consents for the Symonds Hill Pit and Drury Quarry (PDP 2021 and 2012), no reduction in the baseflow in this catchment is expected.

6. Peach Hill Stream

The Peach Hill catchment covering about 1km^2 east of the Drury Fault. The estimated loss of baseflow for the Peach Hill Stream ranges from 74m^3/d (for Stage 2) to 195m^3/d for Stage 5.

The Peach Hill Stream is currently being augmented conservatively as part of the Drury Quarry dewatering consent. The augmentation source water is an abstraction bore in the middle of Peach Hill Stream catchment (PH1). The conservative current augmentation of 470m^3/d is likely to accommodate the above maximum prediction flow loss of 195m^3/d as a result of the Sutton Block. Therefore, no augmentation as part of the proposed Sutton Block dewatering consent is recommended.

7. Hingaia Stream Tributary (South of Maketu Stream)

The estimated baseflow loss for the Hingaia Stream Tributary (South of Maketu Stream, Figure 3) ranges from 42m^3/d to 686m^3/d. Considering the distance between the proposed pit and this catchment (about 3km) and a high potential for intervening faults within this distance, no flow loss before Stage 3 is expected. Any loss of flow for this catchment following Stage 3 and as a result of the proposed quarry (if any) should be confirmed through the stream flow gauging before any augmentation.

8. Mangawheau Stream

The flow losses in Mangawheau Stream as a result of the proposed Sutton Block expansion is predicted to range from $120m^3/d$ (Stage 2, Table 10) to $1,387m^3/d$ (Stage 5, Table 13). Similar to Hingaia Tributary Catchment, considering the distance between the Mangawheau Catchment (>2km) and the proposed pit and a high potential for intervening faults within this distance, it is proposed to commence the augmentation after Stage 3 and only if monitoring shows a loss of flow that can be contributed to the Sutton Block expansion has occurred.

9. Wairoa Stream

The zone of influence reaches the Wairoa Stream only after Stage 3 (Figure 16). The maximum flow loss in the Wairoa Stream for Stage 5 is predicted to be about $165m^3/d$ (1% flow loss, Table 13). However, considering the 6km distance between the proposed pit and the Wairoa Catchment, loss of flow in this catchment as a result of the proposed pit is highly unlikely.

Table 10: Potential Effects of Baseflow (Stage 2)

Catchments	Groundwater catchment area contributing to regional GW throughflow (km^2)	Estimated regional GW throughflow to stream, m^3/d	Estimated maximum predicted drawdowns (m)	Approx. predicted drawdown as % of maximum	**Estimated baseflow loss (inflow to the sump) m^3/d**	Estimated catchment areas for shallow groundwater contribution to streams, km^2	Estimated average MALF ($L/s/km^2$)	Estimated shallow groundwater contribution, m^3/d	Estimated total baseflow, m^3/d	Predicted reduction in baseflow, %
Maketu										
Pre-Quarry Condition	9.9	1142				10.1	2.2	1884	3026	0
Dewatering RL75m			32.00	40	**457**	10.1	2.2	1884	2570	-15
Hays										
Pre-Quarry Condition	1.8	208				19.0	1.7	2791	2998	0
Dewatering RL75m			2.20	3	**6**	19.0	1.7	2791	2993	0
Symonds										
Pre-Quarry Condition	7.0	808				7.0	2.8	1669	2477	0
Dewatering RL75m			16.90	21	**171**	7.0	2.8	1669	2306	-7
Waihoihoi										
Pre-Quarry Condition	5.0	577				5.0	2.1	886	1462	0
Dewatering RL75m			43.00	54	**310**	5.0	2.1	886	1152	-21
Hingaia Sub-Catchment										
Pre-Quarry Condition	3.5	404				32.0	2.1	5668	6072	0
Dewatering RL75m			8.30	10	**42**	32.0	2.1	5668	6030	-1
NT1										
Pre-Quarry Condition	1.7	195				1.7	1.8	261	456	0
Dewatering RL75m			80.00	100	**105**	1.9	1.8	298	298	-35
Peach Hill										
Pre-Quarry Condition	1.4	159				1.4	1.8	215	374	0
Dewatering RL75m			37.10	46	**74**	1.1	1.8	177	263	-30
Mangaheau										
Pre-Quarry Condition	7.0	808				30.4	2.5	6593	7400	0
Dewatering RL75m			11.90	15	**120**	30.4	2.5	6593	7260	-2

Table 11: Potential Effects of Baseflow (Stage 3)

Catchments	Groundwater catchment area contributing to regional GW throughflow (km^2)	Estimated regional GW throughflow to stream, m^3/d	Estimated maximum predicted drawdowns (m)	Approx. predicted drawdown as % of maximum	**Estimated baseflow loss (inflow to the sump) m^3/d**	Estimated catchment areas for shallow groundwater contribution to streams, km^2	Estimated average MALF ($L/s/km^2$)	Estimated shallow groundwater contribution, m^3/d	Estimated total baseflow, m^3/d	Predicted reduction in baseflow, %
Maketu										
Pre-Quarry Condition	9.9	1677				10.1	2.2	1884	3561	0
Dewatering RL30m			72.50	66	**1105**	10.1	2.2	1884	2456	-31
Hays										
Pre-Quarry Condition	10.0	1694				19.0	1.7	2791	4484	0
Dewatering RL30m			12.30	11	**189**	19.0	1.7	2791	4295	-4
Symonds										
Pre-Quarry Condition	7.0	1186				7.0	2.8	1669	2855	0
Dewatering RL30m			40.50	37	**436**	7.0	2.8	1669	2418	-15
Waiholhoi										
Pre-Quarry Condition	5.0	847				5.0	2.1	886	1732	0
Dewatering RL30m			99.50	90	**766**	5.0	2.1	886	966	-44
Hingaia Sub-Catchment										
Pre-Quarry Condition	9.3	1575				32.0	2.1	5668	7243	0
Dewatering RL30m			23.70	22	**339**	32.0	2.1	5668	6904	-5
NT1										
Pre-Quarry Condition	1.7	286				1.7	1.8	261	548	0
Dewatering RL30m			110.00	100	**286**	1.9	1.8	298	298	-45
Peach Hill										
Pre-Quarry Condition	1.4	234				1.4	1.8	215	448	0
Dewatering RL30m			84.70	65	**152**	1.1	1.8	177	259	-42
Mangaheau										
Pre-Quarry Condition	19.5	3302				30.4	2.5	6593	9895	0
Dewatering RL30m			30.60	28	**919**	30.4	2.5	6593	8976	-9

Table 12: Potential Effects of Baseflow (Stage 4)

Catchments	Groundwater catchment area contributing to regional GW throughflow (km^2)	Estimated regional GW throughflow to stream, m^3/d	Estimated maximum predicted drawdowns (m)	Approx. predicted drawdown as % of maximum	**Estimated baseflow loss (inflow to the sump) m^3/d**	Estimated catchment areas for shallow groundwater contribution to streams, km^2	Estimated average MALF ($L/s/km^2$)	Estimated shallow groundwater contribution, m^3/d	Estimated total baseflow, m^3/d	Predicted reduction in baseflow, %
Maketu										
Pre-Quarry Condition	9.9	1699				10.1	2.2	1884	3584	0
Dewatering RL-90m			151	65	**1112**	10.1	2.2	1884	2472	-31
Hays										
Pre-Quarry Condition	17.1	2935				19.0	1.7	2791	5726	0
Dewatering RL-90m			135	59	**1723**	19.0	1.7	2791	4003	-30
Symonds										
Pre-Quarry Condition	7.0	1201				7.0	2.8	1669	2871	0
Dewatering RL-90m			135	59	**705**	7.0	2.8	1669	2166	-25
Waihoihoi										
Pre-Quarry Condition	5.0	858				5.0	2.1	886	1744	0
Dewatering RL-90m			135	59	**504**	5.0	2.1	886	1240	-29
Hingaia Sub-Catchment										
Pre-Quarry Condition	19.1	3278				32.0	4.5	12442	15720	0
Dewatering RL-90m			47	20	**671**	32.0	4.5	12442	15049	-4
NT1										
Pre-Quarry Condition	1.7	290				1.7	1.8	261	551	0
Dewatering RL-90m			230	100	**290**	1.9	1.8	298	298	-46
Peach Hill										
Pre-Quarry Condition	1.4	237				1.4	1.8	215	451	0
Dewatering RL-90m			188	82	**194**	1.1	1.8	177	220	-51
Mangawheau										
Pre-Quarry Condition	30.5	5235				30.4	2.5	6593	11828	0
Dewatering RL-90m			61	26	**1382**	30.4	2.5	6593	10446	-12
Wairoa										
Pre-Quarry Condition	13.2	2266				125.6	2.5	27238	29504	0
Dewatering RL-90m			16	7	**159**	125.6	2.5	27238	29345	-1

Table 13: Potential Effects of Baseflow (Stage 5)

Catchments	Groundwater catchment area contributing to regional GW throughflow (km^2)	Estimated regional GW throughflow to stream, m^3/d	Estimated maximum predicted drawdowns (m)	Approx. predicted drawdown as % of maximum	**Estimated baseflow loss (inflow to the sump) m^3/d**	Estimated catchment areas for shallow groundwater contribution to streams, km^2	Estimated average MALF ($L/s/km^2$)	Estimated shallow groundwater contribution, m^3/d	Estimated total baseflow, m^3/d	Predicted reduction in baseflow, %
Maketu										
Pre-Quarry Condition	9.9	1706				10.1	2.2	1884	3590	0
Dewatering RL-90m			151	65	**1116**	10.1	2.2	1884	2474	-31
Hays										
Pre-Quarry Condition	17.3	2976				19.0	1.7	2791	5767	0
Dewatering RL-90m			135	59	**1747**	19.0	1.7	2791	4020	-30
Symonds										
Pre-Quarry Condition	7.0	1206				7.0	2.8	1659	2876	0
Dewatering RL-90m			135	59	**708**	7.0	2.8	1659	2167	-25
Waihoihoi										
Pre-Quarry Condition	5.0	862				5.0	2.1	886	1747	0
Dewatering RL-90m			135	59	**506**	5.0	2.1	886	1241	-29
Hingaia Sub-Catchment										
Pre-Quarry Condition	19.4	3348				32.0	4.5	12442	15789	0
Dewatering RL-90m			47	20	**686**	32.0	4.5	12442	15104	-4
NT1										
Pre-Quarry Condition	1.7	291				1.7	1.8	261	553	0
Dewatering RL-90m			230	100	**291**	1.9	1.8	298	298	-46
Peach Hill										
Pre-Quarry Condition	1.4	238				1.4	1.8	215	452	0
Dewatering RL-90m			188	82	**195**	1.1	1.8	177	220	-51
Mangawheau										
Pre-Quarry Condition	30.4	5256				30.4	2.5	6593	11849	0
Dewatering RL-90m			61	26	**1387**	30.4	2.5	6593	10461	-12
Wairoa										
Pre-Quarry Condition	13.7	2360				125.6	2.5	27238	29598	0
Dewatering RL-90m			16	7	**165**	125.6	2.5	27238	29433	-1

4.10 Effects on Groundwater Quality

As a result of the quarry dewatering the regional groundwater flow paths are towards the dewatering sump. Therefore, no transport of any potential contaminants from the quarry sump back to the groundwater in the greywacke is likely and no changes in the baseline groundwater quality as a result of the proposed dewatering or abstraction from any augmentation bore is expected. The groundwater quality in the Sutton Block sump will be monitored and will be treated for turbidity before any discharge to the NT1 Stream. Therefore, no adverse effects on the stream water quality are likely.

4.11 Ground Settlement Effects

Lowering of groundwater pressures in the greywacke within the zone of influence can cause the consolidation of softer, near-surface sediments if drawdown effects can reach these sediments. Based on 10 years of monitoring data collected as part pf the Drury Quarry dewatering consent, the predominant drawdown effects occur in the greywacke rocks rather than overlying soft sediments such as coal measures materials. Therefore, the potential for adverse land settlement effects in the overlying sediments east of the Drury Fault is less than minor.

In addition, the monitoring of the shallow groundwater to the west of the Drury Quarry for the past 10 years has also shown no drawdown effects in Tauranga Group to the west of Drury Fault. This demonstrates the flow barrier characteristics of the Drury Fault.

Considering the above, no adverse ground settlement effects as a result of the proposed Sutton Block development are expected.

5.0 Post Quarrying Site Rehabilitation Plan Considerations

The main objective of any quarry rehabilitation programme after completion of the proposed aggregate extraction and cessation of pumping from the sump (after about 50 years), is to maintain the pre-quarry groundwater levels to the east of Hunua Fault. This can be achieved by restoration of the Fault barrier effect by judicial placement of low permeability materials over fracture zones on the quarry floor and the whole western face of the quarry. The options will be covered in detail in the Quarry Management Plan which will include details on the closure and rehabilitation of the Quarry.

6.0 Recommended Monitoring Programme and Mitigation Conditions

The existing monitoring conditions for Consent 40317 (WAT60277068-B) for the Drury Quarry dewatering are appropriate for the proposed Sutton Block expansion with some modifications as discussed below.

6.1 Stream Flow

The overall existing stream flow gauging stations are sufficient to monitor any loss of baseflow as a result of the proposed dewatering for the proposed Sutton Block expansion. However, four additional monitoring gauging sites are proposed to be established in the Southern Tributary (at NT1-8), Mangawheau Stream and Hingaia Tributary. One gauging site is proposed upstream of the AC permanent stream flow station (Station Number 8529) along Mangawheau Stream, two new gauging sites along the Hingaia Tributary and one gauging site downstream of the Southern Tributary (NT1-8). The approximate location of the proposed gauging sites is shown in Figures 17 and 18.

Considering, the distance of the Mangawheau and the Hingaia Tributary Catchments to the proposed pit (Figure 3) and high likelihood of intervening barrier faults occurring within the greywacke over such distances, the baseline monitoring for these catchments is proposed only from the beginning of Stage 3 (when the dewatering level reaches RL60m). In addition, there will be no reduction in the Southern Tributary catchment area (upstream of NT1-8) before Stage 4. Therefore, the baseline monitoring for this station (NT1-8) is also recommended from the beginning of Stage 3.

6.2 Monitoring Bores

The existing Drury Quarry monitoring boreholes consists of 22 deep and shallow piezometers. Five recently drilled monitoring bores are proposed to be incorporated to the groundwater level monitoring network for the proposed Sutton Block expansion. These are SG11L, SG11U, SG12L, SG12U and SG13. The location of these monitoring boreholes is shown in Figure 17.

The proposed trigger levels for the monitoring bores are presented in Schedule A. The trigger levels are based on drawdown predictions discussed in Sections 4.3 to 4.5 and incorporate the seasonal variations (SV) and interference drawdown effects for dewatering at the Symonds Hill Pit (RL-5m) and Drury Quarry (RL-45m).

The SVs are calculated for bores which are predicted to remain unaffected by the dewatering. The SVs are calculated based on groundwater level monitoring records since 2011. A statistical analysis of the measured values was applied to determine a lower “limit of probability” below which it is statistically unlikely that any measured value could be due to rainfall. As per the methodology outlined in the existing Drury Quarry consent (40317), the seasonal variation was assessed using a 99% probability method. The probability limit is determined by subtracting (2.58 x the SD of the measured values) from the calculated median of the measured values. The SV values are presented in Schedule A. As predicted for the existing Drury Quarry consent and confirmed through the ongoing groundwater level monitoring programme since 2012, no drawdowns (other than those in the immediate surrounds of the pit) are expected in the shallow groundwater as a result of the proposed Sutton Block expansion. Therefore, no change to the shallow groundwater trigger levels within the existing consent conditions are recommended (Schedule A).

6.3 Mitigation Options and Augmentation Programme

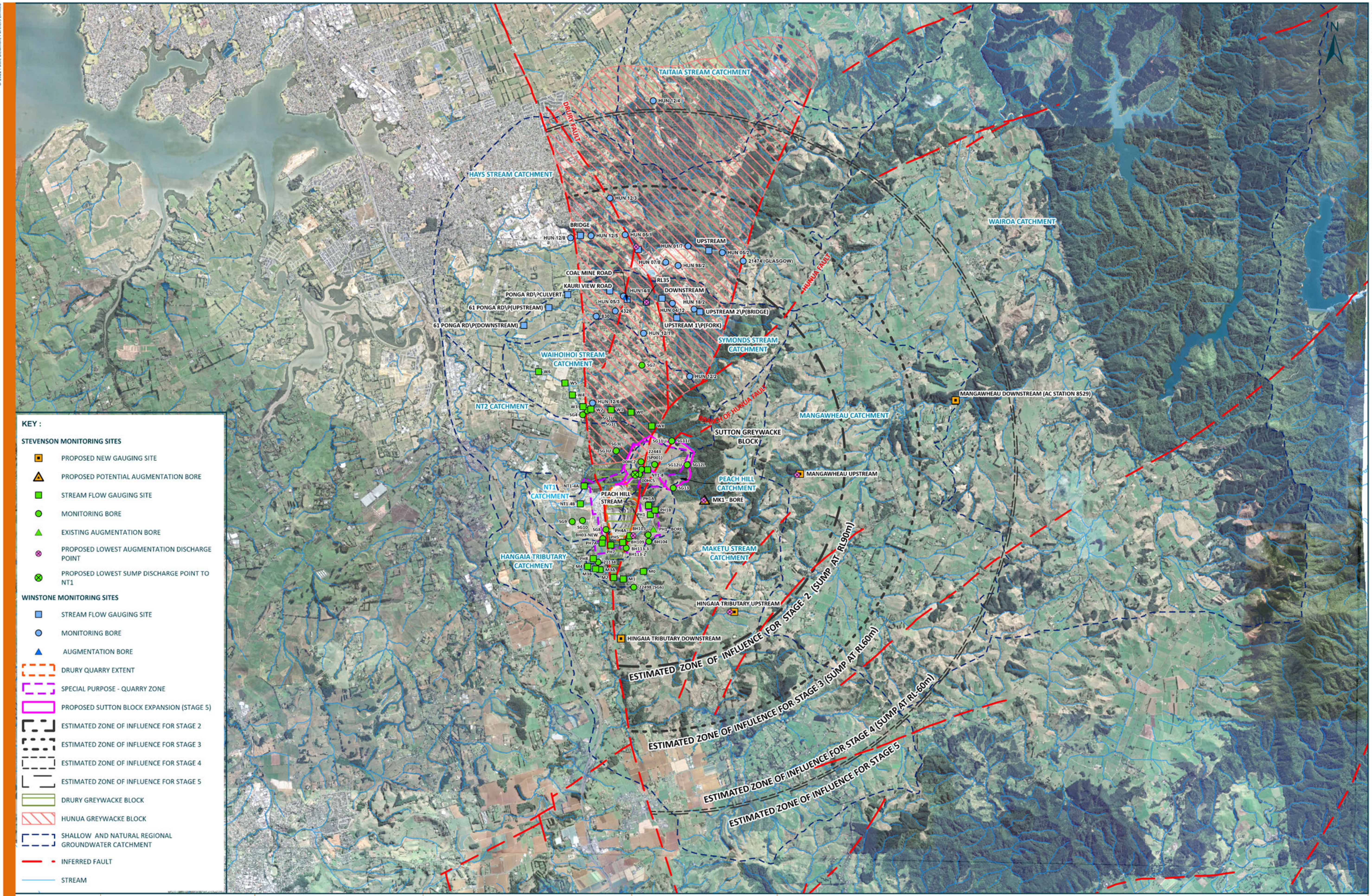
No changes in the farm wells mitigation measures (according to the existing Drury Quarry consent, 40317) are proposed.

The existing stream flow augmentation programme has been updated to accommodate the potential effects on the low flow of the neighbouring tributaries as a result of the Sutton Block expansion. The results indicate that no change in the current augmentation regime for the Symonds, Hays and Peach Hill Streams according to the consents (40317 and WAT60152106-A) is required.

The augmentation regime for all streams may need to be updated based on the result of ongoing and recommended stream flow monitoring programme.

6.4 Recommended Monitoring Conditions

A set of draft monitoring and augmentation conditions are developed by PDP and attached to the AEE (T&T 2025). The recommended conditions are designed to establish the necessary practices and procedures for monitoring and reporting groundwater drawdowns, ensuring compliance with consent conditions. Additionally, augmentation conditions are proposed, requiring augmentation measures, continuous flow monitoring, and water quality assessments. The authorised quantities for taking and use of water specified in the proposed conditions are based on the findings presented in this report.



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NO.	REVISION	DATE	BY
D	ISSUED FOR REVIEW	DEC 24	KB
C	ISSUED FOR RESOURCE CONSENT APPLICATION	NOV 24	BR
B	DRAFT FOR RESOURCE CONSENT APPLICATION	DEC 23	TK
A	ISSUED FOR REVIEW	OCT 23	AS

SOURCE:
1. AERIAL IMAGERY SOURCED FROM LINZ (FLOWN 2021-2022) AND GOOGLE EARTH (FLOWN 2022)
2. CADASTRAL/TOPOGRAPHICAL INFORMATION AND INSET DERIVED FROM LINZ DATA.
3. PROPOSED SUTTON BLOCK EXPANSION (DRAWING SSQ_24_405, ISSUED SEPT 2024), DRURY QUARRY EXTENT, AND SPECIAL PURPOSE – QUARRY ZONE (2021 AND 2022) PROVIDED BY TERRA MINING CONSULTANTS.
4. SHALLOW GROUNDWATER CATCHMENTS DERIVED BY PDP.
5. FAULT LINES PROVIDED BY GNS SCIENCE (2020) (NZL GNS1:250K GEOLOGY (3rd EDITION)) AND, MURRAY, S., GRAEME, F., (2005), PDP (2021).

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FIGURE
FIGURE 17: RECOMMENDED MONITORING PLAN

PROJECT
PROPOSED SUTTON BLOCK EXPANSION – GROUNDWATER & SURFACE WATER EFFECTS ASSESSMENT

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SCALE : 1:30,000 (A3)

NO.	REVISION	DATE	BY
C	ISSUED FOR REVIEW	DEC 24	KB
B	ISSUED FOR RESOURCE	NOV 24	BR
	ISSUED FOR REVIEW		
A	DRAFT FOR RESOURCE CONSENT APPLICATION	DEC 23	TK

SOURCE:
1. AERIAL IMAGERY SOURCED FROM GOOGLE EARTH (FLOWN APRIL 2022) AND PILBROW SURVEYS (FLOWN 2022)
2. CADASTRAL/TOPOGRAPHICAL INFORMATION AND INSET DERIVED FROM LINZ DATA.
3. SHALLOW GROUNDWATER CATCHMENTS DERIVED BY PDP.
4. FAULT LINES PROVIDED BY GNS SCIENCE (2020) (NZL GNS1:250K GEOLOGY (3rd EDITION)) AND, MURRAY, S., GRAEME, F., (2005), PDP (2021).

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FIGURE

FIGURE 18: RECOMMENDED MONITORING PLAN (ZOOM IN ON AUGMENTATION AND ADDITIONAL STREAM FLOW GAUGING SITES)

PROJECT

PROPOSED SUTTON BLOCK EXPANSION – GROUNDWATER & SURFACE WATER EFFECTS ASSESSMENT

7.0 Conclusions

The maximum expected groundwater inflow (including shallow groundwater and storage) to the proposed Sutton Block expansion pit (including storage and shallow groundwater) is about 19,426m^3/d (Stage 5) and the zone of influence extend from 4.4km (Stage 2) to 7.5km (Stage 5). However, it is likely that the intervening faults will reduce the above effects as a result of the compartmental nature of the greywacke. As for other quarries in the greywacke in this region, ongoing monitoring is required to refine the predictions as the quarry floor deepens. The maximum groundwater diversion rate (including the shallow groundwater and short-term storage release) sought in this consent application is 19,426m^3/d.

The proposed dewatering level at Stage 4 (RL-60m) requires partial removal of the barrier faults between the greywacke blocks (e.g., Hunua Fault). Considering the low hydraulic gradient detected in the Hunua and Drury Greywacke Blocks west of the Hunua Fault, Stage 4 dewatering may cause the groundwater within the Hunua and Drury Greywacke Blocks to drop to RL-60m. However, this is less likely scenario as the intervening barrier faults are common in the greywacke in this area and this is likely to reduce the predicted drawdowns. In addition, the facts that only 5% of the Hunua Fault (east of the Hunua and Drury Greywacke Blocks) will be breached during the gradual progression of the proposed pit expansion, is likely to cause further reductions in the theoretical drawdowns predicted for the Hunua and Drury Greywacke Blocks. Therefore, the predictions need to be updated (as part of the consent conditions) as more monitoring data during the pit development becomes available.

Based on the Council database, the farm wells in the greywacke within the zone of influence are significantly deeper than the predicted drawdowns and are likely to accommodate the drawdowns without any adverse effects on their yield. SAL proposes to mitigate any adverse effects on these farm wells which can be attributed to the proposed quarry development. Mitigation options are included in the consent conditions and may include deepening the bores or lowering the pumps.

Given that the Hunua Fault passes through the proposed new quarry, it needs to be removed progressively along with the quarry rock as the pit deepens. Although field data currently indicates a significant groundwater head gradient across the Fault, its progressive removal is not expected to give rise to any specific risks for uncontrolled changes in groundwater flows. The barrier effect of the Fault in the ground outside the quarry is not expected to be disturbed significantly by the quarrying. In addition, the fault is likely to remain intact below the new pit floor and the proposed sump is expected to intercept any westward groundwater throughflow before it can recharge the groundwater to the west of Hunua Fault. The higher heads on the eastern side of the fault will gradually reduce as the quarry is deepened and groundwater is captured in the quarry sump.

Similar to other quarries within the greywacke, the proposed dewatering is unlikely to have any adverse effects on the shallow or perched groundwater in shallow sediments, pockets of saturation in the greywacke or the lava flows (e.g. Kaarearea Paa).

Augmentation flow as percentages of groundwater inflow is recommended for the Maketu Stream to the west of the proposed Sutton Block and the Southern Tributary (at NT1-8) in the upper NT1 Catchment area.

NT1 is the only catchment where partial excavation will occur as part of the Sutton Block development. The majority of NT1 tributaries in the upper catchment area are located within the quarry footprint and consequently will be lost.

Following treatment, the sump water which consist of both shallow and deep groundwater will be discharged back to the NT1 tributaries south of the Stage 5 pit boundary. Considering the sump is also receiving regional groundwater inflow from the neighbouring catchments within the zone of influence, no flow loss in the NT1 tributaries, downstream of the Sutton Block (below the current upper dam) is expected and a gain in the existing NT1 low flows downstream of the quarry is likely. Therefore, no augmentation programme is proposed for NT1 downstream of the Sutton Block.

The applicant proposes to maintain the flow in one of the NT1 tributaries in the upper catchment area referred to as the Southern Tributary (at NT1-8). The stream low flow in the Southern Tributary is predicted to be reduced from 48m^3/d (existing conditions) to 9.5 m^3/d (Stage 5). No loss of flow for this tributary is expected for Stages 2 and 3 as these stages are outside the NT1-8 catchment. Therefore, to maintain the Southern Tributary low flow (at NT1-8), the maximum required augmentation flow to this tributary, after treatment, is about 38m^3/d or 0.44L/s. This is about 0.2% of the predicted sump inflow for Stages 4 and 5.

The maximum loss of low flow for the Maketu Stream (Stage 5) is calculated to be about 1,116m^3/d or 6% of the predicted inflow. The source of the augmentation flow for Maketu Stream will be either from the Sutton Block sump or via an abstraction bore within the SAL property (E1778418/N5889315). The source of the augmentation for NT1-8 will be the sump.

The groundwater quality in the potential augmentation bore will be analysed and the results will be compared against the water quality in the Maketu Stream before any augmentation.

The Peach Hill Stream is currently being augmented conservatively as part of the Drury Quarry dewatering consent. The augmentation source water is an abstraction bore in the middle of Peach Hill Stream catchment. The conservative current augmentation of 470m^3/d is likely to accommodate the maximum prediction flow loss of 195m^3/d as a result of the Sutton Block.

For other streams further away from the proposed Sutton Block (Mangawheau and Hingaia Tributary Streams), it is proposed to define the required augmentation based on any observed loss of low flow. The loss of low flow will be determined by collecting low flow baseline data from the new gauging stations proposed in the above catchments.

The maximum predicted flow loss for the Wairoa Stream is less than 1% (165m^3/d). Considering this stream is 6km away from the Sutton Block and the low predicted flow loss, no flow augmentation for this stream is required.

The results indicate that no change in the current augmentation regime for the Symonds, Hays and Peach Hill Streams according to the consents (40317 and WAT60152106-A) is required.

The main objective of any quarry rehabilitation programme after completion of the proposed aggregate extraction and cessation of pumping from the sump (after about 50 years), is to maintain the pre-quarry groundwater levels to the east of Hunua Fault. This can be achieved by restoration of the Fault barrier effect by judicial placement of low permeability materials over fracture zones on the quarry floor and the whole western face of the quarry. The options will be covered in detail in the Quarry Management Plan which will include details on the closure and rehabilitation of the Quarry.

The exact location of the barrier fault between the Hunua and Sutton Greywacke Blocks is not known. If the recommended monitoring data as the new pit deepens show that the boundary is further to the west and well outside the proposed pit, the predicted effects on groundwater and baseflow will be less than predicted above and likely to be limited to Sutton Greywacke Block.

Considering the conservative nature of the assessments and the recommended augmentation and mitigation programmes, the proposed Sutton Block expansion is expected to have no more than minor effects on the groundwater or surface water environments.

8.0 References

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Appendix A: Borehole Logs

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG11U
Sheet:	1 of 4
Date:	27/05/22
Ground Level mRL:	222.5m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777717.5mE, 5890555.8mN

Geological Description — Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).

Interpretation	Geological Description	Depth (m)	RL (m)
Waipapa Group	CLAY; brown . Dry, moderate plasticity.	0 – 2	222.5 – 220.5
	Sandy SILT; dark brown.	2 – 14	
	Highly weathered; orangish grey ; SANDSTONE; weak; [Greywacke] Waipapa Terrane .	14 – 19.6	
	Moderately weathered; orangish grey ; massive; SANDSTONE; weak; Fractured, becoming less weathered, [Greywacke] Waipapa Terrane .	19.6 – 40.5	
	Unweathered; bluish grey; massive; SANDSTONE; strong; Fractured, [Greywacke] Waipapa terrane .	40.5 –	

Depth scale: 10, 20, 30, 40. RL scale: 220, 210, 200, 190, 180.

Installation

- Cap: Stand-up (lockable)
- 50mm
- Grout — to 19.00m
- Casing: 19.6m, 150mm, Steel Conductor Casing
- Bentonite — 19.00m to 24.00m
- Plain (solid) pipe: 49.44m
- K2 Gravel Pack — from 24.00m
- Slotted pipe: 19.56m (at 49.44m)

Water: 02/2024 00

Remarks

Soil samples taken at 2 m intervals. Logged by drillforce

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- ▼ Standing Water Level
- ◁— In flow
- ▷— Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	165.00 m

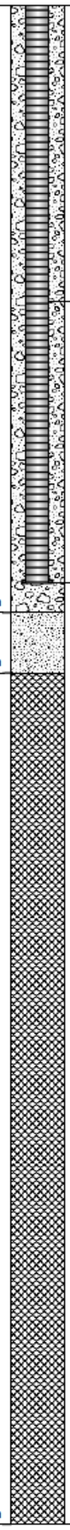
MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG11U
Sheet:	2 of 4
Date:	27/05/22
Ground Level mRL:	222.5m

Client: Stevenson Aggregates Ltd
Project: Sutton Quarry
Site Address: Quarry Road, Runciman 2578
Coordinates: 1777717.5mE, 5890555.8mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Unweathered; bluish grey; massive; SANDSTONE; strong; Fractured, [Greywacke] Waipapa terrane .		60	170, 160				K2 Gravel Pack; Slotted pipe: 19.56m; 69.00m; 70.00m	
	Unweathered; bluish grey; massive; SANDSTONE; strong; Fractured, Greywacke - Backfilled. Waipapa Terrane .		70, 80, 90	150, 140, 130				Blinding Sand 72.00m; Bentonite 100.00m	



Remarks
Soil samples taken at 2 m intervals. Logged by drillforce

Investigation Type
- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water
- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	165.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG11U
Sheet:	3 of 4
Date:	27/05/22
Ground Level mRL:	222.5m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777717.5mE, 5890555.8mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Unweathered; bluish grey; massive; SANDSTONE; strong; Fractured, Greywacke - Backfilled. Waipapa Terrane .		110, 120, 130, 140	120, 110, 100, 90, 80				K2 Gravel Pack (Backfill)	

Remarks

Soil samples taken at 2 m intervals. Logged by drillforce

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	165.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG11U
Sheet:	4 of 4
Date:	27/05/22
Ground Level mRL:	222.5m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777717.5mE, 5890555.8mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
	[CONT] Unweathered; bluish grey; massive; SANDSTONE; strong; Fractured, Greywacke - Backfilled. Waipapa Terrane .		160	70, 60				K2 Gravel Pack (Backfill)	
	EOH: 165.00m							165.00m	
			170, 180, 190	50, 40, 30					

Remarks

Soil samples taken at 2 m intervals. Logged by drillforce

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	165.00 m

Generated with CORE-GS by Geroc - Monitoring Well - Installation - 10/04/2024 3:49:27 pm

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

MONITORING WELL

Job No.:	A02447709
Test No.:	SG11L
Sheet:	1 of 5
Date:	10/12/21
Ground Level mRL:	222.5m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777720.0mE, 5890561.0mN

Geological Description — Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).

Columns: Interpretation | Geological Description | Graphic Log | Depth (m) | RL (m) | PID (ppm) | Samples | Depth Remarks | Installation | Water

Interpretation: Waipapa Group

- CLAY, with some silt; orange brown. Dry, moderate plasticity.
- Clayey SILT; brown with minor orange mottling. Dry, low plasticity; inclusion of fine sand (likely from bottom of sample).
- SILT, with some sand, with trace clay; brown. Dry, non-plastic; sand, fine.
- Sandy SILT; brown. Dry; sand, fine.
- Completely weathered; grey; SANDSTONE; [Greywacke] Waipapa Terrane .
  - 18.0m: colour change to grey blue
  - 24.0m: fine sandy/silt matrix decreases
  - 26.0m: some chips contain stained orange/oxidation in samples from this depth onwards
  - 28.5m: Small fracture at 28.5 m
  - 29.0m: Moisture in samples first recorded at 29 m
  - 30.0m: fine sandy/silt matrix changes from grey to brown between 30 to 32 m
- Moderately weathered; grey blue with orangish staining; SANDSTONE; [Greywacke] Waipapa Terrane .
  - 38.0m: some chips contain stained orange/oxidation and white calcite veins in samples from this depth onwards
- Unweathered; grey blue; SANDSTONE; some orange/oxidation and white calcite veins in samples [Greywacke]. Waipapa Terrane.
  - 39.5m: Small fracture at 39.5 m
  - 42.0m: Flowing water during drilling from 42 m - beginning of fractured Greywacke
  - 46.0m: contains fine sandy/silt matrix changes from 46 to 48 m

Depth (m): 10, 20, 30, 40

RL (m): 220, 210, 200, 190, 180

Installation: Cap: Stand-up (lockable); 50mm; Grout; Plain (solid) pipe: -218.00m

Remarks

Reverse air blasting (RAB) from 0 to 19.5
Downhole hammer from 19.5 to
Soil samples taken at 2 m intervals

Investigation Type: ☐ Hand Auger ☐ Test Pit ☑ Machine Hole

Water: Standing Water Level; In flow; Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	Truck mounted - air hammer		LG	CW/GS	250.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG11L
Sheet:	2 of 5
Date:	10/12/21
Ground Level mRL:	222.5m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777720.0mE, 5890561.0mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Depth (m)	RL (m)	Installation	Water
Waipapa Group	[CONT] Unweathered; grey blue; SANDSTONE; some orange/oxidation and white calcite veins in samples [Greywacke]. Waipapa Terrane.		170		28/02/2024 00:00 (Standing Water Level)
		60	160		
		70	150	Grout; Plain (solid) pipe: 218.00m	
	75.0m: Large fracture at 75 m				
	76.0m: No orange/oxidation staining in samples from 76 onwards, just white calcite veins				
	77.0m: Fracture zone from 77 to 81 m				
		80	140		
	89.0m: Large fracture at 89 m	90	130		
	94.0m: Increasing calcite chips			Casing: 190.0m, 150mm, Steed Conductor	

Graphic Log | PID (ppm) | Samples | Depth Remarks

Remarks

Reverse air blasting (RAB) from 0 to 19.5
Downhole hammer from 19.5 to
Soil samples taken at 2 m intervals

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- ▼ Standing Water Level
- ◁— In flow
- ▷— Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	Truck mounted - air hammer		LG	CW/GS	250.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG11L
Sheet:	3 of 5
Date:	10/12/21
Ground Level mRL:	222.5m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777720.0mE, 5890561.0mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Unweathered; grey blue; SANDSTONE; some orange/oxidation and white calcite veins in samples [Greywacke]. Waipapa Terrane.			120					
	101.0m: contains minor silt matrix change								
			110	110					
	113.0m: Silt matrix increasing, increased Calcite present in chips								
			120						
	119.0m: Lighter grey/ white chips, light grey/white silt matrix cementing chips			100				Grout; Plain (solid) pipe: 218.00m	
			130	90					
	128.0m: Trace silt matrix								
	134.0m: Darker grey, moist, no silt or calcite								
	136.0m: Calcite veins return								
	138.0m: Dark grey, no matrix, no calcite, moist		140	80					
	144.0m: No calcite								

Remarks

Reverse air blasting (RAB) from 0 to 19.5
Downhole hammer from 19.5 to
Soil samples taken at 2 m intervals

Investigation Type

- ☐ Hand Auger
- ☐ Test Pit
- ☑ Machine Hole

Water

- ▼ Standing Water Level
- ◁ In flow
- ▷ Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	Truck mounted - air hammer		LG	CW/GS	250.00 m

PATTLE DELAMORE PARTNERS LTD

solutions for your environment

MONITORING WELL

Job No.:	A02447709
Test No.:	SG11L
Sheet:	4 of 5
Date:	10/12/21
Ground Level mRL:	222.5m

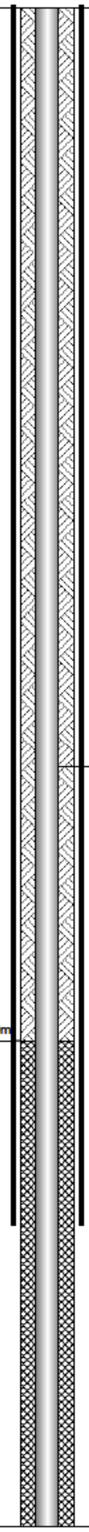
Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777720.0mE, 5890561.0mN

Interpretation	Geological Description Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Unweathered; grey blue; SANDSTONE; some orange/oxidation and white calcite veins in samples [Greywacke]. Waipapa Terrane. 152.0m: Dark grey colour change, no silt 156.0m: Silt matrix, calcite chips through out 158.0m: Larger chip size, increased calcite		160 170 180 190	70 60 50 40 30				Grout Plain (solid) pipe: 218.00m 184.00m Bentonite	



Remarks

Reverse air blasting (RAB) from 0 to 19.5
Downhole hammer from 19.5 to
Soil samples taken at 2 m intervals

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- ▼ Standing Water Level
- ◁— In flow
- ▷— Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	Truck mounted - air hammer		LG	CW/GS	250.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG11L
Sheet:	5 of 5
Date:	10/12/21
Ground Level mRL:	222.5m

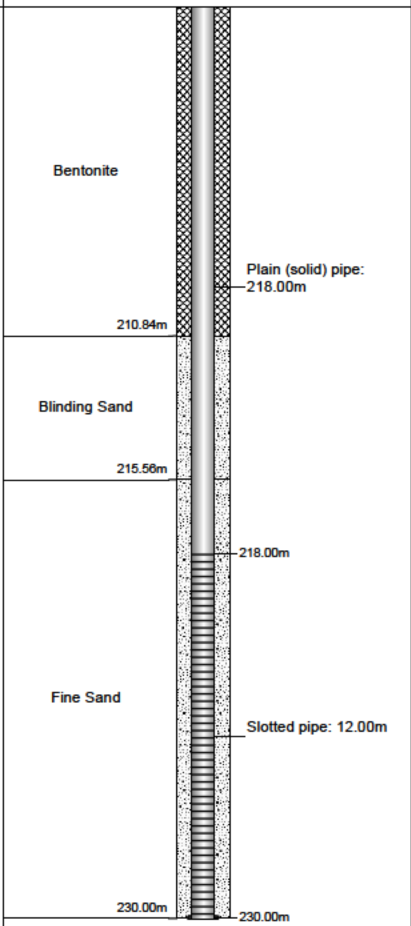
Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777720.0mE, 5890561.0mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Unweathered; grey blue; SANDSTONE; some orange/oxidation and white calcite veins in samples [Greywacke]. Waipapa Terrane.		210, 220, 230	20, 10, 0				Bentonite; Blinding Sand; Fine Sand	
	EOH: 250.00m		240	-10, -20					



Remarks

Reverse air blasting (RAB) from 0 to 19.5
Downhole hammer from 19.5 to
Soil samples taken at 2 m intervals

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	Truck mounted - air hammer		LG	CW/GS	250.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG12U
Sheet:	1 of 2
Date:	15/03/22
Ground Level mRL:	277m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1778044.0mE, 5890046.0mN

Interpretation: Waipapa Group

Geological Description

Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).

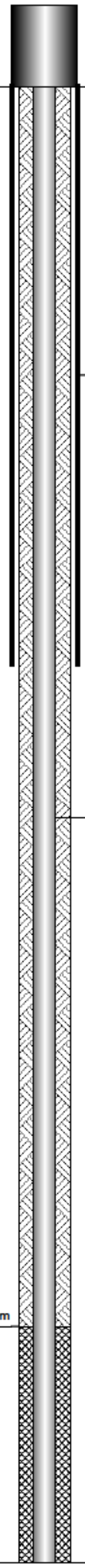
Geological Description
CLAY; light brown. Dry; Logged by Drill Force Ltd. .
CLAY; light brown. With loose boulders. Logged by Drill Force Ltd. .
SANDSTONE; Weathered Greywacke. Logged by Drill Force Ltd. .
Slightly weathered; SANDSTONE; moderately strong; Firm Greywacke. Logged by Drill Force Ltd. .
Unweathered; SANDSTONE; moderately strong; Firm Greywacke. Logged by Drill Force Ltd. .
49.0m: Fractured from 49m onwards

Depth (m): 10, 20, 30, 40

RL (m): 270, 260, 250, 240, 230

Columns: Graphic Log | Depth (m) | RL (m) | PID (ppm) | Samples | Depth Remarks | Installation | Water

Installation



Remarks

Soil samples taken at 2 m intervals. logged by drillforce

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	65.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG12U
Sheet:	2 of 2
Date:	15/03/22
Ground Level mRL:	277m

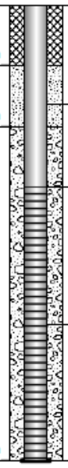
Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1778044.0mE, 5890046.0mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Unweathered; SANDSTONE; moderately strong; Firm Greywacke. Logged by Drill Force Ltd. . EOH: 65.00m		60, 70, 80, 90	220, 210, 200, 190, 180				Bentonite 52.00m; Blinding Sand 54.00m; K2 Gravel Pack 65.00m	28/02/2024 00:00



Remarks	Investigation Type	Water
Soil samples taken at 2 m intervals. logged by drillforce	☐ Hand Auger ☐ Test Pit ☑ Machine Hole	Standing Water Level In flow Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	65.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG12L
Sheet:	1 of 6
Date:	25/02/22
Ground Level mRL:	277m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1778048.2mE, 5890048.6mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	CLAY; light brown . Logged by Drill Force Ltd. .							Cap: Stand-up (lockable)	
	Gravelly CLAY; light brown. Gravel, highly weathered; Logged by Drill Force Ltd. .			270					
	Highly weathered; grey with orange mottling ; SANDSTONE; weak; [Greywacke] Logged by Drill Force Ltd. .		10	260					
	Moderately weathered; grey with orange mottling ; SANDSTONE; weak; Fractured, [Greywacke] Waipapa Terrane. Logged by Drill Force Ltd. .		20 30 40	250 240				Grout Casing: 45.5m, 150mm, Steel Conductor Casing Plain (solid) pipe: 270.00m	
	Slightly weathered; grey with orange mottling ; SANDSTONE; moderately strong; [Greywacke] Waipapa Terrane. Logged by Drill Force Ltd. . 45.0m: Fractured from 45-75m			230					

Remarks

Soil samples taken at 2 m intervals. logged by drillforce

Investigation Type

- ☐ Hand Auger
- ☐ Test Pit
- ☑ Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	280.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG12L
Sheet:	2 of 6
Date:	25/02/22
Ground Level mRL:	277m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1778048.2mE, 5890048.6mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Slightly weathered; grey with orange mottling ; SANDSTONE; moderately strong; [Greywacke] Waipapa Terrane. Logged by Drill Force Ltd. .		60, 70	220, 210				Grout; Plain (solid) pipe: 270.00m	
	Slightly weathered; grey with orange mottling ; SANDSTONE; strong; [Greywacke] Waipapa Terrane. Logged by Drill Force Ltd. .		80, 90	200, 190, 180					▼ 28/02/2024 00:00

Remarks

Soil samples taken at 2 m intervals. logged by drillforce

Investigation Type

- ☐ Hand Auger
- ☐ Test Pit
- ☑ Machine Hole

Water

- ▼ Standing Water Level
- ◁— In flow
- ▷— Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	280.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG12L
Sheet:	3 of 6
Date:	25/02/22
Ground Level mRL:	277m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1778048.2mE, 5890048.6mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	Slightly weathered; dark grey; SANDSTONE; strong; [Greywacke] Waipapa Terrane. Logged by Drill Force Ltd. .								
	Slightly weathered; dark grey; SANDSTONE; strong; Calcite veins throughout, [Greywacke] Waipapa terrane . Logged by Drill Force Ltd. .		110, 120, 130, 140	170, 160, 150, 140, 130				Grout; Plain (solid) pipe: 270.00m	

Remarks	Investigation Type	Water
Soil samples taken at 2 m intervals. logged by drillforce	☐ Hand Auger ☐ Test Pit ☑ Machine Hole	Standing Water Level In flow Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	280.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG12L
Sheet:	4 of 6
Date:	25/02/22
Ground Level mRL:	277m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1778048.2mE, 5890048.6mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Slightly weathered; dark grey; SANDSTONE; strong; Calcite veins throughout, [Greywacke] Waipapa terrane . Logged by Drill Force Ltd. .		160, 170, 180, 190	120, 110, 100, 90				Grout; Plain (solid) pipe: 270.00m	
	Slightly weathered; dark grey; SANDSTONE; strong; Calcite veins throughout, highly fractured, [Greywacke] Waipapa Terrane. Logged by Drill Force Ltd. .								
	Unweathered; dark grey; SANDSTONE; strong; Calcite veins throughout, [Greywacke] Waipapa Terrane. Logged by Drill Force Ltd. .			80					

Remarks

Soil samples taken at 2 m intervals. logged by drillforce

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	280.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG12L
Sheet:	5 of 6
Date:	25/02/22
Ground Level mRL:	277m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1778048.2mE, 5890048.6mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Unweathered; dark grey; SANDSTONE; strong; Calcite veins throughout, [Greywacke] Waipapa Terrane. Logged by Drill Force Ltd. .		210, 220, 230, 240	70, 60, 50, 40, 30				Grout; 216.00m; Bentonite; Plain (solid) pipe: 270.00m	

Remarks

Soil samples taken at 2 m intervals. logged by drillforce

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	280.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG12L
Sheet:	6 of 6
Date:	25/02/22
Ground Level mRL:	277m

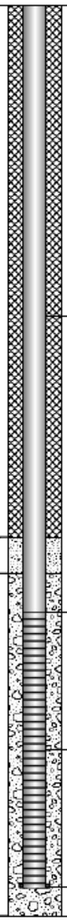
Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1778048.2mE, 5890048.6mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Unweathered; dark grey; SANDSTONE; strong; Calcite veins throughout, [Greywacke] Waipapa Terrane. Logged by Drill Force Ltd. . EOH: 280.00m		260, 270, 280, 290	20, 10, 0, -10, -20				Bentonite; 267.50m; Blinding Sand 268.70m; K2 Gravel Pack; 280.00m; Plain (solid) pipe: 270.00m; 270.00m; Slotted pipe: 9.00m; 279.00m	



Remarks

Soil samples taken at 2 m intervals. logged by drillforce

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- ▼ Standing Water Level
- ◁ In flow
- ▷ Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		Drill Force Ltd.	CW/GS	280.00 m

MONITORING WELL

Job No.:	A02447709
Test No.:	SG13
Sheet:	1 of 6
Date:	29/03/22
Ground Level mRL:	249m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777748.5mE, 5889552.4mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	Silty CLAY; orange . Soft, dry; Crumbly .		10	240				Cap: Stand-up (lockable)	
	Silty CLAY; orange . Soft, dry.		20	230					
	Completely weathered; grey brown ; SANDSTONE; Some oxidization [Greywacke] Waipapa terrane .		30	220				Grout; Plain (solid) pipe: 241.00m	
	Highly weathered; grey brown; Some oxidization [Greywacke] Waipapa terrane .		40	210, 200				Casing: 65.2m, 150mm, Steel Conductor Casing	

Remarks

Soil samples taken at 2m intervals.

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		GMS	CW/GS	250.00 m

PATTLE DELAMORE PARTNERS LTD
solutions for your environment

MONITORING WELL

Job No.:	A02447709
Test No.:	SG13
Sheet:	2 of 6
Date:	29/03/22
Ground Level mRL:	249m

Client: Stevenson Aggregates Ltd
Project: Sutton Quarry
Site Address: Quarry Road, Runciman 2578
Coordinates: 1777748.5mE, 5889552.4mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Highly weathered; grey brown; Some oxidization [Greywacke] Waipapa terrane .		60, 70, 80, 90	190, 180, 170, 160, 150				Grout; Plain (solid) pipe: 241.00m	

Remarks
Soil samples taken at 2m intervals.

Investigation Type
- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water
- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		GMS	CW/GS	250.00 m

PATTLE DELAMORE PARTNERS LTD

solutions for your environment

MONITORING WELL

Job No.:	A02447709
Test No.:	SG13
Sheet:	3 of 6
Date:	29/03/22
Ground Level mRL:	249m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777748.5mE, 5889552.4mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
	[CONT] Highly weathered; grey brown; Some oxidization [Greywacke] Waipapa terrane .		110	140, 130					
Waipapa Group	Moderately weathered; bluish grey ; SANDSTONE; some oxidation and calcite veins throughout [Greywacke] Waipapa terrane .		120						
Waipapa Group	Moderately weathered; grey ; SANDSTONE; [Greywacke] Waipapa terrane .		130	120				Grout; Plain (solid) pipe: 241.00m	
Waipapa Group	Slightly weathered; grey ; SANDSTONE; weak; [Greywacke] Waipapa terrane .		140	110, 100					28/02/2024 00:00

Remarks

Soil samples taken at 2m intervals.

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		GMS	CW/GS	250.00 m

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

MONITORING WELL

Job No.:	A02447709
Test No.:	SG13
Sheet:	4 of 6
Date:	29/03/22
Ground Level mRL:	249m

Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777748.5mE, 5889552.4mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Slightly weathered; grey ; SANDSTONE; weak; [Greywacke] Waipapa terrane .			90				Grout	
	Slightly weathered; grey ; SANDSTONE; Greywacke, Calcite veins .		160	80					
	Unweathered; grey ; SANDSTONE; Calcite veins throughout [Greywacke] Waipapa terrane .		170, 180, 190	70, 60, 50				Plain (solid) pipe: 241.00m; 184.00m; Bentonite	

Remarks

Soil samples taken at 2m intervals.

Investigation Type

- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

Water

- Standing Water Level
- In flow
- Out flow

Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		GMS	CW/GS	250.00 m

MONITORING WELL

PATTLE DELAMORE PARTNERS LTD — solutions for your environment

Job No.:	A02447709
Test No.:	SG13
Sheet:	5 of 6
Date:	29/03/22
Ground Level mRL:	249m

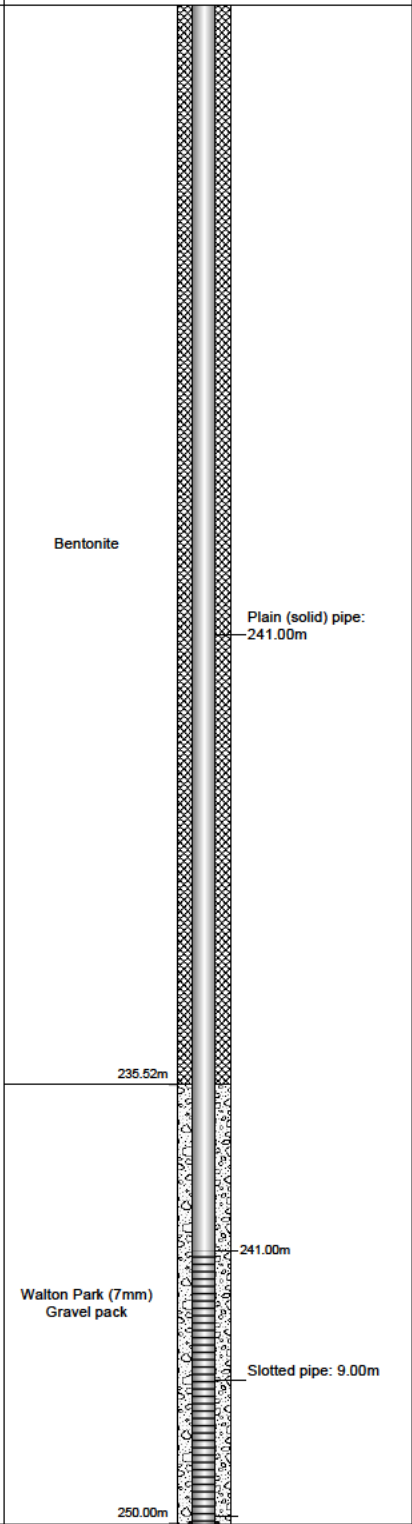
Client: Stevenson Aggregates Ltd

Project: Sutton Quarry

Site Address: Quarry Road, Runciman 2578

Coordinates: 1777748.5mE, 5889552.4mN

Interpretation	Geological Description (Soil and Rock logged in accordance with New Zealand Geotechnical Society field description of soil and rock (2005).)	Graphic Log	Depth (m)	RL (m)	PID (ppm)	Samples	Depth Remarks	Installation	Water
Waipapa Group	[CONT] Unweathered; grey ; SANDSTONE; Calcite veins throughout [Greywacke] Waipapa terrane .		210, 220, 230, 240	40, 30, 20, 10, 0					
	EOH: 250.00m								



Remarks

Soil samples taken at 2m intervals.

Investigation Type

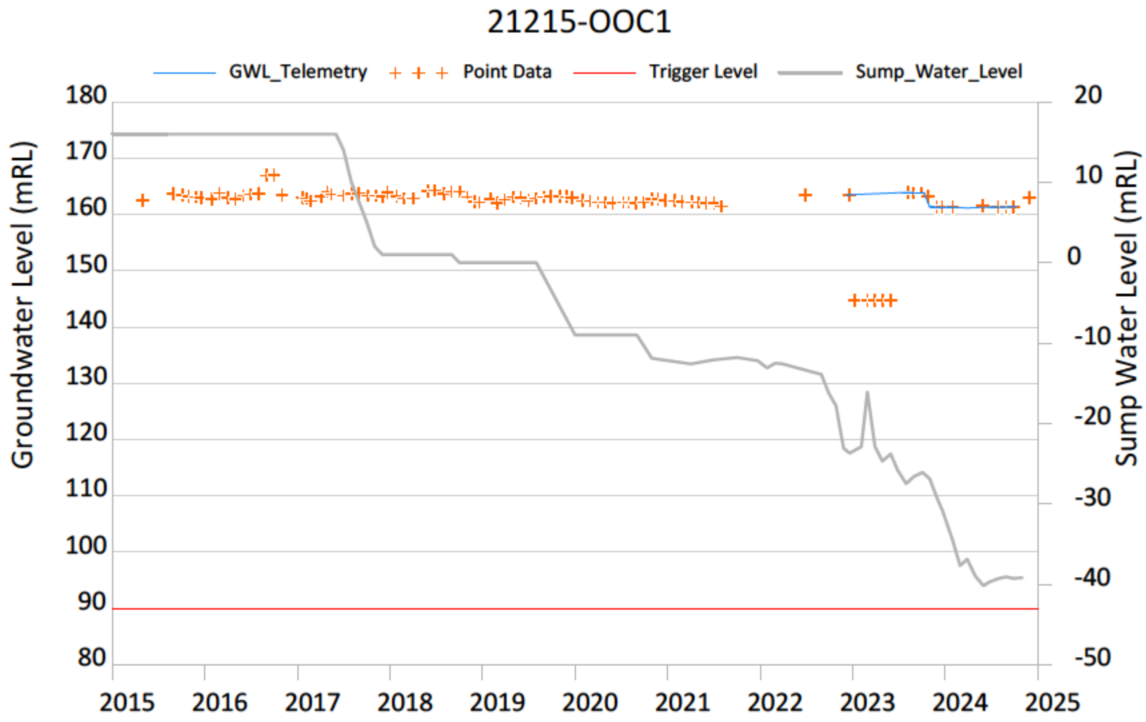
- [ ] Hand Auger
- [ ] Test Pit
- [x] Machine Hole

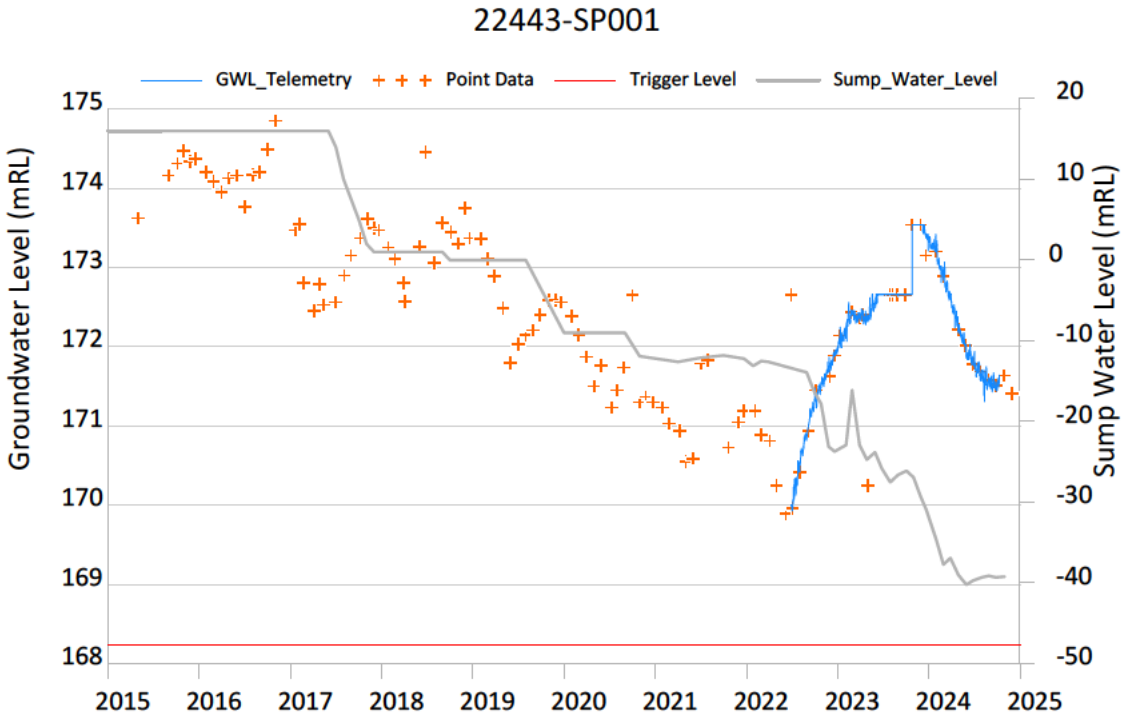
Water

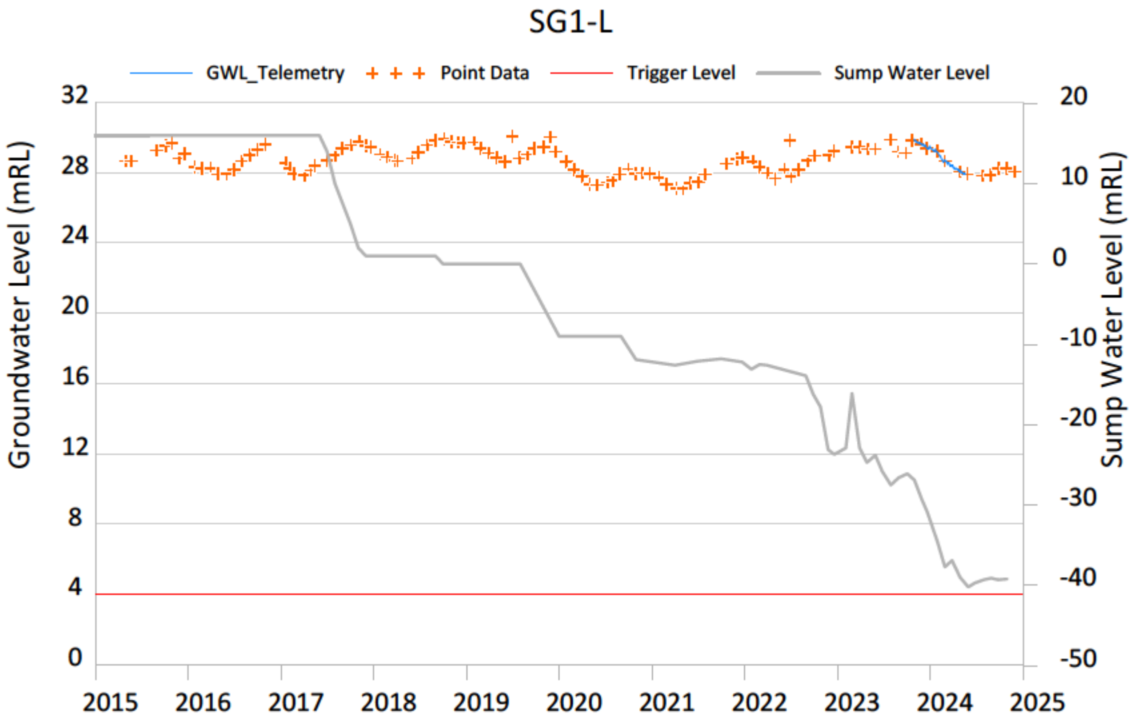
- Standing Water Level
- In flow
- Out flow

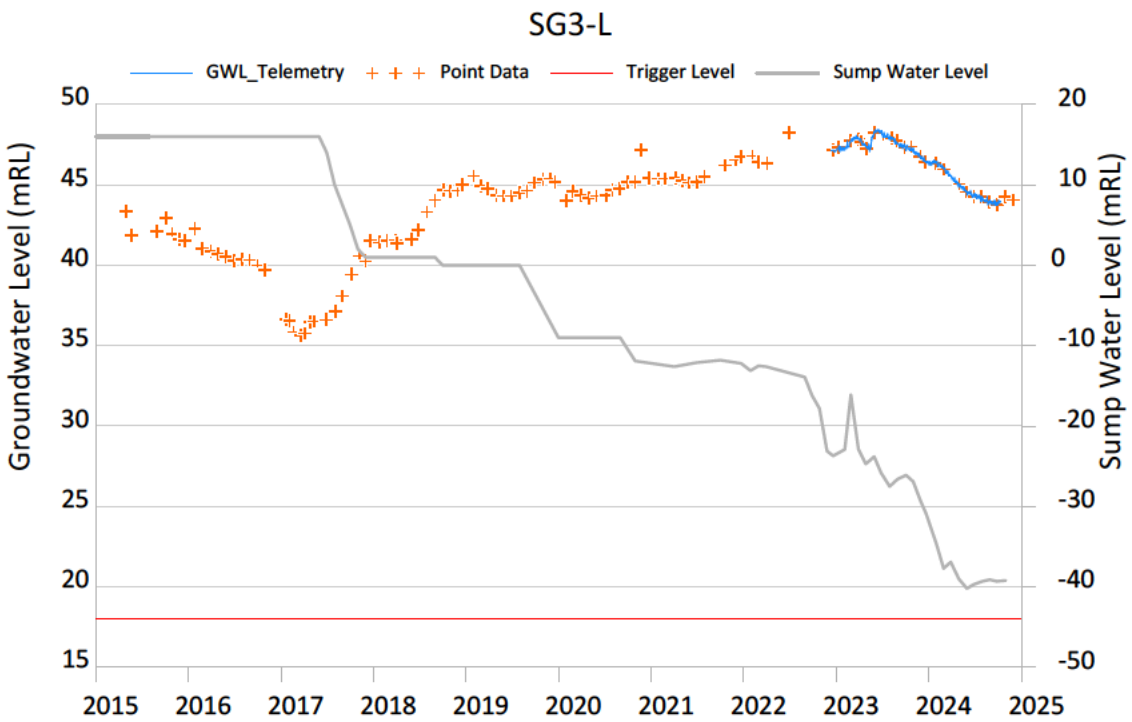
Contractor:	Rig/Plant Used:	Driller:	Logged By:	Checked By:	Hole Depth:
DrillForce	ounted - air hammer		GMS	CW/GS	250.00 m

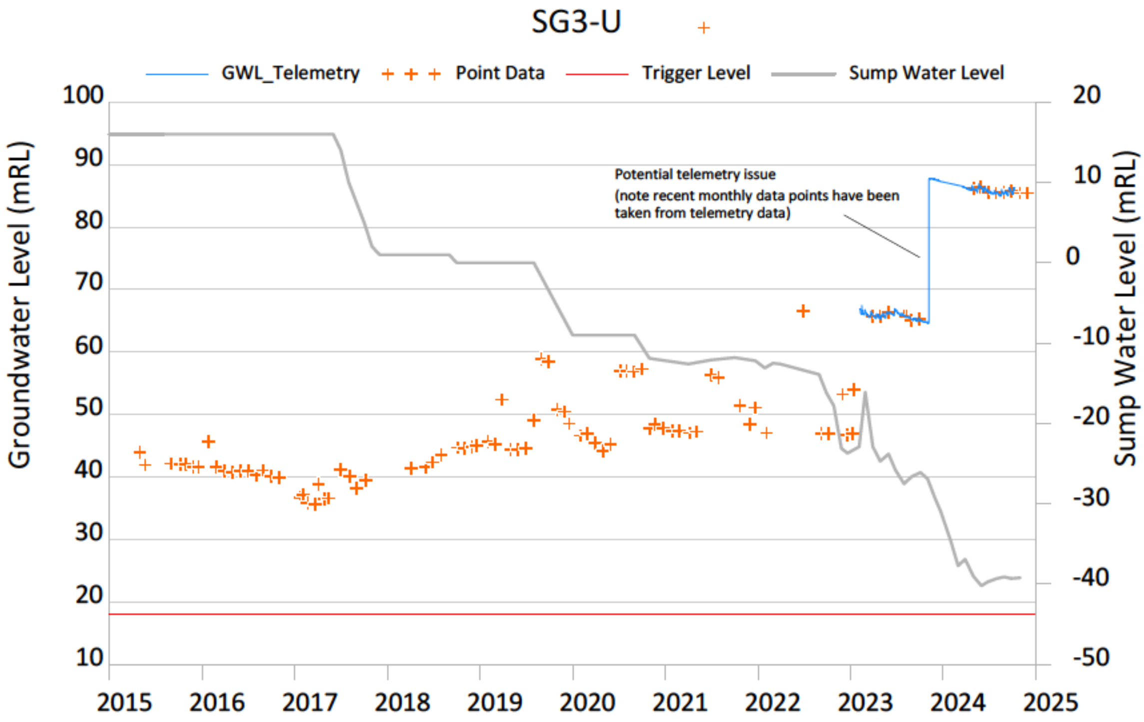
Appendix B: Groundwater Level Hydrographs

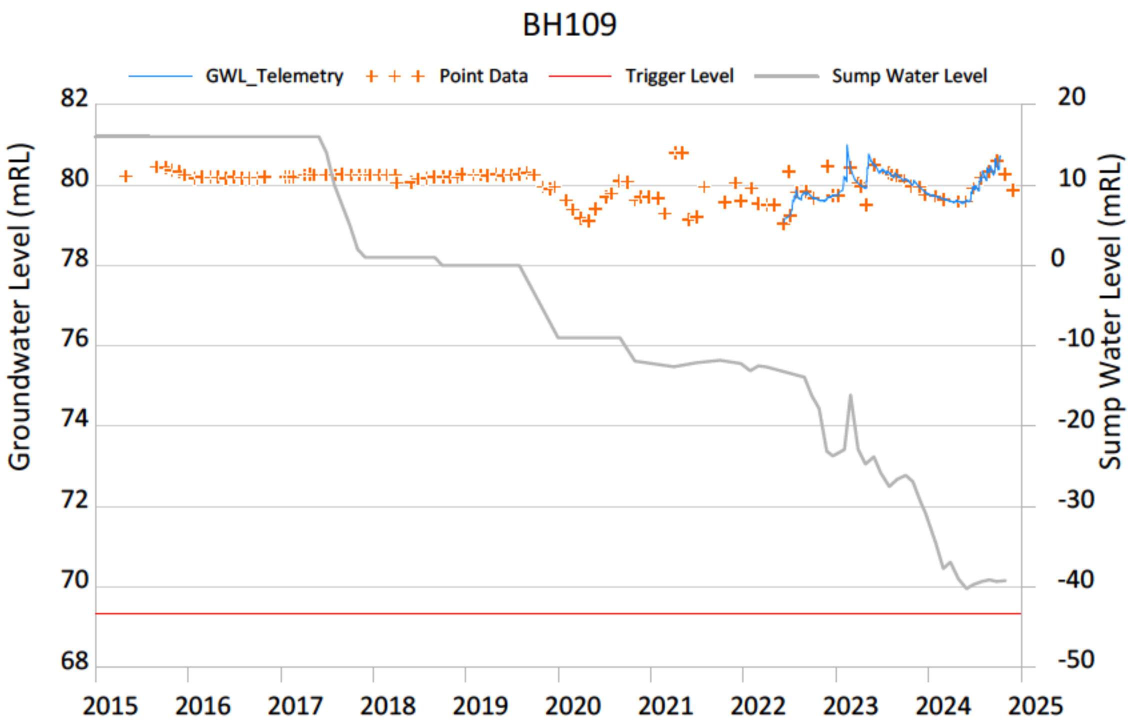

21215-OOC1
GWL_Telemetry
Point Data
Trigger Level
Sump_Water_Level
Groundwater Level (mRL)
Sump Water Level (mRL)
180
170
160
150
140
130
120
110
100
90
80
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

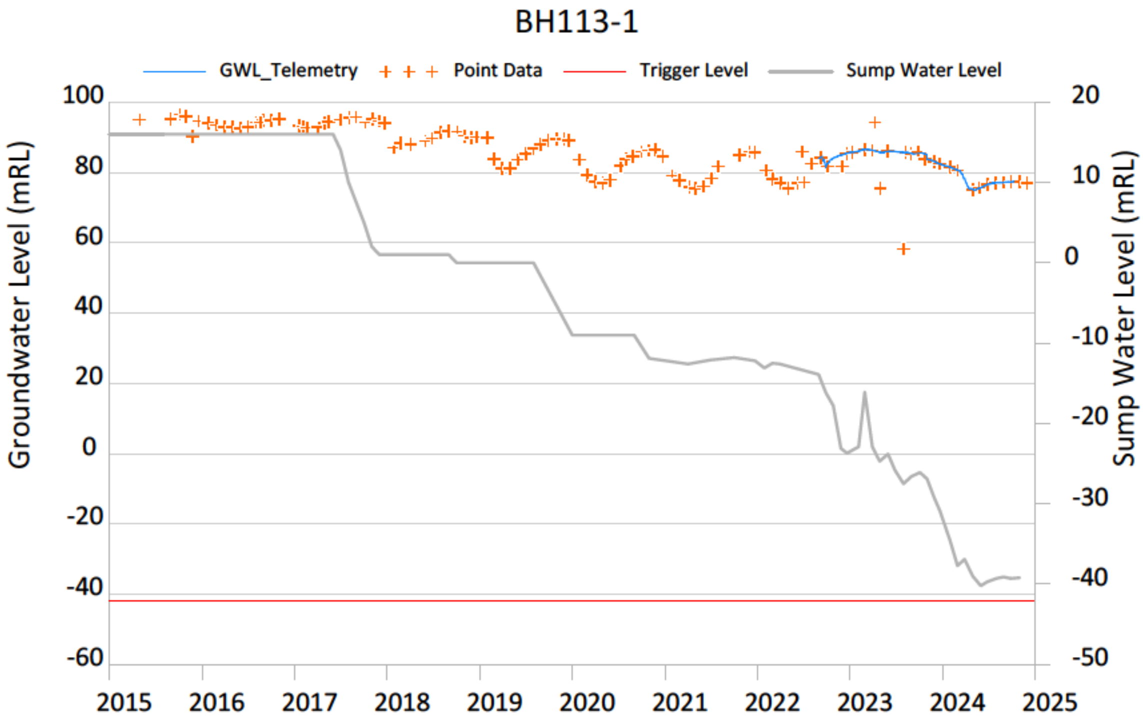

22443-SP001
GWL_Telemetry
Point Data
Trigger Level
Sump_Water_Level
Groundwater Level (mRL)
Sump Water Level (mRL)
175
174
173
172
171
170
169
168
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

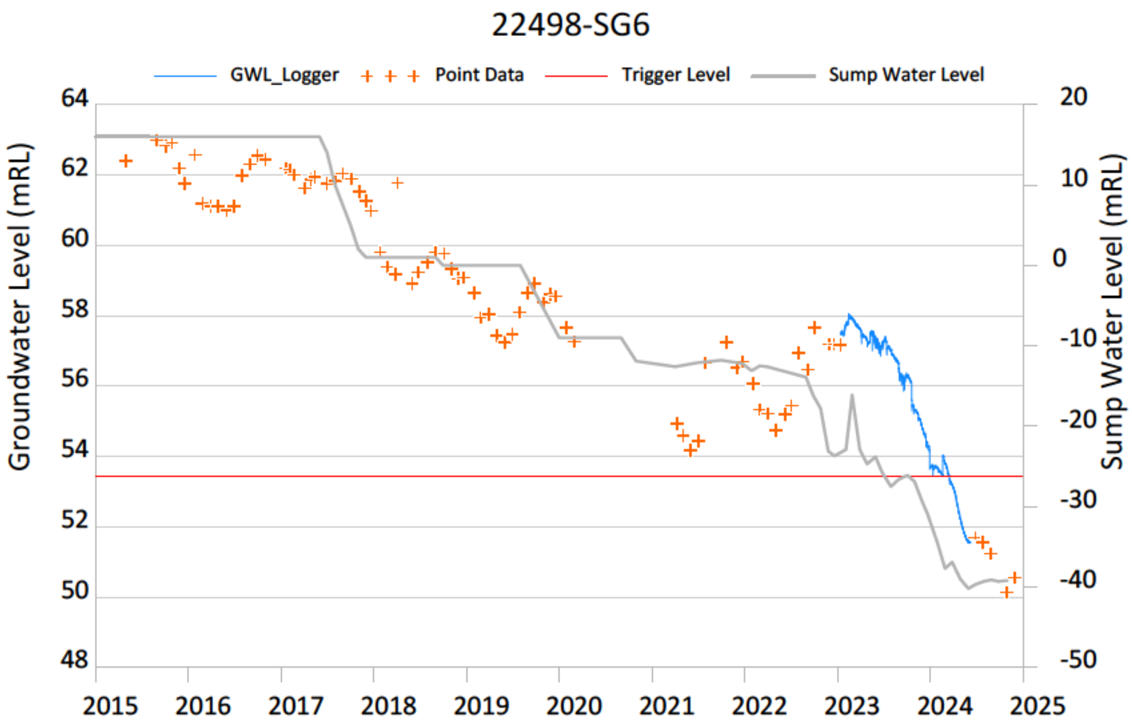

SG1-L
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
32
28
24
20
16
12
8
4
0
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

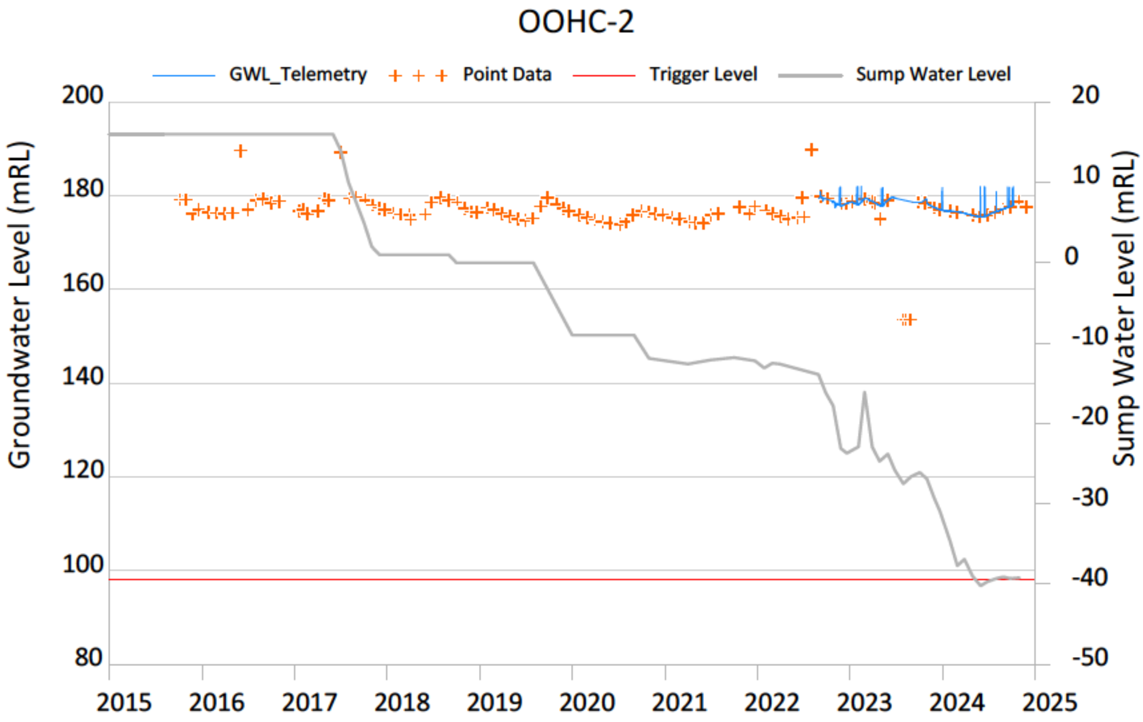

SG3-L
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
50
45
40
35
30
25
20
15
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

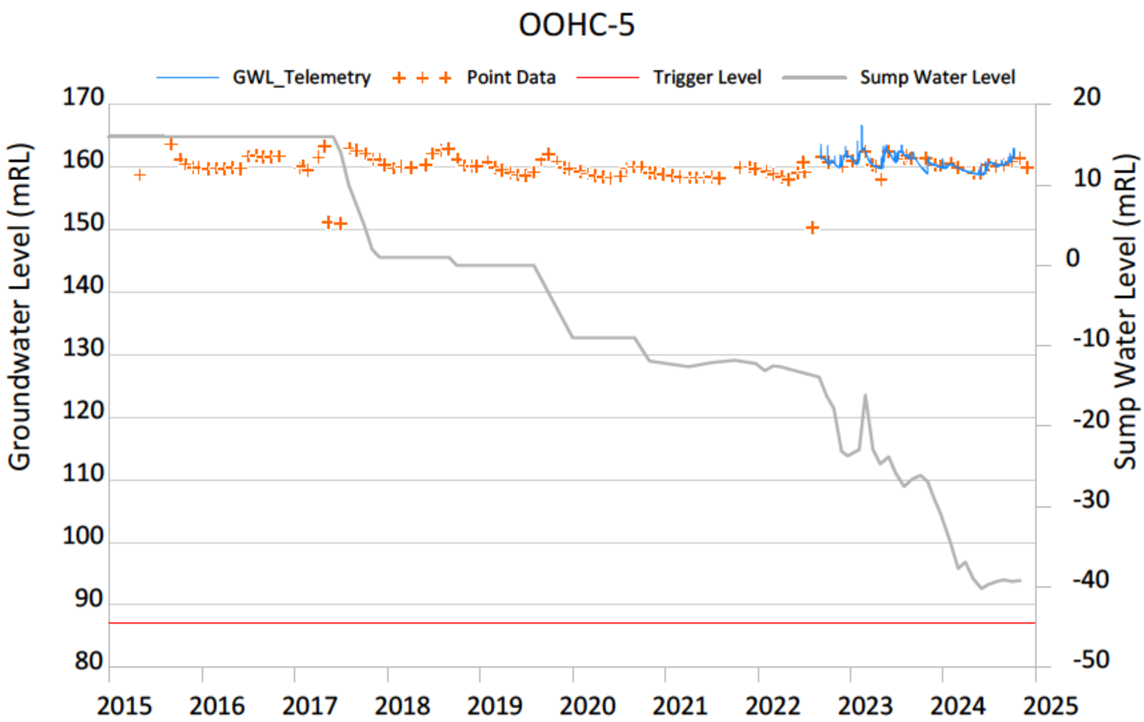

SG3-U
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
Potential telemetry issue
(note recent monthly data points have been taken from telemetry data)
100
90
80
70
60
50
40
30
20
10
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

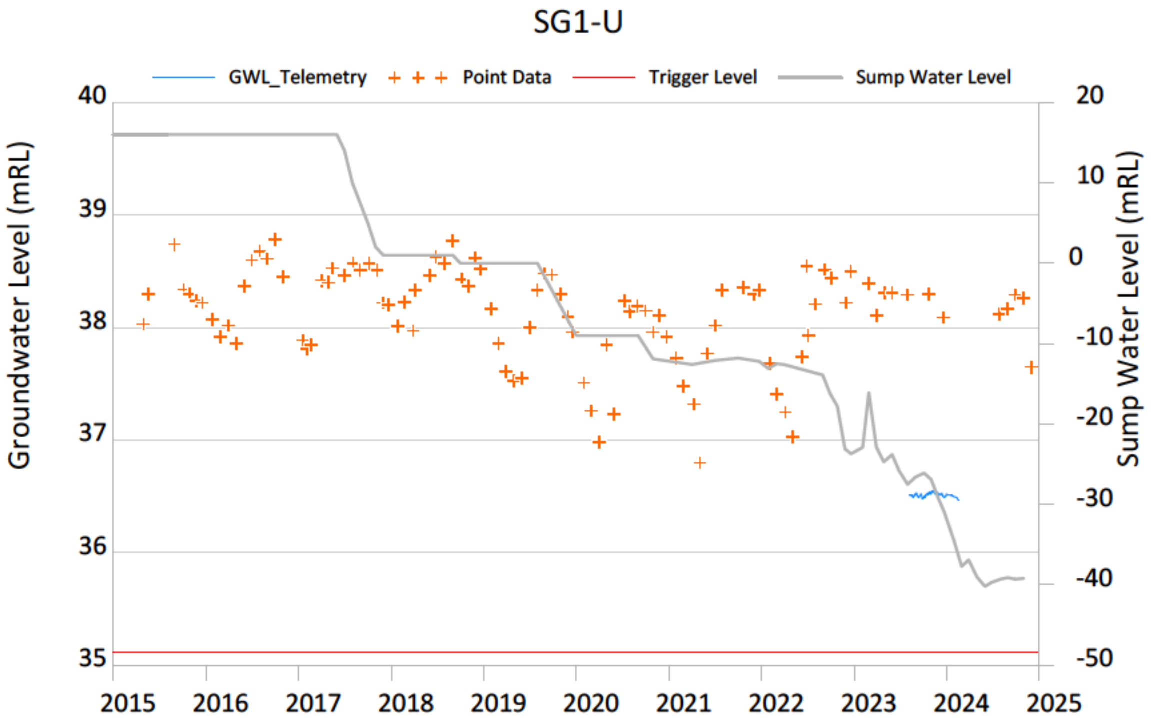

BH109
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
82
80
78
76
74
72
70
68
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

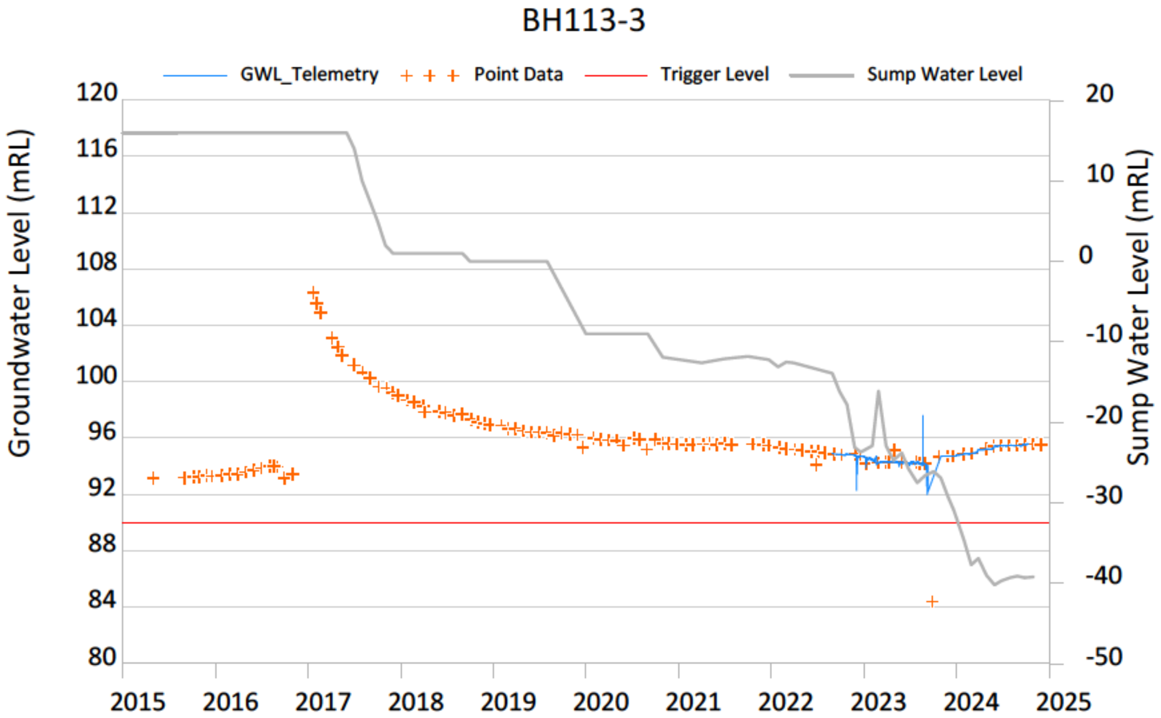

BH113-1
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
100
80
60
40
20
0
-20
-40
-60
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

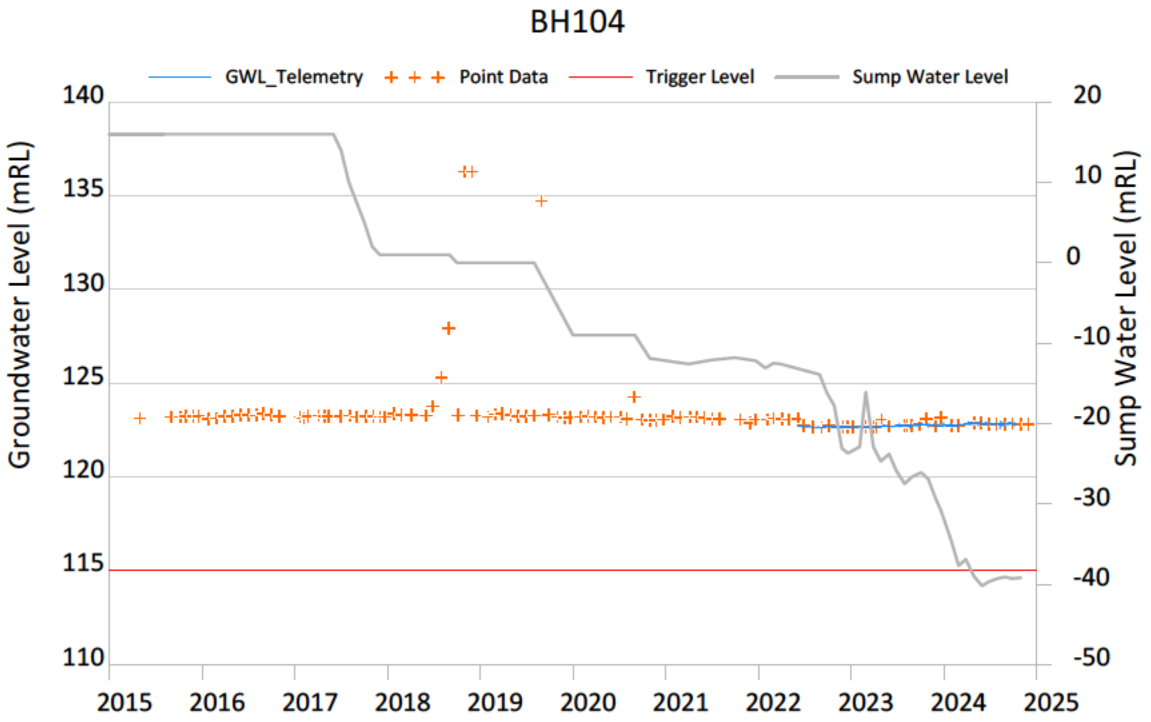

22498-SG6
GWL_Logger
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
64
62
60
58
56
54
52
50
48
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

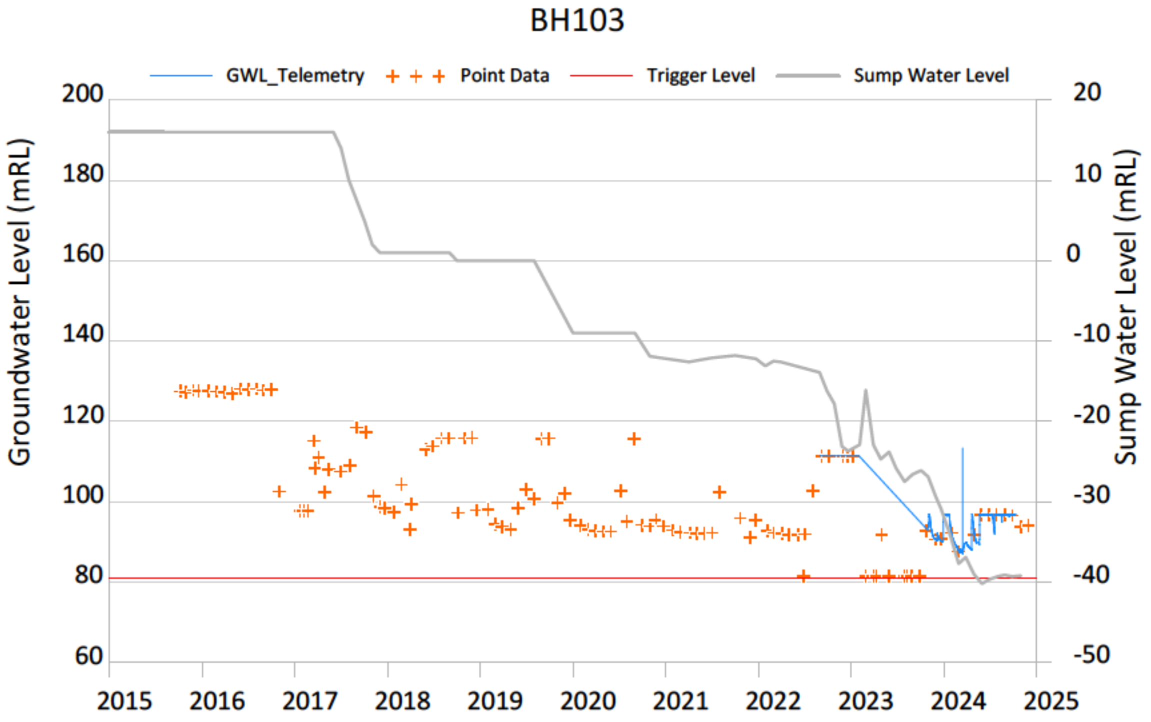

OOHC-2
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
200
180
160
140
120
100
80
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

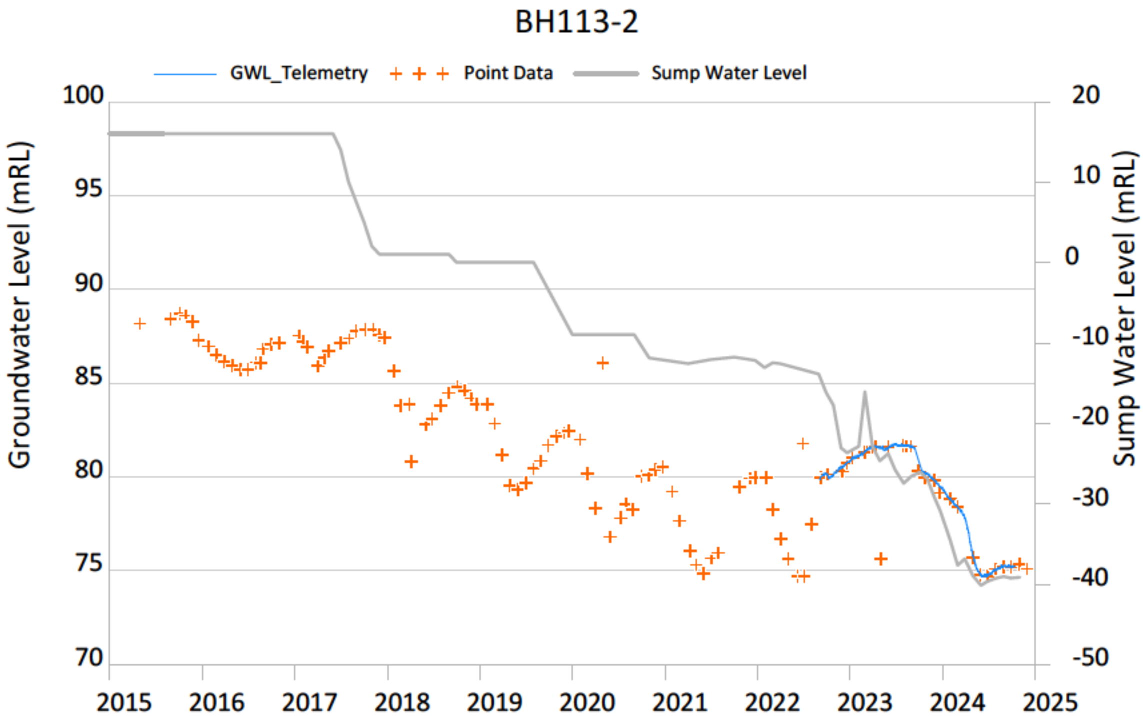

OOHC-5
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
170
160
150
140
130
120
110
100
90
80
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

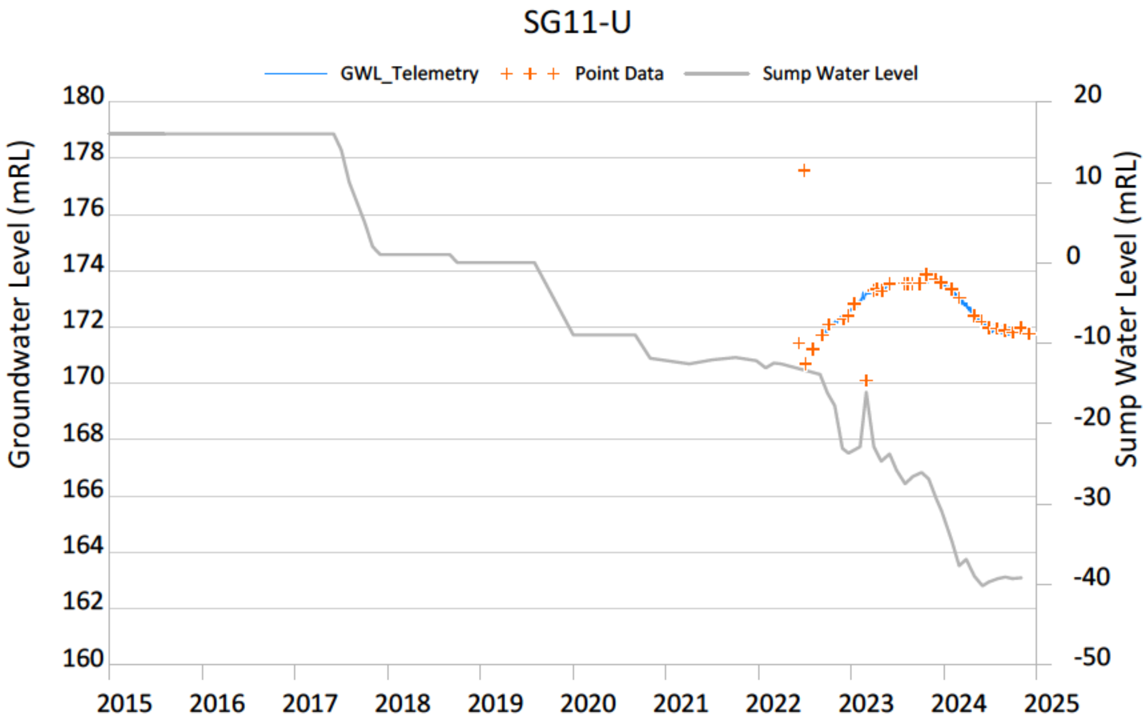

SG1-U
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
40
39
38
37
36
35
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

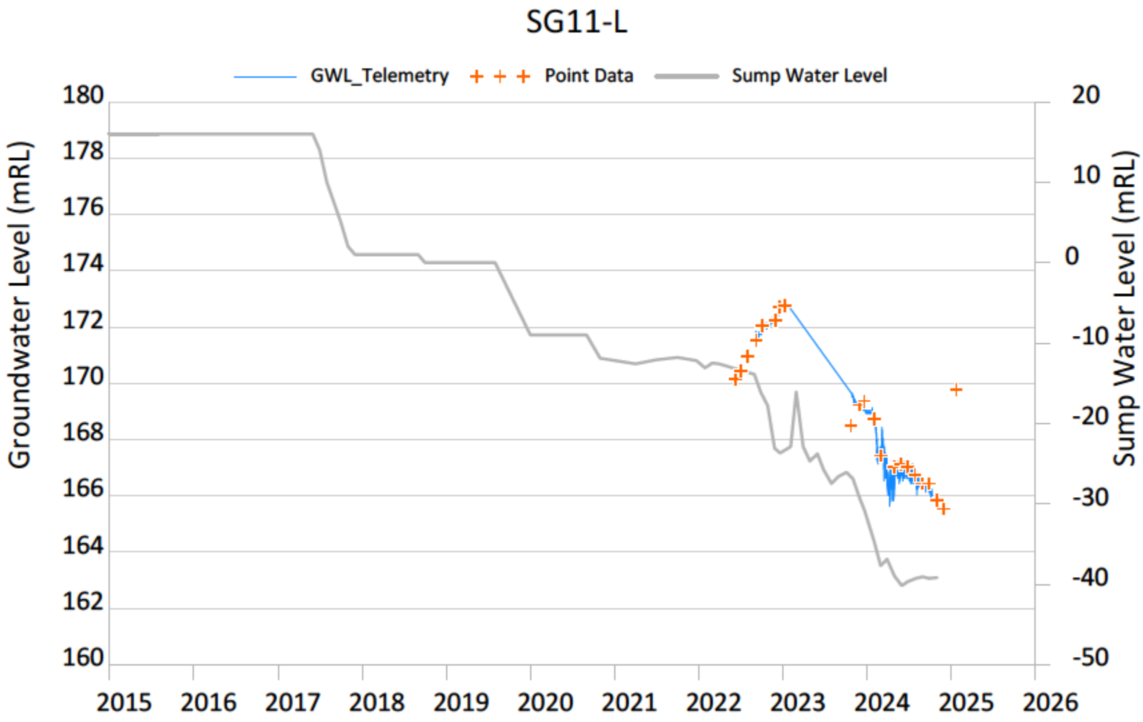

BH113-3
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
120
116
112
108
104
100
96
92
88
84
80
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

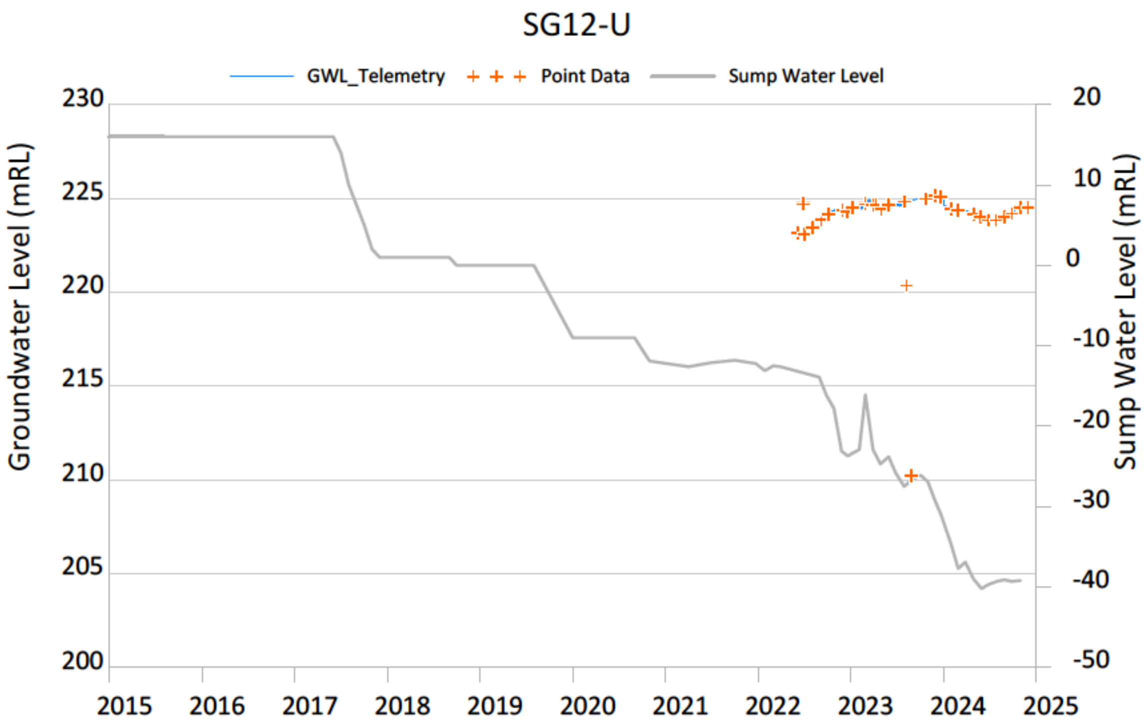

BH104
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
140
135
130
125
120
115
110
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


BH103
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
200
180
160
140
120
100
80
60
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


BH113-2
GWL_Telemetry
Point Data
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
100
95
90
85
80
75
70
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


SG11-U
GWL_Telemetry
Point Data
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
180
178
176
174
172
170
168
166
164
162
160
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


SG11-L
GWL_Telemetry
Point Data
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
180
178
176
174
172
170
168
166
164
162
160
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026


SG12-U
GWL_Telemetry
Point Data
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
230
225
220
215
210
205
200
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
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2020
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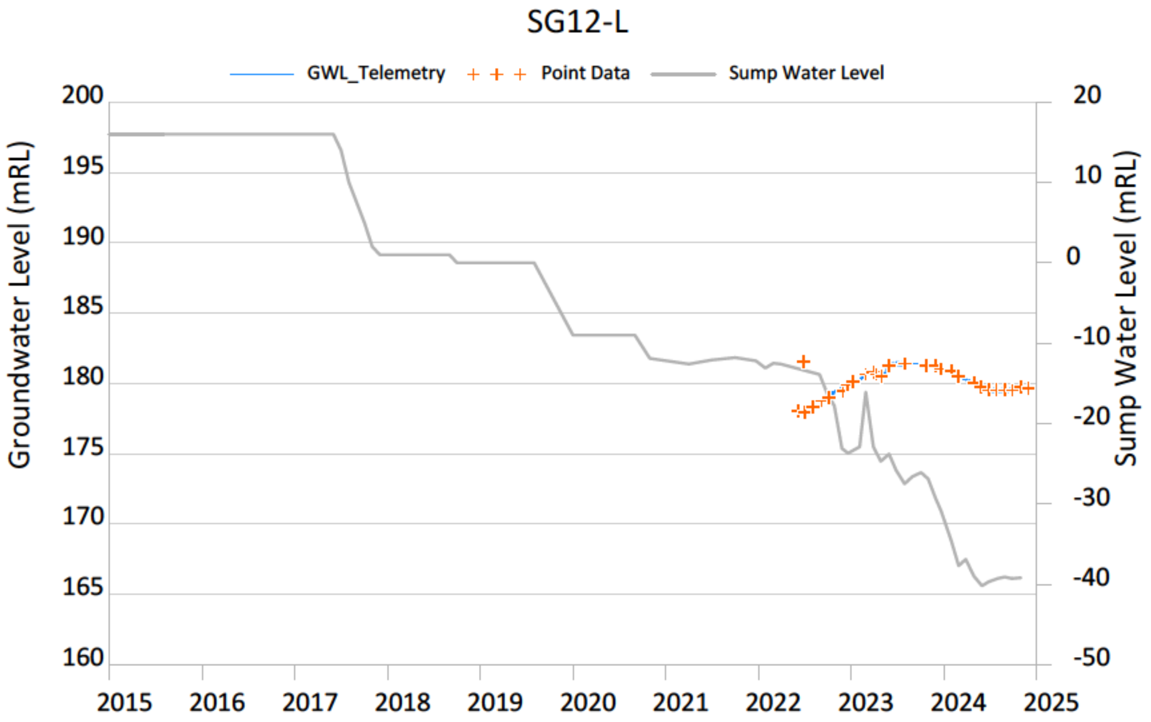
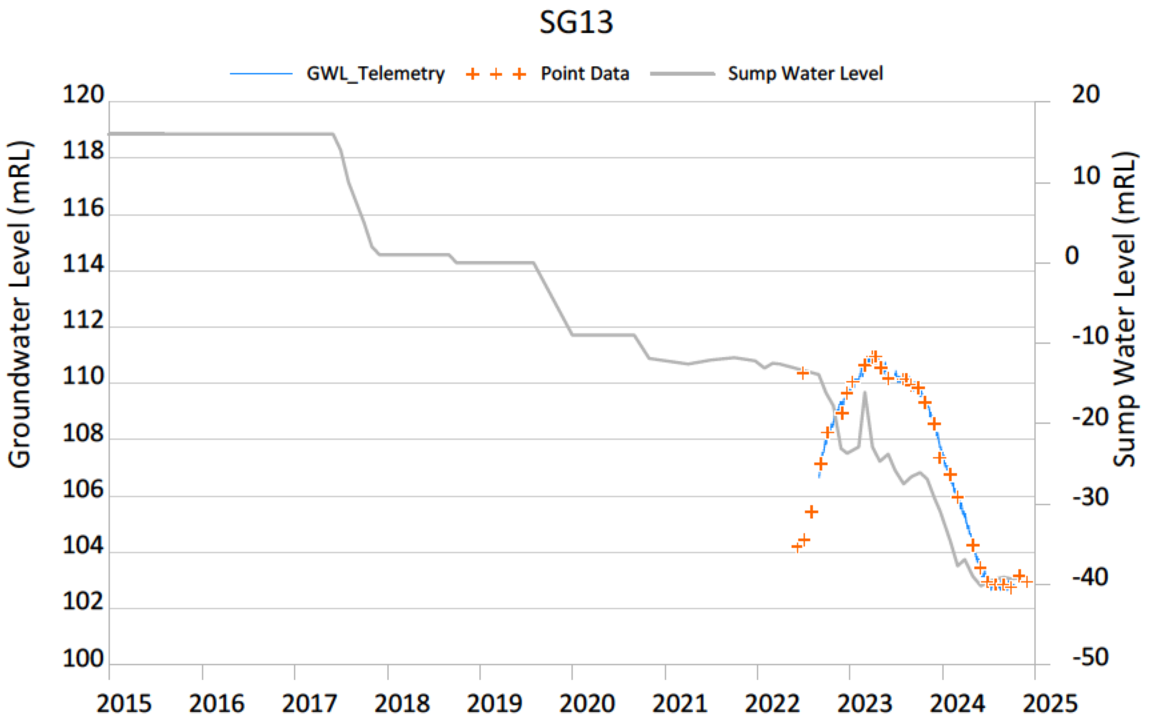
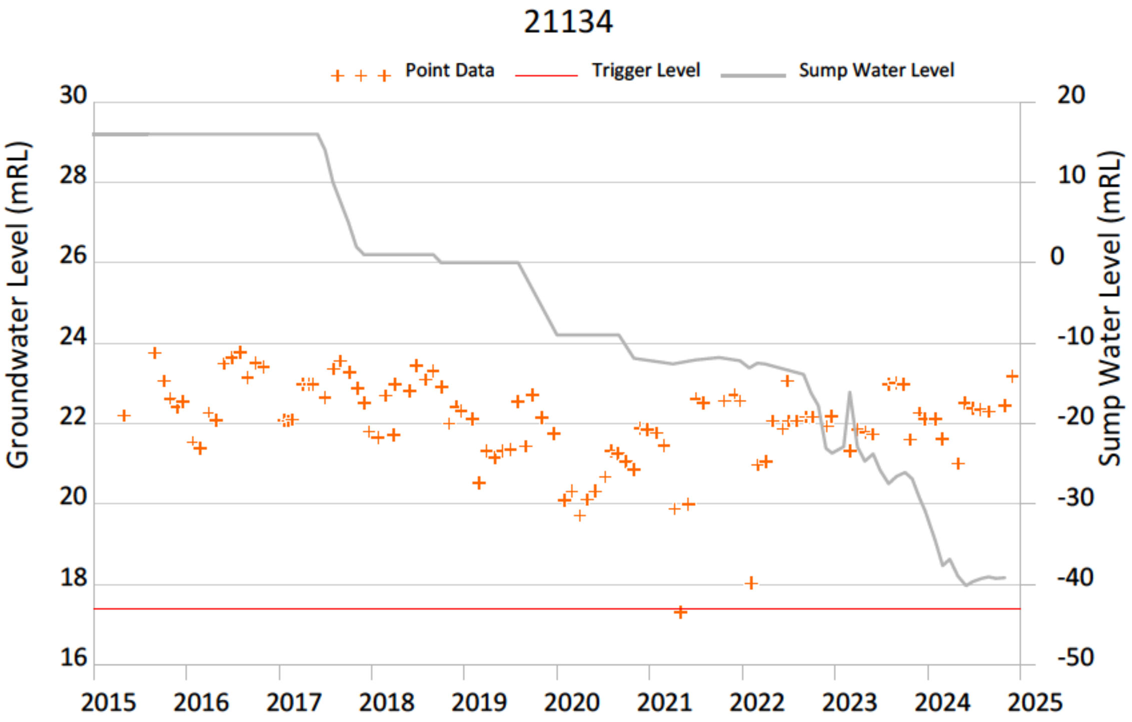
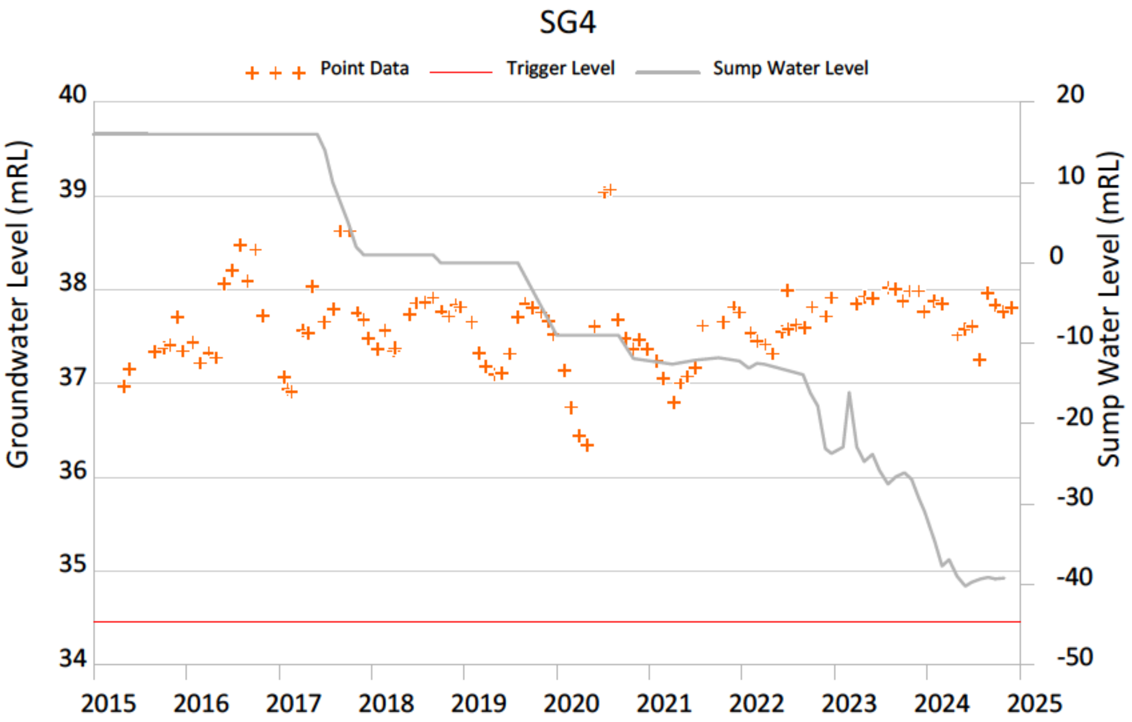
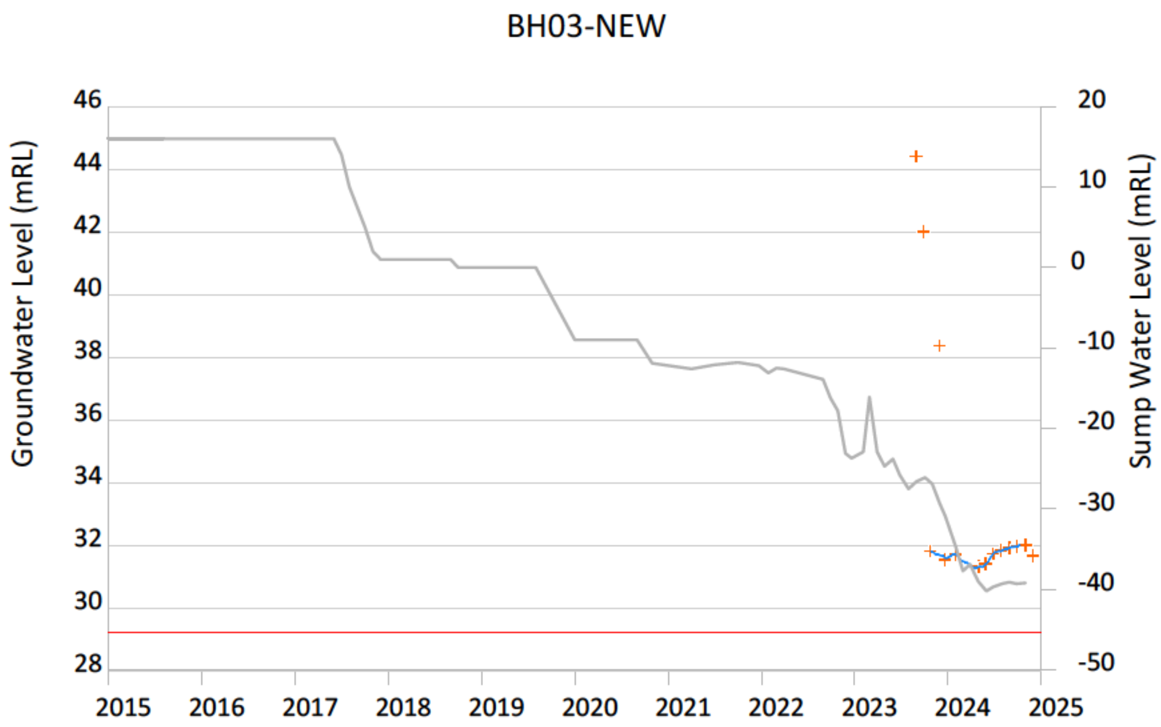
2022
2023
2024
2025

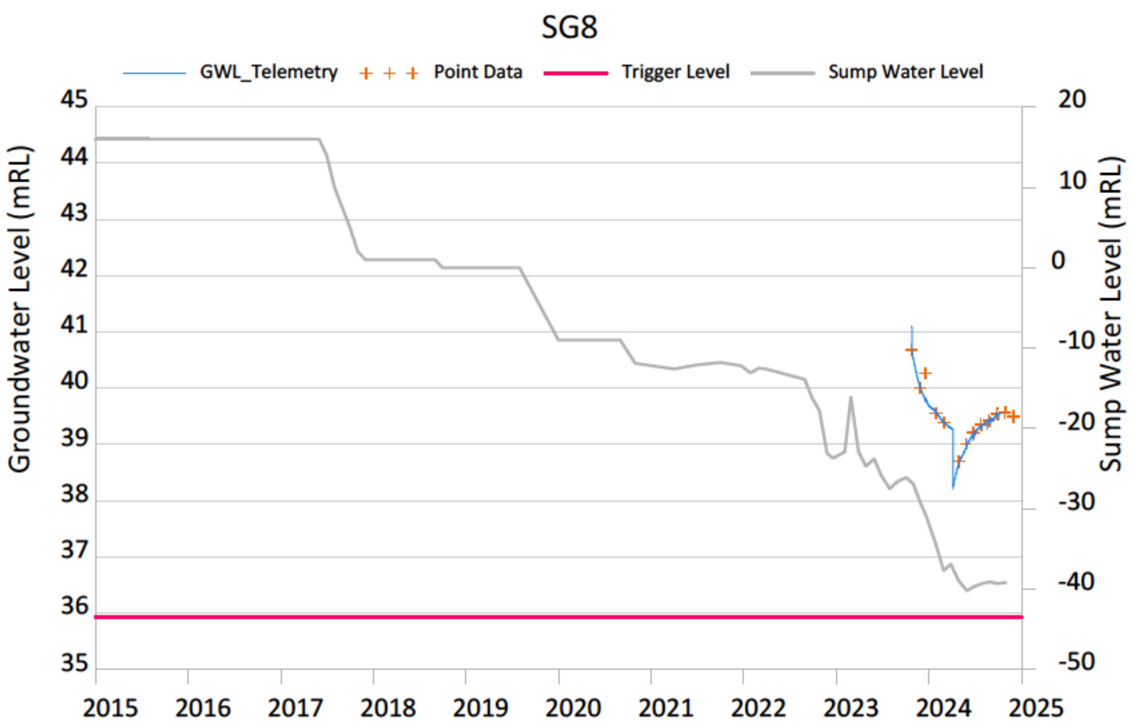

SG12-L
GWL_Telemetry
Point Data
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
200
195
190
185
180
175
170
165
160
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

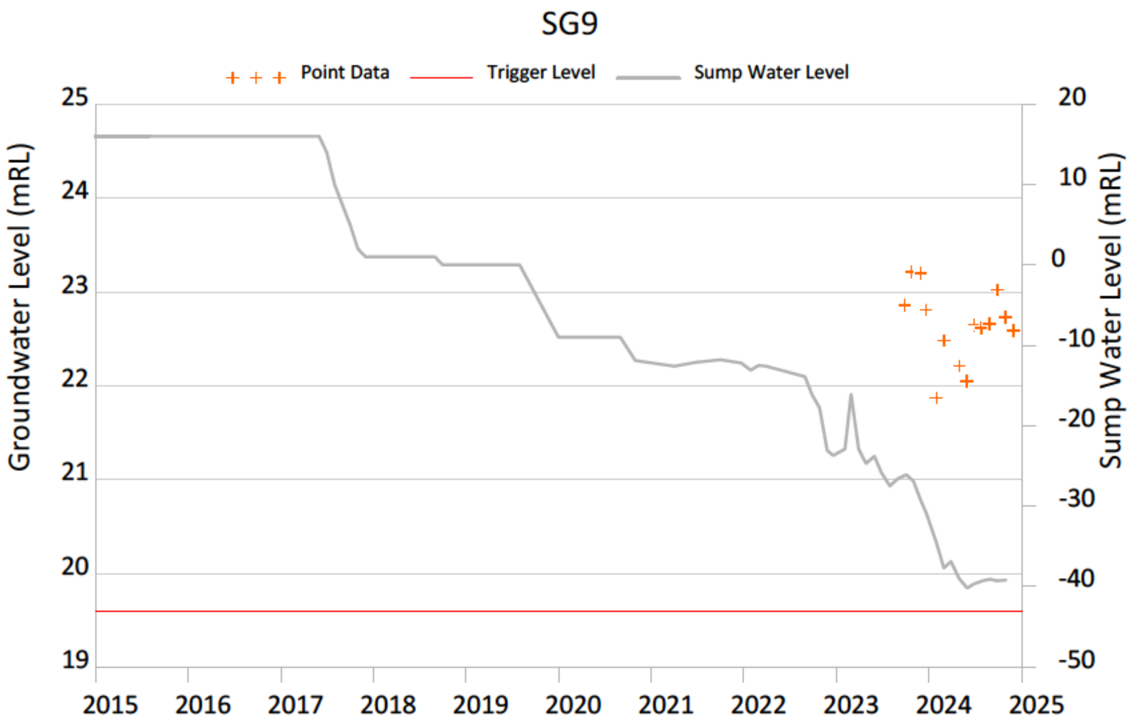

SG13
GWL_Telemetry
Point Data
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
120
118
116
114
112
110
108
106
104
102
100
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

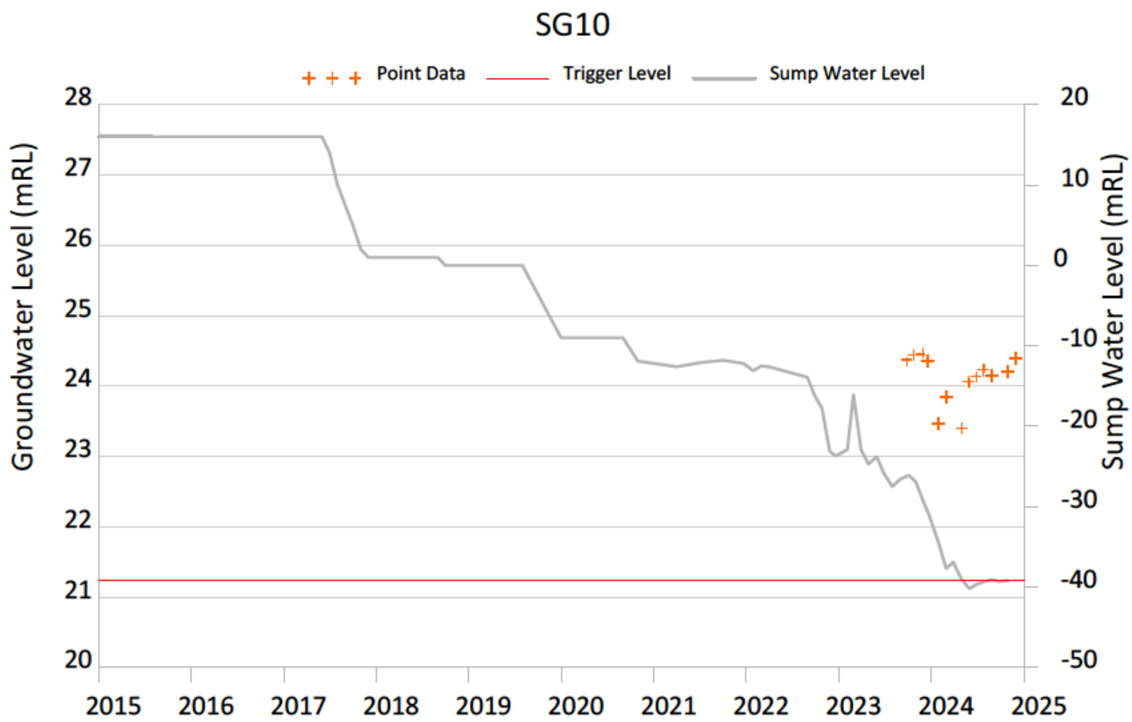

21134
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
30
28
26
24
22
20
18
16
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


SG4
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
40
39
38
37
36
35
34
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


BH03-NEW
Groundwater Level (mRL)
Sump Water Level (mRL)
46
44
42
40
38
36
34
32
30
28
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


SG8
GWL_Telemetry
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
45
44
43
42
41
40
39
38
37
36
35
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


SG9
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
25
24
23
22
21
20
19
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


SG10
Point Data
Trigger Level
Sump Water Level
Groundwater Level (mRL)
Sump Water Level (mRL)
28
27
26
25
24
23
22
21
20
20
10
0
-10
-20
-30
-40
-50
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

Appendix C: NTI Tributaries Gauging Result

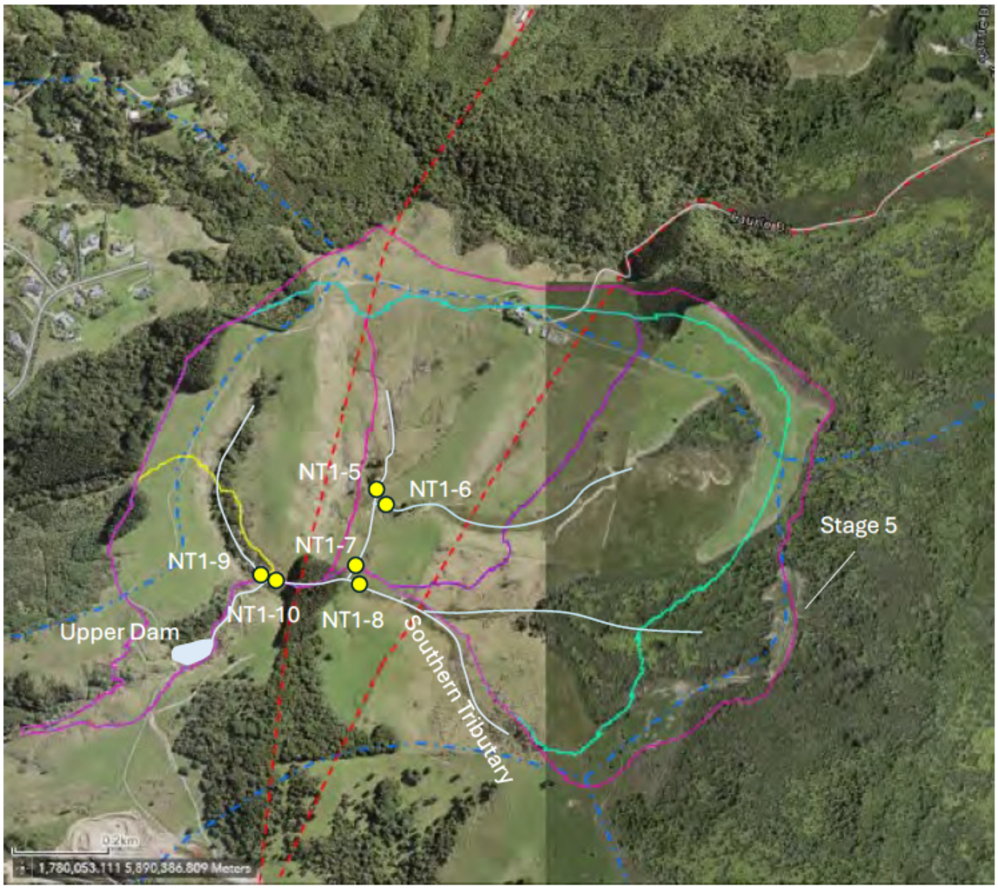


Figure C1: NT1 Upper Catchment Tributaries

Table C1: NT1 Tributary Gauging (20 January 2022)	
Gauging Stations	**Dry conditions (L/s)**
NT1-5	0.24
NT1-6	0.49
NT1-7	0.89
NT1-8	0.95
NT1-9	0.18
NT1-10	1.37

Appendix D: Groundwater and Surface Water Quality Results (2022)

Sample Name:	SG13	SG12L	SG12U	SG11U	SG11L	SUMP	NT-1	NT-2
Sample Taken:	22/07/2022	22/07/2022	22/07/2022	28/07/2022	28/07/2022	11/08/2022	11/08/2022	11/08/2022
Lab Number:	SG13	SG12L	SG12U	SG11U	SG11L	SUMP	NT-1	NT-2
Chemical Oxygen Demand	10	<10	<10	<10	15	-	-	-
Total Kjeldahl Nitrogen	0.34	0.11	<0.10	<0.10	0.22	0.1	0.2	0.15
Total Nitrogen	0.55	0.59	0.47	0.37	0.28	0.327	1.53	1.54
Carbonaceous Biochemical Oxygen Demand	<1.00	<1.00	<1.00	<1.00	<1.00	-	-	-
Total Phosphorus	0.023	0.098	0.2	0.14	0.12	-	-	-
Nitrite-N	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0168	0.0029	0.0028
pH	7.6	7.3	6.9	8	40	7.9	6.6	6.4
Electrical Conductivity	578	176	141	12.8	12.8	-	85.9	87.4
Total Alkalinity (CaCO3)	215	53.4	36.4	7.3	8	168	6.2	5.6
Chloride	24.7	15.3	16.4	135	384	19.6	15.7	15.5
Sulfate	55.7	7.67	5.05	43	197	331	4.71	4.67
Nitrate-N	0.207	0.484	0.471	13.4	31.5	0.311	1.53	1.54
Dissolved Reactive Phosphorus (FIA)	0.003	0.11	0.167	5.51	24.4	0.003	<0.002	0.003
Ammonia as N	0.08	<0.005	<0.005	0.368	0.0608	0.02	0.02	0.02
Sodium	45.7	17.2	17.4	0.051	<0.002	38	11.2	11.8
Potassium	5.9	1.7	1.6	<0.005	0.02	2	1.5	1.5
Calcium	53.3	13.1	6.03	14.3	26.3	129	2.9	3.1
Magnesium	18.8	3.27	2.77	1.4	1.6	36	2	2.06
Iron	<0.0050	<0.0050	<0.0050	9.82	35.1	<0.0050	0.19	0.2
Zinc	3.66	0.496	0.0054	3.3	14.6	0.0013	0.0025	0.003
Manganese	0.787	0.0566	0.0067	<0.0050	<0.0050	0.01	0.023	0.024
Sum of Anions*	6.21	1.7	1.33	0.013	0.344	10.87	0.77	0.76
Sum of Cations*	6.49	1.73	1.33	0.028	0.113	11.11	0.84	0.88
EC/10*	5.78	1.76	1.41	1.38	5.4	8.33	0.86	0.87
Conductivity of Water (mS/m)	58	18	14	1.42	4.15	83	9	9
Arsenic	0.00093	0.00054	0.00055	1.35	3.84	1.11	<0.00050	<0.00050
Aluminium	0.687	0.22	2.07	14	38	-	-	-
Boron	0.12	<0.0050	<0.0050	<0.00050	0.0053	<0.000050	<0.010	<0.010

Appendix E: PH1 Pumping Test Analysis (PDP 2017)

Step Discharge Pump Test Analysis

The step pumping test was conducted on 25 August 2017. The aim of this test was to determine the likely maximum yield of the bore, the aquifer parameters and its efficiency of production.

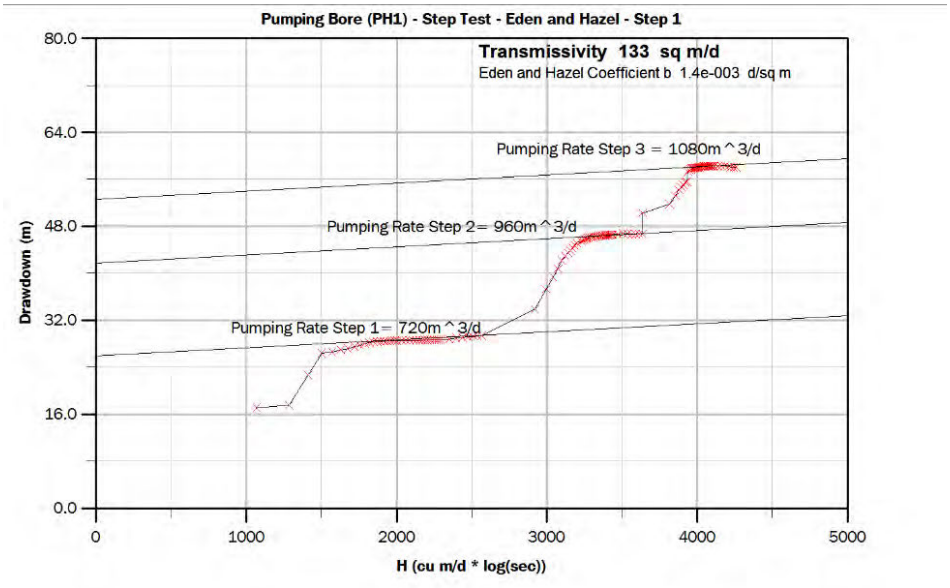
Test consists of three discharge steps, each for 1 hour duration. Pumping rates for each step were 8.5, 11 and 12.5L/sec (see Figure E.1 below).

The test analysis aims to determine the constants for the following equation (Eden & Hazel, 1973)[1] use to describe well performance characteristics.

Sw = (a+b *Log*(t)) Q+CQ²

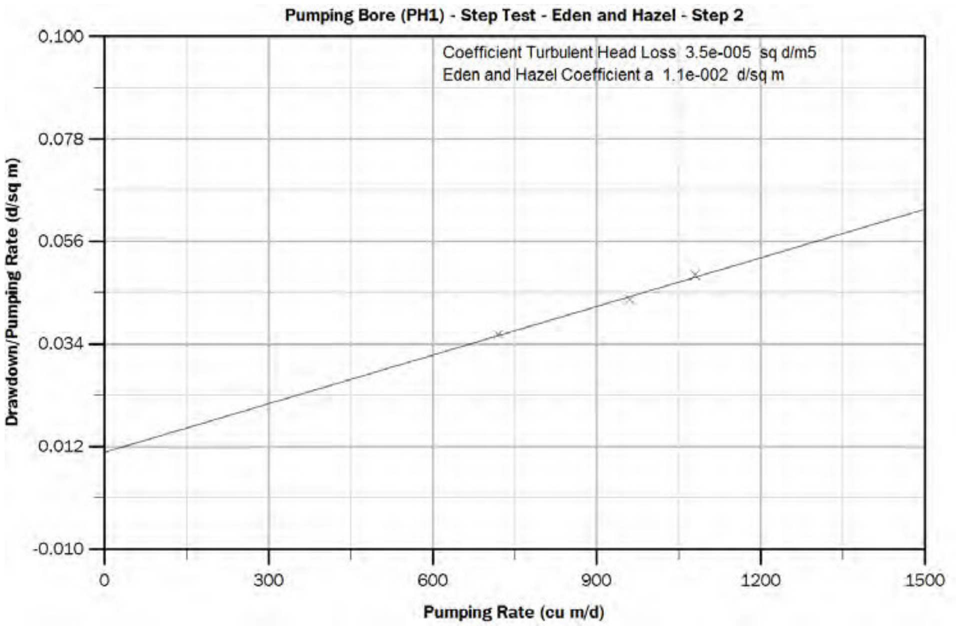
Where:
Sw = Drawdown (m)
a = Eden & Hazel coefficient a (d/m^2)
b = Eden & Hazel coefficient b (d/m^2)
c = Coefficient of Turbulent Head Losses (d^2/m^5)
t = time
Q = pumping rate (m^3/d)

In order to determine the equation constants, a curve matching algorithm was employed to ascertain the parameter set which most closely represents the field data.



E.1: Step Test Analysis using Eden and Hazel method (Part 1)

[1] Eden, R. N and Hazel, C.P (1973) Computer and graphical analysis of variable discharge pumping test of wells. *Inst. Enger. Australia*, Civil Engineering. pp.5-10



E.2: Step Test Analysis using Eden and Hazel Method (Part 2)

The results of the analysis are as follows:

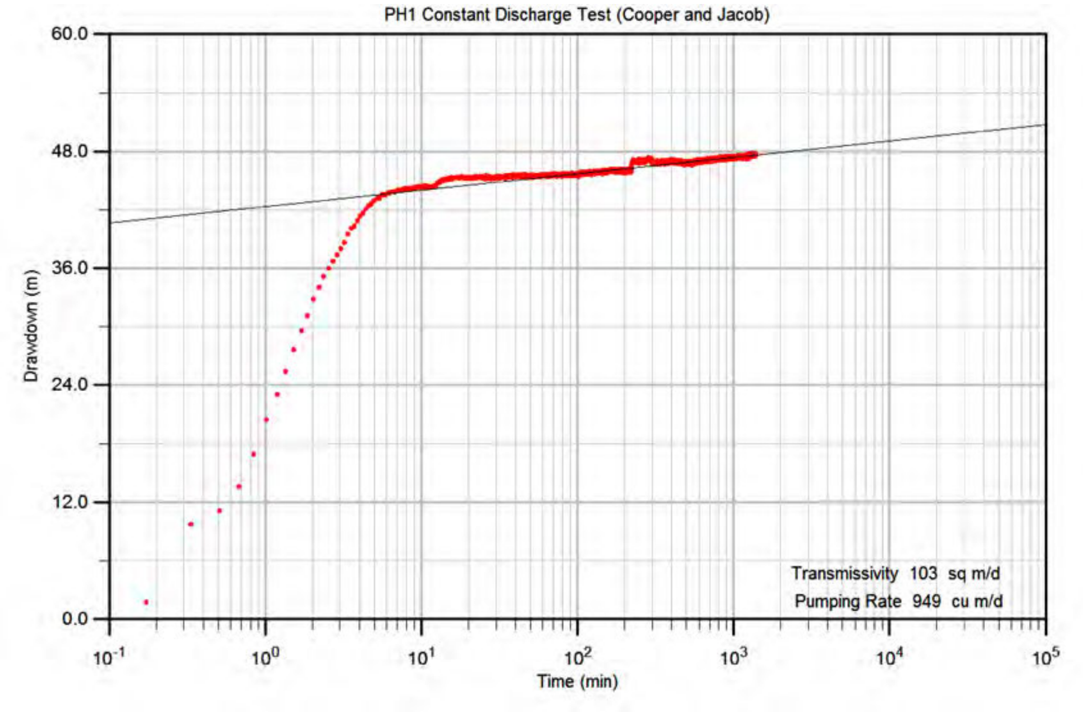
a = 1.1 x 10-2 day/m^2
b = 1.4 x 10-3 day/m^2
c = 3.5 x 10^{-5} day^2/m^5

Constant Rate Pump and Recovery Tests Analysis

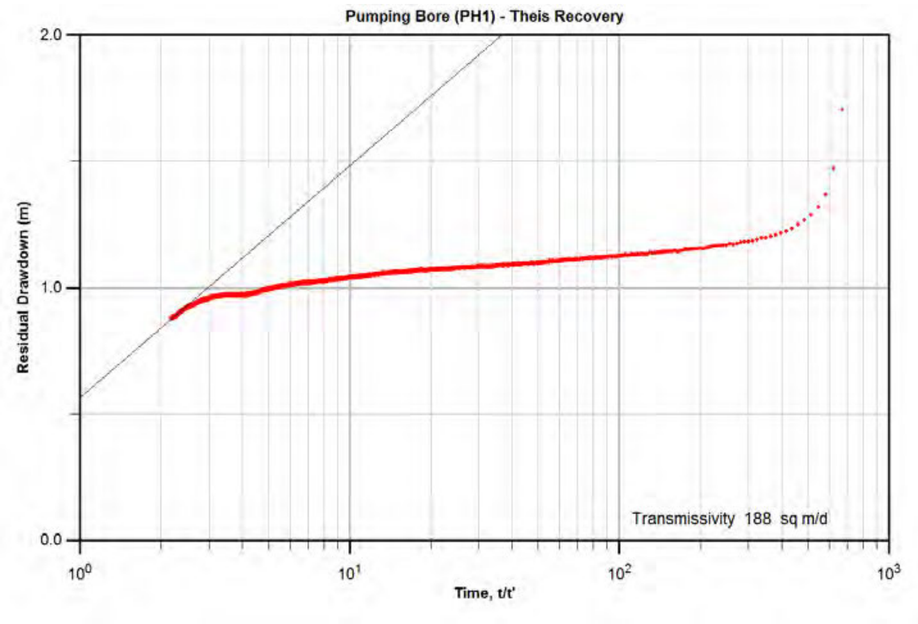
Following the completion of the step test and corresponding recovery, a 24 hour constant rate pump test was conducted. A discharge rate of 960m^3/d was maintained for the duration of the test.

Drawdown was monitored in the pumping bore and 3 monitoring bores; BH103 (162m from the pumped bore), BH104 (276m from the pumped bore) and BH109 (562m from the pumped bore).

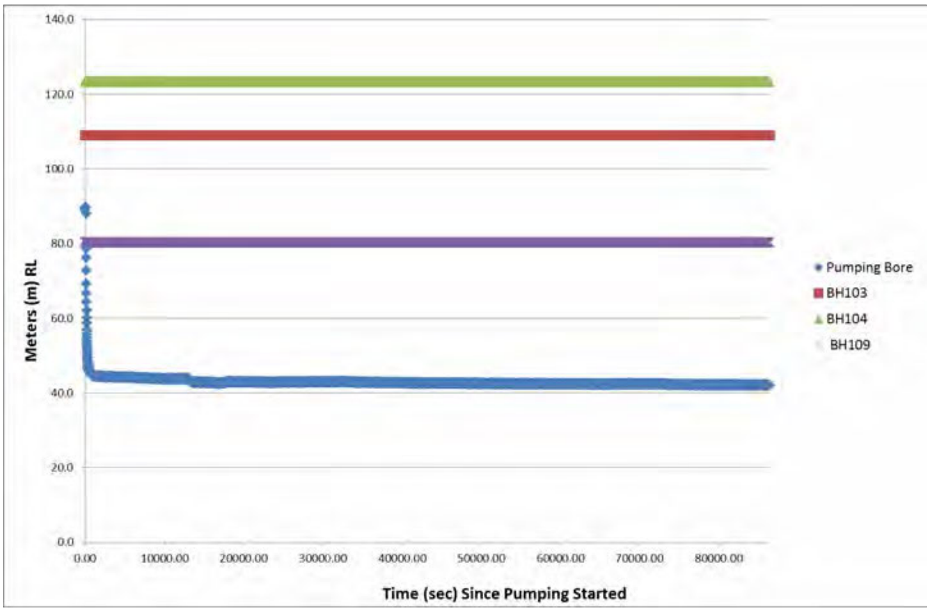
The constant discharge test and the recovery test results are given in the following plots (Figure E.3 and E.4). The boreholes monitoring data during the pumping test is shown in Figure E.5.



E.3: Constant Rate Test Analysis using Copper and Jacob (1946) Method

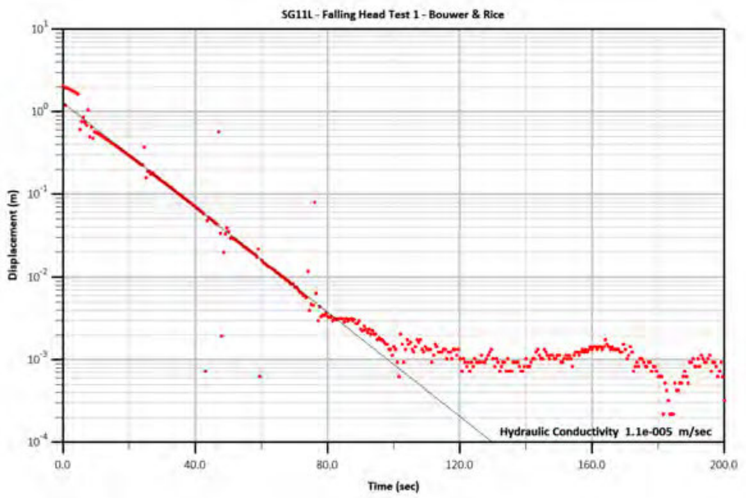


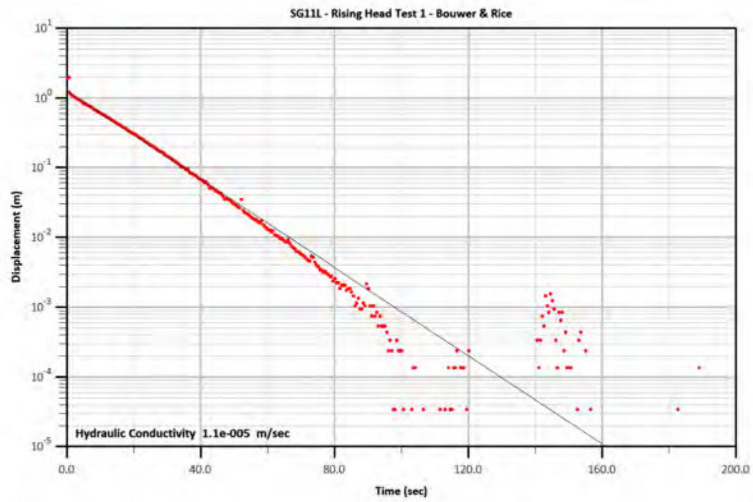
E.4: Constant Rate Test (Recovery) Analysis using Theis Method

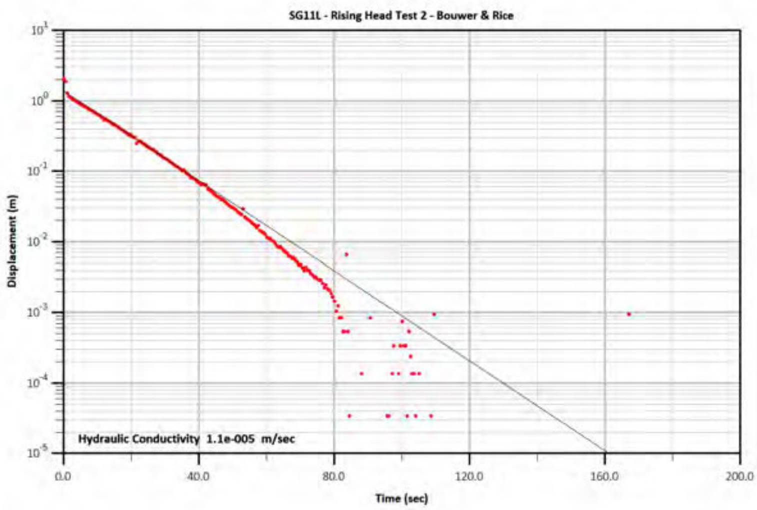


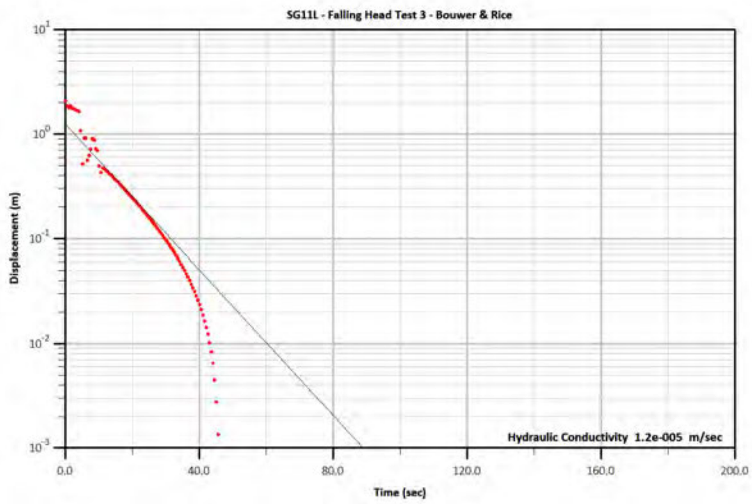
E.5: Monitored Drawdown for the Pumping Bore and each Monitoring Well

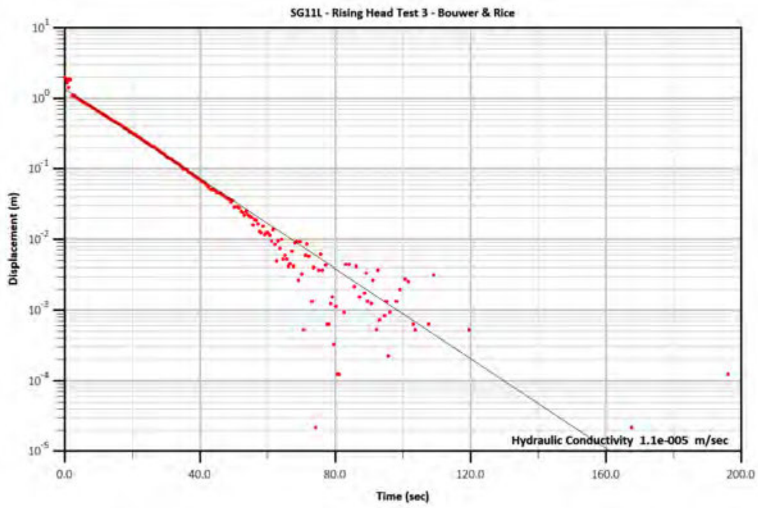
Appendix F: Field Permeability Test Analysis for SG11L, SG12L and SG13

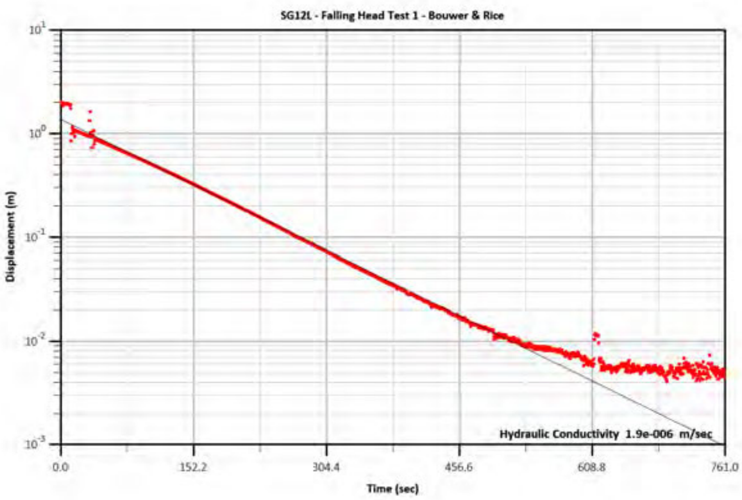

SG11L - Falling Head Test 1 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.1e-005 m/sec

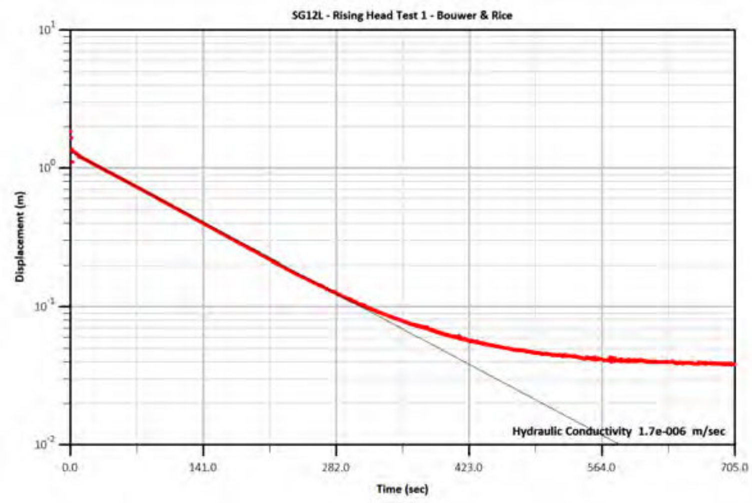

SG11L - Rising Head Test 1 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.1e-005 m/sec

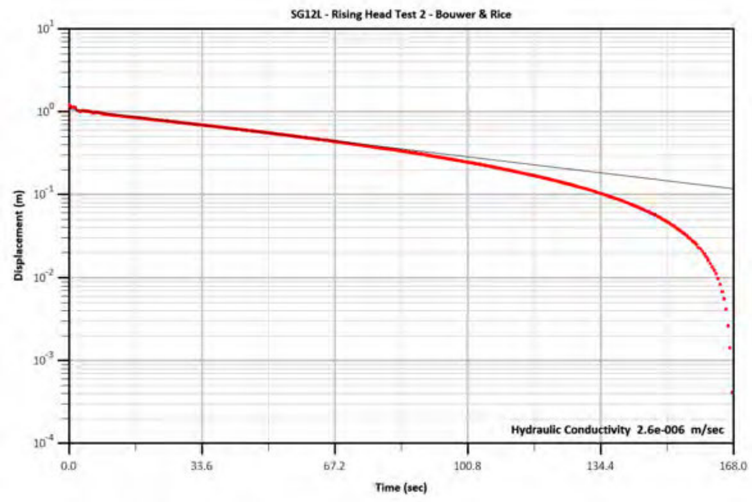

SG11L - Rising Head Test 2 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.1e-005 m/sec

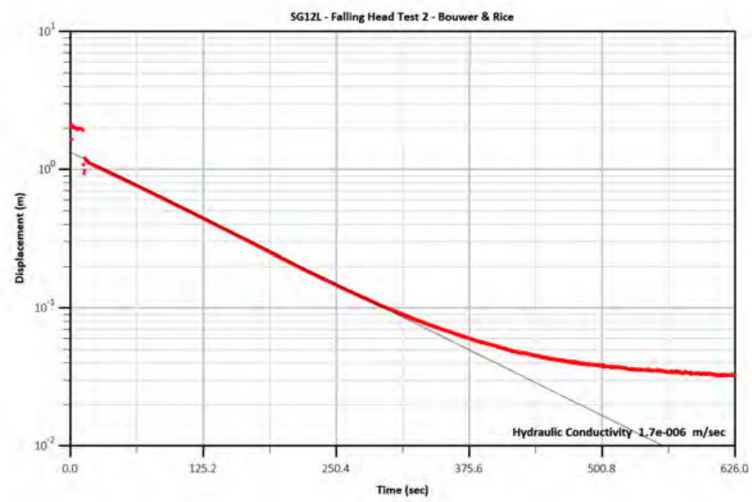

SG11L - Falling Head Test 3 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.2e-005 m/sec

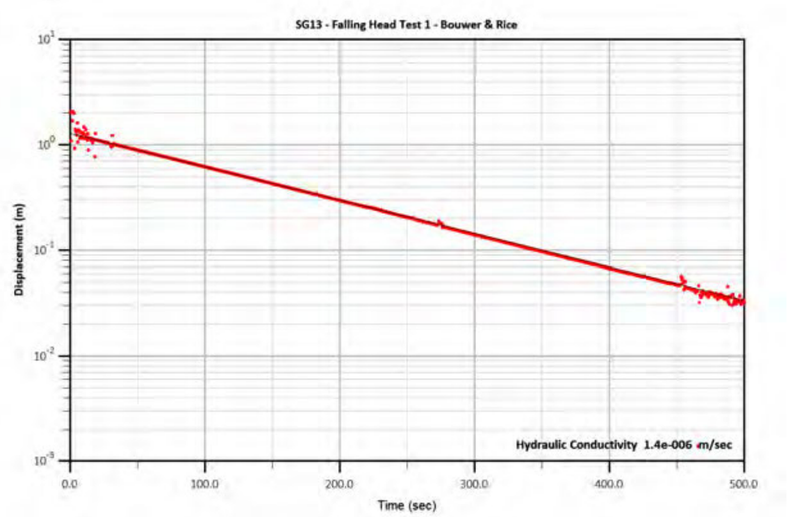

SG11L - Rising Head Test 3 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.1e-005 m/sec

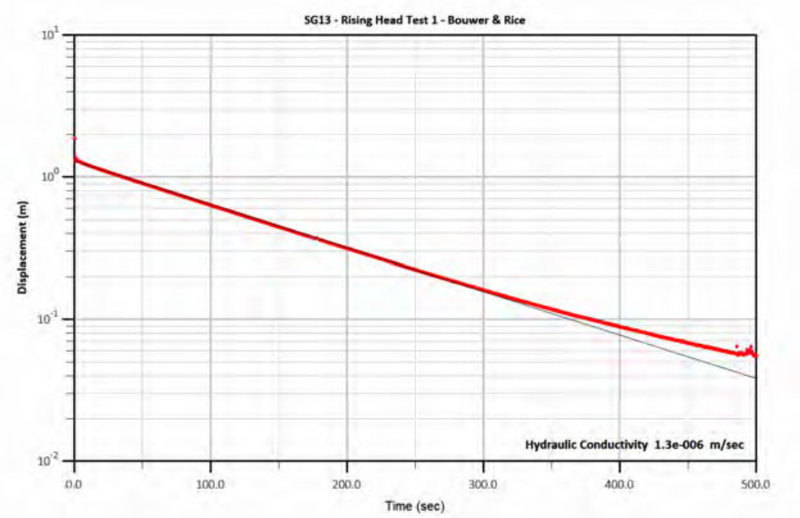

SG12L - Falling Head Test 1 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.9e-006 m/sec


SG12L - Rising Head Test 1 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.7e-006 m/sec
0.0
141.0
282.0
423.0
564.0
705.0


SG12L - Rising Head Test 2 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 2.6e-006 m/sec
0.0
33.6
67.2
100.8
134.4
168.0


SG12L - Falling Head Test 2 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.7e-006 m/sec
0.0
125.2
250.4
375.6
500.8
626.0


SG13 - Falling Head Test 1 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.4e-006 m/sec


SG13 - Rising Head Test 1 - Bouwer & Rice
Displacement (m)
Time (sec)
Hydraulic Conductivity 1.3e-006 m/sec

Appendix G: Zone of Influence and Drawdown Analytical Method

Zone of Influence and Drawdown Analytical Method

The method used in this study (Dupuit-Forchheimer well discharge formula) compares the pit with a large diameter pumping well and assumes unconfined, isotropic and homogeneous aquifer under steady state conditions (Bear, 1979):

$$Q_W = \frac{\pi K(h_1^2 - h_2^2)}{\ln R/rw}$$

where:

Q = pumping rate (m^3/s)

K = hydraulic conductivity (m/s)

h_1 = saturated aquifer thickness (m)

The thickness of the greywacke in the area could be more than 1km, however the effective saturated thickness of the greywacke aquifer (h_1) will be limited to the near surface saturated zone where fractures are more open and plentiful. The effective saturated thickness of the aquifer is generally has been assumed to be about 200m. At depths greater than 200m the permeability is likely to be reduced significantly.

h_2 = steady state dewatering level above the base of the aquifer (m)

R = radius of influence of quarry (m)

rw = effective radius of equal well (assuming a circular excavation) (m)

The total area of proposed pit (Stage 5) below the assumed pre-quarry groundwater level at RL170m is about 750,650m^2. Therefore, the effective radius of the imaginary well for each pit is approximately 489m.

The flow generated by infiltration over the area with radius (R) can be expressed by:

$$Q_R = \pi R^2 (RCH)$$

Assuming equilibrium conditions, the flow toward the proposed quarry (Qw) is equal to flow generated by the infiltration over the radius of influence (QR), thus the radius of influence (R) can be calculated:

$$\pi R^2 (RCH) = \frac{\pi K(h_1^2 - h_2^2)}{\ln R/rw}$$

Where:

R is the radius of influence (m)

RCH is deep groundwater recharge (m/d).

Appendix H: Predicted Drawdowns in Farm Wells East of Hunua Fault (Stages 2 to 5)

Stage 2: Drawdowns East of Hunua Fault				
Bore ID	**Easting**	**Northing**	**Bore Depth (m)**	**Predicted Drawdowns (m)**
152	1776494	5886975	NA	5.4
202	1777000	5887700	NA	10.1
372	1776580	5886380	NA	2.6
700	1779540	5890720	117	9.0
824	1778000	5888500	NA	14.3
4317	1776490	5886490	NA	3.0
4322	1776600	5886900	43	5.0
4323	1776630	5887280	NA	7.2
4327	1776750	5886760	NA	4.4
4340	1777200	5888300	NA	14.9
4350	1777350	5887250	NA	7.0
4351	1777500	5887100	58	6.0
4354	1776580	5886770	NA	4.4
4363	1778400	5887300	NA	5.6
4364	1778500	5887400	NA	5.8
4375	1779400	5890900	102	9.6
4446	1780400	5887800	55	1.1
4523	1779860	5887210	NA	1.3
4978	1777800	5887500	NA	7.9
20895	1776490	5887090	NA	6.0
20932	1776525	5887500	NA	8.4
20943	1776580	5887470	554	8.3
21161	1777200	5888300	NA	14.9
21218	1780600	5887900	108	0.7
21300	1780246	5890891	105	4.8
21328	1777200	5886006	NA	1.1
21481	1779700	5890800	>82	7.9
21555	1777231	5888300	NA	14.9
21618	1777350	5887508	NA	8.6
21641	1777550	5887440	NA	8.0
21642	1777600	5888534	NA	16.3
21659	1777745	5888350	NA	14.1

Stage 2: Drawdowns East of Hunua Fault				
Bore ID	Easting	Northing	Bore Depth (m)	Predicted Drawdowns (m)
21663	1777815	5888720	38	17.2
21665	1777982	5888660	NA	15.7
21718	1780220	5887510	93	1.0
21745	1778034	5887555	NA	7.8
21759	1778056	5886750	NA	3.6
21801	1780472	5887434	88	0.1
21807	1778145	5887560	NA	7.6
21867	1778337	5886572	NA	2.5
21899	1778500	5887402	NA	5.8
21977	1778550	5886110	NA	0.4
21987	1778600	5891300	NA	13.9
21991	1778700	5890060	NA	16.5
21995	1778731	5891306	NA	12.9
22234	1778819	5892190	NA	8.1
22297	1779315	5891648	NA	8.0
22307	1779340	5890300	NA	10.8
22361	1779400	5889290	NA	9.4
22362	1779540	5889245	NA	8.4
22363	1779630	5889430	NA	8.2
22364	1779700	5889530	NA	7.9
22365	1779760	5889378	NA	7.3
22450	1779785	5893074	NA	1.5
22455	1779800	5889300	NA	7.0
22482	1779860	5891265	NA	6.1
22537	1779890	5890440	NA	7.1
22596	1780026	5891929	NA	3.8
22620	1780044	5889717	NA	6.1
22655	1780100	5893054	NA	0.6
22674	1780100	5891320	NA	4.8
22677	1780110	5891626	NA	4.2
22761	1780200	5891550	NA	3.9
22769	1780200	5891222	NA	4.5

Stage 2: Drawdowns East of Hunua Fault				
Bore ID	Easting	Northing	Bore Depth (m)	Predicted Drawdowns (m)
22784	1780210	5891677	NA	3.6
22812	1780210	5891108	NA	4.6
22837	1780220	5890810	NA	5.0
22900	1780246	5888339	NA	2.9
22992	1780355	5888355	NA	2.5
23041	1780400	5887470	NA	0.4
23072	1780500	5890220	NA	3.9
23081	1780525	5890940	NA	3.4
23172	1780550	5892110	NA	1.4
23207	1780660	5888485	NA	1.6
23220	1780700	5891830	NA	1.4
23261	1781002	5890495	NA	1.6
23479	1781200	5889406	NA	0.6
23481	1781200	5889406	NA	0.6
23487	1781205	5889406	NA	0.6
23693	1780026	5892753	NA	1.7
28071	1779630	5887050	121	1.4
WAT60276615	1777329	5887305	NA	7.4
WAT60415780	1777107	5886740	NA	4.4
WAT80324535	1776537	5886164	NA	1.6
LUC60363042	1779689	5889229	120	7.5
LUC60373196	1778586	5891345	200	13.7
LUC80306186	1780007	5887183	NA	0.8
LUC80309065	1780514	5887878	NA	0.9
LUC80309535	1780159	5887399	NA	0.9
LUC80312446	1780021	5887016	NA	0.3

Stage 3: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
152	1776494	5886975	NA	17.5
164	1779785	5894725	123	3.1
194	1775900	5891800	NA	32.6
204	1777000	5887700	NA	26.5
302	1777550	5885450	NA	6.1
372	1776580	5886380	NA	12.5
507	1781762	5892647	>89	3.3
685	1776320	5894290	NA	9.1
686	1776320	5894290	NA	9.7
700	1779540	5890720	117	27.3
824	1778000	5888500	NA	36.3
854A	1780550	5893360	NA	6.8
854B	1780518	5893364	NA	6.9
1179	1778700	5885420	100	4.6
4250	1775700	5895300	NA	2.6
4251	1775700	5895800	NA	0.1
4265	1775800	5895500	NA	1.7
4278	1775970	5890880	NA	46.7
4279	1776000	5895800	NA	0.4
4286	1776100	5893100	NA	19.0
4287	1776100	5895800	NA	0.5
4303	1776300	5895000	NA	5.1
4313	1776520	5892690	NA	23.6
4317	1776490	5886490	NA	13.2
4320	1776600	5893300	NA	17.9
4322	1776600	5886900	43	17.0
4323	1776630	5887280	NA	20.9
4327	1776750	5886760	NA	15.9
4334	1776900	5894600	NA	8.1
4340	1777200	5888300	NA	36.1
4350	1777350	5887250	NA	21.0
4351	1777500	5887100	58	19.3
4354	1776580	5886770	NA	15.8

Stage 3: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
4363	1778400	5887300	NA	19.0
4364	1778500	5887400	100	19.5
4366	1778600	5884900	50	1.9
4367	1778600	5884900	41	1.9
4375	1779400	5890900	102	28.5
4446	1780400	5887800	55	11.2
4447	1780540	5893370	NA	6.8
4447	1780522	5893369	NA	6.9
4451	1781205	5886975	116	3.7
4452	1781200	5893200	NA	4.4
4453	1781200	5893300	NA	4.0
4459	1781400	5894200	NA	0.0
4461	1781500	5893000	61	3.8
4463	1781854	5892773	NA	2.3
4466	1782540	5891020	NA	2.1
4520	1775690	5895310	NA	2.5
4691	1779860	5887210	NA	4.5
4722	1776100	5892792	NA	22.1
4933	1775720	5894810	NA	5.4
4978	1777800	5887500	NA	23.2
4999	1776300	5895000	NA	5.1
5002	1776300	5893000	NA	20.7
5005	1776100	5893100	NA	19.0
5418	1775860	5895322	NA	2.7
5438	1775860	5891960	NA	30.2
5450	1775930	5890900	NA	45.5
5451	1775970	5891640	NA	35.6
5455	1775970	5892070	NA	29.8
5458	1775990	5890570	NA	50.9
5488	1776000	5891970	NA	31.3
5548	1776000	5892080	NA	29.9
5559	1776000	5891690	NA	35.2
5581	1781200	5888160	80	7.7

Stage 3: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
5601	1776060	5894300	NA	9.2
5702	1776070	5891910	NA	32.8
20038	1776100	5894840	NA	5.8
20041	1776100	5893431	NA	16.0
20082	1776100	5890198	NA	56.8
20106	1776100	5892364	76	27.0
20114	1776100	5891630	NA	37.3
20116	1781490	5893170	76	2.8
20127	1776108	5893290	NA	17.3
20137	1776120	5889818	NA	55.4
20141	1777225	5892334	NA	31.2
20154	1776160	5892638	NA	24.1
20166	1776200	5890380	NA	59.9
20167	1776200	5891072	NA	48.7
20249	1776210	5891460	NA	41.5
20255	1776650	5892646	NA	25.9
20300	1776300	5892956	NA	21.2
20302	1776300	5890200	NA	65.3
20382	1776300	5891530	NA	41.4
20444	1776320	5894290	NA	9.1
20449	1776340	5889790	NA	63.3
20455	1776369	5893299	NA	17.9
20458	1776400	5889960	NA	69.0
20496	1776525	5895450	NA	2.7
20497	1776070	5894430	NA	8.4
20497	1776076	5894404	NA	8.5
20532	1776400	5892140	NA	31.9
20644	1776400	5892480	NA	27.1
20644	1775870	5892480	NA	24.3
20644	1775876	5892485	NA	24.3
20645	1776400	5892140	NA	31.9
20646	1776400	5891450	NA	44.3
20647	1776410	5891390	NA	45.7

Stage 3: Drawdowns East of Drury Fault				
Bore ID	**Easting**	**Westing**	**Bore Depth (m)**	**Predicted Drawdown (m)**
20648	1776410	5890570	NA	66.1
20649	1776410	5890480	NA	68.0
20650	1776430	5890120	NA	72.3
20652	1776450	5889920	NA	71.0
20653	1776450	5889860	NA	69.8
20655	1776490	5890030	NA	75.2
20656	1776490	5891770	NA	38.8
20895	1776490	5887090	NA	18.6
20923	1776490	5894620	NA	7.7
20930	1776520	5892120	NA	32.9
20932	1776525	5887500	NA	23.1
20943	1776580	5887470	554	22.9
20954	1776580	5892240	NA	31.3
20959	1776580	5891580	NA	43.5
20960	1776580	5891360	NA	48.7
20961	1776582	5891250	NA	51.7
20962	1776600	5890070	NA	83.8
20963	1776600	5891800	NA	39.0
20975	1776600	5891870	NA	37.7
20989	1776600	5894900	NA	6.0
20991	1776630	5894000	NA	12.3
20992	1776660	5891700	NA	41.5
20993	1776681	5893670	NA	15.1
20994	1776750	5895482	NA	2.7
20997	1776800	5893790	NA	14.2
21001	1776900	5891220	NA	56.8
21002	1776900	5891323	NA	53.3
21038	1776905	5892265	NA	32.0
21046	1780660	5886750	NA	5.2
21135	1777000	5891040	NA	65.2
21155	1777200	5885426	NA	6.1
21161	1777200	5888300	NA	36.1
21169	1777200	5894300	NA	10.3

Stage 3: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
21217	1777200	5891180	NA	59.8
21218	1780600	5887900	108	10.4
21280	1777200	5892200	NA	33.4
21300	1780246	5890891	105	18.7
21328	1777200	5886006	NA	10.0
21416	1781210	5887840	46	6.6
21475	1779300	5894100	NA	7.9
21476	1779800	5893900	40	7.3
21478	1781205	5886975	116	3.7
21481	1779700	5890800	NA	25.0
21481	1779776	5890601	>82	24.6
21486	1781029	5893423	NA	4.3
21555	1777231	5888300	NA	36.1
21618	1777350	5887508	NA	24.0
21641	1777550	5887440	NA	23.0
21642	1777600	5888534	NA	39.8
21642	1777680	5888534	NA	39.3
21653	1777680	5891298	NA	51.7
21659	1777745	5888350	NA	35.5
21663	1777815	5888720	38.0	42.1
21665	1777982	5888660	NA	39.3
21718	1780220	5887510	93	10.9
21745	1778034	5887555	NA	23.0
21759	1778056	5886750	NA	15.1
21801	1780472	5887434	88	9.2
21807	1778145	5887560	NA	22.7
21867	1778231	5886572	NA	13.2
21867	1778337	5886572	NA	13.0
21898	1775920	5894830	NA	5.6
21898	1775814	5894838	NA	5.4
21899	1778500	5887402	NA	19.5
21977	1778550	5886110	NA	9.1
21980	1778600	5885140	NA	3.2

Stage 3: Drawdowns East of Drury Fault				
Bore ID	**Easting**	**Westing**	**Bore Depth (m)**	**Predicted Drawdown (m)**
21987	1778600	5891300	NA	37.3
21991	1778700	5890060	NA	43.6
21995	1778731	5891306	NA	35.3
22152	1778810	5893622	NA	12.7
22234	1778819	5892190	NA	25.0
22247	1778934	5885024	NA	2.0
22297	1779315	5891648	NA	25.0
22307	1779340	5890300	NA	31.1
22309	1779400	5885134	NA	1.7
22361	1779400	5889290	NA	27.8
22362	1779540	5889245	NA	25.8
22363	1779630	5889430	NA	25.5
22364	1779700	5889530	NA	24.9
22365	1779760	5889378	NA	23.7
22450	1779785	5893074	NA	12.0
22455	1779800	5889300	NA	23.0
22482	1779860	5891265	NA	21.5
22537	1779890	5890440	NA	23.4
22596	1780026	5891929	NA	16.8
22620	1780044	5889717	NA	21.4
22634	1780080	5894540	NA	3.1
22655	1780100	5893054	NA	10.5
22674	1780100	5891320	NA	18.9
22677	1780110	5891626	NA	17.5
22712	1780130	5895197	NA	0.1
22761	1780200	5891550	NA	17.1
22769	1780200	5891222	NA	18.3
22784	1780210	5891677	NA	16.5
22812	1780210	5891108	NA	18.5
22837	1780220	5890810	NA	19.2
22879	1778819	5885380	98.0	4.1
22900	1780246	5888339	NA	14.7
22992	1780355	5888355	NA	14.0

Stage 3: Drawdowns East of Drury Fault				
Bore ID	**Easting**	**Westing**	**Bore Depth (m)**	**Predicted Drawdown (m)**
23041	1780400	5887470	NA	9.7
23058	1780472	5886510	NA	5.0
23072	1780500	5890220	NA	17.1
23081	1780525	5890940	NA	16.0
23103	1779315	5886145	NA	7.3
23117	1776065	5891935	NA	32.4
23172	1780550	5892110	NA	12.1
23185	1780600	5893520	NA	5.8
23207	1780660	5888485	NA	12.3
23220	1780700	5891830	NA	12.1
23233	1780080	5886960	NA	8.8
23261	1781002	5890495	NA	12.5
23290	1779340	5894260	NA	6.9
23292	1779400	5894330	NA	6.3
23441	1781108	5893835	NA	2.4
23444	1781200	5893835	NA	2.1
23479	1781200	5889406	NA	10.6
23481	1781200	5889406	NA	10.6
23487	1781205	5889406	NA	10.5
23553	1781400	5889554	NA	9.3
23577	1777680	5892100	NA	34.0
23580	1781440	5890030	NA	9.3
23581	1781460	5888117	NA	6.1
23585	1777680	5892100	NA	34.0
23693	1780026	5892753	NA	12.5
23694	1776163	5892944	NA	20.8
23721	1781500	5887085	NA	2.8
27781	1781587	5887560	NA	3.8
27891	1780914	5893938	NA	2.8
27900	1781762	5893277	NA	1.5
27935	1781846	5893291	NA	1.1
27940	1781854	5891500	NA	5.4
28071	1779630	5887050	121	11.5

Stage 3: Drawdowns East of Drury Fault				
Bore ID	**Easting**	**Westing**	**Bore Depth (m)**	**Predicted Drawdown (m)**
28636	1777293	5885680	NA	7.7
687 & 5645	1776320	5894290	NA	9.0
WAT60276615	1777329	5887305	NA	21.7
WAT60415780	1777107	5886740	NA	16.0
WAT80324535	1776537	5886164	NA	10.8
LUC60355003	1776756	5890526	120	87.2
LUC60363042	1779689	5889229	NA	24.0
LUC60368789	1776879	5891941	NA	37.7
LUC60373196	1778586	5891345	200	37.0
LUC80306186	1780007	5887183	NA	10.4
LUC80306245	1776125	5893178	NA	18.4
LUC80307760	1776018	5892680	NA	22.9
LUC80308081	1781849	5892791	4.9	2.5
LUC80308788	1776645	5892617	NA	26.2
LUC80309065	1780514	5887878	NA	10.9
LUC80309165	1776635	5895744	NA	1.2
LUC80309195	1775912	5894596	NA	7.0
LUC80309431	1777069	5892318	NA	31.4
LUC80309496	1781523	5893175	NA	2.9
LUC80309532	1776394	5894436	NA	8.8
LUC80309535	1780159	5887399	NA	10.7
LUC80309915	1776394	5894436	NA	8.8
LUC80310052	1781240	5887944	NA	6.8
LUC80311209	1777212	5893867	NA	13.7
LUC80311915	1776066	5891840	NA	33.7
LUC80311973	1779345	5886091	NA	6.9
LUC80312359	1780522	5887428	NA	8.9
LUC80312446	1780021	5887016	NA	9.4

Stage 4: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
80	5895199	1781846	>90	5.0
152	5886975	1776494	NA	36.7
163	5896508	1780044	114	3.7
164	5894725	1779785	123	16.3
194	5891800	1775900	NA	54.0
204	1777000	5887700	NA	51.6
302	5885450	1777550	NA	20.6
372	5886380	1776580	NA	29.3
507	5892647	1781762	>89	18.3
619	5893872	1782339	64	8.8
647	5884135	1777740	NA	9.5
685	5894290	1776320	NA	22.8
686	5894290	1776320	NA	23.8
700	5890720	1779540	117	61.6
791	5883668	1778056	NA	6.2
824	1778000	5888500	NA	74.1
854A	5893360	1780550	NA	23.1
854B	5893364	1780518	NA	23.3
894	5883640	1779890	132	3.6
1107	5893260	1784290	111	0.4
1179	5885420	1778700	100	19.0
4250	5895300	1775700	NA	13.1
4251	5895800	1775700	NA	9.5
4253	5895900	1775700	NA	8.8
4265	5895500	1775800	NA	11.8
4278	5890880	1775970	NA	70.6
4279	5895800	1776000	NA	10.1
4286	5893100	1776100	NA	36.5
4287	5895800	1776100	NA	10.3
4303	5895000	1776300	NA	17.0
4304	5896000	1776300	NA	9.2
4313	5892690	1776520	NA	43.8

Stage 4: Drawdowns East of Drury Fault				
Bore ID	**Easting**	**Westing**	**Bore Depth (m)**	**Predicted Drawdown (m)**
4317	5886490	1776490	NA	30.3
4320	5893300	1776600	NA	35.5
4322	5886900	1776600	43	36.1
4323	5887280	1776630	NA	42.0
4327	5886760	1776750	NA	34.7
4334	5894600	1776900	NA	21.8
4340	5888300	1777200	NA	68.0
4347	5883400	1777300	NA	4.6
4350	5887250	1777350	NA	43.9
4351	5887100	1777500	58	41.5
4352	5884022	1777745	NA	8.7
4354	5886770	1776580	NA	34.2
4356	5883584	1777982	NA	5.7
4359	5883100	1778000	55	2.7
4360	5883798	1778034	NA	7.1
4361	5883192	1778810	NA	2.6
4363	5887300	1778400	NA	42.8
4364	5887400	1778500	100	44.0
4366	5884900	1778600	50	14.7
4367	5884900	1778600	41	14.7
4369	5883192	1778810	NA	2.6
4370	5896063	1778852	NA	8.7
4371	5883202	1778934	NA	2.6
4375	5890900	1779400	102	63.5
4441	5883800	1780100	54	4.0
4442	5883800	1780100	75	4.0
4443	5883910	1780130	NA	4.6
4444	5884000	1780200	NA	4.9
4445	5884300	1780200	NA	6.7
4446	5887800	1780400	55	31.9
4447	5893370	1780540	NA	23.1
4447	5893369	1780522	NA	23.2

Stage 4: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
4448	5883800	1780500	92	3.0
4451	5886975	1781205	116	19.2
4452	5893200	1781200	NA	19.7
4453	5893300	1781200	NA	18.9
4459	5894200	1781400	NA	12.3
4461	5893000	1781500	61	18.8
4463	5892773	1781854	NA	16.5
4463	5892773	1781854	NA	17.0
4466	5891020	1782540	NA	16.9
4467	5892500	1782800	60	11.2
4520	5895310	1775690	NA	13.0
4523	5887210	1779860	NA	31.3
4691	5894950	1775700	NA	15.8
4722	5892792	1776100	NA	40.8
4933	5894810	1775720	NA	17.0
4978	1777800	5887500	NA	48.6
4999	5895000	1776300	NA	17.0
5002	5893000	1776300	NA	39.2
5005	5893100	1776100	NA	36.5
5006	5896087	1776369	NA	8.7
5006	5896111	1776408	NA	8.6
5418	5895322	1775860	NA	13.3
5438	5891960	1775860	NA	50.8
5450	5890900	1775930	NA	69.1
5451	5891640	1775970	NA	57.9
5455	5892070	1775970	NA	50.6
5458	5890570	1775990	NA	75.2
5488	5891970	1776000	NA	52.7
5548	5892080	1776000	NA	50.8
5559	5891690	1776000	NA	57.5
5581	5888160	1781200	80	26.2
5601	5894300	1776060	NA	22.7

Stage 4: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
5702	5891910	1776070	NA	54.7
20038	5894840	1776100	NA	17.8
20041	5893431	1776100	NA	32.3
20082	5890198	1776100	NA	82.2
20106	5892364	1776100	NA	47.3
20114	5891630	1776100	NA	60.4
20116	5893170	1781490	76	17.2
20127	5893290	1776108	120	34.1
20137	5889818	1776120	NA	81.9
20141	5892334	1777225	NA	56.9
20154	5892638	1776160	NA	43.6
20166	5890380	1776200	NA	85.7
20167	5891072	1776200	NA	74.1
20249	5891460	1776210	NA	66.1
20255	5892646	1776650	NA	47.2
20300	5892956	1776300	NA	39.8
20302	5890200	1776300	NA	91.9
20382	5891530	1776300	NA	66.4
20444	5894290	1776320	NA	22.8
20449	5889790	1776340	NA	92.0
20455	5893299	1776369	NA	35.4
20458	5889960	1776400	NA	97.3
20496	5895450	1776525	NA	13.7
20497	5894430	1776070	NA	21.5
20497	5894404	1776076	NA	21.7
20532	5892140	1776400	NA	54.7
20578	5895192	1782208	NA	3.5
20644	5892480	1776400	NA	48.3
20644	5892480	1775870	NA	43.2
20644	5892485	1775876	NA	43.2
20645	5892140	1776400	NA	54.7
20646	5891450	1776400	NA	70.4

Stage 4: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
20647	5891390	1776410	NA	72.2
20648	5890570	1776410	NA	93.4
20649	5890480	1776410	NA	95.1
20650	5890120	1776430	NA	99.8
20652	5889920	1776450	NA	100.0
20653	5889860	1776450	NA	99.3
20655	5890030	1776490	NA	103.6
20656	5891770	1776490	NA	64.1
20895	5887090	1776490	NA	38.3
20923	5894620	1776490	NA	20.8
20930	5892120	1776520	NA	56.5
20932	5887500	1776525	NA	45.0
20943	5887470	1776580	554	44.8
20954	5892240	1776580	NA	54.6
20959	5891580	1776580	NA	70.7
20960	5891360	1776580	NA	77.1
20961	5891250	1776582	NA	80.6
20962	5890070	1776600	NA	112.2
20963	5891800	1776600	NA	65.1
20975	5891870	1776600	NA	63.3
20989	5894900	1776600	NA	18.4
20991	5894000	1776630	NA	27.7
20992	5891700	1776660	NA	68.7
20993	5893670	1776681	NA	31.8
20994	5895482	1776750	NA	13.7
20997	5893790	1776800	NA	30.6
21001	5891220	1776900	NA	90.7
21002	5891323	1776900	NA	86.2
21038	5892265	1776905	NA	56.8
21045	5884030	1777000	NA	8.6
21046	5886750	1780660	NA	21.5
21047	5884050	1779760	NA	6.3

Stage 4: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
21135	5891040	1777000	NA	103.1
21155	5885426	1777200	NA	20.2
21161	5888300	1777200	NA	68.0
21169	5894300	1777200	NA	25.3
21217	5891180	1777200	NA	100.2
21218	5887900	1780600	108	30.6
21220	5883740	1778145	NA	6.6
21280	5892200	1777200	NA	60.2
21300	5890891	1780246	105	45.4
21328	5886006	1777200	NA	26.2
21416	5887840	1781210	46	24.3
21475	5894100	1779300	NA	23.7
21476	5893900	1779800	40	23.2
21478	5886975	1781205	116	19.2
21479	5890400	1783500	40	9.8
21481	5890800	1779700	>82	57.0
21481	5890601	1779776	NA	56.5
21484	5893400	1784000	70	1.5
21486	5893423	1781029	NA	19.3
21555	5888300	1777231	NA	68.2
21607	5896860	1780110	NA	1.6
21618	5887508	1777350	NA	48.8
21641	5887440	1777550	NA	47.6
21642	5888534	1777600	NA	77.6
21642	5888534	1777680	NA	77.4
21653	5891298	1777680	NA	96.3
21659	5888350	1777745	NA	70.5
21663	5888720	1777815	38	84.6
21665	5888660	1777982	NA	80.4
21712	5883920	1778000	NA	7.9
21718	5887510	1780220	93	31.1
21728	5884588	1780210	83	8.5

Stage 4: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
21745	5887555	1778034	NA	49.1
21759	5886750	1778056	NA	35.5
21801	5887434	1780472	88	28.2
21807	5887560	1778145	NA	48.7
21867	5886572	1778231	NA	32.6
21873	5894800	1781784	NA	7.2
21873	5894798	1781813	NA	7.1
21883	5883416	1778400	NA	4.4
21898	5894830	1775920	NA	17.4
21898	5894838	1775814	NA	17.0
21899	5887402	1778500	NA	44.0
21914	5890490	1783360	91	10.8
21977	5886110	1778550	NA	26.2
21980	5885140	1778600	NA	16.7
21987	5891300	1778600	NA	77.7
21991	5890060	1778700	NA	99.8
21995	5891306	1778731	NA	74.2
22152	5893622	1778810	NA	31.0
22230	5883408	1778810	NA	3.9
22234	5892190	1778819	NA	52.7
22247	5885024	1778934	NA	15.1
22276	5884520	1779300	NA	10.4
22297	5891648	1779315	NA	55.0
22307	5890300	1779340	NA	70.1
22309	5885134	1779400	NA	14.8
22361	5889290	1779400	NA	63.1
22362	5889245	1779540	NA	59.2
22363	5889430	1779630	NA	58.7
22364	5889530	1779700	NA	57.8
22365	5889378	1779760	NA	55.3
22450	5893074	1779785	NA	31.3
22455	5889300	1779800	NA	53.8

Stage 4: Drawdowns East of Drury Fault				
Bore ID	**Easting**	**Westing**	**Bore Depth (m)**	**Predicted Drawdown (m)**
22482	5891265	1779860	NA	49.7
22537	5890440	1779890	NA	54.5
22596	5891929	1780026	NA	40.7
22620	5889717	1780044	NA	50.9
22634	5894540	1780080	NA	16.6
22655	5893054	1780100	NA	29.0
22674	5891320	1780100	NA	45.1
22677	5891626	1780110	NA	42.3
22712	5895197	1780130	NA	11.6
22761	5891550	1780200	NA	41.6
22769	5891222	1780200	NA	44.1
22784	5891677	1780210	NA	40.5
22811	5884315	1780355	157	6.4
22812	5891108	1780210	NA	44.7
22837	5890810	1780220	NA	46.2
22879	5885380	1778819	98	18.3
22900	5888339	1780246	NA	38.2
22992	5888355	1780355	NA	37.0
23041	5887470	1780400	NA	29.1
23058	5886510	1780472	NA	20.9
23072	5890220	1780500	NA	42.8
23081	5890940	1780525	NA	40.5
23103	5886145	1779315	NA	23.9
23117	5891935	1776065	NA	54.2
23132	5895232	1780540	NA	9.9
23172	5892110	1780550	NA	32.8
23185	5893520	1780600	NA	21.5
23207	5888485	1780660	NA	34.1
23220	5891830	1780700	NA	33.0
23229	5894785	1780900	NA	11.3
23233	5886960	1780080	NA	27.3
23258	5885160	1780914	NA	9.5

Stage 4: Drawdowns East of Drury Fault

Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
23261	5890495	1781002	NA	34.6
23290	5894260	1779340	NA	22.1
23292	5894330	1779400	NA	21.2
23329	5895545	1781107	NA	6.0
23441	5893835	1781108	NA	16.2
23444	5893835	1781200	NA	15.6
23479	5889406	1781200	NA	31.3
23481	5889406	1781200	NA	31.3
23487	5889406	1781205	NA	31.2
23488	5883470	1780525	69	1.2
23538	5895067	1781210	NA	8.3
23547	5895211	1781400	NA	6.7
23553	5889554	1781400	NA	29.1
23573	5896149	1781108	NA	2.8
23577	5892100	1777680	NA	63.7
23580	5890030	1781440	NA	29.1
23581	5888117	1781460	NA	23.5
23585	5892100	1777680	NA	63.7
23627	5885540	1781490	NA	9.2
23693	5892753	1780026	NA	32.5
23694	5892944	1776163	NA	39.1
23721	5887085	1781500	NA	17.7
27781	5887560	1781587	NA	19.6
27840	5883217	1778231	NA	3.3
27891	5893938	1780914	NA	16.6
27892	5895543	1781107	NA	6.1
27892	5895542	1781113	NA	6.0
27893	5897208	1776203	NA	1.5
27894	5897237	1776364	NA	1.5
27895	5896257	1776615	NA	7.8
27896	5897297	1776497	NA	1.3
27898	5895045	1781743	NA	6.2

Stage 4: Drawdowns East of Drury Fault				
Bore ID	**Easting**	**Westing**	**Bore Depth (m)**	**Predicted Drawdown (m)**
27900	5893277	1781762	NA	15.2
27902	5894481	1782110	NA	7.3
27935	5893291	1781846	NA	14.5
27940	5891500	1781854	NA	22.1
27966	5893734	1781860	NA	12.2
28058	5883643	1778550	201	5.7
28071	5887050	1779630	121	31.4
28096	5893115	1782540	NA	10.8
28253	5883044	1778337	NA	2.2
28271	5889635	1783750	NA	7.9
28276	5887932	1783970	NA	4.2
28636	5885680	1777293	NA	22.8
687 & 5645	5894290	1776320	NA	22.5
WAT60276615	1777329	5887305	NA	44.9
WAT60415780	1777107	5886740	NA	35.4
WAT80324535	1776537	5886164	NA	26.7
LUC60355003	5890526	1776756	NA	117.2
LUC60359241	5890847	1783074	NA	12.7
LUC60363042	5889229	1779689	120	55.6
LUC60368789	5891941	1776879	NA	64.8
LUC60372192	5890720	1783268	100	11.3
LUC60373196	5891345	1778586	200	76.7
LUC80306186	5887183	1780007	NA	29.9
LUC80306245	5893178	1776125	NA	35.6
LUC80306566	5896150	1780538	80	4.5
LUC80307760	5892680	1776018	NA	41.7
LUC80308081	5892791	1781849	60	16.9
LUC80308438	5896998	1776583	NA	3.1
LUC80308532	5895149	1782211	NA	3.7
LUC80308788	5892617	1776645	NA	47.7
LUC80308814	5884757	1780127	NA	9.8
LUC80309065	5887878	1780514	NA	31.4

Stage 4: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
LUC80309165	5895744	1776635	NA	11.5
LUC80309195	5894596	1775912	NA	19.4
LUC80309431	5892318	1777069	NA	56.6
LUC80309496	5893175	1781523	NA	17.4
LUC80309532	5894436	1776394	NA	22.4
LUC80309535	5887399	1780159	NA	30.7
LUC80309915	5894436	1776394	NA	22.4
LUC80310052	5887944	1781240	NA	24.6
LUC80310130	5896779	1780088	NA	2.1
LUC80310621	5884270	1780504	120	5.7
LUC80311209	5893867	1777212	NA	30.4
LUC80311270	5890526	1783418	NA	10.3
LUC80311481	5889932	1783833	NA	7.5
LUC80311664	5887375	1783392	NA	6.4
LUC80311915	5891840	1776066	NA	55.9
LUC80311973	5886091	1779345	NA	23.2
LUC80312359	5887428	1780522	NA	27.7
LUC80312446	5887016	1780021	NA	28.2
LUC80313971	5883457	1780555	NA	1.1

Stage 5: Drawdowns East of Drury Fault

Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
80	5895199	1781846	>90	5.4
152	5886975	1776494	NA	37.6
163	5896508	1780044	114	4.0
164	5894725	1779785	123	16.9
194	5891800	1775900	NA	55.3
204	1777000	5887700	NA	52.9
302	5885450	1777550	NA	21.2
372	5886380	1776580	NA	30.1
507	5892647	1781762	>89	18.9
619	5893872	1782339	64	9.3
647	5884135	1777740	NA	10.0
685	5894290	1776320	NA	23.5
686	5894290	1776320	NA	24.5
700	5890720	1779540	117	63.1
791	5883668	1778056	NA	6.6
824	1778000	5888500	NA	75.9
854A	5893360	1780550	NA	23.8
854B	5893364	1780518	NA	24.0
894	5883640	1779890	132	3.9
1107	5893260	1784290	111	0.7
1179	5885420	1778700	100	19.6
4250	5895300	1775700	NA	13.6
4251	5895800	1775700	NA	9.9
4253	5895900	1775700	NA	9.2
4265	5895500	1775800	NA	12.3
4278	5890880	1775970	NA	72.3
4279	5895800	1776000	NA	10.6
4286	5893100	1776100	NA	37.4
4287	5895800	1776100	NA	10.8
4303	5895000	1776300	NA	17.5
4304	5896000	1776300	NA	9.7
4313	5892690	1776520	NA	44.8

Stage 5: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
4317	5886490	1776490	NA	31.2
4320	5893300	1776600	NA	36.5
4322	5886900	1776600	43	37.0
4323	5887280	1776630	NA	43.0
4327	5886760	1776750	NA	35.6
4334	5894600	1776900	NA	22.5
4340	5888300	1777200	NA	69.6
4347	5883400	1777300	NA	4.9
4350	5887250	1777350	NA	45.0
4351	5887100	1777500	58	42.5
4352	5884022	1777745	NA	9.2
4354	5886770	1776580	NA	35.1
4356	5883584	1777982	NA	6.1
4359	5883100	1778000	55	3.0
4360	5883798	1778034	NA	7.5
4361	5883192	1778810	NA	3.0
4363	5887300	1778400	NA	43.9
4364	5887400	1778500	100	45.0
4366	5884900	1778600	50	15.2
4367	5884900	1778600	41	15.2
4369	5883192	1778810	NA	3.0
4370	5896063	1778852	NA	9.2
4371	5883202	1778934	NA	2.9
4375	5890900	1779400	102	65.1
4441	5883800	1780100	54	4.4
4442	5883800	1780100	75	4.4
4443	5883910	1780130	NA	5.0
4444	5884000	1780200	NA	5.3
4445	5884300	1780200	NA	7.1
4446	5887800	1780400	55	32.7
4447	5893370	1780540	NA	23.8
4447	5893369	1780522	NA	23.9

Stage 5: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
4448	5883800	1780500	92	3.4
4449	5883300	1780700	NA	0.3
4451	5886975	1781205	116	19.8
4452	5893200	1781200	NA	20.3
4453	5893300	1781200	NA	19.5
4459	5894200	1781400	NA	12.8
4461	5893000	1781500	61	19.4
4463	5892773	1781854	NA	17.1
4463	5892773	1781854	NA	17.6
4466	5891020	1782540	NA	17.5
4467	5892500	1782800	60	11.7
4520	5895310	1775690	NA	13.5
4523	5887210	1779860	NA	32.2
4691	5894950	1775700	NA	16.3
4722	5892792	1776100	NA	41.8
4933	5894810	1775720	NA	17.6
4978	1777800	5887500	NA	49.8
4999	5895000	1776300	NA	17.5
5002	5893000	1776300	NA	40.2
5005	5893100	1776100	NA	37.4
5006	5896087	1776369	NA	9.2
5006	5896111	1776408	NA	9.0
5418	5895322	1775860	NA	13.8
5438	5891960	1775860	NA	52.1
5450	5890900	1775930	NA	70.7
5451	5891640	1775970	NA	59.2
5455	5892070	1775970	NA	51.8
5458	5890570	1775990	NA	77.0
5488	5891970	1776000	NA	53.9
5548	5892080	1776000	NA	52.1
5559	5891690	1776000	NA	58.9
5581	5888160	1781200	80	26.9

Stage 5: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
5601	5894300	1776060	NA	23.4
5702	5891910	1776070	NA	56.1
20038	5894840	1776100	NA	18.4
20041	5893431	1776100	NA	33.2
20082	5890198	1776100	NA	84.2
20106	5892364	1776100	NA	48.5
20114	5891630	1776100	NA	61.9
20116	5893170	1781490	76	17.8
20127	5893290	1776108	120	35.0
20137	5889818	1776120	NA	83.9
20141	5892334	1777225	NA	58.3
20154	5892638	1776160	NA	44.6
20166	5890380	1776200	NA	87.8
20167	5891072	1776200	NA	75.9
20249	5891460	1776210	NA	67.6
20255	5892646	1776650	NA	48.4
20300	5892956	1776300	NA	40.8
20302	5890200	1776300	NA	94.2
20382	5891530	1776300	NA	68.0
20444	5894290	1776320	NA	23.5
20449	5889790	1776340	NA	94.3
20455	5893299	1776369	NA	36.3
20458	5889960	1776400	NA	99.8
20496	5895450	1776525	NA	14.2
20497	5894430	1776070	NA	22.1
20497	5894404	1776076	NA	22.4
20532	5892140	1776400	NA	56.0
20578	5895192	1782208	NA	3.9
20644	5892480	1776400	NA	49.5
20644	5892480	1775870	NA	44.3
20644	5892485	1775876	NA	44.2
20645	5892140	1776400	NA	56.0

Stage 5: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
20646	5891450	1776400	NA	72.1
20647	5891390	1776410	NA	74.0
20648	5890570	1776410	NA	95.7
20649	5890480	1776410	NA	97.5
20650	5890120	1776430	NA	102.4
20652	5889920	1776450	NA	102.6
20653	5889860	1776450	NA	101.8
20655	5890030	1776490	NA	106.3
20656	5891770	1776490	NA	65.7
20895	5887090	1776490	NA	39.3
20923	5894620	1776490	NA	21.5
20930	5892120	1776520	NA	57.9
20932	5887500	1776525	NA	46.1
20943	5887470	1776580	554	45.9
20954	5892240	1776580	NA	55.9
20959	5891580	1776580	NA	72.4
20960	5891360	1776580	NA	79.0
20961	5891250	1776582	NA	82.6
20962	5890070	1776600	NA	115.2
20963	5891800	1776600	NA	66.6
20975	5891870	1776600	NA	64.8
20989	5894900	1776600	NA	19.1
20991	5894000	1776630	NA	28.4
20992	5891700	1776660	NA	70.3
20993	5893670	1776681	NA	32.6
20994	5895482	1776750	NA	14.2
20997	5893790	1776800	NA	31.4
21001	5891220	1776900	NA	92.9
21002	5891323	1776900	NA	88.3
21038	5892265	1776905	NA	58.2
21045	5884030	1777000	NA	9.0
21046	5886750	1780660	NA	22.1

Stage 5: Drawdowns East of Drury Fault

Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
21047	5884050	1779760	NA	6.7
21135	5891040	1777000	NA	105.7
21155	5885426	1777200	NA	20.8
21161	5888300	1777200	NA	69.6
21169	5894300	1777200	NA	26.0
21217	5891180	1777200	NA	102.8
21218	5887900	1780600	108	31.5
21220	5883740	1778145	NA	7.0
21280	5892200	1777200	NA	61.6
21300	5890891	1780246	105	46.5
21328	5886006	1777200	NA	27.0
21416	5887840	1781210	46	25.0
21475	5894100	1779300	NA	24.4
21476	5893900	1779800	40	23.9
21478	5886975	1781205	116	19.8
21479	5890400	1783500	40	10.3
21481	5890800	1779700	>82	58.4
21481	5890601	1779776	NA	57.9
21484	5893400	1784000	70	1.8
21486	5893423	1781029	NA	19.9
21555	5888300	1777231	NA	69.8
21607	5896860	1780110	NA	1.9
21618	5887508	1777350	NA	50.0
21641	5887440	1777550	NA	48.8
21642	5888534	1777600	NA	79.5
21642	5888534	1777680	NA	79.3
21653	5891298	1777680	NA	98.8
21659	5888350	1777745	NA	72.2
21663	5888720	1777815	38	86.7
21665	5888660	1777982	NA	82.3
21712	5883920	1778000	NA	8.3
21718	5887510	1780220	93	32.0

Stage 5: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
21728	5884588	1780210	83	8.9
21745	5887555	1778034	NA	50.3
21759	5886750	1778056	NA	36.4
21801	5887434	1780472	88	29.0
21807	5887560	1778145	NA	49.9
21867	5886572	1778231	NA	33.5
21873	5894800	1781784	NA	7.7
21873	5894798	1781813	NA	7.5
21883	5883416	1778400	NA	4.7
21898	5894830	1775920	NA	18.0
21898	5894838	1775814	NA	17.6
21899	5887402	1778500	NA	45.1
21914	5890490	1783360	91	11.3
21977	5886110	1778550	NA	27.0
21980	5885140	1778600	NA	17.3
21987	5891300	1778600	NA	79.6
21991	5890060	1778700	NA	102.3
21995	5891306	1778731	NA	75.9
22152	5893622	1778810	NA	31.9
22230	5883408	1778810	NA	4.3
22234	5892190	1778819	NA	54.0
22247	5885024	1778934	NA	15.6
22276	5884520	1779300	NA	10.9
22297	5891648	1779315	NA	56.3
22307	5890300	1779340	NA	71.8
22309	5885134	1779400	NA	15.3
22361	5889290	1779400	NA	64.7
22362	5889245	1779540	NA	60.6
22363	5889430	1779630	NA	60.1
22364	5889530	1779700	NA	59.1
22365	5889378	1779760	NA	56.6
22450	5893074	1779785	NA	32.2

Stage 5: Drawdowns East of Drury Fault

Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
22455	5889300	1779800	NA	55.1
22482	5891265	1779860	NA	50.9
22537	5890440	1779890	NA	55.8
22596	5891929	1780026	NA	41.7
22620	5889717	1780044	NA	52.2
22634	5894540	1780080	NA	17.2
22655	5893054	1780100	NA	29.8
22674	5891320	1780100	NA	46.2
22677	5891626	1780110	NA	43.4
22712	5895197	1780130	NA	12.1
22761	5891550	1780200	NA	42.7
22769	5891222	1780200	NA	45.2
22784	5891677	1780210	NA	41.5
22811	5884315	1780355	157	6.8
22812	5891108	1780210	NA	45.8
22837	5890810	1780220	NA	47.4
22879	5885380	1778819	98	19.0
22900	5888339	1780246	NA	39.2
22992	5888355	1780355	NA	37.9
23041	5887470	1780400	NA	29.9
23058	5886510	1780472	NA	21.5
23072	5890220	1780500	NA	43.8
23081	5890940	1780525	NA	41.5
23103	5886145	1779315	NA	24.6
23117	5891935	1776065	NA	55.5
23132	5895232	1780540	NA	10.4
23172	5892110	1780550	NA	33.6
23185	5893520	1780600	NA	22.2
23207	5888485	1780660	NA	35.0
23220	5891830	1780700	NA	33.9
23229	5894785	1780900	NA	11.8
23233	5886960	1780080	NA	28.0

Stage 5: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
23258	5885160	1780914	NA	10.0
23261	5890495	1781002	NA	35.5
23290	5894260	1779340	NA	22.7
23292	5894330	1779400	NA	21.8
23329	5895545	1781107	NA	6.4
23441	5893835	1781108	NA	16.7
23444	5893835	1781200	NA	16.2
23479	5889406	1781200	NA	32.2
23481	5889406	1781200	NA	32.2
23487	5889406	1781205	NA	32.1
23488	5883470	1780525	69	1.5
23538	5895067	1781210	NA	8.7
23547	5895211	1781400	NA	7.2
23553	5889554	1781400	NA	29.9
23573	5896149	1781108	NA	3.2
23577	5892100	1777680	NA	65.2
23580	5890030	1781440	NA	29.9
23581	5888117	1781460	NA	24.2
23585	5892100	1777680	NA	65.2
23627	5885540	1781490	NA	9.6
23693	5892753	1780026	NA	33.4
23694	5892944	1776163	NA	40.1
23721	5887085	1781500	NA	18.3
27781	5887560	1781587	NA	20.2
27840	5883217	1778231	NA	3.6
27891	5893938	1780914	NA	17.2
27892	5895543	1781107	NA	6.5
27892	5895542	1781113	NA	6.4
27893	5897208	1776203	NA	1.8
27894	5897237	1776364	NA	1.8
27895	5896257	1776615	NA	8.3
27896	5897297	1776497	NA	1.6

Stage 5: Drawdowns East of Drury Fault				
Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
27898	5895045	1781743	NA	6.6
27900	5893277	1781762	NA	15.7
27902	5894481	1782110	NA	7.7
27935	5893291	1781846	NA	15.1
27940	5891500	1781854	NA	22.8
27966	5893734	1781860	NA	12.7
28058	5883643	1778550	201	6.1
28071	5887050	1779630	121	32.3
28096	5893115	1782540	NA	11.2
28253	5883044	1778337	NA	2.5
28271	5889635	1783750	NA	8.4
28276	5887932	1783970	NA	4.6
28636	5885680	1777293	NA	23.5
687 & 5645	5894290	1776320	NA	23.1
WAT60276615	1777329	5887305	NA	46.0
WAT60415780	1777107	5886740	NA	36.3
WAT80324535	1776537	5886164	NA	27.5
LUC60355003	5890526	1776756	NA	120.5
LUC60359241	5890847	1783074	NA	13.2
LUC60363042	5889229	1779689	120	57.0
LUC60368789	5891941	1776879	NA	66.4
LUC60372192	5890720	1783268	100	11.8
LUC60373196	5891345	1778586	200	78.6
LUC80306186	5887183	1780007	NA	30.7
LUC80306245	5893178	1776125	NA	36.6
LUC80306566	5896150	1780538	80	4.8
LUC80307760	5892680	1776018	NA	42.8
LUC80308081	5892791	1781849	60	17.5
LUC80308438	5896998	1776583	NA	3.4
LUC80308532	5895149	1782211	NA	4.1
LUC80308788	5892617	1776645	NA	48.9
LUC80308814	5884757	1780127	NA	10.3

Stage 5: Drawdowns East of Drury Fault

Bore ID	Easting	Westing	Bore Depth (m)	Predicted Drawdown (m)
LUC80309065	5887878	1780514	NA	32.2
LUC80309165	5895744	1776635	NA	12.0
LUC80309195	5894596	1775912	NA	20.1
LUC80309431	5892318	1777069	NA	57.9
LUC80309496	5893175	1781523	NA	17.9
LUC80309532	5894436	1776394	NA	23.1
LUC80309535	5887399	1780159	NA	31.5
LUC80309915	5894436	1776394	NA	23.1
LUC80310052	5887944	1781240	NA	25.3
LUC80310130	5896779	1780088	NA	2.4
LUC80310621	5884270	1780504	120	6.1
LUC80311209	5893867	1777212	NA	31.2
LUC80311270	5890526	1783418	NA	10.8
LUC80311481	5889932	1783833	NA	7.9
LUC80311664	5887375	1783392	NA	6.8
LUC80311915	5891840	1776066	NA	57.3
LUC80311973	5886091	1779345	NA	23.9
LUC80312359	5887428	1780522	NA	28.5
LUC80312446	5887016	1780021	NA	29.0
LUC80313971	5883457	1780555	NA	1.4

Appendix I: Field Survey of Bores with Hunua Greywacke Block (GFIG 2010)

Table I-1: Hunua Well Survey (14/12/2010) - Bores considered to be within regional groundwater in greywacke

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
80	[redacted]	96-102 Garvie Road, R D 3 Papakura 2583	17/08/2010	4.0	1781846	5895199	165	55.8	109	<90	Waipapa (Possibly)?	No Log	Stock (chickens) & domestic (2 houses)	Bore depth, pump setting & water level recorded by Parker Roy F & Son Ltd. Service address is 111 Garvie Road, R D 3 Papakura 2583. Some iron.
163	[redacted]	2 Jones Road, R D 2 Papakura 2582	12/12/2008 (PDP)	2.9	1780044	5896508	162	20.0	142	114	Waipapa	Bore Geology: 0-42m clay and silts (Weathered Waipapa) & 42-EOH Waipapa.	Irrigation, domestic & summer backup	Airlifted 4 cubic meters per hour. The water level data from AC.
164	[redacted]	1500 Hunua Road, R D 3 Papakura 2583	20/07/2010	1.9	1779785	5894725	221	37.0	184	123	Waipapa	0-60m Clays (Waitemata >36m to Weathered Waipapa?) & 60m-EOH Waipapa.	Currently not in use	Off-site owners (family trust). Shown bore by J. Glasgow. Pumped $1.5m^3$/hour at 73m. SWL 37m after drilling (22/3/1988). Good water quality (produced sand?).
258	[redacted]	2151 Hunua Road, R D 3 Papakura 2583		5.4	1783240	5895310	106.5	Above GL		123	Waipapa	0-78m Clays & silts (Tauranga to Weathered Waitemata?) & 78m-EOH Waipapa (variably weathered).	Domestic & stock	Artesian (17 gph, 29/8/1988). Airlifted 455-400 gph at 65m for 2.75 hours (660 to 250 kPa). Possibly located on 2151B Hunua Road.
335	[redacted]	2198 Hunua Road, R D 3 Papakura 2583		5.9	1783740	5894750	103			60.9	Waipapa	0-13.4m Tauranga (pumice silts & timber >10.5m), 13.4-28m Clays & silts (Tauranga/Weathered Waitemata) & 28m-EOH Waipapa (variably weathered, fragmented with silt matrix >39.5m).	Domestic & stock (chickens)	Airlifted 7,000-6,300 gph at 39m for >0.5 hours.
358 (& 4477)	[redacted]	2364 Hunua Road, R D 3 Papakura 2583		6.9	1784700	5893700	124	11.5	112.5	134.5	Waipapa (Probably)?	0-28m Clays (Tauranga to Weathered Waitemata?), 28-51m Silts (sandy >37.5m) (Waitemata?) & 51m-EOH Waipapa (weathered <114.5m).		Airlifted 900-440 gph at 71.5-78m for 4.25 hours (500 to 230 kPa). SWL 11.5m day after drilling (morning 27/4/1989). SWL 24.9m after development (afternoon 27/4/1989). Bore 4477 is duplicate.
396	[redacted]	Cnr Whites Road & Falls Roads (Pt Allot 89), R D 3 Papakura 2583.		6.3	1784100	5895510	138	31.9	106.1	165.5	Waipapa	0-12m Tauranga (clay & silt with peat >10m), 12-29m Silts with weathered rock layers >20m (Tauranga to Weathered Below?), 29-54m Soft to hard rock (basalt >44.5m) (Kerikeri Volcanics/Waitemata (conglomerate)?), 54-92.5m Silts (sandy <69m) (Waitemata?), 92.5-114.5m Weathered rock with silt layers (Waipapa?) & 114.5m-EOH Waipapa.	Domestic & stock	Located in Hunua Domain Recreation Reserve. Airlifted 1,350-1,100 gph at 96.5m (>92 to 52 PSI). SWL 31.9m three days after drilling (14/8/1989). Service address is Private Bag 92300, Auckland 1142.
458	[redacted]	743 Papakura Clevedon Road, R D 2 Papakura 2582	19/08/2010	4.4	1776582	5898812	44	17.2	26	68	Waitemata & Waipapa	0-22m Clays (Tauranga to Weathered Waitemata?), 22-51m Waitemata & 51m-EOH Waipapa.	General supply.	$16m^3$ maximum daily abstraction. Airlifted 240 gph at 65m for >4 hrs (90 to 65 PSI). SWL 17.2m day after drilling (13/12/1989). Some iron.
507	[redacted]	76 Batkin Road, R D 4 Papakura 2584	19/08/2010	4.4	1781762	5892647	188	45.8	142	>89	Waipapa	0-11m Silts & clays, 11-14.5m mudstone & sandstone (Waitemata?), 14.5-51m Te Kuiti (some coal 39.2-45.5m) & 51m-EOH Waipapa.	Stock & cowshed	Airlifted 3,900-3,800 gph at 87.5m for >2.25 hours (470 to 415kPa). SWL 45.3m two days after drilling (12/2/1990). Deepened in late 1990?. Some calcium & E-coli.
619 (& 4465)	[redacted]	Heald Road, R D 3 Papakura (between 88-144) (Lot 1 DP117131)	19/08/2010	4.6	1782339	5893872	119	>-0.67		64.33	Waipapa	0-5m Clays with peat 3-3.6m (Tauranga to Weathered Waitemata?), 5-29m Silts (sandy <22.5m, some shell >21m) (Waitemata?), 29-44m Waitemata & 44m-EOH Waipapa.	Stock	Artesian (1,055 gph) after drilling (13/11/1990). Airlifted 6,092 gph at 57.5m for 3hrs. Surface pumped at 1931-2,400 for drawdowns of >3.7-5.8m. Contact address is 76 Batkin Road, R D 4 Papakura 2584. Old bore cemented off (14/11/1990). Original location of duplicate bore 4465 plots on 2002 Hunua Road (No bore confirmed by J Rennie).
674 (& 675)	[redacted]	7 McGregor Road, R D 2 Papakura 2582		6.2	1782800	5898400	165	62.4	102.6	176	Waitemata & Waipapa	0-106m Waitemata (conglomeratic 58-64m & 68-94m, limestone 64-68m) & 106m-EOH Waipapa.	Domestic & stock	Airlifted 1,050-440 gph at 142m for 5 hours (130 to 76 PSI). SWL 62.4m day after drilling (20/2/1991). Old bore sealed with concrete (20/2/1991).
700	[redacted]	1740 Ponga Road, R D 4 Papakura 2584	28/07/2008 (PDP)	4.1	1779540	5890720	287	28.7	258	116.7	Waipapa	0-18.1m Clays (Weathered Waitemata/Te Kuiti?) & 18.1m-EOH Waipapa (weathered <42.3m).	Stock	Fills 5000 L tank 2-3 times per annum. Airlifted 770-790 gph at 16 rod lengths for >3 hrs (101 to 66 PSI). SWL 28.7m day after drilling (26/3/1991). PDP indicates deepened to 300m?

Table I-1: Hunua Well Survey (14/12/2010) - Bores considered to be within regional groundwater in greywacke

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
830	[redacted]	25 Harry Dreaden Road, R D 4 Papakura 2584	13/09/2010 & 28/07/2008 (PDP)	2.2	1776103	5893225	62	12.4	50	96	Waipapa	0-32m Clays to silt with boulders (>9m) (Kerikeri Volcanic?), 32-63m Waitemata & 63m-EOH Waipapa (weathered <65m).	Domestic	Airlifted 1800 gph?. SWL 10m after drilling (30/3/1992) & 10.97m (28/7/2008).
1107	[redacted]	24 Stevens Road, R D 3 Papakura 2583		6.6	1784290	5893260	165	51.8	113.2	111.4	Waipapa	0-29m Clays (Weathered Waipapa?) & 29m-EOH Waipapa (variably weathered <55m).	Domestic & stock	Airlifted 2,000-1,700 gph at 110.5m (105 to 60 PSI). SWL 51.8m after drilling (16/11/1993). Bore deepened (2000).
1218	[redacted]	161 Hamlin Road, R D 2 Papakura 2582	13/09/2010	4.3	1775614	5898253	51	24.0	27	102	Waipapa	0-16m Clay to silts (Weathered Waitemata?), 16-56m Waitemata (some gravels 16-48m and some limestone >48m) & 56m-EOH Waipapa.	Irrigation (nursery)	40m^3 maximum daily abstraction. Total abstraction of 5,349m^3 (since meter installed). Airlifted 1,500-1,200 gph at 90m (110 to 40 PSI). SWL 26m day after drilling (3/5/1994). Significant iron. Service address is 34 Carrick Glen Avenue, Flatbush Manukau 2016. Tenanted (Paul Running & Hamlin Nurseries (Barbara Morris)).
4313	[redacted]	471 Ponga Road, R D 4 Papakura 2584	18/08/2010	2.2	1776578	5892817	126	n/a		50	Waipapa (Probably)?	No Log	Domestic	Original location plots on 461 Ponga Road (No bore confirmed by J Cumming). Original bore supplying neighbourhood.
4320	[redacted]	55 Coal Mine Road, R D 4 Papakura 2584	12/12/2008 (PDP)	1.9	1776511	5893338	87	20?		50	Waitemata (Probably)?	No Log	Domestic & stock	Old bore (fixed).
4368 (& 87)	[redacted]	1605 Ponga Road, R D 4 Papakura 2584	12/08/2010	3.3	1778731	5891267	284	69.2	215	148	Waitemata (& Waipapa)	0-107m Waitemata, 107-136m Te Kuiti & 136m-EOH Waipapa.	Stock & garden irrigation	Original location plotted on 1189 Ponga Road. Used by two neighbouring properties. Airlifted 800-1800 gph (overnight). Yield of 196.36m^3/day. Drawdown of 2.14m. SWL 66m after drilling (20/11/1987). Meter reads 20,232.1m^3. Some calcium. Bore 87 appears to be pilot hole (cased 15m? & SWL 1.43m).
4370	[redacted]	896 Hunua Road, R D 3 Papakura 2583	28/9/2010 & 11/02/2010 and 23 March 2011 (WA)	1.8	1778852	5896063	253	61.4	191	119.8	Waitemata & Waipapa	0-84.3m Waitemata (limestone >82.2m) & 84.3m-EOH Waipapa (variably weathered <91.6m).	Domestic	Approximate location & elevation only. Private village. 20m^3 maximum daily abstraction. Total abstraction of 15,478m^3 since meter installed. Airlifted 2500 gph. Transmissivity 4.9m^2/d. No sample 54.6-83.2m. Significant calcium & iron. SWL 58.8m (4/5/1984), 57m (1986). Variable water levels recorded during well refurbishment in March 2011 (54.3 to 61.4m).
4375	[redacted]	1720 Ponga Road, R D 4 Papakura 2584	Phoned	4.0	1779400	5890900	265	67.1	198	102.1	Waipapa	0-41m Clays (Weathered Waitemata to Waipapa?) & 41m-EOH Waipapa (weathered <99.4m).		Yield of 43.6m^3/day. Specific Capacity of 4.8m^2/day. Drawdown of 9.1m. SWL 67.1m after drilling (14/12/1962). No surviving bore on 1720 or 1723 Ponga Road confirmed by T. Crowther & N Poles.
4453	[redacted]	5 Batkin Road R D 4 Papakura 2584	Phoned	3.7	1781200	5893300	206	n/a		55	Waipapa (Possibly)?	No Log		No surviving bore (duplicate of 4423 or 21486?). Contact address is 10 Alexander Avenue, Maraetai 2018. No bore on 2169 Ponga Road confirmed by Mr Elliott.
4459	[redacted]	1933 Hunua Road, R D 3 Papakura 2583	18/08/2010	3.7	1781400	5894200	173	n/a			Waipapa (Possibly)?	No Log		No surviving bore (spring supply). Also no bore on 1896-1942 Hunua Road confirmed by B. Taylor & S. Jolley (spring supply visited).
4461	[redacted]	40 Batkin Road, R D 4 Papakura 2584?	2/09/2010	4.0	1781477	5892976	205	n/a		61	Waipapa (Possibly)?	No Log	Filling pool & general back-up supply	Original location plots on 33 Batkin Road (No bore confirmed by K. Powell). Takes 8-9 hrs to fill water tank (5,000 gallon).
4466	[redacted]	199 Sinclair Road, R D 3 Drury 2579		5.9	1782540	5891020	120	1.8	118.2	102.8	Waipapa	0-13.9m Clay (Weathered Waipapa) & 13.9m-EOH Waipapa (variably weathered).	Domestic & stock	20m^3 maximum daily abstraction. Airlifted 426-390 gph at 65m for 1 hour (640 to 140 kPa). SWL 1.8m two days after drilling (11/12/1989). Water analysis. Service address is PO Box 27201, Mount Roskill 1440.

Table I-1: Hunua Well Survey (14/12/2010) - Bores considered to be within regional groundwater in greywacke

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
4467	[redacted]			5.4	1782800	5892500	157.5	15	142.5	59.8	Waipapa	0-7m Clays (Tauranga?), 7- 25m Te Kuiti (coal 23-25m), 25-36m Siltstone (Te Kuiti/Weathered Waipapa?) & 36m-EOH Waipapa (weathered <37.8m).		Yield of 982m^3/day. Drawdown of 5.1m (with airline at 54m). SWL 15m after drilling. Service address is Heald Road, R D 3 Papakura 2583.
4985	[redacted]	424 Creightons Road, R D 2 Papakura 2582	19/08/2010	3.9	1781002	5896865	209	33.4	176	140.3	Waipapa	0-24m Silts (volcanic >3m?) & 24m-EOH Waipapa (variably weathered <74m).	Stock & back-up domestic supply	Airlifted 1,900-1,750 gph at 102.4m for 3.5 hours (90 to 46 PSI). SWL 35.5m day after drilling (10/1/1996).
5246	[redacted]	124 Mullins Road, R D 2 Papakura 2582	2/09/2010	4.9	1777231	5899479	37	8.1	28	76.04	Waitemata (& Waipapa)	0-15m Tauranga, 15-70.9m Waitemata & 70.9m-EOH Waipapa.	Stock & domestic (cottage)	Airlifted 616 gph at 70m for 6 hours (90 to 21 PSI). SWL 7.6m day after drilling (22/4/1996). Estate of Marilyn E Kent.
5421	[redacted]	864 Papakura-Clevedon Road, R D 2 Papakura 2582	18/08/2010	4.1	1775771	5898135	50	26.8	23	181.3	Waipapa	0-6m Clays (Weathered Waitemata?), 6-35.7m Waitemata (gravel & shell 17-18m) & 35.7m-EOH Waipapa.	Stock	Airlifted 188-146 gph at 96m for >3.5 hours (99 to 25 PSI). SWL 26.8m day after drilling (7/11/1996).
20013	[redacted]	7 Bullens Road, R D 2 Papakura 2582	19/08/2010	4.5	1776108	5898808	38	14.0	23	187.7	Waipapa	0-16m Silts (Tauranga to Weathered Waitemata >11m), 16-60.5m Waitemata (some limestone bands >50m) & 60.5m-EOH Waipapa.	Formerly industrial	Airlifted 800 gph at 103m for >5hrs (100 to 55 PSI). SWL 14.1m two days after drilling (10/9/1997).
20141	[redacted]	649 Ponga Road, R D 4 Papakura 2584	14/09/2010	2.4	1777225	5892334	197	145.1	51	182.9	Waipapa	0-4.8m Clay, boulders & silt (Alluvium?) & 4.8m-EOH Waipapa (variably weathered).	Domestic & stock	Airlifted 1,584-1,480 gph at 179m for 4 hours (85 to 82 PSI). SWL 132m two days after drilling (2/4/1998). Also supplies stock water to 671 Ponga Road (P & V Grant), and occasionally other neighbours.
20479	[redacted]	86 Awanui Rise, R D 2 Papakura 2582	11/12/2008 (PDP)	2.6	1776581	5896893	128	84.0	44	117.4	Waipapa	0-82m Clays (Weathered Waitemata to Waipapa?) & 82m-EOH Waipapa (faulted >115m).	Domestic	Bore shared with neighbour. Estimated use of 15-20m^3 per annum. Pumped 400 gph (at 97.5m?) for four days. SWL 84m day after drilling (28/9/1999).
20255	[redacted]	473 Ponga Road, R D 4 Papakura 2584	17/07/2008 (site visited by PDP, no WL measurements)	2.3	1776650	5892646	136	90?		100	Waipapa	0-45.29m Clays (Weathered Te Kuiti to Waipapa >34.56m) & 45.29m-EOH (84.17m) Waipapa (variably weathered).	Pond, spa & summer backup	Deepened in 2008 after running dry (No log). Original hole grouted 64-72m. SWL 70.5m after drilling (17/10/1998). Drawdown of 0.5m from pumping (airlift?) at 400 gph for 4.75 hours. Clean water. No bore recorded in response to ARC Survey. Site visited by PDP but water level could not be measured (the estimation is according to the owner).
21300	[redacted]	1800 Ponga Road, R D 4 Papakura 2584	13/09/2010 & 28/07/2008 (PDP)	4.4	1780246	5890891	217	41.8	175	105.2	Waipapa	0-28.5m Clays (Weathered Te Kuiti?), 28.5-40m Te Kuiti (some coal <31m) & 40m-EOH Waipapa.	Stock & summer backup	Used by Higgins (09-2991700). Airlifted 5,462 gph at 90m for 1.75 hours (78 to 70 PSI). SWL 41.6m after drilling (15/11/2000) & 42.7m (28/7/2008). No bore on 1804 Ponga Road confirmed by A Finley. Tenanted (Joan McLean). Service address is PO Box 38966, Howick Manukau 2145.
21368	[redacted]	752 Papakura Clevedon Road, R D 2 Papakura 2582	8/09/2010	3.4	1776681	5897826	80	32.8	47	149.5	Waipapa	0-23m Clays to silt (Weathered Waitemata?), 23-42m Waitemata (some limestone <33m) & 42m-EOH Waipapa.	Stock	Residence on Ohiwa Road. Airlifted 5,500-3,800 gph at 91m for 2 hours (90 to 50 PSI). SWL 32.8m day after drilling (20/3/2001). Service address is PO Box 2721722, Papakura 2244.
21474	[redacted]	1040 Hunua Road, R D 3 Papakura 2583	20/07/2010	1.4	1779245	5894407	195	35.5	160	101.4	Waipapa	0-62m Waitemata, 62-68.5m siltstone (Waitemata and/or Weathered Waipapa) & 68.5m-EOH Waipapa.	Stock, garden & back-up domestic supply	Formerly used for piggery. Airlifted 770-800 gph at 96m for >5.5 hours (500 to 240 kPa). SWL 34.7m day after drilling (12/7/1987). 0.6 ppm iron. Monitored by WA. Disused bore 10m SE (high iron).
21475	[redacted]	1041 Hunua Road, R D 3 Papakura 2583	18/08/2010	1.6	1779349	5894192	201	n/a		96?	Waipapa (Possibly)?	No Log	Stock & back-up domestic supply	Significant iron. Service address is 101 Middleton Road, R D 3, Papakura 2583.
21479	[redacted]	40 Farquharson Road, R D 3 Papakura 2583.		7.1	1783500	5890400	155			40	Waipapa (Probably)?	No Log		Data from Wairoa River catchment Survey 1995-97. Plots on 40 (or 42) Farquharson Road, R D 3 Papakura 2583. Suspect location.
21481	[redacted]	1742 Ponga Road, R D 4 Papakura 2584	18/08/2010	4.5	1779776	5890601	253	>64		>82.2	Waipapa (Probably)?	No Log	Back-up supply (stock)	Some iron. Possibly same bore as 4375.

Table I-1: Hunua Well Survey (14/12/2010) - Bores considered to be within regional groundwater in greywacke

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
21484	[redacted]	76 Cowan Road, R D 3 Papakura 2583		6.3	1784000	5893400	114.5	3		70	Waipapa (Probably)?	No Log		Data from Wairoa River catchment Survey 1995-97.
21486	[redacted]	2168 Ponga Road, R D 4 Papakura 2584	19/08/2010	3.4	1781029	5893423	214	n/a			Waipapa (Possibly)?	No Log	Stock, garden & back-up domestic supply	Single bore on property.
21838	[redacted]	162 White Road, R D 3 Papakura 2583		6.3	1783970	5895888	128	21.8	106.2	130	Waipapa	0-18m Tauranga (peat 6-8m, 12-12.5m & >15m), 18-84m Clay & silt (Tauranga to Waitemata?) & 84m-EOH Waipapa (weathered <86m).	Domestic & stock	Airlifted 1,760-1,550 gph at 91m for >5 hours (103 to 38 PSI). SWL 21.8m day after drilling (6/3/2003).
21914	[redacted]	40 Farquharson Road, R D 3 Papakura 2583.		6.9	1783360	5890490	162	16.5	145.5	90.5	Waipapa	0-33m Clay (Weathered Waipapa?) & 33m-EOH Waipapa (variably weathered).	Domestic & stock	Airlifted <1.64m^3/hr at 78m. Pumped 1m^3/hr at 48m for 3hours. Drawdown of 25.5m. SWL 16.5m after drilling (4/11/2003).
20476	[redacted]	592 Clevedon Road			1777906	5899444		5.5		62	Waitemata	0-16m clays and silts, 16-44m Waitemata sandstone, 44-60m Waitemata sandstone with limestone bands, 60-EOH Waipapa		The second of two bores drilled in December 1998. The first bore was abandoned and backfilled. The water level data from AC.
22281	[redacted]	75 Munros Road, R D 2 Papakura 2582		6.2	1781460	5899656	69.5	23.6	45.9	123.6	Waipapa	0-17m Silt & clays with weathered rock >10m (Weathered Waipapa) & 17m-EOH Waipapa.	Domestic & stock	Airlifted 684-694 gph at 96.5m for 1.5 hours (120 to 40 PSI). SWL 23.6m day after drilling (5/5/2005).
22443	[redacted]	1189 Ponga Road, R D 4 Papakura 2584	E-mailed	4.6	1777350	5890058	182	n/a		139	Waipapa	0-10m clays, 10-EOH Waipapa	Monitoring	Piezometer at Drury Quarry. Proposed screen interval 133-139m & grouted <112m. No water bores within survey area. Unable to provide any information related to groundwater levels. Service address is 1060 Private Bag 94000, Manukau 2241.
22555	[redacted]	37 Munros Road, R D 2 Papakura 2582		6.3	1781860	5899530	85	29	56.0	57	Waipapa	0-29m Waitemata (conglomeratic >19m) & 29m-EOH Waipapa (weathered <31m).	Domestic & stock	Airlifted 3.6m^3/hr at 50m for 3.5 hours. Drawdown of 16m. SWL 29m after drilling (4/4/2006). Minor iron.
22976	[redacted]	26-36 Munros Road, R D 2 Papakura 2582		5.8	1781587	5898983	84	36	48.0	81	Waipapa	0-37m Clay with rotten rock >5m (Weathered Waipapa) & 37m-EOH Waipapa (weathered <43.5m).	Domestic & stock	Pumped 3.6m^3/hr at 50m for 3 hours. Drawdown of 9m. SWL 36m after drilling (14/11/2007). Minor iron.
23390	[redacted]	18 Sky High Road, R D 3 Papakura 2583		6.2	1783750	5896510	110	11.2	98.8	60	Waipapa	0-49m Clay to rotten rock (less weathered & some red >36m) (Tauranga to Weathered Waipapa?) & 49m-EOH Waipapa.	Stock	Airlifted 3.6m^3/hr. SWL 11.2m after drilling (17/7/2009). Minor iron.
23573	[redacted]	119 Jones Road, R D 3 Papakura 2583	18/08/2010	3.6	1781108	5896149	236	52.3	184	183	Waipapa	0m-EOH Waipapa (variably weathered <70m).	Garden irrigation & domestic back-up supply	Formerly 68 Jones Road. Pumped 2.16m^3/hr for 4hrs at 91m. Drawdown of 27.34m. SWL 54.74m day after drilling (23/4/2010).
20843	[redacted]	Burnsides Rd, Clevedon			1777704	5900243		Artesian		168.7	Waipapa	0-22m Tauranga Group, 22-168m Waitemata (Papakura Limestone at base), 168m EOH Waipapa.	Monitoring	100mm steel casing to 154.25m

Note:

1) *Bore 4370 is considered to be within a shallow groundwater system in greywacke*
2) *Information obtained from ARC databases, responses to mail-out to residents of Ponga Road and consultation by Winstone Aggregates.*
3) *Recorded bores within 5km of Hunua Pit east of Drury Fault and 3km west of Drury Fault.*
4) *Locations of unvisited bores are approximate and may be on nearby properties with different ownership.*
5) *Grey shaded: Wells Identified within the predicted zone of influence in greywacke*

TABLE I-2: Hunua Well Survey (14/12/2010) - Bores considered to be within shallow groundwater

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
180	[redacted]	36 Jack Paterson Road, R D 4 Papakura 2584		2.6	1775640	5893300	30	9.0	21	67.1	Waitemata (Possibly basal Waitemata beds?)	0-57m Tauranga, 56.4 - EOH basal Waitemata beds (greywacke gravels?)	Domestic & stock	Alternative address is 2/18 Walmsley Road, St Heliers Auckland 1071. 80mm casing to 58.5m depth. Pumping test following drilling yielded 42L/min with a 3.6m drawdown (May 1988)
194	[redacted]	46 Elizabeth Place, R D 1		3.4	1775900	5891800	50	11.2	38	69.7	Kerikeri Volcanic	0-68.7m Kerikeri Volcanic (with sediments 16.5-27m) & 68.7-EOH Clays.	Domestic & stock	Possibly located on 449 Drury Hills Road. Pumped 1280 gph at 67m (PWL 59.77m). Recovered from 54.84 to 18.93m in 20 minutes after pumping. SWL 11.2m day after drilling (1/9/1988).
343	[redacted]	230 Fitzgerald Road (Fielding Road Reserve), R D 1 Drury 2577	2/09/2010 (ARC)	5.2	1774444	5890648	19.0	7.8	11	115.6	Tauranga	0-15.3m Clay & Tephra (Weathered Kerikeri Volcanic?), 15.3-45.64m Kerikeri Volcanic (basalt with scoriaceous-ash intervals), 45.64m-EOH Tauranga (variable materials with organic intervals >75.9m).	Monitoring	ARC monitoring bore ("Fielding Road Sand Bore"). Bore backfilled (aggregate) to 64m. Airlifted 1,760 gph at 65m (675 to 270 PSI). SWL 11.8m day after drilling (31/3/1989). Transmissivity of 5.7m²/d. Water level data from 4/04/1989. Service address is Private Bag 92012, Auckland 1142.
344	[redacted]	230 Fitzgerald Road (Fielding Road Reserve), R D 1 Drury 2577	2/09/2010 (ARC)	5.2	1774447	5890658	19.3	3.2	16	46.68	Kerikeri Volcanic	0-15.4m Clay & Tephra (Weathered Kerikeri Volcanic?), 15.4-46.1m Kerikeri Volcanic (basalt with scoriaceous-ash intervals), 46.1m-EOH Tauranga (sandy silts).	Monitoring	ARC monitoring bore ("Fielding Road Volcanic Bore"). Estimated location (ARC records 1774451mE & 5890646mN). Water level data from 4/04/1989. Service address is Private Bag 92012, Auckland 1142.
421	[redacted]	76 Jack Paterson Road, R D 4 Papakura 2584	2/09/2010	2.9	1775478	5892912	32	17.4	14	60.1	Kerikeri Volcanic	0-35.1m Tauranga (variable with organic material near 24.5-25m), 35.1-58.8m Kerikeri Volcanic (basalt with some ash layers), 58.8m-EOH Mudstone with some shell (Waitemata?).	Stock and domestic	Airlifted 2,300-2,100 gph at 32.5m for several hours (58 to 56 kPa). SWL 17.5m after drilling (29/9/1989). Service address is 21 Hauraki Road, Waiheke Island 1081. Tenanted (Rob & Jean).
640	[redacted]	230 Fitzgerald Road (Fielding Road Reserve), R D 1 Drury 2577	2/09/2010 (ARC)	5.2	1774439	5890631	18.4	6.8	12	273	Waitemata	0-10.56m Clay & Tephra (Weathered Kerikeri Volcanic?), 10.56-44.9m Kerikeri Volcanic (basalt & scoria), 45.64-109.2m Tauranga (variable materials with organic intervals), 109.2-149m silts & sands (Tauranga to Weathered Waitemata <128m) & 149m-EOH Waitemata (occasional peat intervals or shell >155m).	Monitoring	ARC monitoring bore ("Fielding Road Waitemata Bore"). Transmissivity of 5m²/d. Water level data from 24/04/1991. Service address is Private Bag 92012, Auckland 1142.
683 (BH106)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	4/05/2010 (URS, Piezo C)	1.5	1776430	5894155	138	41.0	97	50	Waitemata	0m-EOH Waitemata (generally glauconitic >38.2m).	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 39.62m after drilling (26/3/1991). Resistivity logging undertaken. No sample 40-48m. Service address is Private Bag 7 Papakura 2244.
683 (BH107)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	20-21/04/1993 (ECL, Piezo C)	1.8	1776091	5894192	100	34.9	65	35	Waitemata	0-2.5m Kerikeri Volcanic & 2.5m-EOH Waitemata.	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 32.61m after drilling (28/3/1991). Resistivity logging undertaken. No sample 20.7-33m. Piezometer B is often dry (& occasionally Piezo C).
684 (BH105)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	4/05/2010 (URS, Piezo B)	1.7	1776206	5894162	120	32.6	87	50	Waitemata	0m-EOH Waitemata (generally glauconitic >19m).	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 12.8m after drilling (25/3/1991). Resistivity logging undertaken. No sample 9-12.5m.
685 (BH102/1)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	20-21/04/1993 (ECL, Piezo C)	1.5	1776370	5894389	126	39.3	87	50	Waitemata	0m-EOH Waitemata (Faults 25.6-28m & 48.3m-EOH).	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 24.08m after drilling (14/3/1991). Resistivity logging undertaken (uniform response).
685 (BH102/2)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	13/05/1992 (ECL, Piezo D)	1.5	1776372	5894385	126	23.0	103	25	Waitemata	As for BH102/1.	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 14.8m after drilling (18/3/1991). Located 4.75m south (350^{0} mag) of BH102/1. Destroyed by April 1993.
686 (BH101)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	4/05/2010 (URS, Piezo B)	1.2	1776633	5894350	145	39.8	105	50	Waitemata	0m-EOH Waitemata.	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 2.45m (A) & 35.2m (B) after drilling (14/3/1991).
687 (BH103)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	13/05/1992 (ECL, Piezo A)	1.7	1776187	5894366	115	3.8	111	35	Waitemata	0m-EOH Waitemata.	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 3.05m after drilling (19/3/1991). Resistivity logging undertaken (uniform response). Piezometer B dry by 23/4/1991.

TABLE I-2: Hunua Well Survey (14/12/2010) - Bores considered to be within shallow groundwater

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
688 (BH104)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	20-21/04/1993 (ECL, Piezo A)	1.7	1776192	5894249	101	17.5	84	35	Waitemata	0m-EOH Waitemata.	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 30.8m after drilling (20/3/1991). Resistivity logging undertaken. No sample 21.7-32m. Piezometer B is sometimes dry.
689 (BH108)		109 Hunua Road, R D 3 Papakura 2583	4/05/2010 (URS)	1.7	1776194	5894242	102	38.2	64	59	Waitemata	0m-EOH Waitemata (Fault near 57-58m).	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 30.2m after drilling (18/3/1992). No sample 19-57m & 58m-EOH.
690 (BH109)		109 Hunua Road, R D 3 Papakura 2583	4/05/2010 (URS, Piezo B)	1.8	1776093	5894275	98	42.9	56	59	Waitemata	0m-EOH Waitemata (generally glauconitic, common shells by 40m, conglomeratic 44-49m & conglomerate 58.6m-EOH).	Monitoring	Piezometer at Hunua Gorge Landfill. SWL 28.4m (A) & 40.82m (B) day after drilling (16/3/1992).
854		63 Gillespie Road, R D 3 Papakura 2583	11/08/2010	3.0	1780518	5893364	220	44.5	175	77.5	Waitemata	0-25m Clays with some weathered greywacke >16m (Weathered Waitemata), 25-75.4m Waitemata & 75.4m-EOH Clay (Te Kuiti?).	Stock & domestic (cottage toilet)	Labelled 845 in Ponga Survey. Airlifted 2,639-3,167 gph at 69m for 2.75 hours (470 to 460 kPa). SWL 44.3m three days after drilling (12/6/1992). Significant iron. Service address is 27 Gillespie Road, R D 3 Papakura 2583.
885		49 Bullens Road, R D 2 Papakura 2582		5.0	1776100	5899300	38	14.1	24	98	Waitemata	0-8m Clays to silts (Tauranga to Weathered Waitemata?), 8m-EOH Waitemata (generally glauconitic, some shell >64m).	Stock, domestic & orchard	Location recorded as 51 Bullens Road (but plots 49). Slow drilling >89m. No circulation 17-39m & 95.4m-EOH. Airlifted 13,700-14,600 gph at 64m for >4 hours (560 to 510 PSI). SWL 14.1m day after drilling (6/10/1992). Possible alternative contact address is 24 Friedlanders Rd Manurewa 2102.
960		51 Bullens Road (Road Reserve), R D 2 Papakura 2582	16/09/2010 (ARC)	5.0	1775848	5899160	35	11.2	24	75	Waitemata	0-11m Tauranga to Weathered Waitemata (>7.2m), 11m-EOH Waitemata (calcareous >45m & limestone >71m) .	Monitoring	ARC monitoring bore. Water level data from 21/06/1993. Service address is Private Bag 92012, Auckland 1142.
1155		7 Bullens Road, R D 2 Papakura 2582	19/08/2010	4.6	1776052	5898889	38	10.5	27	71.5	Waitemata	0-5m Tauranga & 5m-EOH Waitemata (with some limestone >57.3m) .	Formerly irrigation & industrial	Some greywacke cuttings near EOH. Airlifted 9,900 gph at 45m (75 to 68 PSI). SWL 12.3m after drilling (13/1/1994). Selling property.
2878		140 Hamlin Road, R D 2 Papakura 2582		4.7	1775400	5898600	35	11.2	24	71.3	Waitemata	0-7.6m Tauranga & 7.6m-EOH Waitemata ("peat" 18.3-18.9m & limestone >67.6m).		Same location as bore 2879. Yield of 218.1m^3/day. Specific Capacity of 52.43m^2/day. Drawdown of 4.16m?. SWL 11.2m after drilling (29/10/1975).
2879		146 Hamlin Road, R D 2 Papakura 2582		4.7	1775400	5898600	35	n/a		71	Waitemata (Probably)?	No Log	Stock & domestic	Shared with Fowler's farm. Plots on 140 Hamlin Road.
2883		51 Bullens Road, R D 2 Papakura 2582		5.0	1775900	5899160	35	9.5	25	72.73	Waitemata	0-15m Tauranga, 15-70m Waitemata (conglomeratic limestone near base) & 70m-EOH Waipapa.	Irrigation	Location from Map in Clevedon drilling and pump testing report. 510m^3 maximum daily abstraction. Yield of 870m^3/day. SWL 9.5m after drilling (28/1/1982). Iron 2ppm.
2884		7 Bullens Road, R D 2 Papakura 2582	19/08/2010	4.6	1776140	5898850	37	10.6	26	61.5	Waitemata	0-15m Tauranga & 15m-EOH Waitemata (with thin limestone bands 50-60.1m).	Irrigation & industrial	No surviving bore at recorded location. Airlifted 3,000 gph at 32m. Yield of 327.3m^3/day. SWL 21.2m after drilling (20/12/1985)?
2912		26 Ardmore Quarry Road, R D 2 Papakura 2582		4.1	1777420	5898640	46	18.3	27	72.7	Waitemata	0-15.2m Tauranga & 15.2m-EOH Waitemata (cavity 70.7-71.9m & limestone >71.9m).	Animal pound	SWL 18.3m after drilling (22/8/1975). Service address is Private Bag 76917, Manukau City (Attention Property Manager Commercial).
2925		550 Papakura-Clevedon Road, R D 2 Papakura 2582		4.9	1778500	5899500	29	-0.4	29	35	Waitemata	0-14m Tauranga & 14m-EOH Waitemata (with some limestone >28m).		Yield of 240m^3/day. SWL 0.4m above surface (artesian) after drilling (Dec 1983). Service address is 30 Roscommon Rd, Wiri, Manukau 2025.
4098		73 Boundary Road, Papakura 2110		3.6	1774200	5894700	16	11.6	4	79.2	Waitemata	0-57.9m Soft sediments (Tauranga to Weathered Waitemata) & 57.9m-EOH Waitemata.		Yield of 21.8m^3/day. Specific Capacity of 3.6m^2/day. Drawdown of 6.1m. SWL 11.6m after drilling (Sept 1964). Service address is PO Box 72561, Papakura 2244.
4195		71 Jack Paterson Road, R D 4 Papakura 2584		3.0	1775360	5892920	32	n/a		67	Kerikeri Volcanic (Possibly?)	No Log		

TABLE I-2: Hunua Well Survey (14/12/2010) - Bores considered to be within shallow groundwater

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
4196	[redacted]	51 Jack Paterson Road, R D 4 Papakura 2584		3.0	1775300	5893100	22	n/a			Waitemata (Possibly?)	No Log		
4197	[redacted]	41 Hunua Road, Papakura 2110		2.7	1775200	5894800	23	-0.8	23	25.6	Kerikeri Volcanic	0-8.8m Tauranga (gravel 5.2-6.1m & >7m) & Kerikeri Volcanic (basalt & scoria).		Yield of 196.2m³/day. Specific Capacity of 93.4m²/day. Drawdown of 2.1m. SWL 0.8m above surface (artesian) after drilling (12/10/1961). Almost identical log to Bore 4234. Service address is 342 Great South Road, Opaheke Papakura 2113.
4198	[redacted]	246 Dominion Road, Red Hill		2.7	1775200	5895300	33	5.5	27	15.8	Kerikeri Volcanic	0-10.7m Volcanic soil & ash (basalt boulders >7.9m) (Weathered Kerikeri Volcanic) & 10.7m-EOH Kerikeri Volcanic (hard basalt).		Possibly located on 1 Mack Place. Yield of 21.8m³/day. Specific Capacity of 12.1m²/day. Drawdown of 1.8m. SWL 5.5m after drilling (18/12/1959)
4205	[redacted]	174 Ponga Road, R D 4 Papakura 2584	13/09/2010	2.8	1775160	5893698	32	27.1		40.2	Kerikeri Volcanic (Possibly)?	No Log	Domestic	Original location plots on 154 Ponga Road. SWL 27.1m (5/12/1961). ARC records deeper bore (73m). Fills tank (5,000 g) in <8 hours.
4211	[redacted]	41 Jack Paterson Road, R D 4 Papakura 2584	9/09/2010	2.8	1775404	5893282	25	4.5	21	81.5	Waitemata?	0-16m Clays with pumice silts (10.5-14m) (gravel & timber 4.5-5.5m) (Tauranga), 16-44m Sandstone (<17m) to Mudstone (pumice silts 31-31.6m) (Waitemata?) & 44m-EOH Volcanic sandstone with ash & clay (hard basalt >80m) (Waitemata?).	Abandoned	Old bore indicated by D. Sanford?. Yield of 818.2m³/day. Airlifted 3,000 & 7,500 gph. Pumped 500 gph at 6.8m. SWL 4.5m after drilling (11/7/1985). No surviving bore on 35 Jack Paterson Road confirmed by R & C Turner.
4212	[redacted]	215 Ponga Rd, R D 4 Papakura 2584	28/09/2010	2.5	1775532	5893589	29	5.5	24	54.3	Waitemata?	0-44.5m Clays, undifferentiated sediments (5.5-17.7m) & gravel (17.7-20.7m) (Tauranga to Waitemata?) & 44.5m-EOH Greywacke (Suspect Logging).	Stock & future domestic	Yield of 27.3m³/day. Specific Capacity of 4.5m²/day. Drawdown of 6.1m. SWL 5.5m after drilling (18/3/1965). Some iron. Service address is PO Box 281041, Maraetai Beach Manukau 2148.
4214	[redacted]	198 Ponga Road, R D 4 Papakura 2584	9/09/2010	2.8	1775213	5893815	29	n/a			Kerikeri Volcanic (Possibly)?	No Log	Back-up supply	Old bore (1930's).
4233	[redacted]	233 Ponga Road, R D 4 Papakura 2584	3/09/2010	2.4	1775693	5893553	33	10.8	22	90.86	Waitemata?	0-24m Tauranga (peat 5-8m, sands & pumice >14m), 24-26m Silty clays (Weathered Waitemata?) & 26m-EOH Mudstone & volcanic sandstone with thin ash layers (hard), basalt & greywacke boulders >67.5m (Waitemata?).	Domestic & stock	Original location plots on 24 Jack Paterson Road. Provides water to 221, 233 & 241 Ponga Road and 24 Jack Peterson Road. Airlifted 5,200-11,168gph (at 60m?) for 2.75 hours. Owner indicated original SWL about 15m (30/10/1985). Total abstraction of 36,000m³ since drilled (30/10/1985).
4234	[redacted]	79 Hunua Road, R D 4 Papakura 2584	9/09/2010	2.3	1775551	5894665	26	0.0	26	25.6	Kerikeri Volcanic	0-8.8m Tauranga (gravel 5.2-6.1m & >7m) & Kerikeri Volcanic (basalt & scoria).	Stock	Original location plots on ER 53 Hunua Road. Yield of 218.1m³/day. SWL near surface after drilling. Almost identical log to Bore 4197. Service address is 198 Ponga Road, R D 4 Papakura 2584. No surviving bore on ER 53 or 69 Hunua Road (confirmed in field).
4250	[redacted]	44 Red Hill Road, Papakura 2110		2.3	1775700	5895300	96	44.2	52	75.7	Waitemata	0-51.8m Kerikeri Volcanic & 51.8m-EOH Waitemata (some shell <54.9m).		Yield of 54.5m³/day. Specific Capacity of 36.3m²/day. Drawdown of 1.5m. SWL 44.2m after drilling (25/10/1962).
4251	[redacted]	15 Tanah Merah Place, Papakura 2110		2.5	1775700	5895800	73	18.3	54	67.1	Waitemata	0m-EOH (31.7m) Waitemata.		Yield of 43.6m³/day. Specific Capacity of 29.1m²/day. Drawdown of 1.5m. SWL 18.3m after drilling at 31.7m (20/8/1959). Bore deepened to 67.1m (No Log).
4253	[redacted]	5 Tanah Merah Drive, Papakura 2110	Received Fax & Phoned	2.5	1775700	5895900	63	n/a			Waitemata (Possibly)?	No Log	Abandoned?	No surviving water bore confirmed by L. Hunt. Received map showing locations of three geotechnical bores & two pits by Geotek Services Ltd. Possibly on R 135 Settlement Rd.
4265	[redacted]	3 Gibbs Crescent, Papakura 2110	Received E-mail	2.3	1775800	5895500	97	n/a		82	Waitemata (Possibly)?	No Log		No surviving bore confirmed by D Harrison.
4270	[redacted]	51 Heard Road, R D 2 Papakura 2582		3.6	1775900	5897600	63	Dry?		84.4	Waitemata	0-6.4m Clay (Weathered Waitemata?), 6.4-43.9m Waitemata (some limestone >25.9m & cavity 38.7-40.2m), 43.9-73.2m Mudstone (Waitemata/Te	Abandoned	Abandoned bore ("dry") near 4271. Casing removed after drilling (17/1/1967). Inconsistent data in ARC records. Log details possibly as for 4271.

TABLE I-2: Hunua Well Survey (14/12/2010) - Bores considered to be within shallow groundwater

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
	[redacted]											Kuiti?), 73.2-82.3m Greywacke Gravel & Clay (Weathered Waipapa?) & 82.3m-EOH Waipapa.		
4271	[redacted]	51 Heard Road, R D 2 Papakura 2582		3.6	1775900	5897600	63	30.5	33	39.6	Waitemata	0-8.2m Clay (Weathered Waitemata?), 8.2m-EOH Waitemata (some weathered greywacke >25.9m & cavity >38.7m).		Yield of 65.4m^3/day. Specific Capacity of 27.3m^2/day. Drawdown of 2.4m. SWL 30.5m after drilling (1/7/1966). Inconsistent data in ARC records. Log details possibly as for 4270.
4278	[redacted]	249 Drury Hills Road, Drury 2577		4.2	1775970	5890880	62	n/a		15?	Kerikeri Volcanic (Possibly)?	No Log		
4279	[redacted]	17 Margan Place, Red Hill Papakura 2110		2.2	1776000	5895800	112	n/a			Waitemata (Possibly)?	No Log		
4286	[redacted]	11 Harry Dreadon Road, R D 4 Papakura 2584		2.3	1776100	5893100	62	n/a		94	Waitemata (Probably)?	No Log		Same location as bore 5005.
4287	[redacted]	96 Red Hill Road, Papakura 2110		2.1	1776100	5895800	99	n/a		60	Waitemata (Probably)?	No Log		Plots on 10 Tanah Merah Drive.
4302	[redacted]	36 Harry Dreadon Road, R D 4 Papakura 2584	28/09/2010	2.2	1776300	5893000	99	n/a		45	Waitemata (Probably)?	No Log		No surviving bore confirmed by D Hieatt.
4303	[redacted]	245 Hunua Road, R D 3 Papakura 2583?		1.6	1776300	5895000	86	n/a		33	Waitemata (Probably)?	No Log		Same location as bore 4999. Suspect located on 241 Hunua Road.
4304	[redacted]	248 Settlement Road, Papakura 2110	9/09/2010	2.1	1776300	5896000	121	n/a		100	Waitemata (Probably)?	No Log	Currently not in use	Owner indicated bore near 1776349mE & 5896084mN. Bore damaged & buried (2m down) near service cable. Owner wants to reinstate bore. Recalls bore on property to north in vicinity of 242-246 Settlement Road (but possibly gone). Service address is 250 Settlement Road, Papakura 2110.
4334	[redacted]	489 Hunua Road, R D 3		0.9	1776900	5894600	91	Dry		30.5	None	0-30.5m Weathered Waipapa.	Abandoned	Abandoned ("Dry") bore located near entrance ponds in Hunua Quarry (Jan 1961). Service address is PO Box 17-195 Greenlane 1546.
4447	[redacted]	63 Gillespie Road, R D 3 Papakura 2583	11/08/2010	3.0	1780522	5893369	221	43.2	177	67	Waitemata (Probably)?	No Log	Abandoned	Near bore 854. Back-filled with aggregate & cement to surface. SWL 43.2m prior to abandonment (10/6/1992).
4452	[redacted]	8 Batkin Road, R D 4 Papakura 2584	2/09/2010	3.7	1781230	5893136	208	39.0	169	55	Waitemata	0-28.96 sand and clay (weathered Waitemata) & 28.96-EOH Waitemata	Stock, garden irrigation & domestic back-up supply	Single bore on property. Owner indicated old bore on 1912 Hunua Road (Simon & S I Jolley, 09-2924788).
4463	[redacted]	Batkin Road, R D 4 Papakura (Lot 4 DP44501)	19/08/2010	4.4	1781854	5892773	203	21.5	181.0	51	Waitemata	0-11.28 sand and clay (weathered Waitemata) & 11.28-EOH Waitemata	None	Original location plots on 33 Batkin Road (No bore confirmed by K. Powell). Not used for many years (collapsed?).
4691	[redacted]	72 Hunua Rd, Papakura 2110	1/09/2010 & 8/09/2010	2.9	1774931	5894996	22	13.3	9	251.2	Waitemata	0-1.5m Fill (aggregate & concrete), 1.5-24m Tauranga (gravel & silt with peat-timber 3.5-5m), 24-117m silt & mudstone (peat & timber 60-68m) (Tauranga to Weathered Waitemata) & 117m-EOH Waitemata.	Industrial back-up supply	45m^3 maximum daily abstraction. Total abstraction of 61,454.5m^3 since drilled. Airlifted 6,000-5,800 gph at 64m for >3.75 hours (590 to 390 PSI). SWL 13.3m day after drilling (26/1/1995). Service address is Private Bag 92817, Penrose Auckland 1642.
4722	[redacted]	51 Harry Dreadon Road, R D 4 Papakura 2584	13/09/2010 & 28/07/2008 (PDP)	2.5	1776100	5892792	96	8.3	88	34	Kerikeri Volcanic	0-26m Silt with boulders >16m (Tauranga/Weathered Kerikeri Volcanic), 26-28m Clay & 28m-EOH Kerikeri Volcanic.	Stock	Drawn down 4m in 3 hours at 6m^3/hr. SWL 16m after drilling (4/2/1995). Trace iron. PDP indicates deepened to 160m?
4999	[redacted]	315 Hunua Road, R D 3 Papakura 2583?		1.6	1776300	5895000	86	n/a		32.6	Waitemata	0-29.9m Waitemata (limestone >3m) & 29.9m-EOH Waipapa.		Plots on 245 Hunua Road. Yield of 327m^3/day.

TABLE I-2: Hunua Well Survey (14/12/2010) - Bores considered to be within shallow groundwater

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
5005	[redacted]	11 Harry Dreadon Road, R D 4 Papakura 2584?		2.3	1776100	5893100	88	24.4	64	93.8	Waitemata	0-15.2m Kerikeri Volcanic (tephra >11.9m) & 15.2-EOH Waitemata.		Possibly located on R31 Harry Dreadon Road. Yield of 6.5m^3/day. SWL 24.4m after drilling (7/3/1961).
5006	[redacted]	252 Settlement Road, Papakura 2110	28/09/2010 & 11/12/2008 (PDP)	2.1	1776408	5896111	112	62.7	49	99.5	Waitemata	0m-EOH Waitemata.	Domestic (2 houses)	Airlifted 1,200 gph. Yield of 130.9m^3/day. SWL 58m after drilling (3/7/1985). Small water tank at 1776386mE & 5896100mN. Bore shared with 258 Settlement Road (C & J McLeod).
5645 (BH103C)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	4/05/2010 (URS)	1.7	1776187	5894366	115	46.9	68	48.9	Waitemata	0m-EOH Waitemata.	Monitoring	Piezometer at Hunua Gorge Landfill. No sample below 45m.
5645 (BH110)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	4/05/2010 (URS)	1.6	1776262	5894244	108.08	7.4	101	15	Waitemata	0m-EOH Waitemata.	Monitoring	Piezometer at Hunua Gorge Landfill.
20116	[redacted]	16 McMurray Road, R D 4 Papakura 2584	17/08/2010	3.9	1781506	5893225	192	25.2	167	76	Waitemata (& Te Kuiti)	0-27m Sandy clays (Weathered Waitemata), 27-61m Sandstone (Waitemata?) & 61m-EOH Te Kuiti (some coal >73m).	Stock & back-up domestic supply	Occupied by G B Bassett. Airlifted 9m^3/hr for 5hrs (Drawdown of 1m). SWL 27m after drilling (23/2/1998). Some iron. Fills 4-5 tanks (5,000g) per year.
20444 (BH102d)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	4/05/2010 (URS)	1.5	1776373	5894383	128	43.8	84	56	Waitemata	0-13m Clays (Weathered Waitemata?) & 13m-EOH Waitemata.	Monitoring	Piezometer at Hunua Gorge Landfill. No sample below 44.2m. SWL 40m after drilling (15/1/1999).
20444 (BHL1)	[redacted]	109 Hunua Road, R D 3 Papakura 2583	4/05/2010 (URS)	1.6	1776314	5894245	131	Dry		7.5	Waitemata	0m-EOH Fill.	Monitoring	Piezometer at Hunua Gorge Landfill. No sample below 5.5m.
20496	[redacted]	320 Hunua Road, R D 3 Papakura 2583	28/09/2010 & 17/07/2008 (PDP)	1.6	1776524	5895448	67	23.1	44	43	Waitemata (& Te Kuiti?)	0-34m Waitemata (conglomeratic 19-31m & some shell >31m), 34-41m sandstone (Waitemata/Te Kuiti?) & 41m-EOH Clay.	Domestic, irrigation, stock & summer backup	Airlifted 3.6m^3/hr for 8.5 hours (1.9m drawdown). SWL 23.1m after drilling (3/3/1999) & 23.5m (17/7/2008). Adequate quality.
20497	[redacted]	95 Hunua Road, R D 3 Papakura 2583	28/09/2010 & 25/08/2008 (PDP)	1.8	1776076	5894404	107	41.9	65	72.5	Waitemata	0m-EOH Waitemata (conglomeratic limestone >66m).	Domestic (excl. drinking), irrigation & stock	Airlifted 4m^3/hr for 4 hours (8.4m drawdown). SWL 41.63m after drilling (26/2/1999) & 42.38m (25/8/2008). Service address is 39 Saint Vincent Avenue, Remuera 1050.
20578	[redacted]	63 Garvie Road, R D 3 Papakura 2583	12/12/2008 (PDP)	4.4	1782208	5895192	132	19.5	112	74.2	Waitemata	0-15m Clay (<4m) to silts (Tauranga to Weathered Waitemata), 15m-EOH Waitemata.	Domestic	Airlifted 11,300-11,168 gph at 65m for 4 hours (72 to 65 PSI). SWL 19.5m after drilling (4/5/1999).
20644	[redacted]	296 Appleby Road, R D 1 Drury 2577	1/09/2010	2.9	1775876	5892485	47	20.8	26		Kerikeri Volcanic (Possibly)?	No Log	Domestic & stock	
21048	[redacted]	19 Bullens Road, R D 2 Papakura 2582		4.8	1776240	5899070	37	n/a		83	Waitemata (Probably)?	No Log	Orchard irrigation	250m^3 maximum daily abstraction.
21049	[redacted]	100 Petersons Road, R D 2 Papakura 2582		3.3	1777180	5897870	60	n/a		18	Waitemata (Possibly)?	No Log	Domestic	22m^3 maximum daily abstraction.
21476	[redacted]	27 Middleton Road, R D 3 Papakura 2583	9/09/2010	2.1	1779792	5893892	216	n/a		40	Waitemata (Probably)?	No Log	Domestic & stock	Some calcium (hard). Service address is 34 Middleton Road, R D 3 Papakura 2583.
21607	[redacted]	92 Cherrington Road, R D 2 Papakura 2582		3.2	1780110	5896860	210	Dry		20	None	0m-EOH Clay with silt (Weathered Waipapa?).	Monitoring	
21817	[redacted]	198 Ponga Road, R D 4 Papakura 2584	9/09/2010	2.8	1775200	5893816	28	15.8	12	60.5	Kerikeri Volcanic	0-31m Clay (<4m) to silt (some basalt chips >6.1m) (Tauranga to Weathered Volcanics?), 31-59.8m Kerikeri Volcanic (basalt with scoriaceous interval 40.5-42.8m) & 59.8-EOH Fine sand (Waitemata?).	Irrigation, stock & domestic (2 houses)	Produced sand (spot grouted near 58m?). Airlifted 1,500 gph at 38m for 2 hours (35 to 18 PSI). SWL 17m two days after drilling (9/3/2003). ARC records bore depth of 132m (cased to 82m). Low water level shut down occurred last three summers.
21858	[redacted]	94 Ponga Road, R D 4 Papakura 2584	9/09/2010	3.1	1774846	5893779	22	14.8	7	177	Waitemata	0-19m Tauranga (peat >16m), 19m-50m Soft sandstone & conglomerates (21.5-35m) (Waitemata?) & 50m-EOH Waitemata (trace shell 70-82m).	Domestic & stock	Airlifted 10m^3/hr at 30m for 4.5hrs. Drawdown of 10.6m. SWL 15.4m after drilling (9/4/2003). Service address is 198 Ponga Road, R D 4 Papakura 2584.

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					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
21873	[redacted]	111 Garvie Road, R D 3 Papakura 2583	17/08/2010	4.0	1781813	5894798	163	45.0	117	90.3	Waitemata?	0-11m Clays (Weathered Waitemata?), 11m-EOH Waitemata (uncertain >69m).	Stock (chickens) & domestic (3 houses)	Pump setting & water level recorded by Parker Roy F & Son Ltd. Airlifted 1,800-1,840 gph at <71.5m for 2.25 hours (48 to 31 PSI). SWL 51.7m after drilling (15/4/2003). No sample below 72.8m. Abstraction between 4-12m³/day. Bio-security area.
21898	[redacted]	151 Hunua Road, R D 3 Papakura 2583	13/09/2010	2.0	1775814	5894838	48	8.3	39	68	Waitemata	0-9m Clay to silt with boulders (3-4m) (Landfill to Weathered Waitemata), 9m-EOH Waitemata (conglomeratic 13-14.5m & 25-34m).	Domestic & stock	Airlifted 2.1m³/hr at 40m for 4.5hrs. Drawdown of 21.2m. SWL 10.8m after drilling (1/7/2003). Abandoned first bore (1m west) encountered Te Kuiti Group (coal) near EOH (102m). Owner reluctant for visit (disclaimer required in future).
21920	[redacted]	168 Hamlin Road, R D 2 Papakura 2582	13/09/2010	4.3	1775696	5898327	55	27.5	27	61.8	Waitemata	0-15.5m Clays to silts (Weathered Waitemata?) & 15.5m-EOH Waitemata.	Formerly irrigation (nursery)	SWL 26m on 25/9/1987. Total abstraction of 74,744.6m³ (since drilled?). No contact details for owner. Tenanted (Hamlin Nurseries (Barbara Morris)).
22152	[redacted]	154 Ponga Road, R D 4 Papakura 2584	2/09/2010	2.9	1775118	5893626	31	16.8	14	81.9	Waitemata	0-9m Topsoil (<0.5m) to clays (Tauranga), 9-22m Marine sediments (Tauranga?), 22-30.5m Peat, clay & gravels (Tauranga?), 33-50m Rock (Kerikeri Volcanic?) & 50m-EOH Waitemata (no recovery >70.1m).	Irrigation & domestic (barn)	Produced 3.54m³/hr with test pump at 48.2m. SWL 16.6m day after drilling (21/10/2004). Owner resident in Australia. Service address is C/O Stuart Walker, 8 Raphoe Place, Ellerslie 1051. Owner indicated an old bore north of Hays Stream (N 37 Hunua Road) has been destroyed.
22390	[redacted]	638 Papakura Clevedon Road, R D 2 Papakura 2582		4.7	1777595	5899250	31	n/a		45	Waitemata (Probably)?	No Log	Stock	Location from bore permit 22124.
22391	[redacted]	638 Papakura Clevedon Road, R D 2 Papakura 2582		4.4	1777650	5898990	40	n/a			Waitemata (Possibly)?	No Log	Stock	Location from bore permit 22124.
22392	[redacted]	638 Papakura Clevedon Road, R D 2 Papakura 2582		4.4	1778030	5898980	39	n/a			Waitemata (Possibly)?	No Log	Stock	Location from bore permit 22124. Plots on 40 Church Road Ardmore.
22393	[redacted]	638 Papakura Clevedon Road, R D 2 Papakura 2582		4.2	1778300	5898800	40	n/a			Waitemata (Possibly)?	No Log	Stock	Location from bore permit 22124. Plots on 40 Church Road Ardmore.
23585 (& 23577)	[redacted]	777 Ponga Road, R D 4 Papakura 2584	12/12/2008 (PDP)	2.5	1777680	5892128	225	n/a			Waipapa (Possibly)?	No Log	Domestic	Two filters installed for iron problems. PDP bore N1. Single bore in area confirmed by M. McKeown.
23693 (N2)	[redacted]	160 Gillespie Rd, R D 3 Papakura 2583	12/08/2010	2.9	1780026	5892753	223	n/a			Waipapa (Possibly)?	No Log	Formerly stock	Not in use (broken-down). Tight hole located in old landslide. Significant iron. Current supply from springs & roofs.
27891	[redacted]	1893 Hunua Road, R D 3 Papakura 2583	18/08/2010	3.1	1780914	5893938	193	n/a			Waipapa (Possibly)?	No Log	Stock	Residence at 1883 Hunua Road.
27892	[redacted]	210 Jones Rd, R D 2 Papakura 2582	12/12/2008 (PDP)	3.4	1781113	5895542	254	n/a			Waipapa (Possibly)?	No Log	Stock & irrigation	Shared with neighbours.
27893	[redacted]	21 Patea Place, R D 2 Papakura 2582	11/12/2008 (PDP)	3.1	1776203	5897208	77	n/a			Waipapa (Probably)?	No Log		Owners denied having bore (but visible from neighbouring driveway).
27894	[redacted]	53 Awanui Rise, R D 2 Papakura 2582	11/12/2008 (PDP)	3.0	1776364	5897237	86	n/a			Waipapa (Probably)?	No Log	Currently not in use	Edwards' plan to get bore working in future.
27895	[redacted]	254 Settlement Road, Papakura 2110	11/12/2008 (PDP)	2.1	1776615	5896257	101	n/a			Waitemata (Probably)?	No Log		Owner not home (bore visible from drive).
27896	[redacted]	50 Awanui Rise, R D 2 Papakura 2582	11/12/2008 (PDP)	3.0	1776497	5897297	75	n/a			Waipapa (Probably)?	No Log		Owner indicated water pumped from spring only.

TABLE I-2: Hunua Well Survey (14/12/2010) - Bores considered to be within shallow groundwater

					Co-ordinates (NZTM 2000)									
ARC Bore ID (Labelled N if unavailable)	Bore Owner	Site Address	Date Visited	Distance from sump (km)	Easting	Northing	Ground Level (above msl)	Water Level (m bgl)	Water Level (elevation)	Total Bore Depth (m)	Aquifer Geology	Bore Geology	Uses	Comments
23694	[redacted]	37 Harry Dreadon Road, R D 4 Papakura 2584	2/09/2010	2.4	1776163	5892944	98	27.8	70	28.3	Kerikeri Volcanic (Possibly)?	No Log	Stock & domestic back-up supply (regular)	Bore depth, pump setting & water level recorded (2005) by Parker Roy F & Son Ltd. Takes 4 days to fill water tank (3000 gallon, 1-2 weeks use). Corroded casing. Possibly bore 4302.
27897	[redacted]	772 Papakura-Clevedon Road, R D 2 Papakura 2582	18/08/2010	4.0	1776363	5898356	52	n/a			Waipapa (Possibly)?	No log	Currently not in use	Service address is C/O John Murdoch, 864 Papakura-Clevedon Road, R D 2 Papakura 2582.
27898	[redacted]	111 Garvie Road, R D 3 Papakura 2583	17/08/2010	3.9	1781743	5895045	165	<38		71.88	Waitemata (Probably)?	No log	Stock & domestic back-up supply	Bore depth, pump setting & water level recorded by Parker Roy F & Son Ltd. Significant iron.
27899	[redacted]	161 Hamlin Road, R D 2 Papakura 2582	13/09/2010	4.3	1775661	5898304	53	n/a			Waipapa (Possibly)?	No Log	Currently not in use	Old bore with corroded casing. Service address is 34 Carrick Glen Avenue, Flatbush Manukau 2016. Tenanted (Paul Running & Hamlin Nurseries (Barbara Morris)).
27900	[redacted]	41 Jack Paterson Road, R D 4 Papakura 2584	9/09/2010	2.8	1775394	5893277	25	5.3	20	75	Waitemata?	0-12m Clay (Tauranga), 12-50m Mudstone (peat-timber 18-19m, carbonaceous 19-44m, conglomerate 44-48m & some timber >48m) (Tauranga to Waitemata?) & 50-75m basalt (soft) with thin ash layers (Waitemata?).	Domestic & stock	Airlifted 12m³/hr at 37.5m for 3hrs. Drawdown of 22.5m. SWL 7.5m after drilling (4/10/2006). Some calcium (hard). Abandoned old bore (4211?) approximately 11m ENE.
27901	[redacted]	752 Papakura Clevedon Road, R D 2 Papakura 2582	8/09/2010	4.0	1776599	5898378	51	24.1	27	>24.7	Waitemata (Possibly)?	No Log	Abandoned	Residence on Ohiwa Road. Old bore (collapsed?). Dirty water. Service address is PO Box 2721722, Papakura 2244.
27902	[redacted]	2008 Hunua Road, R D 3 Papakura 2583	18/08/2010	4.3	1782110	5894481	124	2.4	122		Waipapa (Possibly)?	No Log	Stock & pool	Significant iron & some sediment (increasing). Two possible old shallow wells.

Note:

1) *Information obtained from ARC databases, responses to mail-out to residents of Ponga Road and consultation by Winstone Aggregates.*
2) *Recorded bores within 5km of Hunua Pit east of Drury Fault and 3km west of Drury Fault. Refer separate spreadsheet for outstanding bore permits.*
3) *Locations of unvisited bores are approximate and may be on nearby properties with different ownership.*