BEFORE THE CANTERBURY REGIONAL COUNCIL

IN THE MATTER OF	the Resource Management Act 1991
A N D	
IN THE MATTER OF	Water permit applications by Simons Pass Station Limited and Simons Hill Station Limited, Rosehip Orchards New Zealand Limited and High Country Rosehip Orchards Limited

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STATEMENT OF EVIDENCE OF IAN MCINDOE
DATED 18 NOVEMBER 2009

INTRODUCTION

Background and Qualifications

1. My full name is Ian McIndoe. My qualifications and experience have been presented to you in my Mackenzie Water Research Ltd (MWRL) evidence on 22 September 2009.

Code of Conduct

2. I have read the Code of Conduct for Expert Witnesses (Rule 330A, High Court Rules and Environment Court Practice Note) and agree to comply with it. I confirm that I have complied with it in the preparation of this statement of evidence.

Scope of Evidence

3. I have prepared this evidence at the request of Pukaki Irrigation Co Ltd, Simons Hill Station Ltd, Simons Pass Station Ltd, Rosehip Orchards NZ Ltd and High Country Rosehip Orchards Ltd.

4. My evidence covers the following:
   a) Overall description of the proposed activity from an irrigation perspective.
   b) Justification for the proposed take (reasonable use).
   c) Explanation of efficient use.
   d) Hydrological effects of the take and use of water on groundwater and surface water resources.
   e) Response to submissions relevant to my evidence.
   f) Response to S42a reports relevant to my evidence.

Review of Documents

5. In preparing this evidence, I have reviewed the following documents:
   a) Waitaki Catchment Water Allocation Regional Plan (WWAP).
   b) The Canterbury Regional Council Proposed Natural Resources Regional Plan (PNRRP)
   c) The MWRL WQS reports (August 2009).
   d) The evidence of Dr Val Snow, Mr Titus Smith., Dr Melissa Robson, Mr Graeme Ogle.
   e) The evidence of Mr Denis Fastier.
   f) The original AEE's prepared for Simons Hill, Simons Pass and Pukaki Irrigation Company by Aqualinc Research Ltd (Aqualinc).
   g) The original AEE's prepared for Rosehip Orchards New Zealand Ltd and High Country Rosehip Orchards Ltd by Irrigation Resource Solutions Ltd (IR Solutions).
   h) The Farm Environmental Management Plans (FEMP) prepared by Melissa Robson for the properties.

6. This evidence is presented in the following order:
   a) Simons Pass Station Ltd and Simons Hill Station.
   b) Rosehip Orchards New Zealand Ltd – ("Rosehip Orchards") and High Country Rosehip Orchards Ltd – ("High Country")

7. Information common all to properties is included in the appendices at the end of this document.

SIMONS HILL & SIMONS PASS

Overview of Pukaki irrigation scheme

Overall Concept

8. Pukaki Irrigation Company Ltd is proposing to develop a water supply scheme (the Pukaki Irrigation Scheme) to provide water for irrigation, stockwater, dairy shed and domestic use, to parts of Simons Hill Station, Simons Pass Station, Catherine Fields and Maryburn Station, as shown in Figure 1. The possible sources of water being considered for the Scheme are the Tekapo Canal, Lake Pukaki or the Pukaki Canal.

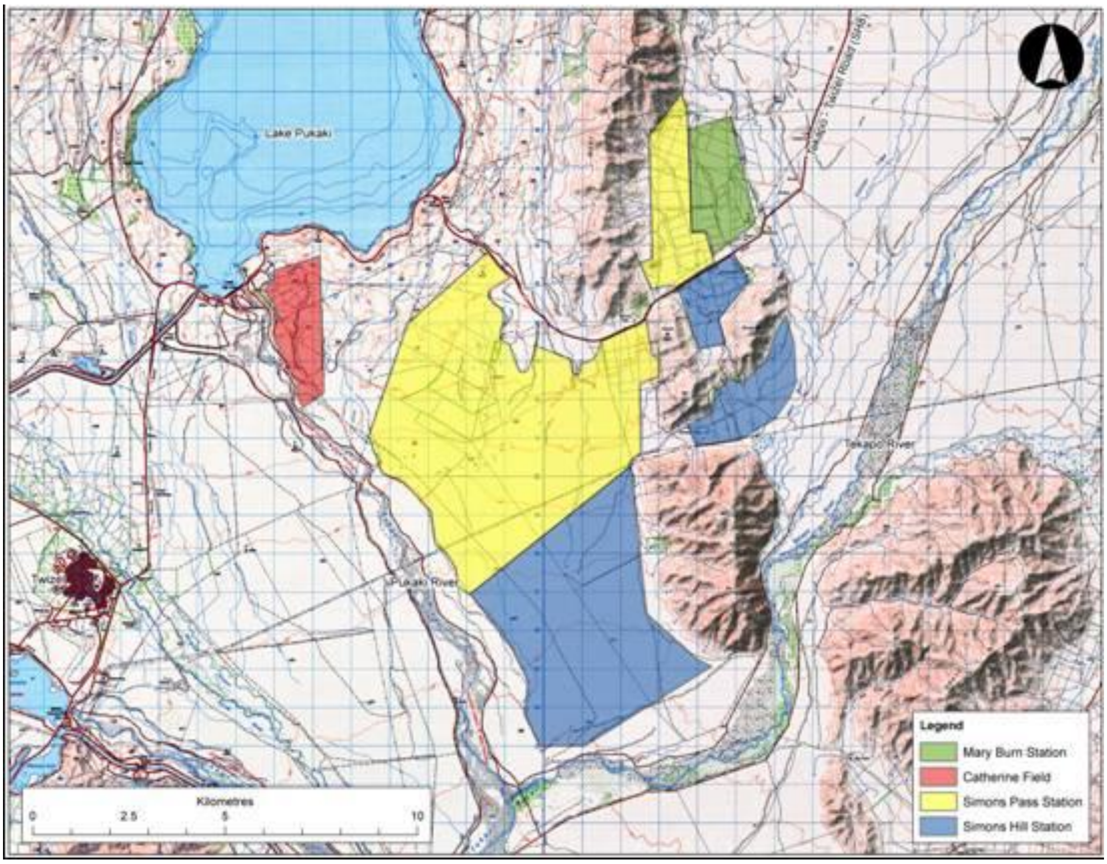

Figure 1: Property locations

9. Simons Pass and Simons Hill Stations are separated by the Mary Range into two areas. The primary proposed irrigation command area is referred to as Pukaki Flats, and is located south-east of Lake Pukaki and State Highway (SH8), between the Pukaki River, the Tekapo River and Mary Range. The secondary area is located to the east of the Mary Range, and is bisected by SH8.

10. The actual areas to be irrigated within the overall command areas are shown in Table 1.

Table 1: Simons Hill and Simons Pass proposed irrigated areas

	Proposed irrigated area
Simons Hill west of Mary Range (Pukaki Flats)	1735 ha
Simons Hill east of Mary Range	491 ha
Subtotal	2226 ha
Simons Pass west of Mary Range (Pukaki Flats)	2287 ha
Simons Pass east of Mary Range (incl Mary Range Farming)	287 ha
Subtotal	2574 ha
TOTAL	**4800 ha**

11. The properties jointly propose to take water either at a maximum rate of 3,062 ℓ/s, 264,560 m^3/d and up to 28,800,000 m^3/y annually from the Pukaki Canal or Lake Pukaki, or at a maximum rate of 2,796 ℓ/s, 241,574 m^3/d and up to 29,162,660 m^3/y annually from the Tekapo Canal, for irrigation of up to 4,800 ha of land, and for stockwater and domestic use.

Water Supply / Scheme Options

12. The location of the three scheme options is shown in Figure 2. Full details of the intake and distribution proposals are given in the evidence of Mr Smith. The final decision as to which intake option will be chosen will be made once the consents have been obtained.

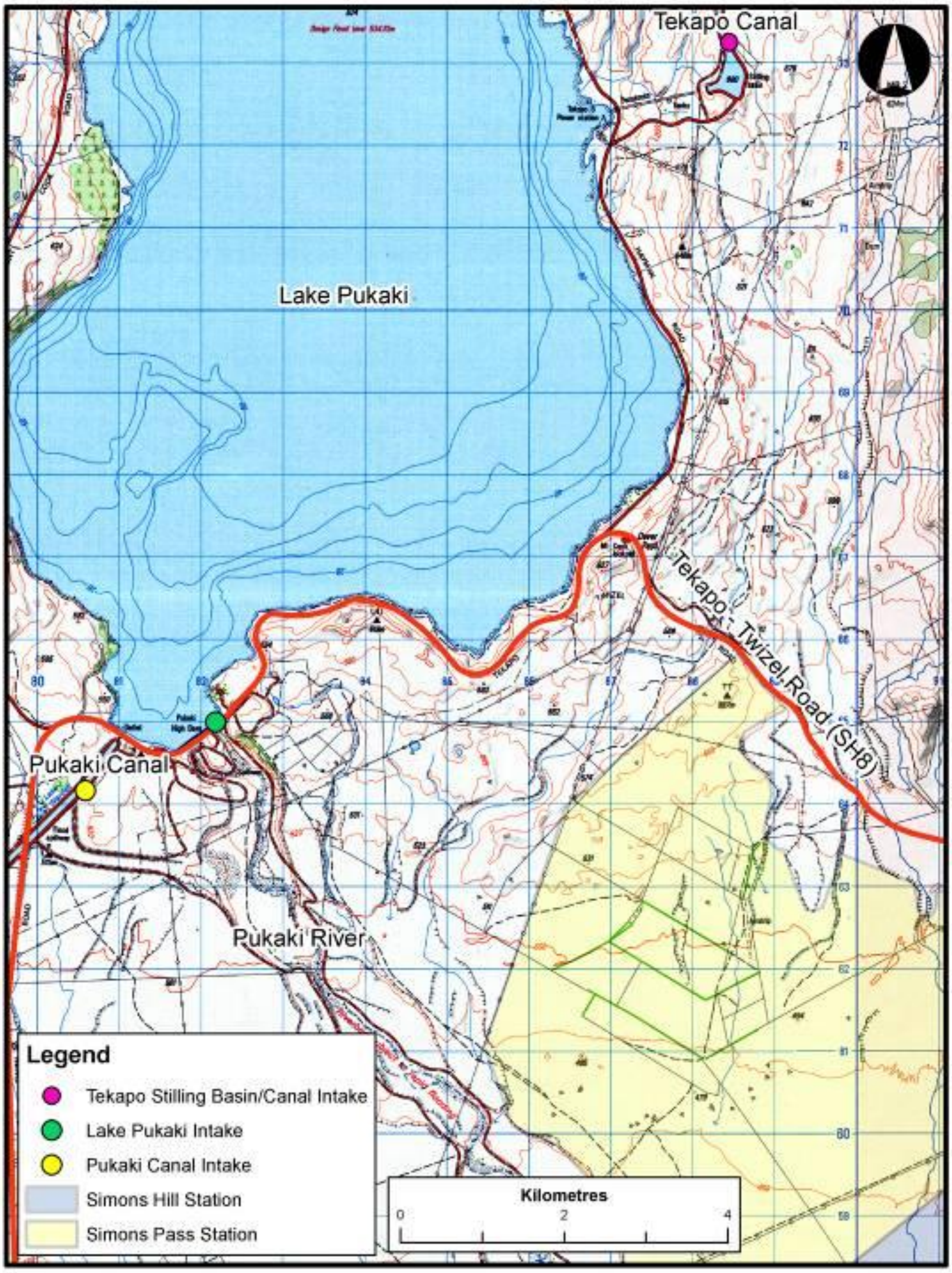

Figure 2: Intake locations

DESCRIPTION OF THE ENVIRONMENT

Climate

13. Simons Pass Station and Simons Hill Station experience hot summers and cold winters, with soil moisture deficits commonly occurring from September to April. On average, evapotranspiration exceeds rainfall from September to April over the growing season. However, there is significant variation about the average values.

