Preliminary Hydrogeological Investigations - Four Northland Aquifers

COOPERS BEACH, CABLE BAY & MANGONUI GROUNDWATER RESOURCE

- Report prepared for Northland Regional Council
- Final
- 8 July 2005

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Sinclair Knight Merz
25 Teed Street
PO Box 9806
Newmarket, Auckland New Zealand
Tel: +64 9 913 8900
Fax: +64 9 913 8901
Web: www.skmconsulting.com

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1. Introduction

Sinclair Knight Merz was commissioned by Northland Regional Council to provide preliminary hydrogeological assessments of four Northland aquifers – Mangawhai, Coopers Beach, Three Mile Bush and Glenbervie. These aquifers are recognised in the Northland Regional Water and Soil Plan as being “at risk” aquifers with respect to groundwater demand and water quality issues (NRC, 2004).

The information obtained from this preliminary hydrogeological study will assist the Northland Regional Council (NRC) to effectively manage allocation of the groundwater resource.

The specific objectives of the studies include the following:

- Develop an understanding of the aquifer hydrogeology (groundwater recharge, hydraulic characteristics and discharge dynamics)
- Provide a preliminary estimation of sustainable yield
- Identify information gaps and recommend future actions required to enable the sustainable management of the groundwater resource.

This report provides an assessment of the Coopers Beach, Cable Bay and Mangonui groundwater resource. The Regional Water and Soil Plan has classified the Cable Bay aquifer as being “at-risk” based on the potential for seawater intrusion. In addition, the area is experiencing significant subdivision expansion, placing further pressure on the groundwater resource.

As groundwater is generally abstracted from the basalt within the study area, this report focuses mainly on the basalt aquifer rather than the alluvial or sandstone aquifers.

2. Background Information

2.1 Site Location and Description

Coopers Beach, Cable Bay and Mangonui are small coastal towns located in Doubtless Bay, Northland. The total study area is 17 km^2 encompassing these towns and extending inland to the top of Cable Bay Block Road, approximately 240 m above mean sea level. The predominant landuse is residential near the coast and rural for the remainder.

Figure 1 shows the main points of interest of the study area, including the aquifer boundary.

- **Figure 1. Locality Plan.**

(see A3 attachment at rear).

2.2 Geology

The surface geology of the study area is described on the IGNS 1:250,000 Geological Map Sheet 1 for Kaitaia, which is reproduced in Figure 2.

The predominant surface geology is Early Cretaceous to Paleocene age (99 to 55 million years BP) basaltic pillow lava and breccia with subvolcanic intrusions of basalt and dolerite belonging to the Tangihua Complex. Gravity surveys have shown that the Tangihua rocks in the area have thicknesses of 300 – 1600 m. The basalts typically weather to soft red-brown clays, with weathering depth up to at least 30 m (Isacc, 1996).

There is a small outcrop of Wairakau Volcanics andesitic breccia and agglomerate in the western part of the study area, which is of Early Miocene age (between 22 and 16.5 million years old).

Overlying the basalt in the eastern part of the study area are Late Miocene age (11 to 5.4 million years BP) Mangonui Formation rocks. The Mangonui Formation consists of weakly indurated conglomerate, pebbly and carbonaceous sandstone, mudstone and lignite. The rocks are approximately 50 - 100 m thick (Isacc, 1996).

Partly consolidated sandstone and minor mudstone of the Awhitu Group are present on the high terraces to the west of Otanenui Stream. They are of Pliocene age (1.8 to 5.4 millions of years BP).

There are also unconsolidated to poorly consolidated sand, mud, peat and shell deposits of estuarine, alluvial and colluvial origins belonging to the Karioitahi Group. They are located on the low areas around the stream mouths along Coopers Beach and Cable Bay and are of Mid Pleistocene to Holocene age (71 to 0 thousands of years BP).

- **Figure 2. Regional Geology.**

(see A3 attachment at rear).

2.3 Drillers Borelogs

The NRC bore database currently contains 82 bores in the study area, where drillers borelogs and other bore information is available. This includes eight boreholes with multi-level piezometers or inclinometers that have recently been installed into the Mangonui Formation at Coopers Beach as part of a slope stability investigation, and nineteen bores identified by a subsequent bore survey at Coopers Beach. A summary of the relevant bore construction and hydraulic test detail is included in Appendix A, while Figure 2 shows the approximate location of the bores.

The bores range from 11.5 to 155 m depth, with an average depth of 57 m in the basalt. The bores are of 75 to 150 mm diameter. The drillers logs typically indicate weathered volcanic clays and ash, alluvium (sand, mud, peat) or sandstone overlying hard, fractured basalt. On some logs the rock is described as greywacke, which is inconsistent with the geological knowledge of the area (ie. basalt). Fractures are recorded at various depths within the basalt and indications of drilling fluid loss/gain are common where this occurs, suggesting water yield zones.

Groundwater is generally abstracted from the basalt aquifer, with the exception of three bores drilled into sandstone at the back of the catchment (Bores 200109, 200110 and 200111). The bores are cased with PVC or galvanised steel through the overlying soft sediments and are generally open (unscreened) through the basalt.

Some logs have brief water quality comments relating to iron, chloride and bacteria.

2.4 Hydrology

There are four main streams draining the study area, and a number of smaller streams (see Figure 1). The streams and tributaries are partly spring-fed, particularly along Otanenui Stream and Kanekane Stream. This was based on field observations detailed in resource consent reports (DBWS Co Ltd, 1996; Tonkin and Taylor, 1999 and 2001). Spring flow occurs over 9 to 12 months of the year.

There is no information available on stream flow.

2.5 Rainfall and Evaporation

Figure 3 shows mean monthly rainfall for Mangonui (Station A43951) for the period 1901 to 1996, and mean monthly open water evaporation for Kaitaia (Station A53021) for the period 1962 to 1985. The annual average rainfall is 1,380 mm. Rainfall exceeds evaporation for seven months of the year, indicating the availability of water for groundwater and surface water recharge.

