Bay Geological Services Ltd
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16 December, 2020 Project Ref: BGS258_01

Grenadier Limited
c/- Bryce Holmes
Land Matters Ltd
RD1
Otaki 5581

Dear Bryce,

PRELIMINARY GROUNDWATER AND HYDROGEOLOGICAL ASSESSMENT REGARDING NEW INVESTIGATION TEST WELL
DOUGLAS LINKS, 765 MUHUNOA WEST ROAD, OHAU

1. BACKGROUND

Grenadier Limited (the Applicant) have proposed to develop coastal land totaling 107 ha near the end of Muhunoa West Road, Ohau and construct a Links golf course. The course will be called Douglas Links. Critical to the project is water for irrigation of the course fairways and greens, along with water to establish landscaping and beautification of the property to establish it as one of the premier links in the country. It is understood that the Applicant requires 1500 m^3 to 2000 m^3/day in order to irrigate 38.76 to 51.68 ha comprising 18 greens, 36 tees and a practice tee with an estimated volume of 168,060 to 224,806 m^3/year. The development will also include a clubhouse and accommodation facilities along with an Owners residence, carparking and maintenance sheds.

No productive groundwater bores exist across the project site, and subsequently Neville Webb Welldrilling commenced water well drilling in October, 2020. The Levin-based welldrillers have extensive expertise in constructing water bores in the area, and currently a deep Investigation/Test Well is being drilled on the property using cable-tool technology being best suited for the coastal sediment conditions.

An earlier feasibility study completed in 2020 by Lattey Group (Lattey) identified potential groundwater resources from reviewing surrounding bore data provided by Horizons Regional Council (HRC). The majority of the surrounding wells are screened across shallow brown sand and deeper blue and brown sand to depths ranging from 10 to 45.80 m bgl. A deep gravel is also identified as a productive aquifer.

Note: This report is provided for preliminary understanding of the aquifer tested only, and robust long-term aquifer pump testing is required to verify any data analysis undertaken or commented on within this report. That information can be provided at completion of the drilling and the project planners (Land Matters) say methods can ensure the overall objective to minimise potential adverse effects on the groundwater resource. Appropriate conditions of consent or information provision can ensure the objective is met through the process.

2. SITE INFORMATION

The property is located off Muhunoa West Road, Ohau, across gently sloping to rolling coastal dunes, bound to the south by the Ohau River and coastline to the west. The exploration Test Well is located centrally within the block. The closest surface water feature is the nearby Ohau River which drains westward into the sea about 400 m south of the Test Well as shown in Figure 1.

Figure 1. Topo map showing project area off Muhunoa West Road, Ohau (Topomap nz)

3. HYDROGEOLOGY

The property lies centrally within the Horowhenua lowlands, across NNE-SSW-trending marine deposits formed sub-parallel to the western coastline north of Paekakariki. The zone is elevated some 5 to 40 m above sea level, and published geological and topographic maps clearly display the stable inland dune formations, and mobile coastal dunes oriented NW-SW, having been formed perpendicular to the coast by longshore drift (Begg and Johnston, 2000).

Holocene beach deposits and marginal marine terraces mantle the project area, adjacent to alluvium deposited by the Ohau River that drains westward into the sea approximately 400 m to the south. A review of bore logs from nearby wells revealed five bores within 1.5 km radius of the Test Well as displayed in Figure 2. However, it is noted that there are no bores within 1 km of the project site, likely due to intensive development of flat land cropping and horticulture further to the east. The bore log records reveal fine to medium brown sand aquifers particularly in the near-surface and shallow depths; with deeper coarse blue and brown sand aquifers; and a productive gravel aquifer identified in a nearby bore below 25 m depth.

Figure 2. Map showing bores within a 4 km radius of the project area (Lattey)

4. INVESTIGATION/TEST WELL SITE

In November 2020, Neville Webb Welldrilling commenced drilling the investigation Test Well using a cable-tool rig which is suited to the sandy conditions (refer Figure 3). The Test Well site is located approximately 400 m north of the Ohau River and 230 m west of the eastern boundary as shown in Figure 2.

It is planned to drill the 150 mm diameter Test Well up to 100 m depth below ground level (bgl) dependent upon subsurface conditions. The cable-tool drilling rig is used to ensure detailed formation location identification and accurate sampling, which allows a comprehensive bore log to be generated (Neville Webb Welldrilling, 2020). The bore log completed to date is included as Appendix A which reflects current well drilling and formation identification.

The static water level (SWL) is recorded when a water-bearing formation is penetrated and identified; and a water quality sample has been collected and analysed by Hill Laboratories (refer Appendix B). The results should be compared to the NZ Ministry of Health Drinking Water Standards.

Figure 3. The Neville Webb Welldrilling cable-tool rig drilling the investigation Test Well. View southwest toward the Ohau River, and coastline to the west.

4.1 Preliminary Well Drilling Data (to 09.12.20)

Well drilling results to 9 December 2020 indicate the bore penetrated a series of sand zones to 67.90 m depth, with medium brown sand from the surface to 12.00 m depth. Below this, zones of predominantly medium grained, silty blue sand with some clay layers and shell material are present to 67.90 m depth. A brown clay layer with peat and wood was logged from 48.70 to 49.10 m bgl, and it is noted that the base of the current depth (67.90 m bgl) included traces of gravel. It is planned that drilling will continue beyond 67.90 m bgl in order to intercept a deeper aquifer; however, any deeper well data are not yet available nor included within this letter report.

Bore hole logging also identifies potentially productive strata during drilling and thus far, water bearing zones described as 'Good' are recorded at the following depths:

- 21.10 – 44.90 m bgl: blue, silty, fine to medium sand with traces of silty clay;
- 44.90 – 48.70 m bgl: blue medium sand with layers of very sandy clay;
- 49.10 – 53.50 m bgl: blue, medium sand; and,
- 53.50 – 65.90 m bgl: blue, medium/coarse with thin clay layers.

A 'Dry' zone was also logged within the brown clay/peat later from 48.70 to 49.10 m bgl.

The SWL recorded during drilling (no screen) to 03.12.20 is detailed as follows:

- casing at 13.80 m depth bgl: SWL = -11.65 m bgl
- casing at 38.00 m depth bgl: SWL = -13.38 m bgl
- casing at 44.00 m depth bgl: SWL = -10.80 m bgl

4.2 Preliminary Constant Flow Aquifer Pump Test 01 (26.11.20)

Once the well reached the first significant water-bearing zone, a screen was installed from 35.90 to 38.90 m depth in preparation for pump testing. The screened interval is across a productive sand aquifer logged from 21.10 to 44.90 m bgl and described as blue, silty fine to medium grained sand with traces of silty clay.

A short duration (360 min) constant flow pump test was completed on 26 November 2020 at a constant flow rate of 9100 l/hour (2.53 l/s), along with a 60-minute Recovery period. The initial SWL for the well prior to pumping was recorded as -11.78 m bgl. Both electronic (data logger) and manual water level data were collected during the pump test with the test results presented in Appendix C.

5. PRELIMINARY TEST WELL AQUIFER PUMP TEST 01 ANALYSIS

5.1 Background Aquifer Test Data

The Lattey (2020) report identified six nearby wells, the pump test data for which provided detail on aquifer parameters and characteristics. The aquifer pump test data for Bores 361021, 361041 and 361051 provided transmissivity values of 23, 41 and 86 m^2/day, respectively. Although the values are low, the reported transmissivities are consistent with a sand aquifer.

A review of the nearby Bore 361063 located to the south of the Ohau River was also completed by Lattey (2020). The bore log revealed that the well produces from a gravel aquifer from 26.70 to 33.90 m bgl overlain by cemented sand and silt to 22m bgl and peat and clay to 26.70 m depth. The well recorded flowing artesian conditions with a SWL of +2.46 m above top of casing (toc) indicating a confined aquifer system. A two-day aquifer pump test was conducted at a rate of 43.60 l/s with responses from an observation well located up to 400 m distant and indications of tidal flux suggesting a level of confinement. The transmissivity value for the gravel aquifer was reported as 5200 m^2/day, and storativity of 1.1E-4, with a relatively low leakage coefficient of K'/B' of 1.3E-4. The aquifer parameters suggest a highly transmissive, leaky confined aquifer. Re-analysis using the aquifer test data by PDP, further quantified the potential for stream depletion and concluded that stream leakage was equivalent to about 5% of the pumped volume after 10 days' pumping. The impact of the leakage was determined to be minor under the One Plan (Policy 16-6) and below the threshold requiring management based on river flows and surface water allocation.

5.2 Investigation Test Well Aquifer Pump Test 01 Analysis

The manual and electronic logger water level data from the 360 min aquifer pump test were plotted as Residual Drawdown (m) against Time (mins), with the results presented as Figure 4. The plotted data shows an immediate response in the water level to commencement of pumping with measurable drawdown of 11.18 m after 60 mins. The drawdown steadied relatively quickly with a drawdown of 11.22 m at 90 mins and 11.30 m at 240 mins where it approached stabilisation. The maximum drawdown was calculated as 11.36 m at cessation of pumping after 360 mins.

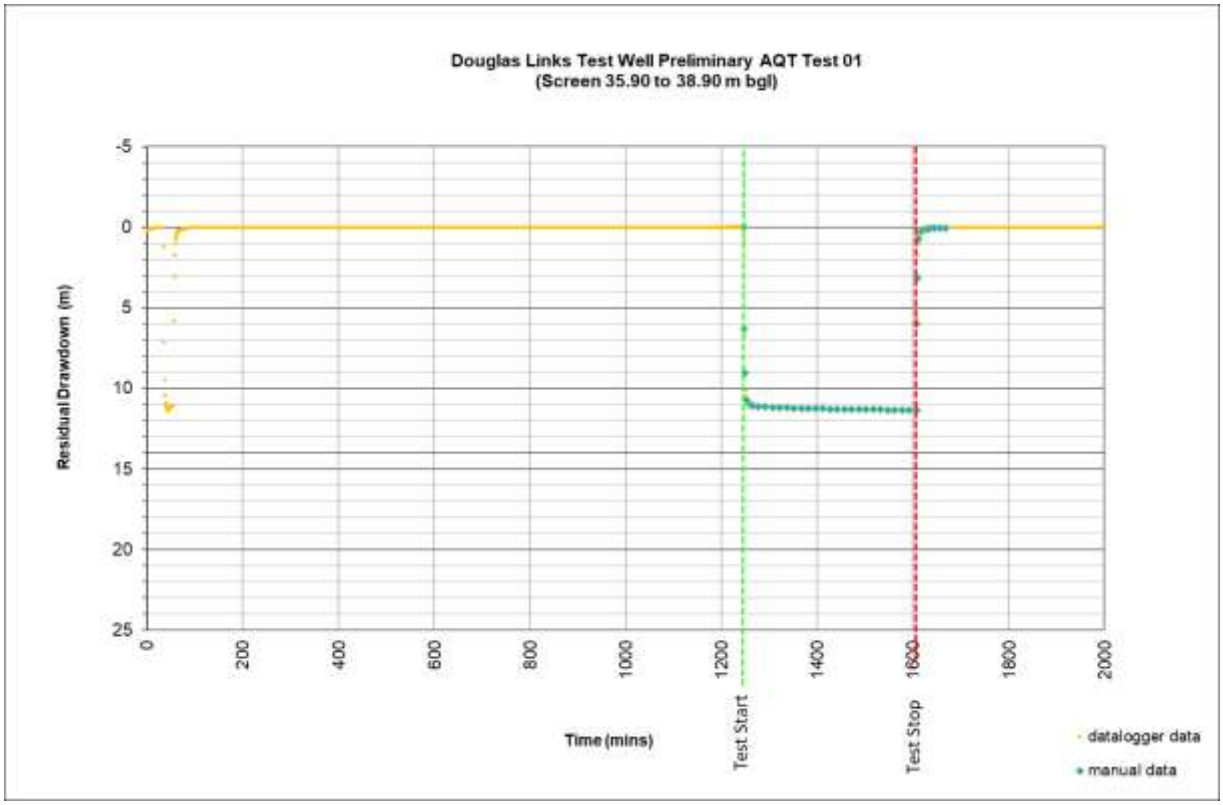


Figure 4. Preliminary AQT Pump Test 01 Residual Drawdown v Time

Analysis of the pump test results focused on the Recovery data which is considered a true reflection of aquifer conditions, as the pump is switched off and down-hole turbulence has ceased. The data exhibits rapid recovery of the water level to within 5.98 m of the initial water level after 1 min of the pump stopping. After 40 mins of Recovery time, the well has recovered to within 0.05 m of the initial water level, and 0.04 m after 60 mins of Recovery time.

The preliminary Recovery electronic data is plotted using Aqtesolv (Duffield, 2007) software and the Theis (1935) solution for confined aquifers (the default recovery curve). Initial analysis of the plotted data determines a range of transmissivity values from about 40 to 94.59 m^2/day as displayed in Figure 5. The values are in line with those reported in the Lattey (2020) report, and correspond to that of a sand aquifer. It is considered that the higher value reflects a relatively rapid (for a sand aquifer) Recovery once the pump is switched off. The full Aqtesolv (Duffield, 2007) analysis Recovery graph using the Theis (1935) solution is presented in Appendix D.

Although the preliminary pump test flow rate of 2.53 l/s is relatively low and the well drew down to a maximum of 11.36 m, the water level did approach stabilisation. This suggests a relatively low aquifer transmissivity while pumping the well; although aquifer recharge presents a higher transmissivity value, suggesting recharge and possibly sustainability of the aquifer as tested.

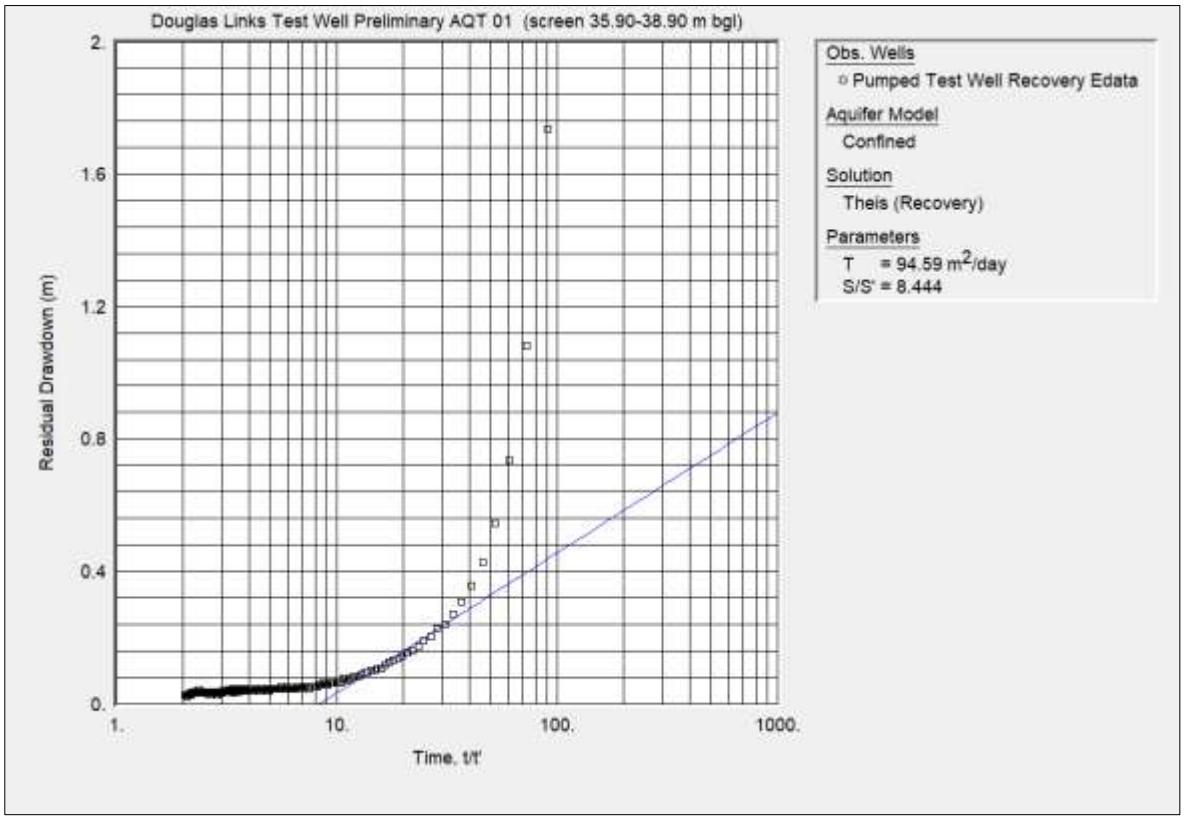


Figure 5. Preliminary AQT Pump Test 01 AQTESOLV Recovery plot

It is unknown what degree of leakage occurs within the aquifer without comprehensive aquifer testing. Although it is thought that a higher transmissivity value would be apparent from analysis and interpretation of the Recovery data should aquifer recharge be highly hydraulically connected to surface water. Although the highest transmissivity value determined during the later time Recovery data (as t/t' approaches 1) is 670 m^2/day.

The gravel aquifer Bore 361063 located to the south of the Ohau River as discussed by Lattey (2020) reported a transmissivity value of 5,200 m^2/day; yet analysis of the data and stream depletion calculations determined that leakage was minor when pumping at 43.6 l/s (Lattey, 2020). It is considered here that pumping the Douglas Links Test Well at a rate of 2.53 l/s may also result in minor stream depletion potential, due to likely aquifer confinement and relatively low aquifer transmissivity. However, the planned continuation of bore drilling to greater depths is likely to provide additional aquifer data to ensure the objective can be achieved. Of course, there is a risk the data may not support such an outcome, but appropriate planning methods can be employed to manage that risk and the Applicant understands that the approach.

6. DISCUSSION

Given the information presented for Bore 361063, the Lattey Feasibility Report (2020), and coupled with the interim aquifer test results determined from the Test Well to date, it is inferred that effects on groundwater are likely to be minor. The drilling and testing to date are consistent with the geology and groundwater assessments in those documents. However, at Douglas Links there is a need for continued drilling, testing and modelling followed by monitoring to confirm or otherwise that conclusion. The planning process will need to make provision for this recommended testing, modelling, and then monitoring post-consent, to manage potential effects of the water resource.

7. REFERENCES

Begg, J.G., and Johnston, M. R. (compilers), 2000: Geology of the Wellington Area. Institute of Geological and Nuclear Sciences 1:250,000 Geological Map 10. Institute of Geological and Nuclear Sciences, Lower Hutt, New Zealand.

Horizons Regional Council website (www.horizons.govt.nz).

Lattey Group, 2020: Water Permit Resource Consent Feasibility Study. Confidential Client Report Project No. J20043-REP-01. Prepared for Grenadier Developments Ltd. Lattey Group, Hastings, New Zealand.

Neville Webb Welldrilling, 2020: Specifications/Requirements for Test/Investigation Well. Confidential Client document. Neville Webb Welldrilling, Levin, New Zealand.

NZ Topo Map: www.topomap.co.nz

Theis, C. V., 1935: The relation between the lowering of the piezometric surface and the rate of duration of discharge of a well using ground-water storage. American Geophysical Union Transactions v16, 519-524.

Report Limitations

This letter report is written based on conditions as reported by third party contractors at the time of the desktop study, and there is no interpretation made on potential changes that may occur across the site or be reported incorrectly. Subsurface conditions may exist across the site that are not able to be detected or revealed by the investigation within the scope of the project, and are therefore not taken into account in this report. Furthermore, statements included within this letter report are assumptions made for the purposes of providing preliminary interpretations of well drilling to date. It is noted that robust pump testing should be completed to verify the interpretation of data analysis and views contained within this report.

APPENDICES

APPENDIX A

Investigation Test Well

Bore Log (to 09.12.20)

(Neville Webb Welldrilling, 2020)

Nevill Webb Welldrilling

Agricultural, Domestic & Industrial Welldrillers

LITHOLOGICAL WELL LOG

Name: *Douglas Links*

Address: *765 Muhunoa West Road, Ohau*

Datum: *Ground Level*

Depth from (m)	Depth to (m)	Description	W/B Code
0.000	0.200	Black sandy topsoil	D
0.200	12.000	Brown sand, medium	D
12.000	15.500	Blue sand, medium W/B	M
15.500	17.300	Blue sand, medium with shell fragments W/B	M
17.300	17.800	Blue sand, medium. Less shell fragments, silty with traces of clay on drill bit W/B	VP/D
17.800	21.100	Blue sand medium, small traces of shell fragments, silty formation W/B	VP
21.100	44.900	Blue sand, medium to fine, quite silty. Traces of silty clay (suggesting thin, silty clay layers) W/B	G
44.900	48.700	Blue sand, medium layers of very sandy clay W/B	G
48.700	49.100	Brown clay, peat & wood	D
49.100	53.500	Blue sand, medium. Layers of very sandy clay W/B. These layers becoming more predominant	G
53.500	65.900	Blue sand, medium/coarse. Thin layers of clay, W/B	G
65.900	67.900 Present Depth	Blue silty sand, coarse. Layers of clay & traces of gravel, W/B	M

Water-bearing Code: V = very good, G = good, M = moderate, P = poor, D = dry

APPENDIX B

Water Quality Testing

(Hill Laboratories, Hamilton)

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Nevill Webb Welldrilling	**Lab No:**	2483618	DW/APv1
Contact:	Donna Madgwick	**Date Received:**	01-Dec-2020	
	C/- Nevill Webb Welldrilling	**Date Reported:**	03-Dec-2020	
	PO Box 1155	**Quote No:**		
	Levin 5540	**Order No:**		
		Client Reference:	Douglas Link	
		Submitted By:	Donna Madgwick	

Sample Type: Aqueous

		Sample Name:	Douglas Link Test Well 35.9 - 38.9m 27-Nov-2020 3:00 pm	Guideline Value	Maximum Acceptable Values (MAV)
		Lab Number:	2483618.1		
Routine Water Profile					
Turbidity	NTU		0.14	< 2.5	-
pH	pH Units		8.1	7.0 - 8.5	-
Total Alkalinity	g/m³ as $CaCO_3$		230	-	-
Free Carbon Dioxide	g/m³ at 25°C		3.5	-	-
Total Hardness	g/m³ as $CaCO_3$		250	< 200	-
Electrical Conductivity (EC)	mS/m		60.3	-	-
Electrical Conductivity (EC)	µS/cm		603	-	-
Approx Total Dissolved Salts	g/m³		400	< 1000	-
Total Arsenic	g/m³		< 0.0011	-	0.01
Total Boron	g/m³		0.068	-	1.4
Total Calcium	g/m³		45	-	-
Total Copper	g/m³		< 0.00053	< 1	2
Total Iron	g/m³		0.31	< 0.2	-
Total Lead	g/m³		< 0.00011	-	0.01
Total Magnesium	g/m³		33	-	-
Total Manganese	g/m³		0.23	< 0.04 (Staining) < 0.10 (Taste)	0.4
Total Potassium	g/m³		12.3	-	-
Total Sodium	g/m³		34	< 200	-
Total Zinc	g/m³		0.0026	< 1.5	-
Chloride	g/m³		57	< 250	-
Nitrate-N	g/m³		< 0.05	-	11.3
Sulphate	g/m³		< 0.5	< 250	-

Note: The Guideline Values and Maximum Acceptable Values (MAV) are taken from the publication 'Drinking-water Standards for New Zealand 2005 (Revised 2018)', Ministry of Health. Copies of this publication are available from https://www.health.govt.nz/publication/drinking-water-standards-new-zealand-2005-revised-2018

The Maximum Acceptable Values (MAVs) have been defined by the Ministry of Health for parameters of health significance and should not be exceeded. The Guideline Values are the limits for aesthetic determinands that, if exceeded, may render the water unattractive to consumers.

Note that the units g/m³ are the same as mg/L and ppm.

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked * or any comments and interpretations, which are not accredited.

Routine Water Assessment for Sample No 2483618.1 - Douglas Link Test Well 35.9 -

pH/Alkalinity and Corrosiveness Assessment
The pH of a water sample is a measure of its acidity or basicity. Waters with a low pH can be corrosive and those with a high pH can promote scale formation in pipes and hot water cylinders.
The guideline level for pH in drinking water is 7.0-8.5. Below this range the water will be corrosive and may cause problems with disinfection if such treatment is used.

The alkalinity of a water is a measure of its acid neutralising capacity and is usually related to the concentration of carbonate, bicarbonate and hydroxide. Low alkalinities (25 g/m^3) promote corrosion and high alkalinities can cause problems with scale formation in metal pipes and tanks.

The pH of this water is within the NZ Drinking Water Guidelines, the ideal range being 7.0 to 8.0.
With the pH and alkalinity levels found, it is unlikely this water will be corrosive towards metal piping and fixtures.
The high alkalinity of this water may cause an increase in the pH in the root zones of plants which are irrigated using this water.

Hardness/Total Dissolved Salts Assessment
The water contains a moderate amount of dissolved solids and would be regarded as being very hard.
There will be difficulty in forming a lather with soap, and a 'scum' will form in baths, showers, etc.
The high value for hardness (200 is considered excessive) indicates that this water may promote scale build-up in pipes and cylinders, and that irrigation systems using this water may be prone to scale build-up and blockage of narrow irrigation capillaries and jets.

Nitrate Assessment
Nitrate-nitrogen at elevated levels is considered undesirable in natural waters as this element can cause a health disorder called methaemaglobinaemia. Very young infants (less than six months old) are especially vulnerable. The Drinking-water Standards for New Zealand 2005 (Revised 2018) suggests a maximum permissible level of 11.3 g/m^3 as Nitrate-nitrogen (50 g/m^3 as Nitrate).

Nitrate-nitrogen was not found in this water.

For household use, it is important that the water is not contaminated with human or animal wastes (e.g. from septic tanks or effluent ponds). Bacteriological analyses may be required if such contamination could exist. For further details, please contact this laboratory.

Boron Assessment
Boron may be present in natural waters and if present at high concentrations can be toxic to plants.
Boron was found at a low level in this water but would not give any cause for concern.

Metals Assessment
Iron and manganese are two problem elements that commonly occur in natural waters. These elements may cause unsightly stains and produce a brown/black precipitate. Iron is not toxic but manganese, at concentrations above 0.5 g/m^3, may adversely affect health. At concentrations below this it may cause stains on clothing and sanitary ware.

Iron was found in this water at a significant level.
Manganese was found in this water at a significant level.
Treatment to remove iron and/or manganese may be required.

Final Assessment
The parameters Total Hardness, Total Iron and Total Manganese did NOT meet the guidelines laid down in the publication 'Drinking-water Standards for New Zealand 2005 (Revised 2018)' published by the Ministry of Health for water which is suitable for drinking purposes.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Routine Water Profile		-	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1
Turbidity	Analysis by Turbidity meter. APHA 2130 B 23rd ed. 2017 (modified).	0.05 NTU	1
pH	pH meter. APHA 4500-H+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Free Carbon Dioxide	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	1 µS/cm	1
Approx Total Dissolved Salts	Calculation: from Electrical Conductivity.	2 g/m³	1
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m³	1
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0053 g/m³	1
Total Calcium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.053 g/m³	1
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00053 g/m³	1
Total Iron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.021 g/m³	1
Total Lead	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00011 g/m³	1
Total Magnesium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.021 g/m³	1
Total Manganese	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00053 g/m³	1
Total Potassium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.053 g/m³	1
Total Sodium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.021 g/m³	1
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m³	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
Nitrate-N	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.05 g/m³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 02-Dec-2020 and 03-Dec-2020. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

APPENDIX C

Test Well Short-Term Constant Flow

Aquifer Pump Test 01

(26.11.20)

Screened Interval: 38.90 m to 39.40 m bgl

Douglas Links
Pump Test

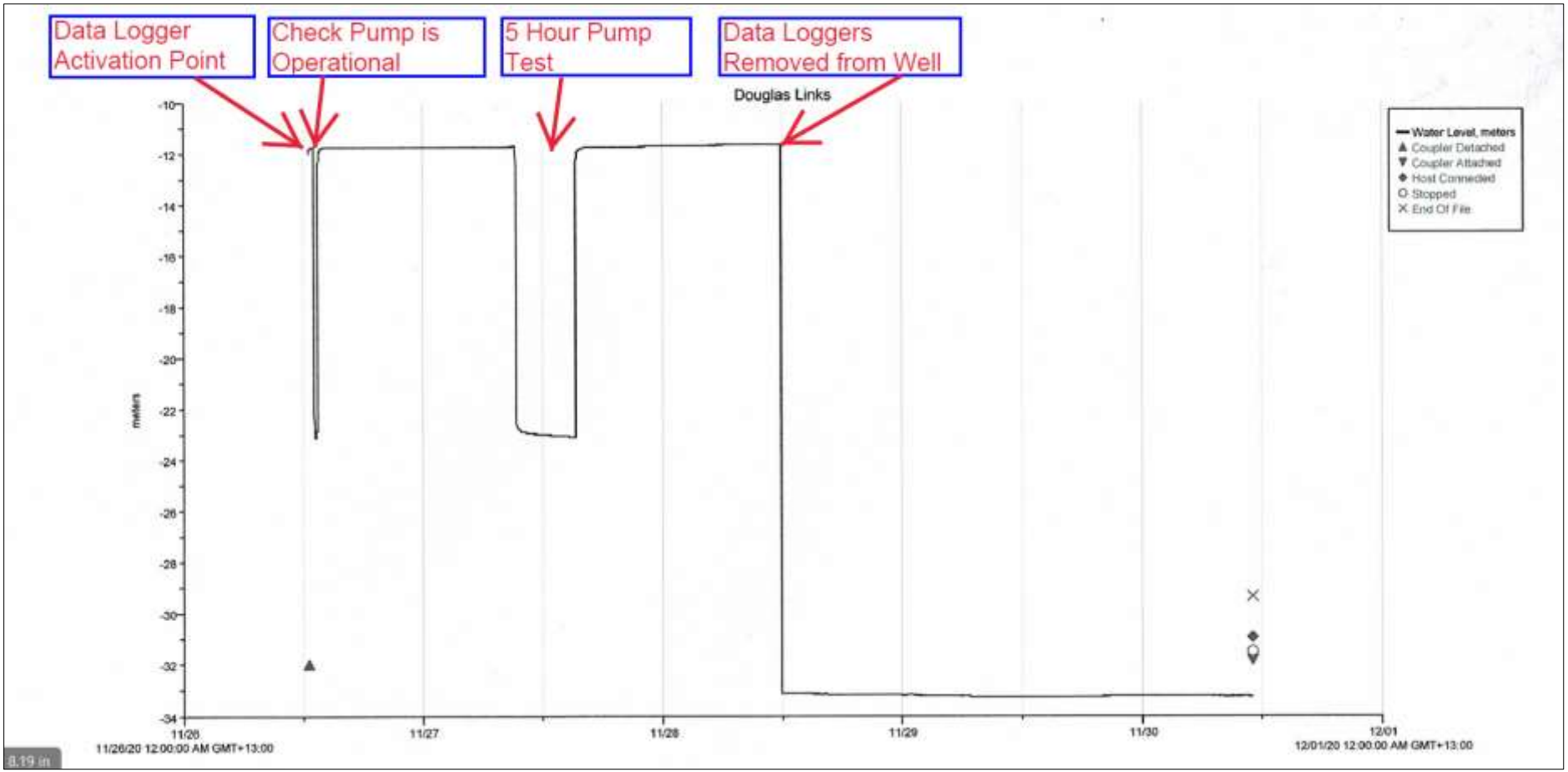
Bore Name:	Test Well		
Location:	765 Muhunoa West Road		
GPS:	N 6059684	E 2693377	Company Mapping System
Data Logger S/N:	1066924		
Datum:	Ground Level		
Screen Depth (m) :	35.90 to 38.90	**Slot Size:**	8 thou (0.2mm)
SWL (m):	**-12.000**		
SWL Date:	26/11/2020	**SWL Time:**	12:30pm

Manual Readings

Date/Flow Rate	Time/Minutes	Water Level (m)
Pump Test Rate:		**9100 L/hr**
27/11/20 - 9:18am	0	-11.780
	1	-18.100
	2	-20.830
	5	-22.530
	10	-22.760
	15	-22.820
	20	-22.870
	30	-22.910
	45	-22.940
10:18am	60	-22.960
	75	-22.980
	90	-23.000
	105	-23.010
11:18am	120	-23.030
	135	-23.050
	150	-23.050
	165	-23.050
12:18pm	180	-23.060
	195	-23.060
	210	-23.070
	225	-23.080
13:18pm	240	-23.080
	255	-23.090

Manual Readings		
Flow Rate	Time/Minutes	Water Level (m)
	270	-23.100
	285	-23.100
14:18pm	300	-23.110
	315	-23.120
	330	-23.120
	345	-23.130
15:18pm	360	-23.140

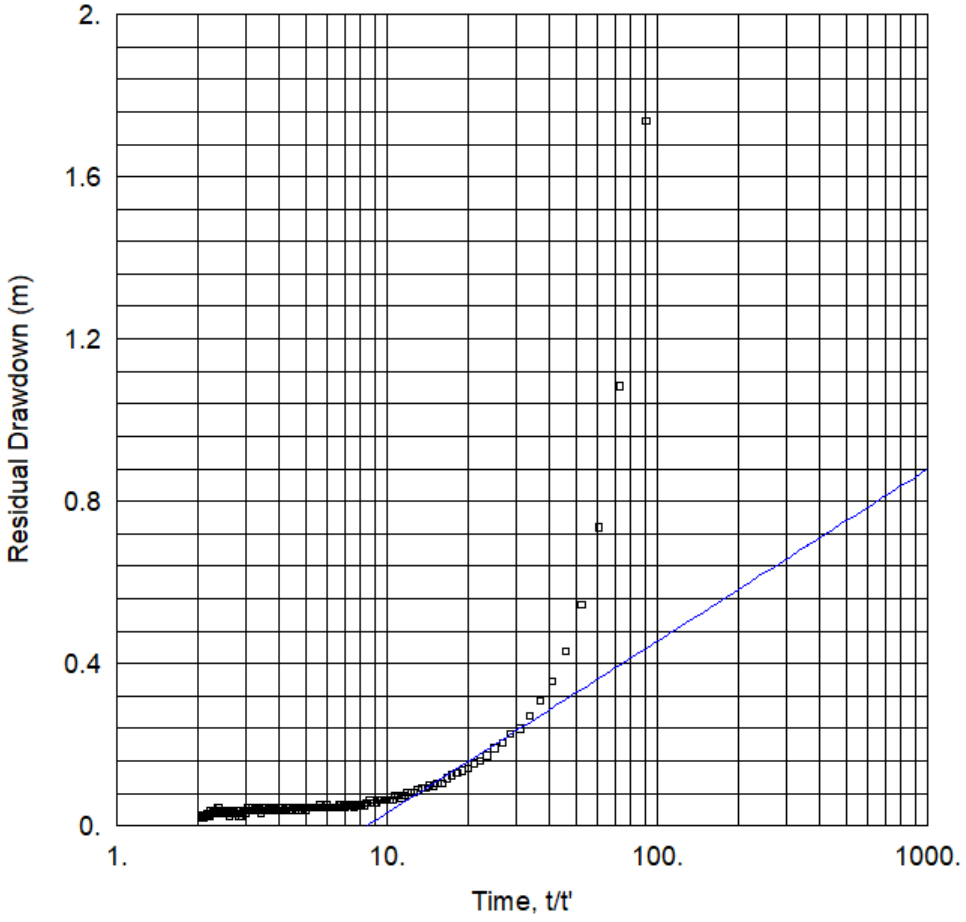
Manual Readings		
	Time/Minutes	Water Level (m)
Recovery		
	1	-17.760
	2	-14.940
	5	-12.530
	10	-12.050
	15	-11.950
	20	-11.910
	25	-11.870
	30	-11.860
	40	-11.830
	50	-11.820
	60	-11.820


Data Logger Activation Point
Check Pump is Operational
5 Hour Pump Test
Data Loggers Removed from Well
Douglas Links
Water Level, meters
Coupler Detached
Coupler Attached
Host Connected
Stopped
End Of File
meters
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
11/26
11/27
11/28
11/29
11/30
12/01
11/26/20 12:00:00 AM GMT+13:00
12/01/20 12:00:00 AM GMT+13:00
8.19 in

APPENDIX D

Recovery Data Analysis using Aqtesolv (Duffield, 2007)

and the Theis (1935) Solution



DOUGLAS LINKS TEST WELL PUMPED 01 35.90-38.90 M

Data Set: C:\...\Pumped Test Well Recovery Edata.aqt
Date: 12/16/20 Time: 13:27:17

PROJECT INFORMATION

Company: Bay Geological Services Ltd
Client: Douglas Links
Project: BGS258-01
Location: 765 Muhunoa West Road, Ohau
Test Well: Test Well
Test Date: 27 November, 2020

AQUIFER DATA

Saturated Thickness: 38.9 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Pumped Test Well Recovery	2693377	6059684

Observation Wells

Well Name	X (m)	Y (m)
▫ Pumped Test Well Recover	2693377	6059684

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 94.59 m^2/day S/S' = 8.444