14. Details of climate (rainfall and evaportranspiration) in the region are given in Appendix A.

Soils

15. The soils information for the property was derived from the Upper Waitaki Basin soil survey undertaken by Webb (1992) and from the NZLRI database.

16. The main soil groups are Mackenzie, Tekapo, Pukaki, Grampian, Larbreck and Simon series, which are shallow to moderately deep sandy loams. A full description of soils is given in Appendix B.

17. The location of the various soil types on Simons Pass Station and Simons Hill Station is shown in Figure 3. Soil profile available water (PAW) is summarised in Table 2.

18. It is likely that PAW values are understated. They are based on growing pasture, when in practice a significant proportion of deeper rooted crops such as lucerne will be grown. Also, Trevor Webb (pers. comm.) considers that his original survey results may understate PAW.

19. On Pukaki Flats, the lightest soils occur along the low river terraces, which are not going to be irrigated.

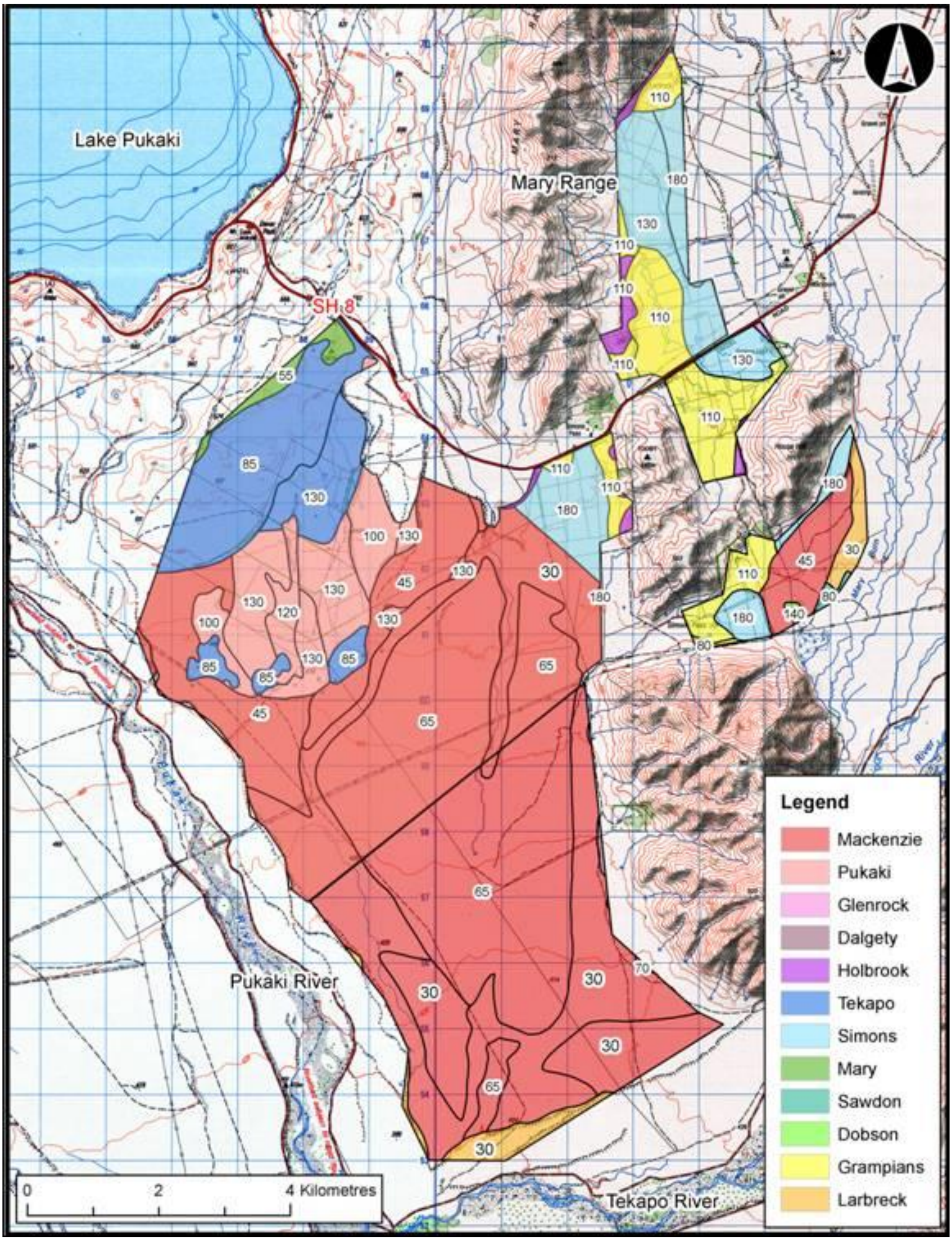

Figure 3: Plan of soils on Simons Pass and Simons Hill Station

Table 2: Soil profile available water

Average soil PAW (mm)	Area (ha)[(i)]	
	Simons Pass	Simons Hill
30	329	1073
45	350	133
55	16	
65	469	842
70		7
80		13
85	302	
100	133	
110	162	204
120	70	
130	438	57
140		5
180	131	66
Total	***2,400***	***2400***

Note (i): Based on coverage of soils over full property area, apportioned to the 2,400 ha.

Waterways

20. The following waterways are relevant to the proposed take and use of water on Simons Hill and Simons Pass Station:

   a) Tekapo Canal
   b) Lake Pukaki
   c) Pukaki Canal
   d) Pukaki River
   e) Tekapo River
   f) Mary Burn.

21. The location of the Tekapo Canal, Lake Pukaki,, Pukaki Canal, Pukaki River, Tekapo River and Mary Burn are shown in Appendix C, where a description of each waterway is also provided.

Topography

22. Key topographical features relevant to the irrigation area are the dry Pukaki River to the west of the Pukaki Flats and the Mary Range, which divides the area proposed to be irrigated.

23. The property in general slopes from north to south, with gradients ranging from 7 m/km to 40 m/km. Figure 4 shows the direction of sloping land.

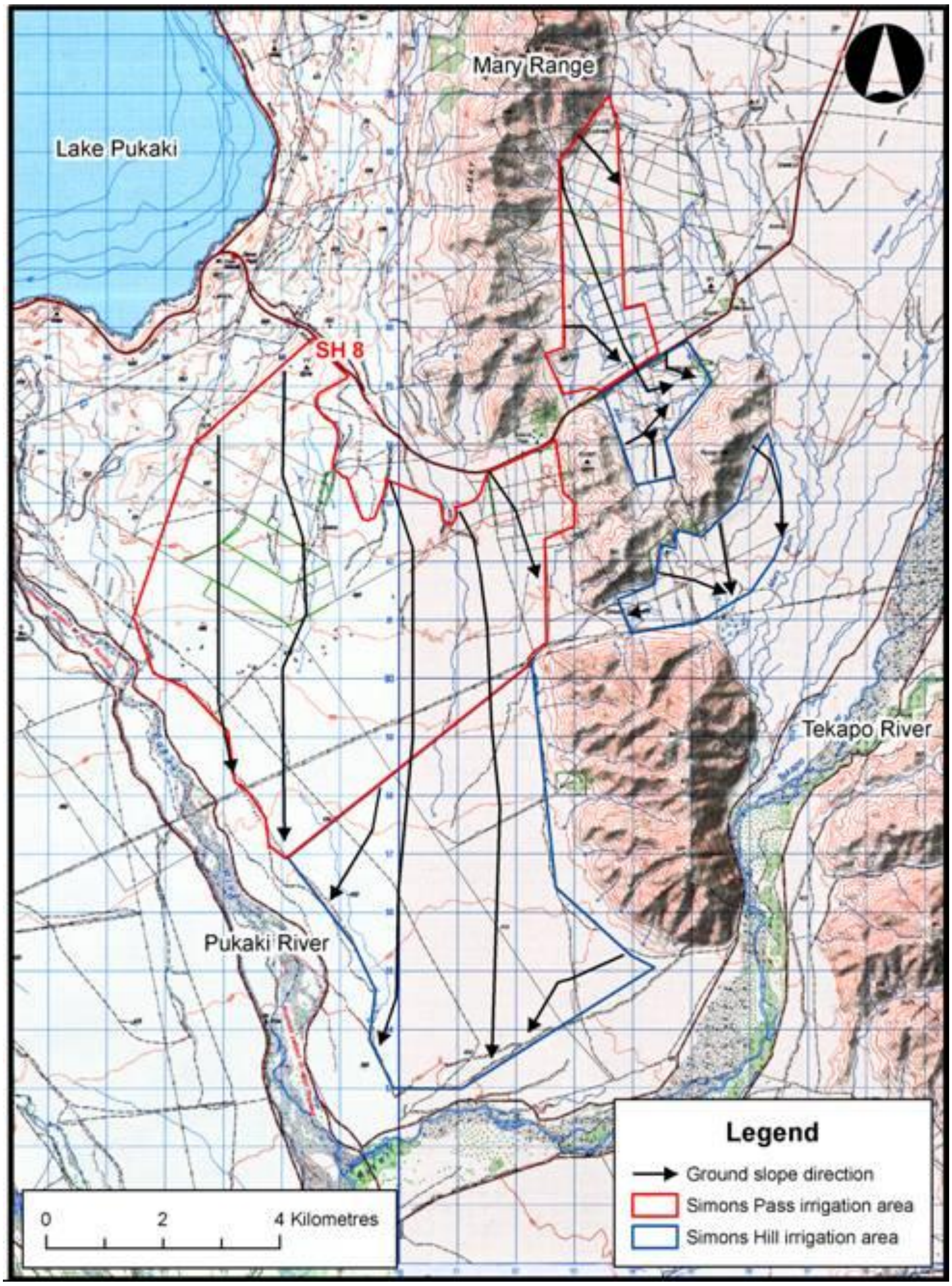

Figure 4: Direction of sloping land over Simons Pass and Simons Hill Station

On-farm Infrastructure

24. Both Simons Pass and Simons Hill propose to use centre-pivot irrigation systems, primarily to grow pasture and forage crops for stock grazing.

25. On-farm pipelines will be PVC pipe or similar, buried with minimum 400 mm cover. Powerlines will be installed to supply electricity to pumps and irrigators and other infrastructure on the property where required. If the preferred Tekapo Canal water supply option is progressed, the irrigation system will not require powerlines, as energy to run the pivots will be generated using water pressure from the mainlines.

26. To allow an assessment of the effects of the proposed irrigation system to be completed, concept plans for the irrigation system have been prepared. Indicative layouts for Simons Pass and Simons Hill are shown in Figure 5. Preliminary irrigation

designs indicate that the pivots will most likely range in radius from about 500 m to 800 m, with typical length being about 620 m. There are no streams within the circumscribed area of irrigation.

27. The irrigation system will be designed so that pivots have the capacity to apply 5 mm/day over the 4,800 ha. Based on a return period of 2-5 days, the application depth will be between 10-25 mm.

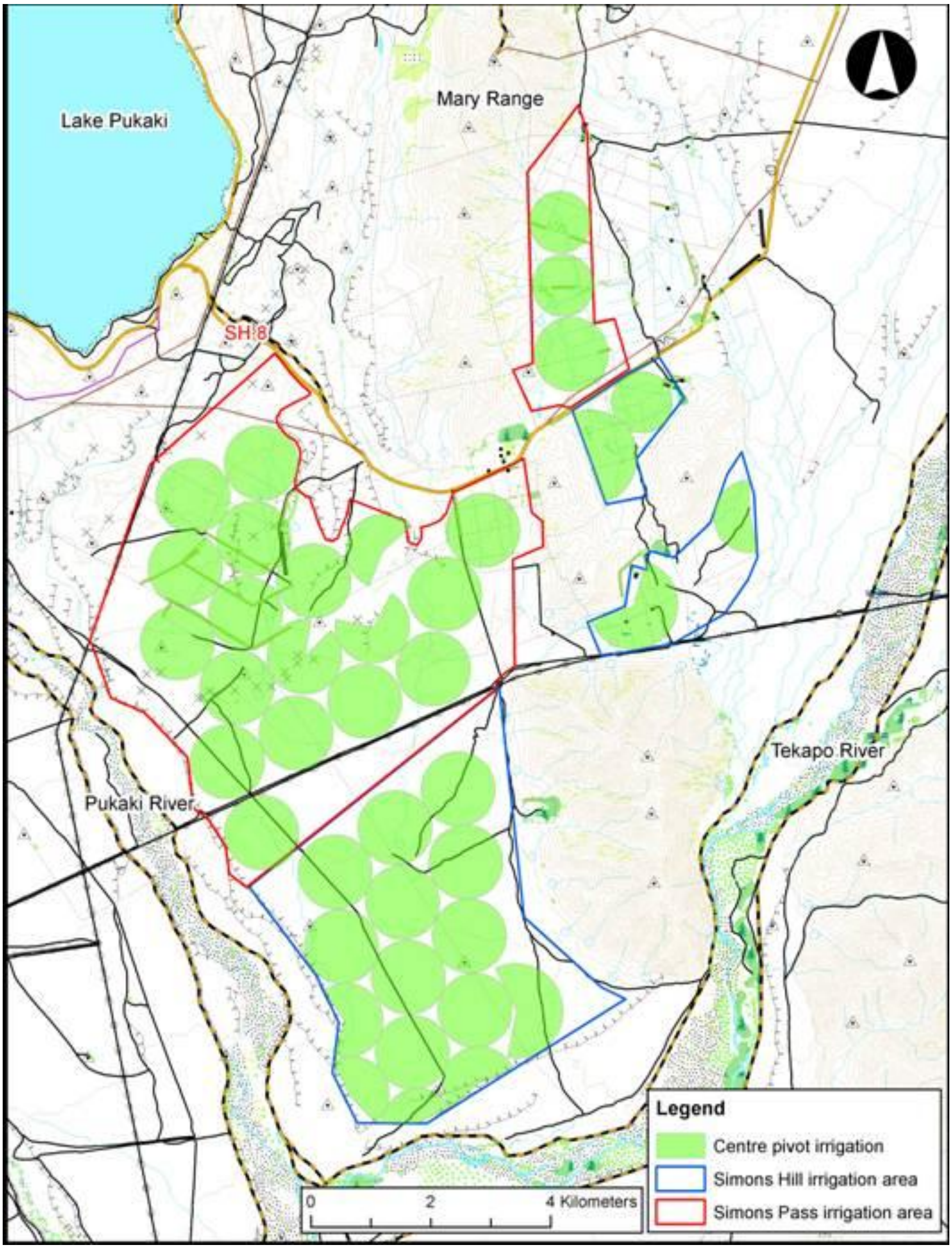

Figure 5: Simons Pass and Simons Hill conceptual irrigation plan

Justification of the Proposed Take

28. New applications for water are subject to the efficiency tests of Policies 15, 16, 17 and 28 in the WWAP. Policies 15, 16 and 17 refer to requirements to ensure that takes are reasonable for the intended use.

29. The WWAP specifies that to meet the requirements of Policy 16, annual volumes are to be based on soil moisture measurements, local rainfall and evapotranspiration modelling for eight-in-ten year reliability and achievement of irrigation application efficiency of at least 80 %.

30. Irrigation demand modelling using IrriCalc, a crop-soil water balance model developed by Aqualinc and routinely used for irrigation demand assessments, has been undertaken for the applicant’s property to determine whether the amount that has been applied for is reasonable. Details of the methodology are presented in Appendix E.

31. The modelling was undertaken in a manner that ensured that consistency with the policies of the Waitaki Catchment Water Allocation Regional Plan (WWAP) and the proposed Natural Resources Regional Plan (NRRP) was achieved.

32. The model was used to assess the volume of water that would have been required each season, based on historical climate for the period 1973-2008, from which the 80th percentile irrigation demand was calculated.

Reasonable Use

33. Of the flow rate of 1,531 ℓ/s or 1,398 ℓ/s for irrigation, stockwater, and domestic supply applied for under resource consent applications CRC062867 and CRC082311 respectively, 1,392 ℓ/s will be used for irrigation of the 2,400 ha. The remaining flow relates to the use of water for domestic and stockwater, and also allows for losses from the distribution system proposed under CRC062867.

34. A flow of 1,392 ℓ/s equates to an average system capacity of 5.0 mm/day over the 2,400 ha that is to be irrigated, which is less than the 5.6 mm/d specified in WQN9v2. The irrigation system capacity is therefore reasonable.

35. The annual volume of water for irrigation that has that has been applied for is 14,400,000 m^3/y, which is based on a Mackenzie Irrigation Company share allocation of 6,000 m^3/ha/year over the irrigation area (i.e. 6,000 m^3/ha x 2,400 ha = 14,400,000 m^3/year).

36. The results of the Irricalc modelling have been summarised in Table 3.

Table 3: Irrigation demand modelling results summary

	Simons Pass			**Simons Hill**		
Average soil PAW (mm)	**Irrigation demand (mm/year)**	**Area (ha)**	**Irrigation demand (m^3/year)**	**Irrigation demand (mm/year)**	**Area (ha)**	**Irrigation demand (m^3/year)**
30	694	329	2,283,260	783	1072	8,393,760
45	719	350	2,516,500	768	133	1,021,440
55	704	16	112,640			
65	667	469	3,128,230	735	842	6,188,700
70				763	7	53,410
80				719	13	93,470
85	689	302	2,080,780			
100	676	133	899,080			
110	639	162	1,035,180	705	204	1,438,200

120	668	70	467,600			
130	652	438	2,855,760	728	57	414,960
140				651	5	32,550
180	627	131	821,370	629	66	415,140
Total	***675***	***2,400***	***16,200,400***	***744***	***2,400***	***18,051,630***

37. The results of the modelling show that an annual allocation of 16,200,400 m^3/y and 18,051,630 m^3/y for Simons Pass and Simons Hill respectively is required to meet full irrigation demand every eight out of ten years. This exceeds what has been allocated by the MIC shares for irrigation and what has been applied for (14,400,000 m^3/y), and shows that the proposed takes will meet the reasonable use test.

38. Because the area of each soil PAW is proportioned over the 2400 ha of each property (see note in Table 2) rather than working out the precise PAW under individual pivots, the key message to take from the above analysis is that the volumes applied for are not excessive.

39. In fact, the analysis indicates that the applicants may have insufficient water to fully meet demand more frequently than 20 % of the time, particularly on the Pukaki Flats section of Simons Hill. The irrigation system will have to be very well designed and managed to ensure that yield losses do not occur in drought years. The implications of this are that the calculated drainage values for the water quality assessments are likely to be higher than will occur in practice – a conservative approach.

40. Soil moisture monitoring is proposed to be carried out to ensure over-watering or under-watering does not occur and maximum possible water use efficiency is achieved.

Efficient Use

41. Efficient use of water is important for two reasons. The first is that without efficient use of water, the system capacity and annual allocation proposed will be insufficient to maximise production in drier than average years. The second is that the irrigation demand and drainage modelling carried out by Aqualinc for the MWRL study, which was used for water quality assessments, was based on an application efficiency of 80%, as required by Policy 16 of the WWAP.

42. From an environmental perspective, the potential for deep drainage to groundwater and for runoff onto adjoining land is of particular interest. Both these factors are site and system specific. An analysis of application efficiency and the potential for surface runoff into waterways has been carried out.

Application efficiency

43. Although application efficiency has been assumed to be 80% as per Policy 16 of the WWAP, centre-pivot application efficiency depends on several site specific factors such as pivot length, irrigation system capacity, sprinkler type and depth of application.

44. Application efficiency changes along the length of pivots. The longer the pivot, the lower the application efficiency, because of higher application rates at the end of the pivot. For that reason, even though the capital cost of using long pivots is lower than for shorter pivots, Simons Pass and Simons Hill changed their original pivot layout using longer pivots and now plan to use shorter pivots.

45. The SPRINK[1] irrigation efficiency model, which is a purpose-built model for assessing application efficiency, has been used to calculate average irrigation application efficiency under a range of conditions at the end of the longest pivots, (i.e. a worst-case situation).

Table 4: Application efficiency – Mackenzie and Larbreck soils

Return period & applied depth	Pivot length (m)	Application rate[(i)] (mm/h)	Average gross irrigation (mm)	Application efficiency (%)
5 days, 25 mm	625	46	523	82
5 days, 25 mm	795	56	540	79
4 days, 20 mm	795	56	511	84
Note (i): Maximum application rate based on the end of the pivot.				

Table 5: Application efficiency – Tekapo and Pukaki soils

Return period & applied depth	Pivot length (m)	Application rate[(i)] (mm/h)	Average gross irrigation (mm)	Application efficiency (%)
3 days, 15 mm	625	46	515	81
2 days, 10 mm	625	46	460	89
Note (i): Maximum application rate based on the end of the pivot.				

Table 6: Application efficiency – Grampian and Simon soils

Return period & applied depth	Pivot radius (m)	Application rate (mm/h)	Average gross irrigation (mm)	Application efficiency (%)
2 days, 10 mm	800	48	561	65
2 days, 10 mm	650	39	550	68
2 days, 10 mm	625	46[(i)]	559	67
2 days, 10 mm	625	46[(i)]	549	68
2 days, 10 mm	530	32[(i)]	539	73
2 days, 10 mm	400	24[(i)]	520	76
Notes: (i) Maximum application rate with boom back.				

46. Application rate decreases as you move towards the centre of a pivot. That means that the lowest application efficiency is likely to be at the end of the pivot, but improves towards the centre. The average application efficiency therefore will exceed the values given in the tables above.

47. Table 4 shows on Mackenzie and Larbreck soils, when the return period is 5 days, the lowest application efficiency will exceed 80% for 625 m pivots. The return period will need to be reduced to 4 days with an applied depth of 20 mm for the longer 775 m

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[1] SPRINK – a stochastic irrigation efficiency model developed at Winchmore Irrigation Research Station , Canterbury, by Dr Marshall English, Oregon State University, USA, modified by Aqualinc for efficiency and redistribution assessments.

pivot. Fortunately, the longer pivots are primarily on the lighter Mackenzie soils where application rate is less of a problem.

48. Table 5 shows that on Tekapo and Pukaki soils, that applying smaller depths more frequently improves the application efficiency to better than 80% throughout the length of the pivots. Therefore, it is proposed that the return period be 3 days with an applied depth of 15 mm.

49. Irrigation on the heavier Grampian and Simon soils is more challenging, due to the lower infiltration rates of the soils. Table 6 shows that applying smaller depths more frequently and having 'boom backs' improves the application efficiency, but achieving 80% application efficiency may be difficult to achieve under the end towers of the longer pivots.

50. However, along the full length of a pivot, average application efficiency will exceed the figures given above. I am confident that irrigation on this property can achieve 80% application efficiency overall.

Irrigation Runoff

51. An INZ Code of Practice assessment and the SPRINK model were used to determine whether there is potential for irrigation redistribution. Details of the methods are described in Appendix F.

52. The results of the analysis according to the INZ Code of Practice are summarised in Table 7.

Table 7: Pivot – Application rate compared to soil infiltration rate

Irrigator type	Soil type	Return period (days)	Irrigator maximum application rate (mm/h)	Soil infiltration rate (mm/h)	Acceptable?
625 m pivot	Mackenzie & Larbreck	5	46	40-65	Yes
795 m pivot	Mackenzie & Larbreck	5	56	50-69	Yes
625 m pivot	Tekapo & Pukaki	3	46	25-46	Yes
530 m pivot(i)	Grampian & Simon	2	32	17	May need to be mitigated
625 m pivot(i)	Grampian & Simon	2	37	18	May need to be mitigated
Note (i): 'Boom back' added to end towers of pivots to reduce application rates					

53. Table 7 shows that application rate is within the soil infiltration range for 625 m pivots on the Mackenzie and Larbreck soils and the Tekapo and Pukaki soils, based on a 3-5 day return interval. However, application rate exceeds soil infiltration rate for pivots located on the Grampian and Simon soils, based on a two day return interval, indicating that surface redistribution may occur.

54. The results of the SPRINK analysis are detailed in Table 8.

Table 8: Potential irrigation redistribution at end of pivots

Soil type	Pivot length (m)	Return period & applied depth	Application rate(i) (mm/h)	Average gross irrigation (mm)	Irrigation redistribution (mm)
Mackenzie & Larbreck	625	5 days, 25 mm	46	523	74
Tekapo & Pukaki	625	2 days, 10 mm	46	460	95
Grampian & Simon	625	2 days, 10 mm	46(i)	559	356
Grampian & Simon	625	2 days, 10 mm	46(i)	549	326
Grampian & Simon	530	2 days, 10 mm	32(i)	539	287
Grampian & Simon	400	2 days, 10 mm	24(i)	520	255

Notes:

(i) Maximum application rate based on the end of the pivot.

55. Table 8 shows that the likelihood of irrigation redistribution and runoff on the Mackenzie, Larbreck, Tekapo and Pukaki soils will be low, which reinforces the findings of the INZ soil infiltration analysis.

56. However, on the Grampian and Simon soils, the lower infiltration rate compared to the application rate could cause surface redistribution of water. Figure 6 shows the areas most at risk of irrigation redistribution.

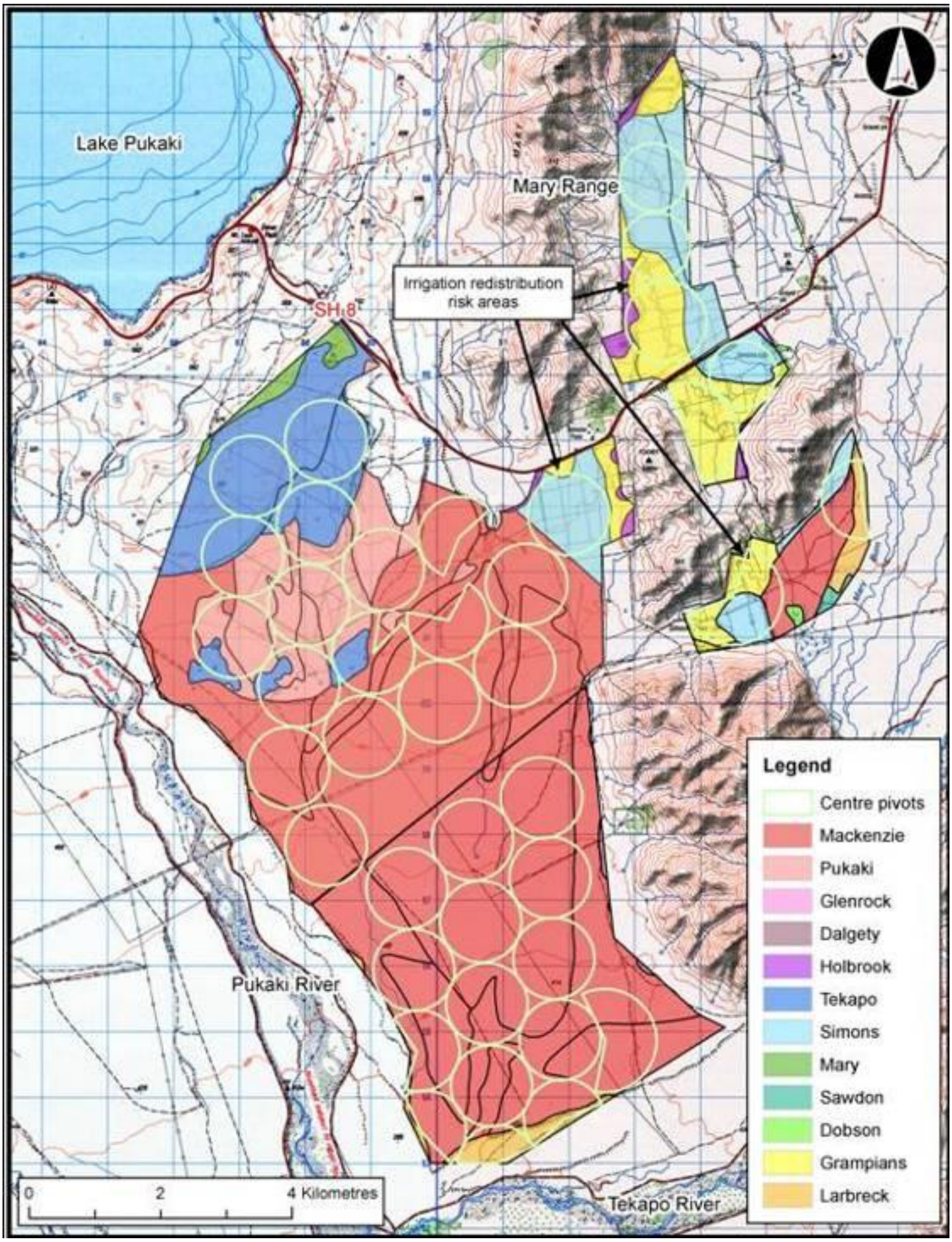

Figure 6: Plan showing areas at risk of irrigation redistribution over Simons Pass and Simons Hill Station

57. On the conceptual plan, a pivot is shown on the Grampian and Simons soils on the north-eastern side of Pukaki Flats where, in the worst-case situation, application rate could exceed soil infiltration rate by up to 15 mm/h.

58. The land slopes gently in a north to south direction (see Figure 4), so irrigation runoff from this pivot, if it occurs, will definitely stay within the circumscribed irrigated area within the property. If ponding becomes apparent, the return period will be reduced to 2 days and 10 mm applied.

59. On Simons Pass and Simons Hill east of the Mary Range, pivots will be located on the Grampian and Simons soils. These pivots are expected to range in size from about 500 – 750 m. On those soils, the worst-case scenario is that application rate could exceed the soil infiltration range by up to 30 mm/h.

60. Current experience with the existing pivot on Simons Hill east of the Mary Range (D Fastier, pers comm.) is that ponding and runoff has not been a problem. The Grampians and Simons soils are described in Appendix D as free-draining with moderate permeability. It is my view that the SPRINK analysis is likely to be overestimating the likelihood of ponding, but it certainly can be used as an early warning signal.

61. Because of that, regular observations will be made for surface ponding and runoff in those areas, and if it becomes an issue, mitigation measures such as applying less water more often, extending the wetted footprint by changing sprinkler configuration, using ‘boom backs’, fitting a variable depth irrigation system, or carefully controlling ground cover, will be taken.

62. I recommend that the irrigation system be designed according to the Irrigation NZ Code of Practice and Design Standards. Adherence to the Code will help to ensure that the design of the system is efficient in terms of water application, labour, energy and the use of capital.

Stockwater

63. Stockwater for Simons Pass and Simons Hill will be integrated with the irrigation system infrastructure and be sourced from either the Pukaki Canal, Lake Pukaki, or the Tekapo Canal, depending on the final choice of irrigation intake location.

64. The stockwater will be reticulated around the farms using polyethylene pipelines. No discharge from the stock water distribution system will occur.

65. The applicant will provide on-farm storage of water as a backup to cover for periods when the irrigation take is on restrictions or not being operated.

66. Stockwater has not been included in CRC062867 or CRC062842. Separate applications will be lodged by the applicants for the take and use of water for stock and domestic supply if the applications for irrigation water are granted and progressed by the applicants. However, until the applications are lodged and granted, the applicants will rely on provisions set out in the WWAP (Rule 1) or the Resource Management Act Section 14(3)(b).

67. CRC082311 and CRC082304 includes stockwater within the rate and volume of water applied for. Stockwater is anticipated to be required on average for 18 stock units per ha over 2,400 ha. Assuming this is to comprise (50/50) of rising 1 year heifers and rising 2 year heifers the daily water requirement will be approximately 0.207 m^3/day/ha, assuming 45 ℓ/head/day (Fleming, 2003). This equates to a need for 497 m^3 per day and 181,330 m^3 per year.

68. No stockwater has been applied for under CRC062867. Therefore, a separate application will be lodged by the applicant for the take and use of water for stock and domestic supply if this application is granted and progressed by the applicant. However, until the application is lodged and granted, the applicant will rely on provisions set out in the Resource Management Act.

ASSESSMENT OF EFFECTS

Effect of Abstraction on the Tekapo and Pukaki Canals (joint)

69. The main effect of abstraction of water from either of the canals is the impact on Meridian Energy in the form of loss in power generation. A second effect relates to the abstraction of water on fish within the canals.

70. Meridian Energy has provided derogation approval for the abstraction.

71. The applicants' representatives have discussed fish screen requirements with Fish & Game. The intakes will be designed to be consistent with an agreed approach between the applicant and Fish & Game to minimise the effects on fish within the canal.

Effect of Abstraction on Lake Pukaki

72. If water is taken directly from Lake Pukaki (the least preferred option from the applicants perspective), the main environmental effect from the taking of water from the lake relates to the effects on the Lake Pukaki water levels.

73. Based on the proposed abstraction limit of 132,280 m^3 per day, or 14,581,330 m^3 per year for each farm, the total volume abstracted will be a maximum of 29,162,660 m^3/y.

74. To put the proposed abstractions into context, the maximum combined effect on lake level is equivalent to only 0.001 m over a day or 0.16 m over a year, assuming no inflows and outflows. The proposed maximum annual volumetric take represents only 0.5 percent of the approximate 6000 Mm^3 usable volume of water held in the lake and 0.7 percent of the 4 billion m^3 annual volume (128 m^3/s average flow) flowing through the lake, ignoring the input from the Tekapo Canal. If the Tekapo Canal flow of 75.6 m^3/s is included, the take represents 0.5 percent of the annual throughflow.

75. Meridian usually controls the level of the lake between 518.2 and 532 metres. That will not change as a result of the proposed abstraction. Abstracting water from the lake will mean Meridian will release less water down the Pukaki canal, reducing power generation. Meridian has provided derogation approval for the proposed abstraction.

76. The applicant is proposing to comply with the minimum lake level of 518 m above mean sea level, as specified in Table 4 of the WWAP for Lake Pukaki.

Effect of Discharging Irrigation Scheme Water into the Pukaki River and Lower Tekapo River

77. Water may be discharged into the dry Pukaki River at flows up to 3 m^3/s from the Pukaki Irrigation Scheme for operational reasons (bypass flow), and in emergencies. There will be no discharge from the piped scheme from the Tekapo Canal, should that be the selected supply option.

Effects on Pukaki River Hydrology

78. The Pukaki River is usually dry and only tends to flow when Meridian Energy releases water over the Lake Pukaki spillway. Very infrequent releases of water by Meridian

Energy from Lake Pukaki over the Pukaki spillway can result in a wide range of flow conditions.

79. Under consent, CRC905323.1, Meridian is authorised to discharge up to 420 m^3/s. However, changes in flow are limited to 35 m^3/s for the first 4 hours, followed by incremental increases per 0.1 m above the maximum control level.

80. The applicants are proposing to discharge a maximum of about 3 m^3/s (1.5 m^3/s for each of Simons Pass and Simons Hill), which is a much smaller flow than already occurs due to spills from Lake Pukaki. In fact, it is trivial compared to spill flows. The proposed discharge will not cause any adverse effects on the flood carrying capacity of the Pukaki River.

Effects of discharge on Lower Tekapo River Hydrology

81. The average flow in the Tekapo River is about 7-10 m^3/s, with the main contributions coming from the Forks and Grays rivers, Irishman Creek, and the Mary Burn (LINZ, 2003). Water discharged into the Pukaki River will flow into the Tekapo River below the confluence with the Pukaki River, approximately 5 km upstream of Lake Benmore.

82. Generally, the discharge of water by the applicant will only reach 3 m^3/s during emergency situations. If the water reaches the lower Tekapo River, (given the permeability of the riverbed, some or all of it may disappear underground), the increase in flow will be smoothed out and well within the limits currently experienced after spills from Lake Pukaki. Therefore, no significant adverse effects on flow in the Tekapo River are expected.

Effects of discharge on River Bed in the Vicinity of Discharge

83. The proposed mitigation measures for prevention of erosion and to ensure compatibility with the Pukaki River flow include :

    a) A small weir in the race at the point it enters the Pukaki River to dissipate energy, and to ensure that flow enters the Pukaki riverbed under sub-critical conditions. The weir will also prevent fish from swimming up into the supply race, should fish ever be present in the river. The height of the weir will be determined based on site conditions, particularly spill flows down the Pukaki River.

    b) Immediately downstream of the weir, rocks will be concreted in to prevent erosion in the area of turbulent flow.

    c) The channel will be gradually opened out so that the flow will be released into a Pukaki River braid at a velocity and depth comparable to that of a natural river channel conveying the same flow. The characteristics of a typical braid will be determined based on site measurements.

    d) The area immediately below the concrete-protected zone will be protected with riprap.

84. There are not expected to be any engineering or hydrological issues arising from the discharge of water into the Pukaki River. The intake at the Pukaki Canal/Lake Pukaki will be closely controlled to deliver the required flow on-farm and to minimise the need to bypass water.

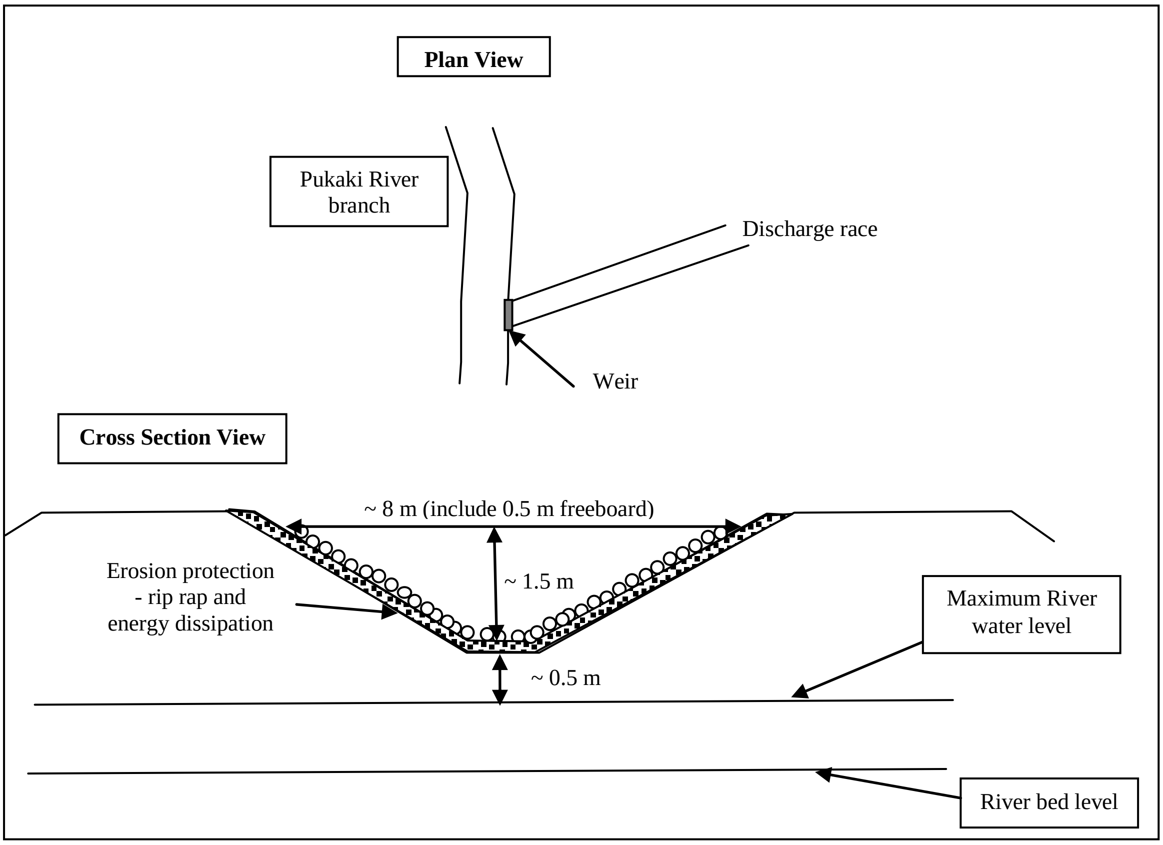

Figure 7: Conceptual layout of discharge channel

Effects of Discharge on Water Quality

85. The water proposed to be discharged to the Pukaki River will be sourced from Lake Pukaki or the Pukaki canal, which is the same source that the Pukaki spill water comes from.

86. Although prior to discharge, the water will be conveyed a distance of about 12 km by open race before being released into the river, the potential for water to be contaminated before entering the river is very low. The race passes through land that is normally has a very low stocking rate as it is undeveloped land with low production. If stock are put on to this land, they are sheep and stocking density is very low. In addition, the race will be fenced.

87. As with the Pukaki River, there will be no change in water quality in the lower Tekapo River as a result of the discharges, because the water discharged by the applicant will originate from Lake Pukaki or from the Pukaki Canal. It is the same water quality as released when Meridian is spilling Lake Pukaki water.

88. Because any water discharged to the Pukaki River will be part of the annual volume allocated for irrigation, it is in the applicant's interest to discharge as little as possible, as it might be needed for irrigation.

89. With the open race option on Pukaki Flats, small buffer storage ponds, with enough storage to cater for about 3 hours of flow to a pivot (typically less than 1000 m^3) will be placed strategically in the system to smooth the effects of flow changes in the system and to use the water as efficiently as possible.

90. For operational reasons, it may be necessary to run water onto land adjacent to the pivot circles within the circumscribed irrigated area (the area between the pivots) from time to time at flows up to 250 l/s. This could occur due to unexpected shutdown of a pump if that coincided with the associated buffer storage ponds being full. There is an extremely low chance of that occurring.

91. The flow of 250 l/s is equivalent to the flow into four 600 m long centre-pivots. The chance of four pivot pumps stopping at once is very remote, except during major electricity supply failures. Major failures would require discharge to the Pukaki River, which has been planned for.

92. Flows in the open race system will be controlled using automated gates. The application to land would only be required if the automated system could not respond to sudden small changes in demand quickly enough for the excess to be accommodated in the buffer storage. If water from one pivot was put onto land for four hours (enough time for flow adjustments to travel 14 km from the intake), the volume applied to land would be only about 950 m^3.

93. Assuming all the water applied to the land drained through the soil profile, it corresponds to about 0.02% of the water likely to drain to groundwater under the proposed irrigation. If water from four pivots needed to be applied to land, it would correspond to 0.08% of the total drainage water, which is of no consequence in terms of impacts on groundwater quantity or quality. Furthermore, the water will be placed on unirrigated land that will be low in nutrients due to not being fertilised and therefore will incur little if any nutrient discharge.

Effects on Downstream Users and Amenity Values

94. If the need to discharge water into the Pukaki River arises, it will only be for a very limited period of time – in emergency situations - long enough for the main control gate at the intake to be closed. The travel time for water to move from the intake to the first discharge point from the system is about three hours.

95. I would not expect any significant effects on downstream users or amenity values arising from the discharge of water. The maximum flow of 3 m^3/s is a very small flow compared to potential spill flows. Once water is in the Pukaki river main channel or braids, I would expect it will rapidly dissipate and become integrated with normal river hydrology.

Effects of Surface Water Takes on Other Water Abstractors

Waitaki Catchment Water Allocation Regional Plan (WARP)

96. Simons Pass Station and Simons Hill Station are each seeking a maximum total volume of 14,581,330 m^3/y from one of the proposed Tekapo Canal, Lake Pukaki, or Pukaki Canal intakes. The combined total is 29,162,000 m^3/y.

97. According to my evidence presented for MWRL, all existing and proposed abstractions upstream of the Waitaki Dam for agricultural and horticultural activities comply with the 275 Mm^3 allocation limit as set out in Table 5 of the WWAP. These applications therefore comply with the 275 Mm^3/y allocation limit.

98. The applicants are proposing to comply with the minimum lake level of 518 m amsl as set out in Table 4 of the WWAP. If Lake Pukaki water level falls to or below this level, abstraction for irrigation will cease.

99. CRC062867 and CRC062842 do not comply with the WWAP Lake Pukaki volumetric allocation limit of 8 Mm^3/y. However, the impact of exceeding that limit is minimal in terms of lake water levels as explained in paragraphs 72 to 76.

100. Details of the relevant WWAP requirements are provided in Appendix H.

Effect of Proposed Takes on Other Users Supply Reliability

101. There are no other existing consents to abstract water from Lake Pukaki or the Pukaki Canal other than those held by Meridian Energy.

102. Aside from Meridian, other consents to abstract water from the Tekapo Canal are summarised in Table 9.

Table 9: Summary of consented users of Tekapo Canal

Consent owner	Consent No	Consent details
The Wolds Station Ltd	CRC952547	Take water for irrigation and stockwater
	CRC952550	Take water for irrigation and stockwater
A & K Simpson	CRC951545.1	Take water for irrigation and stockwater
Irishman Creek Station Ltd	CRC991667	Take water for irrigation

103. All existing consents are located between 1.9 km and 6.2 km upstream of the proposed intake on the Tekapo Canal. Additionally, none of the existing consents are subject to a minimum flow or minimum lake level condition.

104. To mitigate any potential effects that the proposed takes may have on other canal users, the applicants will comply with the minimum lake level for Lake Pukaki of 518 m amsl. A fish screen will also be installed on the proposed intake.

105. Using water for irrigation removes some water from the Benmore/Waitaki hydrological system that could potentially be used for electricity generation and therefore potentially affects Meridian Energy.

106. Meridian Energy Ltd have provided each applicant with derogation approval for their proposed abstraction of up to 14,581,330 m^3 each of water per year for irrigation, stockwater and domestic supply from Lake Pukaki and wider hydrological system, under resource consents CRC0628687 and CRC082311. Meridian therefore consents to the effects of the proposed abstraction on electricity generation.

Effect of Takes on Town, Domestic and Stockwater Supplies

107. The proposed abstraction will not affect the levels of Lake Pukaki; rather the effect will be on how much water Meridian is able to release down the Pukaki Canal. Therefore, as the proposed abstraction will not result in a change to the existing lake level range, there will be no significant effect on surrounding community, domestic and stock water supplies.

Impact of Surface Runoff or Quick Flow on Waterways

108. If irrigation occurs close to or over waterways, there is potential for surface runoff or quick flow to enter surface waterways. The following is proposed to mitigate those potential effects.

Pukaki River

109. A large buffer distance, largely the lower river terrace, which is about 800 ha, will be maintained between the irrigated area and the Pukaki River where irrigation will not occur. The Pukaki River bed, which is dry most of the time, is approximately 1 km west of the proposed irrigation area as shown in Figure 5. Surface runoff or quick flow arising from the proposed irrigation will not come anywhere near the Pukaki riverbed, due to the distance of irrigation from the river.

Tekapo River

110. The Tekapo River flows along the southern boundary of the property. To ensure the effects of irrigation on the property are minor, the applicant is proposing to create a buffer distance of 250-1750 m from the river, within which irrigation will not occur. Irrigation at the southern end of Pukaki Flats is on the main (third) terrace back from the Tekapo River. The lower river terrace and the second terrace at the south-eastern end of Pukaki Flats, which covers about 700 ha, will not be irrigated. No surface runoff or quick flow arising from the proposed irrigation will enter the Tekapo River due to the distance of irrigation from the river.

Mary Burn

111. The Mary Burn is located on the eastern side of Simons Hill Station, with a DoC conservation area and DoC wetland to the south-west of the Simons Hill land and Mary Burn. The land slopes gently in a south-easterly direction, as shown in Figure 4.

112. The closest point that an irrigator will come to the Mary Burn is 150 m. In this immediate area, the soils are Mackenzie soils with good infiltration characteristics, which will minimise the likelihood of runoff. As stated in paragraph 61, these areas will be closely monitored to prevent surface runoff due to irrigation. Further, additional measures, as described in the evidence of Melissa Robson, will be taken to minimise the chance of overland flow from entering the Mary Burn.

Effects on Groundwater Levels

113. Irrigation on Simons Pass and Simons Hill has the potential to increase groundwater levels via drainage through the soil profile.

114. Currently there is no irrigation on Pukaki Flats and groundwater is sourced from a combination of :

    a) Leakage from Lake Pukaki,
    b) Deep groundwater flow from upland catchments,
    c) Gains from or losses to rivers and streams; intermittent (Pukaki River) and ephemeral,
    d) Rainfall recharge, and
    e) Snowmelt.

115. Irrigation will increase rainfall recharge from rain falling on irrigated land and introduce additional water through normal irrigation efficiency dynamics. Irrigation will not significantly change any of the other recharge sources.

116. Aqualinc (2008) estimated dryland drainage to be in the order of 80-200 mm in this area, depending on soil type. Drainage under irrigation would be expected to increase to 170-300 mm due to additional rainfall drainage and irrigation losses.

117. To provide an idea of the scale of effect, assuming an average of 150 mm for dryland recharge and 250 mm for irrigated recharge, an additional 100 mm of drainage could occur. This equates to 4.0 Mm^3/y of additional drainage to groundwater over the approximate 4000 ha of proposed irrigation on Pukaki Flats. Assuming a specific yield of 0.1 for the shallow aquifer material and assuming static conditions, groundwater levels could theoretically rise 1 m over the irrigated area.

118. In practice, groundwater systems are to a large extent self-balancing, with higher levels causing an increase in outflows. Also, water levels tend to flatten out over a larger area to reach a new equilibrium, so actual changes will be significantly lower than 1 m. The additional water will be spread over about 6000 ha (the total area of Pukaki Flats,) so could potentially cause at most a 0.7 m increase in groundwater levels. In my opinion, a maximum 0.7 m increase in groundwater levels will have no adverse effects on groundwater levels in the Pukaki Flats area.

119. Although suitable for irrigation, Simons Hill Station has specifically excluded irrigating all of the two lower terraces of Pukaki Flats (that run along the Tekapo and Pukaki Rivers), to avoid contributing to groundwater close to the rivers.

120. In the Mary Burn area, shallow groundwater does exist and is closer to the surface, but the area of proposed irrigation east of the Mary Range is very small (778 ha) compared to the Pukaki Flats area (4022 ha).

121. Soils in the area east of the Mary Range have higher water holding capacities, i.e. 100-150 mm. Aqualinc (2008) estimates dryland drainage to be 80 mm and irrigated drainage to be 170 mm for this area, which is a net gain of 90 mm.

122. The area of proposed irrigation east of the Mary Range is about half of the flatter area. On that basis, assuming a worst-case scenario where no groundwater rebalancing, increase in groundwater levels will be limited to about 0.5 m, which in terms of groundwater level changes, is very small. There will be no adverse effects due to the proposed irrigation of increases in groundwater levels.

Effects on Groundwater and Surface Water Quality

123. The additional recharge to groundwater due to irrigation will carry nutrients with it that could have an effect on groundwater quality and on surface water quality. The impact on groundwater quality depends on the quantum of nutrients entering the groundwater system and on the dilution of nutrients in the groundwater system.

124. The impact on surface water quality in terms of nutrient concentrations depends on the amount of groundwater that enters surface waterways relative to the size of waterway. Of importance therefore, is where groundwater goes to after drainage water moves through the soil profile into the groundwater system.

125. The MWRL proposition (from the GHD Groundwater Report 2009) was that there is insignificant nutrient drainage to the Tekapo River from Pukaki Flats and that all of the nutrient load and groundwater discharged directly to Lake Benmore. Simons Hill and Simons Pass Stations have carried out further field work and analysis, which has supported the MWRL proposition. The implication of the majority of drainage water from Pukaki Flats discharging to Lake Benmore is that the amount of drainage water and associated nutrients entering the Lower Tekapo River will be low.

Pukaki Flats

126. Pukaki Flats is by far the largest area of proposed irrigation by Simons Hill and Simons Pass – 4022 ha out of 4800 ha. The Pukaki Flats area in the MWRL WQS is included in the Pukaki River Basin groundwater sub-catchment except for about 200 ha of land on the unirrigated south-east corner of the flats, which is in the Tekapo River Basin sub-catchment. (Figure 26). The relevant area is termed Pukaki at Benmore.

127. With the Pukaki Flats area of Simons Hill and Simons Pass, the key waterways that irrigation could potentially affect are the lower Pukaki River and the lower Tekapo River – the area above the Tekapo-Pukaki confluence and the lower reach between the Tekapo-Pukaki confluence and Lake Benmore.

128. If water drains through the soil profile under the irrigated areas, there are several pathways or a combination of pathways that the flow could take:

    a) Drain into deep groundwater, and flow underneath the Tekapo and Pukaki Rivers emerging somewhere in Lake Benmore – the MWRL proposition.

    b) Drain into shallow groundwater, remain in shallow groundwater and flow into the Tekapo and Pukaki Rivers above the Pukaki-Tekapo confluence.

    c) Drain into deeper groundwater and emerge in the Tekapo River above Lake Benmore.

129. GHD concluded that the majority of drainage from Pukaki Flats would go into deep groundwater and emerge in Lake Benmore, i.e. essentially bypass the lower Pukaki and Tekapo Rivers. That conclusion was based on their conceptual understanding of the groundwater system and the results of the Modflow modelling.

130. To add more certainty to the modelling conclusions and to gather base data for on-going monitoring, Simons Pass and Simons Hill have carried out substantial amounts of additional field investigations. The focus was to obtain measurements that provided a better understanding of groundwater flow directions, shallow groundwater sources, and gaining and losing stretches of rivers.

131. Sixteen shallow piezometers were installed along the Tekapo and Pukaki Rivers. Three separate series of water level measurements, water chemistry tests and river flow gaugings (Tekapo River and Lower Pukaki River) have been carried out to find out if actual measurements are consistent with the findings of the GHD modelling. Details of the additional measurements are given in Appendix D.

132. The additional data was provided to GHD to allow the Modflow model to be refined and to allow GHD to provide additional detail on groundwater flow directions, piezometric surfaces and mass balances.

133. The piezometric and groundwater chemistry measurements confirm that shallow groundwater is closely linked to the Pukaki River in its lower reaches. The measurements show that when Meridian is spilling from Lake Pukaki, groundwater levels along the river rise, indicating a movement of water from the river into shallow groundwater.

134. When water is not being spilled, shallow groundwater levels fall and groundwater moves from the shallow strata into the riverbed, creating flowing water above the Pukaki- Tekapo confluence. There is likely to be a high degree of bank storage along the Pukaki River. Eventually, flow in the lower Pukaki River reduces to a trickle (two small streams in the Pukaki River at the Tekapo confluence were measured in September 2009 at 0.025 and 0.03 m^3/s respectively.

135. There is no doubt that groundwater in the riparian land along the Tekapo River is connected to the river (from the water chemistry results), but there does not appear to be any evidence of significant amounts of groundwater from the greater Pukaki Flats moving into the Tekapo River in this area.

136. The piezometric contour map generated by GHD (Figure 14 in the Groundwater report) shows groundwater in the Pukaki Flats to be moving south from Lake Pukaki but turning towards the Tekapo-Pukaki confluence as it is influenced by groundwater from the Tekapo River. Groundwater in the lower reaches tends to run parallel to the Tekapo River.

137. Based on measured piezometric levels, groundwater from Pukaki Flats does not appear to be entering the Tekapo River in significant quantities below the Mary Range. The piezometric levels tend to support shallow groundwater along the south-eastern boundary of Simons Hill moving parallel with the Tekapo River, but the measurements also show that Tekapo River water may move into or out of shallow groundwater, depending on relative water levels of the river and groundwater. The flow gauging (Table D1) shows a small loss in Tekapo River flow along this stretch, indicating recharge to groundwater.

138. My conclusion from the measured data and the GHD modelling is that the majority of drainage from Pukaki Flats is not entering the Tekapo River between the Mary Range and the Iron Bridge.

139. To further reduce the risk of groundwater from Pukaki Flats entering this reach of the Tekapo River, Simons Hill Station has substantially increased the buffer area from what was originally proposed between the irrigation circumscribed area and the Tekapo River above the Pukaki confluence from about 200 ha to 700 ha. The approach is based on the general understanding that the further the irrigation is away from the river, the less chance of nutrients entering the river and the greater chance of drainage going into deep groundwater.

140. Further analysis was carried out to determine whether drainage from Pukaki Flats would be likely to enter the Lower Tekapo River between the Pukaki River – Tekapo River confluence and Lake Benmore.

141. Gauging of the Tekapo River commissioned by GHD and separate additional gauging by Simons Hill/ Simons Pass (Table D2) has not identified any significant gaining or losing stretches between the Pukaki confluence with the Tekapo River and Lake Benmore. If a significant amount of groundwater was entering the lower Tekapo River,

I would have expected to see a measurable gain in flow. As none was identified, my opinion is that the amount of groundwater from Pukaki Flats entering the Lower Tekapo River is low. My view is reinforced by the following.

142. The information presented in Appendix D and in the GHD groundwater report leads me to the conclusion that the groundwater system underlying Pukaki Flats can be treated as one multilayer system. It consists of a number of glacial deposits overlain by a post glacial deposit. There is no evidence of significant confining layers in the profile that would tend to retain shallow groundwater. The upper glacial deposits (the Tekapo and Mt John deposits) and the post glacial alluvial gravels are about 30 m thick and are the most permeable. The deeper deposits (Balmoral, Wolds) are less permeable, but still contain some higher permeable zones.

143. GHD has estimated the flow of groundwater through Pukaki Flats to be 255 Mm^3/y, which equates to about 8 cumecs. This was based on a mass balance of inputs and outputs in the Pukaki sub-catchment.

144. Using Darcy’s Law, I have estimated groundwater flow through Pukaki Flats to be about 1.4 cumecs, based on an overall aquifer thickness of 200 m, a hydraulic conductivity of 12 m/d (estimated from a specific capacity test of bore H38/0035 west of Pukaki Flats), an average width of 5 km and a hydraulic gradient of 0.01 (consistent with the GHD modelling).

145. If the Twizel and Ohau flats between the Pukaki and Ohau Rivers are included, my assessment of flow through the groundwater system increases to 3.4 cumecs, due to the extra width across the Twizel and Ohau flats. Depth to basement is thought to be between 300 m and 2000 m, (Long et al, 2003) so my calculations are likely to significantly underestimate throughflow. It may be 8 cumecs, as GHD has calculated.

146. If a significant proportion of this groundwater throughflow was entering the lower Tekapo River, it should be apparent in an increase in flow in the river.

147. Given that there is no significant change in flow in the lower Tekapo River, and given the potential groundwater contribution from the area is somewhere between 3.4 and 8 cumecs leads me to conclude that most, if not all, groundwater from Pukaki Flats is passing underneath the Tekapo River into Lake Benmore or beyond.

148. The effects of irrigation on Pukaki Flats on surface water quality in the lower Tekapo River is therefore less than minor. Some interaction with the Tekapo River cannot be completely discounted. The GHD modelling showed an increase in groundwater discharge due to increased irrigation of 0.013 m^3/s, which is well below the detection level able to be identified through river gauging and only about 0.13% of average lower Tekapo River flows.

149. GHD (Summary report, Table 17) has estimated that nitrate concentrations in the Pukaki sub-catchment are expected to increase from 0.77 mg/l to 1.02 mg/l. and in the Mary Burn sub-catchment, from 0.56 – 0.87 mg/l.

150. The nitrate concentration of 1.02 mg/l in the Pukaki sub-catchment marginally exceeds the NRRP guideline of 1 mg/l, but the difference is minimal.

Mary Burn

151. The Mary Burn area in the MWRL study is included in the Tekapo River Basin groundwater sub-catchment (Figure 27).

152. The most significant aquifer in the Mary Burn area is a shallow water table aquifer (less than 30 m deep) in the Tekapo or post alluvial gravels. There are two deeper bores in the area, probably in the Balmoral or Mt John formations, but in general, groundwater is not heavily exploited.

153. Moving north in the area east of the Mary range, groundwater does become deeper, probably due to the higher topography rather than due to different aquifers. Although some shallow groundwater could be perched, there is little evidence of confining layers, leading me to the conclusion that the groundwater system probably acts as a single unit.

154. Groundwater flow direction is generally in a south to south easterly direction around Mary Hill and down towards the rivers.

155. Two wetland areas, one near SH8 and the other near the confluence of the Mary Burn and Tekapo River, are probably maintained by shallow groundwater that is connected to the Mary Burn.

156. Based on the description of the hydrogeology, it is likely that any land surface drainage in the area will find its way into the Mary Burn and then into the Tekapo River. It is unlikely to travel into deep groundwater and pass directly to Lake Benmore.

157. GHD (Summary report, Table 17) has estimated that nitrate concentrations in groundwater as a result of the proposed irrigation in the Mary Burn sub-catchment are expected to increase from 0.56 to 0.87 mg/l. These values are less than the NRRP WQL9 policy guideline of 1 mg/l.

158. Although nitrate and chloride levels in the area are generally low, nitrate readings in three samples taken in the area have shown elevated nitrate levels, the higher readings are likely to be due to a local influence, but the specific cause is not known.

159. Mean annual flow of the Mary Burn is about 4.3 cumecs above the confluence of the Mary Burn and Tekapo River. That flow includes contributions from other streams such as Irishman Creek. Mean annual flow of the Tekapo River is about 7.5 cumecs above the confluence with the Pukaki River, which includes Mary Burn flows.

160. Total measured N concentrations in the Mary Burn range from <0.08 to 0.48 mg/l and in the Tekapo River from <0.11 to 0.15 mg/l (Rivers & Lakes Report, Table 8).

RECOMMENDED MITIGATION

161. Throughout the assessment of environmental effects, I have referred to proposed mitigation measures related to irrigation that the applicants intend to implement. They are summarised as follows.

    a) Limit the take to flow rates and volumes specified in the applications (monitor using flow meters).

    b) If water is taken from Lake Pukaki, adhere to minimum water level conditions.

c) Have the irrigation system designed according to the INZ Design Code of Practice.

d) Keep pivots approximately 1 km from the Pukaki River and 0.25 – 1 km from the Tekapo River in accordance with the irrigation command area.

e) Fence off areas of flowing waterways.

f) Implement soil moisture monitoring and use to operate irrigation system as efficiently as practically possible.

g) Carry out regular visual checks for surface ponding and runoff, and implement measures to avoid runoff into streams or minimise runoff in other areas.

h) On Pukaki Flats, where possible discharge water to non-irrigation areas, if required for operational reasons.

i) Install drainage lysimeters to monitor drainage volumes and nutrient concentrations.

j) Continue to measure and record piezometer water levels along the key waterways.

162. A significant amount of research has been carried out by Aqualinc involving discussions with AgResearch (Dr Snow) and Landcare Research (T Webb and M McLeod) on the design of a lysimeter suitable for installation at reasonable cost in the stony ground of the Mackenzie basin. The purpose of the lysimeters is to use them to monitor the volume of drainage and nutrients passing through the soil profile under the irrigation systems and over time to provide information on the performance of nutrient management on the properties.

163. The consensus approach is to use groups of three 1 m diameter lysimeters in at least two locations on Pukaki Flats and possibly two locations east of the Mary Range. The 1 m diameter lysimeters are each equivalent to the area of four standard 0.5 m lysimeters, which means three of them are equivalent to twelve 0.5 m lysimeters, significantly reducing the issue of localised variability. The lysimeters will consist of 300 mm of undisturbed land on top of 300 mm of repacked material, with a collection chamber with 4-5 months storage capacity below that. Normal farming practices will take place over the lysimeters, which removes the need for manual intervention.

ROSEHIP ORCHARDS

Property Locations

164. Rosehip Orchards New Zealand Ltd (Rosehip Orchards) is located south of the Twizel township. The Twizel and Ohau rivers border the property to the west, the Pukaki and Tekapo rivers are to the east, and Lake Benmore is to the south.

165. High Country Rosehip Orchards Ltd (High Country) is located south of the Twizel township. The Twizel River borders the property to the east, the Ohau River is to the west, SH8 is to the north, and Lake Benmore is to the south.

166. The locations of the two properties are shown in Figure 8.

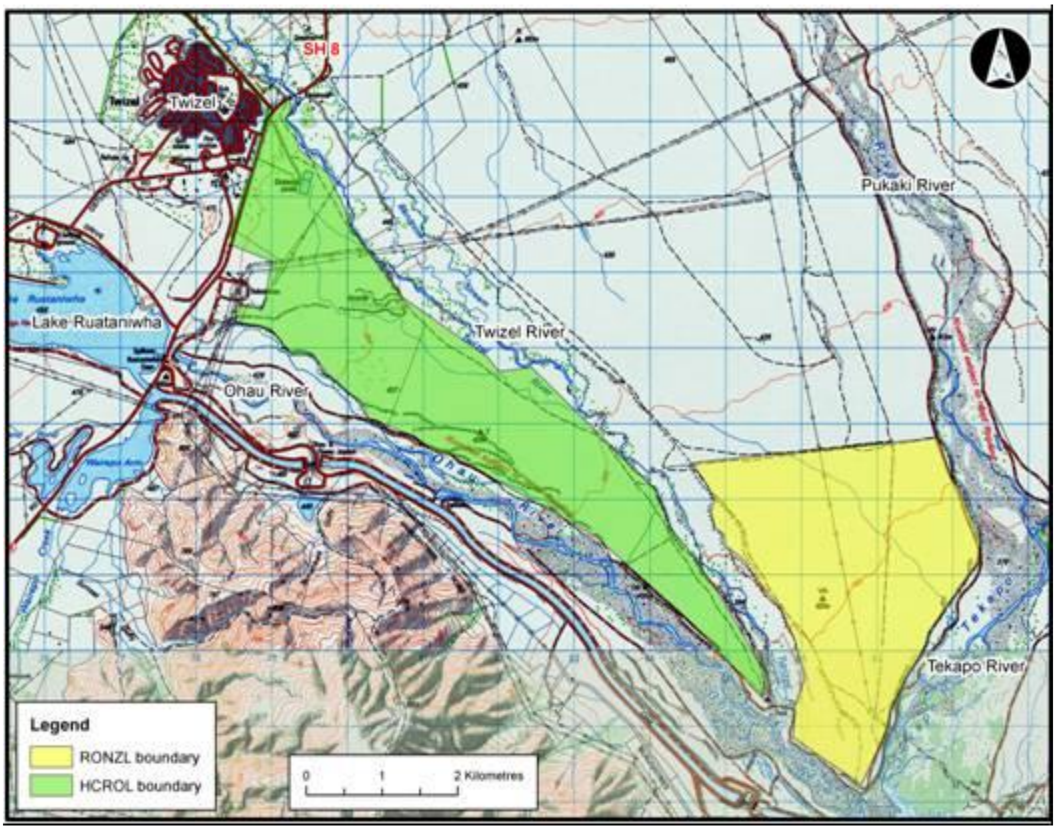

Figure 8: Rosehip Orchards and High Country property locations

167. Rosehip Orchards is proposing to take water at a maximum rate of 422 ℓ/s, 255,226 m^3/7 days and up to 3,660,000 m^3/y annually from the Ohau C canal, for irrigation of up to 610 ha of land between the Pukaki and Twizel rivers (Twizel flats). The irrigation of the 610 ha is in addition to the existing 200 ha of centre-pivot irrigation that currently occurs under resource consent CRC030175. Water will be piped under gravity from the Ohau C Canal to the property.

168. High Country is proposing to take water at a maximum rate of 345 ℓ/s, 208,656 m^3/7 days and up to 3,000,000 m^3/y from the Ohau B canal, for irrigation of up to 500 ha of land between the Ohau and Twizel rivers (Ohau flats). Water will be piped under gravity from the Ohau B Canal to the property.

169. Since the consent application was made, Meridian has recommended that the Rosehip Orchards intake location be moved so that it is 1.5- 2 km upstream from that originally

proposed. Consequently, the supply pipeline route and Ohau River crossing location has changed.

170. The new supply route involves the pipeline gradually dropping down the side of the canal, nearly parallel with the canal. When the pipeline is opposite the confluence of the Ohau and Twizel rivers, it crosses underneath the Ohau River to the property boundary, between H39:851-485 and H38:858-490.

171. With High Country, it was originally proposed to use water for the irrigation of 500 ha within a total command area of 895 ha, consisting of approximately 625 ha of land used for agricultural purposes and 270 ha of land to be used as a golf course/lifestyle area. The applicant is now proposing to irrigate up to 500 ha of land for agricultural purposes only.

Water Supply

172. The location of the proposed intakes is shown in Figure 9.

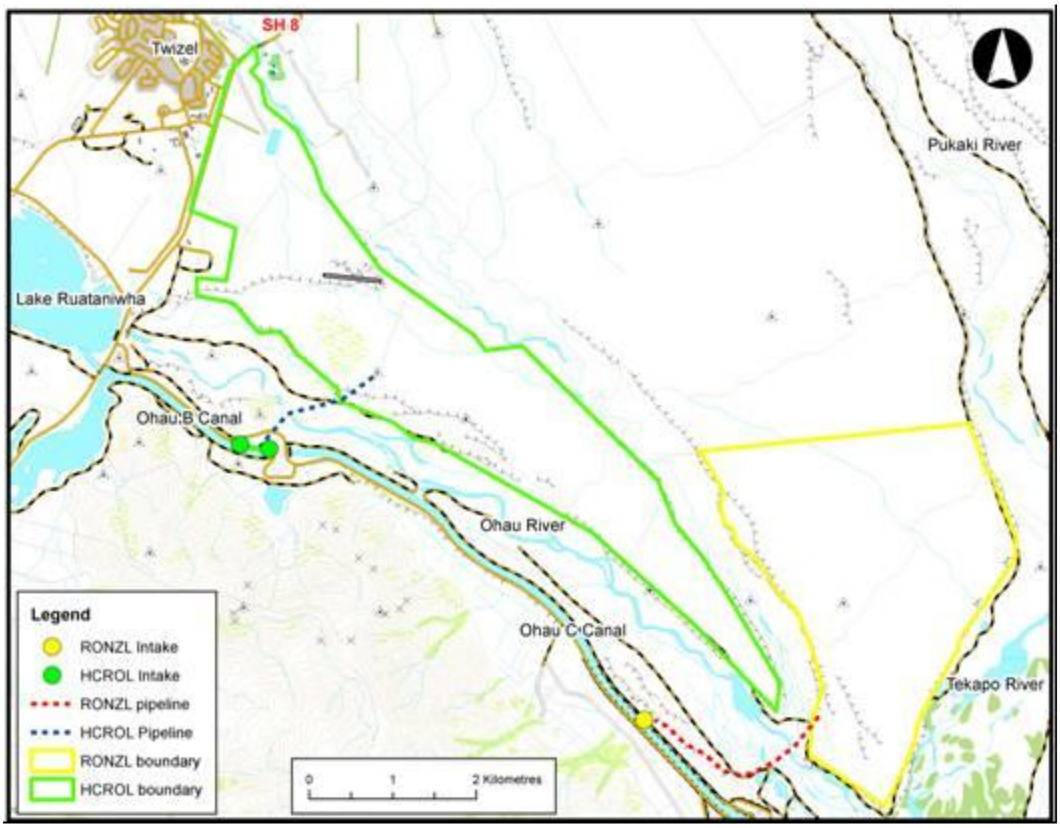

Figure 9: Rosehip Orchards and High Country intake locations

173. Both systems will utilise a gravity operated intake and distribution system. Rosehip Orchards will take water from the Ohau C canal using approximately 600 mm diameter rigid pipe. High Country will take water from the Ohau B canal using approximately 500 mm diameter rigid pipe. Pipe type is yet to be determined. The proposed intake will be designed and built to Meridian Energy Ltd’s approval. A concept design has already been approved by Meridian Energy. Further information on intake design is provided by Mr Smith.

174. From the intakes, the pipes will pass under the existing canal road and will either traverse the escarpment to the base (some benching required) or will be buried for the full length (subject to Meridian Energy’s agreement). From the base of the escarpment, water will be piped under gravity to the irrigated areas. It is anticipated that the pipeline will be completely buried for most of the distance.

175. Water for Rosehip Orchards will be siphoned under the Ohau River at or about map references NZMS 260 H39:851-485 to H39:858-490. This crossing will be above several black stilt ponds administered by DOC, which are located northeast of the Ohau C power station.

176. Water for High Country will be siphoned under the Ohau River at or about map references NZMS 260 H38:797-528 to H38:802-530. This crossing will be below a DOC conservation area, Ruataniwha Wetlands. The pipe will crossing under the wetland outflow.

177. The proposed intake locations and pipeline routes are shown in Figure 9.

Description of the Environment

Climate

178. Rosehip Orchards and High Country experience hot summers and cold winters, with soil moisture deficits commonly occurring from September to April. