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22 August 2018

The Consents Manager
Environment Southland
Private Bag 90116
Invercargill 9840

Dear Sir,

L & P Kirker – 295 Lowther Road, Five Rivers – application for a replacement consent for an existing activity

Please find enclosed an application for a replacement resource consent for Lindsay & Pauline Kirker on their property known as Cromel Farms. The applicants held a previous consent for this activity, consent no. AUTH-204511, to take groundwater for irrigation of the property located on Lowther Road, Five Rivers. Details of the previous consent are as follows:

Consent	Bore numbers	Expiry date	Daily rate (m^3/day)	Annual allocation (m^3/year)	Restrictions
AUTH-204511	E44/0330 & E44/0331	29/01/2018	5,184	735,000	No surface water flow or groundwater level restrictions applied. Note – the original application was to irrigate up to 175 ha anywhere within a 312 ha property.

This application is for a replacement water permit for the same amount of water per day as the previous consent but with a reduced annual allocation. The design of the system is still based on being able to irrigate up to 175 ha but the annual amount required takes into account the amount of water used over the term of the previous consent, with some consideration on how the operation of the system can be improved, and on Appendix O of the Proposed Southland Water & Land Plan (PSWLP) relating to reasonable and efficient use of water.

The water is to be taken via existing and new bores from the Five Rivers Groundwater Zone, which is an unconfined riparian aquifer. The application is for a discretionary activity under both the Regional Water Plan (RWP) and the PSWLP. It is supported by an effects assessment carried out in accordance with the requirements of the RWP, and a new analysis of the pump test data carried out in accordance with Appendices L.2 and L.3 of the PSWLP. This latter assessment was prepared by Pattle Delamore Partners Ltd (PDP) and the report is attached as Appendix 3.

The Kirkers currently operate two OCMIS travelling gun irrigators to irrigate the area, all of which is used for pastoral farming, but propose to add another two irrigators. The irrigation area is shown on the Map 1 in Appendix 2. A full description of the system is provided below.

The application is therefore as follows:

> *To take up to 5,184 m^3/day of groundwater, at a combined maximum rate of 95 litres/second from up to 4 bores, for irrigation of up to 175 ha. The annual allocation applied for is 525,000 m^3/year. The term applied for is 20 years.*

The details of the four bores are as follows (the NZTM co-ordinates are on the Part B form):

Bore name	**ES ID number**	**Depth (m bgl*)**	**Screen Depth+ (m bgl*)**	**Diameter (mm)**	**Pump type**	**Pump capacity**
Bore 1	E44/0330	53.0	2.4–8.0 10–38.3 42.8–48.5	250	Submersible	30.0
Bore 2	E44/0331	52.9	5.4–7.4 7.4–46.9	250	Submersible	30.0
Bore 3	E44/0437	28.5	1.8-22	250	Submersible	15.0
Bore 4	E44/0438	22.4	2.36–7.36 7.36–11.41 11.41-17.41	250	Submersible	20.0

* below ground level.

\+ more screen details are available in the PDP report in Appendix 3.

The application is for a discretionary activity under both the RWP (Rule 23(d)(iv) and the PSWLP (Rule 54(d)). The statutory application form and a site plan are attached as Appendices 1 and 2 respectively.

1. Supporting information

This application is supported by the report from PDP titled "295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting", dated August 2018. A copy of the report is attached as Appendix 3.

This report provides the following information:

- a site description, including location, climate, hydrology and hydrogeology;
- analysis of the pump test data;
- an assessment of the environmental effects on:
  - aquifer storage volumes;
  - interference effects on neighbouring wells and bores;
  - steam depletion;
  - wetland and lake levels; and
  - ground and surface water quality.

The original PDP report for the previous consent that was granted in 2008 is not included because the latest report includes the new methodology for assessing the effects of groundwater takes based on Appendix L.5 of the PSWLP. A copy of the earlier report can be provided if required but it is a matter of record in the file for this applicant.

2. Description of property

The Kirkers' main block on which the irrigation occurs is located at 295 Lowther Road, Five Rivers, and has an area of 312 ha (see Map 2, Appendix 2). The application is to take groundwater in order to irrigate approximately 175 ha of that block.

The property lies between the Irthing and Acton Streams, and has the Cromel Stream running through it. The land is flat to undulating and there are a number of minor tributaries flowing through it but these generally only flow intermittently.

Rainfall in the area is low compared to coastal areas and the area is subject to seasonal dry periods. Records from the Lumsden Cableway site on the Oreti River (approximately 7 km south east of the Kirkers' residence) show an annual average rainfall of 794 mm.

There is no representative evapo-transpiration data available in this area so data from the Gore weather site is relied upon. Evapotranspiration and the consequent soil moisture deficit would be expected to be higher at Five Rivers, so relying on the Gore data is conservative. However, it is only a potential issue in the driest part of the season, typically sometime during the period January – February.

Potential evapo-transpiration data at Gore can exceed 5 mm/day during the hottest months of the year. However, it is variable from day to day, depending on air temperature, cloud cover and wind conditions.

The soils in the irrigation area are a mix of Riversdale (dominant), Gore and Lumsden on the left bank side of the Cromel Stream; and Gore, Ardlussa, Riversdale and Lumsden on the right bank side (see Map 4, Appendix 2). They are free draining for the most part and respond well to irrigation. A summary of the soil properties is attached as Appendix 5.

In regard to physiographic data, the same division applies as for soils, namely, Riverine on the left bank side of the Cromel Stream; and Oxidising on the right bank side (see Map 3, Appendix 2). The Riverine zone is typically found on the margins of rivers, and can include the floodplain and low terraces, which are all areas that "... are strongly influenced by runoff from the Alpine zone" (from Environment Southland factsheet).

Soils in the Riverine zone are well drained and approximately 75% have a severe vulnerability to nutrient leaching. The remainder have a moderate vulnerability. While contaminants leached are diluted by incoming clean alpine water and their levels are generally low in groundwater within this zone, they are a contributor to contaminant levels downstream, including in estuaries. It is therefore important that irrigation is controlled to ensure excess water is not applied.

As its name suggests, soil water and groundwater in the Oxidising zone are well aerated, which allows nitrogen to accumulate. The denitrification potential is low. In free draining soils, as is the case on this property, water seeps straight down to the underlying aquifers that are recharged by rainfall. In regard to contaminant losses, deep drainage is the main pathway rather than surface drainage to rivers and streams.

Nitrate levels, for the most part, are in the moderate to high land use impacts (3.5 – 8.5 mg/l) category based on the 2007-2012 nitrate levels study (see Map 5, Appendix 2. There is a small portion of minor to moderate land use impacts (1.0 – 3.5 mg/l) at the western corner of the property. There are two hotspots in the Five Rivers area but they do not appear relevant to this property or the application to take water.

More details on the soils are shown in the soil property summary and Environment Southland soil factsheets attached in Appendices 5 & 6. The factsheets for the two physiographic zones are also included.

3. Hydrogeology

See Section 4.4 of the PDP report, Appendix 3.

Under the Regional Water Plan (RWP), up to 50% of the mean annual land surface recharge (LSR) can be allocated as a discretionary activity for takes over 2 litres per second. The mean annual LSR for the Five Rivers Groundwater Zone (Appendix H of the RWP) was estimated to be 52,900,000 m^3/year so 50% is 26,450,000 m^3/year. The information provided by Environment Southland (dated 6 August 2018) shows that approximately 330,839 m^3/ year is currently allocated from this zone

Under the PSWLP, the discretionary allocation is limited to the primary allocation for the aquifer that is specified in Table Y.4, Appendix L.5 (there are other criteria for a discretionary activity and these are discussed in the relevant sections below). The primary allocation for the Five Rivers Groundwater Zone is 17,050,000 m^3/year, which is lower than the discretionary limit in the RWP. Of this amount, 605,564 m^3/year is currently allocated. Although the areal extent of this zone has increased under the PSWLP, the primary allocation is reduced, presumably based on better information about the aquifer and how it is recharged. Regardless of the reason, there is sufficient water available to grant this consent.

Under both plans, the amount of water allocated is very low, and will still be once this take included. The application is therefore for a discretionary activity under both plans.

4. Irrigation system and water usage

This property is currently irrigated by two OCMIS hard hose, travelling rain guns but the Kirkers intend to increase that number to four. Although the same area is still to be irrigated, the additional irrigators provide better coverage for the whole area, hence more complete use of the water allocated. It will reduce the time lost when shifting irrigators as irrigation can continue while other units are being set up.

It is possible that all four irrigators could be operating at once, hence the need for a peak instantaneous take of 95 l/s, but that will not happen for 24 hours continuously. The daily rate applied for is equivalent to an average rate over 24 hours of 60 l/s.

As described in Section 3 of the PDP report, water will be taken from up to four bores at the rates listed in Table 2. The yields from bores in this zone are relatively low compared to more high yielding sources such as the confined aquifers and alluvial aquifers like Riversdale and Waipounamu. The Kirkers therefore propose to use a network of bores to get sufficient water to irrigate the total area.

This application is for the same volume of water on a daily basis that the previous consent authorised, i.e. 5,184 m^3/day, and the design irrigation rate is 3 mm/day over 175 ha. While this amount will be sufficient at times, particularly around the shoulders of the irrigation season (October-November and March-April), there will be drier periods when more water will need to be applied (up to 5 mm/day). At such times, areas will be prioritised to fit the farming activity at the time, e.g. crop or pasture, land under cultivation, etc.

The area of the farm that is to be irrigated are shown on the site plan in Appendix 2. The irrigators can be run in conjunction with each other, or separately. The irrigation water is pumped straight from the bores and no storage for buffering flows is used.

The use of hard hose travelling irrigator units means that sufficient water must be applied to last until the irrigator returns. The two key soil moisture points are field capacity and wilting point. Typical irrigation practice for this type of irrigator is to allow the soil moisture level to drop to 50% of the difference between those two measurements before recharging the soil moisture back to at or about field capacity. For the soils on this property, using the 50% criteria, the amount of water to apply will range from 35 to 64 mm per application.

Because the soil types are mixed and there is no practical way of changing the irrigator operating parameters on a 200 – 400 m run, the system is operated so that it applies no more than 40 mm on a run. The actual application depth and return period will vary over the season. It will mostly depend on the soil and climate conditions at that time but it can be also be affected by crop type and foliage length. The depth applied is 24 - 40 mm with the return period varying from 8-12 days. In the shoulders of the season, 12 days is sufficient, but the rotation shortens to 8 days during the peak irrigation season as the conditions become drier. The system is flexible enough to be adjusted to the conditions. Cooling of the pasture from irrigation provides additional benefit for plant growth, so it is not just water in the soil that provides benefit.

In a very dry season, the system will be managed to optimise pasture production, which will mean areas for irrigation will be prioritised. The application rate can be varied to match the evapotranspiration rate through the season but that rate would not exceed an average of 5 mm/day.

Taking water at the maximum daily amount of 5,184 m^3/day enables irrigation to be carried out on 101 days per year due to the low design rate of 3 mm/day. Whether or not that number of days is used will depend on rainfall over the summer and decisions made about crops and pastural renewal, i.e. some paddocks may not be available due to cultivation. This application is for 525,000 m^3/year, which is sufficient to apply 300 mm/year (equivalent to 3,000 m^3/ha/year) over the 175 ha. This amount is consistent with Environment Southland's guideline for reasonable water use in Appendix O of the PSWLP.

The water requirement is determined by consideration of the water budget for Gore (the closest site with evapotranspiration data), typical usage within this part of the region and past water usage by the Kirkers. The budget is based on rainfall information from NIWA's CliFlo database for the Balfour, Lumsden, Mandeville, and Waipounamu data sites, while evapotranspiration has been based on information from Gore. The property is located closest to the Lumsden site, however it has limited data, so the surrounding sites have been investigated to better understand the rainfall in the area. The property is some distance from Gore, however, it is the closest site that has evapotranspiration data.

The volume of water required is therefore based on how much water the bore will yield, and the seasonal deficit to be replaced under irrigation. The amount that can, on average, be applied each day, 3 mm/day, is sufficient for the majority of the season. However, as stated above, if conditions are particularly dry the rotation may be shortened, more water applied and less area irrigated.

The historic water use data for this site, up to the 2013-14 season, is rather sporadic and not reliable. This problem has been due to issues with telemetry service providers and getting a reliable system in place, something that is not uncommon for many irrigators. However, data from 2014 to the present is reasonably reliable and is shown in the table below.

Season	Pump 1 - E44/0330 (m^3/year)	Pump 2 - E44/0331 (m^3/year)	Total (m^3/year)
2014-15	50,698.1	1,743.7	52,441.8
2015-16	107,557.3	57,973.7	165,531.0
2016-17	88,368.5	76,109.5	164,478.0
2017-18	91,552.1	73,722.7	165,274.8

To make better use of the water allocated, the Kirkers have made two significant improvements. Firstly, two additional bores have been drilled to enable a higher instantaneous rate of water to be extracted; and secondly, two additional irrigators will be purchased to improve the capacity and flexibility of the system, and make it easier to effectively irrigator all of the 175 ha. No additional water, on a daily or seasonal basis is required, and the latter has, in fact, been reduced.

With only two irrigators available, it was difficult to manage the shifts without significant downtime while the units a shifted for the next run. Upgrading the system is reliant on a consent being granted in the terms applied for, in particular, the increased instantaneous rate of extraction while maintaining the daily rate authorised in the previous consent.

The previous consent for this take did not require soil moisture to be monitored. There is a reasonably representative site approximately 2 km away alongside the Mossburn Five Rivers Road that the Kirkers have been able to refer to for information.

5. Assessment of environmental effects

The potential adverse effects to be considered are sustainability of the aquifer, stream depletion, effects on other bores, and impacts on water quality. While not effects in themselves, it is also appropriate to consider alternative sources and efficiency of water use. The overall assessment is that the potential adverse effects of this activity are no more than minor.

The PDP report provides the analysis of the pump test data for each of the four bores. It assesses aquifer sustainability, interference effects and stream depletion. The sections that follow summarise the outcome of the analysis by PDP and comment is provided where necessary.

5.1 Aquifer sustainability

See Section 6.1 of the PDP report and Section 3 above.

Based on the primary allocation specified in the PSWLP, which is lower that the discretionary limit in the RWP, aquifer sustainability is not considered to be an issue. The total allocation if this consent is granted would be 1,130,564 m^3/year or 6.6% of the discretionary limit.

Recharge of groundwater in this zone is a combination of rainfall and river recharge, the latter being from the Oreti River and its tributaries. Rainfall recharge is mainly a winter/spring phenomenon that raises increases storage in the aquifer, which drains out over the summer/autumn period.

The Acton, Cromel and Irthing Streams have substantial catchments upstream of the Five Rivers Groundwater Zone that flow into and out of the zone. They provide both recharge when aquifer levels are rising and drainage when levels are falling. Over the summer months flows can get very low and the Cromel Stream is known to be ephemeral, with little or no flow for up to 3 months of the year.

The effect of the take on aquifer storage is assessed as less than minor.

5.2 Stream depletion

See Section 6.3 of the PDP report.

The results of the stream depletion assessment by PDP are summarised in the following table:

Bore	Pumping rate (l/s)	Stream	Depletion period (days)	Depletion (l/s - %age)		Connectivity[1]
				(l/s)	(Percentage)	
1	30	Total	7	2.6	9	
	30		90	20.3	68	
	30	Irthing	7	0.0	0	
	30		90	1.3	4	Low

1 Connectivity has only been determined based on Table L.2 of Appendix L of the PSWLP. As a technical requirement, it is considered to now be more appropriate than Policy 29 of the RWP, although the outcome is unlikely to be significantly different.

	30	Cromel	7	2.6	9	
	30		90	19.0	64	High
	30	Acton	7	-	-	
	30		90	-	-	
2	30	Total	7	14.3	48	
	30		90	27.0	90	
	30	Irthing	7	0.0	0.0	
	30		90	1.7	5.6	Low
	30	Cromel	7	14.3	47.7	
	30		90	25.3	84.3	High
	30	Acton	7	-	-	
	30		90	-	-	
3	15	Total	7	0.7	5	
	15		90	11.0	73	
	15	Irthing	7	0.0	0	
	15		90	2.3	15	Low
	15	Cromel	7	0.7	5	
	15		90	8.7	58	Moderate
	15	Acton	7	-	-	
	15		90	-	-	
4	20	Total	7	0.0	0	
	20		90	8.8	44	
	20	Irthing	7	-	-	
	20		90	-	-	
	20	Cromel	7	0.0	0	
	20		90	8.0	40	Moderate
	20	Acton	7	0.0	0	
	20		90	0.8	4	Low

In accordance with Appendix L.2, fourth bullet point, of the PSWLP, the stream depletion effect on the Cromel Stream has not been considered. While there is no actual monitoring of flow in this stream, there is strong anecdotal evidence that, for about 3 months over the summer period, it is no more than a few disconnected pools for about 3 km south of the Mossburn Five Rivers Road (Environment Southland technical comment, dated 9 July 2017, prepared by Karen Wilson for the original application for the Kirkers previous consent – see Appendix 4).

The degrees of connectivity of each of the bores to all other watercourses that were assessed are moderate to low, which means that no specific minimum flow restrictions are required to be imposed on the takes. The overall effect on stream depletion of the four takes is assessed as no more than minor.

5.3 Effects on other bores

See Section 6.2 of the PDP report.

The assessment of the interference effects on neighbouring bores, i.e. bores on properties adjacent to the Kirkers property, is fully assessed in the PDP report. It is assumed that as the scale of the take and the overall allocation of the water from the zone is relatively low, there will not be an overall lowering of water levels as result of granting this application.

The analysis is hampered by a lack of detailed information on some of the neighbouring bores, which is not uncommon for minor stockwater and domestic bores that were installed prior to a resource consent being required. However, on the basis of suitably conservative assumptions, the assessment is that the interference effects are within the thresholds specified in Appendix L.3 of the PSWLP. Drawdown interference effects are therefore assessed as less than minor.

5.4 Impacts on water quality

As stated above, this property is used predominantly for pastoral farming (sheep) with some cropping. It is subject to seasonal dry spells and irrigation is an important part of maintaining production through those periods. In the early stages, irrigation was an "add-on" to the farming operation but with the addition of two more bores and two more irrigators, it will become an integral part of the operation. In this way, the Kirkers will be able to use more of the water authorised more efficiently.

The use of irrigation is more about maintaining production and reducing the use of imported supplementary feed rather than increasing production, although that is a possible consequence. No change of farming type is proposed. Groundwater nitrate concentrations under the property are mostly classified as moderate to high land use impacts (3.5 – 8.5 mg NO_3/l). There are two hotspots within the Fiver Rivers zone but beyond those areas, the levels are lower.

Irrigation can increase nutrient uptake by increasing pasture production. Conversely, by maintaining soil moisture levels artificially high, there is the potential for nutrients to leach sooner when it rains. Under a sheep farming regime, fertiliser use is not as high as for dairy farming, nor are there the larger urine patches that occur during dairy grazing.

Within the irrigated area, there are two physiographic zones, namely, Riverine and Oxidising. The main pathway for nutrient losses for both zones on this property is by drainage through the soil to groundwater. Nutrient losses are not expected to be any different to the previous years under irrigation and under the new land use rules in the PSWLP, some improvement may be possible. However, there has been no detailed analysis of this aspect.

This application is not for a new activity and, apart from improving the use of the water authorised, no changes in water quality effects are anticipated. The impact on water quality from this activity is assessed as minor and will be the same or similar to what is occurring now.

5.5 Alternative sources

The only alternative sources of water for irrigation are either surface water or a different aquifer. Within the property boundary, the only surface water resource of any size is the Cromel Stream and, as already noted, it is ephemeral. Taking surface water is also less reliable because of the imposition of minimum flows, so, in this catchment, water is unlikely to be available when it is most needed.

In regard to groundwater, the unconfined aquifer in the Five Rivers Groundwater Zone is the only known, accessible resource. The property is outside the boundary of the Lumsden Aquifer, but even if it could be accessed, it is near enough to being fully allocated.

Another alternative is to capture rainfall and runoff in storage but this approach is not considered to be a practical alternative. Providing sufficient, reliable storage is expensive, given that a large volume would need to be stored to provide the amount of water that is needed. Aquifers are a natural storage system that, in the right circumstances, can be used effectively with minimal impact on the environment.

Although it is relatively low yielding, the Five Rivers Groundwater Zone is considered to be the best source of water for irrigation for this property in terms of reliability of supply and impact on the environment. Alternative sources are therefore not considered further.

5.6 Efficiency of water use

The efficiency of water use has been discussed to some extent in Section 4 above. The amount extracted daily is considered to be appropriate and an efficient use of water. Applying 3 mm/day on average is sufficient under most circumstances to get a good response to irrigation, but 4-5 mm/day will be necessary in really hot, dry conditions.

The seasonal allocation is also believed to be appropriate for the area that can be irrigated. It is equivalent to 300 mm over 175 ha for a full season. In particularly dry conditions, the daily water use will need to be prioritised to gain maximum benefit from the available water. This has been done in the past by decreasing the irrigated area during the peak of the irrigation season and applying the maximum of 5 mm/day. While there have been some years drier than others during the term of the consent, there has not been a significant drought in the region in that time.

The Kirkers are applying for a reduced seasonal allocation compared to what was authorised on their previous consent to meet the reasonable use requirement of Appendix O of the PSWLP. It is therefore considered that the rates and volumes of water applied for, for the size of area to be irrigated, represent an efficient use of water.

5.7 Summary

The potential adverse effects of this activity are assessed as no more than minor, although some aspects are assessed as less than minor. The design of the system is considered to enable the efficient use of water and is appropriate for the soil types to be irrigated. The volume of water applied for is reasonable and consistent the Council's practice in regard to allocation.

6. Relevant Planning Documents

The relevant planning documents for the region are the Regional Policy Statement (RPS), the Regional Water Plan (RWP) and the decisions version of the Proposed Southland Water and Land Plan (PSWLP). It is noted that the take is also covered by the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010. The Kirkers has a telemetered flow measurement system installed that will comply with these regulations and it is anticipated that any future consent granted will have an appropriate condition imposed.

The Water Conservation (Oreti River) Order 2008 (WCO) is also relevant as there is a stream depletion effect to consider.

No detailed review of the RPS is provided. Typically, the objectives and policies are given effect through the provisions and requirements of the Plan, which cannot be inconsistent with the RPS. It is also noted that Policy B7 of the National Policy Statement for Freshwater Management 2011 does not apply to this application but it has been included for completeness.

The decisions on the submissions to the PSWLP have now been released and it is the decisions version of the Plan that must be considered. A number of appeals have been lodged to the decisions and it is noted that some of these relate to the groundwater provisions, so full weight cannot be given to the proposed Plan at this time.

The RWP is the still the operative Plan under which the application should be considered but some of its provisions are dated, particularly in regard to allocation of water from aquifers and groundwater management zones, and the methodology required for carrying out pump tests on bores and aquifers. However, it should be noted that the application is not inconsistent with or contrary to either plan, and has the same status, namely, discretionary.

6.1 Regional Water Plan

In regards to the objectives and policies identified as being most relevant in this Plan (see Schedule 1), the following specific points should be noted:

Objective 9	The issue of sustainability of the water supply has been addressed in the application but it does rely on the primary allocation specified in the PSWLP, which is the most conservative of the two relevant Plans. Granting this application would bring the total amount allocated to only 6.6% of the primary allocation
Policy B7	This application is for the same scale of activity that has previously been authorised and the assessment is that the adverse effects will be no more than minor. This existing take will not adversely affect the life supporting capacity of any freshwater bodies. This matter has been discussed in the sections above.
Policy 14A	The Kirkers are seeking a term of 20 years, which is considered to be reasonable given the relatively low impact of this take on the environment, the low demand for water from this zone and the investment made in his irrigation system (it is acknowledged that section 124 does not apply but this point is still considered to be relevant for the consideration of the consent term). The irrigated land is used for sheep farming so the return on the investment is lower and a longer term is required to realise the value from it. The location of the take and the nature of the aquifer are such that no restrictions based on surface water flows are required. In regard to the specific matters to be considered when setting the term, the following information is provided:

(a) the certainty for each of the matters listed is reasonably high for this aquifer. It is a low yielding aquifer sufficiently distant from any significant watercourse to avoid having anything more than a moderate effect on stream depletion, apart from the ephemeral Cromel Stream. The take is not a new one and no effects on neighbouring bores has been identified. Adverse effects vary from less than minor to minor;

(b) the Five Rivers Groundwater Zone is an unconfined aquifer that has a number of water-bearing layers. There is a reasonable degree of confidence in the nature of it and the way it behaves. Most uncertainty would occur on the margins but this site is not close to them;

(c) no impact on tangata whenua values have been identified. Because stream depletion effects are no more than minor, surface water values are not reduced;

(d) the allocation status of the aquifer is very low. Despite having gone through a period of high interest in irrigation, few have tried to develop on-farm schemes from this zone;

(e) the information provided in support of this application, including the PDP report, is the main documentation supporting the term applied for. The low allocation status of the zone, the lack of any significant adverse effects and the ongoing seasonal need for water on this property is the main reason for seeking a 20 year term. The Kirkers are also investing in additional bores and irrigators, as well as the preparation of this application, to make full use of the water allocated more efficiently;

(f) the activity, namely taking water, can carry on indefinitely as long as the take is sustainable. Although climate change is an issue, there is no indication that the take will become unsustainable within the 20 year timeframe applied for. In terms of economic life, all parts of the system, including the bores, pumps, pipes and irrigators can be maintained and, if necessary replaced, so irrigation can carry on indefinitely. However, if farming were to become uneconomic, the demand for water for irrigation would cease. Permanence and economic life of the activity are there for not reasons to reduce the consent term;

(g) the Kirkers have made an initial investment in irrigation and are now looking to at least double that to be able to improve their system in ways already described. The cost is substantial, particularly when relying on a farming economy that can vary from year to year;

(h) water usage is recorded via a telemetered system. Soil moisture levels are monitored at a reasonably close Environment Southland site;

(i) not relevant; and

(j) apart from early issues getting a suitable water metering system in place, the Kirkers compliance history is good.

Policy 21	The rate of abstraction and seasonal allocation are discussed above. Both the daily extraction rate and the seasonal allocation are considered to be reasonable.
Policy 28	The take has been assessed in accordance with the requirements of Appendix L of the PSWLP and the information forms the basis of the adverse effects assessment. The matters to be considered under this policy are addressed.
Policy 29	The stream depletion issue has been addressed earlier in the application. The ephemeral Cromel Stream has the most significant effects but because it is dry for long periods over the summer months, the effect of stream depletion on it has not been considered (not supported by policy in this Plan but addressed in the explanation to Policy 29). Stream depletion effects on other watercourses are considered to be no more than minor.
Policy 31	Interference effects are addressed above and are within the requirements for a riparian aquifer.
Rule 23 (d)(iv)	The application is for a discretionary activity under this rule, i.e. the take exceeds 2 l/s and the aquifer is less than 25% allocated.

The remaining policies are relevant to the granting of the consent and setting of conditions but do not prevent it being granted for the same or similar terms as consent AUTH-204511.

6.2 Proposed Southland Water & Land Plan

The following specific points should be noted about the objectives and policies of the PSWLP identified as being most relevant (see Schedule 2):

Objective 1	This objective requires that natural resources be managed in an integrated way and makes specific reference to the connectivity between surface water and ground water resources.
Objective 2	This objective recognises the economic importance of water and land to the region. Reference to "primary production" has been added to the objective following the Plan hearings.
Objectives 3 & 4	The overall importance of water to the health and mauri of people, water, and the environment and its cultural value is noted. Further comment is provided in Section 6.3 below.
Objective 7	As this groundwater zone is not over-allocated, this objective does not relevant to this application.
Objective 9	This take will not impact the values of those matters that are listed in this objective.
Objective 9A	Sustainably managing surface water "... to support the reasonable needs of people and communities to provide for their social, economic and cultural wellbeing" is a core part of the Resource Management Act and is brought into the PSWLP through this objective. Stream depletion effects for this take minor as connectivity is moderate or less.
Objective 11	Allocation and efficient use are discussed above and have been addressed in the design of the system.
Objective 12	The nature of the aquifer is such that water levels will be maintained if this application is granted. The degree of connectivity has been assessed and is addressed in the effects assessment.
Objective 18	The Kirkers operate in a way that the expectation stated in this objective is achieved. Going to the expense of installing an irrigation scheme

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	means that there is an incentive to get the best from it, and adopting good management practices is part of that process.
Policies 1 & 2	Policy 1 is noted and the role of papatipu rūnanga in the consent process is noted. The Iwi Management Plan for the region is considered below.
Policies 4 to 12	The physiographic zone policies are noted and, to the extent that they are relevant to this application, have been addressed in the sections above.
Policy 13(1)	Recognises that use and development of land and water resources has positive benefits. Although not specifically mentioned, it is noted that this policy is constrained by the provisions of the Resource Management Act and other policies in the PSWLP.
Policy B7	As for the RWP in Section 6.1 above.
Policy 20	Policy 20(1A) repeats Policy 13 and is discussed above. Because of the moderate to low connectivity, surface water values are not impacted to any significant degree. The matters to be addressed under policies 20(2) and (3) have been discussed and addressed in the consideration of adverse effects. Aquifer storage is not a limiting factor in the use of this aquifer, nor are the stream depletion effects. The aquifer is recharged from flows coming down from the hills behind and rainfall directly onto it so it will generally always recover. This application will therefore not be inconsistent with this policy.
Policy 21	Allocation with respect to the primary allocation has been addressed and is not an issue.
Policy 22 & 23	Stream depletion and interference effects have been assessed in accordance with Appendix L.2 and are addressed in Section 5 above. It is noted that Appendix L.2 excludes consideration of stream depletion effects on ephemeral watercourses (fourth bullet point).
Policy 40	See Policy 14A in Section 6.1 above, which is essentially the same.
Policy 41	This policy is relevant to the setting of monitoring conditions. The risk of significant adverse effects in regard to this take is low.

Policy 42	In regard to the matters to be considered under this policy, it is noted that:	
	1 & 2	the aquifer is not over-allocated so these matters do not apply;
	3	as this application is for an existing system, telemetered water metering is in place; and
	4 & 5	no cut-offs based on aquifer levels or surface water flows are considered to be necessary for this take.
Rule 54(d)	As the four criteria in this rule are met, the application is for a discretionary activity.	

6.3 Te Tangi a Tauira

Te Tangi a Tauira is also known as the Ngāi Tahu ki Murihiku Natural Resource and Environmental Management Plan 2008. The specific policies relating to Water Quantity – Abstractions are in Section 3.5.14 (see Schedule 3).

A number of the policies are addressed by the policies in the RWP and PSWLP, both of which take the provisions of Te Tangi a Tauira into consideration when being drafted. This application is considered to be consistent with the provisions of the Iwi plan, directly and through compliance with the provisions of the relevant planning documents.

6.4 Water Conservation (Oreti River) Order (WCO)

The WCO applies to waters below Rocky Point down to Wallacetown (it also applies to waters above Rocky Point but those provisions are not relevant to this application). The rivers outstanding characteristics or contribution to outstanding features identified are habitat for brown trout and for black-billed gulls (see Schedule 2 of the WCO). The WCO does not set any minimum flow limits but does, in Clause 8, require fish passage to be maintained.

Because of the moderate to low connection to the watercourses considered (Irthing and Acton Streams) no minimum flow cut-offs are required and granting this application will not impact on flows in such a way that fish passage will be affected. On the basis of the stream depletion assessment, it is unlikely that any change in flow could be measured or observed.

The potential adverse effect of this take on the provisions of the WCO is therefore considered to be less than minor.

6.5 Summary

The overall assessment is that this application is not inconsistent with, or contrary to, the relevant planning documents. Where necessary, it complies with the policies to ensure the overall objectives will be met.

The application is also considered to be consistent with the provisions of Te Tangi a Tauira.

7. Conclusion

This application is for a replacement consent to enable the continued use of a water take that was first granted in 2007. The take is from a riparian aquifer, the allocation from which will be only 6.6% of the primary allocation after this consent is granted.

The application is consistent with the objectives and policies in the Regional Policy Statement, the Regional Water Plan and the Proposed Southland Water & Land Plan. As such, the weighting that is applied to the two Plans makes little, if any, difference to the consideration of the application and whether or not it should be granted.

The potential adverse effects are assessed as no more than minor at the current level of allocation and the information that is now available about the aquifer properties.

It is therefore submitted that the application can be processed without notification and granted in the terms sought.

Yours faithfully,

John Engel

Manager, Bonisch Environmental

Schedule 1

Extract of relevant objectives and policies from the Regional Water Plan.

Objective 5 Sufficient water availability.	To have sufficient water to support the reasonably foreseeable needs of current and future generations and enable people and communities to provide for their social, economic and cultural wellbeing while protecting aquatic ecosystem health and the life supporting capacity and natural character of surface water bodies.
Objective 9 Sustainable allocation.	To ensure that the total volume and rate of groundwater abstraction is sustainable.
Policy B7 of the National Policy Statement for Freshwater Management 2014	1. When considering any application, the consent authority must have regard to the following matters: (a) the extent to which the change would adversely affect safeguarding the life-supporting capacity of freshwater and of any associated ecosystem; and (b) the extent to which it is feasible and dependable that any adverse effect on the life-supporting capacity of freshwater and of any associated ecosystem resulting from the change would be avoided. 2. This policy applies to: (a) any new activity; and (b) any change in the character, intensity or scale of any established activity; that involves any taking, using, damming or diverting of freshwater or draining of any wetland, which is likely to result in any more than minor adverse change in the natural variability of flows or level of any freshwater, compared to that which immediately preceded the commencement of the new activity or the change in the established activity (or in the case of a change in an intermittent or seasonal activity, compared to that on the last occasion on which the activity was carried out).

	3. This policy does not apply to any application for consent first lodged before the National Policy Statement for Freshwater Management 2011 took effect on 1 July 2011.
Policy 14A Determining the term of a water permit.	To determine the term of a water permit consideration will be given, but not limited, to: (a) the degree of certainty regarding the nature, scale, duration and frequency of adverse effects from the activity; (b) the level of knowledge of the resource; (c) relevant tangata whenua values (d) the allocation sought, particularly the proportion of the resource sought; (e) the duration sought by the applicant, plus material to support the duration sought; (f) the permanence and economic life of the activity; (g) capital investment in the activity; (h) monitoring and review requirement in permit conditions; (i) the desirability of applying a common expiry date for water permits that allocate water from the same resource; and (j) the applicant's compliance with the conditions of the previous permit (where a new water permit is sought for a previously authorised activity).
Policy 14B Considering a water permit application for a previously authorised activity.	In addition to the matters specified in section 104 of the Act, when considering a water permit application for a previously authorised activity where: (a) the status of the activity has altered solely as a consequence of subsequent permits being granted to increase allocation from that resource;

	(b) the activity and knowledge of its adverse effects are the same or similar in character, intensity, and scale to that which existed previously; and (c) the adverse environmental effects of the activity are not significant; regard will be given to: (i) the status of the activity at the time the original water permit was granted; and (ii) the conditions that applied to that permit.
Policy 21 Reasonable use of water.	To ensure that the rate of abstraction and abstraction volumes specified on water permits to take and use water are no more than reasonable for the intended end use.
Policy 28 To manage groundwater abstraction.	To manage groundwater abstraction to avoid significant adverse effects on: ➢ long-term aquifer storage volumes ➢ existing water users ➢ surface water flows and aquatic ecosystems and habitats ➢ groundwater quality
Policy 29 Stream Depletion effects	(a) Manage the stream depletion effect of any groundwater abstraction with a rate of take exceeding 2 litres per second as follows: (i) where there is a direct hydraulic connection between the groundwater source and an adjacent surface water body, the stream depletion effect will be determined as the maximum instantaneous rate of take and will be managed in the same manner as a surface water abstraction for flow and allocation purposes. The abstraction will therefore be subject to any relevant minimum flow regime; (ii) where there is a high degree of hydraulic connection between the groundwater source and an adjacent surface water body, the stream depletion effect will be determined as the greater of:

	1. the effect of 150 days pumping at the continuous pump rate required to deliver the seasonal volume; 2. the effect of continuous pumping at the maximum permitted pump rate over the period required to deliver the seasonal volume. The calculated rate of stream depletion will be managed in the same manner as a surface water abstraction for allocation purposes with the remainder of the abstraction included in the allocation volume for the relevant groundwater zone. Where the calculated rate of stream depletion exceeds 2 litres per second, the abstraction will be subject to any relevant minimum flow regime; (iii) where there is a moderate degree of hydraulic connection between the groundwater source and an adjacent surface water body, the stream depletion effect will be determined as the effect of 150 days of pumping at the continuous pump rate required to deliver the seasonal volume. The calculated rate of stream depletion will be managed in the same manner as a surface water abstraction for allocation purposes with the remainder of the abstraction included in the allocation volume for the relevant groundwater zone; (iv) where there is a low degree of hydraulic connection between the groundwater source and an adjacent surface water body, the stream flow effect is considered to be minor and the individual abstraction will not be taken into account in determining surface water allocation but will be included in the allocation volume for the relevant groundwater zone. [*Definitions omitted*] (b) Minimise the cumulative stream depletion effect of groundwater abstraction by: (i) imposing minimum flows on resource consents for groundwater abstraction where there is a direct or high degree of hydraulic connection and the stream

	depletion effect exceeds two litres per second in accordance with any relevant surface water minimum flow regime (including those established under any Water Conservation Order); (ii) managing the total stream depletion effect of groundwater abstractions greater than two litres per second with a direct, high or moderate degree of hydraulic connection in accordance with any relevant surface water allocation regime (including those established under any Water Conservation Order); (iii) ensuring the total stream depletion effect of groundwater abstractions greater than two litres per second with a direct, high or moderate degree of hydraulic connection does not result in surface water flows less than prescribed minimum flows or surface water allocation regimes being exceeded.
Policy 30 Groundwater abstraction	(a) Use a staged management approach to allocate groundwater for abstraction in Southland to allow the knowledge gained by the progressive development of the region's groundwater resources to be built into its future management. (b) Recognise the different characteristics of the following aquifer types when managing groundwater abstraction: (i) riparian aquifers; (ii) terrace aquifers; (iii) lowland aquifers; (iv) confined aquifers; (v) fractured rock aquifers. (c) Use an assessment of available hydrogeological information from resource consent applications supplemented by investigations and monitoring undertaken by the Council, on a case-by-case basis, to determine if an aquifer is confined. Where an aquifer is determined to be sufficiently confined to warrant management as a separate groundwater resource a

	preliminary allocation volume shall be determined on the basis of aquifer throughflow. (d) Provide for: (i) a level of permitted groundwater abstraction where there is a minimal risk of adverse effects; (ii) a primary allocation for consented water abstraction and use; and (iii) a supplementary allocation for consented water abstraction and use. (e) Require resource consent applications for groundwater abstractions to be supported by a level of information that corresponds to the level of risk of adverse environmental effects. Information to be supported by a conceptual hydrogeological model that corresponds to the level of allocation from the aquifer. (f) Where appropriate, impose minimum level and/or flow cut-offs and seasonal recovery triggers on resource consents for groundwater abstraction. (g) Impose monitoring on resource consents for groundwater abstractions that corresponds to the level of risk of adverse environmental effects. (h) Where monitoring shows adverse environmental effects are occurring in a specific groundwater zone, remedy or mitigate those effects using one or more of the following methods: (i) reviewing the conditions of existing groundwater abstraction consents for that groundwater zone in accordance with Section 128 of the Resource Management Act 1991; (ii) ceasing any further allocation of groundwater from that groundwater zone; and (iii) temporarily restricting the abstraction of water from that groundwater zone by issuing a water shortage

	direction under Section 329 of the Resource Management Act 1991. (i) Ensure that groundwater abstractions that have a high risk of adverse environmental effects will not result in: (i) a long-term decline in groundwater levels; (ii) surface water allocation regimes being exceeded.
Policy 31 Interference effects	(a) Limit the cumulative interference effect of any new groundwater abstraction (in conjunction with other lawfully established groundwater takes) to no more than 20 percent of the available drawdown in any unconfined aquifer or up to 50 percent of the potentiometric head in any confined aquifer. The effects on any neighbouring bore will be considered where that bore is lawfully established and an assumption will be made that the bore fully penetrates the aquifer. An increased volume or increased pumping rate for any lawfully established groundwater abstraction will be considered a new groundwater abstraction under this policy. (b) Limit the cumulative interference effect of any new groundwater abstraction on any bore that is notified to the Council and utilised for long-term monitoring of water levels to no more than 10 percent of the available drawdown in a unconfined aquifer, or no more than 20 percent of the available potentiometric head in a confined aquifer that exists 50 percent of the time during natural conditions when no pumping is occurring. An increased volume or increased pumping rate for any lawfully established groundwater abstraction will be considered a new groundwater abstraction under this policy. (c) An exception to clause (a) and (b) above may be appropriate for aquifer testing and necessary infrastructure works, and in certain circumstances for mining activities where dewatering occurs for a short duration.

Rule 23(d), (e), (f) & (g) Abstraction & Use of Groundwater	(d) Except as provided for in Rules 23(a) and 23(b) and the takes authorised by Section 14(3) of the Act, the abstraction and use of groundwater from any of the following sources is a discretionary activity: (i) a riparian or terrace aquifer where the total volume of water allocated from the relevant groundwater zone is between 25 and 50 percent of mean annual land surface recharge; (ii) a lowland aquifer where the total volume of water allocated from the relevant groundwater zone is less than or equal to 15 percent of mean annual land surface recharge; (iii) a confined aquifer where the total volume of water allocated from the relevant groundwater zone is between 25 and 75 percent of aquifer throughflow; (iv) a riparian, terrace, confined or, fractured rock aquifer, or a source outside of the groundwater zones identified on Groundwater Map 1 of Appendix D, where the rate of take is greater than 2 litres per second, except as provided for in Rule 23(e); or (v) a source outside of the groundwater zones identified on Groundwater Map 1 of Appendix D, or a fractured rock aquifer, where the total volume of water applied for is between 25 and 50 percent of the rainfall recharge over the relevant land area where the water is to be used. (e) Except as provided for in Rules 23(a) and (b) and the takes authorised by Section 14(3) of the Act, the abstraction and use of groundwater from any of the following sources is a non-complying activity: (i) a riparian or terrace aquifer where the total volume of water allocated from the relevant groundwater zone is greater than 50 percent of mean annual land surface recharge; (ii) a lowland aquifer where the total volume of water allocated from the relevant groundwater zone is

	greater than 15 percent of mean annual land surface recharge; (iii) a confined aquifer where the total volume of water allocated from the relevant groundwater zone is greater than 75 percent of aquifer throughflow; or (iv) a source outside of the groundwater zones identified on Groundwater Map 1 of Appendix D, or a fractured rock aquifer, where the total volume of water applied for is greater than 50 percent of the rainfall recharge over the relevant land area where the water is to be used. (f) The status of the activity under Rules 23(c) to (e) is determined by the total volume of water allocated at the date the resource consent application is notified. The phrase "total volume of water allocated" in Rules 23(c) to (e) includes the water that is allocated through current resource consents, the water that is proposed to be taken under consent applications that have been notified and the additional water proposed to be taken by the consent applicant. (g) Notwithstanding Rules 23(c), (d) and (e) above, where: (i) the rate of take of any abstraction and use of groundwater exceeds 2 litres per second; and (ii) there is a direct, high degree or moderate degree of hydraulic connection between the groundwater source and an adjacent surface water body, as defined in Policy 29 "Stream Depletion Effects", The stream depletion effect component of the groundwater abstraction and use, calculated in accordance with Policy 29 "Stream Depletion Effects", shall be considered in accordance with Rule 18 as though the abstraction and use was from the adjacent surface water body.

Schedule 2

Extract of relevant objectives and policies from the Proposed Southland Water & Land Plan.

Objective 1	Land and water and associated ecosystems are sustainably managed as integrated natural resources, recognising the connectivity between surface water and groundwater, and between freshwater, land and the coast.
Objective 2	Water and land is recognised as an enabler of primary production and the economic, social and cultural wellbeing of the region.
Objective 3	The mauri of waterbodies provide for te hauora o te tangata (health and mauri of the people), te hauora o te taiao (health and mauri of the environment) and te hauora o te wai (health and mauri of the waterbody).
Objective 4	Tangata whenua values and interests are identified and reflected in the management of freshwater and associated ecosystems.
Objective 7	Any further over-allocation of freshwater (water quality and quantity) is avoided and any existing over-allocation is phased out in accordance with freshwater objectives, freshwater quality limits and timeframes established under Freshwater Management Unit processes.
Objective 9	The quantity of water in surface waterbodies is managed so that aquatic ecosystem health, life-supporting capacity, outstanding natural features and landscapes and natural character are safeguarded.
Objective 9A	Surface water is sustainably managed to support the reasonable needs of people and communities to provide for their social, economic and cultural wellbeing.
Objective 11	The amount of water abstracted is shown to be reasonable for its intended use and water is allocated and used efficiently.

Objective 12	Groundwater quantity is sustainably managed, including safeguarding the life-supporting capacity, ecosystem processes and indigenous species of surface water bodies where their flow is, at least in part, derived from groundwater.
Objective 18	All activities operate in accodance with "good management practice" or better to optimise efficient resource use, safeguard the life supporting capacity of the region's land and soils, and maintain or improve the quality and quantity of the region's water resources.
Policy 2 Take into account iwi management plans	Any assessment of an activity covered by this plan must: 1. take into account any relevant iwi management plan; and 2. assess water quality and quantity taking into account Ngāi Tahu indicators of health.
Policy 4 to 12 Physiographic zone	Policies not included.
Policy 13(1) Management of land use activities and discharges	Recognise that the use and development of Southland's land and water resources, including for primary production, enables people and communities to provide for their social, economic and cultural wellbeing.
Policy B7 of the National Policy Statement for Freshwater Management 2014	1. When considering any application, the consent authority must have regard to the following matters: (a) the extent to which the change would adversely affect safeguarding the life-supporting capacity of freshwater and of any associated ecosystem; and (b) the extent to which it is feasible and dependable that any adverse effect on the life-supporting capacity of freshwater and of any associated ecosystem resulting from the change would be avoided. 2. This policy applies to:

	(a) any new activity; and (b) any change in the character, intensity or scale of any established activity; that involves any taking, using, damming or diverting of freshwater or draining of any wetland, which is likely to result in any more than minor adverse change in the natural variability of flows or level of any freshwater, compared to that which immediately preceded the commencement of the new activity or the change in the established activity (or in the case of a change in an intermittent or seasonal activity, compared to that on the last occasion on which the activity was carried out). 3. This policy does not apply to any application for consent first lodged before the National Policy Statement for Freshwater Management 2011 took effect on 1 July 2011.
Policy 20 Management of water resources	Manage the taking, abstraction, use, damming or diversion of surface water and groundwater so as to: 1A. recognise that the use and development of Southland's land and water resources, including for primary production, can have positive effects including enabling people and communities to provide for their social, economic and cultural wellbeing; 1. avoid, remedy or mitigate adverse effects from the use and development of surface water resources on: (a) the quality and quantity of aquatic habitat, including the life supporting capacity and ecosystem health and processes of waterbodies; (b) natural character values, natural features, and amenity, aesthetic and landscape values; (c) areas of significant indigenous vegetation and significant habitats of indigenous fauna; (d) recreational values; (e) the spiritual and cultural values and beliefs of tangata whenua; (f) water quality, including temperature and oxygen content;

	(g) the reliability of supply for lawful existing surface water users, including those with existing, but not yet implemented, resource consents; (h) groundwater quality and quantity; (j) mātaitai, taiāpure and nohoanga; 2. avoid, remedy or mitigate significant adverse effects from the use and development of groundwater resources on: (a) long-term aquifer storage volumes; (b) the reliability of supply for lawful existing groundwater users, including those with existing, but not yet implemented, resource consents; (c) surface water flows and levels, particularly in spring-fed streams, natural wetlands, lakes, and aquatic ecosystems and habitats (including life supporting capacity and ecosystem health and processes of water bodies) and their natural character; and (d) water quality; 3. ensure water is used efficiently and reasonably by requiring that the rate and volume of abstraction specified on water permits to take and use water are no more than reasonable for the intended end use following the criteria established in Appendix O and Appendix L.4.
Policy 21 Allocation of water	Manage the allocation of surface water and groundwater by: 1. determining the primary allocation for confined aquifers not identified in Appendix L.5, following the methodology established in Appendix L.6; 2. determining that a waterbody is fully allocated when the total volume of water allocated through current resource consents and permitted activities is equal to either: (a) the maximum amount that may be allocated under the rules of this Plan, or (b) the provisions of any water conservation order;

	3. enabling secondary allocation of surface water and groundwater subject to appropriate surface water environmental flow regimes, minimum lake and wetland water levels, minimum groundwater level cutoffs or seasonal recovery triggers, to ensure: (a) long-term aquifer storage volumes are maintained; and (b) the reliability of supply for existing groundwater users (including those with existing resource consents for groundwater takes that have not yet been implemented) is not adversely affected.
Policy 22 Management of the effects of groundwater and surface water use	Manage the effects of surface and groundwater abstractions by: 1. avoiding allocating water to the extent that the effects on surface water flow would not safeguard the mauri of that waterway and mahinga kai, taonga species or the habitat of trout and salmon; 2. ensuring interference effects are acceptable, in accordance with Appendix L.3; 3. utilising the methodology established in Appendix L.2 to: (a) manage the effects of consented groundwater abstractions on surface waterbodies; and (b) assess and manage the effects of consented groundwater abstractions in groundwater management zones other than those specified in Appendix L.5.
Policy 23 Stream depletion effects	Manage stream depletion effects resulting from groundwater takes which are classified as having a Riparian, Direct, High or Moderate hydraulic connection, as set out in Appendix L.2 Table L.2, to ensure the cumulative effect of those takes does not: 1. exceed any relevant surface water allocation regime (including those established under any water conservation order) for groundwater takes classified as

	Riparian, Direct, High or Moderate hydraulic connection; or 2. result in abstraction occurring when surface water flows or levels are less than prescribed minimum flows or groundwater levels for takes classified as Riparian, Direct or High hydraulic connection.
Policy 40 Determining the term of resource consents	When determining the term of a resource consent consideration will be given, but not limited, to: 1. granting a shorter duration than that sought by the applicant when there is uncertainty regarding the nature, scale, duration and frequency of adverse effects from the activity or the capacity of the resource; 2. relevant tangata whenua values and Ngāi Tahu indicators of health; 3. the duration sought by the applicant and reasons for the duration sought; 4. the permanence and economic life of any capital investment; 5. the desirability of applying a common expiry date for water permits that allocate water from the same resource or land use and discharges that may affect the quality of the same resource; 6. the applicant's compliance with the conditions of any previous resource consent consent, and the applicant's adoption, particularly voluntarily, of good management practices; and 7. the timing of development of FMU sections of this Plan, and whether granting a shorter or longer duration will better enable implementation of the revised frameworks established in those sections.

Policy 41 Matching monitoring to risk	Consider the risk of adverse environmental effects occurring and their likely magnitude when determining requirements for auditing and supply of monitoring information on resource consents.
Policy 42 Consideration of water permit applications	When considering resource consent applications for water permits to take and use water: 1. except for non-consumptive uses, consent will not be granted if a water body is over allocated or fully allocated; or to grant consent would result in a water body becoming over allocated or would not allow an allocation target for a water body to be achieved within a time period defined in this Plan; and 2. except for non-consumptive uses, consents replacing an expiring resource consent for an abstraction from an over-allocated water body will generally only be granted at a reduced rate, the reduction being proportional to the amount of over-allocation and previous use, using the method set out in Appendix O; and 3. installation of water measuring devices will be required on all new permits to take and use water and on existing permits in accordance with the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010; and 4. where appropriate, minimum level or flow cut-offs and seasonal recovery triggers on resource consents for groundwater abstraction will be imposed; and 5. conditions will be specified relating to a minimum flow or level, or environmental flow or level regime (which may include flow sharing), in accordance with Appendix K, for all new or replacement resource consents (except for water permits for non-consumptive uses, community water supplies and water bodies subject to minimum flow and level regimes established under any water conservation order) for: (a) surface water abstraction, damming, diversion and use; and

	(b) groundwater abstraction in accordance with Policy 23.
Rule 54 Abstraction and use of groundwater	... (d) Other than as provided by Rules 54(a), 54(b), 54(c) and 54(ca) the take and use of groundwater from groundwater management zones listed in Appendix L.5 is a discretionary activity provided the following conditions are met: (i) the total volume of authorised groundwater abstraction is within the primary allocation limits established in Appendix L.5; and (ii) if the degree of hydraulic connection, calculated in accordance with Appendix L.2 Table L.2. is Riparian, Direct, High or Moderate the relevant surface water minimum flows and allocation limits specified in Table L.2 are complied with; and (iii) any interference effects are 'acceptable' in accordance with Appendix L.3; and (iv) minimum groundwater level cut-offs and seasonal recovery triggers are established in accordance with criteria outlined in Appendix L.6. (g) The take and use of groundwater that does not comply with Rules 54(b) to 54(f) is a non-complying activity.

Schedule 3

Extract of relevant policies from Te Tangi a Tauira.

Section 3.5.14 Water Quantity - Abstractions	**Ngā Kaupapa** – Policy 1. Adopt the precautionary principle when making decisions on water abstraction resource consent applications, with respect to the nature and extent of knowledge and understanding of the resource. 2 Support and encourage catchment management plans, based on the principle of *ki uta ki tai*, to manage the cumulative impacts of water abstractions in a given area. 3. Require that scientifically sound, understandable, and culturally relevant information is provided with resource consent applications for water abstractions, to allow Ngāi Tahu ki Murihiku to fully and effectively assess cultural effects. 4. In the Southland Plains region, the preference of Ngāi Tahu ki Murihiku is for water takes from bores, as opposed to surface water abstractions. 5. Recommend, as a condition of consent, that any application for irrigation puts in on-farm rainwater holding facilities, to help with dairy washdown and irrigation. 6. Encourage water users to be proactive and use water wisely. To encourage best practice and efficient use of water, particularly in terms of: – sustainable irrigation design, delivery and management; – making best use of available water before water levels get too low; – reducing the amount of water lost through evaporation by avoiding irrigating on hot windy days.

	7. Consideration of consent applications for water abstractions should have particular regard to questions of: a. how well do we understand the nature and extent of the water resource; b. how well can we monitor the amount of water abstracted; c. whether land capability (e.g. soil type, vulnerability of underlying groundwater resources) matches the land use enabled by irrigation; d. what might happen in the future (e.g. rainfall and recharge of aquifers, climate change). 8. Applications for water abstractions may be required to undergo isotope/chemistry analysis determining where the water came from, and its age. This information will assist in the assessment of potential adverse effects on the water resource. 9. Applications for water abstractions may be required to justify the quantities of water requested. Information may need to be provided to Te Ao Mārama Inc. regarding the proposed water use per hectare, estimated water losses, stocking rates, and the level of efficiency for the scheme. This will enable iwi to put the quantity of water sought in context, and ensure that a test of reasonableness can be applied to consents. 10. Require catchment based cumulative effects assessments for activities involving the abstraction of water. 11. Avoid excessive drawdown of aquifer levels as a result of groundwater abstractions, and to ensure that abstractions do not compromise the recovery of groundwater levels between irrigation seasons. 12. The establishment of environmental flow regimes must recognise and provide for a diversity of values, including the protection of tangata whenua values.

	13. Ensure that environmental flow allocation and water management regimes for rivers recognise and provide for the relationship between water quality and quantity. 14. Avoid compromising fisheries and biodiversity values associated with spring fed creeks and rivers for the purposes of water abstractions. 15. Avoid compromising river health as a result of water abstractions for hydro power generation. 16. Encourage the installation of appropriate measuring devices (e.g. water meters) on all existing and future water abstractions, to accurately measure, report, and monitor volumes of water being abstracted, and enable better management of water resources. 17. Advocate for durations not exceeding 25 years on resource consents related to water abstractions. 18. Require, where necessary, a consent condition providing for a review of the volumes able to be abstracted from the bores on the basis of the observed seasonable recovery of groundwater levels. Also include a provision for review of both the annual recovery between individual irrigation seasons and the cumulative effects on longer-term water level recovery. 19. Require that Ngāi Tahu are provided with the opportunity to participate through pre hearing meetings or other processes in the development of appropriate consent conditions including monitoring conditions to address our concerns. 20. Avoid adverse effects on the base flow of any waterway, and thus on the mauri of that waterway and on mahinga kai or taonga species. 21. Oppose any further abstractions/diversions of water from the Waiau River for hydroelectric generation, as current levels of abstractions are having adverse effects on cultural values associated with the river.

	22. Ngāi Tahu's right to development, as per the Treaty of Waitangi, must be recognised and provided for with respect to water allocation from freshwater resources.

Appendix 1

Application Forms

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Application for Resource Consent (PART A)

This application is made under Section 88 of the Resource Management Act 1991

environment SOUTHLAND REGIONAL COUNCIL
Te Taiao Tonga

The purpose of this Part A form and the relevant Part B form(s) is to provide applications with guidance on information that is required under the Resource Management Act 1991. Please note that these forms are to act as a guide only, and Environment Southland reserves the right to request additional information.

To: Environment Southland
Private Bag 90116
Invercargill 9840

Full name, address and contact details of applicant *(in whose name consent is to be issued)*

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Address: Cromel Farms, 295 Lowther Road, Five Rivers, RD 3, Lumsden 9793

Email: cromel@netspeed.net.nz

Phone: 03 248 7130 (*Preferred*) 027 432 1649 (*Additional*) Fax:

Consultant contact details *(if different from above)*

Contact name/agent: John Engel

Address: Bonisch Environmental, PO Box 1262, Invercargill 9840

Email: john@bonisch.nz

Phone: 027 222 1874 (*Preferred*) 03 218 2546 (*Additional*) Fax: 03 214 4285

Please tick the box for the consent(s) you are applying for and complete the relevant Part B form(s) where available:

Land Use
- [ ] Bore/well
- [ ] New or expanded dairy farming
- [ ] Effluent storage
- [ ] Cultivation
- [ ] Tree planting
- [ ] Gravel extraction
- [ ] Hill country burning
- [ ] Riverbed activity (incl. streams/creeks and stopbanks)
- [ ] Bridges and culverts

Discharge
- [ ] To air
- [ ] To water
- [ ] To land

Water
- [ ] Take and use surface water
- [x] Take and use groundwater
- [ ] Dam water
- [ ] Divert water

Coastal
- [ ] Whitebait stand
- [ ] Structures/occupation of space
- [ ] Removal of natural materials
- [ ] Disturb foreshore/seabed
- [ ] Discharge/deposit substances
- [ ] Commercial surface water activity
- [ ] Reclaim/drain foreshore/seabed
- [ ] Marine farming
- [ ] Other coastal activities

1 Are there any **current** or **expired** consents relating to this proposal? ☑ Yes ☐ No

If yes, please provide consent number(s) and description:

Consent no. AUTH-204511

2 Are any other consents required from Environment Southland or **other authorities**? ☐ Yes ☑ No

If yes, please state the relevant authority and the type of consent(s) required:

3 For what **purpose** is this consent(s) required: (e.g. discharge of effluent, gravel extraction etc.)

Irrigation of pasture and crop.

4 **Location** of proposed activity

Address: 295 Lowther Road, Five Rivers

Legal Description: Lot 19 DP 1664

Map Reference (NZTM 2000): ________ E ________ N Various - see attached AEE.

5 The name and address of the **owner /occupier:** (if other than the applicant)

Name: ________ Phone: ________

Address: ________

6 **Please attach a map or a coloured aerial photograph, showing at a minimum, the location of the proposed activities.**

Attached as Appendix 2.

8 Affected Parties

Please attach written approval from parties who may be affected by your activity. *Written Approval of an Affected Party* forms are available on the Environment Southland website. During the processing of your application, Council may determine that additional approvals are required.

None attached.

Checklist: Have you included the following?

✓	Payment of the required deposit *(see attached fee schedule)* Paid by online banking
—	Written approval from all potentially affected parties *(forms available from the Environment Southland website)*
✓	Site plan/location map/sketch of the proposed activity
NA	A copy of the Certificate of Incorporation (*where applicant is a company*)
✓	Part B form(s) specific to your activity and/or a separate assessment of environmental effects (AEE)

Notes:

(a) If your application does not contain the necessary information and the appropriate fee, Environment Southland must return the application.

(b) Council cannot accept electronic lodgement of applications at this time.

Correspondence from Council when using a consultant

It is standard practice that both you and your consultant are copied into all correspondence relating to the consent process. This is so that you know what is going on with your application. Please let us know below if you would like us to only contact your consultant. This means you will only hear from us when your application is/is not accepted, when a decision is made or if we feel that you need to be contacted.

I want all correspondence about my application to go to my consultant only ☐ Yes ☑ No

Signature of applicant

I hereby certify that to the best of my knowledge and belief, the information given in this application is true and correct.

I undertake to pay all actual and reasonable application processing costs incurred by Environment Southland.

Name (block capitals) JOHN ENGEL

Signed [signature] **Date** 21/8/2018

(*Signature of applicant or person authorised to sign on behalf of applicant*)

Application for a Water Permit (PART B)
- To Take and Use Groundwater

This application is made under Section 88 of the Resource Management Act 1991

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

A complete Part A form needs to be provided with this Part B form. The purpose of this Part B form is to provide applicants with guidance on information that is required under the Resource Management Act 1991. These forms are to act as a guide only and Environment Southland reserves the right to request additional information. **Please also refer to Appendix A of the Regional Water Plan for Southland, 2010 AND Appendix L of the proposed Southland Water and Land Plan 2018 .**

User Charges: Please note that annual User Charges will apply to all water permits. Schedule 6 of Environment Southland's User Charges and Fees document outlines the Annual Research and Monitoring Charges, which you should consider before applying for a water permit. Please refer to www.es.govt.nz/resource-consent/fees for more information on annual user fees and charges.

To: Environment Southland
Private Bag 90116
Invercargill 9840

1 What is this application for?

☐ a new groundwater take ☑ the renewal of existing consent no: AUTH-204511

2 What duration of resource consent is sought? 20 years

3 For what purpose(s) will the water be used?

☐ Stock water and/or dairy shed use ☑ Irrigation ☐ Community supply ☐ Commercial/industrial
☐ Other

If other, please describe: __________

4 Please provide details of the bore(s) from which you wish to take water. *If you do not have an existing bore, you will need to apply for a consent to construct a bore before you apply to take groundwater. Please refer to the relevant Part B form.*

Bore 1: NZTM 2000	1242133	E	4935575	N	Bore number:	E44/0330
Bore 2: NZTM 2000	1242187	E	4935228	N	Bore number:	E44/0331
Bore 3: NZTM	1242479	E	4935214	N		E44/0437
Bore 4: NZTM	1241376	E	4935111	N		E44/0438

	Bore depth (m)	Screen depth (m)	Diameter (mm)	Pump type	Pump capacity (l/s)
Bore 1	See page 2 of AEE.				
Bore 2					

5 How much water do you propose to take and at what rate will it be taken?

Maximum rate of take	95	litres per second
Maximum daily volume	5,184	cubic metres per day
Maximum weekly volume	36,288	cubic metres per week
Maximum monthly volume	160,704	cubic metres per month
Maximum annual volume	525,000	cubic metres per year

6 What is the frequency of the proposed water take?

How many hours per day (maximum)? 24

How many days per week (maximum)? 7

How days per month (maximum)? 31

7 Please state the name of the aquifer that you propose to take water from.

Five Rivers Groundwater Zone

8 Do you intend to store your water before subsequent use? No.

If yes, what/how much storage will be provided? ______ m^3

What type of storage facilities are proposed? ______

You may need a building permit and/or additional resource consents for the construction of storage facilities.

9 **What type of water metering system is installed or proposed to be installed?** Environment Southland prefers all takes for 5 l/s or more to be fitted with telemetry to report in line with the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010.

☐ Water meter ☐ Data logger ☑ Telemetry

10 **If you propose to use water for stock and/or dairy shed use – please answer the following:** NA

(a) What type of animal and numbers of stock will be supplied with water for drinking?

☐	Sheep	Number:	______	Water required: ______	litres/head/day
☐	Beef cattle	Number:	______	Water required: ______	litres/head/day
☐	Dairy cows	Number:	______	Water required: ______	litres/head/day
☐	Other	Number:	______	Water required: ______	litres/head/day

(b) How much water do you require for your dairy shed? ______ litres/head/day

11 **If you propose to use water to irrigate land – please answer the following:**

(a) How many hectares of land will be irrigated? 175 ha

(b) What is the soil type(s) of the land being irrigated See Section 2 of AEE attached.

(c) What will you be irrigating (i.e. crop, pasture etc)? Mostly pasture but also some crop.

(d) What type of irrigation system will be used? Hard hose travelling gun (OCMIS) x 4

(e) What is the target application rate (mm/day and mm/year)? 3 mm/day & 300 mm/year.

(f) How have you calculated the amount of water you need? (attach separate pages if required)

See Section 4 of AEE attached.

12 **If you propose to use water for industrial use – please answer the following:** NA

(a) What type of industry will be using the water and how will the water be used?

___

(b) How have you calculated the amount of water you need? (attach separate pages if required)

___

13 **If you propose to use water for commercial/domestic supply – please answer the following:** NA

(a) What type of establishment will use the water?

☐	Households – number of households to be supplied:	___
☐	Camping grounds – maximum number of visitors and staff per year:	___
☐	Schools – maximum number of students and staff per year:	___
☐	Motel units – number and expected occupancy:	___
☐	Other:	___

(b) How have you calculated the amount of water you need? (attach separate pages if required)

___

14 **If you propose to use water for any other purpose, please describe the amount of water you will need and how this has been calculated (please attach a separate sheet to this application, if necessary).**

NA

15 **Please describe any other sources of water available for the property. Describe how much water is available and what it is used for.**

Groundwater is the only reliable source but surface water is available. Some groundwater is also taken for domestic use and stockwater.

16 **Please also describe any measures you are proposing to minimise wastage of water and maximise its efficient use:**

Monitoring water usage so that volumes applied are accurately known.

Monitoring soil moisture levels at the ES soil moisture site adjacent to the Mossburn Five Rivers Road.

Using 4 irrigators to minimise down time between irrigator runs.

17 **Does your proposed water take have any associated discharges? If yes, please describe.**

☐ Yes ☑ No

Please note that a discharge into the environment may require a resource consent application to be made specifically for the discharge (please refer to the relevant Part B form).

Existing Environment

18 **Are any of the following features found within the existing environment of the proposed activity? Describe these features in the space below, along with details of the assessment undertaken to determine the presence of these features.**

	Yes	No
(a) Signs of instream life (e.g. fish, eels, bullies, crayfish, native birds, frogs)?	✓	
(b) Areas where food is gathered from a water body (e.g. watercress, eels, wildfowl)?		✓
(c) Wetlands, wildlife habitats or bird nesting habitats (e.g. swamp areas)?	✓	
(d) Other activities occurring in the area (e.g. commercial activity, fishing, swimming, boating)?		✓
(e) Areas of particular aesthetic, cultural, heritage or scientific value (e.g. archaeological sites)?		✓
(f) Waste discharges and/or monitoring sites?		✓
(g) Other water takes?	✓	
(h) Surface water bodies? Natural springs?	✓	

(a) Two streams are close to the property but the Cromel is ephemeral. The presence of instream life is assumed but no survey has been carried out.

(c) No known habitats although some bird species could dwell in the stream beds.

(g) There are other takes from this zone for domestic and stockwater, and possibly some irrigation.

(h) Acton and Cromel Streams.

More details are provided in the AEE attached.

Please also include a map or aerial photograph showing the following: Attached in Appendix 2.

- the location(s) of the existing points of take;
- the location of proposed points of take(s);
- the location of water measuring device(s);
- the total property area boundary;
- the area(s) to be irrigated (if relevant);
- the area(s) of community supply (if relevant);
- distances to any discharge activities;
- other surface water bodies and wetlands nearby and the distance from the point of take(s) to them;
- the coastline and the distance to it (if relevant);
- the location of any dairy sheds (if relevant).

Assessment of Effects

19 Will the take and use of groundwater have any effects on the following:

	Yes	No
(a) Aquifer storage volumes	✓	
(b) Existing bore or well yields	✓	
(c) River and stream flows, including minimum flows and allocation levels	✓	
(d) Wetland and lake water levels		✓
(e) Groundwater quality	✓	

*For those answered **No** above, please describe why there will be no effects. For those answered **Yes**, please describe how these effects may occur.*

For parts (a), (b), (c) and (e), see the PDP report attached as Appendix 3.

For part (d), there are no wetlands or lakes in the vicinity that could be affected.

20 Pursuant to Schedule 4 of the Resource Management Act, 1991, there are a number of matters that must be addressed by an assessment of environmental effects. Please discuss what effects the proposed activity will have on the following:

(a) any effect on those in the neighbourhood and, where relevant, the wider community, including any social, economic, or cultural effects

Less than minor - improved productivity for economic benefit on farm, with some flow on benefit to wider community. No particular social or cultural benefit over and above what is already occurring.

(b) any physical effect on the locality, including any landscape and visual effects

The locality is rural and irrigation occurs on a number of properties in the wider area. As a visual element, it is common in rural areas. There is no effect on any outstanding landscapes or natural features.

(c) any effect on ecosystems, including effects on plants or animals and any physical disturbance of habitats in the vicinity

(d) any effect on natural and physical resources having aesthetic, recreational, scientific, historical, spiritual, or cultural value, or other special value, for present or future generations

Apart from the effects on the aquifer as set out in the AEE and PDP report, there are no other matters or effects to consider.

(e) any discharge of contaminants into the environment, including any unreasonable emission of noise, and options for the treatment and disposal of contaminants

None.

(f) any risk to the neighbourhood, the wider community, or the environment through natural hazards or the use of hazardous substances or hazardous installations

None.

21 Please include a description of the monitoring or mitigation measures (including safeguards and contingency plans where relevant) to be undertaken to help avoid, reduce, remedy or mitigate the actual or potential effects on environmental features and values.

See AEE attached.

22 Please include a description of any possible alternative locations or methods for undertaking the activity and why these alternatives have not been selected.

See Section 5.5 of AEE.

23 Please include evidence of any consultation undertaken for this application. This may include (but not be limited to) consultation with adjoining landowners, other consent holders in the immediate area, iwi (e.g. Te Rūnanga O Ngāi Tahu, Te Ao Marama Inc.), government departments/ministries (e.g. DOC), territorial authorities and recreational associations.

Nil.

24 Appendix A of the Regional Water Plan for Southland, 2010, details the level of further assessment required as part of your application. This may include the following assessments (please attach as a separate report):

- interference effects/drawdown;
- radius of influence;
- stream depletion effects;
- an assessment of the dynamic aquifer response to abstraction.

25 Appendix L of the proposed Southland Water and Land Plan, 2016, details the level of further assessment required as part of your application. This may include the following assessments (please attach as a separate report):

- aquifer test requirements;
- stream depletion effects;
- interference effects;
- calculation of seasonal groundwater allocation;
- establishing allocation volumes for confined aquifers.

24 & 25 - see PDP report attached as Appendix 3.

Please note that in accordance with Schedule 4 of the RMA, you may also be required to provide an assessment of whether or not the proposed activity is contrary to any of the relevant provisions of the following documents.

(a) Regional Policy Statement for Southland, 1997
(b) Southland Regional Policy Statement, 2017 (and any proposed/subsequent versions)
(c) Regional Water Plan for Southland, 2010
(d) Proposed Southland Water and Land Plan, 2018(and any proposed/subsequent versions)
(e) National Policy Statement for Freshwater Management, 2014
(f) National Environmental Standard for Sources of Human Drinking Water, 2007
(g) Resource Management (Measurement and Reporting of Water Takes) Regulations, 2010

Staff are able to advise whether this is required, as it is dependant on the location, scale and complexity of your proposal. We invite you to come in for a pre-application meeting with Environment Southland consents staff to discuss this.

END OF FORM

Appendix 2

Site Plans

1. *Site plan*
2. *Locality plan*
3. *Physiographic zones*
4. *Soil types*
5. *Nitrate levels*

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Last Edited by: Chris on 21/08/2018 3:44:09 PM

REV	REVISION DETAILS	DRN	CHK	APP	DATE
A	Consent Issue	CHM	JFE	JFE	21/08/2018

bonisch environmental
T 03 218 2546 F 03 214 4285 FP 0800 802 546
19 The Crescent, P.O. Box 1262, Invercargill 9840
E john@bonisch.nz
W www.bonischenvironmental.nz

CLIENT: LINDSAY & PAULINE KIRKER

PROJECT: RESOURCE CONSENT APPLICATION, LOWTHER ROAD, LOWTHER, SOUTHLAND

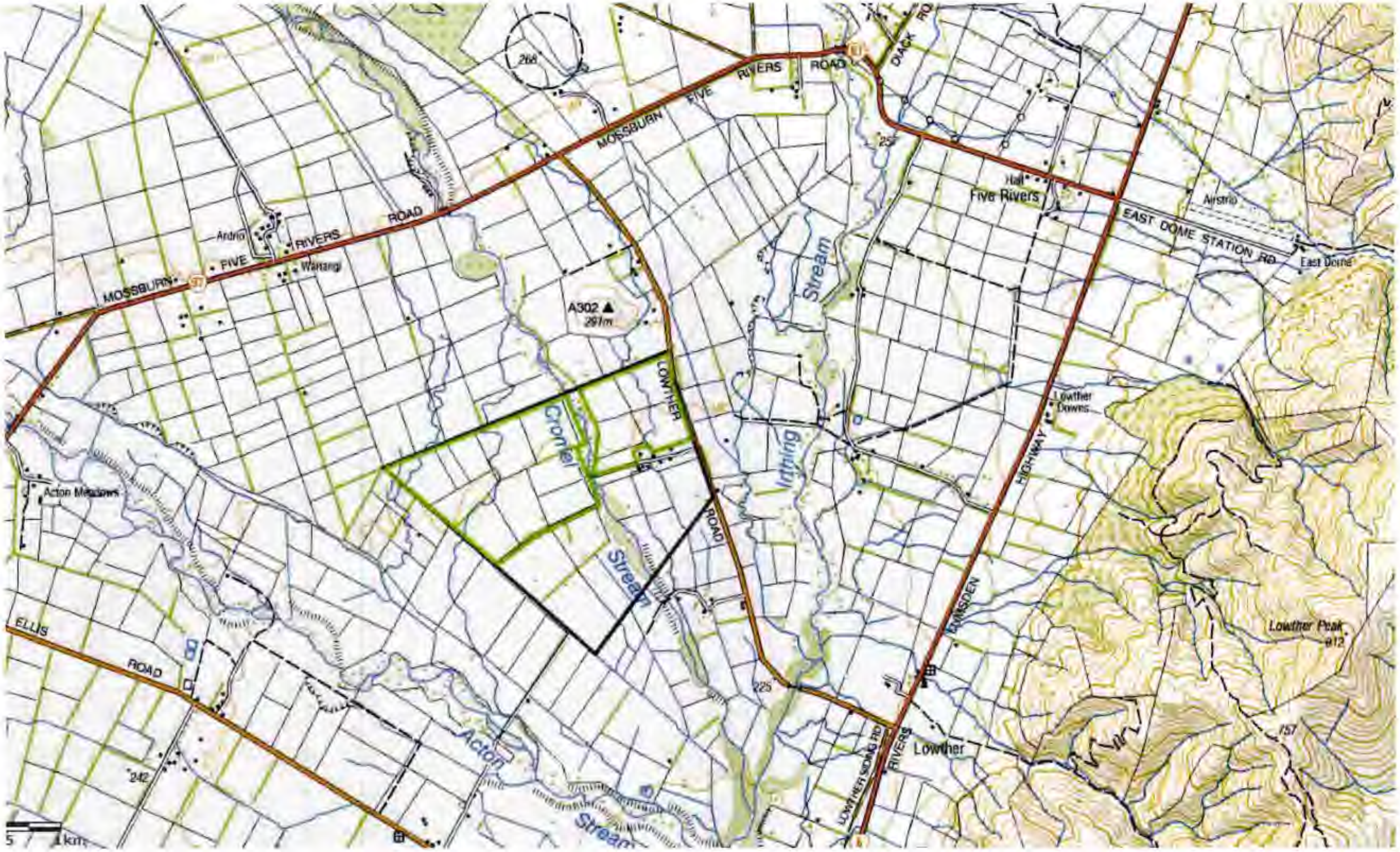
SHEET TITLE: IRRIGATION EXTENTS PLAN

SURVEYED:		
DESIGNED:		
DRAWN:	CHM	21/08/2018
DRAWING CHECK:	JFE	21/08/2018
DESIGN CHECK:		
APPROVED:	JFE	21/08/2018

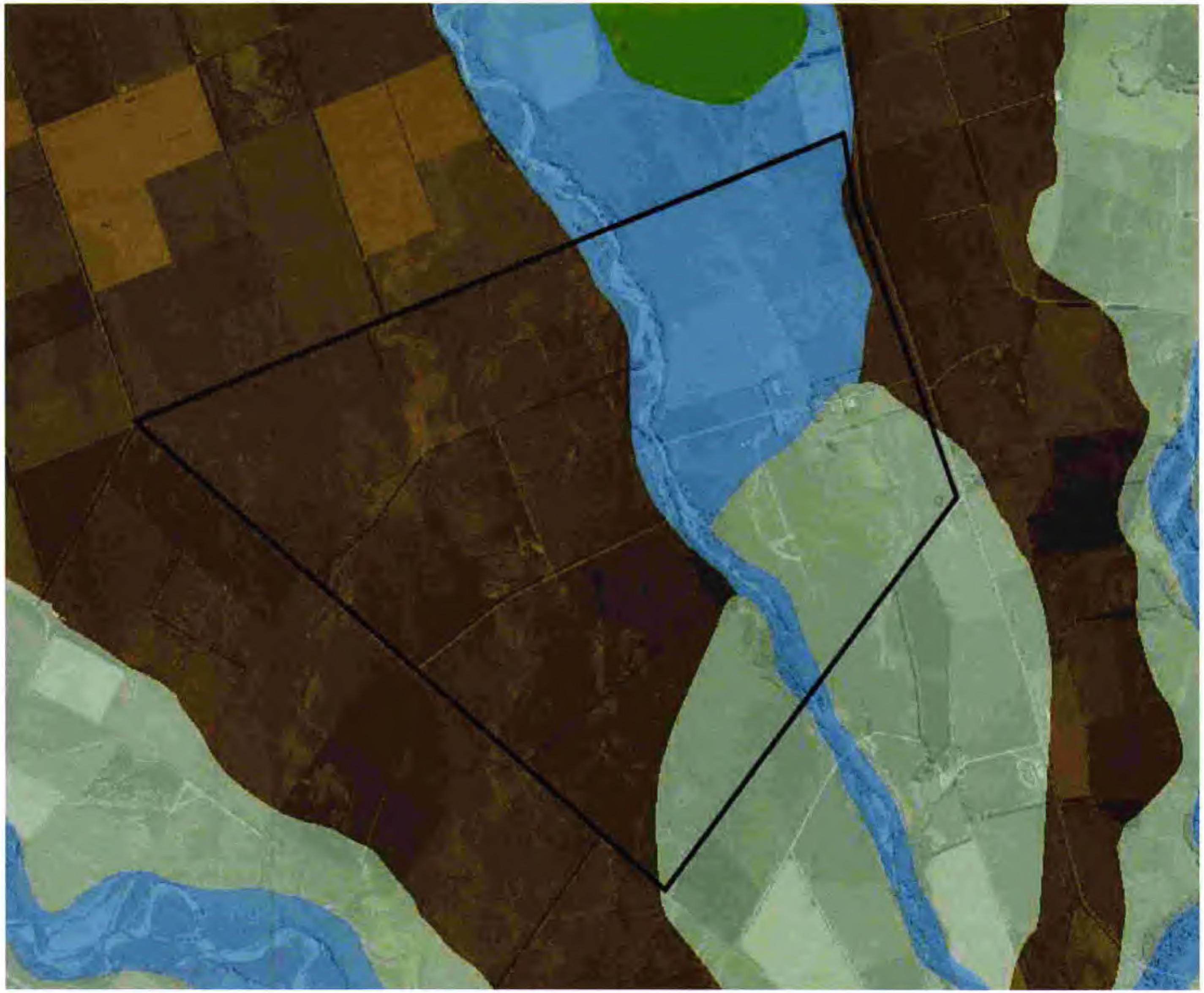
SCALE (ORIGINAL SIZE A1): 1:5,000
DATE ISSUED: 21/08/2018
JOB NO: 8094 SHEET: 1 of 1 REV: A

J:\Bonisch Surveyors\8000 - 8099\8094 - Lindsay & Pauline Kirker, consent application, Five Rivers\AutoCAD\8094-FM1.dwg

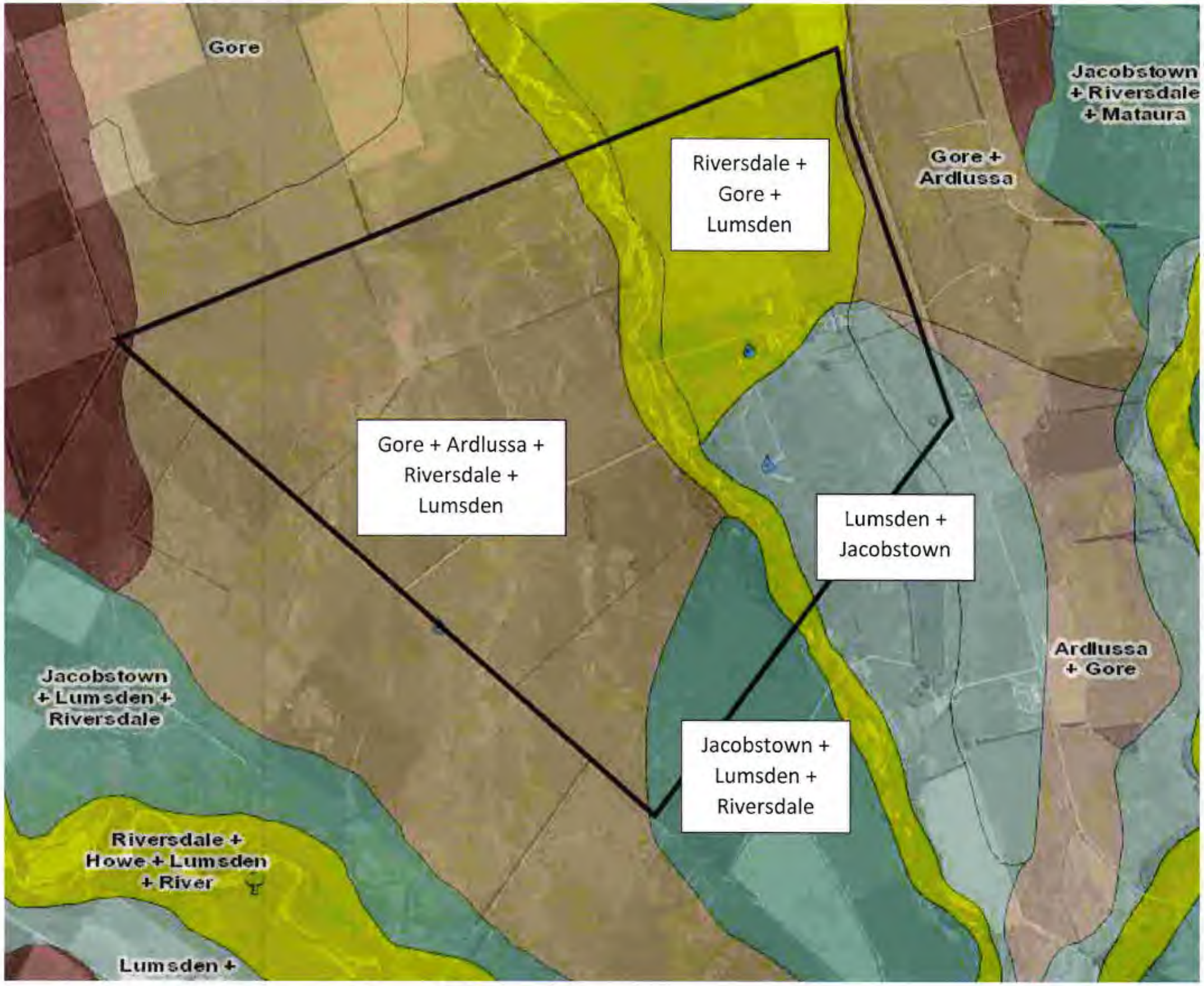
Map 2 - Location plan



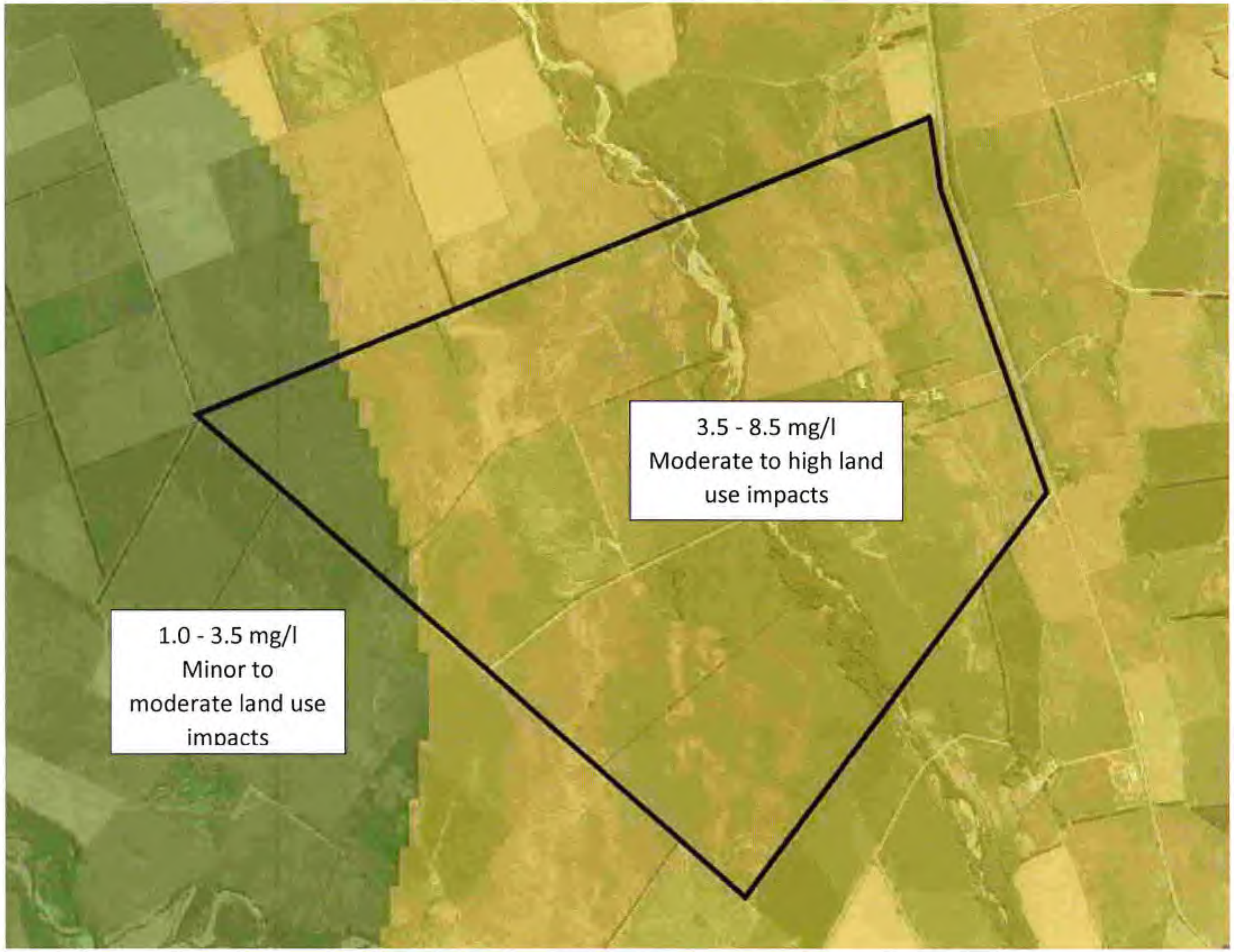
Map 3 - Physiographic zones



Map 4 - Soil types



Map 5 - Regional groundwater nitrate levels 2007 - 2012



Appendix 3

295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting – Pattle Delamore Partners Ltd, 1 August 2018

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295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting

Prepared for

L & P Kirker

August 2018

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solutions for your environment

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PATTLE DELAMORE PARTNERS LTD

295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting

L & P Kirker

solutions *for your environment*

Quality Control Sheet

TITLE	295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting
CLIENT	Lindsay and Pauline Kirker
VERSION	Final
ISSUE DATE	1 August 2018
JOB REFERENCE	CJ874504
SOURCE FILE(S)	CJ874504R001_Technical Assessment of Effects_Final

DOCUMENT CONTRIBUTORS

Prepared by

SIGNATURE

Carl Steffens

Reviewed and Approved by

SIGNATURE

Hilary Lough

Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Lindsay and Pauline Kirker and others (not directly contracted by PDP for the work), including Bonisch Environmental and Barber Well Drilling Services. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Lindsay and Pauline Kirker for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Table of Contents

Summary of Tables

Appendices

1.0 Introduction

1.1 Background

Lindsay and Pauline Kirker (the applicant) are applying for resource consent to take groundwater from four bores E44/0330 (Bore 1), E44/0331 (Bore 2), E44/0437 (Bore 3) and E44/0438 (Bore 4) on their property on the western side of Lowther Road, at Lowther (north of Lumsden) in Southland, for the purpose of pasture and crop irrigation. This application is to replace a previous consent (Environment Southland (ES) water permit 204511) that expired on 29 January 2018.

The legal description of the property is LOT 19 DP 1664 and Bores 1, 2, 3 and 4 are located at map references NZTM 1242135-4935573, 1242187-4935226, 1242480-4935212, 1241379-4935111, respectively.

An application to renew consent 204511 was lodged by the applicant in late 2017, however it was considered incomplete by ES and returned in accordance with Section 88 (3A) of the Resource Management Act (RMA). The requirements for the application to be considered complete are outlined in a letter from ES to the Applicant dated 11 December 2017.

Pattle Delamore Partners Limited (PDP) has been engaged by the applicant to provide a technical assessment of effects as requested by ES in their return letter. The following points are noted with regard to the proposal and the assessment provided:

- The application includes two additional bores (bores 3 and 4), compared to the previously consented situation where abstraction occurred only from bores 1 and 2. This change is to enable the water allocated to be used more efficiently.
- The daily abstraction rates remain the same as the previous consent, however a higher total maximum instantaneous rate has been requested, while the total annual volume requested has been reduced.
- A technical assessment of effects using historical pump test results and regional information on aquifer properties is provided and it is considered that additional pump testing is not required as part of this application.

Figure 1, Appendix A shows the location of the applicant's property and the four bores that are the subject of this application.

2.0 Bore Details

Table 1 below provides details for all four of the applicant's bores (all drilled by Barber Well Drilling Services (Barber)). These consist of the initial two bores (bores 1 and 2) that were previously used for irrigation purposes via consent 204511 and the two additional bores (bores 3 and 4), that are now also proposed for irrigation use. The drilling logs and bore construction details are provided in Appendix B.

Table 1: Bore Details

Bore Name	Bore ID Number	Bore Depth (m)	Bore Diameter (m)	Screen Interval (m bgl)	Static Water Level (m bgl)
Bore 1	E44/0330	53	0.25	2.4 to 8 (slotted steel) 8 to 10 (stainless steel) 10 to 38.3 (slotted steel) 42.8 to 48.5 (slotted steel)	1.5
Bore 2	E44/0331	52.9	0.25	5.4 to 7.4 (stainless steel) 7.4 to 46.9 (slotted steel)	0.5
Bore 3	E44/0437	28.5	0.25	1.8 to 22 (slotted steel)	1.34
Bore 4	E44/0438	22.4	0.25	2.36 to 7.36 (slotted steel) 7.36 to 11.41 (stainless steel) 11.41 to 17.41 (slotted steel)	1.85

The screened intervals for bore 4 are not entirely clear based on the information provided by Barber and therefore the intervals given in Table 1 are assumed based on our interpretation of the drilling records.

The driller's logs for bores 1 and 2 describe mainly claybound gravels (underlying topsoil) across the drilled depths, with water bearing gravels between 8.0 and 10.0 m bgl in bore 1 and between 5.0 and 7.0 m bgl in bore 2. These thin zones described as water bearing gravels generally correspond with the intervals over which the stainless steel screen is present in each bore and the slotted steel casing is typically present over the soil intervals described as mainly claybound gravels which are likely less permeable.

The logs for bores 3 and 4 describe sandy gravels underlying topsoil from 0.3 m to 3.0 m bgl. A 1 m layer of claybound gravels was observed in both bores between 3.0 m and 4.0 m bgl, underlain by soils generally described as wet gravels and sand and/or wet sandy gravels to at least 17 m bgl. Claybound gravels are described at greater depths in the logs from both of these bores.

3.0 Flow and Volume Limits

3.1 Previous Consent

In 2009, a water permit consent (204511) was granted to take groundwater from Bores 1 and 2, which became the main supply for spray irrigation of pasture and crops of this land. This technical assessment of effects is for the renewal of the previous consent, with the addition of Bores 3 and 4, for a 15 year duration.

The previously consented rates and volumes of abstraction were as follows

- Maximum combined flow rate of 60 L/s for up to 24 hrs a day during the irrigation period.
- Maximum daily volume of 5,184 m^3/day.
- Maximum annual volume of 735,000 m^3/year.

3.2 Proposed Water Requirements

The Applicant requests consent to take groundwater at the following rates and volumes. These are summarised in Table 2.

- Increased maximum combined flow rate of up to 95 L/s.
- Maximum daily volume remains unchanged at 5,184 m^3/day.
- Reduction of the maximum annual volume to 525,000 m^3/year. The annual allocation is based on reducing the target application rate from 420 to 300 mm/year over 175 ha of land.

Table 2: Requested flow and volume limits

Bore Name	Bore ID Number	Previous Consent Number	Maximum Flow Rate (L/s)	Maximum Daily Volume (m^3/d)	Maximum Annual Volume (m^3/y)
Bore 1	E44/0330	204511	30	5,184	525,000
Bore 2	E44/0331	204511	30		
Bore 3	E44/0437	-	15		
Bore 4	E44/0438	-	20		

The online Irricalc annual volume calculator was used to confirm that the requested seasonal volume is reasonable and efficient as required by Appendix O of the Proposed Southland Water and Land Plan (pSWLP). S-Map online indicates that the property is underlain by a number of soils types, although the two dominant soil appear to be of Lumsden and Eurakef type. Profile Available Water (PAW) values for these soils given on S-Map online are around 107 mm (Lumsden) and 165 mm (Eurakef), while values for the other soil types on the property are between 64 and 104 mm.

For PAWs in this range, the minimum annual volume calculated using Irricalc for the range of PAW values above and an area of 175 ha is 672,525 m^3/year. Given that the requested volume is less than that calculated by Irricalc, it is considered that the requested volume is reasonable and will be consistent with efficient irrigation practices.

4.0 Site description

4.1 Location

The bores are located at 295 Lowther Road, which is situated approximately 10 km north-north-east of Lumsden and approximately 12 km east-north-east of Mossburn in the Southland Region. The nearest settlement to the property is Lowther, located approximately 2 km to the south-east. The bores are located within 1 km of each other on the western side of Lowther Road (see Figure 1, Appendix A).

4.2 Climate

The property is located in an area of temperate climate, with moderate temperatures and rainfall throughout the year. The average annual rainfall is 879 mm and appears to be relatively stable based on the available climate data (1991 – 2018) from the NIWA weather station in Lumsden.

4.3 Hydrology

As shown in Figure 1, Bores 1, 2 and 3 are situated on the eastern side of Cromel Stream, within around 500 m of the stream, and around 1 km west of Irthing Stream and over 2 km east of Acton Stream. Bore 4 is situated on the western side of Cromel Stream approximately 1.4 km to the north-east of Acton Stream and around 2 km west of Irthing Stream. Acton, Cromel and Irthing Streams converge around 3 km south of the bores, and drain into the Oreti River upstream of the State Highway 94 bridge.

Environment Southland (2011) describe how Cromel Stream loses water to groundwater in its lower reaches and becomes dry when flows in the Irthing Stream reach around 1 m^3/s. Conversely, the Irthing and Acton Streams gain water in their lower reaches.

4.4 Hydrogeology

The location of the proposed abstraction is within the Five Rivers groundwater zone, and the hydrogeology is summarised in the ES Five Rivers groundwater zone information sheet. The zone occupies a roughly triangular area of approximately 140 km^2 bounded by the Oreti River to the south, the Lintley Ranges to east and the Eyre Mountains to the north. These main streams in the area, particularly the Cromel Stream in the vicinity of the applicant's bores, appear to have a significant influence on groundwater levels providing recharge to the aquifer near the basin margins and groundwater drainage closer to the Oreti River.

The Five Rivers area occupies a large basin underlain by basement rocks of two geological terranes and infilled by a sequence of Tertiary marine sediments and Quaternary alluvial deposits. The thickness of the alluvial deposits is largely unknown, however based on available borehole data, at least 80 m of alluvial gravels are thought to overlie basement throughout the central area.

In the northern portion of the zone the Quaternary gravel sequence is poorly stratified consisting of dominantly poorly sorted claybound gravel deposits. Further south the gravel deposits appear to have been reworked by the ancestral Oreti River forming extensive deposits of highly permeable gravels overlain by a significant thickness of tightly claybound gravels. This claybound gravel unit is overlain by a thin (around 10 m thick) veneer of recent gravel deposits associated with the present Oreti River and tributaries. The upper unconfined aquifer comprises the main groundwater resource of the zone while the lower gravel unit forms a separate confined aquifer system known as the Lumsden Aquifer.

The nature of the hydraulic connection between the unconfined aquifer and the Lumsden Aquifer is not known, however the significant vertical head differences indicate limited leakage across the claybound gravel under natural conditions.

Based on the logs from the applicant's bores, it is assumed that these bores are located north of the area underlain by the Lumsden Aquifer. The permeable unconfined aquifer appears to be relatively thin and is targeted by the stainless steel screens installed in each bore. Large sections of slotted casing are present above and below the stainless steel screens targeting the thick and less permeable claybound gravel strata.

5.0 Analysis of Pump Test Data

The pump test data analysis consisted of re-analysing aquifer test data collected by Barber Drilling Services in November 2006 for bores 1 and 2 and also analysis of December 2009 pumping test data for bores 3 and 4, included in Appendix B. No additional observation bores had their water levels monitored during the testing.

The test for Bore 1 comprised of three steps at approximately 20, 22, and 27 L/s for a total of 25.25 hours with a maximum drawdown of 7.25 m, while the test for Bore 2 comprised of 4 steps at around 8, 15.75, 23.3 and 25 L/s for a total of 14 hours with a maximum drawdown of 6.8 m.

Bore 3 was pumped at 5, 10 and 15 L/s for 32 hours with a maximum drawdown of 17.1 m, and Bore 4 was pumped at 10, 17 and 20 L/s for 32 hours with a maximum drawdown of 14.1 m.

The water level measurements recorded during each test are plotted in Figures 2, 3, 4 and 5, Appendix A for bores 1, 2, 3 and 4 respectively. The sharp steps that are observed in the drawdown curves from each bore represent an increase in the pumping rate. The measured drawdown records generally start to stabilise in most cases prior to a step up in pumping rate and in the final step.

A distinct increase in drawdown can be seen in the record of water levels recorded in Bore 2 during the third pumping step (Figure 3). This appears to occur when the water level in the bore is drawn down below the top of the main screen section (upper stainless steel screen). As the main screen is dewatered, a greater proportion of the water abstracted from the bore is sourced from the less permeable clay bound gravels resulting in a greater drawdown. This is representative of a reduction in the overall permeability of the strata from which the well is drawing water.

The results of these tests were analysed using the Eden and Hazel and Cooper-Jacob methods described in Kruseman & de Ridder (1991). The Cooper-Jacob analyses are based on analysis of the drawdown data from the first pumping step of the tests carried out in each bore. The Eden and Hazel analyses involved fitting a theoretical drawdown record to the measured datasets for all pumping steps. The results of the analysis are presented in Appendix C and are summarised in Table 3.

Table 3: Summary of pump test analysis

Pumped Bore	Maximum Rate Tested (L/s)	Maximum Drawdown (m)	Eden-Hazel Transmissivity (m^2/d)	Cooper-Jacob [1] Transmissivity (m^2/d)
ES44/0330 (Bore 1)	27	7.25	586	218[2]
ES44/0331 (Bore 2)	25	6.8	220	666
ES44/0437 (Bore 3)	15	17.1	-[3]	220
ES44/0438 (Bore 4)	20	14.1	-[3]	1061

Notes:
1. The Cooper-Jacob Straight Line Method was applied to the first time step data in each pumping well to obtain an estimate of the transmissivity in the pumped aquifer.
2. Limited data available for analysis.
3. Very poor data fit so not possible to accurately estimate transmissivity with this method.

Note the accuracy of the derived values using the Cooper-Jacob method for bores 2 and 4 is considered poor and the derived values are expected to overestimate transmissivity. This is because of observed changes (increases) in the slope and scale of drawdown in the latter pumping steps during testing in these bores.

Based on these values and the results of the pump test analysis, the lowest derived transmissivity value of 220 m^2/day is considered to provide a conservative estimate of transmissivity for the shallow strata in this area.

6.0 Assessment of Environmental Effects

The following potential effects of this application on the environment have been considered based on the Environment Southland approach to processing groundwater take consent applications.

- Aquifer storage volumes
- Existing bore or well yields
- River and stream flows (stream depletion effects), including minimum flow and allocation levels
- Wetland and lake water levels (stream depletion effects)
- Groundwater quality

Each of these matters is assessed in the following sections of this report.

6.1 Aquifer Storage Volumes

Staged allocation volumes have been adopted for the various aquifer types in Southland based on the level of risk of adverse environmental effects. The total allocation for the Five Rivers groundwater zone in the pSWLP is 17,050,000 m^3/year, with the amount currently allocated below 4%. The total allocation in the Regional Water Plan for Southland (RWPS) is 13,200,000 m^3/year, with the amount currently allocated below 3%.

The proposed take represents less than 4% of either allocation limit, and therefore granting of this consent application would mean that the total allocation within the Five Rivers groundwater zone is still well within the limit. Allocation volumes are based on sustainable recharge to ensure that the abstractions can be sustained without causing long term reductions in available groundwater. Therefore, it is considered that the effects of this application on the storage volumes within the aquifer would be less than minor.

6.2 Existing Bore or Well Yields

The abstraction of groundwater creates a drawdown cone that extends laterally from the pumped bores which may result in a lowering of groundwater levels in neighbouring bores. Such a lowering as a result of abstraction may affect the ability of existing users to access the groundwater resource through localised well interference effects and/or a decline in the aquifer-wide groundwater level due to the cumulative impact of abstraction.

As discussed in Section 5.1 the volume of water under application is less than 4% of the allocation limit in the area. Therefore, the proposed abstraction is unlikely to contribute to a decline in the aquifer-wide groundwater level as a result of the cumulative impact of abstraction. Subsequently, this section of the report focuses on localised well interference effects on existing groundwater users.

Policies 22 and 31 "Interference effects" in the pSWLP and RWPS, respectively, state that the drawdown effect should not be more than 20% of the available drawdown where the existing bore adequately penetrates an unconfined aquifer and is not used for long-term monitoring of water levels, or no more than 10% where the bore is used for long-term monitoring of water levels.

Any assessment of the effects of abstraction on neighbouring bores requires knowledge of the hydraulic properties of the aquifer from which abstraction is occurring, together with information on the available drawdown in neighbouring bores. Analysis and interpretation of the historic pumping tests are discussed in Section 4.0 of this letter. Based on the pumping test data a transmissivity value of 220 m^2/day has been used for the assessment of drawdown interference effects on neighbouring bores resulting from the proposed abstraction. A typical unconfined aquifer storage coefficient of 0.1 has been assumed for the assessment.

Information obtained from the online Environment Southland BEACON GIS system indicates that there are 18 bores located within 2 km of Bores 1, 2, 3 and 4. However, discounting Bores 1 through 4 and the other seven bores located on the applicant's property, there are a total of seven neighbouring bores located within 2 km.

The locations of the applicant's bores and neighbouring bores situated within 2 km are shown in Figure 6, Appendix A. Details for the seven neighbouring bores are given in Table 4 below.

Table 4: Neighbouring bores within 2 km of Applicant's bores

Well No.	Well Use	Depth (m)	Depth to top of screen (m bgl)	Static Water Level (m bgl)	Distance from Applicants bores (km)
E44/0090	Domestic	7.4	-	4.6	1.3 – 2.48
E44/0107	Domestic/Stock	4.03	-	2.59	0.4 to 1.47
E44/0108		6.39	-	2.06	0.75 to 1.49
E44/0301	Domestic	4	-	1.8	0.3 to 1.4
E44/0397	Monitoring	10	-	-	0.45 to 1.42
E44/0440	Monitoring	12	9	7	0.6 to 1.48
E44/0600	Dairy	77	-	-	1.53 to 2.6

It should be noted that the ES GIS database indicates that the casing has been retrieved in bore E44/0600 and as a result the drawdown effects at the location of this bore are not considered as it is assumed that this bore is no longer present. As a result there are six neighbouring bores situated within 2 km of the applicant's property for which we have carried out an assessment of drawdown interference effects.

To assess the potential effects on neighbouring bores requires groundwater level, bore/screen depth, aquifer parameter and well performance (yield versus drawdown) information.

Based on Table 4 above, it is evident that all of the six active neighbouring bores are very shallow (between 4 and 12 m bgl) and therefore the available drawdown in all these bores will be small. None of these bores have associated consents to abstract groundwater and the recorded uses for the bores are mainly domestic or monitoring, however one bore is also used for stock water (in addition to domestic supply) and one bore has no recorded use. Given that no consents are held, the rates and volumes of water that will potentially be abstracted from each bore will be low.

The only groundwater level information from these bores is an initial static water level measurement in some following drilling (the measurements ranging between 1.8 to 4.6 m bgl in four bores and a measurement of 7 m bgl in a single bore). There are two long-term shallow ES monitoring bores situated around 3 km from the applicant's bores. Bore E44/0015 (8 m deep) is situated to the north-west at Mossburn Fiver Rivers Road, while bore E44/0232 (also 10 m deep) is located to the south-west at Ellis Road.

The groundwater level records from the ES monitoring bores extend back to early 2002 (E44/0015) and early 2004 (E44/0232). The ES database gives a Reduced Level (RL) for E44/0015 of 259 m. We assume that this value represents the elevation of the measuring point in the bore and that the measuring point is relatively close to ground level. The water level record in this bore ranges between an RL of approximately 256.2 m to 258.7 m (2.5 m variation) over the full monitoring period. In the majority of years seasonal fluctuations of around 1.5 m are observed. If it is assumed that the RL given on the ES database represents the elevation of ground level then the measurements from this bore indicate that water levels vary between approximately 0.3 to 2.8 m bgl in the bore.

The ES RL (assumed measuring point elevation) for bore E44/0232 is 229.24 m and the measured water level range given over the full record varies from approximately an RL of 225.35 to 226.66 (variation of around 1.3 m). In most years seasonal fluctuations of around 0.7 m are recorded. Assuming that the measurement RL is the same as ground elevation at the site then the depth to groundwater would vary from around 2.74 to 3.89 m bgl.

To assess the potential drawdown interference effect a representative water level is required in each individual bore. Based on the available water level information above and to provide a conservative assessment we have assumed that the static water levels for individual bores in Table 4 are high values and that these bores may experience a fall in water level of up to 2.5 m (the magnitude of fluctuations observed in monitoring bore E44/0015). Bore E44/0397 has no recorded static water level and therefore the average of the values from the other five bores is assumed for this bore (3.61 m bgl). This results in a range of assumed low water levels in the six bores for which assessment is required of between 4.3 m bgl (E44/0301) and 9.5 m bgl (E44/0440).

Based on the reported depths of these neighbouring bores the assumed low water levels are either close to or below the depth of the bore. As a result there is very little or no available drawdown in these neighbouring bores. Based on the information provided in Sections 2.0 and 4.4 of this report, it appears that the most permeable zones of gravel in the area are at shallow depths of generally less than 10 m bgl. As a result, bores in the area have very shallow upper screens so as to maximise yields from the permeable strata. This is the case for the applicant's bores, although the screen zones in these four bores also extend well below the permeable gravels into claybound strata that is also water bearing but of overall lower permeability. This is required to ensure that yields can be maintained when groundwater levels are naturally low and the saturated thickness of the shallow permeable gravel zone is small.

Both the RWP and the pSWLP require that existing bores should adequately penetrate the aquifer. Policy 31 of the RWP states that bores should penetrate the entire saturated thickness of aquifer while Appendix L.3 of the pSWLP defines an adequately penetrating depth as where the interval over which groundwater enters the bore is located at a depth exceeding 3 times the average seasonal groundwater level variation (1.5 m in this case) below the mean groundwater level. We have adopted the specific methodology in the pSWLP to determine an adequate penetrating depth for each of the bores in Table 4. Given that there is no information for the mean groundwater depth in each bore we have assumed that the mean depth is half the maximum seasonal fluctuation of 2.5 m (1.25 m) above the assumed minimum groundwater level (2.5 m below the static water level as discussed above). Following the pSWLP Appendix L.3 outline for wells without screen information, we assume there are 1 m long screened sections at the base of bores for wells without screened interval information.

Based on the above we have carried out a drawdown interference assessment assuming pumping simultaneously from the applicant's four irrigation bores for a period of 150 days. The assessment calculates drawdown in each of the six neighbouring bores using the Theis (1935) solution and the aquifer parameters given above (transmissivity of 220 m^2/day and S of 0.1). The calculations take into account the principle of superposition so that the combined effects from each of the applicant's four bores are taken into account. The assessment assumes continuous abstraction at 10.13 L/s (875 m^3/day) in each bore which equates to a combined daily volume of 3,500 m^3/day. This daily volume over 150 days results in the abstraction of the full annual volume of 525,000 m^3 over this period.

The results of the assessment in Table 5 (below) indicate that none of the wells have an adequate aquifer penetration depth under the unconfined aquifer rules of the pSWLP Appendix L.3 given an assumed screen length of 1 m. On this basis, the effects are considered to be within the specified thresholds.

Table 5: Maximum potential drawdown in neighbouring bores resulting from proposed abstraction

Well No.	Total bore depth (m bgl)	Assumed min water level (m bgl)	Assumed mean water level (m bgl)	Adequate penetration depth (m bgl)	Available drawdown (m)	Applicants drawdown (m)	Remaining drawdown (m)	Remaining drawdown (%)
E44/0107	4.03	5.09	3.84	8.34	-0.81	1.06	-1.87	0
E44/0108	6.39	4.56	3.31	7.81	2.08	0.42	1.66	79.8
E44/0301	4	4.3	3.05	7.55	-0.05	1.26	-1.31	0
E44/0397	10	6.11	4.86	9.36	4.14	0.60	3.54	85.5
E44/0440	12	9.5	8.25	12.75	0.75	0.69	0.06	8.0
E44/0090	7.4	7.1	5.85	10.35	0.55	0.08	0.47	85.4

It can be seen from Table 5 that, based on the water level assumptions discussed above, the resulting available drawdown in each bore can have a negative value due to the estimated mean water level and screened interval assumptions. The applicant's drawdown effect is between 0.08 m and 1.42 m (20.2% to 100% of the available drawdown). All of the wells do not have an adequate aquifer penetration depth and are therefore considered exempt from the 20 % allowance in all cases required by both the RWP and the pSWLP. If the bores were sufficiently deep, they would unlikely be adversely affected. Both plans require a lesser level of effect for long-term monitoring bores (the pSWLP only allows for a 10 % allowance), however while some of the neighbouring bores are used for monitoring purposes, none are used by ES for long-term monitoring purposes.

It should also be noted that the proposal represents the renewal of a groundwater abstraction that has been in operation for the last 10 years. In addition, the annual volume of the renewed consent is lower than that of the previous consent. We are not aware of any previous adverse drawdown interference effects as a result of the operation of the former consent and therefore this is expected to also be the case for a renewed consent.

In addition, given that none of the neighbouring bores in the area hold resource consents to take groundwater, the individual yields required by these bores are very low as they will need to be within the abstraction limits for a permitted activity. As a result the amount of self-induced drawdown required to meet each individual bores requirements will be very small and these low yield requirements also mean that cumulative drawdown effects will also be very small.

Based on the information provided above, the drawdown interference effects in neighbouring bores as a result of the proposal are considered to meet the specific planning criteria and therefore are considered to be less than minor

6.3 Stream Depletion Effects

Declining aquifer levels can impact on surface water ecosystems and habitats by reducing surface water flows in rivers, lakes and wetlands. Policy 29 of the RWP and Appendix L.2 of the pSWLP set out the methodology for determining the degree of hydraulic connection between surface water and groundwater and how stream depleting groundwater takes need to be managed.

The Cromel, Acton and Irthing streams are located within the vicinity of the proposed abstraction. The closest stream to the production bores is the Cromel Stream, which is located 0.125 km from Bore 2. Irthing Stream is the next closest stream to the bores, and is located 0.9 km from Bore 3. Acton Stream is the farthest stream from the bores, with Bore 4 located 1.3 km from the stream. The Hunt (2003) solution was modified to not include an aquitard as an equivalent to the Jenkins solution and used to assess the effect of the proposed abstraction on stream flow in the Cromel, Irthing and Acton Streams bordering each bore. The assessment is based on the following assumptions:

- Aquifer transmissivity of 220 m^2/day.
- Aquifer storativity of 0.1 (assuming the shallow aquifer interacting with stream bed deposits is unconfined).
- There is no significant aquitard underlying the streambed deposits restricting groundwater flow (equivalent to the Jenkins method).
- Stream bed hydraulic conductivity is 100 m/d set conservatively to allow for well sorted sands and gravels on the streambeds with no clogging layer.
- Stream width is measured from aerial photos in the vicinity of where each bore is closest to each bounding stream.
- Stream bed thickness of 1 m.

The results of the stream depletion analyses are shown in Appendix A for each stream (Cromel, Irthing, and Acton) bounding each bore (1, 2, 3, and 4). According to pSWLP (Appendix L.2), the sum of the instantaneous steam depletion rate after 90 days for a given bore exceeding 90% of the maximum pumping rate (Q) is considered to be in direct hydraulic connection under the Table L.2 Classification and Management Approach for the Oreti River catchment.

Bore 1 pumping rate is 30 L/s with sums of stream depletion at 2.6 L/s (7 days: 9%Q) and 20.3 L/s (90 days: 68%Q). Bore 2 pumping rate is 30 L/s with sums of stream depletion at 14.3 L/s (7 days: 48%Q) and 27.0 L/s (90 days: 90%Q). Bore 3 pumping rate is 15 L/s with sums of stream depletion at 0.7 L/s (7 days: 5%Q) and 11.0 L/s (90 days: 73%Q). Bore 4 pumping rate is 20 L/s with sums of stream depletion at 0.0 L/s (7 days: 0%Q) and 8.8 L/s (90 days: 44%Q). This classifies Bore 2, based on the depletion sums (above), as in direct hydraulic connection with surface water, primarily to the Cromel stream (Appendix A). Based on the stream depletion sums (above) that are less than 90% of the maximum pumping rate (Q), Bores 1, 3, and 4 need to be assessed for their effects on each stream individually.

Bore 1 stream depletion on Cromel stream is at 9%Q (7 days) and 64%Q (90 days). Under Table L.2, Bore 1 has a high hydraulic connection with Cromel stream. Bore 1 stream depletion on Irthing stream is at 0%Q (7 days) and 4%Q (90 days). Bore 1 therefore has a low hydraulic connection with Irthing stream. Bore 3 stream depletion on Cromel stream is at 5%Q (7 days) and 58%Q (90 days). Bore 3 has a moderate hydraulic connection with Cromel stream. Bore 3 stream depletion on Irthing stream is at 0%Q (7 days) and 15%Q (90 days). Bore 3 has a low hydraulic connection with Irthing stream. Bore 4 stream depletion on Cromel stream is at 0%Q (7 days) and 40%Q (90 days). Bore 4 has a moderate hydraulic connection with Cromel stream. Bore 4 stream depletion on Acton stream is at 0%Q (7 days) and 4%Q (90 days). Bore 4 has a low hydraulic connection with Acton stream.

Under Table L.2 Classification and Management Approach, for the Oreti river catchment, there are four different management approaches pertinent to the degree of hydraulic connection between the three relevant streams and four bores. Cromel stream has direct hydraulic connection to Bore 2, high connection to Bore 1, and moderate connection to Bores 3 and 4. Irthing Stream has low connection to Bores 1, 2, and 3. Acton Stream has low connection to Bore 4.

The management approach (Table L.2) indicated for direct connection is that the groundwater take (Bore 2) would be managed as an equivalent surface water take for flow and allocation purposes subject to relevant minimum flow regimes for the Cromel Stream. Bore 1 has a high connection to Cromel stream and the magnitude of stream depletion exceeds 2 L/s after 7 days of pumping (Appendix A) so the stream depletion effect would also be managed as an equivalent surface water take (subject to minimum flow regimes) with the remainder of the abstraction allocated to the groundwater zone under Table L.2. The moderate connections between bores 3 and 4 with the Cromel stream do not require minimum flow restrictions, however the stream depletion effect is allocated to the surface water body with the remaining abstraction allocated to the groundwater zone. The low connection between Irthing stream and Bores 1, 2, and 3 as well as low connection of Acton stream with Bore 4 do not require minimum flow restrictions or surface water allocation.

Prior to applying any restrictions to this consent, it would be worth considering that Cromel Stream loses water to groundwater and is frequently dry for long periods during the irrigation season and therefore the proposed abstraction may not have any significant effect on flow in the stream for much of the irrigation season.

6.4 Wetland and Lake Water Levels

There are no wetlands or lakes located in the vicinity of the proposed abstraction and therefore it is considered that the proposed abstraction will not have any effect on water levels, ecosystems or habitats in wetlands or lakes.

6.5 Groundwater and Surface Water Quality

The proposed use of water to irrigate land used for growing crops and for irrigated pasture could degrade water quality due to leaching of nitrates and other contaminants. There have not been any concerns regarding groundwater or surface water quality over the course of the previous consent, which is considered to be due to the management practices in place to minimise nutrient leaching within the irrigated area. These include maintaining an irrigation water balance and nutrient balance for the property.

The ES Five Rivers groundwater zone information sheet states that groundwater quality is generally very good with the "best" water along the riparian margins and towards the northern extent of the groundwater zone. Despite this, all groundwater ultimately re-emerges as surface water either in the Irthing Stream or the Oreti River, so it is important that leaching of nutrients to groundwater, as well as direct run-off, is well managed on the property to prevent effects on surface water quality, in addition to groundwater quality.

The LAWA website (Land Air Water Aotearoa) summarises surface water quality information for the Irthing Stream at Ellis Rd, which is downstream of the site. This indicates that nitrogen concentrations are relatively high for a stream of this nature, although no long term increasing trends are determinable. Phosphorous concentrations are relatively low for this type of stream, with an improving trend. E.Coli levels are also relatively good. The Macroinvertebrate Community Index (MCI) sampling at this site, which provides a useful indication of the health of streams based on aquatic macroinvertebrates, indicates that the site has good to excellent water quality and habitat conditions.

Given the high nitrogen concentrations in the stream, it would seem important to manage, across the wider catchment, both nitrogen, to limit further increases, and phosphorus to avoid increases in periphyton occurring.

Overall, it is considered that as long as the Applicant upholds good management practices and minimises the leaching of nutrients and any direct run-off, the proposed abstraction will not have a significant adverse effect on groundwater or surface water quality.

7.0 Conclusions

The Applicant proposes to abstract water from four bores for the purpose of pasture and crop irrigation. Based on the information and assessment of environmental effects carried out in this report, it is considered that the potential effects on the aquifer sustainability, neighbouring bores, surface water features and water quality will be less than minor, with appropriate controls via consent conditions and good farm management practices.

8.0 References

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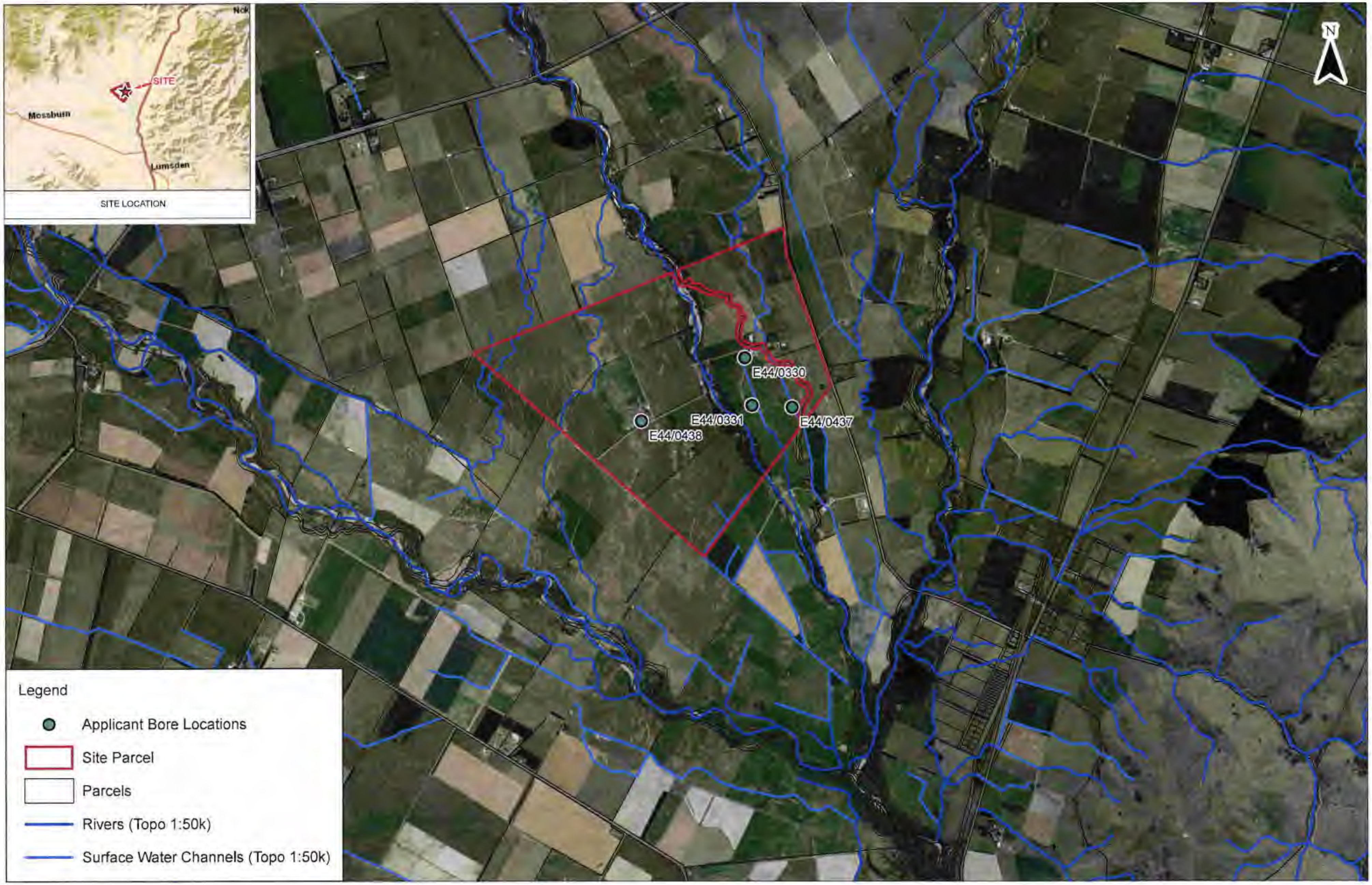
Appendix A

Figures

[redacted]



SCALE: 1:25,614 (A3)

0 500 1,000 2,000 3,000 Meters

FIGURE 1: SITE LOCATION MAP

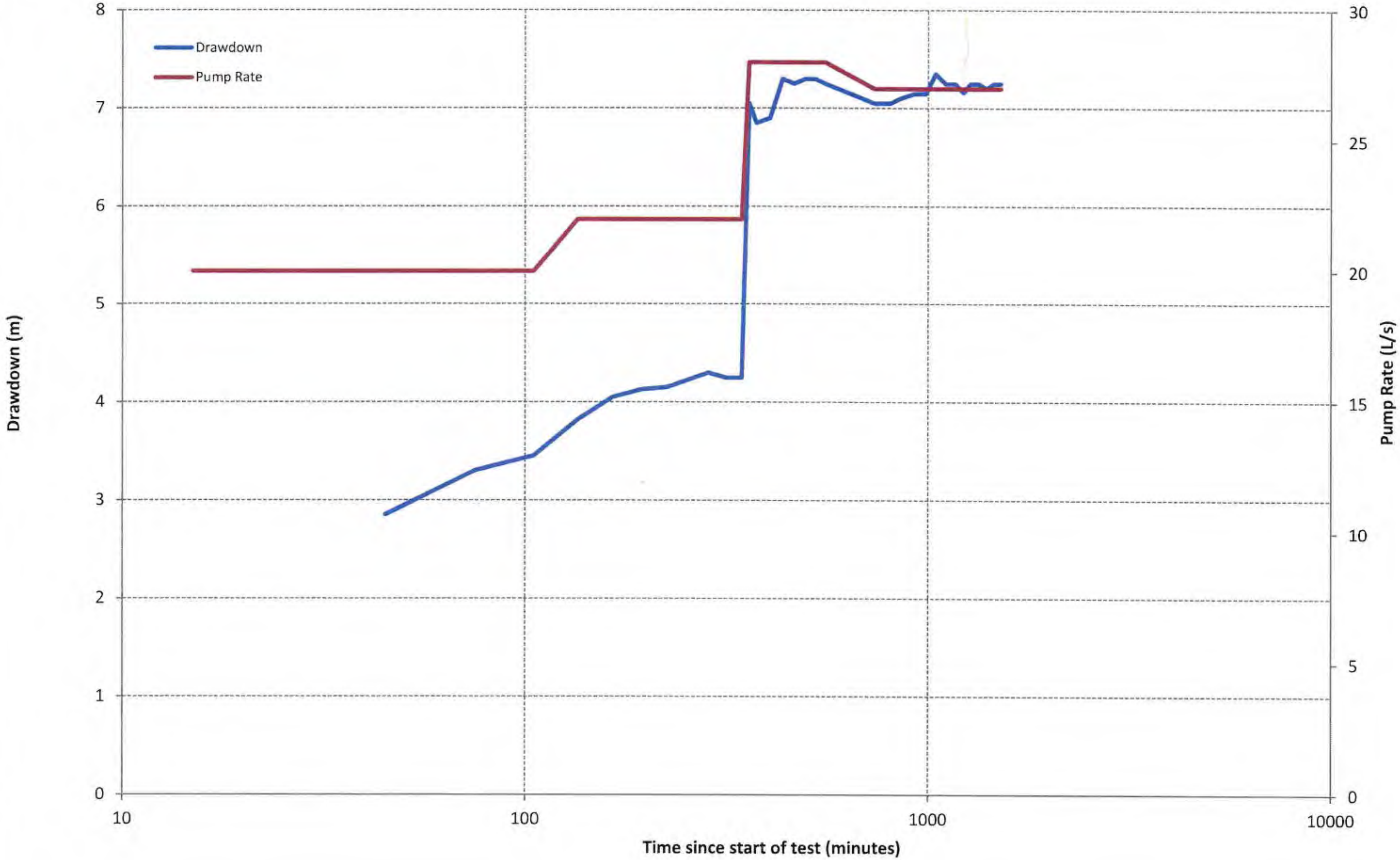


Figure 2: Bore 1 Step Rate Test

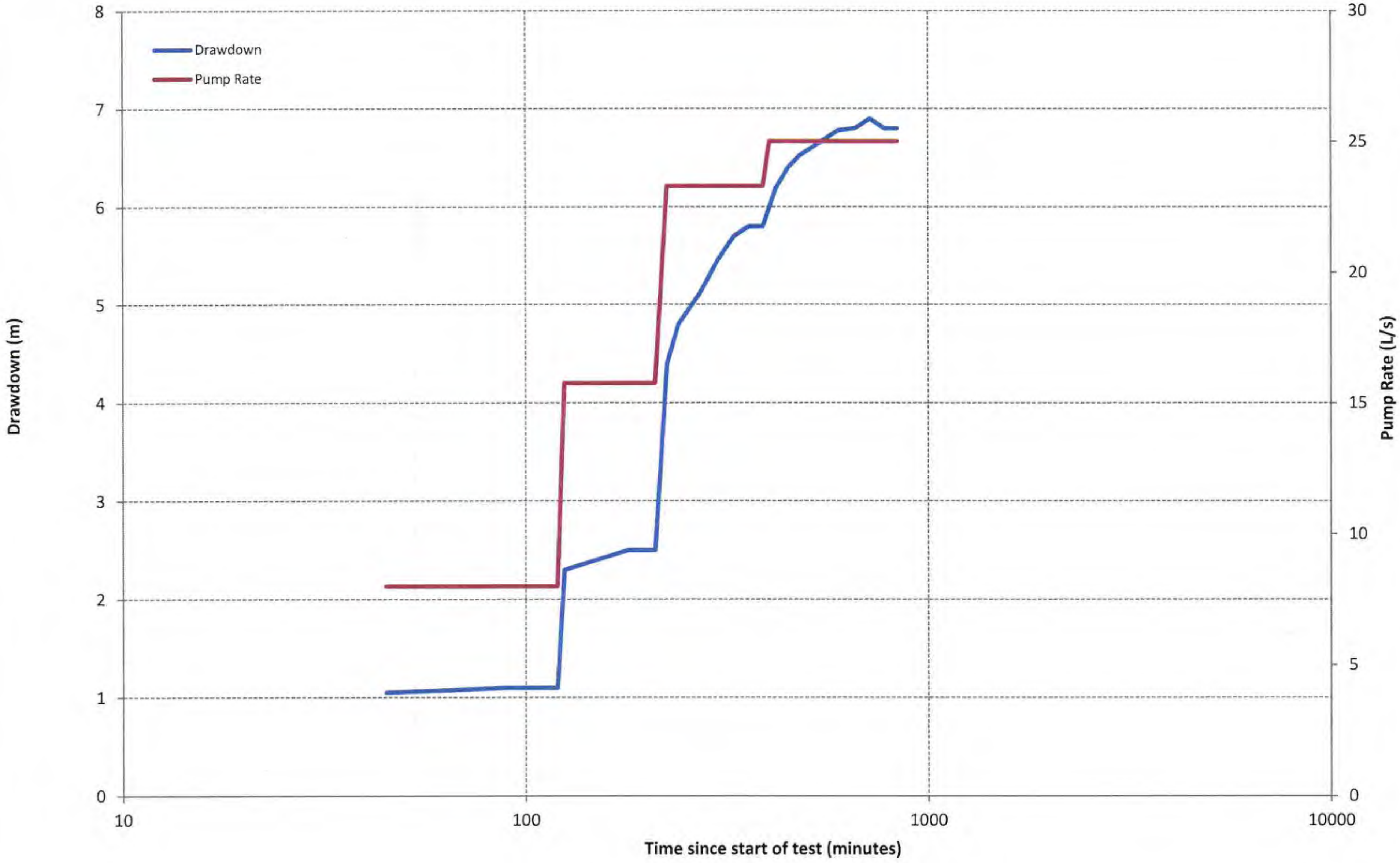


Figure 3: Bore 2 Step Rate Test

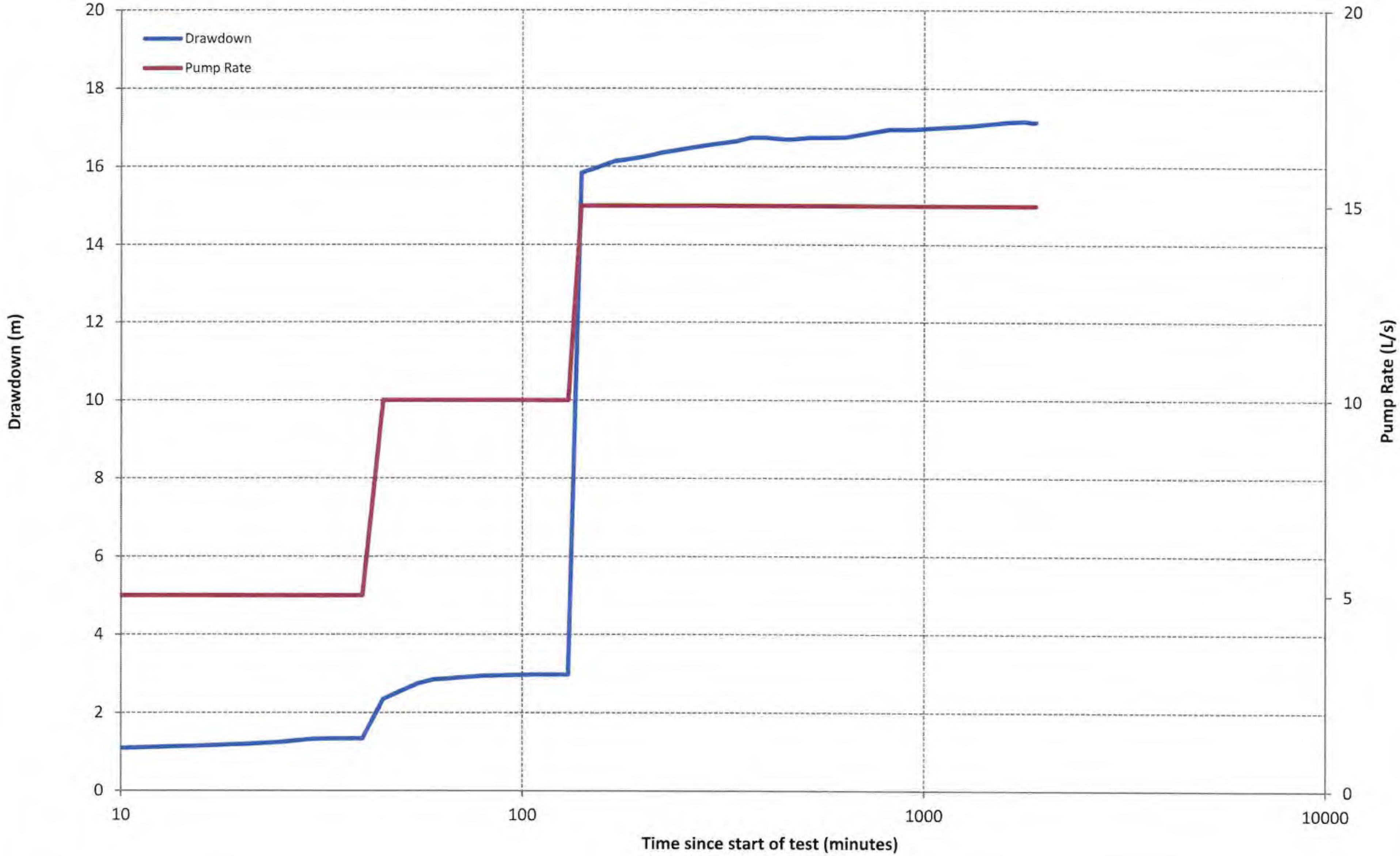


Figure 4: Bore 3 Step Rate Test

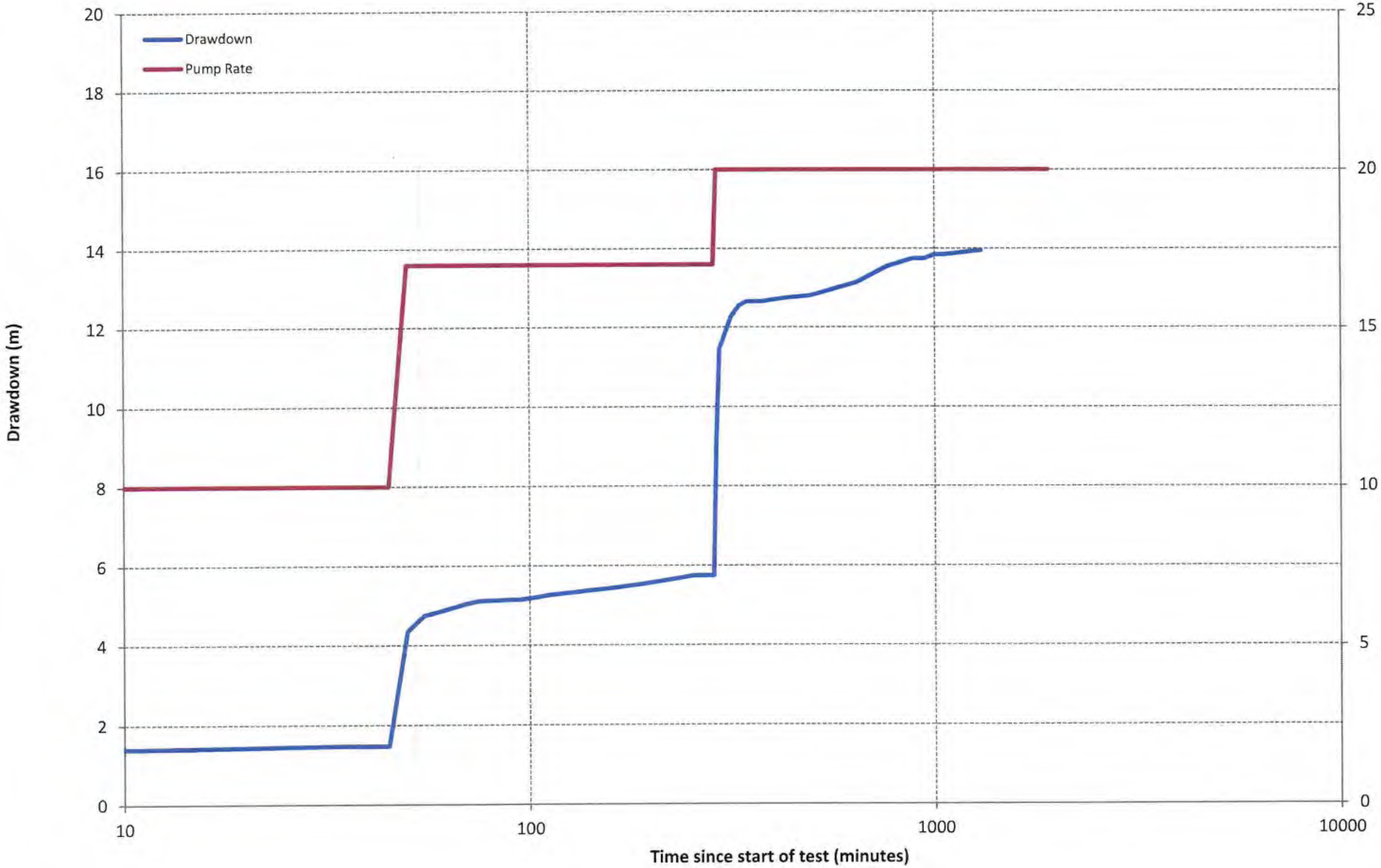


Figure 5: Bore 4 Step Rate Test

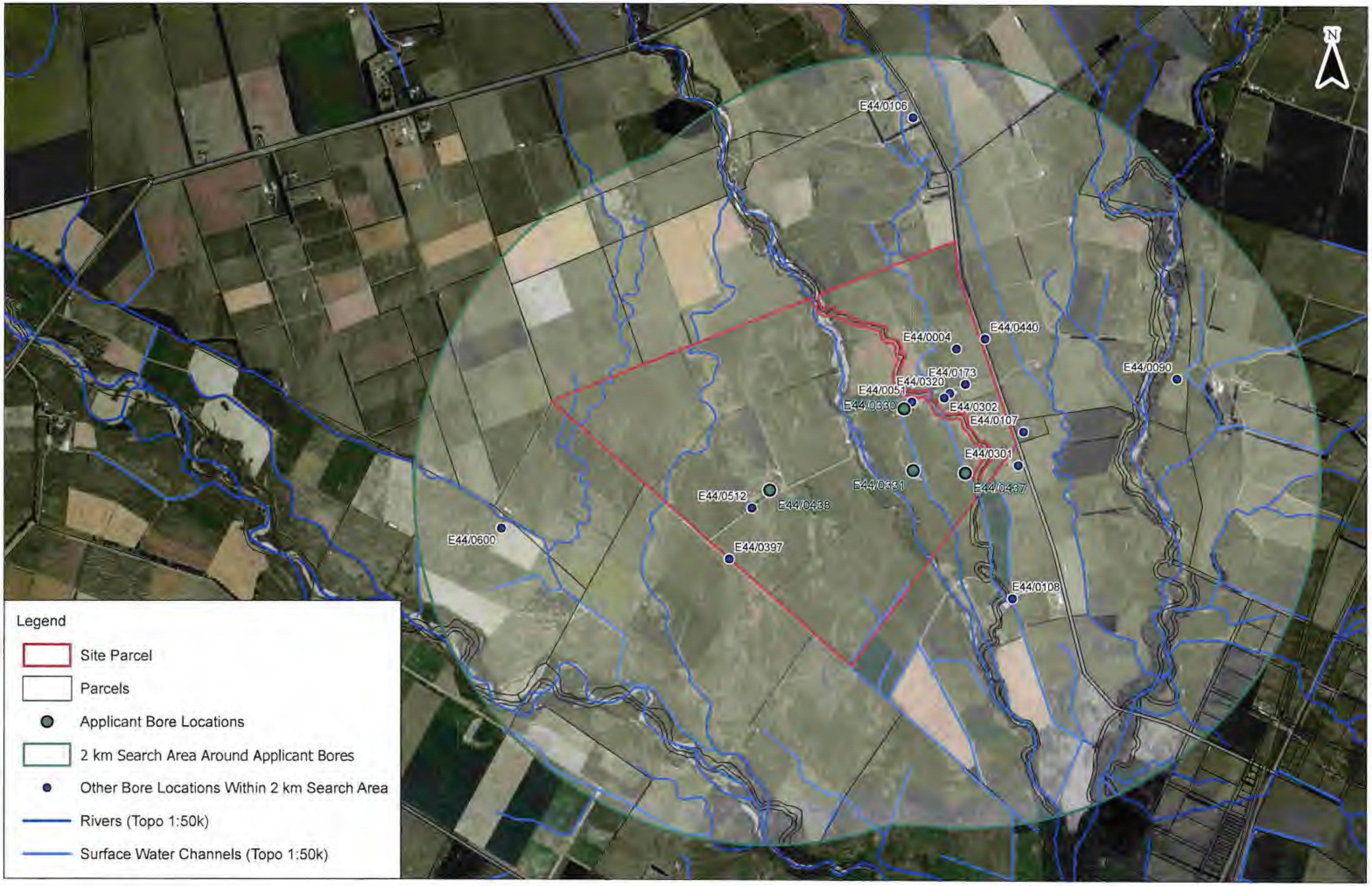


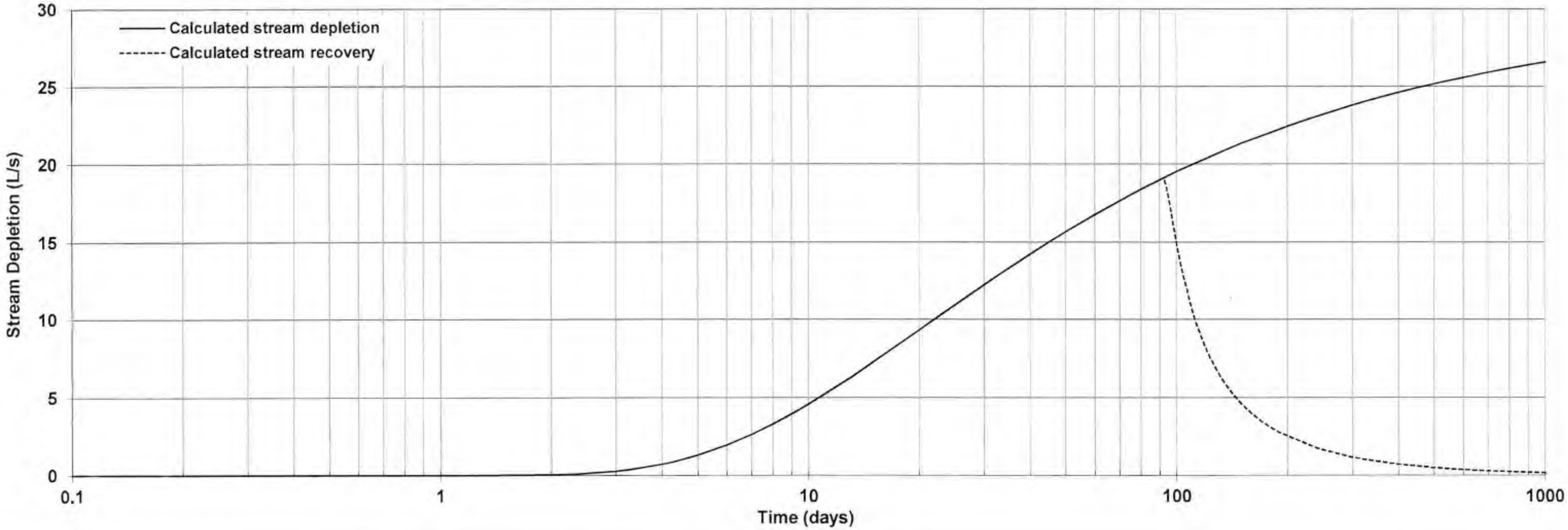
FIGURE 6: BORES WITHIN 2 KM OF APPLICANT BORES

295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting – Stream Depletion Assessment

E44/0330 (Bore 1) Effect on Cromel Stream

T (m^2/day)	S (Sy for unconfined)	K'/B' (1/day) (0 is Jenkins)	S_y	λ (m/day)	Stream Width (m)	K Streambed (m/d)	Streambed Thickness (m)
220	0.1	0	0.1	3000	30	100	1
Duration of Pumping (days)				Q (m^3/day)	x (m)	y (m)	L (m)
90				2592	300	0	300

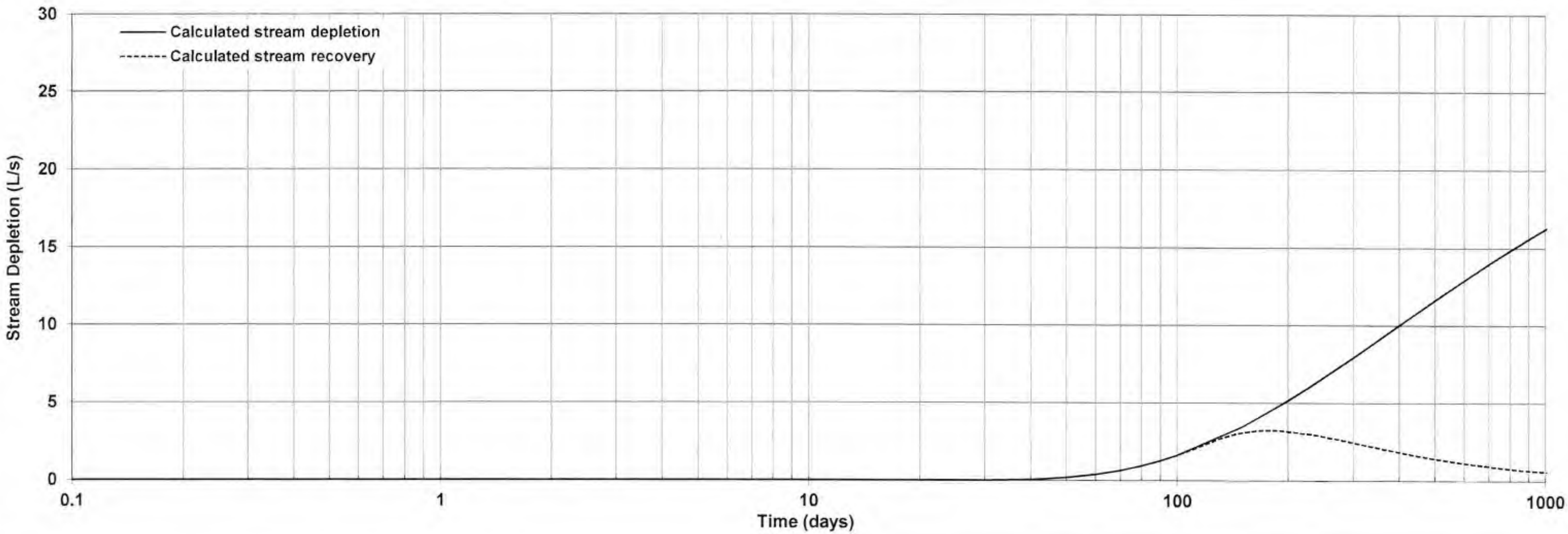
Estimated Stream Depletion	
t(days)	Q (L/s)
7	2.6
90	19.0



295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting – Stream Depletion Assessment

E44/0330 (Bore 1) Effect on Irthing Stream

T (m^2/day)	S (Sy for unconfined)	K'/B' (1/day) (0 is Jenkins)	S_y	λ (m/day)	Stream Width (m)	K Streambed (m/d)	Streambed Thickness (m)
220	0.1	0	0.1	4000	40	100	1
Duration of Pumping (days)				Q (m^3/day)	x (m)	y (m)	L (m)
90				2592	1280	0	1280
Estimated Stream Depletion							
t(days)		Q (L/s)					
7		0.0					
90		1.3					

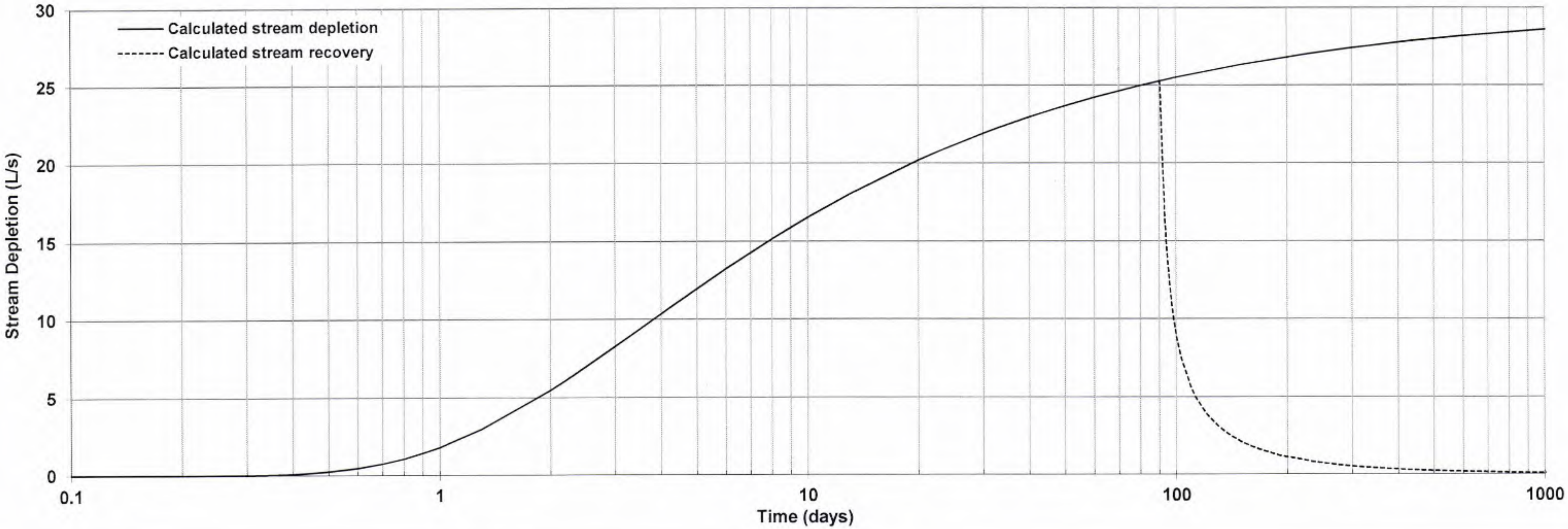


295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting – Stream Depletion Assessment

E44/0331 (Bore 2) Effect on Cromel Stream

T (m^2/day)	S (Sy for unconfined)	K'/B' (1/day) (0 is Jenkins)	S_y	λ (m/day)	Stream Width (m)	K Streambed (m/d)	Streambed Thickness (m)
220	0.1	0	0.1	3000	30	100	1
Duration of Pumping (days)				Q (m^3/day)	x (m)	y (m)	L (m)
90				2592	125	0	125

Estimated Stream Depletion	
t(days)	Q (L/s)
7	14.3
90	25.3

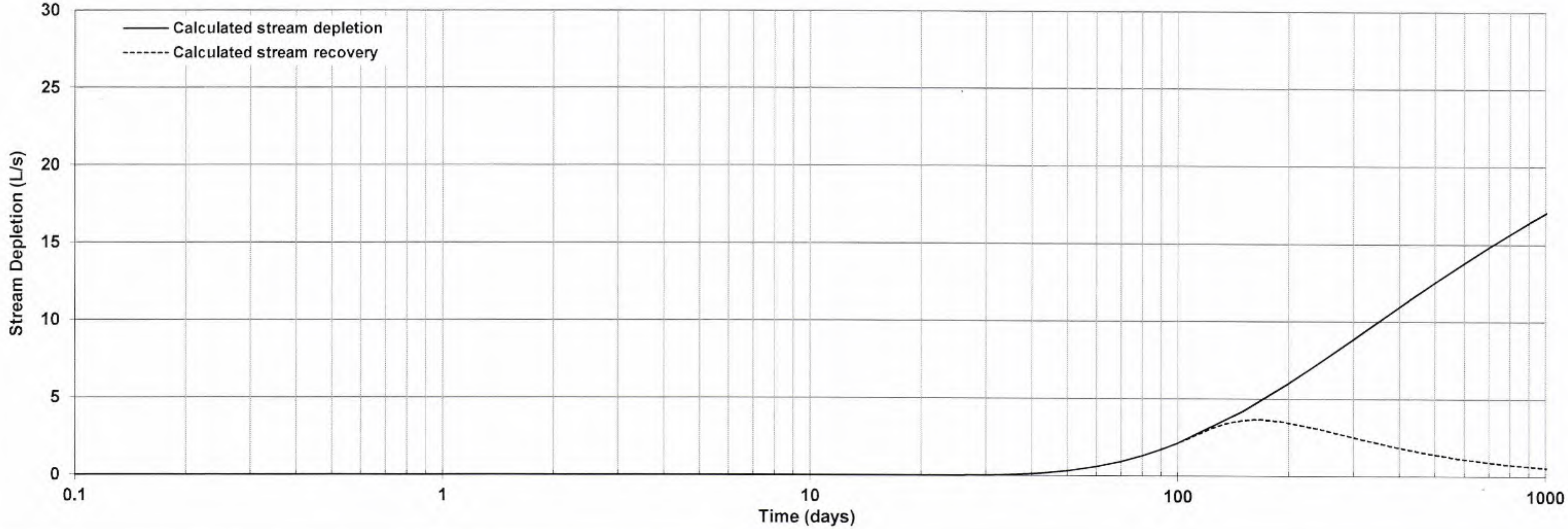


295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting – Stream Depletion Assessment

E44/0331 (Bore 2) Effect on Irthing Stream

T (m^2/day)	S (Sy for unconfined)	K'/B' (1/day) (0 is Jenkins)	S_y	λ (m/day)	Stream Width (m)	K Streambed (m/d)	Streambed Thickness (m)
220	0.1	0	0.1	4000	40	100	1
Duration of Pumping (days)				Q (m^3/day)	x (m)	y (m)	L (m)
90				2592	1200	0	1200

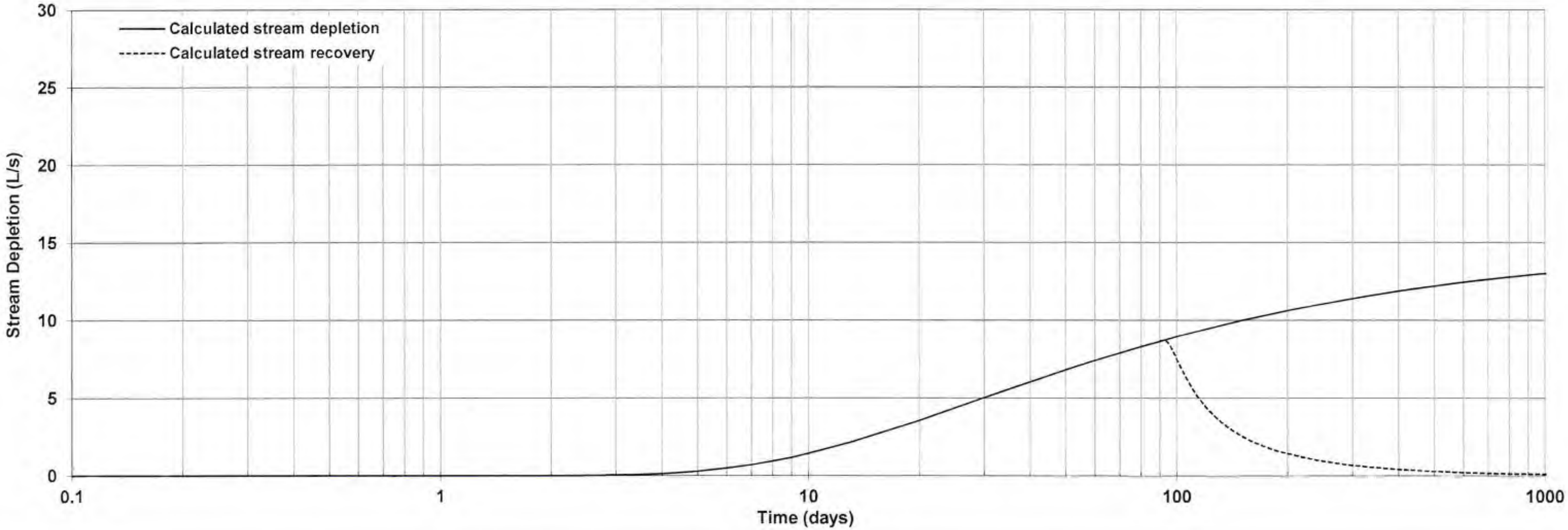
Estimated Stream Depletion	
t(days)	Q (L/s)
7	0.0
90	1.7



295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting – Stream Depletion Assessment

E44/0437 (Bore 3) Effect on Cromel Stream

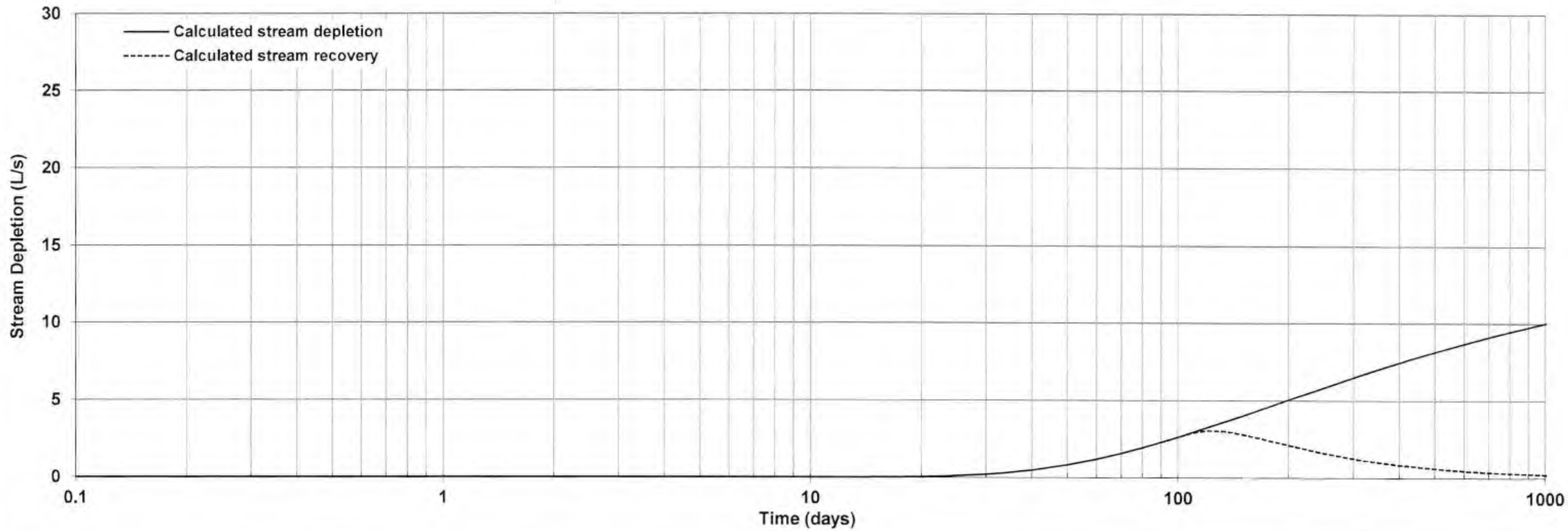
T (m^2/day)	S (Sy for unconfined)	K'/B' (1/day) (0 is Jenkins)	S_y	λ (m/day)	Stream Width (m)	K Streambed (m/d)	Streambed Thickness (m)
220	0.1	0	0.1	4000	40	100	1
Duration of Pumping (days)				Q (m^3/day)	x (m)	y (m)	L (m)
90				1296	350	0	350
Estimated Stream Depletion							
t(days)		Q (L/s)					
7		0.7					
90		8.7					



295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting – Stream Depletion Assessment

E44/0437 (Bore 3) Effect on Irthing Stream

T (m^2/day)	S (Sy for unconfined)	K'/B' (1/day) (0 is Jenkins)	S_y	λ (m/day)	Stream Width (m)	K Streambed (m/d)	Streambed Thickness (m)
220	0.1	0	0.1	4000	40	100	1
Duration of Pumping (days)				Q (m^3/day)	x (m)	y (m)	L (m)
90				1296	900	0	900
Estimated Stream Depletion							
t(days)		Q (L/s)					
7		0.0					
90		2.3					

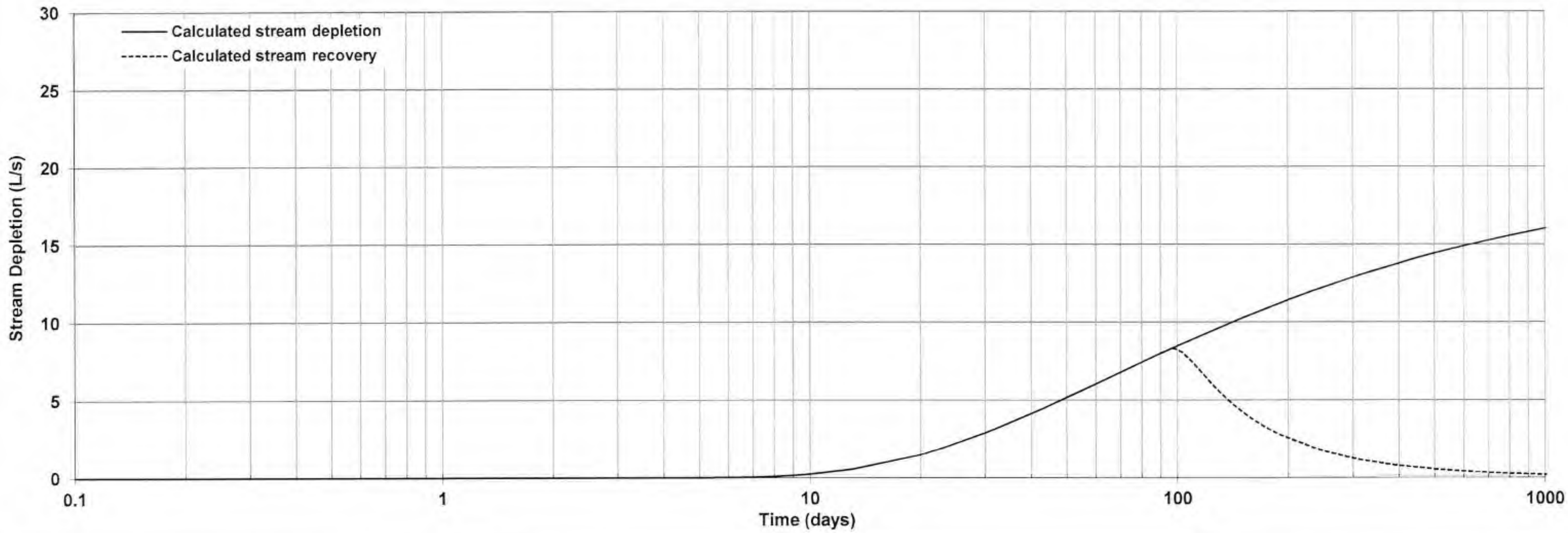


295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting – Stream Depletion Assessment

E44/0438 (Bore 4) Effect on Cromel Stream

T (m^2/day)	S (Sy for unconfined)	K'/B' (1/day) (0 is Jenkins)	S_y	λ (m/day)	Stream Width (m)	K Streambed (m/d)	Streambed Thickness (m)
220	0.1	0	0.1	5000	50	100	1
Duration of Pumping (days)				Q (m^3/day)	x (m)	y (m)	L (m)
90				1728	530	0	530

Estimated Stream Depletion	
t(days)	Q (L/s)
7	0.0
90	8.0



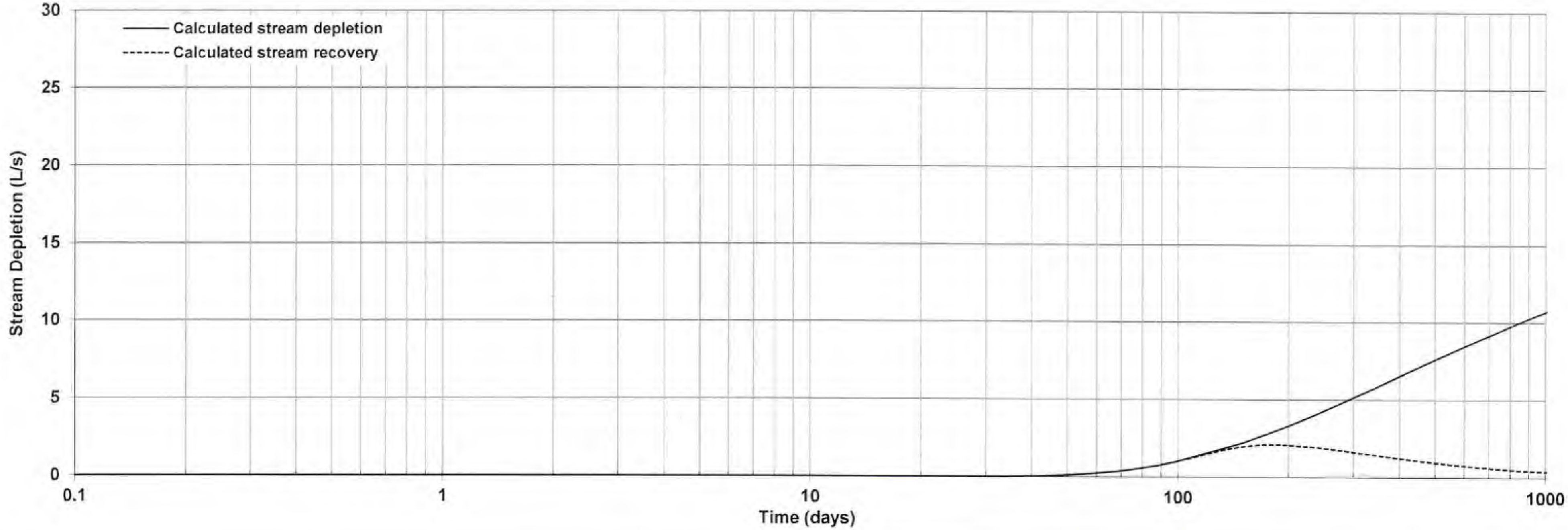
295 Lowther Road – Technical Assessment of Effects for Groundwater Take Re-consenting – Stream Depletion Assessment

pdp

E44/0438 (Bore 4) Effect on Acton Stream

T (m^2/day)	S (Sy for unconfined)	K'/B' (1/day) (0 is Jenkins)	S_y	λ (m/day)	Stream Width (m)	K Streambed (m/d)	Streambed Thickness (m)
220	0.1	0	0.1	4000	40	100	1
Duration of Pumping (days)				Q (m^3/day)	x (m)	y (m)	L (m)
90				1728	1300	0	1300

Estimated Stream Depletion	
t(days)	Q (L/s)
7	0.0
90	0.8



Appendix B

Bore logs and pump test data

WELL #1

BARBER WELL DRILLING SERVICES

TELEPHONE No. (03) 693 1403 **FAX No. (03) 693 1403** **A.H. TELEPHONE No. (03) 693 7066**

Client:	Lindsay & Pauline Kirker	*Driller:*	Sam Richards	*Job No:*	
Company:		*Drilling Method:*	Dual Rotary	*CRC No:*	203740
Address	295 Lowther Rd	*Date:*		*Bore No.:*	
	Lumsden	*Grid Ref / Lot No.:*		*Inv No.*	

Site Location: Lumsden

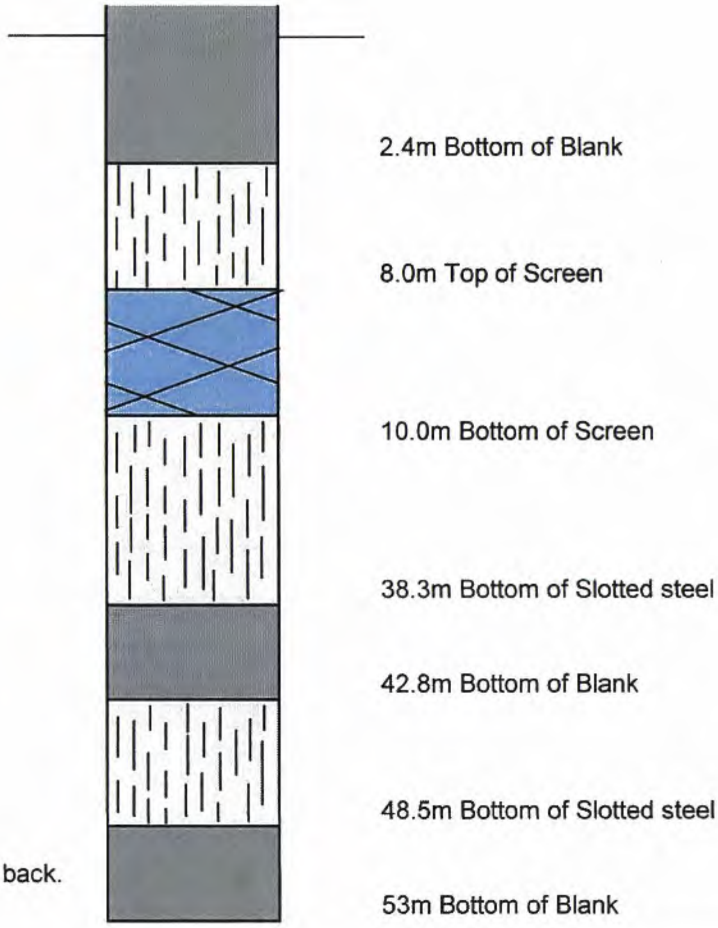
Casing Diam:	250 mm	*Final W.L.:*	1.5 m	*Art'n Head:*	m
Well Depth:	53 m	*Top of Leader:*	m	*Top of casing above g:*	0.5 m

Leader Length: m *Leader Diam:* mm

	Screen Type:	*Slot Size:*	*Diam:*	*Length:*	*Set From:*		
a)	S/Steel	60 °	250 mm	2 m	8.00 m	to	10.00 m
b)		°	mm	m	m	to	m
c)		°	mm	m	m	to	m

Developing Hours:	12 *hrs*	*Pumping Details:*	As per attached Report		
		Flow Rate:	*GPM D/D:*	*m*	*Hrs:*
Pumping Hours:	8 *hrs*	*Flow Rate:*	*GPM D/D:*	*m*	*Hrs:*
		Flow Rate:	*GPM D/D:*	*m*	*Hrs:*

SCREEN DESIGN



Casing drilled to 54m but pulled back.

Environment Southland

Bore Owner: LR & PA Kirker
Address: 295 Lowther Rd
Five Rivers
Lumsden

Bore Consent No: 203740
Map Reference:
Well # 1

Drilling Method Dual Rotary

Depth From	Depth to	Description of strata	Static Water Level
0.0	0.4	Topsoil	
0.4	2.4	Claybound gravels	
2.4	8.0	Claybound gravels some water	
8.0	10.0	Water bearing gravels	1.5m
10.0	48.5	Claybound gravels some water	
48.5	53.0	Thick claybound gravels	

WELL #2

BARBER WELL DRILLING SERVICES

TELEPHONE No. (03) 693 1403 **FAX No. (03) 693 1403** **A.H. TELEPHONE No. (03) 693 7066**

Client:	Lindsay & Pauline Kirker	*Driller:*	Joe Eddy	*Job No:*	
Company:		*Drilling Method:*	Dual Rotary	*CRC No:*	203740
Address	295 Lowther Rd	*Date:*	24/11/2006	*Bore No.:*	
	Lumsden	*Grid Ref / Lot No.:*		*Inv No.*	

Site Location: Five Rivers Lumsden

Casing Diam:	250 mm	*Final W.L.:*	0.5 m	*Art'n Head:*	m
Well Depth:	52.9 m	*Top of Leader:*	0.3 m	*Top of casing above g:*	0.3 m
Leader Length:	5.4 m	*Leader Diam:*	250 mm		

	Screen Type:	*Slot Size:*	*Diam:*	*Length:*	*Set From:*
a)	S/Steel	60 °	250 mm	2 m	5.40 m to 7.40 m
b)	Slotted Steel	°	250 mm	39.5 m	7.400 m to 46.900 m
c)		°	mm	m	m to m

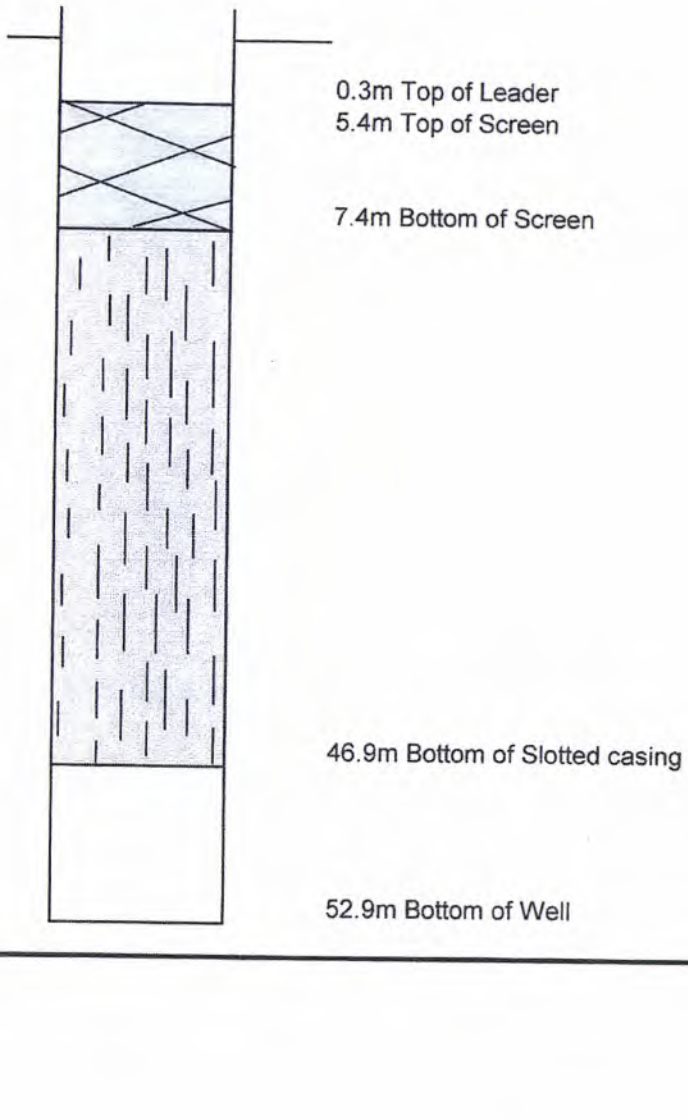
Developing Hours: 15 *hrs*

Pumping Hours: 12 *hrs*

Pumping Details: As per attached Report

Flow Rate:	*GPM D/D:*	*m*	*Hrs:*
Flow Rate:	*GPM D/D:*	*m*	*Hrs:*
Flow Rate:	*GPM D/D:*	*m*	*Hrs:*

SCREEN DESIGN



Environment Southland

Bore Owner:	LR & PA Kirker	Bore Consent No:	203740
Address:	295 Lowther Rd	Map Reference:	
	Five Rivers	Well # 2	
	Lumsden		

Drilling Method Dual Rotary

Depth From	Depth to	Description of strata	Static Water Level
0.0	1.0	Topsoil	
1.0	5.0	Claybound gravels	
5.0	7.0	Water bearing gravels	0.5m
7.0	32.0	Claybound gravels	
32.0	34.0	Claybound gravels some water	0.5m
34.0	42.0	Claybound gravels less water	
42.0	54.0	Claybound gravels water gone	

Form 2 (Bore Log and Aquifer Test)

Otago Regional Council

Bore Log and Aquifer Test Form

Consent No....206930........

Well No.........................

Driller: Barber Drilling - Nigel Kroon

Location (map ref.):

Drilling method: Dual Rotary

Bore Depth: 28.53m

Static Water Level: 1.34

Level Control: Top of casing
(ground/top of bore/other datum)

Water Quality tests:

Bore Owner: LR & PA Kirker

Address: 295 Lowther Rd
R.D.3
Lumsden 9793

Start date: 02/12/2009

Finish date: 08/12/2009

Final Pump Test rate: 15 lps

Other Notes:

Note: A Record of each geological layer penetrated is required

Depth from surface (m)	Description of strata (colour/type etc)	SWL/ Pressure	Water yield from layer	Permeability of layer
0.00 -	As per attached			

P.T.O.

Form 2 (Bore Log and Aquifer Test)

Pump Test Record

- Development - Type: Air — No. of hours: 10hrs
- Casing - Type: Steel — Wall thickness (mm): 9.6mm
  - Diameter (cm): 250mm — Length (m):
  - Diameter (cm): — Length (m):
  - Diameter (cm): — Length (m):
- Screening/Leader - Type: As per attached — Set at (m):
  - Length (m): — Slot size (mm): 1.5mm
- Artesian Flow (l/s) - 15 lps
- Description of Water (appearance/smell) -
- Other Comments -

Pump Testing: Drawdown 17.14 metres after 29.5 hours pumping at 15 l/min.

Pump type: Pump Depth: 24m

Initial static water level: 1.36m Time test commenced:

Time	Drawndown	Pump rate
	As per attached	

Time	Drawdown	Pump rate

BARBER WELL DRILLING SERVICES

TELEPHONE No. (03) 693 1403 **FAX No. (03) 693 1403** **A.H. TELEPHONE No. (03) 693 7066**

Client:	Lindsay & Pauline Kirker	*Driller:*	Nigel Kroon	*Job No:*	
Company:		*Drilling Method:*	Dual Rotary	*CRC No:*	*206930*
Address	295 Lowther Rd Lumsden	*Date:*	8/12/2009	*Bore No.:*	*K027-005*
		Grid Ref / Lot No.:		*Inv No.*	

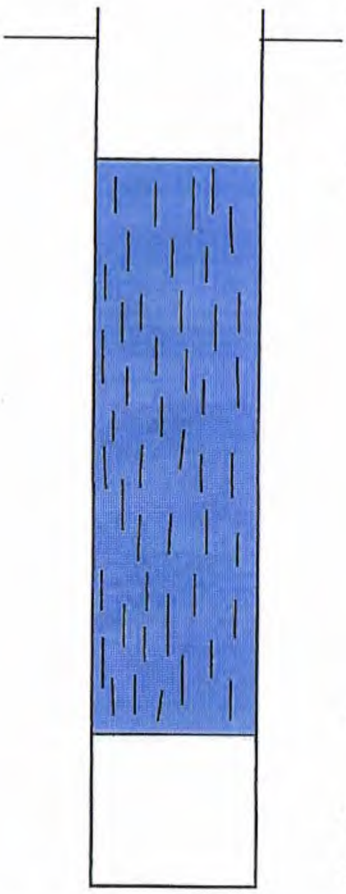
Site Location: Lumsden

Casing Diam:	250 mm	*Final W.L.:*	1.34 m	*Art'n Head:*		m
Well Depth:	28.53 m	*Top of Leader:*	4.3 m	*Top of casing above g:*	0.3	m
Leader Length:	4.3 m	*Leader Diam:*	250 mm			

	Screen Type:	*Slot Size:*	*Diam:*	*Length:*	*Set From:*		
a)	Slotted Steel	1.5 mm	250 mm	20.73 m	1.80 m	to	22.53 m
b)		°	mm	m	m	to	m
c)		°	mm	m	m	to	m

Developing Hours:	9.5 *hrs*	*Pumping Details:*	As per attached Report		
		Flow Rate:	*GPM D/D:*	*m*	*Hrs:*
Pumping Hours:	*hrs*	*Flow Rate:*	*GPM D/D:*	*m*	*Hrs:*
		Flow Rate:	*GPM D/D:*	*m*	*Hrs:*

SCREEN DESIGN



0.3 Above ground

Top of Leader at Top of Casing

1.8m Top of Slotted Steel

11.53m Bottom of Slotted Steel

6m Blank

28.53m Bottom of Well

Bore Log STRATA

Lindsay Kirker

Top	Bottom	Colour	Description	Water Level
0.0	0.3		Topsoil, gravels	
0.3	3.0		Sandy gravels	
3.0	4.0		Wet Claybound gravels	
4.0	8.0		Wet gravels & sand	5.6m
8.0	17.0		Wet gravels, cobbles & sand	3.8m
17.0	21.0		Wet claybound gravels	17m
21.0	30.0		Wet Claybound sandy gravels	25m
30.0	42.0		Damp Claybound gravels tight	41m

BARDER WELLDRILLING SERVICES

Pump Test Details

Clients Name: Lindsay Kirker
Location of Well: Lowther Rd, Lunsden
Well No.: K027/005
Bore permit No.: 206930

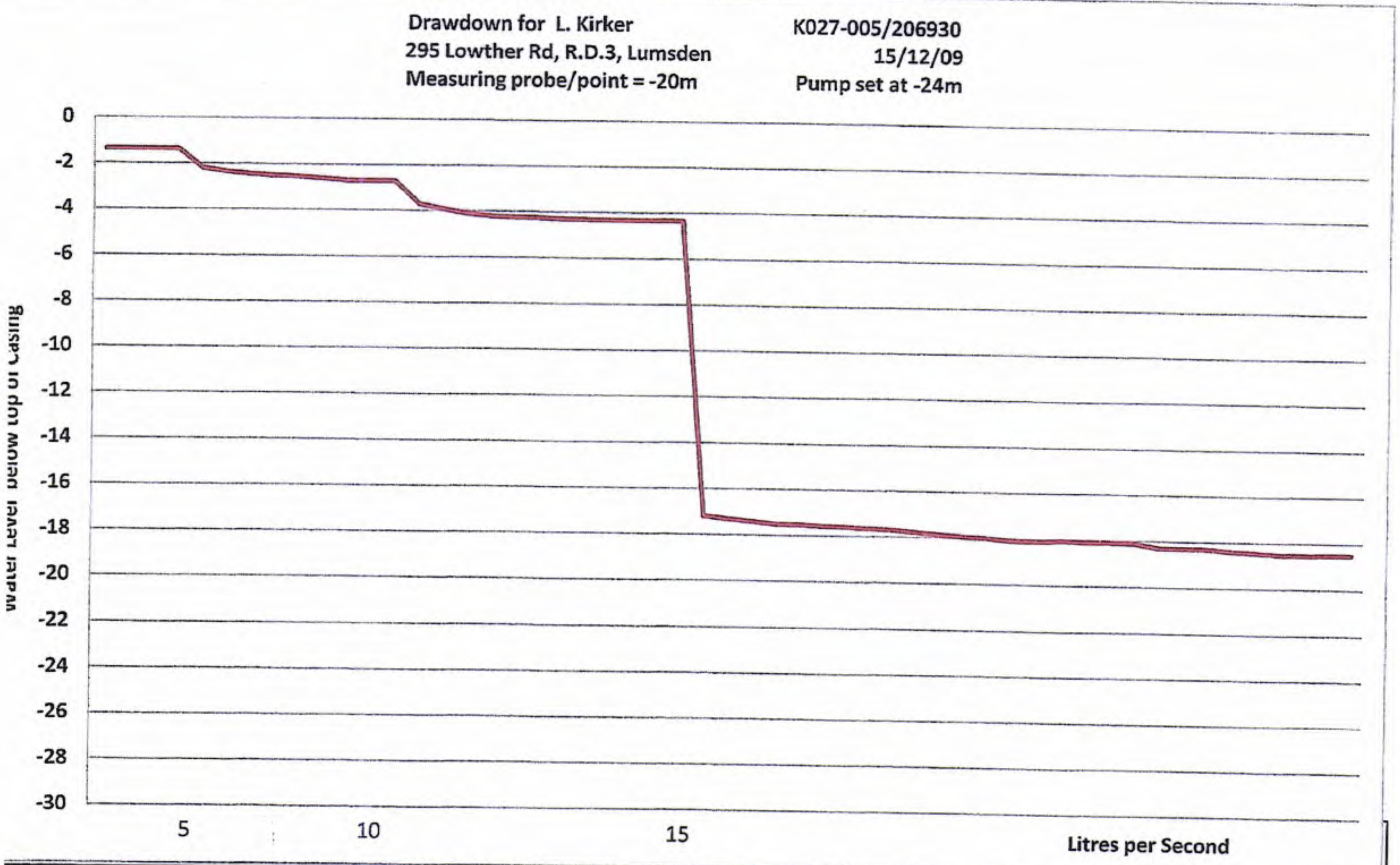
Well Details
Well Depth 28.53m
Screen set from 1.8m to 22.53m
Pump Rate : Lires per second
Test Pump Depth 20.00 + Pump

Starting water level: 1.36m

Measured from TOC

Date	Time	Depth to Water	Pump Rate	Comments
17/12/2009	9.00	-1.36		
	9.05	-1.36		
	9.10	-1.36		
	9.15	-1.36		
	9.20	-2.20	5.0	Start Pumping - Cloudy
	9.25	-2.35	5.0	Cloudy
	9.30	-2.45	5.0	Cloudy
	9.35	-2.50	5.0	Clearing
	9.40	-2.55	5.0	Clearing
	9.45	-2.60	5.0	Clearing
	9.50	-2.68	5.0	Clear
	9.55	-2.70	5.0	Clear
	10.00	-2.70	5.0	Clear
	10.05	-3.70	10.0	Cloudy
	10.10	-3.91	10.0	Cloudy
	10.15	-4.10	10.0	Cloudy
	10.20	-4.20	10.0	Cloudy
	10.25	-4.23	10.0	Clearing
	10.30	-4.26	10.0	Clearing
	10.40	-4.30	10.0	Clearing
	10.50	-4.31	10.0	Clearing
	11.00	-4.32	10.0	Clearing
	11.10	-4.33	10.0	Clear
	11.20	-4.33	10.0	Clear
	11.30	-4.33	10.0	Clear
	11.40	-17.20	15.0	Cloudy
	11.50	-17.30	15.0	Cloudy
	12.00	-17.40	15.0	Cloudy
	12.10	-17.50	15.0	Cloudy
	12.20	-17.53	15.0	Cloudy
	12.30	-17.57	15.0	Clearing
	12.40	-17.61	15.0	Clear
	12.50	-17.65	15.0	Clear
	1.00	-17.70	15.0	Clear
	1.30	-17.80	15.0	Clear
	2.00	-17.88	15.0	Clear
	2.30	-17.95	15.0	Clear
	3.00	-18.00	15.0	Clear
	3.30	-18.10	15.0	Clear
	4.00	-18.10	15.0	Clear

	5.00	-18.05	15.0	Clear - Start Flow Test 24 hrs @ 15 lps
	6.00	-18.10	15.0	Clear
	7.00	-18.10	15.0	Clear
	8.00	-18.11	15.0	Clear
	11.00	-18.31	15.0	Clear
	12.00	-18.31	15.0	Clear
16/12/2009	1.00	-18.31	15.0	Clear
	7.00	-18.40	15.0	Clear
	9.00	-18.44	15.0	Clear
	12.00	-18.50	15.0	Clear
	3.00	-18.52	15.0	Clear
	4.00	-18.50	15.0	Clear
	5.00	-18.50	15.0	Clear
Recovery Rate		18.50 →		6.00m = 1.10 Sec
		6.00 →		3.00m = 1.00 Sec
		3.00 →		2.00m = .38 Sec



The above results relate to the information and the depths to groundwater recorded at the time of testing.
Pump yields will alter with natural changes in climatic conditions and static water level depths.

Otago Regional Council

Bore Log and Aquifer Test Form

Consent No. 206930

Well No. ....

Driller: Barber Drilling - Nigel Kroon

Location (map ref.):

Drilling method: Dual Rotary

Bore Depth: 22.41m

Static Water Level: 1.85m

Level Control: Top of Casing
(ground/top of bore/other datum)

Water Quality tests:

Bore Owner: LR & PA Kirker

Address: 295 Lowther Rd
R.D.3, Lumsden 9793

Start date: 02-12-2009

Finish date: 10-12-2009

Final Pump Test rate: 20 lps

Other Notes:

Note: A Record of each geological layer penetrated is required

Depth from surface (m)	Description of strata (colour/type etc)	SWL/ Pressure	Water yield from layer	Permeability of layer
0.00 -	As per attached			

Pump Test Record

- Development - Type: Air — No. of hours: 10.5hrs
- Casing - Type: Steel — Wall thickness (mm): 9.6mm
  Diameter (cm): 250mm — Length (m):
  Diameter (cm): — Length (m):
  Diameter (cm): — Length (m):
- Screening/Leader - Type: As per diagram — Set at (m):
  Length (m): — Slot size (mm):
- Artesian Flow (l/s) - 20 lps
- Description of Water (appearance/smell) -
- Other Comments -

Pump Testing: Drawdown ....14.10.... metres after ....27.......... hours pumping at ....20....l/min.

Pump type: — Pump Depth: 22m

Initial static water level: 1.45m — Time test commenced:

Time	Drawndown	Pump rate
	As per attached	

Time	Drawdown	Pump rate

BARBER WELL DRILLING SERVICES

TELEPHONE No. (03) 693 1403 **FAX No. (03) 693 1403** **A.H. TELEPHONE No. (03) 693 7066**

Client:	Lindsay & Pauline Kirker	*Driller:*	Nigel Kroon	*Job No:*	
Company:		*Drilling Method:*	Dual Rotary	*CRC No:*	*206930*
Address	295 Lowther Rd Lumsden	*Date:*	9/12/2009	*Bore No.:*	*K027-005*
		Grid Ref / Lot No.:		*Inv No.*	

Site Location: Lumsden

Casing Diam:	250 mm	*Final W.L.:*	1.85 m	*Art'n Head:*	m
Well Depth:	22.41 m	*Top of Leader:*	2.36 m	*Top of casing above g:*	0.42 m
Leader Length:	2.36 m	*Leader Diam:*	250 mm		

	Screen Type:	*Slot Size:*	*Diam:*	*Length:*	*Set From:*		
a)	S/Steel	60 °	250 mm	4.05 m	7.36 m	to	11.41 m
b)		°	mm	m	m	to	m
c)		°	mm	m	m	to	m

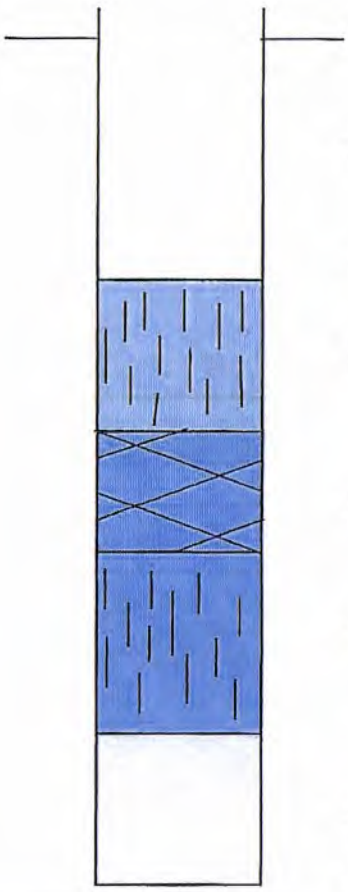
Developing Hours: 10.5 *hrs*

Pumping Hours: 31.5 *hrs*

Pumping Details: As per attached Report

Flow Rate:	*GPM D/D:*	*m*	*Hrs:*
Flow Rate:	*GPM D/D:*	*m*	*Hrs:*
Flow Rate:	*GPM D/D:*	*m*	*Hrs:*

SCREEN DESIGN



0.42 Above ground

2.36m Top of Leader

7.36m Top of Screen

5m slotted 250mm Pipe size

5.04 Stainless Steel 60° Pipesize screens

6m Slotted 250mm Pipesize

5m Blank

22.41m Bottom of Well

Bore Log

Lindsay Kirker

STRATA

Top	Bottom	Colour	Description	Water Level
0.0	0.3	Brown	Topsoil, gravels	
0.3	3.0	Brown	Sandy gravels	
3.0	4.0	Yellow	Claybound gravels	
4.0	6.0	Grey	Wet gravels & sand	4.8m
6.0	7.0	Yellow	Wet weathered gravels & sand	
7.0	13.0	Grey	Wet sandy gravels	6.0m
13.0	18.0	Grey	Wet mixed gravels & sand	3.1m
18.0	24.0		Claybound gravels	3.8m

Pump Test Details

Clients Name: Lindsay Kirker
Location of Well: Lowther Rd, Lunsden
Well No.: K027/005
Bore permit No.: 206930

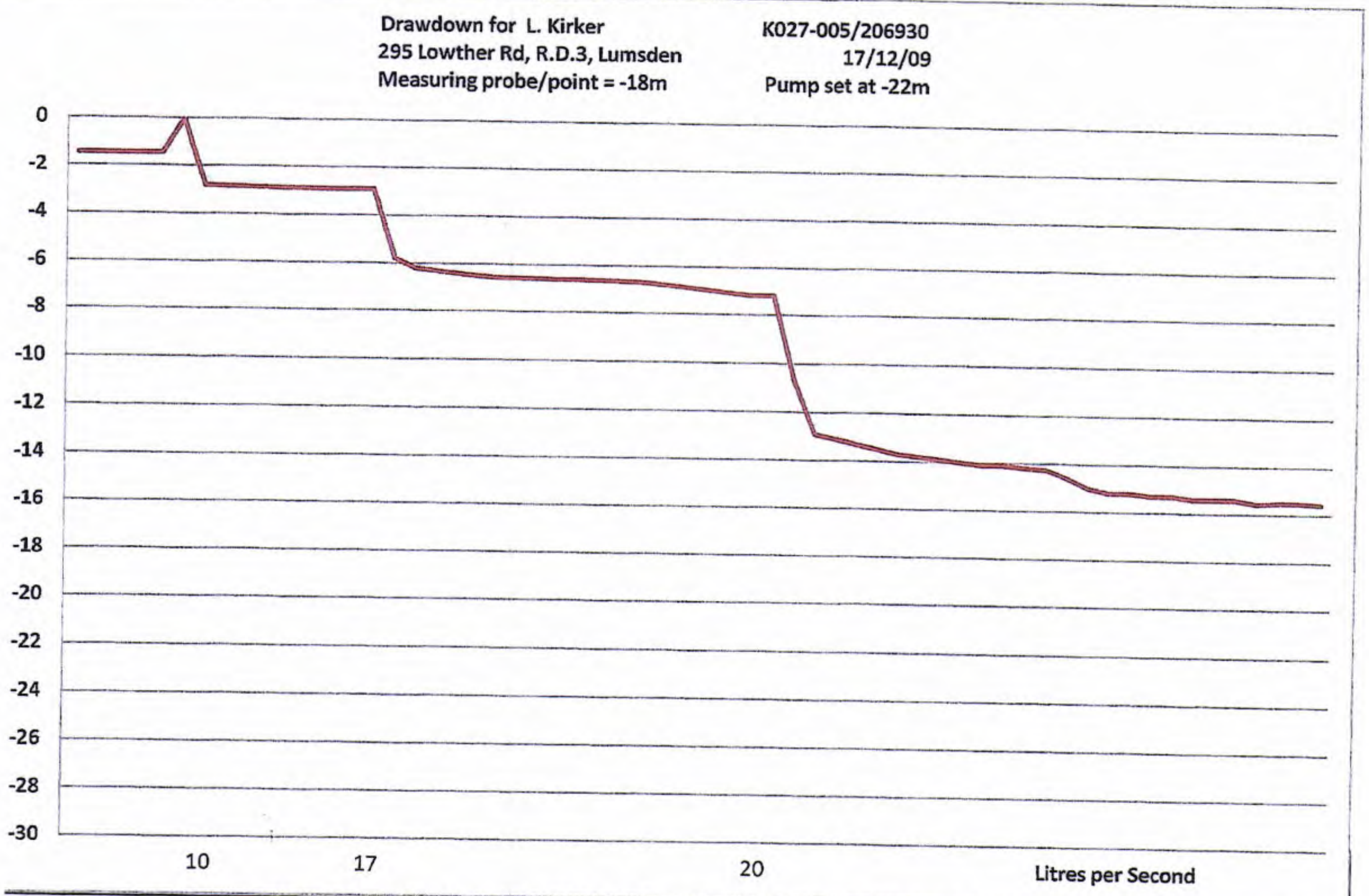
Well Details
Well Depth 22.41m
Screen set from 1.94m to 22.41m
Pump Rate GPM / l/s (delete one)
Test Pump Depth 18.00 + Pump

Starting water level: 1.45m

Measured from TOC

Date	Time	Depth to Water	Pump Rate	Comments
17/12/2009	9.00	-1.45		
	9.10	-1.45		
	9.20	-1.45		
	9.30	-1.45		
	9.40	-1.45		
	9.45	S/D/P	10.0	Start Pumping - Cloudy
	9.50	-2.82	10.0	Cloudy
	9.55	-2.84	10.0	Cloudy
	10.00	-2.86	10.0	Clearing
	10.05	-2.88	10.0	Clearing
	10.10	-2.90	10.0	Clearing
	10.15	-2.91	10.0	Clearing
	10.20	-2.92	10.0	Clear
	10.25	-2.92	10.0	Clear
	10.30	-2.92	10.0	Clear
	10.35	-5.80	17.0	Cloudy
	10.40	-6.20	17.0	Cloudy
	10.45	-6.30	17.0	Cloudy
	10.50	-6.40	17.0	Clearing
	10.55	-6.50	17.0	Clearing
	11.00	-6.56	17.0	Clearing
	11.50	-6.57	17.0	Clearing
	11.10	-6.58	17.0	Clearing
	11.15	-6.60	17.0	Clearing
	11.20	-6.60	17.0	Clear
	11.25	-6.63	17.0	Clear
	11.30	-6.66	17.0	Clear
	11.35	-6.70	17.0	Clear
	12.00	-6.80	17.0	Clear
	12.30	-6.90	17.0	Clear
	1.00	-7.00	17.0	Clear
	1.30	-7.10	17.0	Clear
	2.00	-7.20	17.0	Clear
	2.30	-7.20	17.0	Clear
	2.35	-10.70	20.0	Clear
	2.40	-12.90	20.0	Clear
	2.45	-13.10	20.0	Clear
	2.50	-13.30	20.0	Clear
	2.55	-13.50	20.0	Clear
	3.00	-13.70	20.0	Clear

	3.05	-13.80	20.0	Clear
	3.10	-13.90	20.0	Clear
	3.15	-14.00	20.0	Clear
	3.30	-14.10	20.0	Clear
	4.00	-14.10	20.0	Clear
	5.00	-14.20	20.0	Clear - Start Flow Test 24 hrs @ 20 lps
	6.00	-14.25	20.0	Clear
	8.30	-14.60	20.0	Clear
	10.30	-15.00	20.0	Clear
18/12/2009	12.30	-15.20	20.0	Clear
	1.30	-15.20	20.0	Clear
	2.30	-15.30	20.0	Clear
	3.30	-15.30	20.0	Clear
	7.30	-15.40	20.0	Clear
	9.30	-15.40	20.0	Clear
	10.30	-15.40	20.0	Clear
	1.30	-15.55	20.0	Clear
	3.30	-15.50	20.0	Clear
	4.30	-15.50	20.0	Clear
	5.30	-15.55	20.0	Clear
Recovery Rate		15.55 →	→	6.00m = 45 Sec
		6.00 →	→	3.00m = 20 Sec
		6.00 →	→	2.00m = 1.02 Sec



The above results relate to the information and the depths to groundwater recorded at the time of testing.
Pump yields will alter with natural changes in climatic conditions and static water level depths.

Well I

BARBER WELLDRILLING SERVICES

Pump Test Details

Clients Name: Lindsey Hister
Location of Well: Lowther Rd
Well No.: I
Bore permit No.:

Well Details
Well Depth 53.000 m
Screen set from ____ m to 53.000 m
Pump Rate ~~GPM~~ l/s (delete one)
Test Pump Depth 45.000 + Pump.

Starting water level: 1.450 m

Measured from T/C m

Date	Time	Depth to Water	Pump Rate	Comments
28/11/06	9:45			Check & Warm up.
	10:00	S/O/P	20	Clay
	10:30	4.300	"	"
	11:00	4.750	"	Clearing
	11:30	4.900	"	"
	12:00	5.270	22	Clear
	12:30pm	5.500	"	"
	1:00	5.880	"	"
	1:30	5.600	"	"
	2:30	5.750	22	Clear
	3:00	5.700	"	"
	3:30	5.700	"	"
	3:45	8.500	28	Clear
	4:00	8.300	"	"
	4:30	8.350	"	"
	5:00	8.750	"	"
	5:30	8.700	"	"
	6:00	8.750	"	"
	6:30	8.750	"	"
	7:00	8.700	"	"
	10:00	8.500	27	Clear
	11:10	8.500	"	"
	12:00	8.550	"	"
				ALL NIGHT PUMP.
29/11/06				
	1:10 Pm	8.600	27	Clear
	2:10	8.600	"	"
	3:10	8.800	"	"
	4:10	8.700	"	"
	5:10	8.700	"	"
	6:10	8.610	"	"
	7:00	8.700	"	"
	8:00	8.700	"	"
	9:00	8.650	"	"
	10:00	8.700	"	"
	11:00	8.700	"	"

R/R. 8.700 → 2.000 = :21 Sec

Well II

BARBER WELLDRILLING SERVICES

Pump Test Details

Clients Name: Lyndsey Kirker
Location of Well: Lowther Rd Pemberton
Well No.: II
Bore permit No.:

Well Details
Well Depth 53·000 m
Screen set from ______ m to 53·000 m
Pump Rate GPM / l/s (delete one)
Test Pump Depth 44·000 + Pump

Starting water level: 1·200 m

Measured from T/C m

Date	Time	Depth to Water	Pump Rate	Comments
28/11/06	11:00 pm			Check & Warm up
	11:15	S/D/P	8·3	Cloudy
	11:45	2·250	"	"
	12:00	2·270	"	Clearing
29/11/06	12:30 pm	2·300	8	Clear
	1:00	2·300	"	"
	1:05	3·500	15·75	S/ Cloudy
	1:30	3·600	"	Clearing
	2:00	3·700	"	Clear
	2:30	3·700	"	"
	2:45	5·600	23·3	Clear
	3:00	6·000	"	"
	3:30	6·300	"	"
	4:00	6·650	"	"
	4:30	6·900	"	"
	5:00	7·000	"	"
	5:30	7·000	"	"
	5:45	7·200	25	Clear / Cloudy
	6:00	7·390	"	"
	6:30	7·600	"	Clear
	7:00	7·720	"	"
	9:00	7·980	25	Clear
	10:00	8·000	"	"
	11:00	8·100	"	"
	12:00	8·000	"	"
	1:00pm	8·000	"	"
R/R		8·000	→ 2·000	= :45 SEC

Page no. 1 of 1 pages

Appendix C

Pump test analysis

Copper & Jacob (1946) - Straight Line approximation of Theis

PATTLE DELAMORE PARTNERS

after Kruseman & de Ridder (1976)

Project: 295 Lowther Rd | **Job No:** CJ874504 | **Bore ID:** Bore 1

Test date:	28/11/2006
Test time:	9:45
Performed by:	BDS
Analysed by:	OA
Reviewed by:	KG

Discharge rate (Q):	20	L/s
Observation radius (r):		m
Sat. thickness (B):	38	m
Aquifer type:	Unconfined	

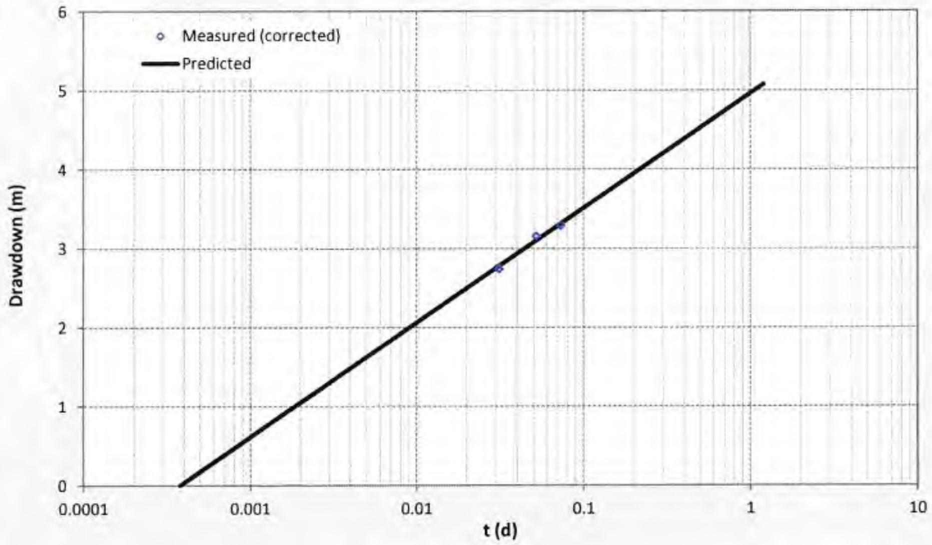
$$s = \frac{2.30Q}{4\pi T} . \log\left(\frac{2.25T.t_0}{r^2 S}\right)$$

Curve fitting:

x-axis intercept (t0):	3.80E-04	d
Δs per log cycle t:	1.45	m

Tranmissivity (T):	218.1	m^2/d
Storativity (S):	N/A	
Hydraulic conductivity (K):	5.74	m/d
Specific storage (Ss):	N/A	1/m

Elapsed time (t)	Drawdown (s)
minutes	m
45	2.85
75	3.3
105	3.45



Notes:
Analysis of dip data for first step

$T = 218\ m^2/d$

Copper & Jacob (1946) - Straight Line approximation of Theis

PATTLE DELAMORE PARTNERS

after Kruseman & de Ridder (1976)

Project: 295 Lowther Rd | **Job No:** CJ874504 | **Bore ID:** Bore 2

Test date:	28/11/2006	**Discharge rate (Q):**	8	L/s
Test time:	9:45	**Observation radius (r):**		m
Performed by:	BDS	**Sat. thickness (B):**	37	m
Analysed by:	OA			
Reviewed by:	KG	**Aquifer type:**	Unconfined	

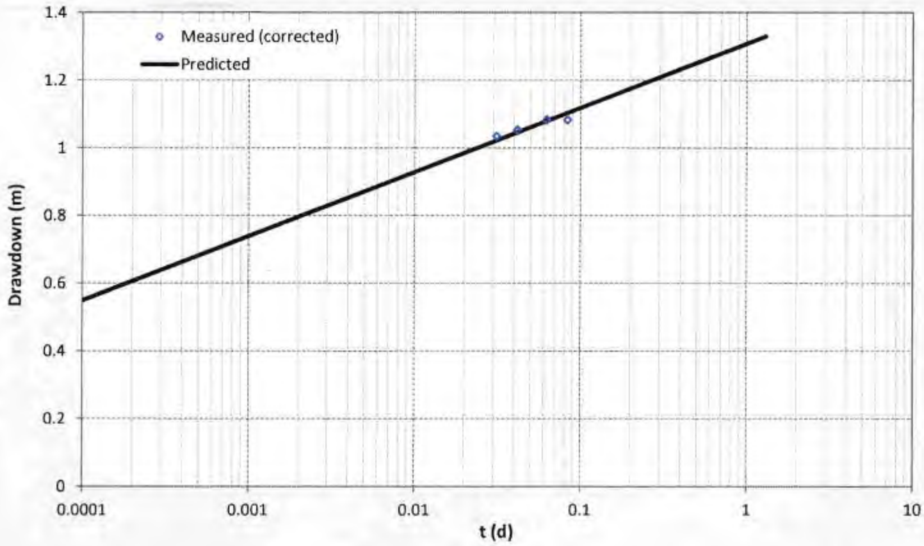
$$s = \frac{2.30Q}{4\pi T} . \log\left(\frac{2.25T.t_0}{r^2 S}\right)$$

Curve fitting:

x-axis intercept (t0):	1.30E-07	d
Δs per log cycle t:	0.19	m

Tranmissivity (T):	665.8	m²/d
Storativity (S):	N/A	
Hydraulic conductivity (K):	18.00	m/d
Specific storage (Ss):	N/A	1/m

Elapsed time (t)	Drawdown (s)
minutes	m
45	1.05
60	1.07
90	1.1
120	1.1



Notes:
Analysis of dip data for first step

T = 666 m²/d

Copper & Jacob (1946) - Straight Line approximation of Theis

PATTLE DELAMORE PARTNERS

after Kruseman & de Ridder (1976)

Project: 295 Lowther Rd | **Job No:** CJ874504 | **Bore ID:** Bore 3

Test date:	17/12/2009
Test time:	9:20
Performed by:	BDS
Analysed by:	OA
Reviewed by:	KG

Discharge rate (Q):	5	L/s
Observation radius (r):		m
Sat. thickness (B):	28	m
Aquifer type:	Unconfined	

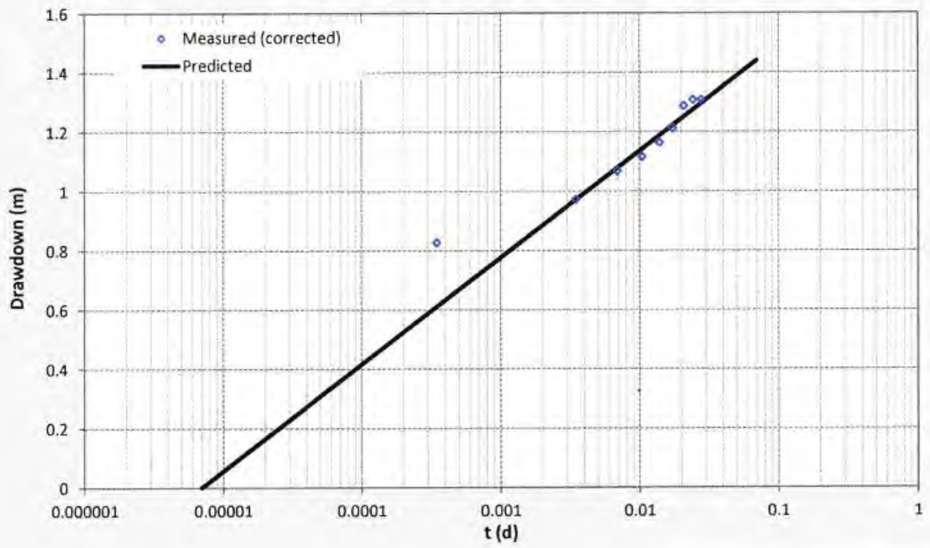
$$s = \frac{2.30Q}{4\pi T} . \log\left(\frac{2.25T.t_0}{r^2 S}\right)$$

Curve fitting:

x-axis intercept (t0):	7.00E-06	d
Δs per log cycle t:	0.36	m

Tranmissivity (T):	219.6	m²/d
Storativity (S):	N/A	
Hydraulic conductivity (K):	7.84	m/d
Specific storage (Ss):	N/A	1/m

Elapsed time (t)	Drawdown (s)
minutes	m
0.5	0.84
5	0.99
10	1.09
15	1.14
20	1.19
25	1.24
30	1.32
35	1.34
40	1.34



Notes:
Analysis of dip data for first step

T = 220 m²/d

Copper & Jacob (1946) - Straight Line approximation of Theis

PATTLE DELAMORE PARTNERS

after Kruseman & de Ridder (1976)

Project: 295 Lowther Rd | **Job No:** CJ874504 | **Bore ID:** Bore 4

Test date:	17/12/2009
Test time:	9:45
Performed by:	TBC
Analysed by:	OA
Reviewed by:	KG

Discharge rate (Q):	10	L/s
Observation radius (r):		m
Sat. thickness (B):	20	m
Aquifer type:	Confined	

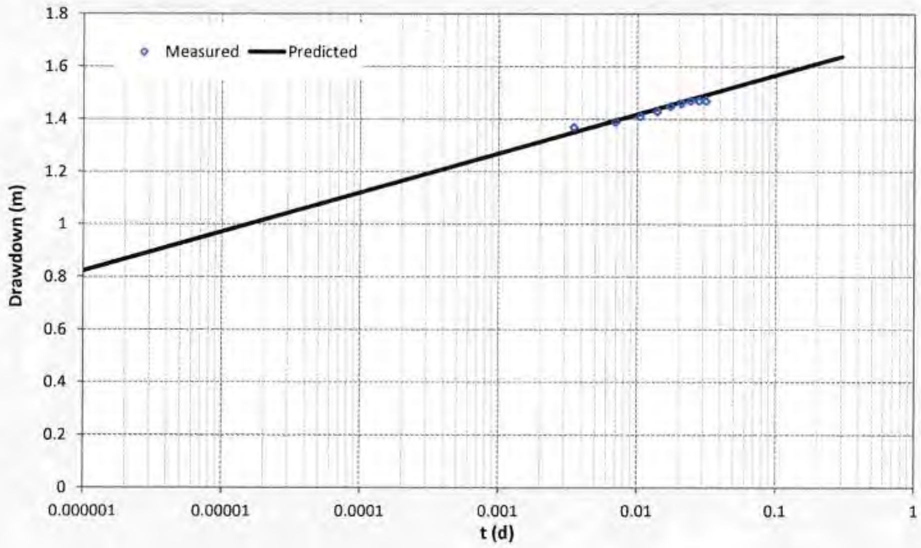
$$s = \frac{2.30Q}{4\pi T} . \log\left(\frac{2.25T.t_0}{r^2 S}\right)$$

Curve fitting:

x-axis intercept (t0):	3.00E-12	d
Δs per log cycle t:	0.149	m

Tranmissivity (T):	1061.3	m²/d
Storativity (S):	N/A	
Hydraulic conductivity (K):	53.07	m/d
Specific storage (Ss):	N/A	1/m

Elapsed time (t)	Drawdown (s)
minutes	m
5	1.37
10	1.39
15	1.41
20	1.43
25	1.45
30	1.46
35	1.47
40	1.47
45	1.47



Notes:
Analysis of dip data for first step

T = 1060 m²/d

Eden-Hazel Method for Step Test Analysis

PATTLE DELAMORE PARTNERS

after Kruseman & de Ridder (1976)

Project: 295 Lowther Road **Job No:** CJ874504 **Bore ID:** Bore 1

Test date:	28/11/2066		
Test time:	9:45		
Performed by:	BDS		
Analysed by:	OA	0.2	
Reviewed by:	KG	0.46	
		2.05	
		-0.9	

Number of steps: 4

Calculated transmissivity (T): 586 m²/d

	Time from:	Time to:	Discharge:
	minutes	minutes	L/s
Step 1:	0	130	20
Step 2:	130	355	22
Step 3:	355	730	28
Step 4:	730	1515	27

Curve fitting:		
a:	0.27	0
b:	0.45	0.58
C:	1.90	2.15
x:	2.1	2
k:	-0.80	-1.31

Ignored data before: 1 min

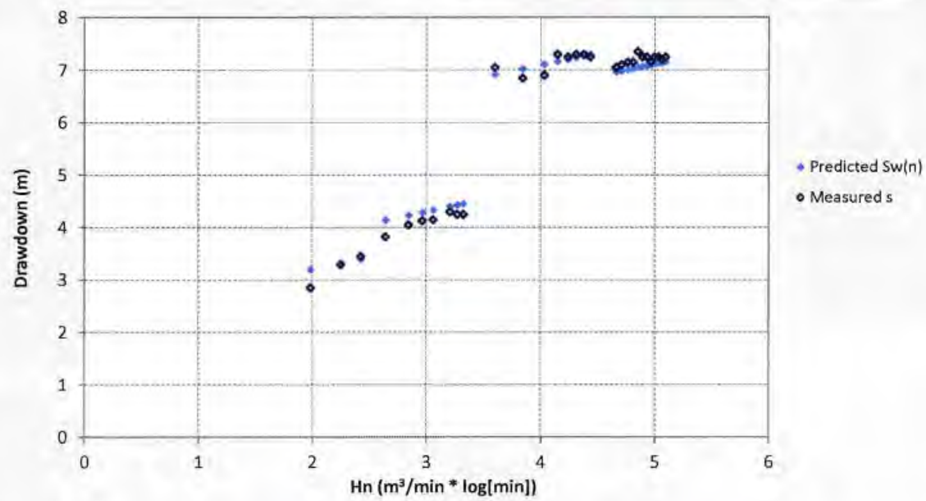
RMS error (s): 0.025 m

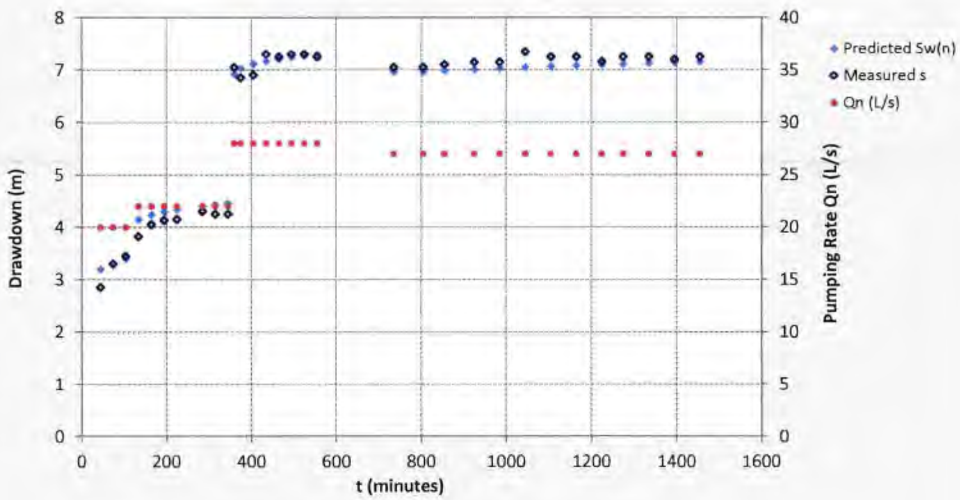
Elapsed time (t)	Drawdown (s)
minutes	m
45	2.85
75	3.3
105	3.45
135	3.82
165	4.05
195	4.13
225	4.15
285	4.3
315	4.25
345	4.25
360	7.05
375	6.85
405	6.9
435	7.3
465	7.25
495	7.3
525	7.3
555	7.25
735	7.05
805	7.05
855	7.1
925	7.15
985	7.15
1045	7.35
1105	7.25
1165	7.25
1225	7.16
1275	7.25
1335	7.25
1395	7.2
1455	7.25

$$S_{w(n)} = aQ_n + bH_n + CQ_n^x + k$$

$$H_n = \sum_{i=1}^{n} \Delta Q_i \log(t - t_i)$$

Sw(n) = Drawdown (m)
Qn = Step discharge (m³/min)
ΔQi = Incremental discharge between steps (m³/min)
t = time since start of test (min)
ti = time since start of current step (min)
a, b, C, x, k = fitting parameters
For analysis of step-drawdown tests in fully confined aquifers and fully penetrating wells.





Well Formula: Sw = (0.27 + 0.45log[t])Q + 1.9Q^2.1 + -0.8

Notes:

Eden-Hazel Method for Step Test Analysis

PATTLE DELAMORE PARTNERS

after Kruseman & de Ridder (1976)

Project: 295 Lowther Rd **Job No:** CJ874504 **Bore ID:** Bore 2

Test date:	29/11/2006
Test time:	9:20
Performed by:	TBC
Analysed by:	OA
Reviewed by:	KG

Number of steps: 4

Calculated transmissivity (T): 220 m²/d

	Time from:	Time to:	Discharge:
	minutes	minutes	L/s
Step 1:	0	120	8
Step 2:	120	220	15.75
Step 3:	220	400	23.3
Step 4:	400	840	25

Curve fitting:

a:	0.00
b:	1.20
C:	0.99
x:	2
k:	-0.35

Ignored data before: 1 min

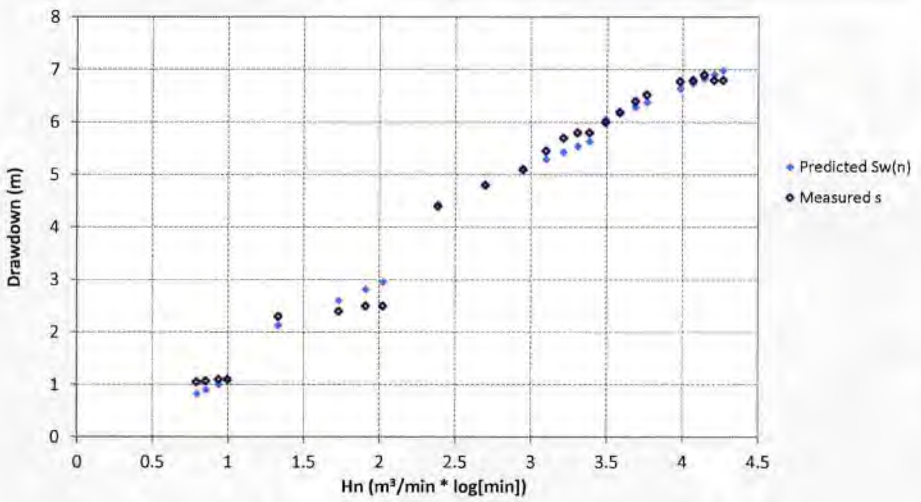
RMS error (s): 0.032 m

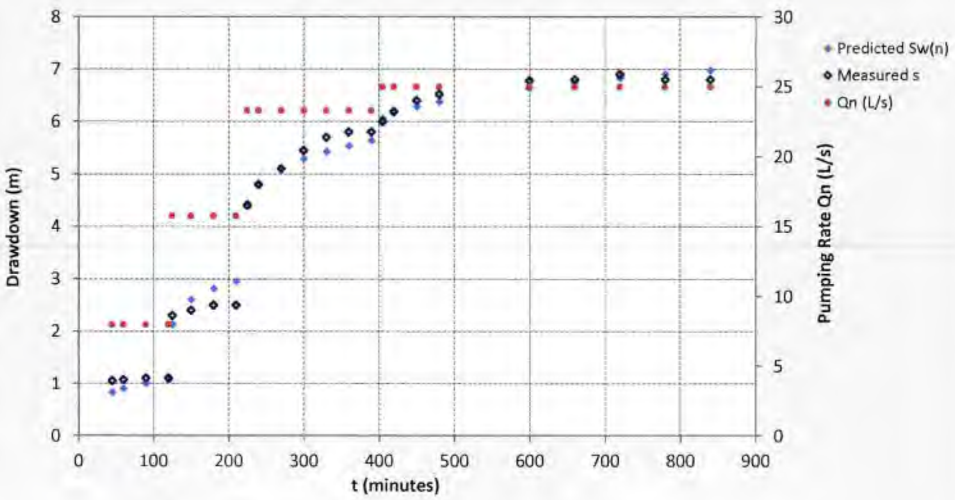
Elapsed time (t)	Drawdown (s)
minutes	m
45	1.05
60	1.07
90	1.1
120	1.1
125	2.3
150	2.4
180	2.5
210	2.5
225	4.4
240	4.8
270	5.1
300	5.45
330	5.7
360	5.8
390	5.8
405	6
420	6.19
450	6.4
480	6.52
600	6.78
660	6.8
720	6.9
780	6.8
840	6.8

$$S_{w(n)} = aQ_n + bH_n + CQ_n^x + k$$

$$H_n = \sum_{i=1}^{n} \Delta Q_i \log(t - t_i)$$

Sw(n) = Drawdown (m)
Qn = Step discharge (m³/min)
ΔQi = Incremental discharge between steps (m³/min)
t = time since start of test (min)
ti = time since start of current step (min)
a, b, C, x, k = fitting parameters
For analysis of step-drawdown tests in fully confined aquifers and fully penetrating wells.





Well Formula: Sw = (0 + 1.2log[t])Q + 0.99Q^2 + -0.35

Notes:

Appendix 4

ES Technical Comment – Karen Wilson – 9 July 2007

bonisch
environmental

Technical Comment

environment SOUTHLAND

Te Taiao Tonga

Environment Southland is the brand name of Southland Regional Council

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Web site www.es.govt.nz

From:	Karen Wilson Groundwater Scientist
Date:	Tuesday, 9th July 2007
File Reference:	K027-005
Subject:	***Water Permit Application –*** ***L R & P A Kirker***

Note:

L R and P A Kirker have applied for a resource consent to abstract groundwater from two production bores located adjacent to Lowther Road, Five Rivers. The application proposes abstraction at a maximum daily rate of 60 L/sec up to 5,184 m^3/day for pasture irrigation over an area of 175 hectares.

1. Environmental Setting

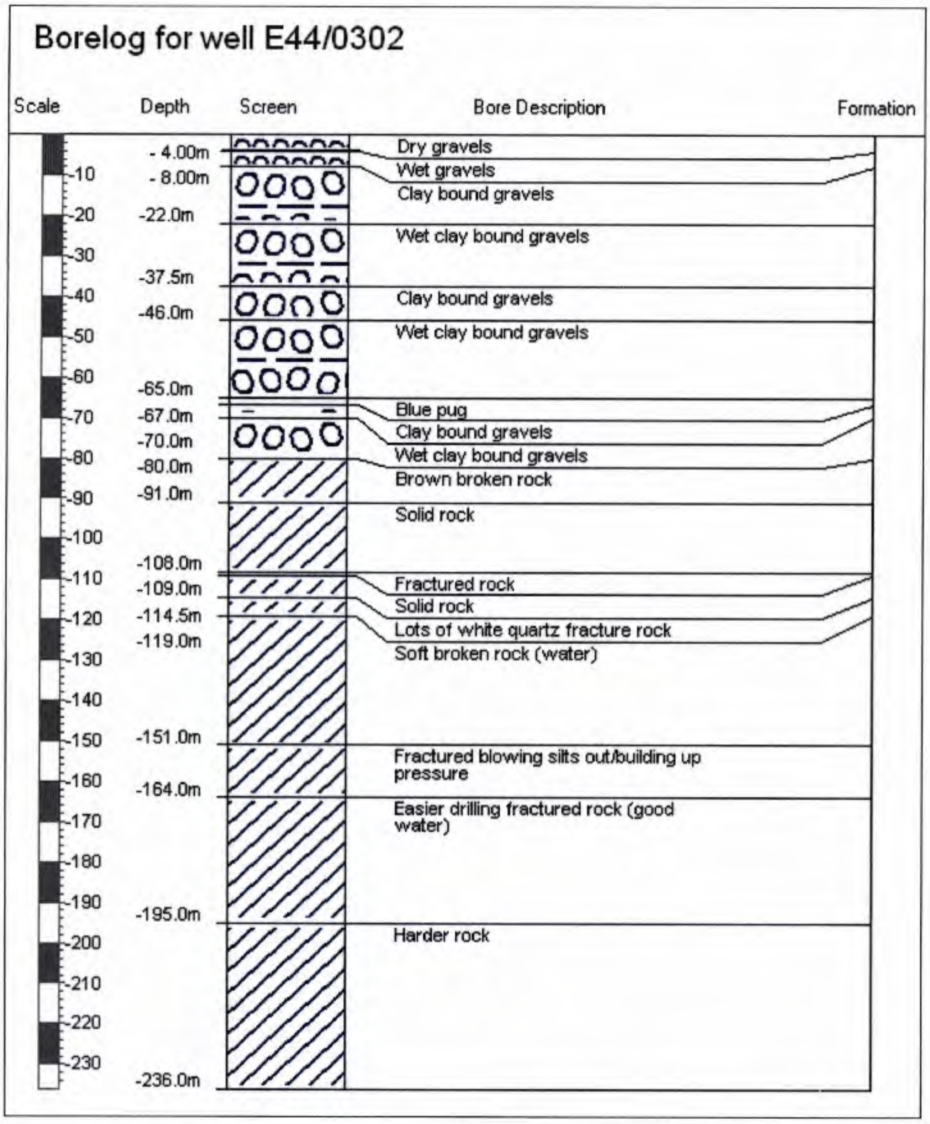
The Five Rivers basin is a large intermountain basin formed by extensive fault movement during the Cretaceous Period. The basin is underlain by basement rocks of two geological terranes and has been infilled by a sequence of Tertiary marine sediments and Quaternary fluvioglacial gravel deposits.

Volcanioclastic sandstone and mudstone sediments of the Caples Group underlie the northern portion of the Five Rivers groundwater zone and grade to the northeast into the semischists of the Haast Group that form the Hector and Garvie Mountains. The southern portion of the Five Rivers groundwater zone is underlain by rocks of the Dun Mountain - Matai terrane and these rocks are extensively faulted.

The alluvial sediments infilling the Five Rivers basin have a relatively complex depositional history reflecting both Quaternary climatic variations as well as the influence of faulting and folding on local drainage patterns. The thickness of these deposits is largely unknown however, based on available drillhole data, at least 80 metres of alluvial gravels are thought to overlie basement throughout the central area of the basin.

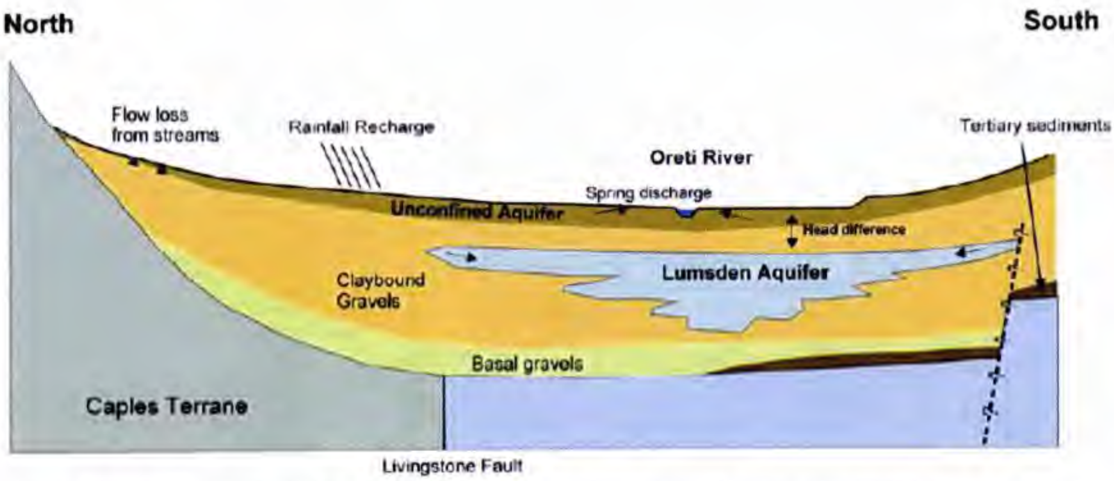
South of Ellis Road the gravel deposits appear to have been reworked by the ancestral Oreti River forming extensive deposits of highly permeable gravels overlain by a significant thickness of tightly claybound gravels. These gravels are overlain by a thin thickness of recent gravel deposits associated with the present Oreti River and tributaries. The gravel upper unit comprises the main groundwater resource of the Five Rivers groundwater zone while the lower gravel deposits forms a separate confined aquifer system known as the Lumsden Aquifer.

The hydrogeology north of Ellis Road is less certain but borelog data show a sequence consistent elsewhere in the basin. Figure 1 shows a borelog from the Kirkers' property which consists of two water-bearing claybound gravel layers between 4 to 37.5 meters and 46 to 65 meters. These units are separated by more tightly claybound gravels. This gravel sequence overlies basal gravels and basement geology which also contains a water-bearing layer within a fractured rock zone.



- **Figure 1 Drillers log from E44/0302 (applicants property) Lowther Road, Five Rivers**

Based on available data it does not appear that the Lumsden Aquifer extends north of Ellis Road. If the deeper water-bearing layer shown in Figure 1 was part of the Lumsden Aquifer, we could expect to observe a potentiometric head of approximately 26 meters below ground (or 209.45 meters above mean sea level) based on extrapolation of a measured hydraulic gradient between Castlerock (E44/0012) and Ellis Road (E44/0252). Given the groundwater level recorded on the borelog for E44/0302 is 3 meters below ground level we can assume E44/0302 did not intercept the Lumsden Aquifer. Other data supports the assumption the Lumsden Aquifer does not extend past Ellis Road with some borelogs showing a largely undifferentiated sequence of claybound gravels to approximately 80 meters that becomes increasingly semi-confined with depth. Rather than being part of the Lumsden Aquifer, it is more likely the water-bearing layer between 46 and 65 meters in Figure 1 reflects a laterally discontinuous channelisation of the ancestral Oreti River.

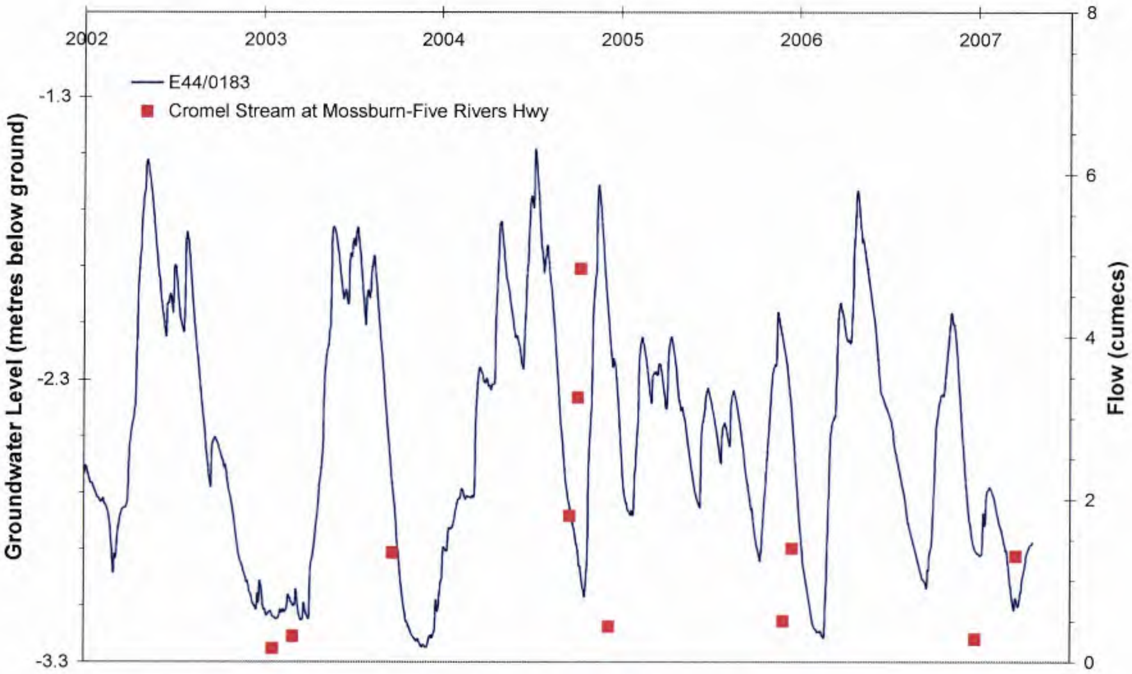


- **Figure 2 Schematic Cross-section of the Five Rivers Basin (source: SKM, 2005)**

The nature of the hydraulic connection between the unconfined aquifer in the Five Rivers groundwater zone and the Lumsden Aquifer is not known, however the significant vertical head differences indicate limited leakage across the claybound gravel under natural conditions. Piezometric contours indicate an overall pattern of groundwater drainage toward the confluence of the Irthing Stream and Oreti River.

Recharge to the confined Lumsden Aquifer occurs via throughflow from the surrounding claybound gravel deposits while the unconfined aquifer in the Five Rivers groundwater zone is recharged by direct rainfall as well as flow loss from streams around the outer margin of the basin. Concurrent gaugings on the Cromel and Acton Streams show as much as 80 percent of the flow is lost as these streams cross the alluvial plain, with anecdotal evidence indicating some sections of streams dry up completely. Gaugings on the Irthing Stream show the stream is a gaining stream with flow increasing by approximately 50 L/sec/km between Mossburn – Five Rivers Hwy and the Lowther Road bridge. This is interpreted to reflect the return of flow lost to groundwater by other streams in the basin as well as drainage from the surrounding alluvial gravel aquifer. The flow losses and gains illustrates the direct hydraulic connection between groundwater and surface water resources in the Five Rivers basin hence classification of the Five Rivers groundwater zone as a riparian aquifer in Appendix H, Variation No. 2 (Groundwater) in the Proposed Regional Freshwater Plan.

Although there is a strong hydraulic relationship between groundwater levels and stream discharge at a catchment scale, this may not occur to such a high degree across all parts of the catchment. This is evident in Figure 3 which shows a poor relationship between flow measurements in the Cromel Stream and groundwater levels at the Mossburn - Five Rivers Hwy. However a poor localised relationship does not preclude the aquifer from being hydraulically connected in these areas as evident by the observed flow losses.



- **Figure 3 Graph of Gaugings on the Cromel Stream and Groundwater Levels at the Mossburn - Five Rivers Hwy**

2. Potential Environmental Effects

Existing Allocation

The preliminary groundwater allocation for a riparian aquifer has been established at 25 percent of the mean annual land surface recharge in Appendix H, Variation No 2 (Groundwater). Estimations by Lincoln Environmental (2003) suggest a groundwater recharge rate of 400mm/year for the Five Rivers groundwater zone and this application will bring the total volume of allocation to 2,357,136 m^3 per year or 5% of the mean annual land surface recharge, as shown in Table 1. It is important to note that the total allocation figure excludes groundwater abstractions screened in the Lumsden Aquifer because confined aquifers are managed as separate systems.

- **Table 1 Current Allocation in the Five Rivers Groundwater Zone and the Oreti Catchment above Lumsden Cableway**

Consent Number	Holder	Well Number	Maximum Abstraction Rate (L/sec)	Maximum Abstraction Rate (m^3/day)	Seasonal Allocation (m^3/year)
Groundwater Takes - Five Rivers Groundwater Zone					
L005[a]	J R Craigie			7,608	2,221,536
200635[a]	M D & D W Heenan	E44/0042		126	36,792
204366[a]	M D & D W Heenan	E44/0096		126	36,792
204568[c]	Waitoru Farm Ltd	E44/0115		168	49,056
204511[c]	L R & P A Kirker	E44/0330 E44/0331	60	5,184	12,960
Total				**13,212**	**2,357,136**
Surface Water Takes – Oreti Catchment upstream of Lumsden Cableway					
L004[a]	JM Hamilton (Estate)	Cromel Stream	63.7	5,504	1,607,168
L006[a]	WJ Humphries (from L004)	Cromel Stream	(45.3)	(3,914)	(1,142,865)
L048[a]	GJ Hamilton	Oreti River	56.6	4,890	1,427,950
200184[b]	Castlerock Dairies Ltd	Murray Creek	38	1,400	350,000
98250	G J Hamilton	Oreti River	340	29,362	2,202,150
97376[a]	SDC	Tank Creek	1.4	120	35,040
203409[a]	Houkura Holdings Ltd	Spring	3.2	280	81,760
201052[d]	W M McMeeken	Roe Burn	1.2	104	26,000
200181[d]	SDC - Mossburn	Oreti River	1.0	83	24,236
Total			**505.1**	**41,743**	**5,754,304**
Surface Water Takes – Oreti Catchment upstream of Wallacetown					
Total			**1,560**		

[a] Assuming 365 days usage assuming average usage of 80 percent of allocation

[b] Assuming 150 days irrigation season with average usage of 60 percent of allocation as not stated in the resource consent

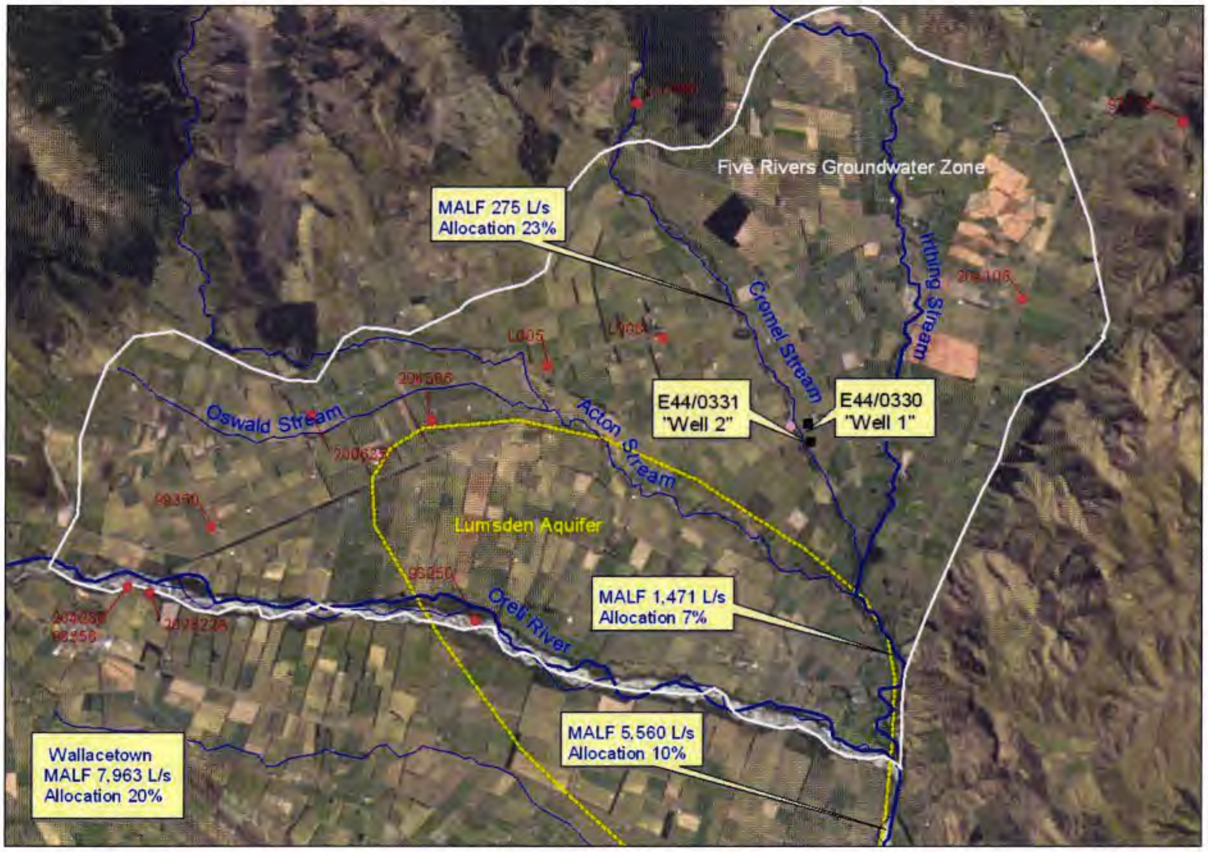
[c] Application

[d] Is the stream depletion component of a direct, high or moderate hydraulically connected groundwater take

In any riparian aquifer there is potential for groundwater abstraction to affect surface water flows. Policy X – Stream Depletion Effects in Variation No. 2 (Groundwater) proposes that a proportion of groundwater abstraction should be counted as surface water allocation depending on the degree of hydraulic connection. Groundwater takes which have a direct or high hydraulic connection are subject to minimum flow cut-off's based on the surface water allocation level.

Variation No. 3 (Water Quantity) sets out a surface water allocation framework based on a portion of mean annual low flow (MALF) at any downstream point in the catchment so estimated by the Southland Regional Council from measurements taken at that point. Environment Southland has three flow recorders downstream of the proposed take. Figure 4 shows the location of two of these sites with respect to the proposed abstraction and it can be seen in this Figure that allocation in the Oreti catchment increases downstream with respect to flow. Surface water allocation ranges from 7 percent of MALF in the Irthing Stream at Ellis Road to 20 percent of MALF in the Oreti River at Wallacetown. Allocation in the Oreti River at Lumsden Cableway is at 10 percent of MALF, and this site is closest to Ram Hill which acts as a natural control for drainage in the Five Rivers basin.

Given allocation in the Oreti catchment is greater than 10 percent of MALF, any minimum flows applied to this application should be determined by a Generalised Habitat Model as described in Appendix I – Methods for Determining Minimum Flows and Levels in Variation No. 3 (Water Quantity).



- **Figure 4 Consented Water Takes and Surface Water Allocation in the Five Rivers Groundwater Zone**

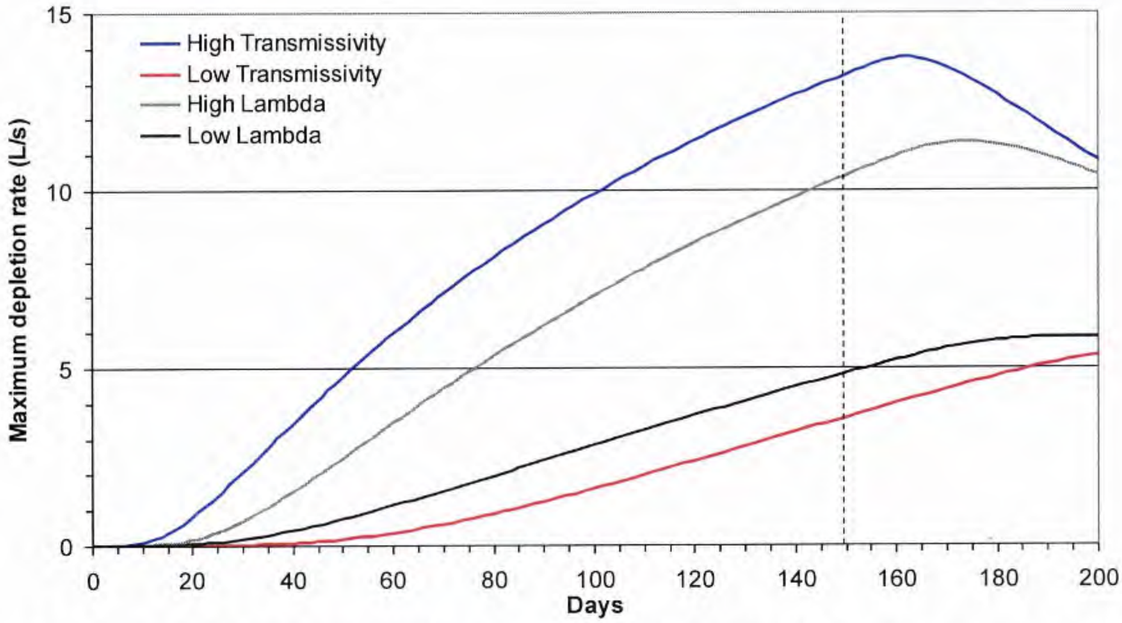
Hydraulic Connection to Surface Water

The abstraction wells are located near the Cromel Stream between the base of the Eyre Mountains and the confluence with the Irthing Stream as shown in Figure 4. As the Cromel Stream emerges from the Eyre Mountains onto the floodplain, flow is lost from the stream into the surrounding aquifer. Anecdotal evidence indicates that during summer up to 3 kilometres of the Cromel Stream downstream of the Mossburn - Five Rivers Hwy can stop flowing and will become a series of disconnected standing pools.

The Stream Depletion Effects Policy in Variation No. 2 (Groundwater) states "*stream depletion effects of groundwater abstractions are to be calculated in relation to the nearest permanent surface water body in hydraulic connection with the aquifer concerned*". Given the Cromel Stream naturally dries up during dry periods, it is the potential depletion of the Irthing Stream, the closest permanent stream, which is most critical to this application.

Calculation of stream depletion effects resulting from groundwater abstraction are sensitive to estimates of streambed conductance (lambda) values. These values reflect the presence of low permeability sediments on the bed of the stream which inhibit the movement of water between the stream and surrounding aquifer. Rough calculations based on concurrent gauging and piezometric survey data indicate the Irthing Stream has a lambda value of between 5 – 10 m/day. This is similar to values applied to other second and third order streams in other resource consent applications in Southland.

Results from the pump test data provided in the application are inconclusive as illustrated by the large variation in hydraulic properties reported for the two abstractions bores (transmissivity equals 279 m^2/day in E44/0330 and 1,017 m^2/day in E44/0331). Transmissivity values are a sensitive component to stream depletion calculations as illustrated in Figure 5 which shows how sensitive stream depletion calculations using Hunt (2003) are sensitive to lambda and transmissivity values.



- **Figure 5 Sensitivity Analysis of Stream Depletion[1] in the Irthing Stream after 150 days Pumping at a Proposed Maximum Seasonal Allocation Rate of 3,110 m^3/day**

Due to the large degree of uncertainty in parameter estimations, stream depletion is between 4 and 13 L/sec. The Irthing Stream gains approximately 50 L/sec/km over the reach closest to the abstraction bores hence it is hydraulically connected to groundwater in this part of the catchment. Given this, it is therefore reasonable to adopt a conservative approach and assess stream depletion as mostly likely being within the range 5 to 10 L/sec. The proposed take therefore defaults to the moderate hydraulic connection category by virtue of the fact that the resulting effect is greater than 5 L/s. The mean annual low flow in the Irthing Stream closest to the abstraction bores is estimated to be 446 L/sec.

[1] High T = 1,000 m^2/day, Low T = 200 m^2/day, High λ = 10 m/day, Low λ = 1 m/day; otherwise the following values were used: T = 500 m^2/day, λ = 5 m/day, Q = 36 L/s, distance = 1,200m

Under Policy X – Stream Depletion Effects, the categories of hydraulic connection show that those with a direct or high degree of hydraulic connection have some benefit to a minimum flow cut off because the aquifer recovery rate is quicker than the rate of stream flow decline/recession. However, in this case, the hydraulic connection is moderate so there is no net benefit to a minimum flow cut off because of the slow rate at which stream depletion effects dissipate following cessation of pumping. This effect can be seen in Figure 4 where although pumping is ceased after 150 days, the calculated rate of stream depletion does not decline below that occurring at the time pumping stops for at least 40 days and thereafter the rate of decline is equally slow.

A stream depletion assessment on the Cromel Stream is not required given the reach near the abstraction wells can become naturally dry. Although the Cromel Stream is known to dry up near the abstraction point, this does not exclude the possibility of adverse effects on the aquatic habitats in the standing pools by affecting the duration, extent and rate of drying. Policy 28 in Variation No. 2 (Groundwater) states groundwater abstractions should be managed to avoid significant adverse effects on aquatic ecosystems and habitats and there has been no consideration of this addressed in the application.

Interference Effects

The nearest bore recorded on the WELLS database (E44/0301) is located approximately 585 metres east of E44/0331 ("Bore 2"). Using conservative estimates of aquifer parameters[2], the drawdown in E44/0301 after 150 days of pumping at a maximum seasonal rate of 3,110 m^3/day is calculated to be 0.96 metres based on the Theis equation. This equates to approximately 3 percent of the saturated thickness of the first hydrological unit, which is well within the 20% saturated thickness drawdown permitted in the Interference Effects Policy in the Groundwater Variation to the Proposed Regional Freshwater Plan.

3. Recommendations

Based on existing information there remains uncertainties regarding the potential adverse effects of the proposed abstraction and because of this, consideration of the following issues should be addressed:

- The addition of a condition setting a maximum combined daily and seasonal allocation limit of 5,184 m^3/day and 466,560 m^3 respectively to be restricted to the existing bores E44/0330 ("Well 1") and E44/0331 ("Well 2").

- The completion of a constant rate pump test including groundwater level monitoring in neighbouring bores where appropriate to provide an indication of the mean aquifer parameters. The pump test should be performed for at least 24 hours at the maximum rate sought in the application.

[2] T = 500 m^2/day, Sy = 0.1, and Q = 3,110 m^3/day

- Although the Cromel Stream can become naturally dry, and as such, does not require a stream depletion assessment, the proposed abstraction may result in adverse effects on the aquatic ecosystems and habitats in the residual pools by affecting the duration, extent and rate of drying. No consideration has been given to this in the application.

References

Lincoln Environmental, 2003. *Southland Water Resources Study – Stages 1 to 3.* Report prepared for Venture Southland. Report No. 4597/1.

Sinclair Knight Merz, 2005. *Hydrogeology of the Oreti Basin.* Report prepared for Environment Southland.

Appendix 5

Summary of soil properties

Summary of soil properties[1]

Soil type	Description	Profile available water	Drainage class	*N leaching*	*Structural vulnerability*	*Waterlogging vulnerability*
Riversdale	Silt to sandy loam	Moderate to low	Well drained	Very severe	Severe	Nil
Gore	Silt loam	Moderate	Well drained	Very severe	Moderate	Nil
Ardlussa	Silty loam	Moderately high	Well drained	Moderate	Moderate	Slight
Lumsden	Silty loam	Moderate	Poorly drained	Very low	Moderate	Severe

1 Data taken from Topoclimate Information Sheets.

Appendix 6

Environment Southland Fact Sheets

1. *Physiographic zones – Riverine, Oxidising & Gleyed*
2. *Soil types –Riversdale, Gore, Ardlussa & Lumsden*
3. *Groundwater zone – Five Rivers*

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Physiographic zone: Riverine

Southland's physiographic zones allow us to better understand why we have variations in water quality in different areas. We've divided Southland into nine different zones according to factors such as soil type, geology and topography. Through them we can target solutions to higher risk areas as opposed to a region-wide, generalised approach.

Understanding your zone

Each zone is different in the way contaminants build up and move through the soil, areas of groundwater, and into our streams and rivers. Physiographic zones allow us to target advice and management strategies to keep farm nutrients on the farm and out of waterways.

The Physiographics of Southland project was developed as part of *Water and Land 2020 & Beyond* so we can better understand:

- where our water comes from
- how water moves through the landscape
- why we have differences in water quality across the region

What does 'Riverine' mean?

The Riverine zone refers to areas adjacent to the main rivers and streams in Southland.

It extends beyond the riparian margin to include floodplains and low elevation terraces.

These areas are strongly influenced by runoff from the Alpine zone.

Key features of the Riverine zone

- Located in northern inland basins and along margins of main rivers to the coast.
- Mostly flat to undulating land located on alluvial terraces and floodplains adjacent to main rivers.
- Steeper slopes occur in headwater areas where this zone extends towards Alpine areas.
- Low denitrifying potential in soils and aquifers.

Water source and movement:

- Main rivers are fed by Alpine zone water, particularly as snow melts during spring.
- Water sourced from a mixture of the Alpine zone and soil water drainage from land adjacent to main rivers and streams.
- Soil water drains quickly through shallow, stony soils to underlying shallow aquifers.
- Aquifers are highly connected to main rivers with water flowing between them in a relatively short space of time.
- Recharge from alpine rivers dilutes local land surface recharge.

Contaminant movement

The Riverine zone receives water from two main sources:

1. The Alpine zone, which has a diluting effect.

2. Intercepting aquifers, which potentially carry contaminants.

River water quality is best closest to alpine areas, where contaminants in rivers and aquifers are diluted by large volumes of pristine alpine water. Water quality declines in downstream areas due to the cumulative discharge of contaminants from surrounding lowland areas.

Soils in the Riverine zone are well-drained with little risk of waterlogging or overland flow. However, there is a severe risk of nitrogen leaching down to aquifers. As rivers make their way down to the coast, the amount of groundwater intercepted increases, which increases the risk of receiving contaminants.

Contaminant concentrations are unlikely to build up in the aquifers themselves due to extensive mixing with river water. However, they can contribute high nitrogen loads to intercepting rivers, which then flow to receiving environments such as lakes, estuaries and lagoons.

What does this mean for water quality?

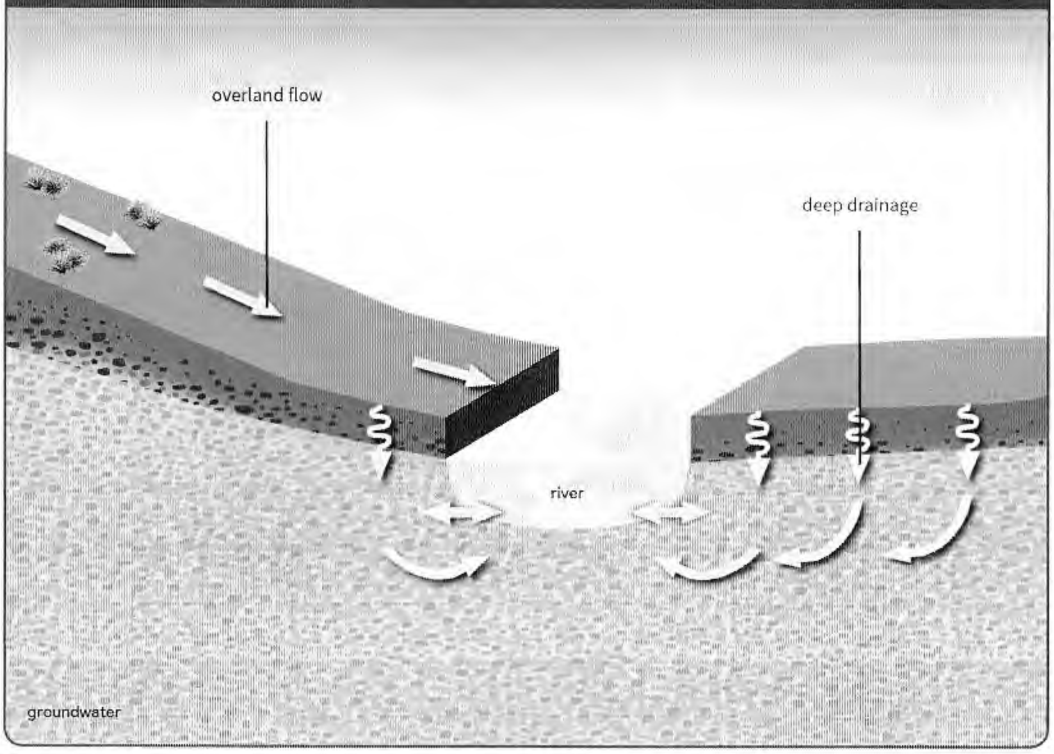
√ Rivers and aquifers are diluted by pristine water coming from the Alpine zone.

√ Contamination from phosphorus, sediment and microbes is generally low.

X Aquifers can contribute nitrogen to intercepting rivers.

X Contaminants flow with rivers to coastal estuaries and lagoons.

Contaminant movement and flow of diluting water from the Alpine zone



▶ Streams in parts of this zone with increased slope are at risk of receiving high levels of nitrogen, phosphorus, sediment and microbes from overland flow. In flatter areas, nitrogen leaching to groundwater via deep drainage is the main contaminant pathway. Aquifers in this zone are highly connected to rivers with water flowing quickly between them.

Improving Southland's water quality

The following good management practices are applicable to all physiographic zones in Southland:

- Capture nutrients, sediment and microbes in wetlands and sediment traps
- Nutrient management
- Riparian management
- Effluent management

Good management in the Riverine zone

In addition to the above, good management in the Riverine zone includes measures for reducing the effects of deep drainage, and overland flow.

Reduce the effects of deep drainage of nitrogen by:

- Reducing the accumulation of surplus nitrogen in the soil, particularly during autumn and winter

Reduce the effects of overland flow by:

- Protecting soil structure, particularly in gullies and near stream areas
- Managing critical source areas (CSA)
- Reducing phosphorus use or loss

Physiographic zones and the Southland Water and Land Plan

Environment Southland has developed a proposed Southland Water and Land Plan, using the science behind the physiographic zones to inform the plan and provide a tailored approach to particular issues that have been identified for each zone.

The main aim of the plan is to introduce new methods that help to halt any further decline in water quality by managing activities that we know adversely affect the quality of Southland's freshwater – such as land use intensification, wintering and stock in waterways. A key focus of the changes is to shift all land owners towards good management practices in ways that will give the best gains for maintaining water quality.

Further information For more information about physiographic zones and good management practices contact Environment Southland. Phone 0800 76 88 45 or email service@es.govt.nz. You can also find out more about the Physiographics of Southland and your zone on our website, www.es.govt.nz.

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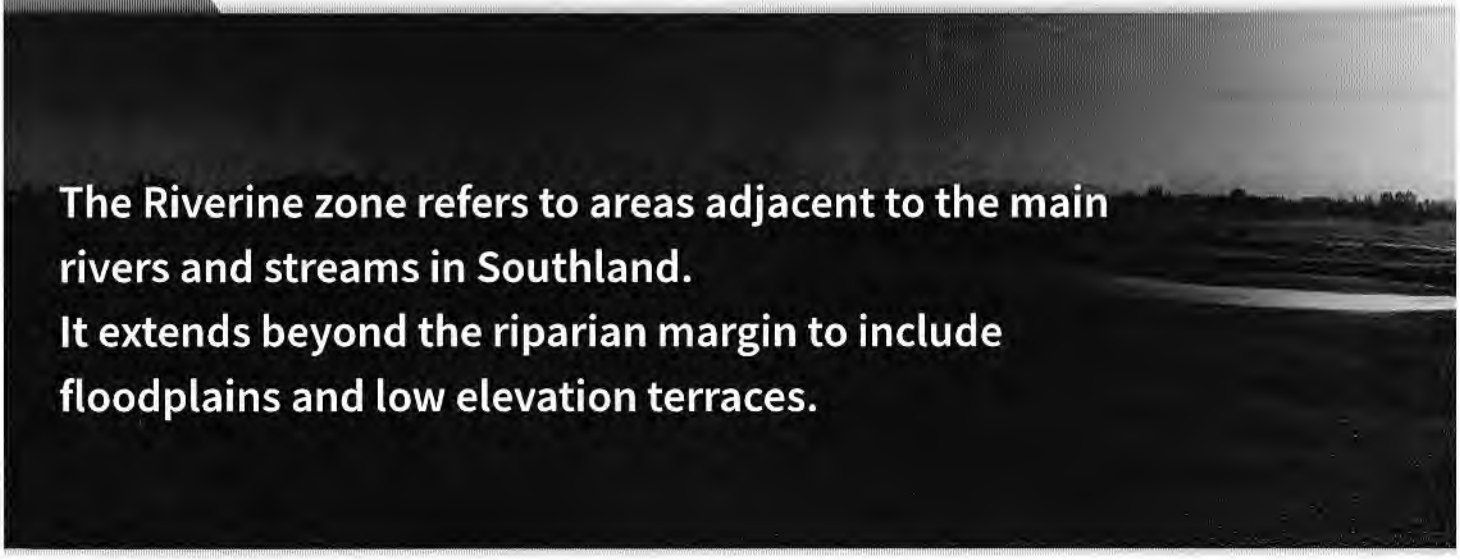

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Physiographic zone: Oxidising

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Understanding your zone

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- where our water comes from
- how water moves through the landscape
- why we have differences in water quality across the region

What does 'Oxidising' mean?

Oxidising means well aerated, with plenty of oxygen.

The Oxidising zone is characterised by soil water and groundwater that contains high levels of oxygen, which allows nitrogen to accumulate.

Key features of the Oxidising zone

- Low elevation, flat to gently undulating land on elevated terraces along the outer margins of the major river systems.
- Also located in inland basins and some lowland areas.
- Soils and aquifers have low denitrification potential.

Water source and movement

- A high density of small streams runs through the zone, which can rise rapidly during heavy rainfall.
- Alluvial deposits contain an extensive groundwater resource.
- Drainage to waterways varies depending on slope, soil texture and permeability.
- Flat, free-draining soils - water seeps straight down to underlying aquifers (areas of groundwater). Groundwater in this zone is 'recharged' (topped up) by rainfall that drains down through the soil.
- Slowly permeable soils may experience seasonal waterlogging. On flatter areas, they will often have artificial drainage when elevated above nearby streams. On more sloping areas, they will often have overland flow.

Contaminant movement

Groundwater in the Oxidising zone is susceptible to nitrate accumulation. Soils and underlying aquifers in the Oxidising zone have little ability to remove nitrogen (via a process called denitrification).

Streams in this zone rise rapidly during heavy rain when soils are wet. Soil water and groundwater carries with it contaminants, which continue to seep into streams after periods of heavy rain.

Oxidised soils can be very good at absorbing and storing water and any nitrogen it contains. During drier months, nitrogen is able to accumulate in soil to high levels. During winter when soils are wet, any nitrogen not used by plants leaches down into the underlying aquifer (deep drainage).

Artificial drainage (mole and tile drains) is used where soils have low subsoil permeability to help to reduce waterlogging. Contaminant loss through artificial drains to nearby streams can be high during wetter months. Overland flow may also occur during periods of heavy rain when soils are wet, especially where soils are sloping.

What does this mean for water quality?

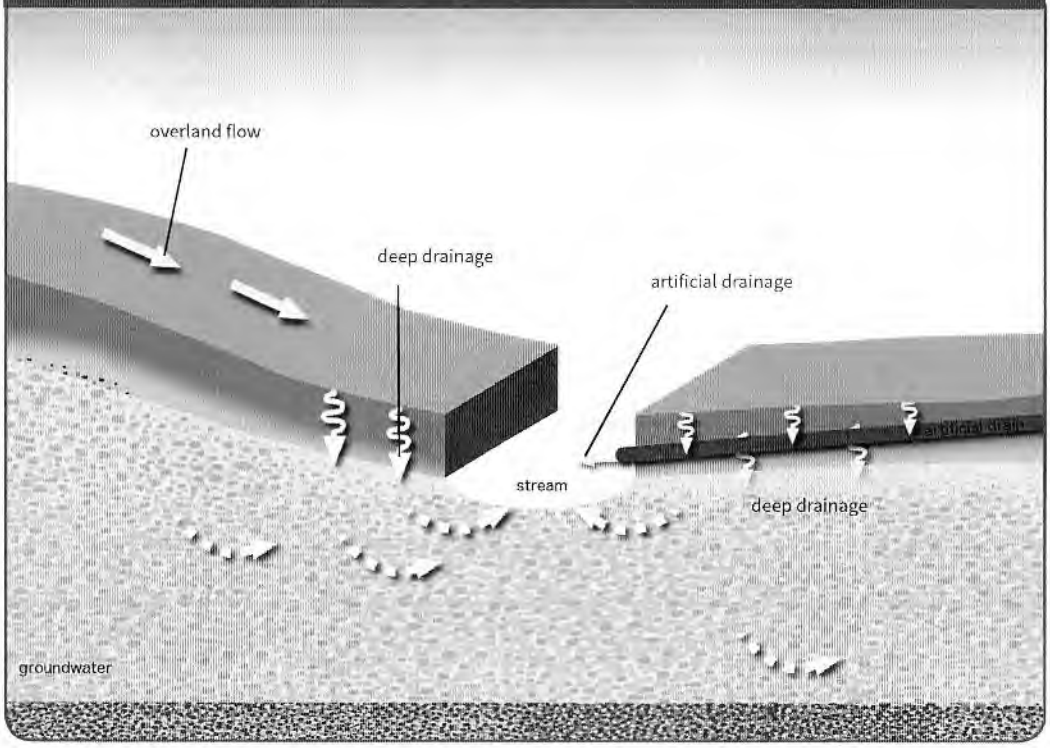
√ Soils have good phosphorus retention.

√ Limited potential for contaminant losses to rivers and streams as deep drainage is the main pathway.

X High risk of nitrogen build-up in groundwater.

X Following heavy or prolonged rainfall, contaminant losses to rivers and streams may occur via overflow or artificial drainage.

Contaminant loss during wet months



▶ Deep drainage (leaching) of nitrogen to groundwater is the main contaminant pathway in this zone. Artificial drainage and overland flow are also important contaminant pathways in some parts of the zone and can carry nitrogen, phosphorus, sediment and microbes.

Improving water quality

The following good management practices are applicable to all physiographic zones in Southland:

- Capture nutrients, sediment and microbes in wetlands and sediment traps
- Nutrient management
- Riparian management
- Effluent management

Good management in the Oxidising zone

In addition to the above, good management in the Oxidising zone includes measures for reducing the effects of deep drainage, artificial drainage and overland flow.

Reduce the effects of deep drainage by reducing the accumulation of surplus nitrogen in the soil, particularly during autumn and winter.

Reduce the effects of artificial drainage by:

- Protecting soil structure, particularly in gullies and near stream areas
- Reducing phosphorus use and loss
- Reducing the accumulation of surplus nitrogen in the soil, particularly during autumn and winter
- Avoiding preferential flow of effluent through drains
- Capturing contaminants at drainage outflows

Reduce the effects of overland flow by:

- Protecting soil structure, particularly in gullies and near stream areas
- Managing critical source areas (CSA)
- Reducing phosphorus use or loss

Physiographic zones and the Southland Water and Land Plan

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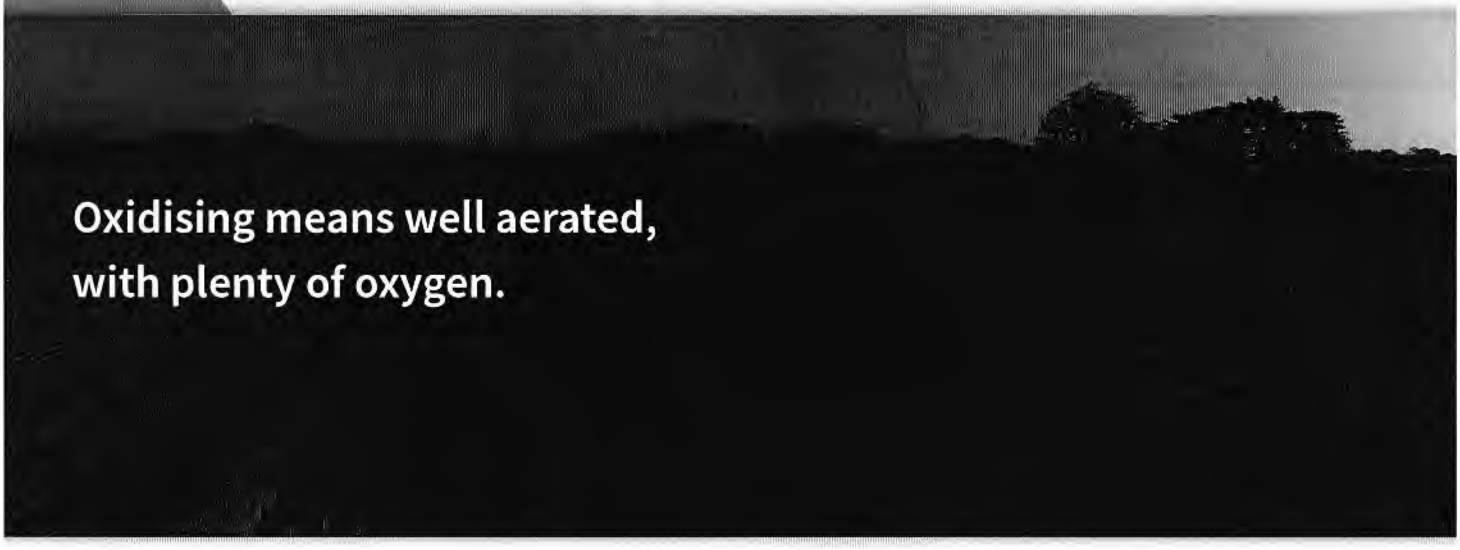

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Physiographic zone: Gleyed

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- why we have differences in water quality across the region

What does 'Gleyed' mean?

The Gleyed zone is found in low-lying areas.

Soils are poorly drained, prone to waterlogging, and have distinctive grey or rust-coloured spots or mottles.

Soils and aquifers can remove some to all nitrogen via denitrification.

Key features of the Gleyed zone

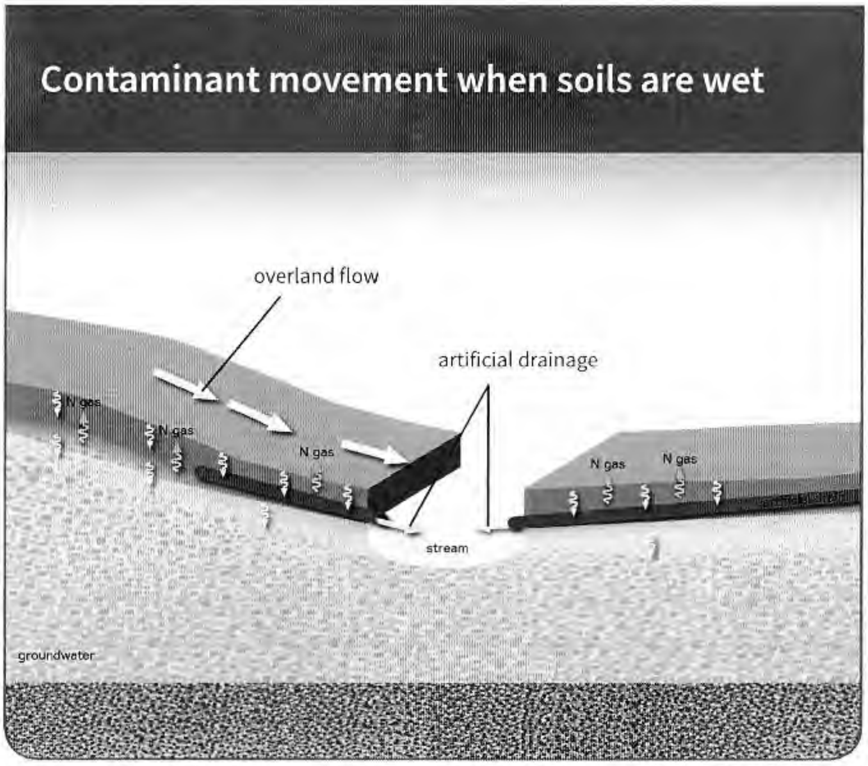
- Low-lying flat to undulating land on alluvial terraces, located between the major river systems on northern and southern plains.
- Generally found in historic wetland areas, and have a high water table during winter that's up to one metre below ground.
- Soils are generally fine textured, prone to water-logging, and have extensive artificial drainage (mole and tile drains).
- Some nitrogen is removed from water infiltrating through the soil zone via denitrification (lost as nitrogen gas).
- Loss of nutrients, sediments and microbes via artificial drains following heavy or prolonged rainfall are a key feature of this zone.
- Water in this zone is not directly linked to any of the major rivers and therefore does not experience dilution from Alpine or pristine Bedrock/Hill Country zones.

Water source and movement

- When soils are wet, excess water from rainfall in flatter areas will flow via an extensive drainage network to nearby streams.
- In undulating areas excess water may also flow across the land surface as overland flow (runoff) during heavy rainfall.
- Some water will slowly make its way down to underlying aquifers.
- Aquifers are shallow and interconnect with streams and drains.

Contaminant movement

Soils may accumulate and store nitrogen during summer and early autumn when soil moisture levels are low. However, some nitrogen will be removed from the soil and aquifers via denitrification (lost as nitrogen gas), resulting in relatively low groundwater nitrate concentrations. Accumulated nitrogen starts moving with water when soils become wet in late autumn and winter and may be lost via artificial drains or overland flow.



During periods of heavy rain, phosphorus, nitrogen, sediment and microbes flow with water overland (overland flow) and via artificial drain networks to neighbouring streams. Some nitrogen is lost to underlying groundwater however the denitrifying ability of soils results in low levels of nitrogen contamination in groundwater.

What does this mean for water quality?

√ Some denitrification may occur within the soil zone.

X Artificial drainage rapidly move excess soil water and contaminants to rivers and streams particularly during heavy rainfall and wet periods.

Improving Southland's water quality

The following good management practices are applicable to all physiographic zones in Southland:

- Capture nutrients, sediment and microbes in wetlands and sediment traps
- Nutrient management
- Riparian management
- Effluent management

Good management in the Gleyed zone

In addition to the above, good management in the Gleyed zone includes measures for reducing the effects of artificial drainage and overflow drainage.

Reduce the effects of artificial drainage by:

- Protecting soil structure, particularly in gullies and near stream areas
- Reducing phosphorus use and loss
- Reducing the accumulation of surplus nitrogen in the soil, particularly during autumn and winter
- Avoiding preferential flow of effluent through drains
- Capturing contaminants at drainage outflows

Reduce the effects of overland flow by:

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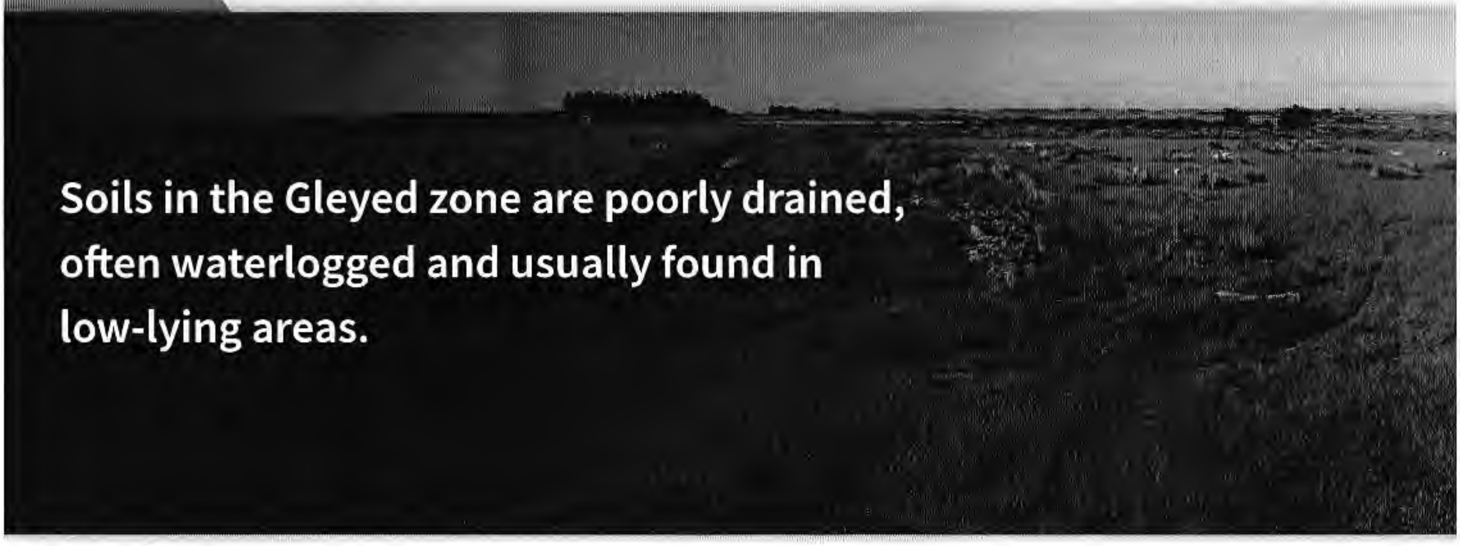

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Soil name: Riversdale

Overview

Riversdale soils occupy about 19,200 ha on the flood plains of the Mataura, Oreti and Pomahaka rivers and their tributaries. They are formed in gravelly alluvium derived from greywacke and schist rocks. Riversdale soils are shallow (<45 cm to gravels) and free draining soils that are still occasionally flooded. They are moderately fertile, with silty to sandy texture, but the rooting depth and water capacity is limited by the gravels. Riversdale soils are used for sheep and dairy production with some cropping, but their versatility is limited by the stoniness and flood risk. Summer rainfall is often sub-optima l and the soils tend to be droughty.

Riversdale profile

Physical properties

Riversdale soils have a moderate to slightly deep rooting depth, depending on the gravelliness of the subsoil. Plant available water will vary from moderate to low depending on the amount of gravels present. The soils are well drained (sometimes excessively) and aerated. Textures are usually silt loams to sandy loams in the topsoil, grading to sand in deeper horizons, with topsoil clay content of less than 18%. Topsoils often are slightly to moderately gravelly, and moderately to extremely gravelly below.

Fertility properties

Topsoil organic matter levels range from 3 to 7%; P-retention values mostly under 15%; pH values are moderate, with little change down the profile. Cation exchange values are moderate in topsoils but low in subsoils; base saturation values are moderate. Values for available calcium, magnesium, potassium and sodium are all low to very low. Phosphorus and sulphur reserves are also low, with good responses to these nutrients. Micro-nutrient levels are generally adequate.

Associated and similar soils

Some soils that commonly occur in association with Riversdale soils are:

- Mataura: gravels occur at greater than 45 cm depth
- Lumsden: also shallow, but poorly drained due to a high water table
- Jacobstown: poorly drained, and gravels occur at greater than 45cm depth
- Howe: on active accumulating floodplain; variable soils due to active flooding

Some soils that have similar properties to Riversdale soils are:

- Upukerora: shallow recent soil on the floodplain of the Aparima and Waiau Rivers (including tributaries), in gravelly alluvium from tuffaceous greywacke and volcanic rocks
- Waiau: shallow soil on floodplain & low terraces of the Aparima and Waiau Rivers (including tributaries); some limited B horizon development
- Gore: shallow soil on low terraces of the Mataura and Oreti Rivers (including tributaries); has a more developed profile.

Sustainable management indicators

Note: the vulnerability ratings given in the table below are generalised and should not be taken as absolutes for this soil type in all situations. The actual risk depends on the environmental and management conditions prevailing at a particular place and time. Specialist advice should be sought before making management decisions that may have environmental impacts. Where vulnerability ratings of Moderate to Very severe are indicated, advice may be sought from Environment Southland or a farm management consultant.

Vulnerability factor	Rating	Vulnerability compared to other Southland soils
Structural compaction	Severe	These soils have a severe vulnerability to structural degradation by long-term cultivation, or compaction by heavy stocking and vehicles. This rating reflects the low clay and P-retention in the topsoil that results in low structural stability.
Nutrient leaching	Very severe	These soils have a very severe vulnerability to leaching to groundwater. This rating reflects the rapid permeability and low water holding capacity.
Topsoil erodibility by water	Slight	Due to the low–moderate clay and organic matter content, erodibility in these soils is slight. Erodibility is highly dependent on management, particularly when there is no vegetation cover.
Organic matter loss	Moderate	Vulnerability to long-term decline in soil organic matter levels is partly dependent on soil properties and highly dependent on management practices (e.g., crop residue management and cultivation practices).
Waterlogging	Nil	These soils have little vulnerability to waterlogging during wet periods. This rating reflects the good drainage and rapid permeability.

General landuse versatility ratings

Note: The versatility ratings in the table below are indicative of the major limitations for semi-intensive to intensive land use. These ratings differ from those used in the past in that sustainability factors are incorporated in the classification. Refer to the Topoclimate district soil map or property soil map to determine which of the soil symbols listed below are applicable, then check the versatility ratings for that symbol in the appropriate table.

RiU3 (Riversdale undulating shallow)

Versatility evaluation for soil RiU3		
Landuse	**Versatility rating**	**Main limitation**
Non-arable horticulture	Limited	Rooting depth and vulnerability to leaching to groundwater
Arable	Limited	Vulnerability to leaching to groundwater
Intensive pasture	Limited	Vulnerability to leaching to groundwater
Forestry	Limited	Rooting depth; risk of flooding

Management practices that may moderate versatility limitations

- Riversdale soils would benefit from flood protection for intensive landuses.
- Cultivation and intensive stocking or vehicular traffic should be minimised during wet periods. Long-term cultivation should be carefully managed to minimise structural degradation
- Organic matter levels should be carefully maintained and enhanced
- Management of nutrient applications that minimise leaching losses

Topoclimate Southland Soil Information Sheet No. **13**

Soil name: Gore

Overview

Gore soils occupy 17,800 ha on the low terraces of the Mataura and Oreti rivers. They are formed in gravelly alluvium containing stones derived from schist and greywacke rock. Gore soils are well drained, with silt loam topsoil texture. Gore soils are stony in both the topsoil and subsoil, which limits the rooting depth and water-holding capacity. They are suitable for pasture and some cropping, being presently used mostly for sheep and dairy production. In northern Southland they can be seasonally dry.

Gore profile

Physical properties

Gore soils have slightly deep rooting depth, with gravels restricting deep rooting. The soils are well drained, with good aeration, and moderate plant available water. Textures are silt loams in the topsoil grading to sandy textures in the subsoil. Topsoil clay content is 20–30%, and typically contains gravels. Subsoils are commonly very to extremely gravelly from 30cm depth.

Fertility properties

Topsoil organic matter levels are 6-8%; P-retention values 30–40%; pH values are moderate and tend to increase down the profile. Cation exchange values are moderate in the topsoil but low in the subsoil, with base saturation following the same pattern. Available cation values for calcium, magnesium, and potassium are very low. Soils respond well to phosphate and potassium fertilisers. Minor nutrient levels are generally adequate.

Associated and similar soils

Some soils that commonly occur in association with Gore soils are:

- Mataura: well drained, deep or moderately deep recent soils found on the accumulating floodplain
- Ardlussa: well drained, deep or moderately deep, found on similar landforms as the Gore soils
- Jacobstown: poorly drained due to high groundwater; deep to moderately deep; silty textures.
- Lumsden: poorly drained; gravels within 45cm depth

Some soils that have similar properties to Gore soils are:

- Riversdale: Recent soils on the accumulating floodplain
- Oreti: Brown soil with cemented subsoil pan on intermediate terraces
- Waiau: Recent soil on floodplains and low terraces of the Aparima and Waiau Rivers and their tributaries.

Sustainable management indicators

Note: the vulnerability ratings given in the table below are generalised and should not be taken as absolutes for this soil type in all situations. The actual risk depends on the environmental and management conditions prevailing at a particular place and time. Specialist advice should be sought before making management decisions that may have environmental impacts. Where vulnerability ratings of Moderate to Very severe are indicated, advice may be sought from Environment Southland or a farm management consultant.

Vulnerability factor	Rating	Vulnerability compared to other Southland soils
Structural compaction	Moderate	These soils have a moderate vulnerability to structural degradation by long-term cultivation and compaction by intensive stocking and vehicles.
Nutrient leaching	Very Severe	These soils have a very severe vulnerability to leaching to groundwater. This reflects the moderate water holding capacity and rapid permeability.
Topsoil erodibility by water	Minimal	Due to the moderate clay and organic matter content, the topsoil erodibility of these soils is minimal. Erodibility is highly dependent on management particulary when there is no vegetation cover.
Organic matter loss	Moderate	Vulnerability to long-term decline in soil organic matter levels is partly dependant on soil properties and highly dependent on management practices (e.g., cultivation practices and crop residue management)
Waterlogging	Nil	These soils have a nil vulnerability to waterlogging during wet periods. This rating reflects the good drainage and rapid permeability.

General landuse versatility ratings

Note: The versatility ratings in the table below are indicative of the major limitations for semi-intensive to intensive land use. These ratings differ from those used in the past in that sustainability factors are incorporated in the classification. Refer to the Topoclimate district soil map or property soil map to determine which of the soil symbols listed below are applicable, then check the versatility ratings for that symbol in the appropriate table.

GeU3 (Gore undulating shallow)
GeU3vi (Gore undulating shallow imperfectly drained variant)
GeU3vh (Gore undulating shallow humose subsoil variant)
GeU3b (Gore undulating shallow bouldery phase)

Versatility evaluation for soil GeU3, GeU3vi, GeU3vh, GeU3b		
Landuse	**Versatility rating**	**Main limitation**
Non-arable horticulture	Limited	Rooting depth and vulnerability to leaching to groundwater
Arable	Limited	Vulnerability to leaching to groundwater
Intensive pasture	Limited	Vulnerability to leaching to groundwater
Forestry	Limited	Rooting depth

Management practices that may improve soil versatility

- Long-term cultivation should be carefully managed to minimise structural degradation
- Organic matter levels should be carefully maintained and enhanced
- Management of nutrient applications so as to minimise leaching losses

Topoclimate Southland Soil Information Sheet **No. 2**

Soil name: Ardlussa

Overview

Ardlussa soils occupy about 6,700ha on the slowly accumulating floodplains and low terraces of the major rivers in northern Southland and west Otago. They are formed into moderately deep to deep fine alluvium over gravel. These soils are generally well drained, with good rooting depth. Ardlussa soils are suitable for a wide range of farming activities. Climate is temperate with occasional dry periods during some summers.

Ardlussa profile

Physical properties

These soils have a moderately deep potential rooting depth, limited by gravel and high density in the subsoil. Ardlussa soils have moderately high available water and are well drained, with few aeration limitations except in the imperfectly drained variant, which can be wet in winter. Textures are generally light silt loams, with clay content of 15-25% in the topsoil. The deep phase will have deep rooting depth and high plant readily available water.

Fertility properties

Topsoil organic matter levels are 4-7%; P-retention values 25-45%; pH values mostly above 5.5; moderate to low cation exchange capacity and base saturation values, which decrease down the profile. Natural reserves of phosphorus, potassium, sulphur, and magnesium are low to moderate. Micro-nutrient levels are generally adequate.

Associated and similar soils

Some soils that commonly occur in association with Ardlussa soils are:

- Mataura: well drained, deep or moderately deep recent soils found on the accumulating floodplain
- Gore: well drained stony soils found on similar landforms as the Ardlussa soils
- Jacobstown: poorly drained due to high groundwater. Silty textures.
- Fleming: poorly drained due to water perching on fragipan

Some soils that have similar properties to Ardlussa soils are:

- Winton: occurs on low terraces and floodplains in the lower Oreti Valley, south of Dipton. Forming into alluvium, but have clayey textures and P-retention of less than 30%.
- Charlton: imperfectly drained soils of the Mataura Valley, south of Gore. Equivalent soil to the Ardlussa, imperfectly drained variant.
- Crookston: occurs on intermediate to high terraces. Although they have similar NZSC, Crookston soils are formed on windblown loess of greater than 45cm depth.

Sustainable management indicators

Note: the vulnerability ratings given in the table below are generalised and should not be taken as absolutes for this soil type in all situations. The actual risk depends on the environmental and management conditions prevailing at a particular place and time. Specialist advice should be sought before making management decisions that may have environmental impacts. Where vulnerability ratings of Moderate to Very severe are indicated, advice may be sought from Environment Southland or a farm management consultant.

Vulnerability factor	Rating	Vulnerability compared to other Southland soils
Structural compaction	Moderate	These soils have a moderate vulnerability to structural degradation by long-term cultivation, or compaction by heavy stocking and vehicles. This rating reflects the good drainage, but low clay and P-retention in the topsoil that results in low structural stability. The imperfectly drained variant will have severe vulnerability
Nutrient leaching	Moderate	These soils have a moderate vulnerability to leaching to ground water. The vulnerability is due to the moderate permeability and moderately high water holding capacity.
Topsoil erodibility by water	Slight	Due to the low clay content, the topsoil erodibility of these soils is slight. Erodibility is highly dependent on management, particularly when there is no vegetation cover.
Organic matter loss	Slight	Vulnerability to long-term decline in soil organic matter levels is partly dependent on soil properties and highly dependent on management practices (e.g., crop residue management and cultivation practices)
Waterlogging	Slight	These soils have slight vulnerability to waterlogging during wet periods. This rating reflects the good drainage and moderate permeability. The imperfectly drained variant will have moderate vulnerability to waterlogging.

General Landuse versatility ratings

Note: The versatility ratings in the table below are indicative of the major limitations for semi-intensive to intensive land use. These ratings differ from those used in the past in that sustainability factors are incorporated in the classification. Refer to the Topoclimate district soil map or property soil map to determine which of the soil symbols listed below are applicable, then check the versatility ratings for that symbol in the appropriate table.

AdU2 (Ardlussa undulating moderately deep)
AdU1 (Ardlussa undulating deep)
AdU1vi (Ardlussa undulating deep, imperfectly drained variant)

Versatility evaluation for soil AdU2, AdU1, AdU1vi		
Landuse	**Versatility rating**	**Main limitation**
Non-arable horticulture	Moderate	Subsoil root penetrability for deep rooting crops
Arable	Moderate	Vulnerability to soil structure degradation and risk of flooding
Intensive pasture	Moderate	Vulnerability to soil structure degradation and risk of flooding
Forestry	Low	Risk of flooding

AdU2vi (Ardlussa undulating moderately deep, imperfectly drained variant): as above, except that main limitations for arable and non-arable horticulture are inadequate aeration for sustained periods and vulnerability of topsoil to structural degradation by cultivation and compaction.

Management practices that may improve soil versatility

- Cultivation and intensive stocking or vehicular traffic should be minimised during wet periods.

Soil name: Lumsden

Overview

Lumsden soils occupy about 2800 ha on the floodplains of major streams and rivers in northern and central Southland and in west Otago. They are formed in shallow fine alluvium overlying gravels from greywacke and schist rocks. They are shallow, silty, poorly drained soils that have a high water table. Present use is pastoral farming with sheep, deer, beef cattle and dairy, with some cropping. Climate is cool temperate with warm summers in northern Southland. Soils seldom dry out.

Lumsden profile

Physical properties

Lumsden soils have a shallow rooting depth and moderate plant available water that is limited by the subsoil gravelliness. Permeability is slow, with poor aeration due to the high water table. Textures are silt loams grading to coarser loamy sands at depth. Topsoil clay content is 25–35%, with a slight to moderate gravel content. Subsoils are very to extremely gravelly.

Fertility properties

Topsoil organic matter content is 6-7%; P-retention 20–45% and pH moderate (mid/high 5s). Cation exchange is high and base saturation low. Available calcium levels are moderate and magnesium and potassium levels low. Reserve phosphorus and sulphur levels are also low. Micronutrient levels are generally adequate although molybdenum responses in legumes and boron responses in brassicas can be expected.

Associated and similar soils

Some soils that commonly occur in association with Lumsden soils are:

- Jacobstown: moderately deep to deep Gley soil
- Riversdale: well drained, shallow Recent soil
- Howe: variable depth, well drained accumulating Recent soil of the active floodplain

Some soils that have similar properties to Lumsden soils are:

- Caroline: shallow to moderately deep, with a thick cemented ironpan
- McLeish: forming in tuffaceous greywacke alluvium, and has clayey textures

Otepuni: forming predominantly into quartz gravels on stream floodplains of the Southland Plain

Sustainable management indicators

Note: the vulnerability ratings given in the table below are generalised and should not be taken as absolutes for this soil type in all situations. The actual risk depends on the environmental and management conditions prevailing at a particular place and time. Specialist advice should be sought before making management decisions that may have environmental impacts. Where vulnerability ratings of Moderate to Very severe are indicated, advice may be sought from Environment Southland or a farm management consultant.

Vulnerability factor	Rating	Vulnerability compared to other Southland soils
Structural compaction	severe	These soils have a severe vulnerability to structural degradation by long-term cultivation, or compaction by heavy stocking and vehicles. This rating reflects the poor drainage and low P-retention.
Nutrient leaching	moderate	These soils have a moderate vulnerability to leaching to groundwater. This rating reflects the slow permeability and poor drainage, but only moderate water holding capacity.
Topsoil erodibility by water	slight	Due to the moderate organic matter and clay content, topsoil erodibility in these soils is slight. Erodibility is highly dependent on management, particularly when there is no vegetation cover.
Organic matter loss	severe	Vulnerability to long-term decline in soil organic matter levels is partly dependent on soil properties and highly dependent on management practices (e.g., crop residue management and cultivation practices).
Waterlogging	severe	These soils have a severe vulnerability to waterlogging during wet periods. This rating reflects the poor drainage and slow permeability.

General landuse versatility ratings

Note: The versatility ratings in the table below are indicative of the major limitations for semi-intensive to intensive land use. These ratings differ from those used in the past in that sustainability factors are incorporated in the classification. Refer to the Topoclimate district soil map or property soil map to determine which of the soil symbols listed below are applicable, then check the versatility ratings for that symbol in the appropriate table.

LmU3 (Lumsden undulating shallow)

Versatility evaluation for soil LmU3		
Landuse	**Versatility rating**	**Main limitation**
Non-arable horticulture	Limited	Inadequate aeration during wet periods; restricted rooting depth
Arable	Limited	Inadequate aeration during wet periods; short-term waterlogging after heavy rain
Intensive pasture	Limited	Short-term waterlogging after heavy rain
Forestry	Limited	Inadequate aeration during wet periods; flooding risk

Management practices that may improve soil versatility

- Careful management after heavy rain and wet periods will reduce the impact of short-term waterlogging. Intensive stocking, cultivation and heavy vehicle use should be minimised during these periods.
- Installation of subsurface tile drains and ditches will reduce the risk of short-term waterlogging.
- If compaction occurs, aeration at the correct moisture condition and depth can be of benefit
- Organic matter levels should be carefully maintained and enhanced

Five Rivers

GROUNDWATER ZONE INFORMATION SHEET

Hydrogeology

The alluvial sediments infilling the Five Rivers basin have a relatively complex depositional history reflecting both Quaternary climatic variations as well as the influence of faulting and folding on local drainage patterns. The thickness of these deposits is largely unknown however, based on available drillhole data, at least 80 metres of alluvial gravels are thought to overlie basement throughout the central area of the basin.

In the northern portion of the Five Rivers groundwater zone the Quaternary gravel sequence is poorly stratified consisting of up to 80 metres of poorly sorted claybound gravel deposits. Near the Cromel Stream a 52 metre investigation bore drilled by Environment Southland encountered a largely undifferentiated sequence of claybound gravels.

South of Ellis Road the gravel deposits appear to have been reworked by the ancestral Oreti River forming extensive deposits of highly permeable gravels overlain by a significant thickness of tightly claybound gravels. In turn this claybound gravel unit is overlain by a thin (~10 metre) thickness of recent gravel deposits associated with the present Oreti River and tributaries. The upper unconfined aquifer comprises the main groundwater resource of the Five Rivers groundwater zone while the lower gravel unit forms a separate confined aquifer system known as the Lumsden Aquifer.

The nature of the hydraulic connection between the unconfined aquifer in the Five Rivers groundwater zone and the Lumsden Aquifer is not known, however the significant vertical head differences indicate limited leakage across the claybound gravel under natural conditions.

Piezometric contours indicate an overall pattern of groundwater drainage toward the confluence of the Irthing Stream and Oreti River.

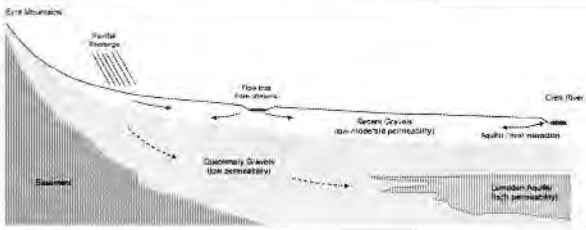

Figure 2: Schematic cross-section of the Five Rivers Groundwater Zone.

Recharge and discharge

Recharge to the Five Rivers groundwater zone occurs from a combination of rainfall recharge and river recharge from the Oreti River and tributaries. During the winter months rainfall recharge events occur relatively frequently resulting in an overall increase in aquifer storage volume. During summer and autumn when soil moisture is below field capacity, groundwater levels gradually decline as water is progressively drained from the aquifer system. Lincoln Environmental (2003) calculated a mean annual land surface recharge of 400 mm/year for the Five Rivers groundwater zone.

Many of the Oreti River tributaries which cross the Five Rivers groundwater zone interact with the surrounding unconfined aquifer. During summer these streams lose water to the surrounding aquifer helping to maintain a "base" aquifer level characteristic of riparian aquifers. During winter and spring this situation is reversed with local streams and associated springs draining groundwater from the unconfined aquifer across a majority of the Five Rivers area.

There are also numerous springs and surface drainage in the downgradient portion of the groundwater zone. Spring-fed streams mostly originate adjacent to the Acton and Cromel Streams below Mossburn-Five Rivers Highway, although there are several large springs which occur along Ellis Road near the Irthing Stream – Oreti River confluence.

Five Rivers

GROUNDWATER ZONE INFORMATION SHEET

Groundwater zone: Five Rivers

Aquifer type: Riparian

Size: 13,795 ha

Allocation status: Low

environment SOUTHLAND
Te Taiao Tonga

water

Extent

The Five Rivers groundwater zone encompasses a roughly triangular area bounded by the Oreti River to the south, the Lintley Ranges to the east and the Eyre Mountains to the north. The area is crossed by a number of streams, namely the Acton, Oswald, Dillston, Cromwell and Irthing Streams which drain into the Oreti River upstream of the State Highway 94 bridge. These streams appear to have a significant influence on groundwater levels in the Five Rivers groundwater zone providing recharge to the aquifer close to the basin margins and significant groundwater drainage closer to the Oreti River.

Groundwater Quality

Groundwater quality is generally very good with the "best" water along the riparian margins and towards the northern extent of the groundwater zone. After very intensive rainfall events the top of the aquifer can become contaminated as nutrients are flushed through the soil. Bores which are less than 10 metres deep or have poor well head protection are susceptible to this type of contamination which is why Environment Southland recommends all bores be screened at the base of an aquifer.

Poor wellhead protection is a significant issue in Southland. Inappropriate location, construction and maintenance of bores and wells can lead to localised groundwater contamination, particularly in regards to bacterial and nutrient concentrations. Contact Environment Southland for more information.

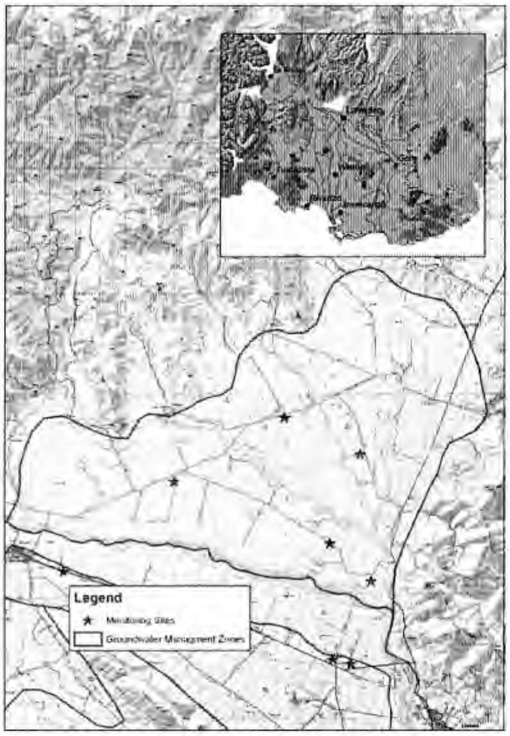

Figure 1: Map of the Five Rivers Groundwater Zone (above).

Hydrogeology

The Five Rivers area occupies a large intermountain basin formed by extensive fault movement during the Cretaceous Period. The basin is underlain by basement rocks of two geological terranes and has been infilled by a sequence of Tertiary marine sediments and Quaternary fluvioglacial gravel deposits.

Volcanioclastic sandstone and mudstone sediments of the Caples Group underlie the northern portion of the Five Rivers groundwater zone. These sediments grade to the northeast into the semischists of the Haast Group that form the Hector and Garvie Mountains. The southern portion of the Five Rivers groundwater zone is underlain by rocks of the Dun Mountain - Matai terrane. These rocks are extensively faulted and in part represent remnants of a slice of Early Permian oceanic crust (gabbro and peridotite of the Dun Mountain Ultramafics Group) and associated volcanics and volcanioclastic sediments (the Livingstone Volcanics Group). Outcrop of these rocks is restricted to areas along West Dome to the north of Mossburn.