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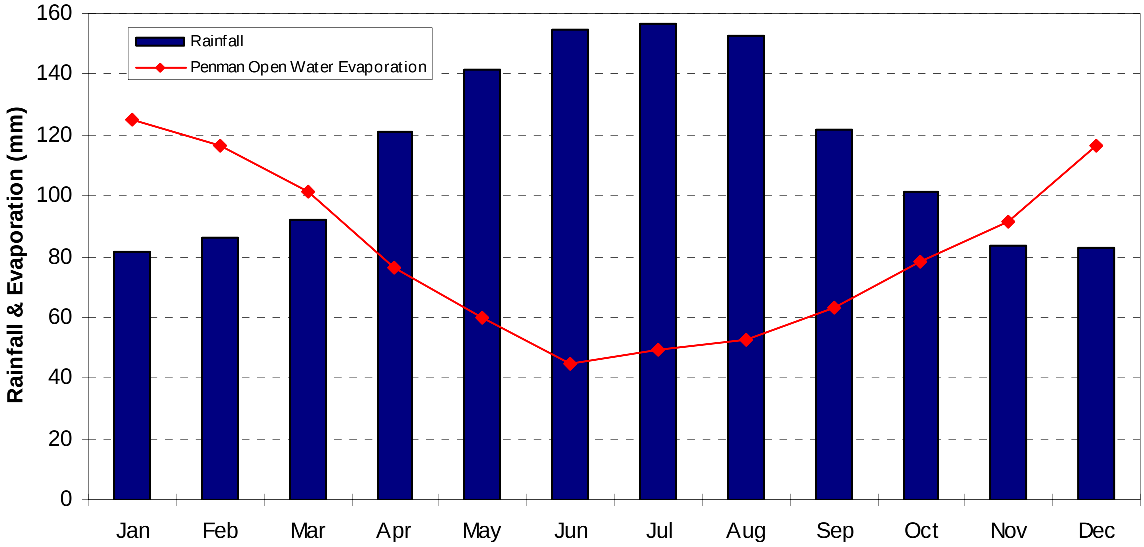


- **Figure 3. Mean Monthly Rainfall and Evaporation.**

2.6 Groundwater and Surface Water Abstraction

The current allocation for groundwater is summarised in Table 1. There are three consents for groundwater takes, varying from 30 m^3/day to 400 m^3/day. There are also two applications currently being processed by the NRC. Assuming these consents are granted, the total consented groundwater allocation is 828 m^3/day.

The NRC Regional Water and Soil Plan (NRC, 2004) allows up to 30 m^3/day of groundwater to be abstracted as a permitted activity for reasonable stock drinking needs or up to 2 m^3/day for reasonable domestic uses. This does not apply to abstraction from Cable Bay, which is classified under the Water and Soil Plan as an “at risk” aquifer due to the potential for seawater intrusion. The permitted abstraction from Cable Bay is 1 m^3/day for reasonable domestic needs only.

There are nine bores on the NRC bore database that do not have consents and are located within the Cable Bay “at risk” zone. This equates to a maximum permitted allocation of 9 m^3/day. There are 51 additional bores on the NRC bore database outside of Cable Bay that do not have consents or abstract groundwater (ie. Earthquake Commission investigation bores). In the absence of metering, assuming that all of these additional bores use their permitted allocation for domestic use only, the maximum permitted allocation would be 102 m^3/day. Actual water use from bores surveyed at Coopers Beach in 2004 used a maximum of 1 m^3/day for domestic purposes (see Appendix B). Total groundwater allocation, including permitted and consented activities, is estimated to be approximately 939 m^3/day.

The current allocation for surface water, which is fed partly from groundwater, is summarised in Table 2. The total surface water allocation is 40 m^3/day and the total water allocation for the area is 979 m^3/day.

The locations of the groundwater and surface water consents are shown on Figure 4.

Table 1. Existing Groundwater Consents.

NRC No.	Name	Allocation	Bore depth	Expiry date	Use
		(m^3/day)	(m)		
19970421301	Doubtless Bay Water Supply Co Ltd	400	65	31-Oct-2006	Public water supply
19990885701	J. Trussler	150	65	31-Oct-2010	Private water supply
19980840901	Crystal Waters Development Ltd	30	104	30-Jun-2010	Private water supply
20010794601	Doubtless Bay Water Supply Co Ltd	200	36	Application in process	Public water supply
20010785601	L.J. Wallis	48	42	Application suspended	Public water supply
TOTAL		828			

Table 2. Existing Surface Water Consents.

NRC No.	Name	Allocation	Expiry date	Use
		(m^3/day)		
20010404201	Cable Bay Water Supply	30	31-Oct-2011	Public water supply
19980267401	W. Pearson	10	31-Oct-2013	Crop irrigation
TOTAL		40		

Figure 4. Existing Consents.

(see A3 attachment at rear).

3. Aquifer Conceptualisation

3.1 Aquifer Lithology

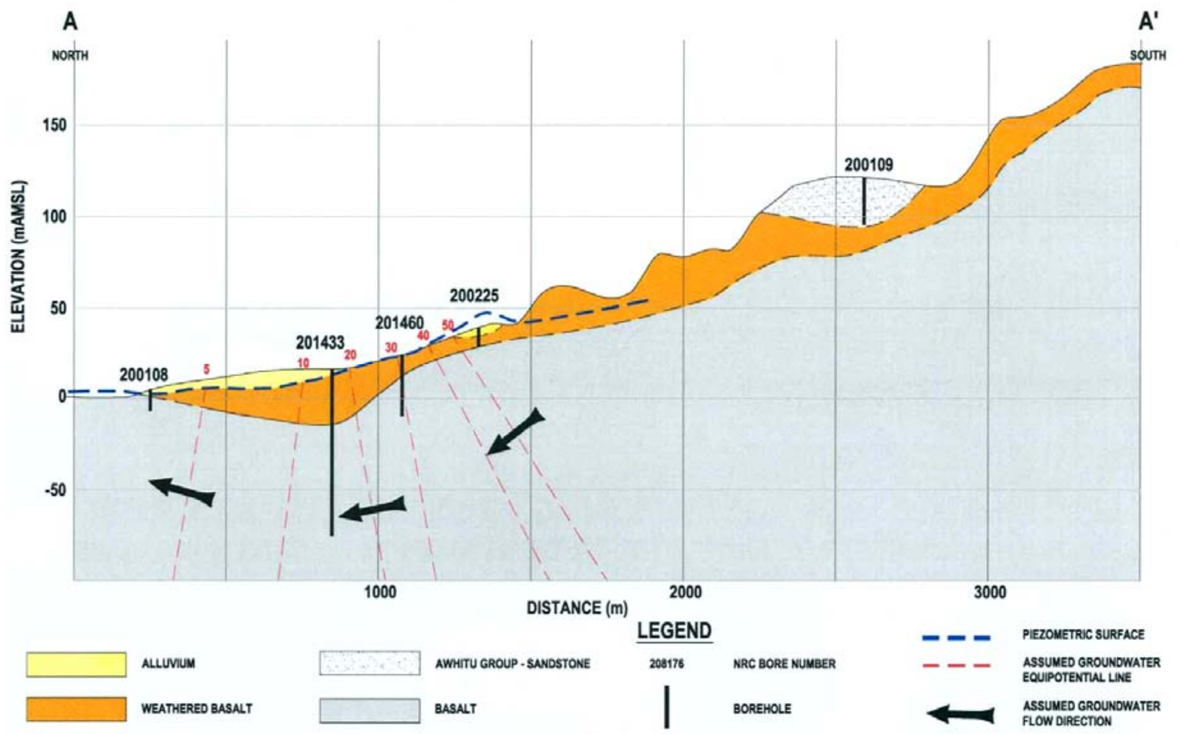
Borelogs from the NRC bore database show the site geology to typically consist of hard fractured basalt overlain with either:

- sticky or firm brown clay (weathered basalt) up to 54 m thick
- light grey siltstone with some gravel and lignite layers (Mangonui Formation) up to 55 m thick
- hard sandstone (Awhitu Group) up to 17 m thick, or
- soft grey and blue marine clay and peat (Karioitahi Group) up to 60 m thick.

Fracturing within the basalt aquifer occurs at variable depths, with good groundwater yields (ie. maximum of 864 m^3/day) encountered where the basalt is well fractured or the fracture thickness is large.

These geological descriptions are consistent with the regional geology described in Section 2.2.

A hydrogeological cross-section (A-A') orientated north to south through the study area has been compiled from the drillers logs. The section position is indicated on Figure 2 and the cross-section is shown in Figure 5.



- **Figure 5. Hydrogeological Cross-Section.**

3.2 Groundwater Levels

Depth to groundwater in the basalt aquifer ranges from above ground level (artesian conditions) to 65 mBGL. The artesian conditions occur at a topographic elevation of 20 to 40 mAMSL in three bores near Otanenui Stream (Bore 200225, 201433 and 201460) and three bores along Coopers Beach (201342, Kitney and Hall). The locations of the Otanenui Stream bores can be seen on the hydrogeological cross-section in Figure 5.

The artesian pressures were encountered in the weathered basalt and/or shallow unweathered basalt zone in bores 200225 and 201460, and in the deeper fractured basalt in bore 201433 and 201342. The upward groundwater pressures at these locations may be a function of the low topographic position within the catchment, with the surrounding hills imparting lateral groundwater pressure on the lower areas. The Kitney and Hall bores do not have borelogs, however it is likely that these bores are screened through the basalt also.

Groundwater pressures over the inland portion of the study area indicate that groundwater movement is downwards, based on limited groundwater pressure information in bores screened at different depths in the aquifer and in close proximity to each other. Evidence for upwelling exists only where the artesian pressures occur, however it is likely that groundwater movement is also upwards in bores along the coast (groundwater discharge area).

Depth to groundwater in the Awhitu Group sandstone ranges from 4 to 8.5 mBGL. It is unknown based on the information available whether groundwater pressures in the sandstone are connected to the underlying basalt or whether the water table is perched.

Depth to groundwater in the Mangonui Formation has been monitored from May 2003 to August 2004 in five bores with multi-level piezometers at Coopers Beach. The piezometers are installed into displaced landslide materials (dune sand or clayey silt) at the top of the Mangonui Formation, and Mangonui Formation conglomerate/sandstone, or lower lignite mudstone/siltstone units. Figure 6 shows the groundwater hydrographs for the three main units.

Groundwater levels in the displaced landslide materials are relatively high, ranging between 0.52 mBGL in piezometer T3-2 and 2.80 mBGL in piezometer T4-2[1]. Groundwater in the landslide materials is perched above the Mangonui Formation.

Groundwater levels in the Mangonui Formation down to the base of a conglomerate/sandstone layer range in depth between 10.80 mBGL (T1A-2) and 19.13 mBGL (T2A-2). The groundwater levels generally coincide with the conglomerate layer, indicating that this layer controls groundwater pressures within the upper Mangonui Formation.

Groundwater levels within the lower units of the Mangonui Formation range between 0.5 mBGL (T4-1) and 16.64 mBGL (T1A-1). Groundwater pressures are higher than those in the overlying conglomerate/sandstone layers and are likely to be connected to the underlying basalt.

[1] Based on data from June 2003 onwards.

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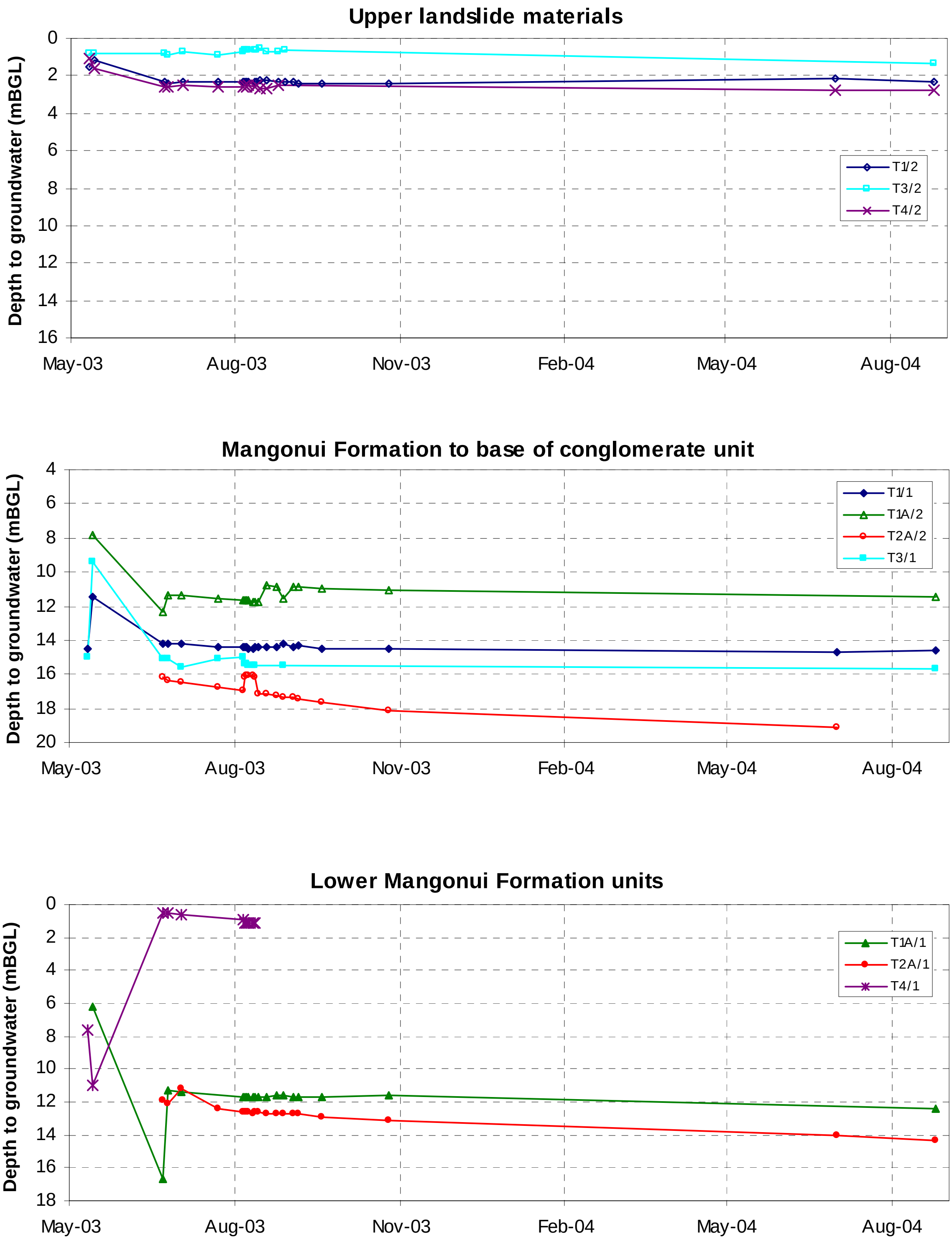

▪ **Figure 6. Groundwater Levels in the Mangonui Formation.**

3.3 Piezometric Surface Distribution

Figure 7 shows the piezometric surface distribution for the basalt aquifer, which was constructed from depth to groundwater information contained in drillers logs, Coopers Beach bore survey and consultants reports (Tonkin & Taylor Ltd, 1999 and 2001) and estimated ground level elevations. Groundwater elevations along the streams were assigned ground level elevation to represent the location of springs (ie. constrain potentially high groundwater pressure to ground level).

Groundwater pressure ranges from approximately 0 mAMSL near the coastline to 70 mAMSL approximately halfway up the catchment. The groundwater flow direction is from the higher ground towards the coast.

- **Figure 7. Piezometric Surface.**

(see A3 attachment at rear).

3.4 Aquifer Hydraulic Properties

Information on aquifer properties is available from aquifer test pumping exercises conducted on four bores in the study area. The information is contained within consultant reports for resource consent applications (Tonkin & Taylor Ltd, 1999 and 2001) and drawdown data for bores 201460 and 201539 analysed during this study. Appendix C contains the aquifer test pumping analysis results.

The hydraulic properties are summarised in Table 3. Hydraulic conductivity ranges between 0.170 m/day and 0.934 m/day. These values are consistent with literature values for permeable basalt, which are reported to range from 10^{-3} m/day to 10^{3} m/day (Freeze & Cherry, 1979). The hydraulic conductivity values for bores 201433 and 201542 were estimated from the transmissivity values, in the absence of hydraulic conductivity values in the resource consent applications.

Basalt transmissivity ranges between 11 m^2/day and 15 m^2/day. Higher transmissivity values (approximately 218 m^2/day) were obtained from mid-time test pumping data from Bore 201542 (Tonkin & Taylor, 1999), but this declined over time when a boundary condition was encountered. Only the more conservative later-time data for this bore is presented in Table 3.

Storativity has been estimated at between 3.4×10^{-6} and 4.9×10^{-3}, which indicates that the basalt behaves as a confined aquifer.

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Table 3. Summary of Aquifer Hydraulic Properties.

Bore	Owner	Bore depth (m)	Casing depth (m)	Discharge (m^3/day)	Hydraulic conductivity (m/day)	Transmissivity (m^2/day)	Storativity (-)
201433	Coopers Beach Retirement Resort	88	29.5	179	0.256[1]	15.0	4.9×10^{-3}
201460	Doubtless Bay Water Supply Co Ltd	33	6.4	240	0.934	25.4	-
201539	McBreen Jenkins North Ltd	104	7	219	0.186	18.0	4.7×10^{-6}
201542	J. Trussler	65	16	430	0.230[2]	11.6[3]	3.4×10^{-6}
AVERAGE						17.5	1.6×10^{-3}

Notes: [1]Assumes a saturated thickness of 58.5 m to estimate hydraulic conductivity; [2]Assumes an average saturated thickness of 50.5 m (pumping bore & observation bore); [3]Transmissivity values from later time data.

3.5 Groundwater Recharge

Annual average rainfall recharge to the basalt aquifer has been estimated as 3,200 m^3/day to 9,650 m^3/day, based on an area of 17 km^2, average annual rainfall of 1,377 mm, and an average annual recharge coefficient of 5% to 15%.

The recharge coefficient for the basalt aquifer takes into account the low permeability of the weathered basalt (ie. clays) and the large soil moisture zone. Most of the rainfall that infiltrates into the weathered basalt will be removed via soil evaporation and plant uptake, limiting the amount of recharge to the basalt. In comparison, a sand aquifer with high permeability would have higher recharge coefficients, in the range of 20% to 30% of annual rainfall.

The range in values (ie. 5% to 15%) accounts for the uncertainty involved in selection of the recharge coefficient.

Table 4 summarises the parameters used in the assessment of groundwater recharge.

Table 4. Estimated Daily Groundwater Recharge.

Recharge area (m^2)	Average annual rainfall (mm)	Rainfall recharge (m/yr)	Average daily recharge (m^3/day)
17×10^6	1,377	0.069 – 0.207	3,214 – 9,641

3.6 Groundwater Discharge

An assessment of groundwater discharge for the basalt aquifer has been calculated from the average hydraulic parameters shown in Table 3 and from the piezometric surface plot shown in Figure 7. Table 5 summarises the data that has been used in the discharge calculation.

Discharge from the basalt aquifer is estimated at approximately 8,750 m^3/day. This is within the range of the recharge estimation of 3,200 m^3/day to 9,650 m^3/day assessed in Section 3.6.

The discharge estimate is affected by uncertainties involved in the analytical calculation, in particular the average transmissivity of fractured basalt. In reality, groundwater discharge from the basalt aquifer will also include a component of recharge sourced from outside of the study area (regional recharge). This component has not been included in the estimation of groundwater recharge in Section 3.5.

- **Table 5. Summary of Aquifer Discharge Calculation Parameters.**

	Average hydraulic gradient (m/m)	Average transmissivity (m/day)	Discharge boundary length (m)	Discharge volume (m^3/day)
Basalt	0.05	17.5	10,000	8,750

3.7 Groundwater Quality

Groundwater quality information is available for nine bores in the study area, see red bores in Figure 4. The information is contained within resource consent applications (eg. Tonkin & Taylor Ltd, 1999 and 2001) and the NRC borelog and water quality database. Table 6 summarises the sampling results for these bores. The NRC has monitored water quality in bores 201387 and 201574 on four separate occasions, however only data from the most comprehensive sampling round (November 2003) has been included in Table 6.

Values in Table 6 that exceed the Drinking Water Standards for New Zealand (Ministry of Health, 2000) are highlighted in red. Exceedances occur for the following list of parameters (guideline value in brackets). Faecal coliforms and Escherichia coli (E.coli) exceed the microbiological Maximum Acceptable Value (MAV) for health, while the remaining parameters listed below are all aesthetic determinands under the Drinking Water Standards of New Zealand (DWSNZ):

- Faecal coliforms and E.coli (<1 cfu/100 mL)
- Iron (0.2 mg/L)
- Manganese (0.05 mg/L)
- pH (7.0-8.5) – Bore 201433 only

Exceedance of the microbiological MAV in bores 201387, 201433 and 201574 suggests that groundwater from these locations may not be secure from surface contamination. Periodic sampling in bores 201387 and 201433 by the NRC show that regular exceedances of the microbiological MAVs occur in bore 201387 only. Groundwater from this bore may need to be treated for domestic use. Sampling has been conducted in bore 201433 on one occasion only.

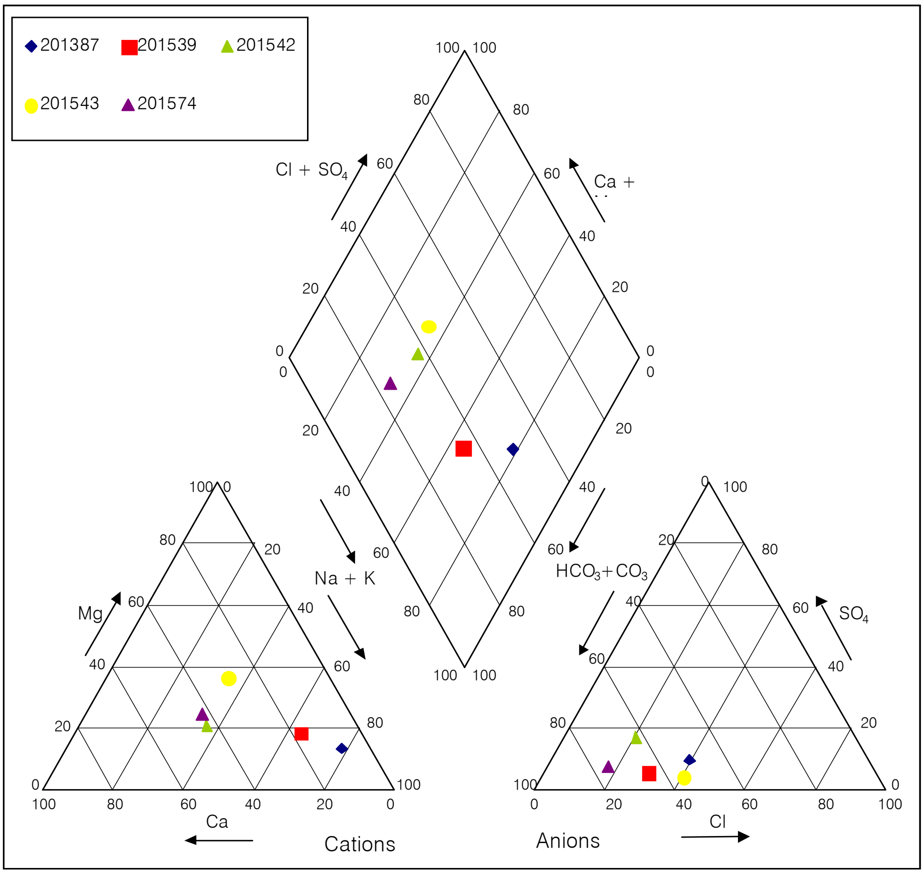
Exceedance of the Guideline Values for aesthetic determinands indicates that the groundwater has an unpleasant taste and appearance. Elevated iron and manganese has the potential to cause "rusting" of bore and plumbing fixtures, while the low pH measured in Bore 201433 is potentially corrosive. Manganese and iron are common constituents of basalt, and are also common in alluvial aquifers where reducing conditions may be present.

Figure 8 is a Piper Diagram of the major anions and cations (presented in milli-equivalents) in five bores for which data are available. The tri-linear diagram enables the water to be characterised in terms of its major constituents, which are governed by geologic and chemical processes.

Groundwater from bores 201542, 201543 and 201574 has no dominant cations and is proportionately higher in bicarbonate than other anions. The water is of Ca-HCO_3 type, which indicates that the groundwater is relatively young recharging water that has not had time to dissolve rock minerals or mix with other water types. These bores are located near Mangonui.

Bores 201387 and 201539 are located near the coast at the western end of Cable Bay. Water from these bores is of Na-HCO_3 type, indicating that the groundwater is within the freshwater/seawater-mixing zone. However, the water is not saline enough to be of concern.

Cable Bay is classified under the Proposed Water and Soil Plan as an "at-risk" aquifer in terms of seawater intrusion. The water quality results presented in Table 6 do not indicate seawater intrusion at the time of monitoring.



■ **Figure 8. Groundwater Chemical Characterisation Plot (Piper Diagram).**

Table 6. Summary of Groundwater Quality Results.

Parameter (mg/L)	201342	201369	201378	201387	201433	201539	201542	201543	201574
Date sampled	Sep 1999	1995	1995	Nov 2003	Nov 2001	Sep 1997	Sep 1999	Dec 2000	Nov 2003
Acidity							<1		
Alkalinity		148.7	148.7	149		195	170	78	198
Aluminium			0.03		<0.003		<0.003		
Ammoniacal-N				0.05		0.26	0.03		0.04
Antimony							<0.0002		
Arsenic					<0.001		<0.001		
Barium					<0.0001				
Bicarbonate				182			207		240
Boron (total)								0.016	
Boron (soluble)					0.033	0.26	0.049		
Bromide	0.081								<0.05
Cadmium					<0.00005		<0.00005		
Calcium		40.1	25.0	9.5		20	48	18.1	45.8
Chloride	21.1			81.5	37.9	63.0	39.3	40.1	32.6
Chromium							<0.0005		
Cobalt							<0.0002		
Colour		3	2						
Conductivity (mS/m)	11.5			61.4			52.4	32.8	51.6
Copper (total)								<0.006	
Copper (soluble)					0.0106	<0.05	<0.0005		
Cryptosporidium (cfu/100mL)					0				
Cyanide (total)							<0.003		
Dissolved oxygen				1.1					4.8
DRP				0.022					0.055
Escherischia coli (cfu/100mL)				122			<2		<1
Enterococci (cfu/100mL)							<2		
Faecal coliforms (cfu/100mL)				>2419	4		<2		57
Fluoride				0.28	0.15		<0.05		0.33
Free carbon dioxide						14		80	
Giardia (cfu/100mL)					0				
Hardness						102	178	102	
Iron (total)					3.05	1.02	1.55	0.06	
Iron (soluble)	<0.02	0.05	0.10	3.57			0.06		1.2
Lead					0.0005		<0.0001		
Lithium							0.0035		
Magnesium		18.2	8.80	9.83		13	14	13.8	16.2
Manganese (total)							0.205	0.082	
Manganese (soluble)	0.0044			0.192	0.152	0.13	0.217		0.291
Mercury (total)					<0.00008				

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- **Table 6 Continued.**

Parameter (mg/L)	201342	201369	201378	201387	201433	201539	201542	201543	201574
Molybdenum					<0.0002		<0.0002		
Nickel					<0.0005		<0.0005		
Nitrate-N				0.011	<0.05	<0.05	<0.002	1.1	<0.002
Nitrite-N				0.011	<0.05		<0.002		<0.002
Nitrogen (total)							0.2		
pH (pH units)	7.4			7.1	6.7	7.08	7.5	8.4	7.4
Phosphorus							0.02		
Potassium				0.37		2.0	1.2	0.4	1.21
Salinity				0.3					0.2
Selenium					<0.001				
Silica							87		
Sodium	12.9			108	34.9	83	45.9	24.3	40.2
Styrene					0				
Sulphate				27.5		16	45	6	19.1
Tin							<0.0005		
Total dissolved solids					290	352	389	218	
Total kjeldahl nitrogen							0.2		
Total oxidisable nitrogen							<0.002		
Turbidity (NTU)		1.0	0.1						
Vanadium							<0.001		
Zinc (total)								0.028	
Zinc (soluble)					0.027	<0.05	<0.001		
2 - Dichlorphenol					0				
2,4 – Dichlorophenol					0				
2,4,6 - Trichlorophenol					0				

Notes: Metal concentrations are for soluble metals unless otherwise stated; Only one of four sampling rounds from 201387 & 201574 has been presented.

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3.8 Summary of Conceptual Aquifer Understanding

The conceptual understanding of the aquifer is as follows:

- It is likely that areal groundwater recharge (downward movement) occurs over most of the study area, with groundwater discharge (upwelling) occurring at low topographic elevations. However, due to the limitation of available groundwater pressure information in coastal bores, this is not verifiable.
- Groundwater bore yields range from 0.06 to 10 L/s, which is sufficient to meet the needs of existing domestic uses and development. The higher yields occur within the fractured basalt, however the extent of fracturing is spatially variable and bore depths, which governs the number of fractures encountered, is variable.
- Poor groundwater quality (high iron, manganese and bacteria) is common within the basalt, however there is no clear trend across the study area. There are likely to be many variables contributing to the water quality including bore construction, integrity, location and interaction with surface water. Poor water quality due to seawater intrusion may also occur in bores near the coastline, however limited water quality information is currently available to assess this.

4. Assessment of Sustainable Yield

The sustainable yield of an aquifer is defined in this study as the volume of groundwater available for abstraction without compromising the performance of environmental systems, which in this case relates to habitat associated with perennial stream flow, and without inducing saline intrusion at the coast.

Groundwater recharge for the aquifer was estimated in Section 3.5 as ranging between 3,200 m^3/day and 9,650 m^3/day based on a rainfall recharge coefficient of 5% to 15% of average annual rainfall, respectively. Rainfall recharge represents the potential upper limit of groundwater availability, without considering the potential adverse effects from over utilisation such as seawater intrusion and depletion of spring flow.

In the absence of more detailed site-specific investigations, 30% of groundwater recharge is generally set aside for sustaining environmental flows. An additional 30% has been allowed for conservatism and to account for permitted surface water use (which is groundwater-fed) and mitigating potential loss of artesian flows. Therefore, the sustainable yield of the aquifer is estimated at 40% of groundwater recharge. Using the recharge estimates of 3,200 m^3/day to 9,650 m^3/day, a sustainable yield estimate of approximately 1,280 m^3/day to 3,860 m^3/day is suggested.

Current abstraction from the aquifer is 979 m^3/day, which is below the most conservative estimate of sustainable yield. This suggests that the basalt aquifer has not reached its full allocation potential.

5. Summary & Conclusions

This study provides a preliminary hydrogeological assessment of the Coopers Beach, Cable Bay and Mangonui groundwater resource. The assessment is based on information from borelogs, groundwater quality and groundwater level monitoring, Coopers Beach bore survey and resource consent applications.

The surface geology of the study area is comprised of fractured basalt overlain with up to 60 m of volcanic clays (weathered basalt), sandstone, mudstone or alluvium. Groundwater is generally abstracted from the fractured basalt, with bores cased through the overlying softer sediments. Groundwater yields vary between 8.6 m^3/day and 864 m^3/day depending on the extent of fracturing encountered in the bore, which is variable between bores, and also on the bore construction (depth, diameter, cased interval).

Groundwater pressures range from approximately 0 mAMSL to 70 mAMSL, with artesian pressures occurring at lower ground elevations near Otanenui Stream and along Coopers Beach. Areal groundwater recharge (downward movement) occurs over most of the study area, with groundwater discharge (upwelling) occurring where the artesian pressures exist and possibly along the coastline.

Groundwater quality information is limited. The available data does not indicate the presence of seawater intrusion, although high iron, manganese and bacteria in some bores is common.

A preliminary assessment of sustainable yield suggests that groundwater is not fully allocated in the study area. However, due to the uncertainties involved in the assessment of sustainable yield and the lack of long-term monitoring data to indicate adverse environmental effects, the amount of additional groundwater that can be potentially allocated is uncertain.

The main issues potentially affecting the quality and quantity of groundwater in the study area include the following:

- ***Seawater intrusion*** – there is no evidence of seawater intrusion from the water quality results assessed in this report, however the available data is limited.
- ***Iron and manganese*** – elevated concentrations occur in some bores, which is most likely a function of the geology.
- ***Bacteria*** – concentrations that exceed the NZ drinking water guidelines occur in some bores, which suggests that the groundwater may not be secure from surface contamination at these locations.

- ***Artesian flow*** – artesian pressures should be maintained in the aquifer, as reduced pressures may adversely affect stream flow (due to reduced baseflow) and artesian flow in bores, and increase the potential for seawater intrusion.
- ***Abstraction*** – the preliminary assessment of sustainable yield compared to current groundwater allocation indicates that the basalt aquifer is not fully allocated. However, a refinement of the sustainable yield is recommended in order to provide a more accurate assessment of the volume of groundwater available for allocation.

6. Recommendations

Based on the preliminary findings contained within this report, SKM recommend the following:

- Groundwater quality and level monitoring of coastal bores to assess the potential for seawater intrusion at Cable Bay (1), Coopers Beach (1) and the Mangonui Waterfront (2). Should seawater intrusion be found, the "at-risk" classification in the Regional Water and Soil Plan that is currently applicable only to Cable Bay may need to be extended to include these other locations.
- Groundwater pressure monitoring further inland to assess seasonal variations and the effects of abstraction. An appropriate bore may be 201330 (40 m depth).
- Measurement of spring and stream flow. This will provide a benchmark to assess potential adverse effects of increased groundwater demand and will assist in refinement of sustainable yield.
- Should further subdivision expansion be likely in the study area, a refinement of the sustainable yield of the aquifer is recommended in order to provide a more accurate assessment of the volume of groundwater available for allocation. A model based on dynamic estimates of groundwater recharge would provide a better assessment of sustainable yield, especially during the critical period when extended dry conditions prevail. The groundwater monitoring information initiated now will also assist in refinement of the sustainable yields in the future.

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7. References

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Appendix A Bore Details

■ **Table A-1. Summary of Bore Details and Test Pumping.**

Bore	Owner	Drilled date	Depth (m)	Cased depth (m)	Yield (L/s)	Drawdown level (m)
200090	Sutton	2/05/1983	47.5	44.3	-	-
200091	Frear	25/05/1983	33.5	12.2	-	-
200107	Logan	19/07/1969	30	-	-	-
200108	Eady	27/09/1984	11.5	3	0.5	0.6
200109	Lands and Survey	28/06/1963	27.4	12.2	0.5	-
200110	Lands and Survey	19/03/1965	24.4	12.8	0.4	-
200111	Lands and Survey	6/08/1969	-	6.5	-	-
200112	Knocks	4/10/1984	40	21.3	-	-
200113	Coopers Beach Motor Camp	6/10/1982	18	9.8	0.4	-
200114	Richmond	27/05/1975	27.4	19.2	0.4	-
200115	Sparksman	14/08/1969	35	-	-	-
200116	Hikurangi Fisheries	24/09/1979	19.5	5	0.3	-
200117	Hikurangi Fisheries	24/09/1979	19		0.06	-
200118	Sutton	1/06/1969	19	18	-	-
200166	Sumich	20/05/1985	50	6	0.06	14.6
200178	Lawson	8/03/1986	117	53.6	0.1	-
200225	Sutton	5/10/1987	30	9.4	1.4	22
201326	Dean	30/12/1988	109	15	1.1	30
201329	Garland	29/10/1990	70	23	1.1	55
201330	Tavinar	30/10/1990	40	9.3	0.5	33
201331	McCormick	2/11/1990	48	13	0.7	40
201334	Temple	19/04/1990	70	36.5	10	32
201342	Morrison	20/05/1991	48	28	0.8	9
201343	Coopers	16/05/1991	120	41	0.4	-
201351	Parker	6/07/1992	28	14	0.3	-
201353	Schwemberger	-	44	18	2.2	32
201357	Deveney	22/11/1991	56	17	8.3	40
201358	Brett	30/11/1991	150	-	-	-
201368	DBWS Co Ltd	26/04/1994	59	42	10	5
201369	Wallis	22/08/1995	42	19	0.6	35
201377	Myers	8/02/1993	30	2.5	0.3	8.5
201378	Nicall	19/04/1994	65	39.6	0.6	53
201379	Baker	30/09/1991	90	56	0.3	55

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■ **Table A-1. Continued.**

Bore	Owner	Drilled date	Depth (m)	Cased depth (m)	Yield (L/s)	Drawdown level (m)
201380	Laurent	16/02/1993	70	-	-	-
201383	Sparksman	31/01/1995	20	16.2	3.3	-
201384	Sumich	27/01/1995	155	48.8	0.1	-
201387	Croquet Club	1/02/1995	27	-	-	-
201392	Etekell	10/03/1993	14	5	0.1	-
201433	Retirement Resort	31/01/1997	88	29.5	4.33	7
201441	Laurent	25/09/1996	83	-	-	-
201442	Gates	31/08/1996	29	-	-	-
201455	Sutton	27/04/1994	59	42	0.9	-
201460	DBWS Co Ltd	27/06/1996	33	6.4	2.8	20.7
201485	Ward	12/10/1998	28	8	0.7	16
201538	McBreen Jenkins North Ltd	22/08/1997	104	7	2.5	30
201539	McBreen Jenkins North Ltd	27/08/1997	104	7	0.06	90
201541	Trussler	15/09/1999	74	22	0.3	70
201542	Trussler	15/09/1999	65	16	0.3	70
201543	Catteral	9/06/2000	37	19	1.1	20
201574	Christian Camp	21/03/2001	45	25	1.4	-
201578	Thorne	28/08/2001	59	35	0.8	-
201589	Dodds	8/01/2002	114	61	0.1	85
209213	Stratford	12/03/2004	34	4.3	0.8	-
209214	DBWS Co Ltd	10/03/2004	62	12.7	3.3	-
209224	GE & YH Sworn	8/02/2004	52	-	-	-
-	Earthquake Commission	7/05/2003	15	T1-2: 4.6 T1-1: 15.0	-	-
-	Earthquake Commission	13/05/2003	31	T1A-2: 20.4 T1A-1: 31.0	-	-
-	Earthquake Commission	9/05/2003	39	Inclinometer	-	-
-	Earthquake Commission	20/05/2003	30	T2A-2: 21.5 T2A-1: 30.0	-	-
-	Earthquake Commission	8/05/2003	23	T3-2: 3.2 T3-1: 16.5	-	-
-	Earthquake Commission	14/05/2003	27	Inclinometer	-	-
-	Earthquake Commission	11/05/2003	25.2	T4-2: 4.1 T4-1: 25.2	-	-
-	Earthquake Commission	15/05/03	30	Inclinometer	-	-

- **Table A-1. Continued.**

Bore	Owner	Drilled date	Depth (m)	Cased depth (m)	Yield (L/s)	Drawdown level (m)
-	M H Finkel	-	-	-	-	-
-	K S & J H Nice	1989	48.7	-	-	-
-	M Corry, W Grayson & G MacDonald	-	10	-	-	-
-	L T Taylor	1978	106.7	-	-	-
-	D & S Kitney	1988	50	-	-	-
-	A Staines, B Mason & G Landford	1980	80	-	-	-
-	D & J Knight	-	-	-	-	-
-	D & I Shalders	-	8	-	-	-
-	B & H Benson	-	6	-	-	-
-	T Mason & A Gibson	-	-	-	-	-
-	D & J Bradnam	-	-	-	-	-
-	D Caughey	1984	60	-	-	-
-	C & G Hill	1982	63	-	-	-
-	B Gaynor & A Gibbons	-	-	-	-	-
-	G & F Grbich	1983	55.4	-	-	-
-	T Drury	-	-	-	-	-
-	Artesian bore that flows onto Mr Hall's property	-	-	-	-	-
-	H & S Castle	-	-	-	-	-
-	N & M Dodds	2001	91.4	-	-	-

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Appendix B Coopers Beach Bore Survey Results

- **Table B-1. Results from Bore Survey Returns.**

Bore	Owner	Drilled date	Depth (m)	Bore in use?	Average water use (m^3/day)	Maximum water use (m^3/day)
209224	G & Y Sworn	8/02/04	52	Y	-	1
201334	I & J Temple	19/04/90	70	Y	0.1	0.7
200114	J & J Littlejohn	27/05/75	27.4	N	1.36	-
201342	M Morrison	16/05/91	48	Y	0.1	1
-	M H Finkel	-	-	N	-	-
-	K S & J H Nice	1989-1990	48.7?	Y	0.3	
-	M Corry, W Grayson & G MacDonald	-	10?	N	-	-
-	L T Taylor	1978	106.7?	N	-	-
-	D & S Kitney	1988	50	N	-	-
-	A Staines, B Mason & G Landford	1980	80	Y	0.7	1
-	D & J Knight	-	-	Y	0.6	1
-	D & I Shalders	-	8	Y	-	1
-	B & H Benson	-	6?	N	-	-
-	T Mason & A Gibson	-	-	N	-	-
-	D & J Bradnam	-	-	N	-	-
-	D Caughey	1984	60-80	Y	-	1
-	C & G Hill	1982	63 m	Y	0.5	-
-	B Gaynor & A Gibbons	-	-	N	0.1	-
-	G & F Grbich	1983	55.4	Y	-	1
-	T Drury	-	-	Y	0.1	0.5
-	H & S Castle	-	-	Y	0.05	0.1
-	N & M Dodds	-	capped	N	-	-
-	N & M Dodds	2001	91.4	Y	1	1

Notes: 141 surveys sent out, 71 surveys returned, 22 properties have bores.

Appendix C Aquifer Test Results

Table B-1. Summary of Aquifer Test Pumping Results.

NRC Bore No.	Name	Analysis	Hydraulic conductivity (m/day)	Transmissivity (m^2/day)	Storativity (-)
201460	Doubtless Bay Water Supply Co Ltd	Cooper-Jacob – pumping bore	1.530	41.6	-
		Theis recovery – pumping bore	0.337	9.14	-
AVERAGE			0.934	25.4	-
201539	McBreen Jenkins North Ltd	Cooper-Jacob – Pumping bore	0.275	26.7	-
		Cooper-Jacob – Obs. bore	0.210	20.4	4.69×10^{-6}
		Theis recovery – pumping bore	0.091	8.9	-
		Theis recovery – obs. bore	0.166	16.1	-
AVERAGE			0.186	18.0	4.69×10^{-6}