TECHNICAL MEMORANDUM

PROJECT NO.: WGA211193
DATE: 15 APRIL 2025

COMPANY NAME	Brymer Farms
ATTENTION	Sanjil Mistry
SUBJECT	Outline of Hydrogeological Assessment for Fast track

1. PROJECT DESCRIPTION

The proposed project for which a fast-track application is being applied for is the consenting and construction of:

- Brymer housing development
- The operation of groundwater bores for domestic drinking water supply
- Stormwater infrastructure
- Wastewater treatment and disposal infrastructure

The purpose of this project is to provide the necessary infrastructure pertaining to drinking water supply, stormwater management and wastewater management. This is to enable residential development at Brymer Road.

Brymer is a residential development that comprises circa 1,650 residential units of varying typologies, such as detached, duplexes, terraces, apartment units and retirement village units, along with a supporting mixed-use neighbourhood centre, open spaces, and infrastructure. The Brymer Masterplan is shown in Figure 1 and contained within the Urban Design Memorandum.

The residential community is underpinned by a series of design principles, which focus on creating a well-connected, legible and diverse community on Hamilton City's urban fringe. The proposed transport network, with a 20-metre-wide spine road running north-to-south, is supported by local roads, cycle connections and pedestrian pathways to create an accessible and legible development. As aforementioned, a range of housing typologies and densities are proposed to meet the growing and changing needs of the housing market to ensure there are options for future residents. Each typology has been thoughtfully located, based on opportunities and constraints, with density ranging from terraces, duplexes and standalone dwellings to ensure integration with the adjoining urban footprint.

In the heart of Brymer is a 0.3-hectare mixed-use neighbourhood centre that will provide a range of amenities and services to support the residential development. This mixed-use neighbourhood centre will likely include commercial properties, cafés and a local superette. Apartment units are provided above the neighbourhood centre. The commercial element of the residential development has been scaled to support the density proposed, located directly adjacent to the majority of apartment building typology. Sitting at the higher, northern point of the site is a retirement village, which comprises approximately 3.4 hectares, and provides villa terraces, apartment units and an amenity building. This will be serviced by its own private transport network, infrastructure, and high amenity open spaces.

Integrated throughout the residential development are a number of open spaces that are well distributed to create a highly amenable community that will be a pleasant and enjoyable place to live for future residents. The open spaces support ecological restoration through the retention of a number of natural wetlands and riparian revegetation. The development will be appropriately serviced via a robust infrastructure strategy, which includes a new pump station, wastewater discharge and treatment area, stormwater ponds, and utilisation of the existing water bores.

Figure 1: Brymer High-level Masterplan

2. INTRODUCTION

The hydrogeological assessment is for the following activities at the Brymer subject site:

- The operation of two Production Bores to provide temporary domestic water supply for the residents of the Brymer development.
- The construction and on-going effects of stormwater management infrastructure.
- The construction and on-going effects of wastewater treatment and disposal Infrastructure.
- General construction for excavations below the water table.

The site has a shallow groundwater table that is connected to existing important surface water bodies (i.e., lakes and natural wetlands). Therefore, a detailed assessment is required to ensure that the effects of the proposed urban development are acceptable. The types of activities required to establish the necessary infrastructure for the Brymer development that may result in effects on groundwater and connected wetlands are listed in Table 1.

The proposed activities are relatively standard for land development projects in the Hamilton area. Commonly used monitoring and mitigation measures could be used at the site, such as groundwater monitoring bores, changes to drainage methods, reductions in pumping rates and reductions in hydraulic connections to reduce potential effects in sensitive areas.

Table 1: Activities which Require Resource Consent and Affect Hydrogeology

ACTIVITY	TECHNICAL ASSESSMENTS REQUIRED	CONSENTS
Drinking Water Infrastructure		
Abstraction of Groundwater for domestic water supply	Groundwater/hydrogeology including effects on surface waterbodies/wetlands, other groundwater users.	Controlled activity under WRP Rule Section 3.
Stormwater Management Infrastructure		
Temporary and permanent diversion of surface water	Groundwater/hydrogeology including effects on wetlands and settlement	Discretionary Activity under WRP Rule 3.6.4.13 Discretionary Activity under Regulation 45 of the NESFW
Permanent damming and diversion of groundwater (changes to groundwater flows resulting from creation of the stormwater infrastructure)	Groundwater/hydrogeology including effects on surface water bodies/wetlands, other groundwater users, mobilisation of contaminants, and settlement. The stormwater infrastructure may permanently lower the local water table, therefore requiring consent for a groundwater diversion.	Discretionary Activity under WRP Rule 3.6.4.13 Discretionary Activity under Regulation 45 of the NESFW
Temporary water takes during construction for dewatering/lowering of the groundwater table	Dewatering during construction to lower the groundwater table or maintain a dry environment within excavations may be undertaken using spears. The take will be classified as a groundwater take and will require an assessment of the effects on aquifer sustainability, other bore users, and surface water bodies (including wetlands), mobilisation of contaminants, ecological and cultural effects.	Controlled activity under WRP Rule 3.8.4.7 (drilling) Discretionary Activity under WRP Rule 3.3.4.24 (groundwater take)
Construction of specified infrastructure including earthworks and clean fill disposal	Groundwater/hydrogeology including effects on wetlands.	Discretionary Activity under Regulation 45 of the NESFW
Geotechnical and groundwater investigations	There will be a need to facilitate further groundwater and geotechnical investigation and monitoring to obtain additional information and to monitor the impact of the works on groundwater levels. This will occur prior to works, during works, and post-works.	Controlled Activity under WRP Rule 3.8.4.7 (drilling) Discretionary Activity under WRP Rule 3.3.4.24 (groundwater take) Controlled Activity under WRP Rule 3.6.8.2 (well and aquifer testing discharges)
Wastewater Treatment and Disposal Infrastructure		
Permanent damming and diversion of groundwater (changes to groundwater flows resulting from creation of the wastewater treatment and disposal infrastructure)	Groundwater/hydrogeology including effects on surface water bodies/wetlands, other groundwater users, mobilisation of contaminants, and settlement. The stormwater infrastructure may permanently lower the local water table, therefore requiring consent for a groundwater diversion.	Discretionary Activity under WRP Rule 3.6.4.13 Discretionary Activity under Regulation 45 of the NESFW
Temporary water takes during construction for dewatering/lowering of the groundwater table	Dewatering during construction to lower the groundwater table or maintain a dry environment within excavations may be undertaken using spears. The take will be classified as a groundwater take and will require an assessment of the effects on aquifer sustainability, other bore users, and surface water bodies (including wetlands), mobilisation of contaminants, ecological and cultural effects.	Controlled activity under WRP Rule 3.8.4.7 (drilling) Discretionary Activity under WRP Rule 3.3.4.24 (groundwater take)

ACTIVITY	TECHNICAL ASSESSMENTS REQUIRED	CONSENTS
Construction of specified infrastructure including earthworks and clean fill disposal	Groundwater/hydrogeology including effects on wetlands.	Discretionary Activity under Regulation 45 of the NESFW
Treatment and disposal of wastewater	The potential effects of discharging treated wastewater will need to be assessed. This required assessment will need to assess effects on surface water bodies/wetlands and other groundwater users.	Controlled Activity under WRP Rule 3.5.7.5

3. BACKGROUND

A high-level desktop review of the hydrology of the Brymer Site is documented in WGA (2021) (Appendix A). Overall, the review outlines that at the Brymer property the ability to use soakage to reduce stormwater run-off volumes is limited due to the relatively shallow groundwater located in the lower areas of the proposed development site, and the presence of lower permeability clays in the near surface. Potential flooding effects downstream of the proposed development will require assessment through detailed hydrological and hydraulic modelling. Significant effects on groundwater recharge are not anticipated based on this high-level desktop assessment.

Initial investigatory geotechnical drilling of the Brymer property by Tonkin and Taylor (2021) shows that low-lying areas of the site are characterised by shallow groundwater levels, low permeability soils and a well-established drainage network. Groundwater under the low-lying hills at the site was generally not evident from CPT test holes due to collapse of the holes. One bore hole (BH101) showed groundwater level at 15 m below ground level (bgl), which is equivalent to 30.5 m above mean sea level (m RL) (Tonkin and Taylor 2021).

The geotechnical investigation information also indicated that the peatland within the site boundary was once a large ombrotrophic bog with a smaller portion to the south once part of a fen complex. The peatland is being actively drained and there is evidence of ground settlement.

WGA has supervised the construction and aquifer testing of two Production Bores targeting the deeper confined aquifer at the site. WGA has determined that these two bores are capable of providing domestic water supply for the Brymer development.

The Brymer property is just outside the Integrated Catchment Management Plan (ICMP) area for Rotokauri. Given the proximity to the Rotokauri catchment, similar water management conditions are expected. The Rotokauri ICMP states:

“Maintaining natural hydrology

Stormwater and land drainage systems are designed, operated and maintained so that the post-development hydrological cycle is as close as practicable to the predevelopment situation and ensure:

i. groundwater levels in peat soils are sustained

ii. wetland function and health is protected

iii. base flows in freshwater receiving environments are maintained

iv. peak flow rates and extended flow volumes do not adversely affect receiving water bodies.

Wastewater management

Wastewater generation is minimised and wastewater discharges are managed to avoid potential adverse effects on Hamilton City Council’s existing infrastructure network or the natural environment.”

4. KEY HYDROGEOLOGICAL EFFECTS TO BE ASSESSED

The key groundwater effects to be considered in the hydrogeological assessment include:

Drinking Water Supply

- Groundwater drawdown effects from operating the water supply bores on nearby groundwater users', streams and wetlands.

Earthworks and Stormwater Network

- Groundwater seepage inflows into any temporary work excavations and any associated dewatering activities.
- Groundwater drawdown effects from the works, including potential effects on existing road infrastructure and wetlands (i.e., lowering the water table in the vicinity of a wetland can impact the wetland hydrology).
- Effects from disposal of the pumped groundwater.
- Potential groundwater mounding effects of any soakage system or constructed wetland.

Onsite Wastewater Treatment and Disposal

- Groundwater seepage inflows into any temporary work excavations and dewatering activities.
- Effects from the disposal of treated wastewater.

5. METHODOLOGY FOR THE GROUNDWATER ASSESSMENT

The Brymer area has been under investigation in terms of hydrogeological conditions since 2021. As outlined in Section 3, a combination of shallow and deep groundwater investigations has been undertaken. This existing knowledge and information will be used as a foundation for more refined focused assessment of the effects of construction of the urban development.

WGA have been involved in modelling groundwater effects for the recent excavations for nearby residential developments, Rotokauri Rise and Rotokauri Greenway. The information gained at these nearby sites will be applied to the assessment. In addition, WGA staff have been highly involved in reviewing groundwater effects of the recently completed Waikato Expressway – Hamilton Section.

5.1 Drinking Water Supply

In 2023, WGA undertook a groundwater drawdown assessment associated with the operation of the two on-site groundwater bores for potable supply to the future development (Appendix B). Since the assessment in 2023, three new bores have been drilled within a 2 km radius of the bores. WGA has undertaken an additional assessment to include the three additional bores). The updated assessment shows that the effects on these newly constructed bores will also be less than minor. This assessment assumed that there will be 2,500 dwellings at the Brymer development. WGA understands that only 1,650 dwellings are proposed. Less dwellings will result in a corresponding reduction in water requirements and associated groundwater drawdown effects.

5.2 Earthworks and Stormwater Network

WGA proposes collaborating closely with geotechnical specialists and design engineers to build upon current groundwater knowledge and provide guidance for additional testing of the local hydraulic properties. Once the underlying local soil hydraulic properties are ascertained WGA will then be able to assess the potential mounding effects of any planned soakage systems within the stormwater management network. Given the high groundwater levels and expected low permeability of the shallow soils, WGA proposes using the MOUNDSOLV software package developed by HydroSOLVE to assess potential groundwater mounding effects of the planned soakage systems.

Additionally, once local soil hydraulic properties are ascertained the potential dewatering effects of any construction activities that require the excavations below the water table can be assessed. WGA proposes to use a combination of analytical tools such as trench models and pit models to assess temporary and long-term groundwater drawdown as a result of any construction activities that require excavations below the water table. Additionally, WGA can build upon these models to undertake 2D finite element groundwater modelling if deemed required for excavations conducted in sensitive areas.

Once mounding and groundwater drawdown risk has been analyzed, WGA propose that a monitoring plan will be developed to ensure any potential groundwater drawdown or mounding linked to potentially significant impacts can be detected and mitigated before these impacts arise.

Building upon this monitoring plan, mitigation measures will be developed and documented so that they may be put in place to reduce any calculated groundwater drawdown at the site both during the construction period and following completion of the earthworks, including for example:

- Design, installation and monitoring of groundwater level measurement systems.
- Options to modify dewatering systems to reduce the magnitude and extent of groundwater drawdown.
- Optimize pumping rates and incorporate transient adjustments in pumping rates.
- Returning pumped water to ground in areas where drawdown may lead to excessive ground settlement or other impacts.
- Reduction in hydraulic connections between groundwater and surface water bodies to reduce the effects of drawdown in sensitive areas.

5.3 Onsite Wastewater Treatment and Disposal Infrastructure

WGA proposes to assess the effects of the planned wastewater treatment and discharge facilities by undertaking attenuation modelling using microbial removal rates documented in Pang (2009). WGA proposes to use *E.coli* and rotavirus in the attenuation modelling as these are less likely to be removed by natural attenuation compared to other pathogens.

Once the groundwater quality risk from the wastewater treatment and discharge facilities have been assessed, WGA propose that a monitoring plan will be developed to ensure groundwater is not affected by any wastewater discharge.

If excavations below the water table are required for the construction and operation of the wastewater treatment and disposal infrastructure, WGA will assess these using the same methods proposed for the dewatering associated with the stormwater infrastructure and detailed in Section 5.2. WGA propose that a similar groundwater monitoring plan will be developed to ensure any potential groundwater drawdown or mounding linked to potentially significant impacts can be detected and mitigated before these impacts arise.

6. CONCLUSION

Based on WGA's experience and the information which has been received and known to date, WGA can see no reason why the following development could not proceed under a fast-track application, as the effects on the environment can be managed with suitable conditions.

7. QUALIFICATIONS AND EXPERIENCE

7.1 Clare Houlbrooke – Principal Hydrogeologist, Project Lead

Clare is a Principal Hydrogeologist (BSc, MSc (Hons) Earth Sciences) with more than 20 years' experience in hydrological resource investigations. Clare's focus is sustainable management of groundwater resources and connected surface water systems. Clare has worked in two regional councils as a Groundwater Scientist over a 9-year period and as a consultant has continued to support regional councils with the review of groundwater related resource consent applications, including reviewing the groundwater effects of the recently completed Waikato Expressway. Clare has been based in the Waikato for 11 years and has in-depth knowledge of the local hydrogeological conditions. She has prepared and presented evidence in regional council resource consent hearings and in Environment Court as an expert witness.

7.2 Brett Sinclair – Senior Principal Hydrogeologist, Project Reviewer

Brett is a Principal Hydrogeologist (BSc, MSc Geology) with more than 30 years' experience in hydrogeology, geology, water management, water quality assessment and environmental effects mitigation. He specialises in the evaluation, utilisation, management, and protection of groundwater resources and groundwater-dependent surface water resources. Brett provides specialist hydrogeological support for geotechnical assessments including major civil infrastructure projects. He has undertaken numerous peer reviews of applications for site dewatering and infrastructure construction projects on behalf of regulatory authorities.

7.3 Catherine Howell – Senior Hydrogeologist, Technical Assessments

Catherine is a Hydrogeologist with a Masters in Groundwater Studies and over 15 years of experience in the United Kingdom, Australia and New Zealand. Catherine has gained experience in hydrogeological investigations through roles in both regulatory bodies and consultancy. Her hydrogeological assessment experience includes pump test analysis, regional scale water assessments, water quality monitoring, and project management. Catherine has prepared technical assessment of effects for other nearby construction works within the Rotokauri development area including effects of dewatering and soakage.

8. REFERENCES

Pang, L. (2009). Microbial removal rates in subsurface media estimated from published studies of field experiments and large intact soil cores. Journal of Environmental Quality. 38, American Society of Agronomy, Crop Science Society of America, Soil Science Society pp. 1531–1559.

Tonkin and Taylor (2021). Preliminary Geotechnical Assessment Report. Brymer Farms, 584 Whatawhata Road, Hamilton. Report number 1017075.

WGA. (2021). Byrmer Ridge Hydrology Review High-Level Desktop Groundwater Assessment. Report No. WGA211193-RP-HY-0001_B.

WGA. (2023). Brymer Farms Groundwater Assessment. Pumping Test Analysis and Effects Assessment. Report No. WGA211193-RP-HY-0003_B.

Yours Sincerely

Catherine Howell
Senior Hydrogeologist
WALLBRIDGE GILBERT AZTEC

APPENDIX A - BRYMER RIDGE HYDROLOGY REVIEW
APPENDIX B - BRYMER FARMS GROUNDWATER ASSESSMENT

APPENDIX A - BRYMER RIDGE HYDROLOGY REVIEW

WALLBRIDGE GILBERT AZTEC

Brymer Ridge Limited

Brymer Ridge Hydrology Review

Revision History

Rev	Date	Issue	Originator	Checker	Approver
A	22/7/2021	Draft to Maven	CHO	BAS	CHO
B	15/9/2021	Final	CHO	Maven	CHO

CONTENTS

Figures

1 INTRODUCTION

1.1 BACKGROUND

Brymer Ridge Limited (Brymer Ridge) is investigating a potential urban development called Brymer Ridge (the site), located between Brymer Road and Whatawhata Road on the western side of Hamilton. Brymer Ridge is investigating the possibility of constructing 1,800 dwellings on the northern section and 700 on the southern section of the site. The northern section of the site conceptually comprises:

- 700 medium density lots,
- 350 retirement village units,
- 400 dwellings in comprehensive development consisting of small standalone or duplex units,
- 350 dwellings in terrace housing.

The Southern section of the site conceptually comprises:

- 700 units in terrace housing and low-rise apartments.

WGA understands that Brymer Ridge is intending to make a presentation on the proposed development to the “Future Proof” group, who are looking at development potential around the edges of Hamilton’s urban area. Future Proof is a joint project set up to consider how the sub-region should develop into the future. The partners in Future Proof include Ngā Karu Atua o te Waka, Waikato-Tainui, Tainui Waka Alliance, Waikato Regional Council, Waipa District Council, Waikato District Council, Hamilton City Council, Waka Kotahi and Waikato District Health Board.

1.2 SCOPE OF SERVICES

Wallbridge Gilbert Aztec (WGA) has been retained by Brymer Ridge to:

- Prepare a high-level desktop assessment review of the relevant plans, designs and geotechnical information in relation to the hydrogeological and hydrological setting.
- Undertake a high-level assessment on the potential for a bore water supply to the proposed suburban development area (Brymer Ridge) together with comments on potential issues, constraints, and opportunities.

WGA has undertaken the following tasks and documented the results in this report:

- A review of the relevant plans, designs and geotechnical information in relation to the hydrogeological and hydrological setting. This review includes a high-level desk top assessment by WGA’s wetland specialist of the proposed Brymer wetland.
- A high-level assessment of the potential for groundwater supply based on nearby bore information.

2 HYDROLOGICAL ASSESSMENT

2.1 GEOLOGICAL AND HYDROGEOLOGICAL SETTING

The Hamilton Basin is a large tectonic basin centred on Hamilton City with an area of approximately 2,000 km^2 and traversed by the Waikato River. The basin is surrounded by ranges of Mesozoic (Manaia Hill Group) and Tertiary age (Te Kuiti and Waitemata Groups) rocks. At depth, basement greywacke underlies the sedimentary deposits that infill the basin (GNS 2005).

The basin is infilled with Tauranga Group alluvial sediments, dating from the Pliocene to the middle Holocene. Underlying the low hills are older ignimbrites, tephra fall deposits and alluvium of the Walton Subgroup (Figure 1; Lowe 2010). The Tauranga Group sediments are up to 300 m thick and include gravels, sands, silt, muds and peats of fluvial, lacustrine and distal ignimbritic origin. The Hinuera Formation of the Tauranga Group underlies much of the Hamilton basin. This formation was deposited by braided river systems of the Waikato River, initiated by the supply of large volumes of sediment from volcanism in the Taupo Volcanic Zone (Petch 1987).

Overlying the Tauranga Group deposits of the Hamilton Basin are late Holocene unconsolidated alluvial and colluvial sediments. In the low lying area at the site, Hinuera Formation sediments are overlaid by recent Holocene soft, dark brown to black, organic mud, muddy peat and woody peat deposits (GNS 2005).

The Hinuera Formation contains the aquifers used most extensively for water supplies across the Hamilton Basin. Within this formation, the most productive aquifers consist of well sorted coarse sands and gravels. Discontinuous sequences of rhyolitic and pumiceous gravelly sands and gravels are interspersed with pumiceous silt, clay and peat layers. Lithological variability generally results in a number of zones of higher permeability within the formation rather than a single, continuous aquifer (Figure 1; Schofield 1972). The upper layers contain perched aquifers that tend to drain to the closest gully system and can dry out over the summer period.

Literature values for the hydraulic conductivity of sediments in the Hamilton Basin range from 0.5 m/day in the silt and peat layers to 13.5 m/day in the course gravelly sands. Aquifer transmissivity values derived from pumping tests range from 10 m^2/day to 1,000 m^2/day but are generally less than 100 m^2/day. The deeper aquifers have variable aquifer properties and local pumping tests near the site have resulted in transmissivities calculated at between 10 m^2/day and 120 m^2/day. Aquifer storativity values vary from 0.001 for deep, confined or semi-confined aquifers to 0.1 for shallow, unconfined aquifers in the Hamilton Basin (Petch and Marshall 1988). In some areas these discontinuous aquifers may provide bore yields of up to 30 L/s (Petch 1987). Flow rates from bores located near the site are described in Section 2.3.

Regional groundwater flows in the area of Hamilton are generally towards the northwest, from the basin edges to the southeast. Major groundwater discharges occur into the Waipa River and the Waikato River and their tributaries that are located in deeply incised gullies (Petch and Marshall 1988).

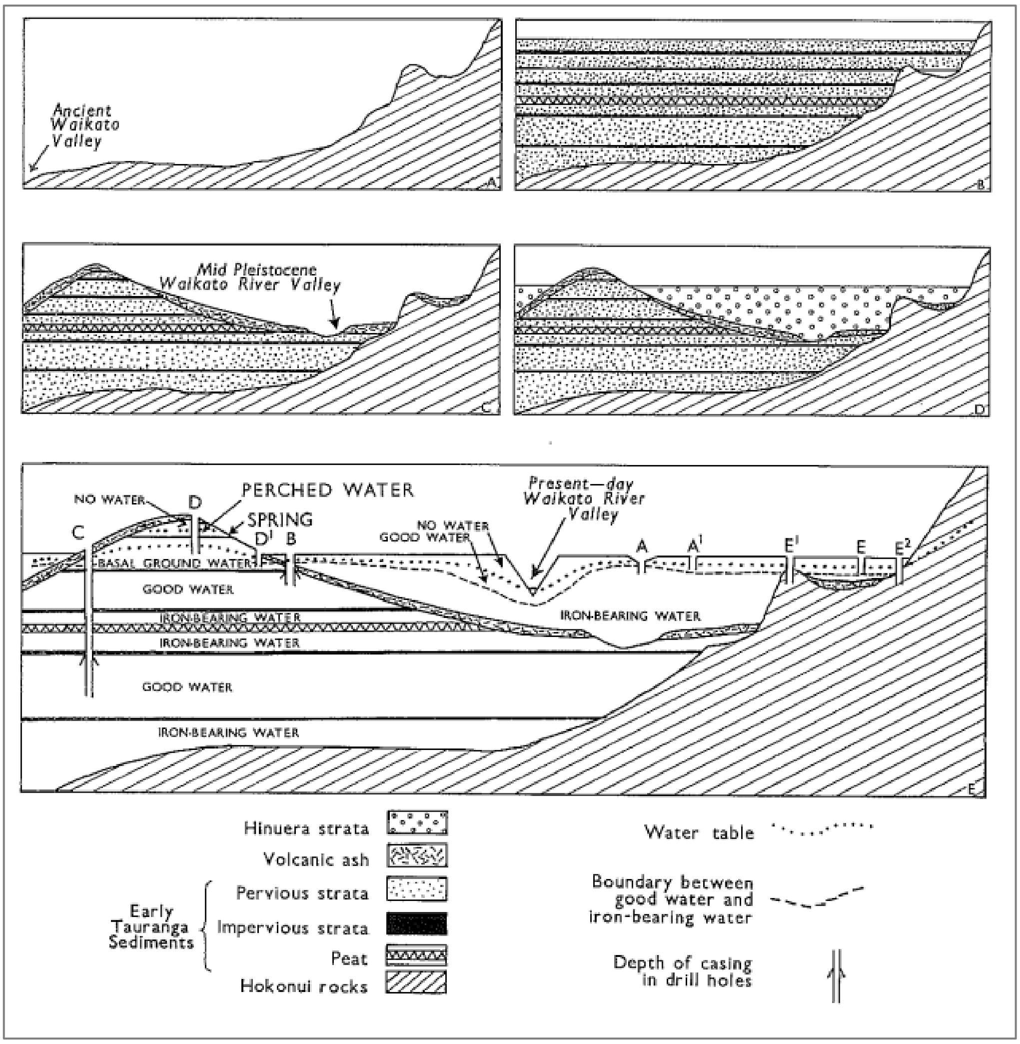

Figure 1: Simplified Geological History and Formation of Local Aquifers (Schofield 1972).

2.2 GROUNDWATER LEVELS

From the initial geotechnical investigation drilling, groundwater levels under the low-lying hills (Walton Group) were generally not evident from CPT test holes due to collapse of the holes. One bore hole (BH101) showed groundwater level at 15 m below ground level (bgl), which is equivalent to 30.5 m above mean sea level (m RL)(Tonkin and Taylor 2021). One area of ponded water was observed on aerial photographs, which could be a seepage feature located in a topographic low point. Shallow groundwater levels in the Waikato Region are currently lower than usual due to low rainfall recharge over the past two years. Therefore, some seepage features associated with perched aquifers within the Walton Subgroup sediments may currently be dry or have lower than normal seepage rates.

In lower lying areas of the site the groundwater level was observed to be within 0.4 m to 0.7 m bgl, which is equivalent to 24.5 to 24.8 m RL (Tonkin and Taylor 2021). This shallow unconfined groundwater is considered to have been recharged from on-site rainfall. In other rainfall recharged areas of Hamilton (Silverdale), groundwater levels during January 2021 have been observed to be approximately 0.7 m below typical summer levels. A significant drainage network is present across the low-lying area of the site and extending into neighbouring properties.

Given the shallow groundwater levels in the low-lying areas and low permeability of the underlying shallow clay-rich sediments, downward soakage is likely to be very limited. The peat and clay soils underlying the low-lying areas of the site offer several options for wetland development, as described in Section 4 of this report.

Artesian groundwater pressures, where the measured pressure is above the ground surface, were observed in some of the deeper drill holes and exploration holes drilled to a depth of 15 m to 18 m bgl. These pressures are considered to arise from the aquifer underlying the surrounding hills being confined by clay-rich layers which restrict the release of groundwater from the aquifer.

2.3 GROUNDWATER QUANTITY

Current groundwater use and historical flow testing information provides some indications on the potential flow rates from production bores. As most local bores (within five kilometres) have targeted domestic supply quantities, they have been designed to meet smaller demands and only been tested at rates up to 150 m^3/day.

Within a wider area (within ten kilometres) there are three larger abstractions for irrigation. These three irrigation consents are:

- A resource consent (AUTH140833.01.01) to take 1,050 m^3/day for irrigation, held by Pandarosa Farms Limited.
- A resource consent (AUTH140211.01.01) to take 1,200 m^3/day for irrigation, held by Grayling Agriculture Limited.
- A resource consent (AUTH137525.01.01) to take 1,200 m^3/day for horticultural irrigation, held by Savannah Holdings Limited.

2.4 GROUNDWATER QUALITY

The local aquifers contain some areas where the groundwater is characterised by elevated dissolved iron concentrations. Dissolved iron concentrations vary between aquifers (Figure 1) and laterally within the same aquifer. The iron concentrations in water from a targeted aquifer will not be known until test bores are drilled and samples taken. Dissolved iron causes staining and taste effects but is not considered a health risk in potable water supplies. Removal of iron through water treatment is not a complicated process and usually involves aeration followed by filtration. Sometimes the process can also involve increasing the pH, chemical oxidation followed by filtration, greensand filters or ion exchange.

Groundwater abstracted from deeper bores is characterised by low nutrient concentrations, which is beneficial as elevated nutrients can be problematic with respect to complying with the drinking water standards. For example, nitrate removal through water treatment is costly. It is generally easier and more cost effective to target deeper aquifers with low nutrient concentrations in the water, even if the water in these aquifers has elevated dissolved iron concentrations.

2.5 CATCHMENT MANAGEMENT

The site is drained by a tributary of the Ohote Stream, which flows into the Waipa River. The Brymer Ridge property is just outside the Integrated Catchment Management Plan (ICMP) area for Rotokauri. Given the proximity to the Rotokauri catchment, similar water management conditions are expected. The Rotokauri ICMP states:

Maintaining natural hydrology

Stormwater and land drainage systems are designed, operated and maintained so that the post-development hydrological cycle is as close as practicable to the predevelopment situation and ensure:

i. groundwater levels in peat soils are sustained

ii. wetland function and health is protected

iii. base flows in freshwater receiving environments are maintained

iv. peak flow rates and extended flow volumes do not adversely affect receiving water bodies.

Wastewater management

Wastewater generation is minimised and wastewater discharges are managed to avoid potential adverse effects on Hamilton City Council's existing infrastructure network or the natural environment.

2.6 HYDROLOGICAL SETTING

The site is located within the Ohote sub-catchment, which flows into the Waipa River. Based on NIWA modelled flows, the Ohote Stream has a modelled median flow of 50 L/s and a mean flow of 75 L/s at the site. The Ohote sub-catchment covers an area of 18.53 ha. The catchment is part of the Waikato Central Drainage Scheme: Ohote Basin.

Modelling undertaken by NIWA on regional surface water flows indicates that the Ohote Channel 01 has a mean annual low flow of approximately 14 L/s. On average, approximately 13 events occur annually when the flow exceeds three times the median flow.

The low-lying area of the site and in adjacent site to the southeast has been subjected to intensive drainage to support pasture development. The central drain, which forms part of the site boundary, is named the Ohote Channel 01. A second major drain, the Yates drain, flows into the Ohote Channel 01 from the south, with the confluence located at the southern boundary of the site. The Yates drain appears to have a larger contributing catchment upstream from the confluence than the Ohote Channel 01. The drainage scheme has flood control systems and a network of stop banks on the channel downstream from the site.

In terms of maintaining the natural hydrological cycle, as is sought in the neighbouring Rotokauri Catchment, the proposed development is not expected to significantly affect recharge to groundwater. The hilly area within the site is relatively steep with most rainfall reporting to local streams and drains as run-off. Furthermore, the confined shallow aquifers under the lower slopes are characterised by artesian groundwater pressures, which means natural recharge to these areas will not occur under current conditions. Therefore, these hilly areas are not considered to be significant recharge areas for the local aquifer under current conditions. The additional runoff due to additional paved surfaces will require a stormwater management plan.

The low-lying area of the site is characterised by a shallow groundwater level, low permeability soils and a well-established drainage network, which would collectively limit recharge to the local shallow groundwater system. Therefore, the proposed changes to the low-lying area of the site are not considered to present a significant issue in reducing groundwater recharge.

The low-lying area of the site extends past the boundary of the proposed development area toward the west (Ohote catchment). Additionally, the neighbouring property to the southeast also contains a significant low-lying area bounding the site along Ohote Channel 01. A plan to manage risks of off-site flooding will be needed to support the proposed development. Detailed hydraulic modelling may be required to meet future resource consent requirements.

The use of soakage to reduce stormwater volumes discharging to Ohote Stream is considered to be limited due to:

1. The relatively shallow depth to groundwater under the low-lying areas of the site.
2. Shallow soils under the low-lying and some of the hilly areas of the site consisting of lower permeability clays.
3. Artesian groundwater pressures in aquifers under the lower hillslopes.

3 POTENTIAL FOR GROUNDWATER SUPPLY

3.1 OPPORTUNITIES

If we consider the average water requirement as 600 litres per person per day average (MfE 2007), a bore that can produce 1,200 m^3/day (1,200,000 L/day) is equivalent to an average supply for 2,000 people. MfE (2007) outlines that peak demand rates can be variable and are not consistent throughout New Zealand. They recommend storage of treated water to meet short-term peak demands. If the option of groundwater supply is to be further investigated, the average and peak daily water demands in Hamilton should be investigated further.

Using bores for a water supply could provide a “transition” option for a future development area, to supply water for the initial stages of the development. This would enable the proposed development to start while waiting for the Hamilton town network to be developed to a standard to support the new subdivision areas.

Aquifers provide natural water storage in comparison to artificial surface water storage reservoirs. This capacity can be utilised through installing bores that will be less affected by climate fluctuations and summer low flow conditions as experienced in rivers and streams in summer.

In terms of costs and timing of a water supply set up, it is cheaper and quicker to install a bore (short vertical pipe) compared to long distribution pipelines. Additionally, one or more connection points to the town network would need to be identified through which an appropriate volume and pressure of water could be supplied.

Aquifers also offer increased water supply security from surface events that might disrupt a water supply take from the Waikato River (e.g. volcanic eruptions, spills). Therefore, the infrastructure could potentially be promoted to the Hamilton City Council as a future back up supply system in case of emergency when presenting the plans to council.

3.2 REQUIREMENTS

Based on the available information from nearby bores, it appears that multiple water supply bores would be needed to provide the volumes required to meet the potential demand from a development of this size. These bores could be strategically positioned to allow for future connection to the Hamilton City Council supply network.

Local water treatment would be required for pathogens and potentially iron through standard water treatment systems. These treatment systems can be designed based on initial water testing results from test bores.

Higher water flow rates are expected to be needed to meet peak use demands. Local storage of treated water may be required to match the expected peak rates. Further investigation onto the peak and average rates is recommended.

Regular local water testing and treatment system operation and maintenance will be required for the water supply at each of the bore sites. This will be an operational cost and responsibility that may be delegated once the system has been installed.

Overall, based on our high-level review of the available information, it appears that new water supply bores could potentially provide a transitional supply to enable initial development of the Brymer Ridge land development area. These bores could then provide a supplementary supply for the development and for the wider Hamilton area if required into the future. Further investigation is recommended to refine the areas for exploratory drilling and carry out test drilling to determine flow rates and water treatment requirements.

4 PEATLANDS AND WETLANDS

4.1 EXISTING ENVIRONMENT

4.1.1 Introduction

As detailed in the geotechnical report for the Brymer Ridge development area the low-lying areas of the proposed development are underlain by between one and eleven metres of peat. The areas with a significant thickness of peat are planned to be utilised for utility, recreation, alternative development. There are opportunities to enhance the hydrology of the peatland while managing the runoff from the development in terms of stormwater management.

Peatlands are freshwater wetlands whose vegetation produces peat (a dark to brown organic substrate with high contents of organic carbon). These wetland types include ombrotrophic bogs, fens, swamps, marshes and Pakihi. Peatlands are of exceptional conservation value because of their biodiversity, importance in biogeochemical cycling and function in retaining flood waters. As these ecosystems accumulate organic matter from plants in the form of peat, they serve as carbon sinks. Thus, making them one of the most effective ecosystems for storing soil carbon (Adhikari et al. 2009). The dense carbon stores in peatlands are the result of slow peat accumulation under saturated conditions that has been taking place for thousands of years as the climate warmed following the last ice age (Yu et al., 2010).

The mechanisms responsible for carbon storage in peatlands rely on high water tables close to the surface to maintain anaerobic conditions. Lowering of the water table exposes the peat layers to aerobic conditions, under which microbes break down the high organic content of the peat and convert it into carbon dioxide (Figure 2). Drained peat shrinks physically as well as being oxidised. As the soil compacts and mineralises, the land surface settles. Thus, settlement and carbon dioxide release occur when the hydrological integrity of a peatland is compromised.

4.1.2 Historical Extent of Wetland and Remaining Peat Layers

New Zealand has lost over 90% of its historic wetlands since Europeans arrived 150 years ago (Ausseil et al. 2008) and wetlands continue to be drained and degraded (Denyer and Peters 2020). Across New Zealand, peatlands cover around 240,000 ha and the Waikato region contains about half of this total. However, around two-thirds of these systems have been drained for livestock grazing (Denyer and Peters 2020).

The proposed area for development intersects an area that what once dominated by two different categories of wetland type: 1) ombrotrophic bog, and 2) largely fen system with a mosaic of swamp and bog (Figure 3; MFE 2015). The area once dominated by these wetlands is now maintained by drainage for grazing, with the peat deposits remaining under the topsoil.

Ombrotrophic bogs are systems that accumulate thick peat layers. They are hydrologically recharged by rainfall only and as a result have low nutrient levels. The groundwater table is at or just below the surface and remains relatively constant (Figure 4).

Fens have a predominantly peat substrate, and the peat is shallower and more decomposed than bog systems. Fens are recharged by both rainfall and groundwater, resulting in low to moderate acidity and nutrient conditions. The water table is just below the peat surface with noticeable fluctuations (Figure 4).

Swamps are typically a combination of mineral soils and well decomposed peat. Like fen systems they are fed by groundwater, rainwater and partly by surface water. However, the nutrient conditions tend to be high and often sediments through surface run-off. The water table is usually above the ground surface through can fluctuate (Figure 4).

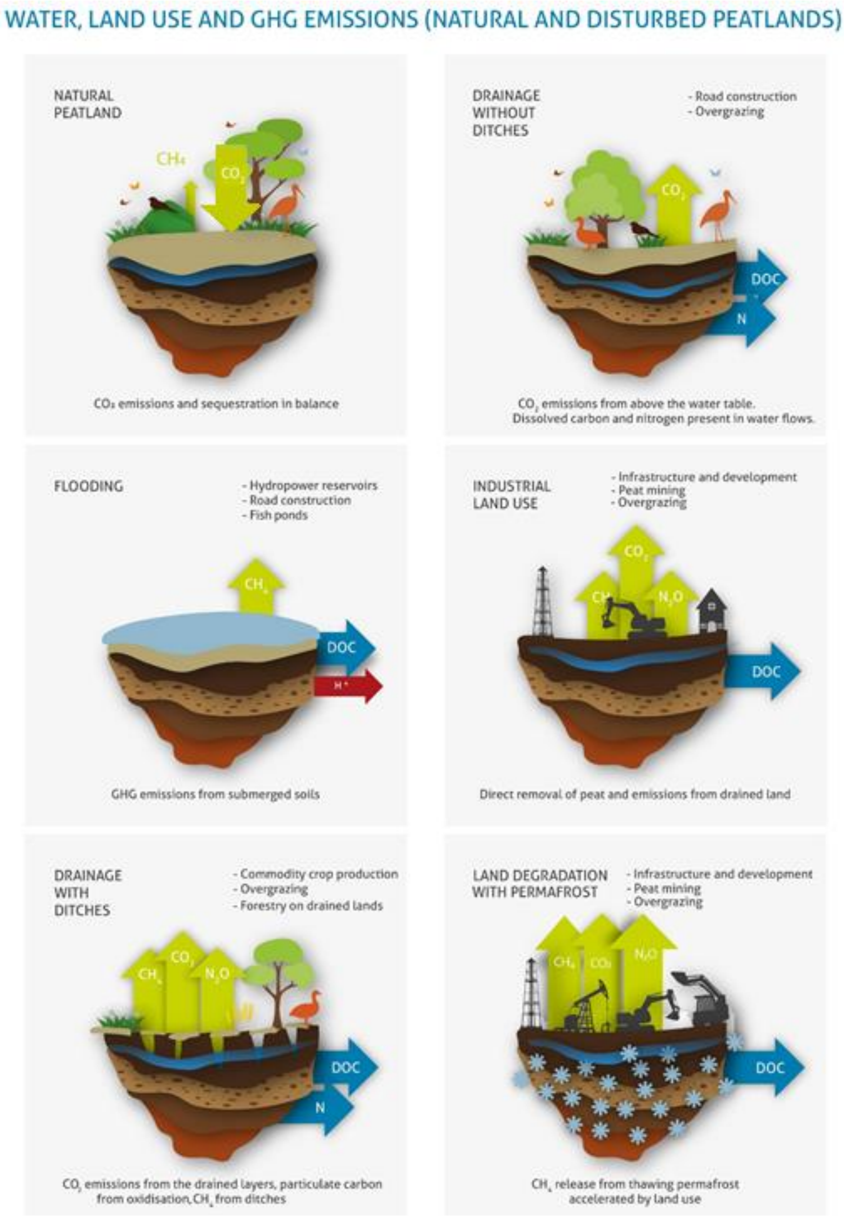

Figure 2: Peatlands and Associated Impacts on GHG Emissions Under Different Land Uses (adapted from Anisha et al. 2020).

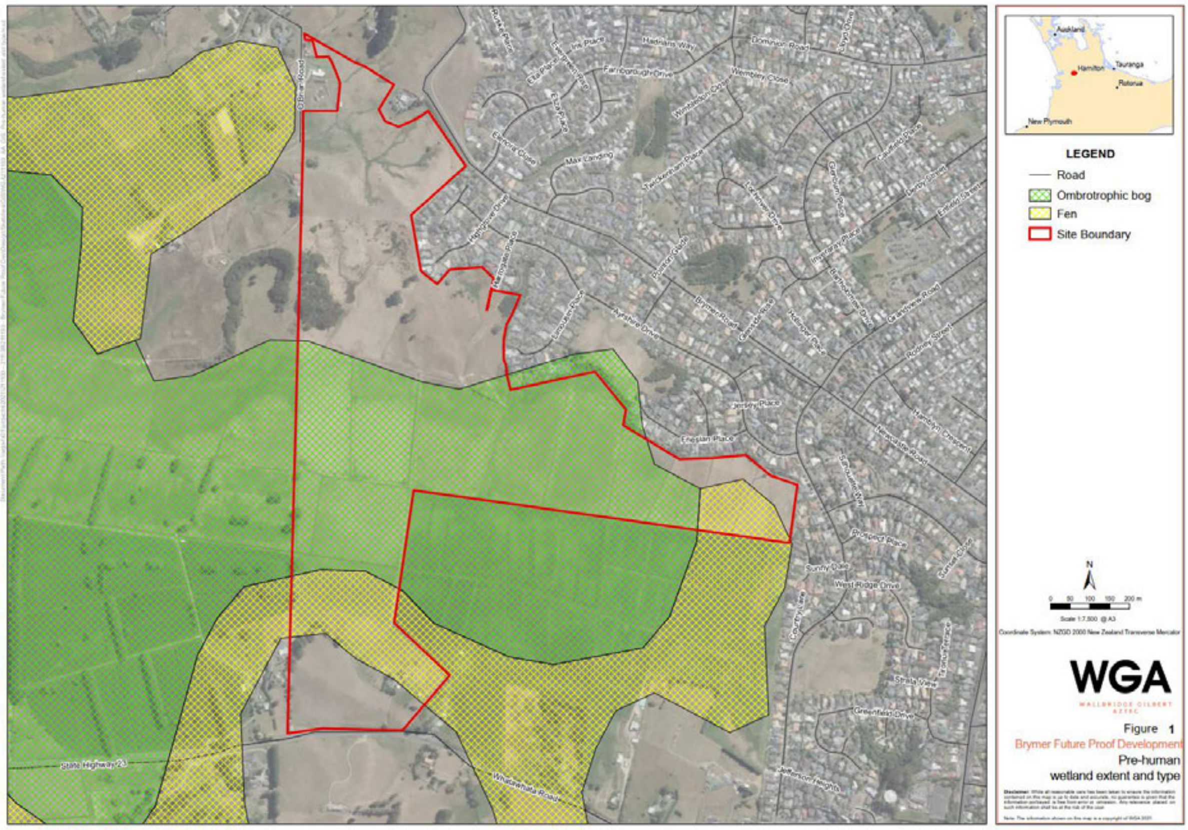

Figure 3: Pre-Human Wetland Extent Including Wetland Type In The Project Area.

Wetland Type	BOG	FEN	SWAMP	MARSH
	SHALLOW WATER*			
Water Source	Rainfall	→ Groundwater	→	Surface water
Water flow & fluctuation	Low	→ Medium	→	High
Nutrient availability	Low	→ Medium	→	High
pH	Low/acidic	→ Medium	→	High/neutral
Peat Content	High	→ Medium	→	Low/none

Figure 4: Key Environment Characteristics of Wetland Type (Clarkson and Peters 2010).

Tonkin & Taylor (2021) carried out a geotechnical investigation between May and June 2021 where they drilled three machine boreholes, excavated 10 trial pits, and conducted 14 cone penetration tests. The results align well with the pre-human wetland extent for the trial pits (TP) and cone penetration tests. WGA notes that the boreholes may not represent the full thickness of peat as the organic material is subject to compression during drilling. Combining the TP and cone penetration tests from Tonkin & Taylor (2021), we can determine that TP 104 and TP 106 are dominated by clay, with thin peat deposits under the topsoil. TP 105 intersected notable peat with a much higher water table compared to the other test pits (Figure 5). TP 103 intersected well defined thick peat layers, while TP 107 and TP 108 intersected shallow thinner peat layers that sit above a thick clay horizon (Figure 5). This investigative work indicates that the thick peat layers are located under the western side of the proposed development area, with the areas upstream to the east categorised by thinner and more variable peat layers (Figure 5).

Based on our desktop assessment, the areas of former wetland extent are no longer classed as wetlands under the Resource Management Act 1991 (RMA), National Policy Statement for Freshwater Management 2020 (NPS-FM) and Resource Management (National Environmental Standards for Freshwater) Regulations 2020 (NES-F). Peat deposits are now managed by Waikato Regional Council (WRC) under Operative Waikato Regional Policy Statement, Section 14.5:

14.5.1 Manage Peat Subsidence
Regional plans shall control activities on peat soils to promote best practice land management to:
slow the rate of subsidence of peat soils and carbon loss;

a. *mitigate the adverse effects resulting from use and development of peat soils, including off-site effects on habitats, infrastructure, properties and other development; and*
b. *ensure drainage infrastructure minimises any adverse effects on peat soils and subsidence on peat lakes.*

WRC's management of peat in the Waikato region is largely focused on land settlement and carbon loss from drained peat soils. The rate of settlement has been measured at 3.4 cm year^{-1} in the Waikato region (Schipper and McLeod et al. 2002). On the low-lying peatland areas of the site, there is evidence in the topographical contours of historical (and ongoing) ground settlement taking place, which is associated with the installation and operation of the drainage network (Figure 6).

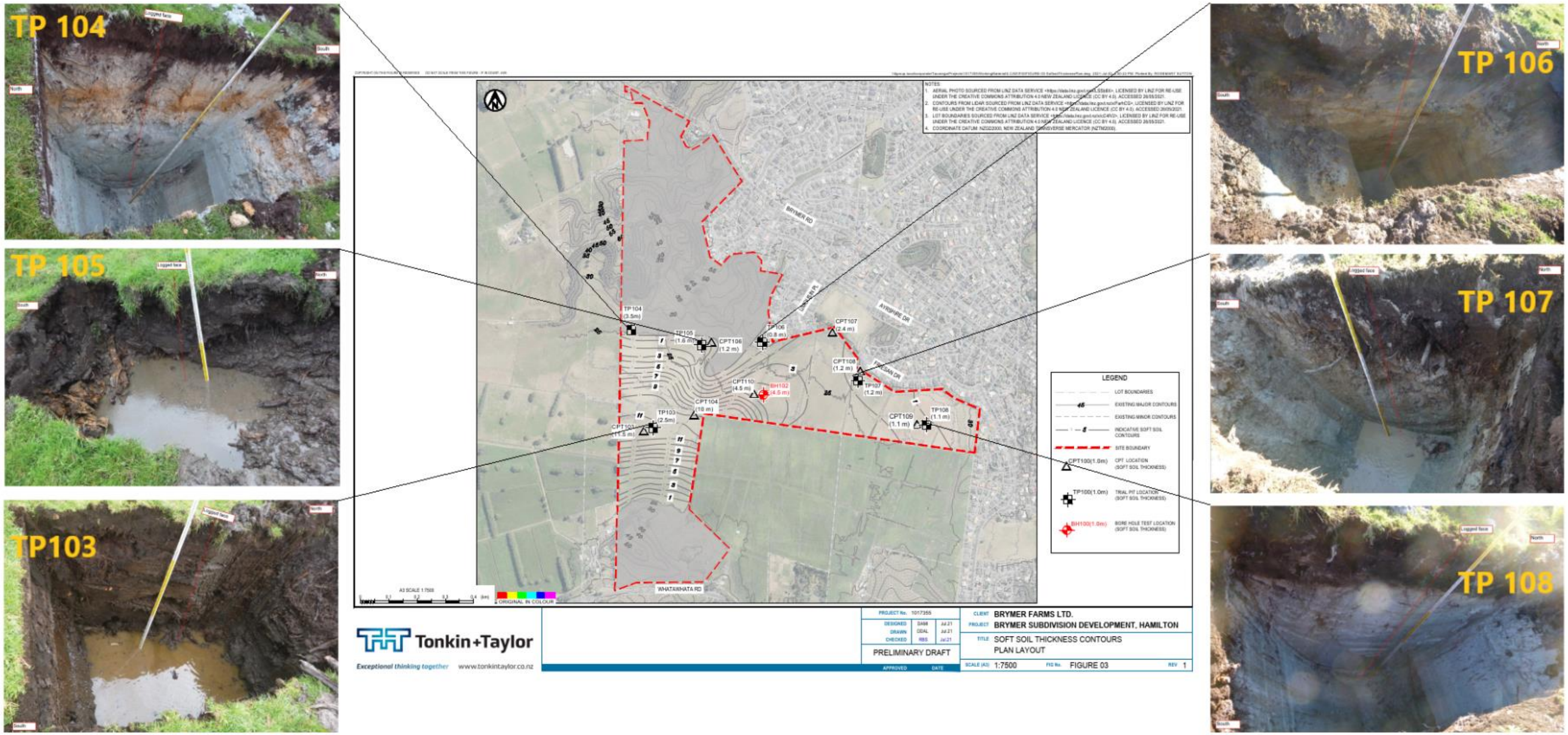

Figure 5: Images and Associated Numbers of Test Pits (TP) and Map Showing Soft Soil Contours from Cone Penetration Tests Modified from Tonkin & Taylor (2021).

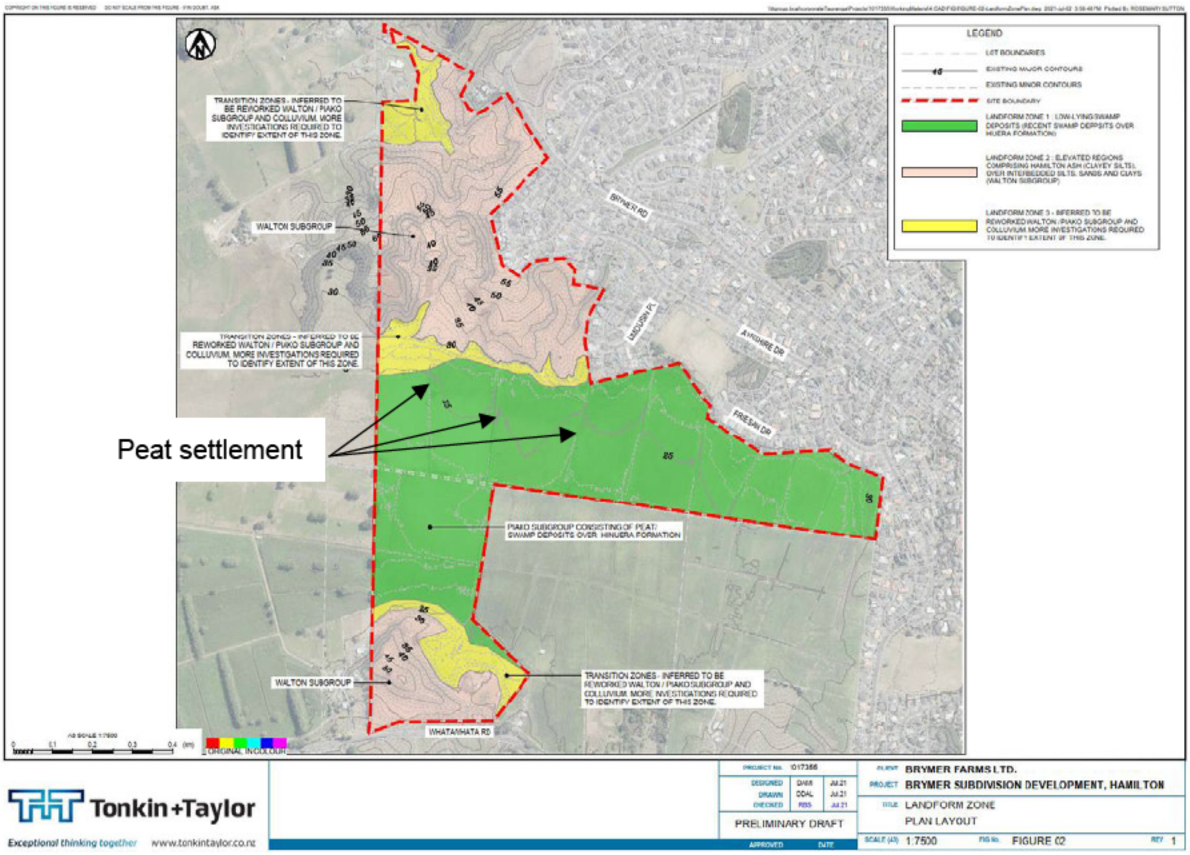

Figure 6. Map Showing Contours within Boundary Area (modified from Tonkin and Taylor 2021).

4.2 POTENTIAL OPPORTUNITIES

The information collated in this report indicates that the peatland within the site was once part of a large ombrotrophic bog, with a smaller portion to the south once being part of a fen complex (Figure 3). The peatland is being actively drained and there is evidence of ground settlement. There are several options that could be carried out to achieve novel best management practices at the site:

4.2.1 Option A. Integrating the Peatland into a Constructed Wetland System

This proposed wetland system could be largely built adjacent to the peatland, with potential use of the peatland drains to become part of the water management system. This scenario could follow one or more of the following options:

1. Treated water from the constructed wetland could be discharged through the adjacent peatland in the already constructed drains as an option to manage stormwater in the area. This would provide additional water to support aquatic life that occupy these human-created freshwater drain systems.

2. The drains in the peatland could be re-engineered to become part of the wetland treatment system. The water levels in the drains could be raised through the use of small check-dams to reduce/halt water discharging from the peatland. During wetter periods water from the drains could flow out across the wetland areas to promote higher water tables. Raising the groundwater table would help reduce future ground settlement and promote future carbon sequestration as the vegetation recovers.

   Once these changes in the drainage system are implemented, the drains could be incorporated as part of the overall water treatment system for the development. It is important to ensure the system is designed to avoid permanently flooding the peatland. Once hydrological integrity is restored in the peatland using this approach, plants associated with ombrotrophic peatlands could be re-introduced. This revegetation could be carried out over the deeper peat deposits in the western section of the site lowlands. This process would:

   i) Optimise land-use in the area, which would give the peatland an economic value through reducing the land necessary for treatment wetland development in areas adjacent to the peatland.

   ii) Provide an aesthetic and educational amenity to the development, showcasing best practice water reuse being applied by the development for peatland restoration.

   iii) Restore the peatland through an engineered approach. This would reduce ground settlement, increase carbon sequestration and increase biodiversity values in the area.

3. If aquatic life in the peatland drains is an issue and Option A2 is not viable, the peatland could still be integrated into the water treatment system through the installation of a floating wetland systems in the drainage network. Floating wetlands can be designed to mitigate potential impacts to aquatic life in drains. However, unlike Option A2, ongoing ground settlement would remain a potential issue.
4. The potential to add further value also exists, where the discharged water from the constructed wetland could be used to irrigate the adjacent peatland as a form of rewetting. As the peatland was formerly an ombrotrophic bog, which relied on recharge from rainfall, a simple irrigation system could be installed at the peatland. For this to be effective, the drains need to be dammed or significantly reduced in depth. This could be carried out for the deeper peat deposits in the western peatland area. If this option is achievable, the rewetting of the peat would help to reduce ground settlement in the area and would also increase carbon sequestration in the peatland area. This option would be considered a best practice management in the area.

4.2.2 Option B. Paludiculture on the Peatland.

The concept of paludiculture is the transition from agriculture on drained peatlands to the cultivation of moisture tolerant plants on rewetted peatlands (Wichtman et al. 2016). The biomass production and low decomposition rate of dead wetland plant material results in peat accumulation (and carbon sequestration) as only the above-ground biomass is harvested (Joosten et al. 2012). Thus, the peatland could be used to harvest biofuels on the surface, while preserving the peat layers beneath.

There is real potential for the use of such peatlands in this manner as the biomass produced through paludiculture can be used as a substrate for biogas production (Eller et al. 2020) and have benefits for supporting New Zealand's transport sector. Biogas produced through anaerobic digestion can be upgraded to biomethane, which constitutes an environmentally friendly energy supply for vehicle fuel that can replace diesel (Ohlrogge et a. 2009; Olsson and Fallde 2015). The by-product of biomethane production is also a valuable fertiliser for agricultural land, which can be used instead of chemical fertilisers. *Typha orientalis* (raupō) has been suggested as a viable plant for paludiculture cultivation in New Zealand (Kerckhoffs & Renquist 2013). Thus, rewetting peatland for paludiculture can provide an alternative source of revenue and protect the peatland from further degradation (reduce settlement and sequester carbon).

4.3 POTENTIAL ISSUES AND CONSTRAINTS

There are some potential issues and constrains associated with any of the options presented in Section 4.2. These issues and constraints are summarised below with pathways on how to potentially overcome them.

a) Any alterations to the peatland drains will require an ecological assessment of these systems. For example, the presence or absence of mudfish in the drains will need to be assessed as they have "Nationally Critical" conservation status under the New Zealand Threat Classification System.

b) Consideration of potential flooding risks to neighbours is a significant factor that will require detailed on-site investigation to support the engineered design. Detailed hydrological assessments of the stormwater wetland and any modifications to the peatland drainage systems should be conducted.

c) WGA recommends that the wetland plants used for wetland revegetation should be in keeping with the local area or region. Doing so would ensure better ecological resilience and performance for water treatment. Plants selected for the constructed wetland would not be plants naturally associated with ombrotrophic bogs due to different pH, hydrological and nutrient conditions. The wetland would be composed of plants associated more with swamp and marsh wetland types. If any action were done to modify the peatland drains for rewetting purposes, the plants that would occupy this space would likely not resemble what was originally there (i.e., bog vegetation). The benefits of rewetting the peatland would outweigh the introduction of wetland plants to the present drain system, which is currently only draining the grass covered peatland.

5 CONCLUSIONS

The ability to use soakage to reduce stormwater run-off volumes is limited due to the relatively shallow depth to groundwater in the lower areas of the proposed development site, and the presence of lower permeability clays in the near surface. Potential flooding effects downstream of the proposed development will require assessment through detailed hydrological and hydraulic modelling. Significant effects on groundwater recharge are not anticipated based on this high-level desktop assessment.

Geotechnical investigation information indicates that the peatland within the site boundary was once a large ombrotrophic bog with a smaller portion to the south once part of a fen complex. The peatland is being actively drained and there is evidence of ground settlement. This report documents several options that could be carried out to achieve novel best management practices at the site, including utilising the existing drainage network to develop a re-engineered wetland treatment system.

Using bores for a water supply option could provide a “transition” option to supply water for the initial stages of the development. This would enable development to start while waiting for the Hamilton town network to be developed to a standard to support the new subdivision areas. Aquifers provide natural water storage in comparison to surface water storage. This capacity can be utilised through installing bores that will be less affected by climate fluctuations and summer low flow conditions as experienced in rivers and streams in summer.

There are only limited deeper abstraction bores in the vicinity of the site (within five kilometres) and exploratory drilling would be the next step to determining the capacity of the local aquifers to provide sufficient volume for a water supply. Local treatment will be required and potentially on-site storage to cater for peak demand periods.

6 LIMITATIONS

This report is a desktop high level assessment only. WGA's assessment has relied on the results of drilling and sampling carried out by Tonkin and Taylor. WGA staff were not on site during the drilling. WGA notes that our assessments are based on the site-specific testing results which were provided to us. Natural variations may occur within the area in and around of the proposed basins which have not been identified from the Tonkin and Taylor field testing programme and therefore have not been incorporated in this assessment. WGA accepts no responsibility or liability if the field conditions at the site vary spatially or temporally from those described by Tonkin and Taylor in the documentation of their field-testing programme.

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APPENDIX B - BRYMER FARMS GROUNDWATER ASSESSMENT

Brymer Farms Limited

Brymer Farms Groundwater Assessment

PUMPING TEST ANALYSIS AND EFFECTS ASSESSMENT

WGA211193

WGA211193-RP-HY-0003_B

May 2023

Revision History

REV	DATE	ISSUE	ORIGINATOR	CHECKER	APPROVER
A	5 May 2023	Draft to Client	JM	CMH	CHO
B	24 May 2023	Final	CMH	CHO	CHO

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1 INTRODUCTION

1.1 Background

Brymer Farms Limited (Brymer Farms) is planning an urban development, located between Brymer Road and Whatawhata Road on the western side of Hamilton. Currently there is no Hamilton City Council water supply infrastructure available on the site. Previous work completed by Wallbridge Gilbert Aztec (WGANZ Pty Ltd; WGA) has assessed the potential for Brymer Farms to supply water for development from groundwater sources (WGA 2021). The assessment concluded that groundwater bores could provide a “transition” option to supply water for the initial stages of the development. This would enable development to start while waiting for the Hamilton town network to be developed to a standard to support the new subdivision areas. It was recommended to undertake exploratory drilling and aquifer testing to determine the capacity of the local aquifers to supply a sufficient volume for development.

Two test bores were drilled at different locations on site to assess the geology and locate higher permeability layers which could provide sufficient water. Based on the lithological logs and initial testing on the Test Bores two Production Bores were constructed. The Test Bores were left in place to act as observation bores for aquifer testing. A stepped-rate test was carried out on each Production Bore followed by a constant rate test.

This report details the exploratory drilling exercise, subsequent testing and provides a technical assessment of effects for long term pumping from the two bores at the Brymer Farms site.

1.2 Water Requirements

Brymer Farms is seeking to abstract groundwater from Production Bore 72_11239 and Production Bore 72_11240 to provide domestic water supply to 2,500 dwellings at the Brymer site at the following rates:

- At a maximum daily rate of 1,836 m^3/day for Production Bore 72_11239 for 100 days during peak water usage season.
- At a maximum daily rate of 864 m^3/day for Production Bore 72_11240 for 100 days during peak water usage season.
- At a maximum daily rate of 1,193 m^3/day for Production Bore 72_11239 for 265 days during average water usage conditions.
- At a maximum daily rate of 562 m^3/day for Production Bore 72_11240 for 265 days during average water usage conditions.

This equates to a total maximum annual abstraction of 735,075 m^3.

The amount of water requested is based upon providing domestic supply to 2,500 dwellings with an assumption of 2.7 people per dwelling. Water required per dwelling is based upon an average water usage of 260 litres per person, per day for 265 days in Hamilton. Additionally, a high-water usage value of 400 litres per person, per day for a period of 100 days was used for the remainder of the year to allow for peak period usage during the dryer months.

Production Bore 72_11239 will be abstracted at a maximum rate of 26 L/s and Production Bore 72_11240 will be abstracted at a maximum rate of 12 L/s. These rates allow for a balanced pumping schedule while taking into account the capacities of each bore. It is likely that there will be times when operations will vary, and one bore maybe required to pump independently at a higher rate for periods of time but not exceeding the maximum daily limits.

Figure 1
Brymer Future Proof Development
Bore locations surrounding the Brymer development area

1.3 Well Construction

The well construction details for the two production bores are summarised in Table 1 below.

Table 1. Construction Details for the two Production Bores.

PARAMETER	PRODUCTION BORE 1	PRODUCTION BORE 2
Bore number	72_11239	72_11240
Owner	Brymer Farms Ltd	Brymer Farms Ltd
Address	Brymer Road	Whatawhata Road
Easting NZTM	1795223	1795408
Northing NZTM	5814854	5816356
Depth (m)	113.0	139.5
Casing depth (m btoc) (3)	97.5	105.0
Screen interval	97.0 to 109.0	105.0 to 111.0
Static water level (m btoc) (3)	25.53	7.3
Diameter of casing (mm)	200	200
Diameter of screens (mm)	200	150
Estimated elevation (m asl) (4)	50	32

Notes: 1) Data obtained from Waikato Regional Council (WRC) bore database.
2) Data obtained from Brown Bros Drilling Limited
3) Below top of casing (btoc)
4) above sea level (asl)

2 HYDROGEOLOGY OVERVIEW

2.1 Regional Geology and Hydrogeology

The Hamilton Basin is a large tectonic basin centred on Hamilton City with an area of approximately 2,000 km^2 and traversed by the Waikato River. The basin is surrounded by ranges of Mesozoic (Manaia Hill Group) and Tertiary age (Te Kuiti and Waitemata Groups) rocks. At depth, basement greywacke underlies the sedimentary deposits that infill the basin (GNS 2005).

The basin is infilled with Tauranga Group alluvial sediments, dating from the Pliocene to the middle Holocene. Underlying the low hills are older ignimbrites, tephra fall deposits and alluvium of the Walton Subgroup (Figure 2; Lowe 2010). The Tauranga Group sediments are up to 300 m thick and include gravels, sands, silt, muds and peats of fluvial, lacustrine and distal ignimbritic origin. The Hinuera Formation of the Tauranga Group underlies much of the Hamilton basin. This formation was deposited by braided river systems of the Waikato River, initiated by the supply of large volumes of sediment from volcanism in the Taupo Volcanic Zone (Petch 1987).

Overlying the Tauranga Group deposits of the Hamilton Basin are late Holocene unconsolidated alluvial and colluvial sediments. In the low-lying area at the site, Hinuera Formation sediments are overlaid by recent Holocene soft, dark brown to black, organic mud, muddy peat and woody peat deposits (GNS 2005).

The Hinuera Formation contains the aquifers used most extensively for water supplies across the Hamilton Basin. Within this formation, the most productive aquifers consist of well sorted coarse sands and gravels. Discontinuous sequences of rhyolitic and pumiceous gravelly sands and gravels are interspersed with pumiceous silt, clay and peat layers. Lithological variability generally results in a number of zones of higher permeability within the formation rather than a single, continuous aquifer (Figure 2; Schofield 1972). The upper layers contain perched aquifers that tend to drain to the closest gully system and can dry out over the summer period.

Literature values for the hydraulic conductivity of sediments in the Hamilton Basin range from 0.5 m/day in the silt and peat layers to 13.5 m/day in the course gravelly sands. Aquifer transmissivity values derived from pumping tests range from 10 m^2/day to 1,000 m^2/day but are generally less than 100 m^2/day. The deeper aquifers have variable aquifer properties and local pumping tests near the site have resulted in transmissivities calculated at between 10 m^2/day and 120 m^2/day. Aquifer storativity values vary from 0.001 for deep, confined or semi-confined aquifers to 0.1 for shallow, unconfined aquifers in the Hamilton Basin (Petch and Marshall 1988). In some areas these discontinuous aquifers may provide bore yields of up to 30 L/s (Petch 1987).

Regional groundwater flows in the area of Hamilton are generally towards the northwest, from the basin edges to the southeast. Major groundwater discharges occur into the Waipa River and the Waikato River and their tributaries that are located in deeply incised gullies (Petch and Marshall 1988).

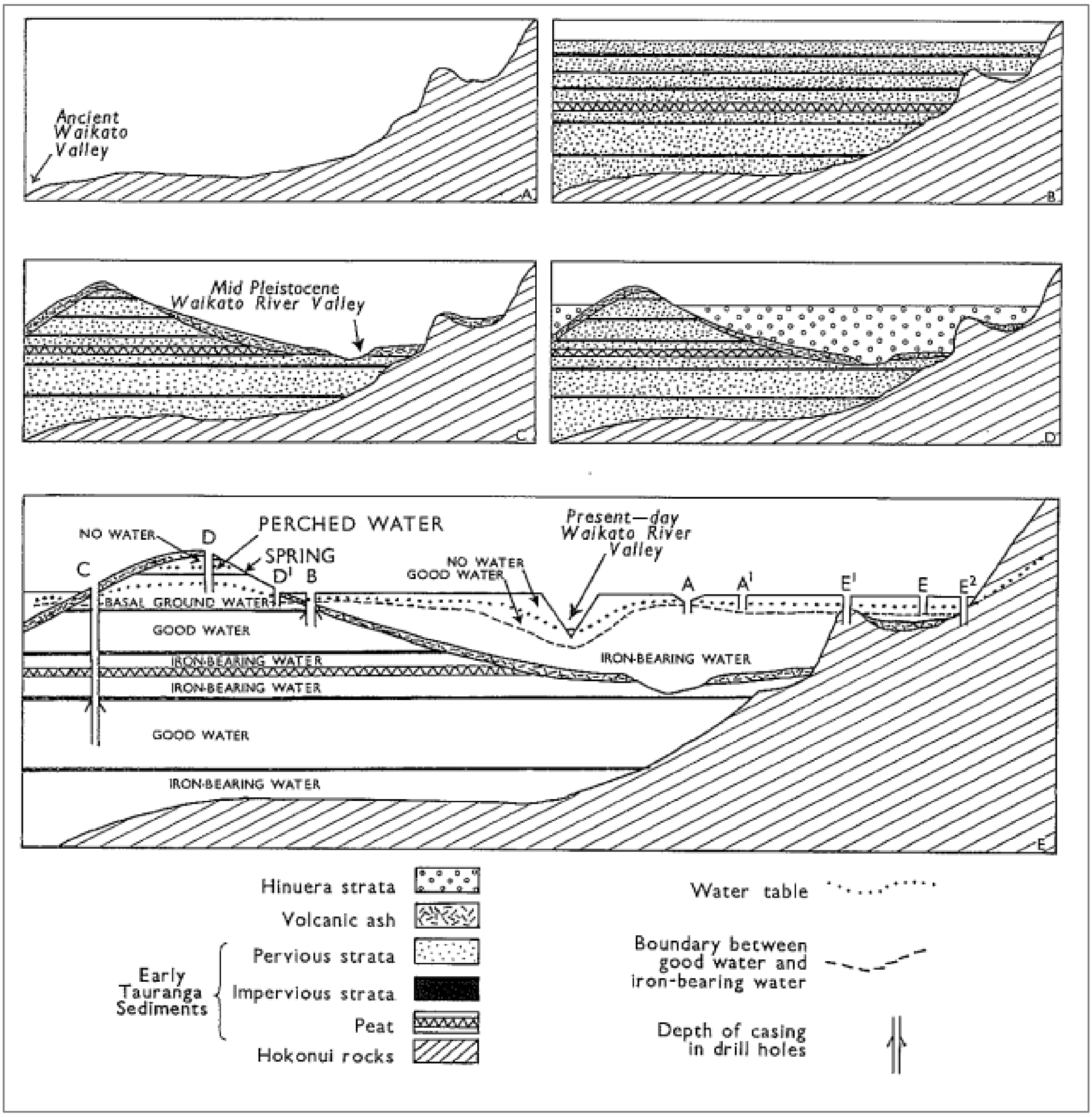

Figure 2. Simplified Geological History and Formation of Local Aquifers (Schofield 1972).

2.2 Local Aquifer Definition

The lithological descriptions for the two Production Bores obtained from Brown Bros Drilling are summarised in Table 2 and Table 3. Overall, the lithological logs suggest that in the immediate area the local aquifer is overlain by a stratified sequence of silt, pumice and peat layers. These layers will have varying hydrogeological properties, especially in terms of permeability.

There is a layer of pumice sand between 2.9 m and 11.9 m in Production Bore 1 (72_11239) which is not present in Production Bore 2 72_11240. This is considered to be a shallow unconfined aquifer that is discontinuous across the area and dependant on elevation. This shallow aquifer is located at between 38 and 47 m asl above the ground level at the bore head for Production Bore 2 (72_11240) which is 32 m asl.

The lithological logs suggest a multi-layered aquifer system with a shallow confined aquifer located at a depth of 25.5 – 51 m below ground level (bgl; 72_11239) and 21.5 to 29.5 m bgl (72_11240). The deep pumped aquifer is at a depth of 97.5 – 109 m bgl (72_11239) and 104.5 to 115.5 m bgl (72_11240). The logs indicate that while the upper aquifer is continuous across both bores, it is thinner in the southern bore (72_11240).

The lithological log for Production Bores (Table 2 and Table 3) describes the screened section of the bores intersecting approximately 11 m of grey blue gravel in 72_11239 and 72_11240 respectively in the deep aquifer. The screened sections of both Production Bores are assumed to be in the same aquifer and are overlain by stratified layers of low permeability material (peat, pumice and silt) which is 47 to 75 m thick. These low permeability layers will provide an aquitard between the source aquifer and the upper aquifer.

According to the WRC database, there are 92 bores within two kilometres of the Production Bores, most of which are drilled into the shallow unconfined aquifer or the shallow confined aquifer overlying the source aquifer of the Production Bores.

Table 2: Lithological Log for Production Bore 1 - 72_11239.

FROM (M)	TO (M)	DESCRIPTION	HYDROGEOLOGICAL INTERPRETATION
0.0	2.9	Surface silt	Aquitard
2.9	11.9	Pumice Sand	Aquifer
11.9	25.5	White Silt	Aquitard
25.5	28.5	Blue gravel sand	Aquifer
28.5	36.5	White gravel pumice	
36.5	48.0	Yellow sand	
48.0	51.0	Grey sand gravel	
51.0	61.0	Brown silt	Aquitard
61.0	88.5	Peat, pumice, silt	
88.5	97.5	Peat, fine sand	
97.5	109.0	Grey blue gravel	**Source Aquifer**
109.0	110.5	Grey silt	Aquitard
110.5	112.5	Grey silt - water loss	
112.5	113.0	No return EOH	

Table 3: Lithological Log for Production Bore 2 - 72_11240.

FROM (M)	TO (M)	DESCRIPTION	HYDROGEOLOGICAL INTERPRETATION
0.0	17.0	Yellow silt	Aquitard
17.0	17.5	Peat	
17.5	21.5	Grey silt	
21.5	29.5	Yellow sand gravel pumice	Aquifer
29.5	73.5	Gritty silt	Aquitard
73.5	75.5	Peat	
75.5	84.0	Fine sand silt	
84.0	104.5	Green silt	
104.5	115.5	Blue gravel	**Source Aquifer**
115.5	120.5	Peat silt	Aquitard
120.5	139.5	Brown silt	

3 PUMPING TEST ANALYSIS

3.1 Overview

A stepped-rate pumping test and a constant rate pumping test was performed on both Production Bores. The pumping test methodology and results for both bores are discussed in this section. The pumping test analysis sheets for Production Bore 1 (72_11239) are provided in Appendix A and Production Bore 2 (72_11240) are provided in Appendix B.

3.2 Production Bore 1: 72_11239

3.2.1 Stepped-Rate Pumping Test

A stepped-rate pumping test was performed on Production Bore 1 (72_11239) on 27 October 2022. The initial static water level was 25.55 m bgl at the commencement of pumping. The pumping test began at 8:00 am and the bore was pumped at a rate increasing every hour over a total of four hours. The initial pumping rate was 15.3 L/s, increasing to 22.4 L/s, 28.8 L/s and 33.3 L/s (Figure A1). A maximum drawdown of approximately 19.98 m was recorded after 240 minutes of pumping.

Recovery of the water level was monitored for 140 minutes following the cessation of pumping (Figure A2). After this time, the bore water level had not yet reached a level within 5% of the starting static water level. The recovery trajectory notably changes direction at approximately 80 minutes, indicating a possible change in boundary conditions (e.g. a lower transmissivity zone). It is noted that during the constant rate pumping test the recovery curve reached within 5% of starting head conditions after 1,600 minutes following the cessation of pumping.

3.2.2 Well Efficiency

Well efficiency is presented in Figure A3. The results show well efficiency at 91%, 88%, 85% and 83% at flow rates of 15.3 L/s, 22.4 L/s, 28.8 L/s and 33.3 L/s, respectively. At lower flow rates the well efficiency is greater, as is expected for production bores.

3.2.3 Constant Rate Pumping Test

A constant rate pumping test was performed on Production Bore 1 (72_11239) with water level measurements recorded during the test and following the end of the pumping period. Two nearby bores were monitored during the pumping and recovery periods, a test bore, located 4 m from Production Bore 1 (72_11239), and Production Bore 2 (72_11240), located 1.5 km from Production Bore 1 (72_11239). The constant rate pumping test commenced on 28 October 2022 at 8:59 am. The bore was pumped at a rate of approximately 104 m^3/hour (or 28.8 L/s) for 32 hours (1,920 minutes). The pumping test was originally planned to last 72 hours however after noise complaints were received from neighbouring properties, the pumping test was halted. Following the cessation of pumping, the water level recovery in the production bore was monitored for a further 2,378 minutes.

The static water level was recorded in the production bore at 25.5 m bgl prior to the commencement of the constant rate pumping test. A water level of approximately 45.7 m bgl was recorded at 1,920 minutes following the start of pumping, equating to a maximum drawdown of 20.1 m (Figure A4). After 1,600 minutes (26 hours) following the end of pumping the water level in the production bore had recovered to 95% of the maximum drawdown (Figure A5).

Pumping induced drawdown was observed in the Test bore where a maximum of 11.1 m drawdown was observed after 1,919 minutes. Recovery of the bore water level followed an almost identical trajectory to the Production Bore following the cessation of pumping (Figure A5). A delayed response to pumping was observed in 72_11240 with a maximum drawdown of 0.04 recorded at the end of monitoring 72 hours after the start of pumping.

Extrapolation of the drawdown curve (Figure A6) indicates drawdown in the Production Bore would be approximately 28 m after 365 days of continuous pumping at 104 m^3/hour. This drawdown does not reflect the planned pumping schedule and is instead a projection of drawdown if the pump in the Production Bore was run continuously for an extended period at the pumping test flow rate. This drawdown projection also takes no account of external influences on water levels in the Production Bore.

3.3 Production Bore 2: 72_11240

3.3.1 Stepped-rate Pumping Test

A stepped-rate pumping test was performed on Production Bore 72_11240 on 30 September 2022. An initial static water level of 6.2 m bgl was recorded prior to the commencement of pumping. The pumping test began at 8:00 am and pumped at a rate increasing every hour over a total of four hours. The initial pumping rate was 9.4 L/s, increasing to 12.5 L/s, 14.7 L/s and 17.8 L/s (figure B1). A maximum drawdown of approximately 44.5 m was recorded after 240 minutes of pumping.

Recovery of the water level was monitored for 140 minutes following the cessation of pumping (figure B2). After this time, the bore water level recovered past 5% of the starting static water level.

3.3.2 Well Efficiency

Well efficiency is presented in (figure B3). The results show well efficiency at 84%, 80%, 77% and 73% at flow rates of 9.4 L/s, 12.5 L/s, 14.7 L/s and 17.8 L/s respectively. At lower flow rates the well efficiency is greater, as is expected for production bores.

3.3.3 Constant Rate Pumping Test

A constant rate pumping test was performed on Production Bore 2 (72_11240) with water level measurements recorded during the test and following the end of the pumping period. Two nearby bores were monitored during the pumping and recovery periods, the Test Bore, located 4 m from Production Bore 2 (72_11240), and Production Bore 1 (72_11239), located 1.5 km from Production Bore 1 (72_11239). The constant rate pumping test commenced on 1 October 2022 at 8:59 am. The bore was pumped at a rate of approximately 57 m^3/hour (15.8 L/s) for 24 hours (1,440 minutes). Following the cessation of pumping, the water level recovery in the production bore was monitored for a further 1,460 minutes.

The static water level was recorded in the production bore at 6.2 m bgl prior to the commencement of the constant rate pumping test. A water level of approximately 46.8 m bgl was recorded at 1,440 minutes following the start of pumping, equating to a maximum drawdown of 40.6 m (Figure B4). After 100 minutes (2 hours) following the end of pumping the water level in the production bore had recovered to 95% of the maximum drawdown and had recovered to within 99% at the end of monitoring (Figure B5).

Extrapolation of the drawdown curve (Figure B6) indicates drawdown in the Production Bore would be approximately 46 m after 365 days of continuous pumping at 57 m^3/hour. This drawdown does not reflect the planned pumping schedule and is instead a projection of drawdown if the pump in the Production Bore was run continuously for an extended period at the pumping test flow rate. This drawdown projection also takes no account of external influences on water levels in the Production Bore.

3.4 Pumping Test Analysis

The Theis (1935) method was used to assess the constant rate pumping tests for both bores using AQTESOLV version 4.50 software. The following standard set of assumptions is incorporated in the Theis solutions:

1. The aquifer has an apparent infinite extent.
2. The aquifer and confining layer are homogenous, isotropic and of uniform thickness over the area influenced by pumping.
3. The piezometric surface was horizontal prior to pumping.
4. The well is pumped at a constant discharge rate.
5. The water removed from storage is discharged instantaneously with decline of head.
6. The diameter of the well is small, i.e., the storage in the well can be neglected.
7. The head in any un-pumped aquifer(s) remains constant.
8. Storage in the confining layer is negligible.
9. Flow to the well is unsteady.

3.5 Pumping Test Analysis Results

Transmissivity and storativity values derived from the pumping test are described in Table 4 and copies of the analysis sheets are provided in Appendix A7 and A8 (72_11239) and Appendix B7 and B8 (72_11240). These values are consistent with expected transmissivity values for the area, as described in Section 1.4

Table 4. Pumping Test Analysis Results

BORE	ANALYSIS METHOD	TRANSMISSIVITY (m^2/day)	STORATIVITY
72_11239 (Production Bore)	Theis Solution	179	N/A
72_11239 (observation bores)	Theis Solution	168	0.002
72_11240 (Production Bore)	Theis Solution	152	N/A
72_11240 (Observation bore)	Theis Solution	164	0.001

The transmissivity and storativity value derived from the pumping test analysis are similar for both Production bores. These values are consistent with expected transmissivity values for the area, as described in Section 1.4.

Based on the pumping test analysis outcome, together with review of existing information on the deep Hamilton basin aquifer gravels, the following properties for a fully confined aquifer were adopted for the purpose of assessing effects on nearby bores and surface water bodies:

- Transmissivity: 165 m^2/day
- Storativity: 0.001

4 ASSESSMENT OF EFFECTS

4.1 Projected Drawdown Calculations

An assessment of the potential drawdown has been undertaken based on two bores pumping concurrently. An assessment of effects on nearby water supply has been undertaken for bores within a two kilometre buffer of the pumping bores (Figure 1) using parameters derived from the constant rate pumping tests as described in Section 3.5. The pumping scenario assessed is based on continuous pumping up to the annual maximum for 10 years and is summarised in Table 5.

Table 5: Abstraction Rates for Drawdown Assessment.

BORE	BASIS	AVERAGE DAILY DEMAND (m^3)	AVERAGE FLOW RATE (L/s)
72_11239	Pumping at 1,370 m^3/day for 365 consecutive days (based on annual volume of 499,851 m^3)	1,370	7.5
72_11240	Pumping at 644 m^3/day for 365 consecutive days (based on annual volume of 235,224 m^3)	644	15.9

4.1.1 Pumped and Overlying Aquifer

In order to assess the pumped aquifer and overlying shallow confined (intermediate) aquifer described in Section 2.2 comprising sand and gravel, the Hunt and Scott (2007) solution for a two-aquifer system has been applied for each pumping bore using the scenario set out in Table 5. Parameters derived from the pumping test (Section 3.5) have been used for the pumped bore and literature values for the area have been applied to the upper aquifer as follows:

- Transmissivity of 165 m^2/day in the pumped aquifer.
- Storativity of 0.001 in the pumped aquifer.
- Transmissivity of 50 m^2/day in the overlying Aquifer.
- Storativity of 0.01 in the overlying aquifer.
- An aquitard thickness of 45 m (thickness of separating aquitard material described in lithological log for 72_11239).
- Vertical hydraulic conductivity for the aquitard of 0.0001 m/day (lower hydraulic conductivity value for silts from a range presented by Heath (1983)).

Results from the analysis are shown in Figure 3 (72_11239) and Figure 4 (72_11240). When applying these projected drawdowns to nearby bores, the drawdowns from each assessment are considered and added together as cumulative drawdown. Projected drawdowns for each bore are presented in Table C2.

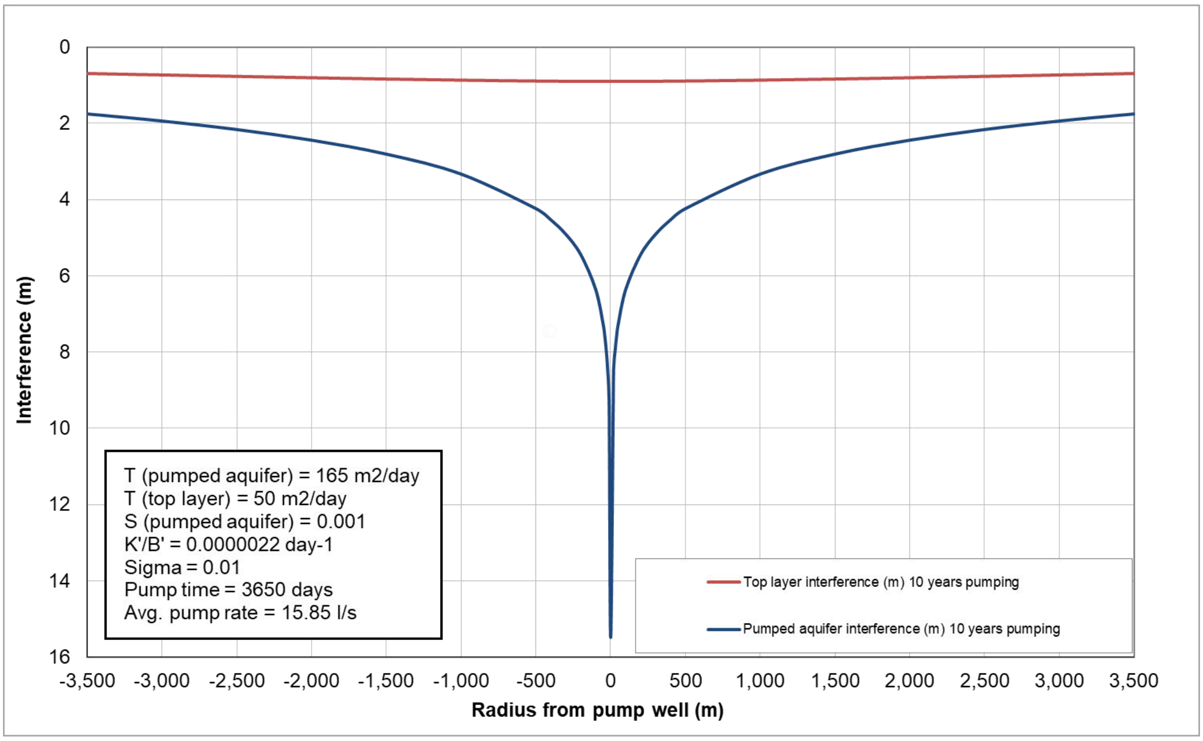

Figure 3: Projected Drawdown in the Deep and Shallow Confined Aquifers based on 10 years of Continuous Pumping of 72_11239 at 1,370 m^3/day.

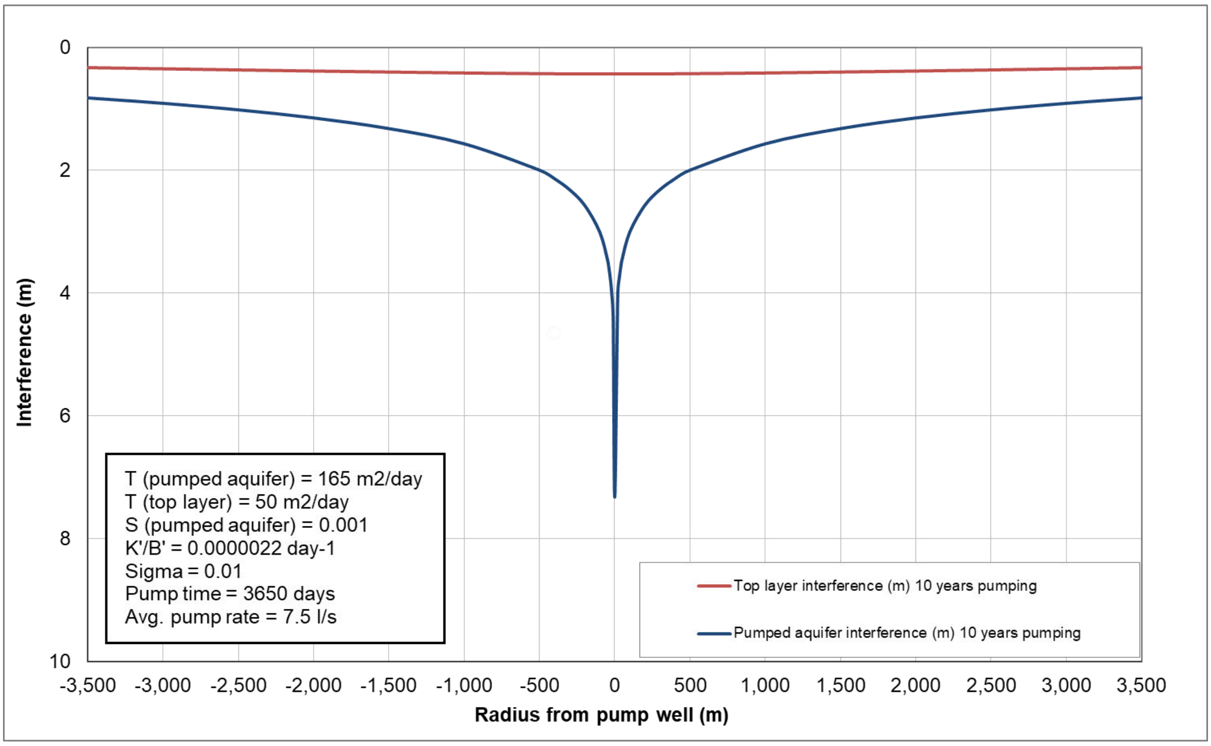

Figure 4: Projected Drawdown in the Deep and Shallow Confined Aquifers based on 10 years of Continuous Pumping of 72_11240 at 644 m^3/day.

4.1.2 Shallow Unconfined Aquifer

In order to assess the shallow unconfined aquifer described in Section 2.2 comprising sand and gravel, the Hunt and Scott (2007) solution for a two-aquifer system has been applied for each pumping bore using the scenario set out in Table 5. Parameters derived from the pumping test (Section 3.5) have been used for the pumped bore and literature values for the area have been applied to the upper aquifer as follows:

- Transmissivity of 165 m^2/day in the pumped aquifer
- Storativity of 0.001 in the pumped aquifer
- Transmissivity of 50 m^2/day in the unconfined shallow aquifer
- Storativity of 0.1 in the unconfined shallow aquifer
- An aquitard thickness of 60 m (thickness of separating aquitard material described in lithological log for 72_11239)
- Vertical hydraulic conductivity for the aquitard of 0.0001 m/day (lower hydraulic conductivity value for silts from a range presented by Heath (1983)).

Results from the analysis are shown in Figure 5 (72_11239) and Figure 6 (72_11240). When applying these projected drawdowns to nearby bores tapping the unconfined aquifer, the drawdowns from each assessment are considered and added together as cumulative drawdown. Projected drawdowns for each bore are presented in Table C2.

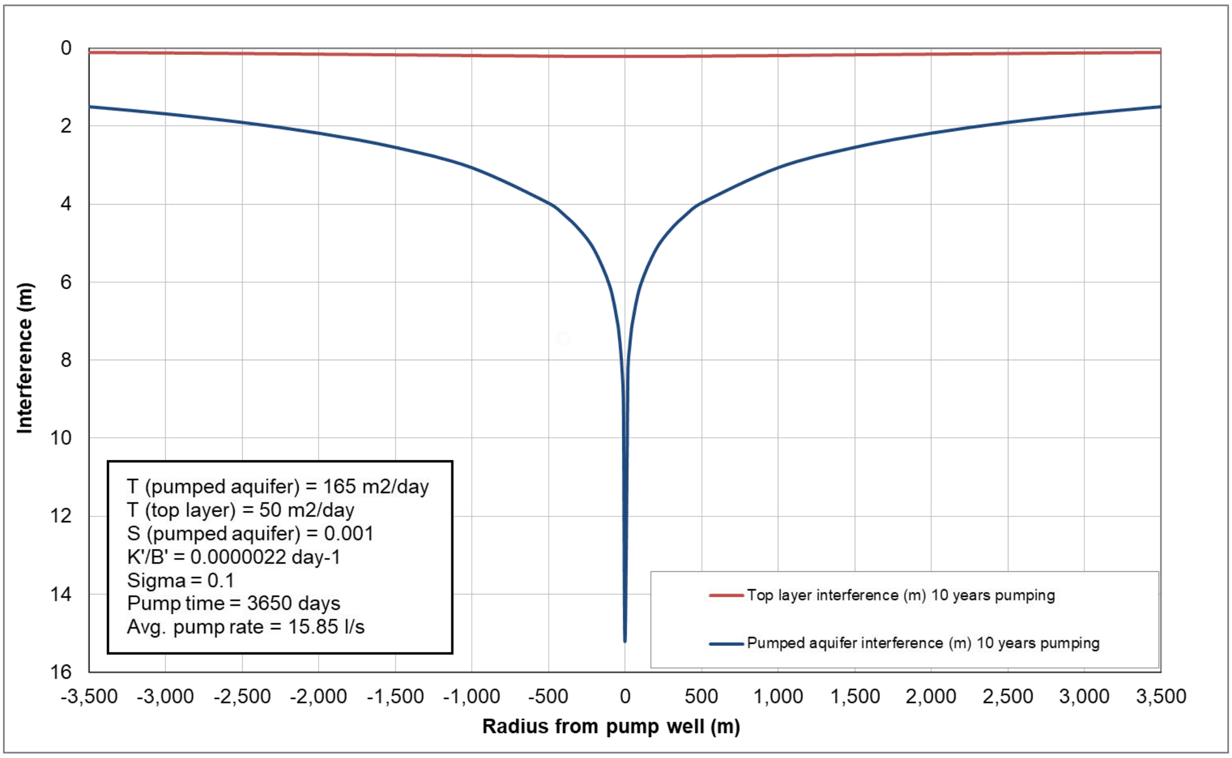

Figure 5: Projected Drawdown in the Shallow Unconfined Aquifer based on 10 years of Continuous Pumping of 72_11239 at 1,370 m^3/day.

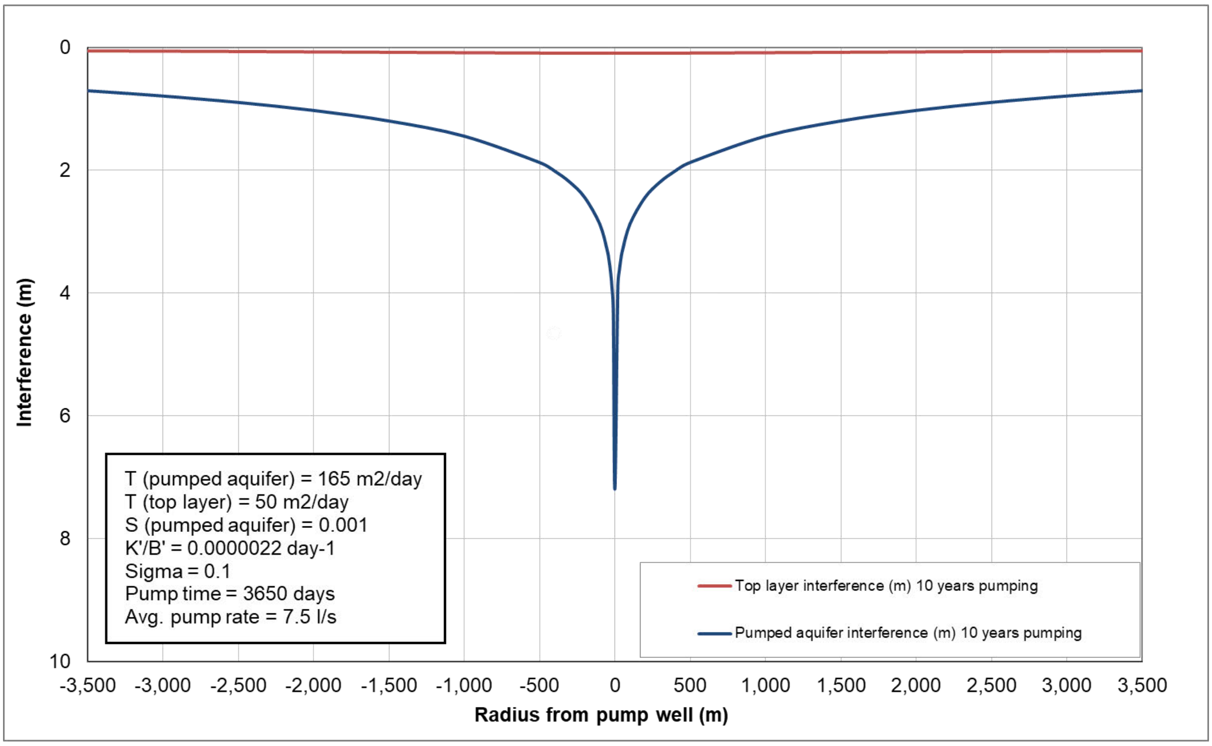

Figure 6: Projected Drawdown in the Shallow Unconfined Aquifer based on 10 years of Continuous Pumping of 72_11240 at 644 m^3/day.

4.2 Effects on Neighbouring Bores

An assessment of the potential groundwater drawdown in the nearby water supply bores within a radial distance of two kilometres from the production bore (Figure 1) has been undertaken using parameters derived from the pumping tests. According to the WRC database, there are 92 bores within the two kilometre buffer shown on Figure 1. The majority of nearby bores are drilled into the shallow unconfined aquifer or the shallow confined (intermediate) aquifer overlying the Production Bores. There are 75 bores that have recorded depths of less than 55 m and a further nine that have no depth information recorded which are assumed to be in the shallow confined aquifer.

There are nine bores with a depth greater than 55 m and further assessment has been undertaken to assess which aquifer these bores are tapping for the purposes of the effects assessment. The lithological logs have been reviewed in terms of their ground elevations and relative levels to assess the depth and continuity of the aquifers in the area (Table C1). The relative level of the top of the source aquifers for 72_11239 and 72_11240 are at 47 m below sea level (m bsl) and 72 m bsl respectively.

Of the nine bores assessed, seven have source aquifers above 17 m bsl and are at similar depths to and have similar lithological descriptions as the shallow confined (intermediate) aquifer noted in the production bore logs. Bore 69_1650 is 80 m deep and has a casing depth of 24 m. If the bore was screened to the full depth when constructed, the bore is tapping the intermediate aquifer between 3 and 7 m bsl and a sand and pumice layer between 34 and 39 m bsl and 41 and 44 m bsl respectively. Nearby bore 72_6800 has no bore log, however, it is located 100 m from bore 69_1650 and drilled to the same depth so is assumed to have a similar lithology. The sand and pumice layers in bore 69_1650 are higher than the source aquifer and differ in the lithological description. However, due to the potential slope on the deep aquifer, these have been assumed to be tapping the same aquifer which is considered to be a conservative approach.

The largest interference drawdown was calculated to be approximately 3.5 m at bore 72_1650 located 2,382 m and 1,668 m from the bores 72_11239 and 72_11240 respectively (Table C2). This represents a 4% change in the available water column in the bore 72_1650. After 10 years of continued pumping the projected interference drawdown was less than 1.3 m in all the bores tapping the shallow confined (intermediate) aquifer and less than 0.3 m in the unconfined shallow aquifer. The calculated interference is less than 10% in all bores within 2 km of the Production Bores.

As the projected interference drawdowns are less than 10% of the available water column in all bores listed in the WRC database within two kilometres of the Production Bore, the effects of the proposed take on nearby bores are considered to be less than minor.

4.3 Effects on Surface water

The proposed abstraction is from an aquifer overlain by an efficient aquitard of approximately 60 m thick. Therefore, it is unlikely the proposed take would significantly affect local shallow aquifers or surface water systems. According to the WRC database, there are no rivers or streams within 2 km of bore 72_11239 however there are some small lakes in the vicinity of the bore associated with the Hamilton Zoo and neighbouring properties. Lake Waiwhakareke, is located approximately 970 m to the north east of 72_11239. There are four small streams within two kilometres of bore 72_11240, according to the WRC database, the closest of which is approximately 870 m to the southwest. The lakes and streams in this area are generally associated with the shallow low permeability peats and are not connected to the deep aquifer being tapped by the Brymer Production Bores.

A stream depletion analysis has been undertaken on the closest of these small streams using the Hunt (2003) method. This method takes into account an aquitard separating the pumped aquifer from the overlying surface water body. The following parameters were applied in the analysis:

- Distance of 870 m from the abstraction bore 72_11240.
- An aquitard thickness of 60 m (thickness of separating aquitard material described in lithological log for 72_11239).
- Vertical hydraulic conductivity for the aquitard of 0.0001 m/day (lower hydraulic conductivity value for silts from a range presented by (Heath 1983)).
- Stream bed width of 1 m (measured from satellite imagery).

For stream depletion assessment it has been assumed that all the annual volume is being taken from the southern bore (72_11240). The results of this analysis indicated the potential stream depletion from the proposed groundwater take would be 0.13 L/s (11.4 m^3/day) following 10 years of continuous pumping. Therefore, the effect on nearby streams is considered to be less than minor.

4.4 Aquifer Sustainability

The WRC's Waikato Regional Plan defines the aquifer in the area of the proposed groundwater abstraction to be the Waipa Aquifer. This aquifer is not currently fully allocated. The consented abstractions nearby are for small quantities. Therefore, WGA concludes that this proposed take will not cause any long-term sustainability issues.

4.5 Other Matters

As part of the consideration of the effects Policy 12 of the Waikato Regional plan outlines several aspects to consider in addition to the effects detailed and modelled above. These include the following:

- Sea water intrusion – not an issue for this proposed abstraction given the bore is located inland and not associated with a coastal aquifer.
- Water quality – the proposed abstraction from a deep confined aquifer is not expected to cause movement of groundwater with lower quality into the aquifer.
- Aquifer compression – the proposed abstraction from a deep confined aquifer with relatively stable aquifer material is such that aquifer compression is expected to be less than minor.

5 CONCLUSIONS

Brymer Farms Limited is investigating a potential urban development, located between Brymer Road and Whatawhata Road on the western side of Hamilton. Brymer Farms is seeking to abstract groundwater from Production Bore 1 (72_11239) and Production Bore 2 (72_11240) to provide domestic water supply to 2,500 dwellings at the site with an annual abstraction of up to 735,075 m^3.

Stepped rate tests and constant rate tests were conducted on both bores and analysed to establish aquifer parameters to be used to assess the effects of taking groundwater from the bores pumping simultaneously for a continuous period of ten years.

Transmissivities derived from the constant rate pumping tests ranged from 152 m^2/day to 179 m^2/day and storativities ranged between 0.001 to 0.002.

The Hunt and Scott method was used to assess the drawdown in the varying aquifer systems in the vicinity of the Production Bores. There are 92 bores listed in the WRC database within two kilometres of the proposed take. Two of these bores were assessed as tapping the same aquifer as the Production Bores, however, all other bores were identified as being in shallower aquifer systems.

The largest interference drawdown was calculated as approximately 3.5 m for bore 72_1650 located 2,382 m and 1,668 m from the 72_11239 and 72_11240 respectively. This represents a drawdown interference of 4% of the available water column in the bore. After 10 years of continued pumping the projected interference drawdown was less than 1.3 m in all the bores tapping the shallow confined (intermediate) aquifer and less than 0.3 m in the unconfined shallow aquifer. The calculated interference is less than 10% of available water column in all bores within 2 km of the Production Bores. Therefore, the effects on nearby bores are considered to be less than minor.

Results from stream depletion analysis indicated the potential stream depletion from the nearby unnamed stream due to the proposed take would be less than 0.13 L/s (11.4 m^3/day). It is therefore considered that the proposed take will have less than minor effects on flows in the nearby streams.

There is sufficient allocation available within the WRC regional plan defined aquifer; Waipa Aquifer to accommodate the proposed abstraction from the Production Bores of up to 735,075 m^3/year.

6 REFERENCES

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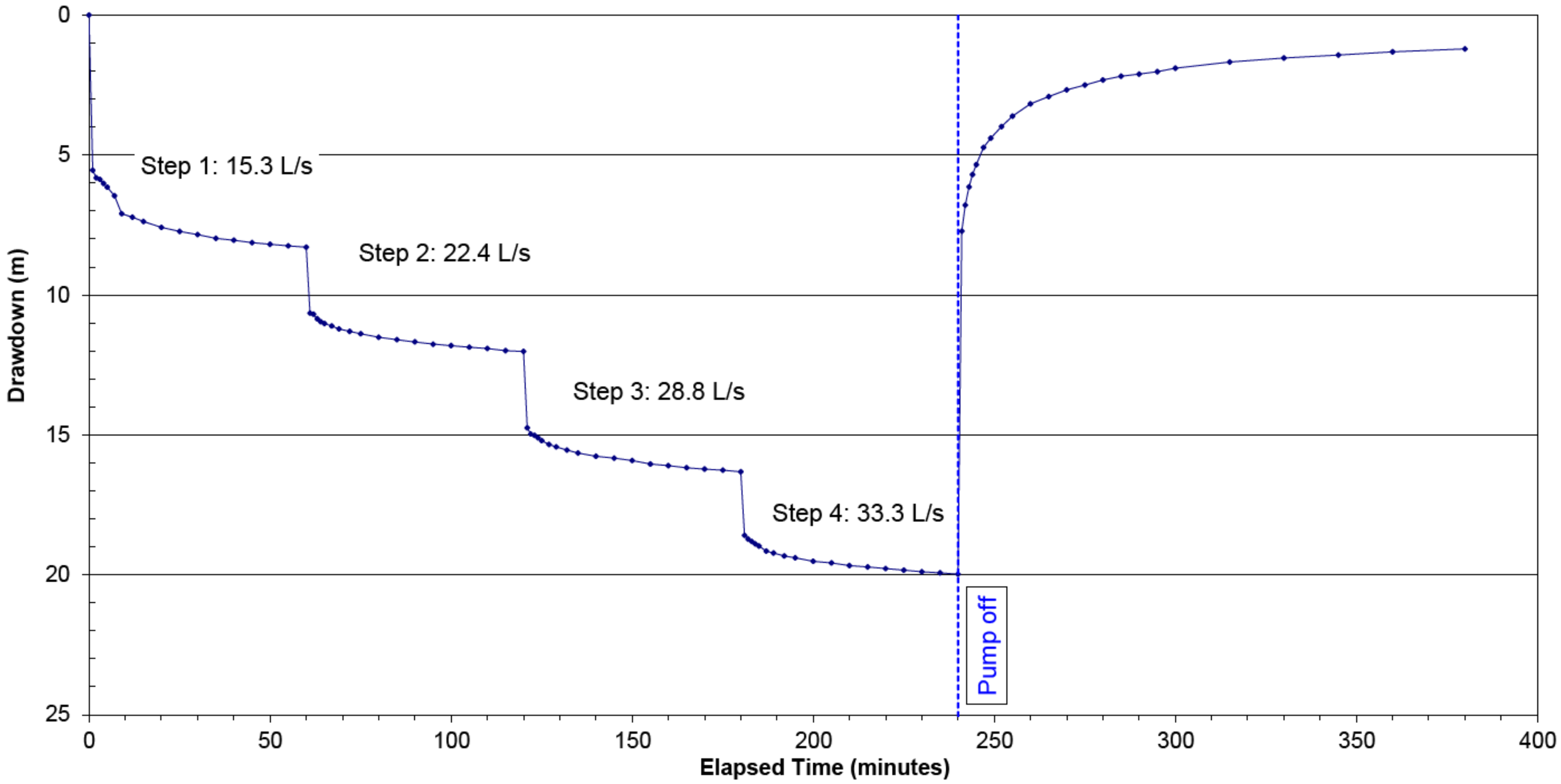
APPENDIX A

BORE 72_11239 PUMPING TEST ANALYSIS SHEETS



72_11239 Brymer Road Brymer Future Proof Dev	TITLE	**Stepped Rate Pumping Test Drawdown and Recovery, 27 October 2022** **Normal - Normal Scale Plot**			
WGA	DRAWN C Howell	DATE 11 November 2022		JOB NO. 211193	
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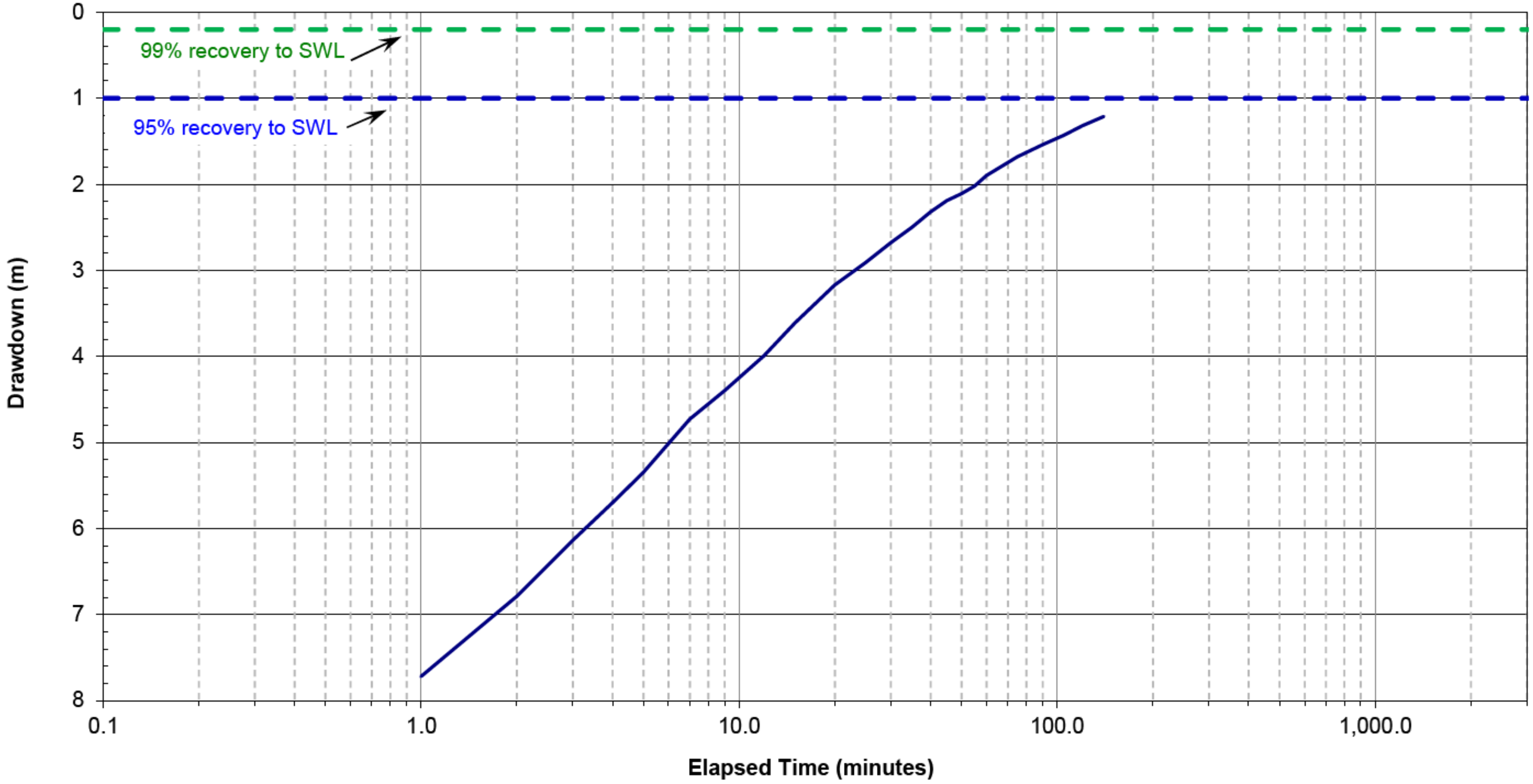
	REVIEWED C. Houlbrooke	FILE NO. na		FIGURE NO. A1	



72_11239 Brymer Road **Brymer Future Proof Dev**	TITLE	**Stepped Rate Pumping Test Recovery, 27 October 2022** **Log - Normal Scale plot**			
WGA	DRAWN	C Howell	DATE 11 November 2022	JOB NO.	211193
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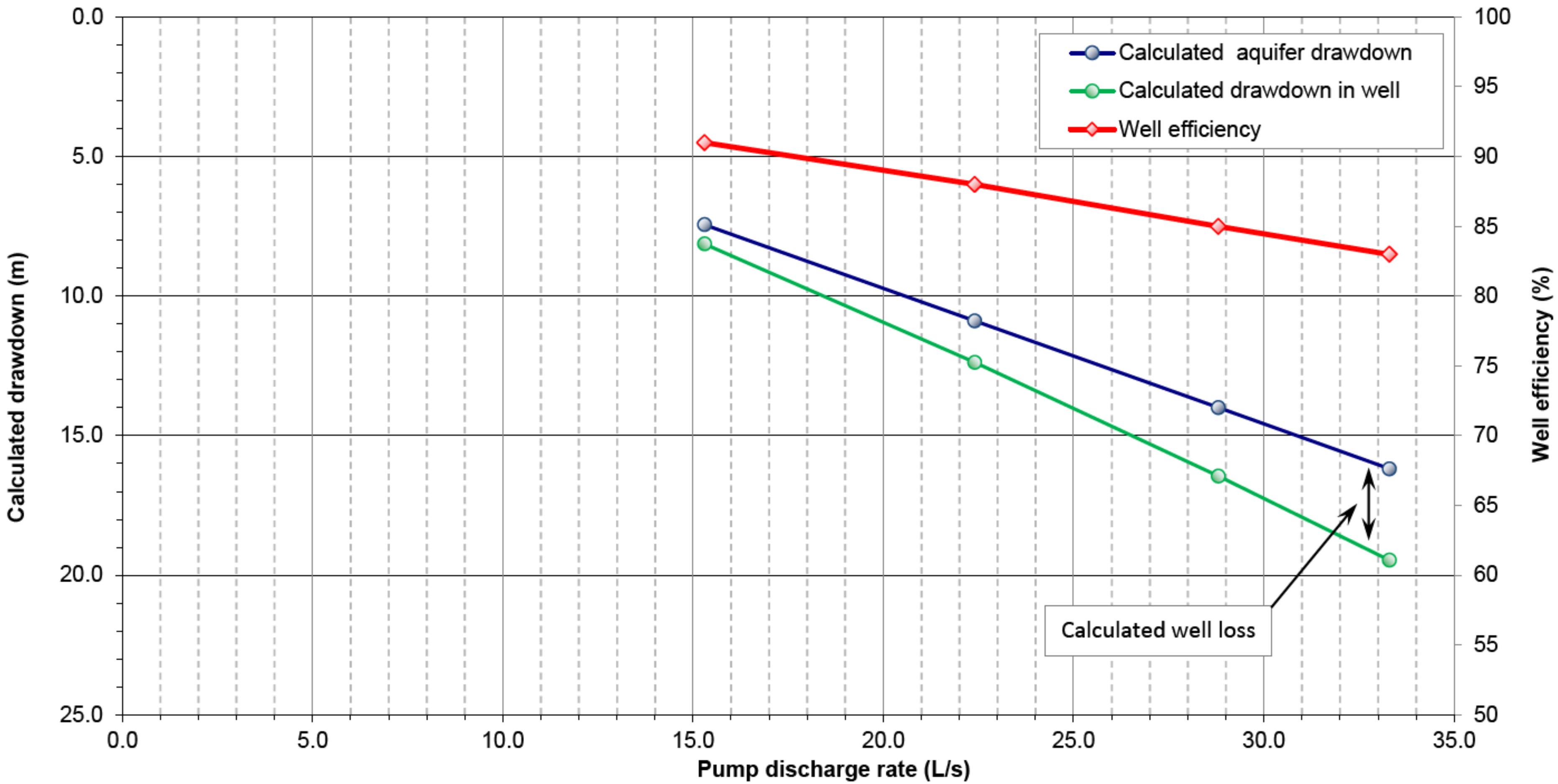
	REVIEWED	C. Houlbrooke	FILE NO. na	FIGURE NO.	A2



72_11239 Brymer Road **Brymer Future Proof Dev**	TITLE	**Stepped Rate Pumping Test Well Efficiency, 27 October 2022** **Normal - Normal Scale plot**			
WGA	DRAWN C Howell	DATE 11 November 2022		JOB NO. 211193	
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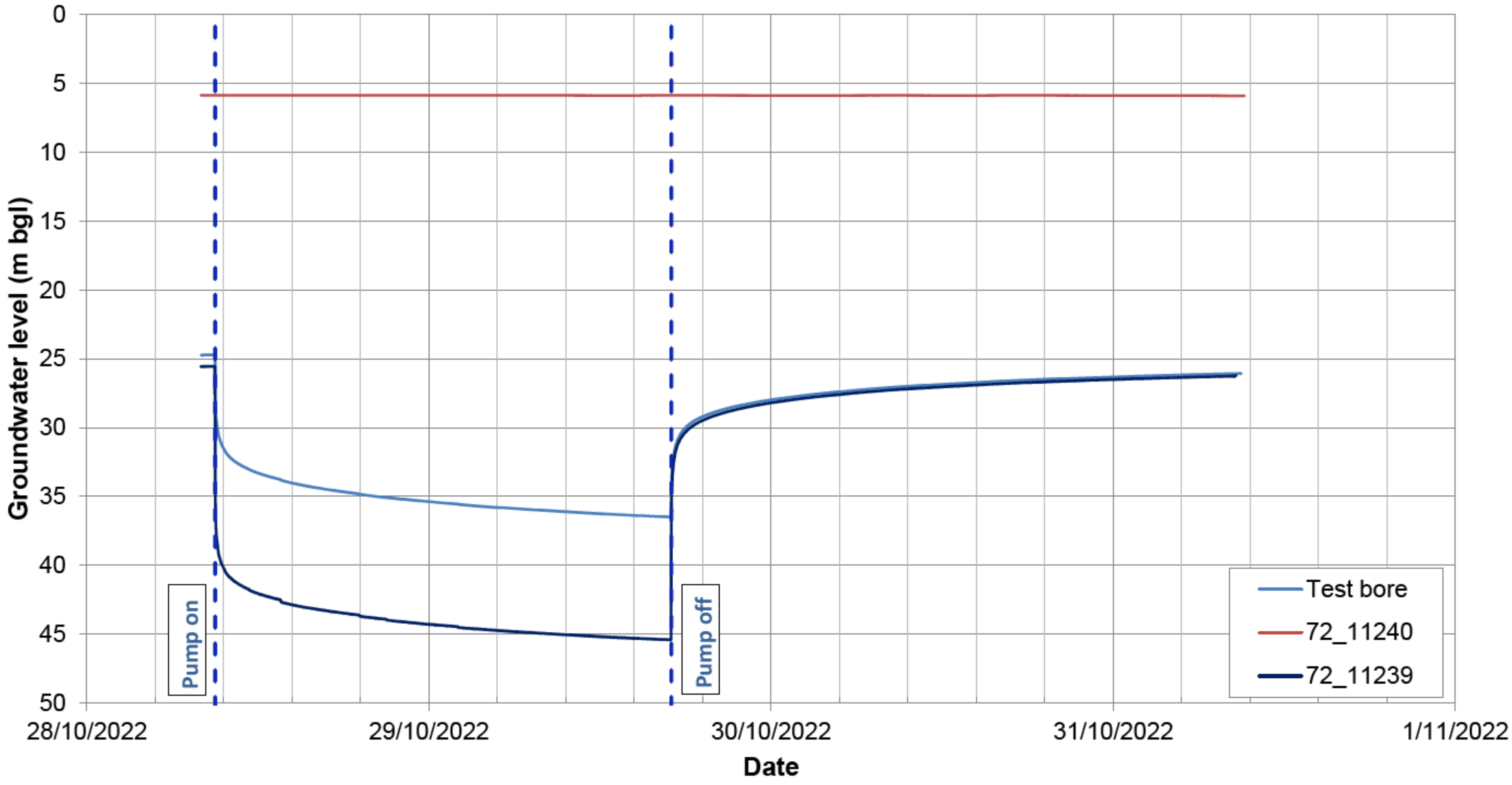
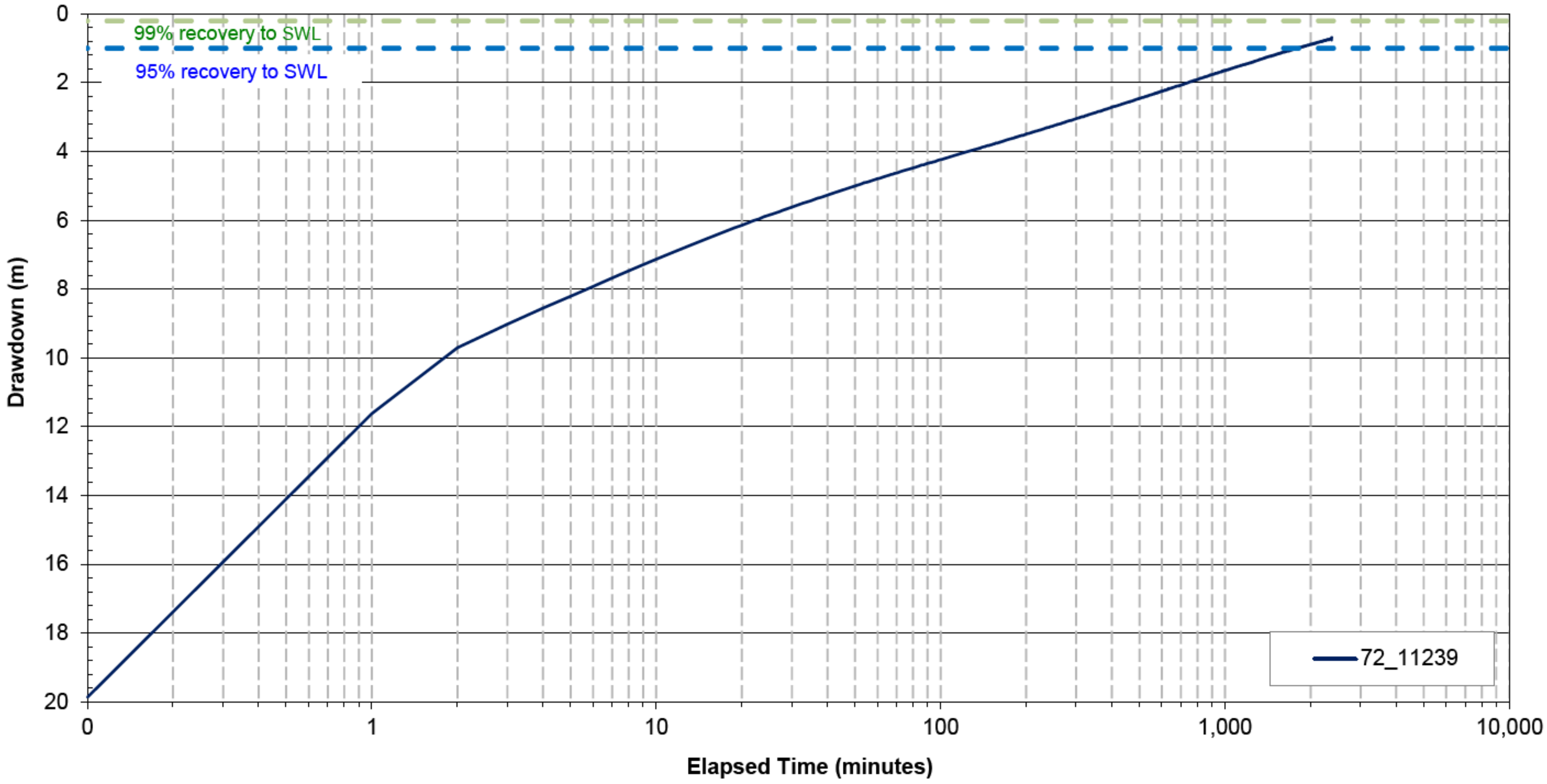
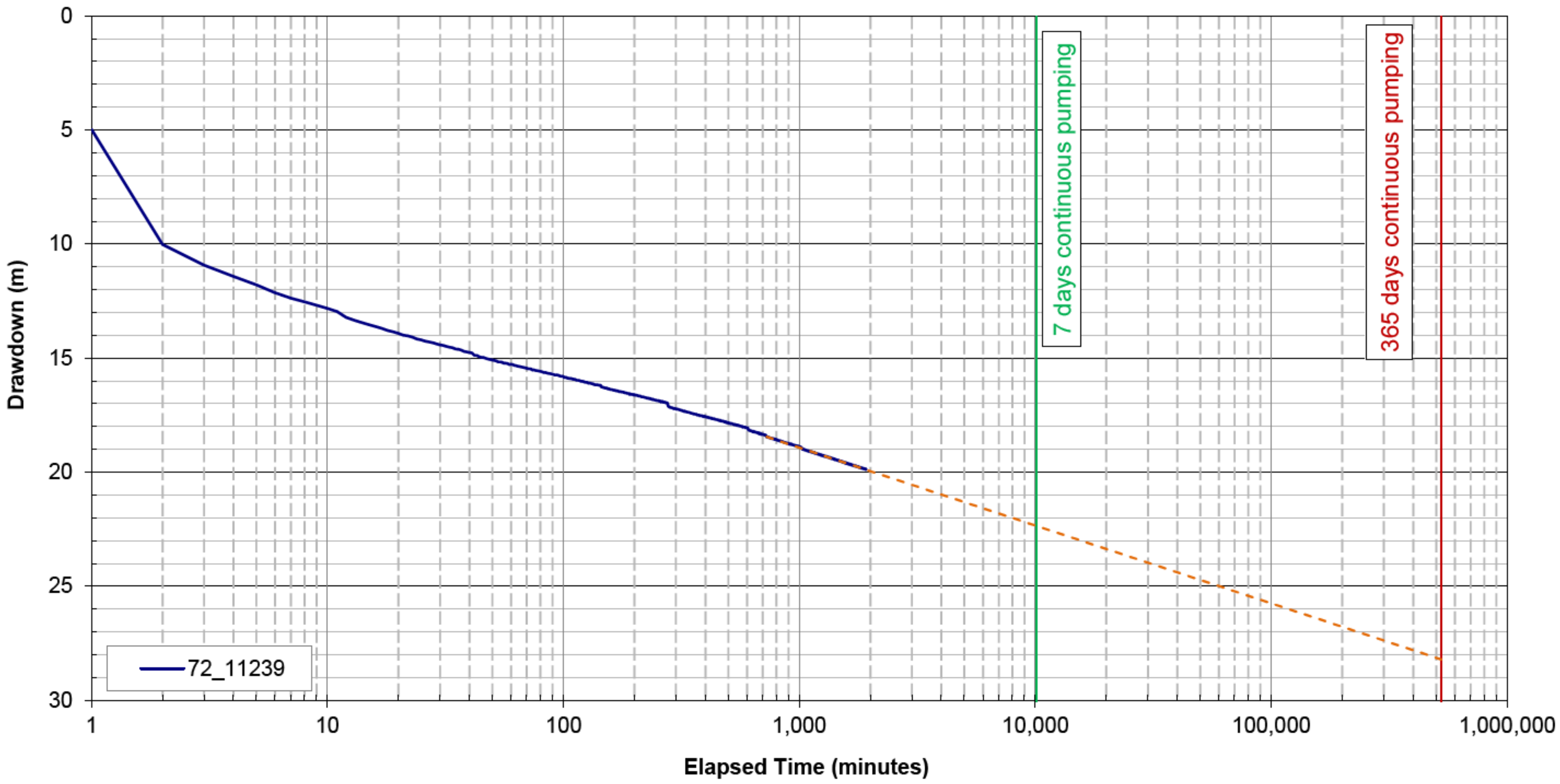
	REVIEWED C. Houlbrooke	FILE NO. na		FIGURE NO. A3	



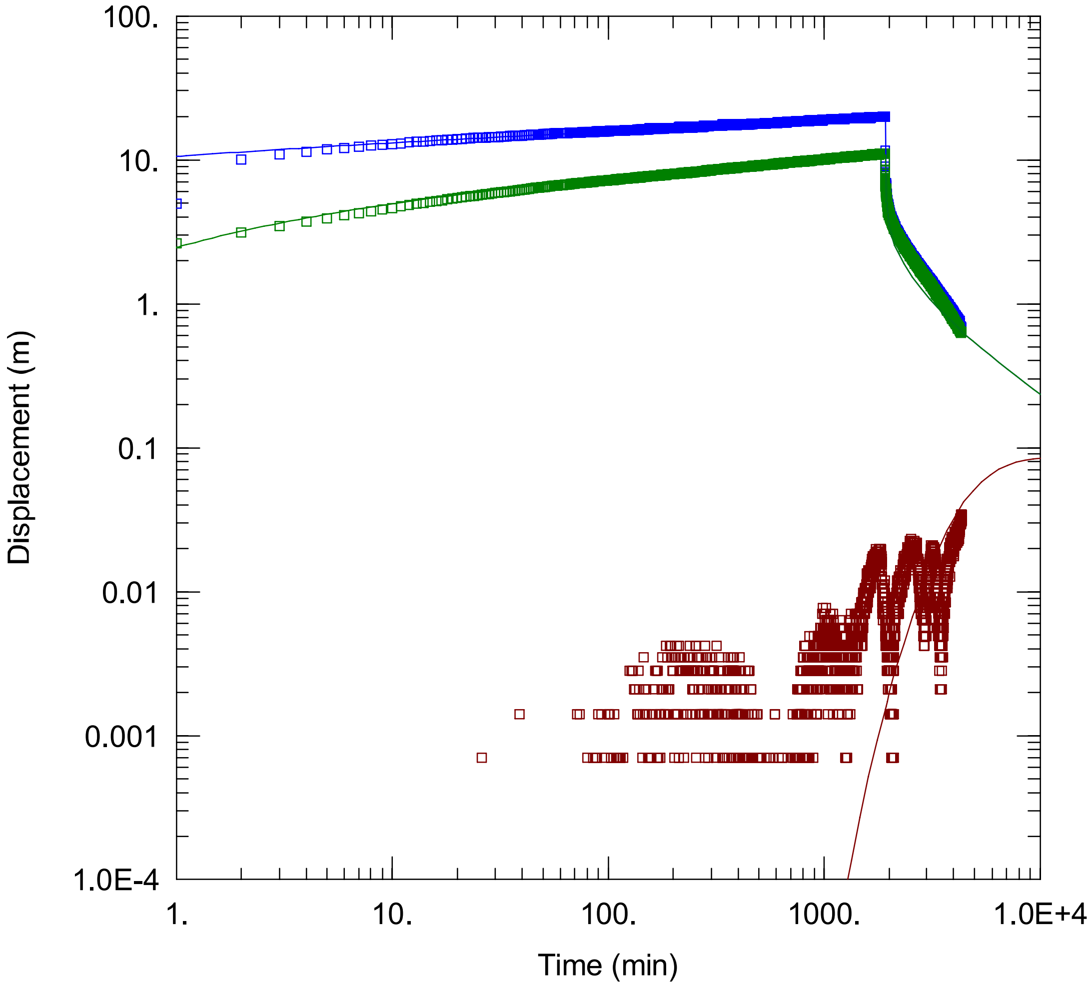
72_11239 **Brymer Future Proof Dev**	TITLE	**Constant Rate Pumping Test Drawdown and Recovery, Date 28 October 2022** **Normal - Normal Scale Plot. Data supplied by Brown Bros Ltd**			
WGA	DRAWN Catherine Howell	DATE 14 November 2022	JOB NO. 211193		
	CHECKED -	SCALE na	DWG. NO. na		
	REVIEWED Clare Houlbrooke	FILE NO. na	FIGURE NO. A4		



72_11239 **Brymer Future Proof Dev**	TITLE	**Constant Rate Pumping Test Recovery Percentage, Date 28 October 2022** **Log - Normal Scale Plot. Data supplied by Brown Bros Ltd**			
WGA	DRAWN	Catherine Howell	DATE 14 November 2022	JOB NO.	211193
	CHECKED	-	SCALE na	DWG. NO.	na
	REVIEWED	Clare Houlbrooke	FILE NO. na	FIGURE NO.	A5



72_11239 **Brymer Future Proof Dev**	TITLE	**Projected Drawdown Following 365 Days Continuous Pumping Period** **Log - Normal Scale Plot. Data supplied by Brown Bros Ltd**			
WGA	DRAWN Catherine Howell	DATE 14 November 2022	JOB NO. 211193		
	CHECKED -	SCALE na	DWG. NO. na		
	REVIEWED Clare Houlbrooke	FILE NO. na	FIGURE NO. A6		



WELL TEST ANALYSIS

Data Set: V:\...\72_11239.aqt
Date: 11/16/22 Time: 10:00:41

PROJECT INFORMATION

Company: WGANZ
Client: Brymer Future Proof Dev
Project: WGA211193
Location: Brymer Road
Test Well: 72_11239
Test Date: 28/10/2022

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
72_11239	1795223	5814854

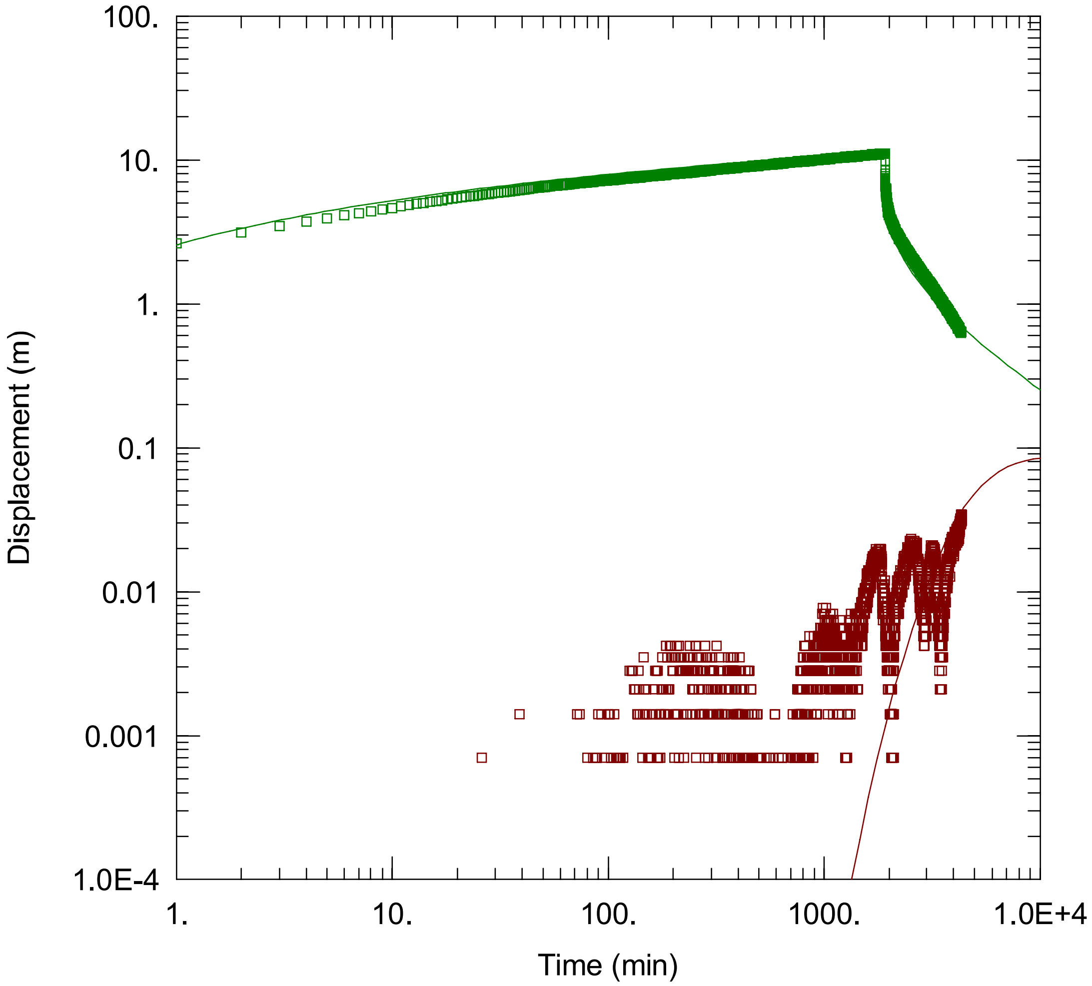
Observation Wells

Well Name	X (m)	Y (m)
72_11239	1795223	5814854
Test Well 2	1795227	5814854
72_11240	1795408	5816356

SOLUTION

Aquifer Model: Confined Solution Method: Theis

T = 179.2 m^2/day S = 0.00202
Kz/Kr = 1. b = 13. m



WELL TEST ANALYSIS

Data Set: V:\...\72_11239.aqt
Date: 02/06/23
Time: 13:43:49

PROJECT INFORMATION

Company: WGANZ
Client: Brymer Future Proof Dev
Project: WGA211193
Location: Brymer Road
Test Well: 72_11239
Test Date: 28/10/2022

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
72_11239	1795408	5816356

Observation Wells

Well Name	X (m)	Y (m)
Test Well 2	1795412	5816356
72_11240	1795223	5814854

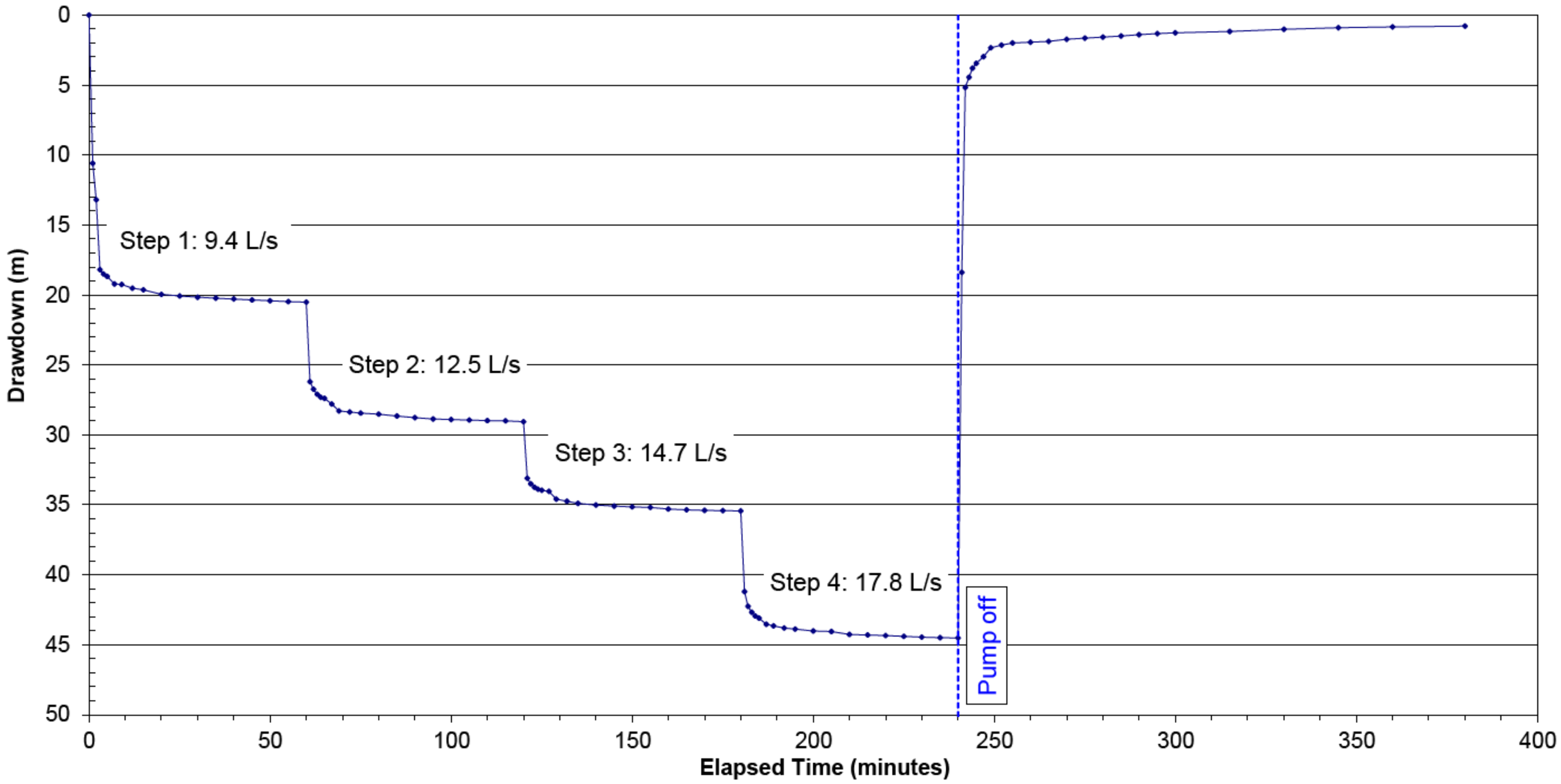
SOLUTION

Aquifer Model: Confined
Solution Method: Theis

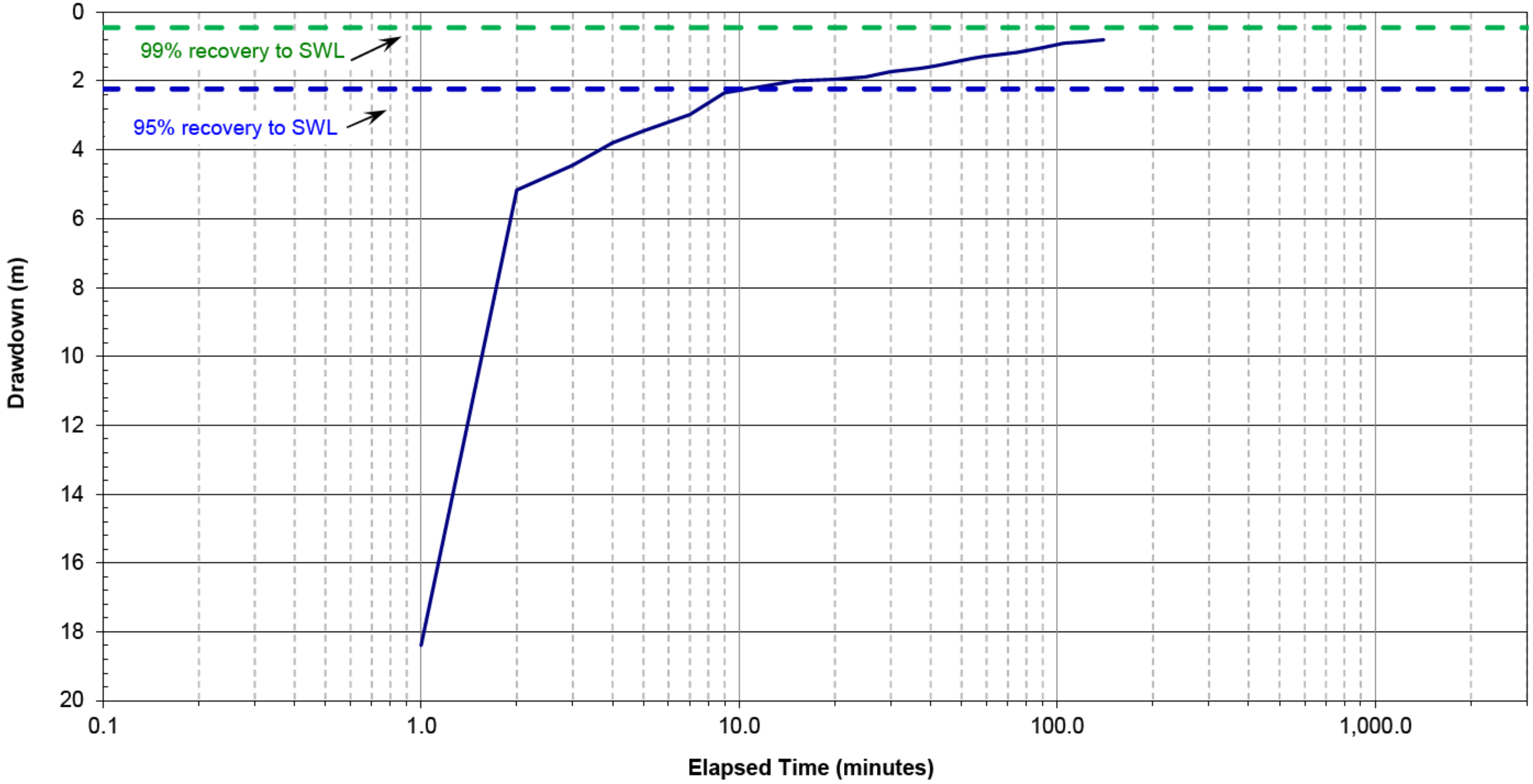
T = 168.1 m^2/day
S = 0.002005
Kz/Kr = 1.
b = 13. m

APPENDIX B

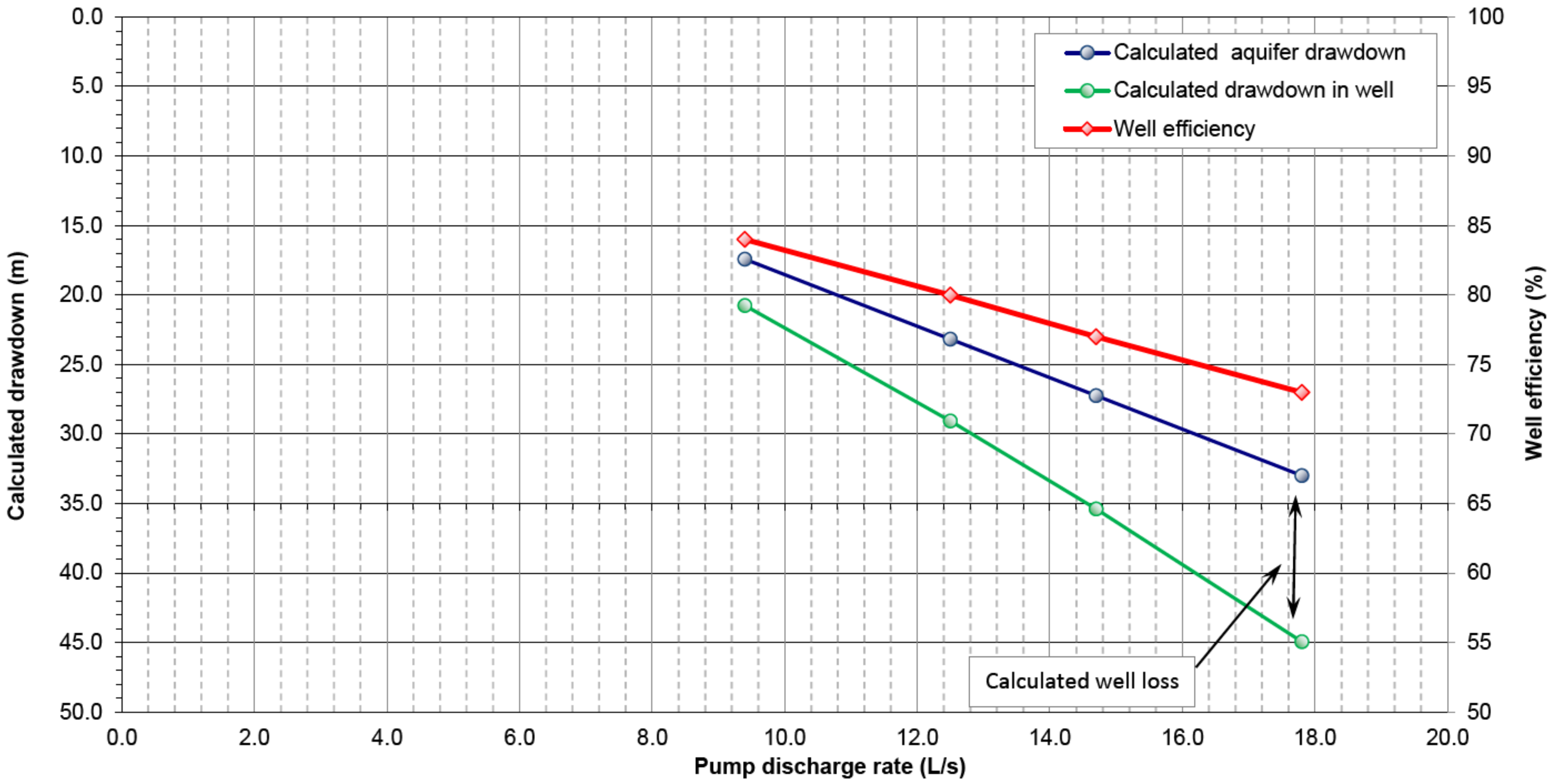
BORE 72_11240 PUMPING TEST ANALYSIS SHEETS



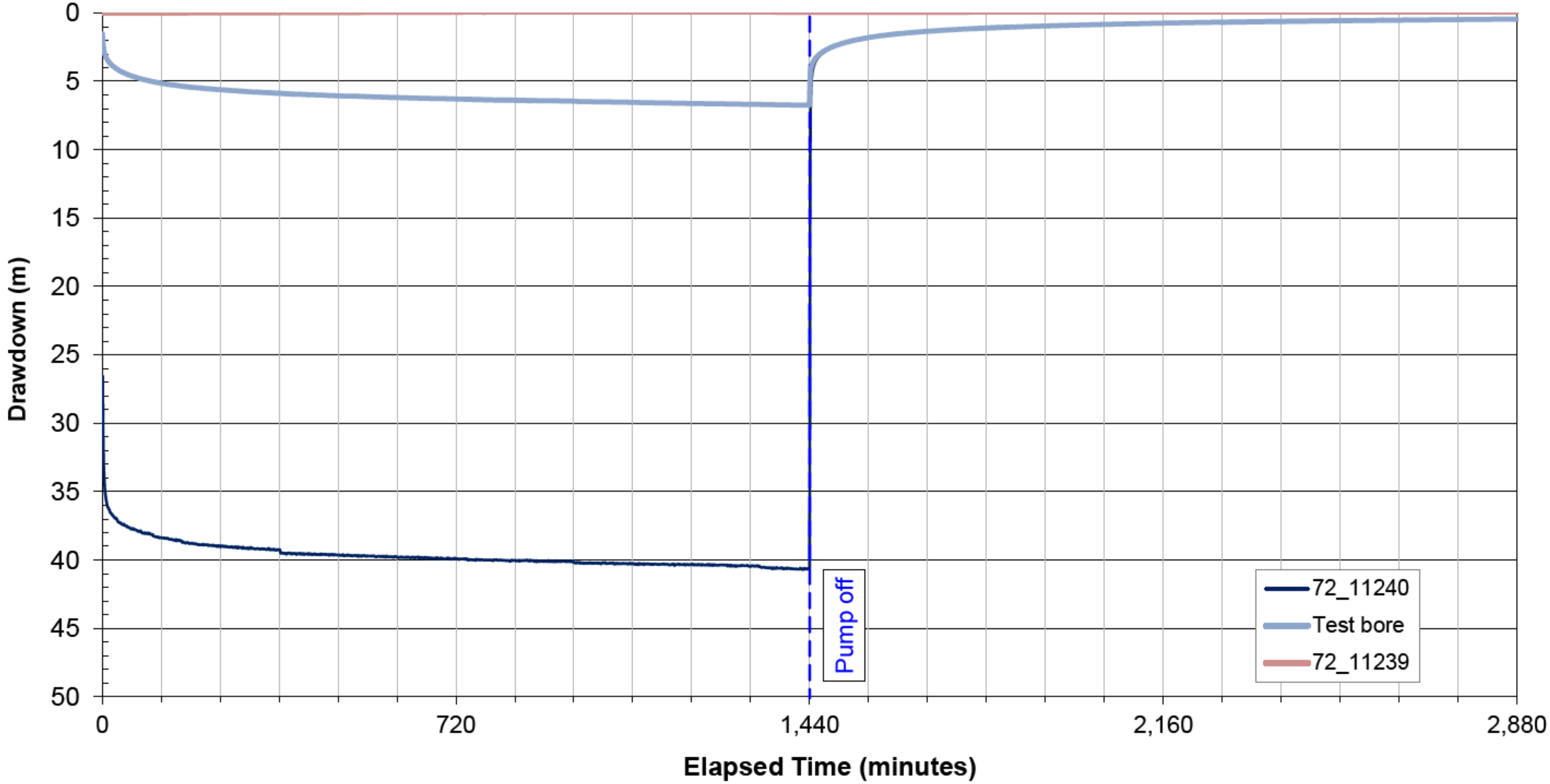
72_11240 Whatawhata Road **Brymer Future Proof Dev**	TITLE	**Stepped Rate Pumping Test Drawdown and Recovery, 30 September 2022** **Normal - Normal Scale Plot**			
WGA	DRAWN	C Howell	DATE	11 November 2022	JOB NO. 211193
	CHECKED	-	SCALE	na	DWG. NO. na
	REVIEWED	C. Houlbrooke	FILE NO.	na	FIGURE NO. B1



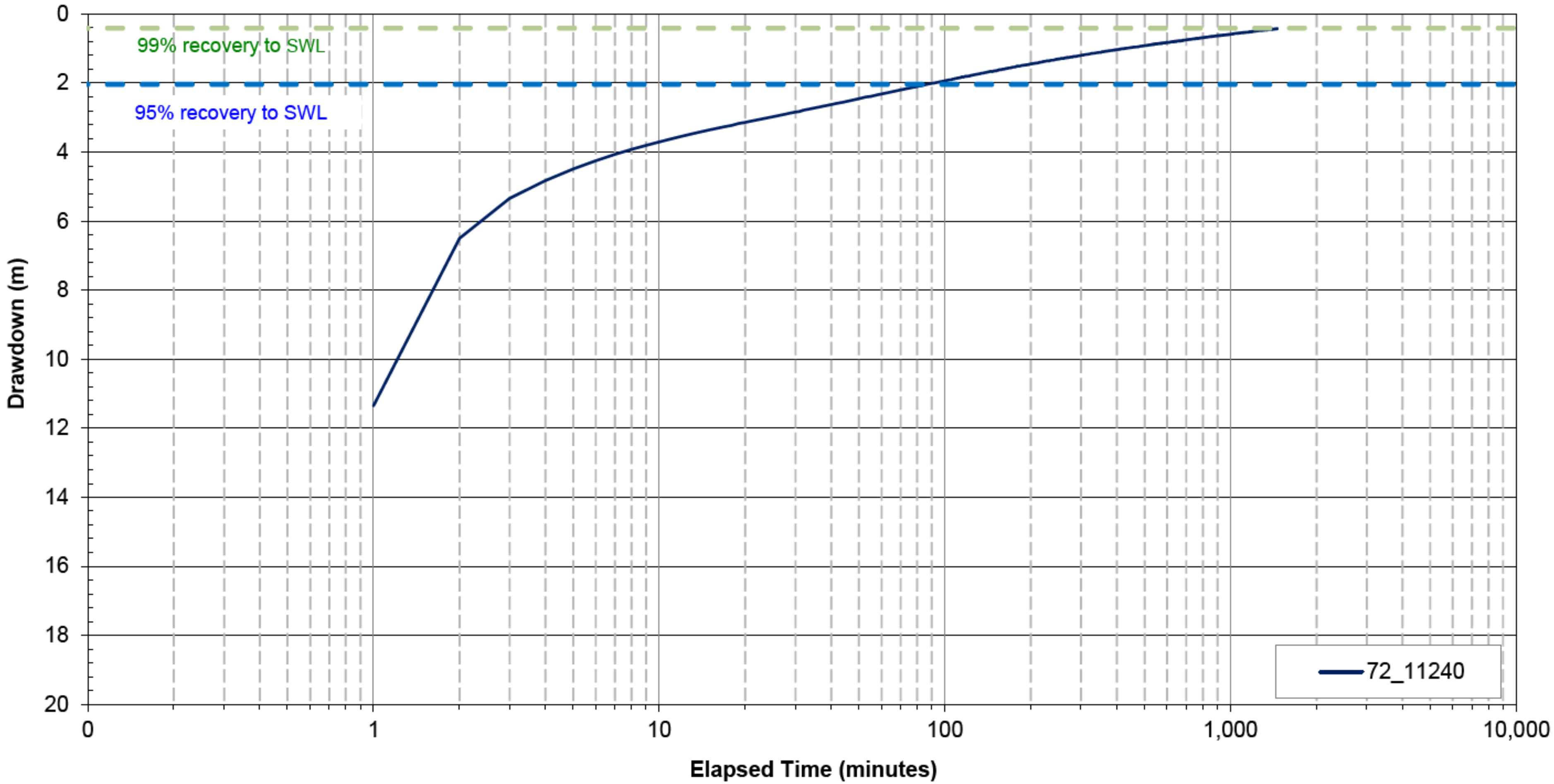
72_11240 Whatawhata Road **Brymer Future Proof Dev**	TITLE	**Stepped Rate Pumping Test Recovery, 30 September 2022** **Log - Normal Scale plot**			
WGA	DRAWN	C Howell	DATE 11 November 2022	JOB NO.	211193
	CHECKED	-	SCALE na	DWG. NO.	na
	REVIEWED	C. Houlbrooke	FILE NO. na	FIGURE NO.	B2



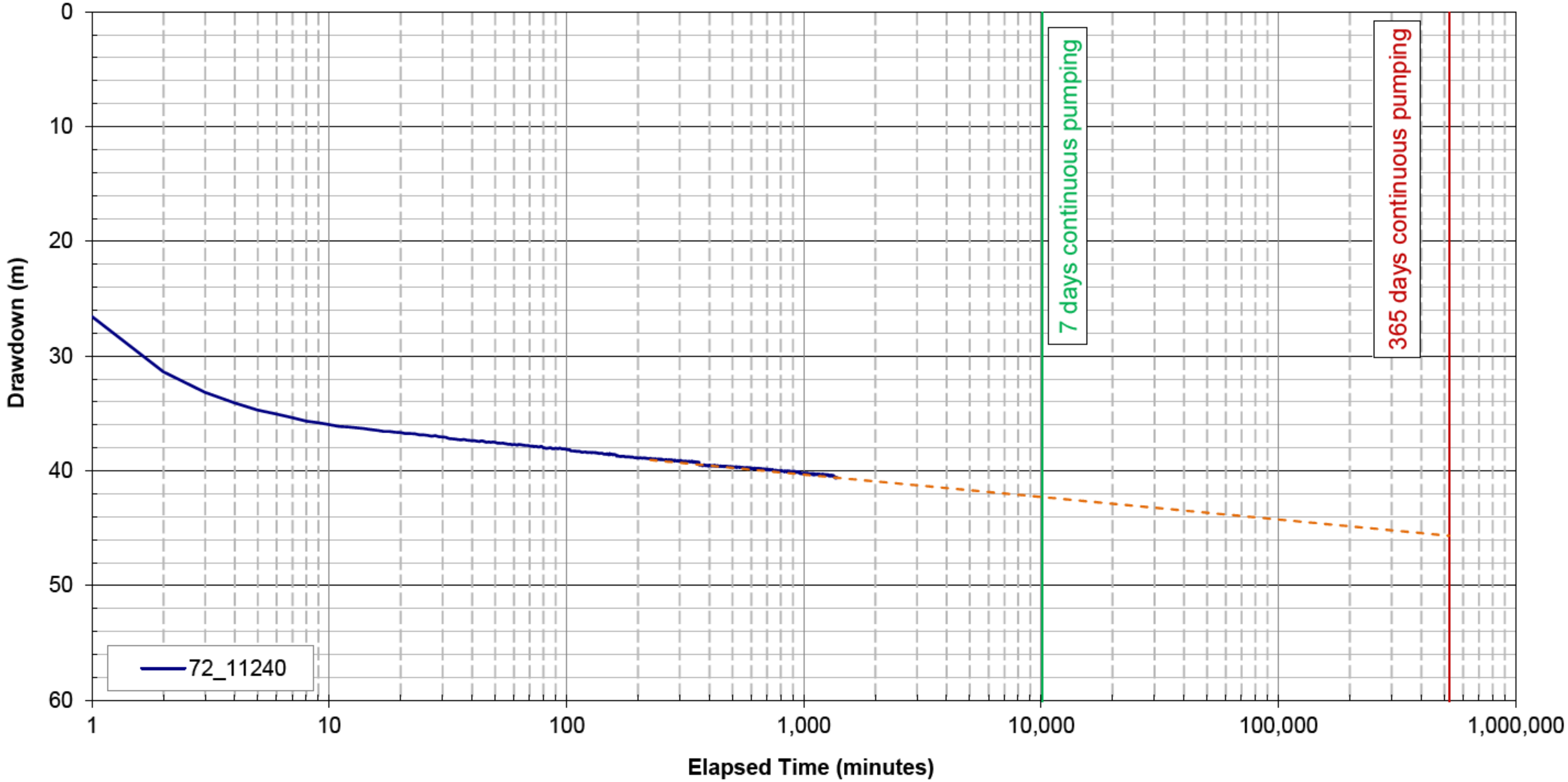
72_11240 Whatawhata Road **Brymer Future Proof Dev**	TITLE	**Stepped Rate Pumping Test Well Efficiency, 30 September 2022** **Normal - Normal Scale plot**			
WGA	DRAWN	C Howell	DATE 11 November 2022	JOB NO.	211193
	CHECKED	-	SCALE na	DWG. NO.	na
	REVIEWED	C. Houlbrooke	FILE NO. na	FIGURE NO.	B3



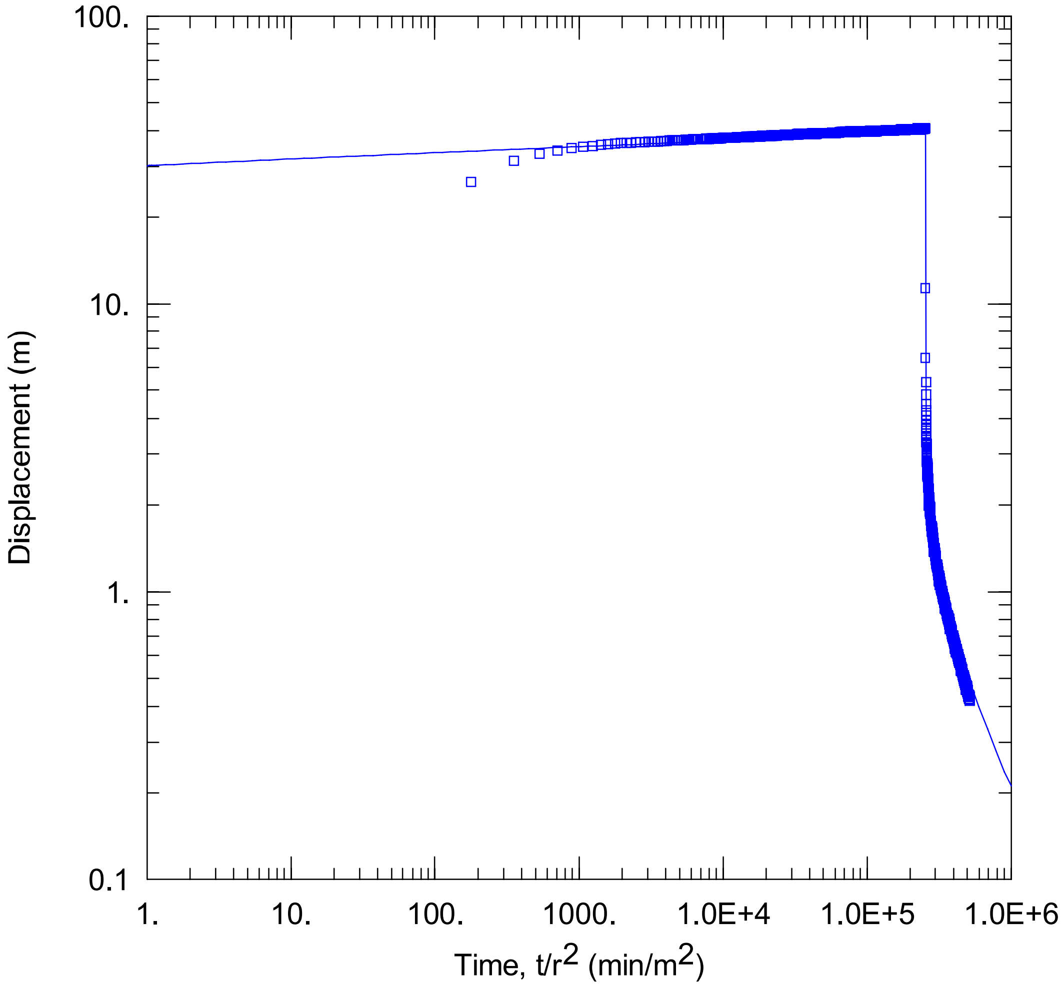
72_11240 Whatawhata Road **Brymer Future Proof Dev**	TITLE	**Constant Rate Pumping Test Drawdown and Recovery, Date 1 October 2022** **Normal - Normal Scale Plot. Data supplied by Brown Bros Ltd**				
WGA	DRAWN	Catherine Howell	DATE	15 November 2022	JOB NO.	211193
	CHECKED	-	SCALE	na	DWG. NO.	na
	REVIEWED	Clare Houlbrooke	FILE NO.	na	FIGURE NO.	B4



72_11240 Whatawhata Road Brymer Future Proof Dev	TITLE	Constant Rate Pumping Test Recovery Percentage, Date 1 October 2022 Log - Normal Scale Plot. Data supplied by Brown Bros Ltd			
WGA	DRAWN	Catherine Howell	DATE 15 November 2022	JOB NO.	211193
	CHECKED	-	SCALE na	DWG. NO.	na
	REVIEWED	Clare Houlbrooke	FILE NO. na	FIGURE NO.	B5



72_11240 Whatawhata Road Brymer Future Proof Dev	TITLE	**Projected Drawdown Following 365 Days Continuous Pumping Period Log - Normal Scale Plot. Data supplied by Brown Bros Ltd**			
WGA	DRAWN	Catherine Howell	DATE 15 November 2022	JOB NO.	211193
	CHECKED	-	SCALE na	DWG. NO.	na
	REVIEWED	Clare Houlbrooke	FILE NO. na	FIGURE NO.	B6



WELL TEST ANALYSIS

Data Set: V:\...\72_11240.aqt
Date: 02/06/23 Time: 13:56:45

PROJECT INFORMATION

Company: WGANZ
Client: Brymer Future Proof Dev
Project: WGA211193
Location: Whatawhata Road
Test Well: 72_11240
Test Date: 1/10/2022

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
72_11240	1795223	5814854

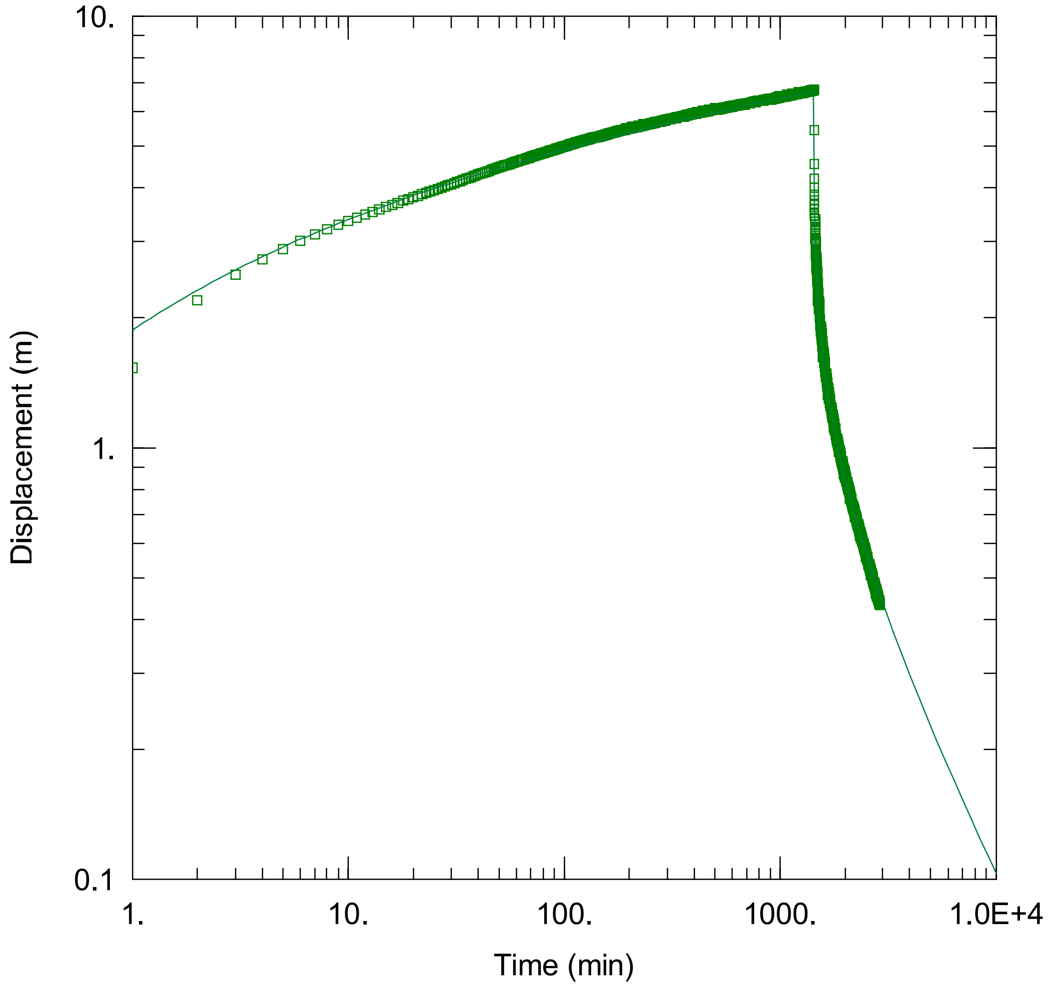
Observation Wells

Well Name	X (m)	Y (m)
72_11240	1795223	5814854

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

T = 151.7 m^2/day
S = 1.149E-19
Kz/Kr = 1.
b = 17. m



WELL TEST ANALYSIS

Data Set: V:\...\72_11240.aqt
Date: 02/06/23 Time: 13:49:57

PROJECT INFORMATION

Company: WGANZ
Client: Brymer Future Proof Dev
Project: WGA211193
Location: Whatawhata Road
Test Well: 72_11240
Test Date: 1/10/2022

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
72_11240	1795223	5814854

Observation Wells

Well Name	X (m)	Y (m)
Test Well 1	1795227	5814854

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

T = 163.5 m^2/day
S = 0.0009931
Kz/Kr = 1.
b = 17. m

APPENDIX C
ASSESSMENT OF EFFECTS

Table C1: Bore logs for nearby bores greater than 55 m deep.

Table C1: Bore logs for nearby bores greater than 55 m deep.

Ground elevation (m asl)	72_11239	72_11240	69_1276	69_2173	72_5190	72_10228	72_6800	69_1650	72_1689	72_3505
-34										
-35										
-36								Sands		
-37										
-38										
-39										
-40								Peat wood		
-41		Peat								
-42	Peat, fine sand							Pumice		
-43										
-44										
-45								Peat wood		
-46										
-47		Fine sand & Silt								
-48								Silt		
-49										
-50										
-51										
-52	Grey blue gravel									
-53										
-54										
-55										
-56										
-57										
-58										
-59	Grey silt									
-60	Grey silt - water loss									
-61		Green Silt								
-62										
-63										
-64										
-65										
-66										
-67										
-68										
-69										
-70										
-71										
-72										
-73										
-74										
-75										
-76										
-77		Blue Gravel								
-78										
-79										
-80										
-81										
-82										
-83										
-84										
-85		Peat Silt								
-86										
-87										
-88										
-89										
-90										
-91										
-92										
-93										
-94										
-95										
-96										
-97		Brown Silt								
-98										
-99										
-100										
-101										
-102										
-103										
-104										
-105										
-106										
-107										

Table C2: Projected Drawdown Effects on Nearby Bores

BORE ID	EASTING (NZTM)	NORTHING (NZTM)	BORE DEPTH (m)	CASING DEPTH (m)	DISTANCE FROM PRODUCTION BORE 1 (m)	DISTANCE FROM PRODUCTION BORE 2 (m)	PROJECTED DRAWDOWN FROM PRODUCTION BORE 1 (m)	PROJECTED DRAWDOWN FROM PRODUCTION BORE 2 (m)	COMBINED PROJECTED DRAWDOWN (m)	PROJECTED CHANGE IN AVAILABLE WATER COLUMN (%)
72_11239	1795408	5816356	109	97.5	0	1,513	15.48	1.32	16.8	N/A
72_11240	1795223	5814854	111	105	1,513	0	2.79	7.32	10.11	N/A
Bores assessed as tapping the shallow unconfined aquifer										
69_681	1795053	5816563	7.2	7.2	411	1,717	0.20	0.08	0.28	4
69_30	1794852	5816663	11	Unknown	635	1,847	0.20	0.07	0.27	2
69_477	1794852	5816663	5(1)	Unknown	635	1,847	0.20	0.07	0.27	5
62_25	1795954	5815764	8.16	Unknown	805	1,167	0.19	0.09	0.28	3
72_5359	1796080	5817480	10.5	7.5	1,310	2,762	0.18	0.06	0.24	2
69_177	1795455	5814963	7.54	Unknown	1,394	256	0.17	0.10	0.27	4
69_1160	1794251	5817462	11	6.5	1,601	2,783	0.17	0.06	0.23	2
69_2075	1794251	5817462	5	Unknown	1,601	2,783	0.17	0.06	0.23	5
72_5360	1796287	5817752	7.1	4.1	1,650	3,087	0.16	0.06	0.22	3
62_70	1794951	5817963	9.4	7.3	1,671	3,121	0.16	0.06	0.22	2
69_314	1793752	5816661	5(1)	Unknown	1,684	2,330	0.16	0.07	0.23	5
72_3491	1794956	5814662	5(1)	Unknown	1,753	329	0.16	0.10	0.26	5
72_3491	1794956	5814662	5(1)	Unknown	1,753	329	0.16	0.10	0.26	5
69_92	1795956	5814564	11.6	Unknown	1,874	788	0.16	0.09	0.25	2
72_4901	1796709	5814842	6	0.5	1,996	1,486	0.15	0.08	0.23	4
69_194	1793955	5814761	5(1)	Unknown	2,158	1,271	0.15	0.08	0.23	5
72_5508	1797056	5814365	4	1	2,585	1,897	0.13	0.07	0.21	5
72_5509	1797056	5814365	4	1	2,585	1,897	0.13	0.07	0.21	5
72_5501	1797056	5814365	4.5	1	2,585	1,897	0.13	0.07	0.21	5
72_5500	1797119	5814394	4	1	2,603	1,951	0.13	0.07	0.21	5
69_370	1795657	5813763	5.65	Unknown	2,605	1,174	0.13	0.09	0.22	4

BORE ID	EASTING (NZTM)	NORTHING (NZTM)	BORE DEPTH (m)	CASING DEPTH (m)	DISTANCE FROM PRODUCTION BORE 1 (m)	DISTANCE FROM PRODUCTION BORE 2 (m)	PROJECTED DRAWDOWN FROM PRODUCTION BORE 1 (m)	PROJECTED DRAWDOWN FROM PRODUCTION BORE 2 (m)	COMBINED PROJECTED DRAWDOWN (m)	PROJECTED CHANGE IN AVAILABLE WATER COLUMN (%)
69_90	1793957	5813761	5[(1)]	Unknown	2,973	1,673	0.12	0.08	0.20	4
69_1586	1794758	5813162	11.5	10	3,259	1,755	0.12	0.08	0.19	2
69_486	1794258	5813261	5[(1)]	Unknown	3,302	1,862	0.11	0.07	0.19	4
Bores assessed as tapping the overlying aquifer										
69_178	1795453	5816163	18.9	Unknown	198	1,329	0.91	0.41	1.31	7
69_193	1795253	5816663	54.8	Unknown	344	1,809	0.90	0.39	1.29	2
72_4635	1795252	5816763	33	23.5	436	1,909	0.90	0.39	1.29	4
72_10731	1794847	5816025	46.3	38.5	651	1,230	0.89	0.41	1.30	3
62_26	1796154	5815864	32.94	Unknown	894	1,374	0.88	0.40	1.29	4
72_899	1794724	5816943	34.1	29.2	901	2,148	0.88	0.38	1.26	4
72_604	1794683	5817036	34	27.2	994	2,248	0.88	0.38	1.25	4
69_768	1794552	5816862	27	24.6	994	2,117	0.88	0.38	1.26	5
72_5925	1795251	5817463	23	20	1,118	2,609	0.87	0.36	1.23	5
69_63	1794531	5817213	18	Unknown	1,226	2,458	0.86	0.37	1.23	7
72_11045	1794548	5817352	29.8	27	1,316	2,588	0.86	0.36	1.22	4
72_3436	1795251	5817663	36	32.5	1,316	2,809	0.86	0.36	1.21	3
72_3676	1795251	5817663	36	32.5	1,316	2,809	0.86	0.36	1.21	3
69_1039	1794352	5817162	43.2	36.5	1,328	2,467	0.86	0.37	1.22	3
69_492	1794951	5817663	24	Unknown	1,385	2,822	0.85	0.36	1.21	5
72_2913	1794252	5817162	29.1	22.6	1,409	2,504	0.85	0.37	1.22	4
72_4769	1794751	5817663	18	10.5	1,463	2,848	0.85	0.35	1.20	7
62_79	1795251	5817863	47	39	1,515	3,009	0.84	0.35	1.19	3
62_47	1794451	5817562	24	19.5	1,540	2,816	0.84	0.36	1.20	5
69_858	1794955	5814862	23.7	21	1,561	268	0.84	0.43	1.27	5
69_667	1794951	5817863	33.5	26.5	1,575	3,021	0.84	0.35	1.19	4
69_179	1793952	5817061	22.8	Unknown	1,618	2,547	0.84	0.37	1.20	5

BORE ID	EASTING (NZTM)	NORTHING (NZTM)	BORE DEPTH (m)	CASING DEPTH (m)	DISTANCE FROM PRODUCTION BORE 1 (m)	DISTANCE FROM PRODUCTION BORE 2 (m)	PROJECTED DRAWDOWN FROM PRODUCTION BORE 1 (m)	PROJECTED DRAWDOWN FROM PRODUCTION BORE 2 (m)	COMBINED PROJECTED DRAWDOWN (m)	PROJECTED CHANGE IN AVAILABLE WATER COLUMN (%)
62_103	1794951	5817963	32	27.5	1,671	3,121	0.83	0.34	1.18	4
62_96	1794889	5818013	26	23.2	1,736	3,177	0.83	0.34	1.17	5
69_214	1794051	5817461	24.38	18.28	1,750	2,858	0.83	0.35	1.18	5
72_3492	1793754	5815661	30.5	21.5	1,794	1,676	0.83	0.39	1.22	4
69_2203	1793754	5815661	30.5	21.5	1,794	1,676	0.83	0.39	1.22	4
72_3492	1793754	5815661	30.5	21.5	1,794	1,676	0.83	0.39	1.22	4
69_2203	1793754	5815661	30.5	21.5	1,794	1,676	0.83	0.39	1.22	4
69_2106	1793851	5817261	33.5	29.5	1,801	2,771	0.83	0.36	1.18	4
72_1432	1796056	5814664	23	17	1,812	854	0.82	0.42	1.24	5
72_5995	1796056	5814664	36	26	1,812	854	0.82	0.42	1.24	3
72_1766	1794750	5818063	47	36	1,829	3,244	0.82	0.34	1.16	2
72_5369	1795079	5818156	36.5	30.5	1,830	3,305	0.82	0.34	1.16	3
72_1689	1793851	5817361	78	45.5	1,853	2,858	0.82	0.35	1.18	2
69_2172	1793751	5817261	40	32.5	1,888	2,821	0.82	0.36	1.17	3
72_3505	1793851	5817461	61.5	53	1,909	2,946	0.82	0.35	1.17	2
72_1633	1793851	5817527	37.5	25	1,948	3,005	0.82	0.35	1.16	3
62_3	1796656	5814765	32.94	Unknown	2,022	1,436	0.81	0.40	1.21	4
69_1582	1793554	5815360	46.9	Unknown	2,105	1,744	0.80	0.39	1.20	3
69_1964	1793554	5815360	52.1	Unknown	2,105	1,744	0.80	0.39	1.20	2
72_11646	1794257	5814464	39	31	2,215	1,042	0.80	0.41	1.21	3
69_2109	1796156	5814264	17.3	13.4	2,222	1,104	0.80	0.41	1.21	7
72_3490	1794656	5814262	36	13	2,225	820	0.80	0.42	1.21	3
72_2810	1795457	5814063	50	23	2,294	825	0.79	0.42	1.21	2
69_1472	1793956	5814561	41.2	32.5	2,309	1,300	0.79	0.41	1.20	3
69_313	1793455	5814860	18.2	Unknown	2,460	1,768	0.78	0.39	1.17	6
69_1545	1793655	5814560	27	20	2,510	1,595	0.77	0.40	1.17	4

BORE ID	EASTING (NZTM)	NORTHING (NZTM)	BORE DEPTH (m)	CASING DEPTH (m)	DISTANCE FROM PRODUCTION BORE 1 (m)	DISTANCE FROM PRODUCTION BORE 2 (m)	PROJECTED DRAWDOWN FROM PRODUCTION BORE 1 (m)	PROJECTED DRAWDOWN FROM PRODUCTION BORE 2 (m)	COMBINED PROJECTED DRAWDOWN (m)	PROJECTED CHANGE IN AVAILABLE WATER COLUMN (%)
69_347	1796457	5813964	31	25	2,612	1,521	0.77	0.40	1.17	4
69_315	1793255	5814860	15.24	13.72	2,622	1,968	0.77	0.39	1.15	8
69_979	1796157	5813764	23.77	Unknown	2,698	1,435	0.76	0.40	1.16	5
69_1004	1796157	5813764	27	14	2,698	1,435	0.76	0.40	1.16	4
69_2173	1796157	5813764	55.5	45.5	2,698	1,435	0.76	0.40	1.16	2
72_5831	1793856	5813960	32.5	30	2,855	1,633	0.75	0.40	1.14	4
69_1310	1796057	5813564	29	Unknown	2,866	1,536	0.75	0.40	1.15	4
69_256	1794057	5813761	49	42.3	2,926	1,598	0.74	0.40	1.14	2
69_171	1794758	5813362	28.9	25.8	3,064	1,563	0.73	0.40	1.13	4
69_1158	1795858	5813263	35.66	Unknown	3,126	1,713	0.73	0.39	1.12	3
72_5190	1793957	5813560	65	50.5	3,150	1,810	0.73	0.39	1.12	2
72_10228	1796047	5813231	73.2	45.1	3,190	1,820	0.72	0.39	1.11	2
70_531	1796058	5813164	61	45.5	3,258	1,885	0.72	0.39	1.11	2
69_1276	1793857	5813460	72.8	Unknown	3,285	1,952	0.72	0.39	1.10	2
69_32	1794258	5813261	27.4	Unknown	3,302	1,862	0.71	0.39	1.10	4
69_160	1795558	5812963	24.3	Unknown	3,396	1,920	0.71	0.39	1.09	5
72_10444	1795573	5812946	53	41.5	3,414	1,940	0.71	0.39	1.09	2
70_30	1795858	5812963	21.35	Unknown	3,423	1,995	0.70	0.38	1.09	5
Bore assessed as in source aquifer										
69_1650	1793555	5814860	80.4	24	2,382	1,668	2.22	1.26	3.48	4
72_6800	1793456	5814849	80.5	Unknown	2,466	1,767	2.17	1.23	3.40	4

Notes: 1) Where depth of bore unknown a depth has been assumed.

WGA

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FOR FURTHER INFORMATION CONTACT:

Clare Houlbrooke
Principal Hydrogeologist

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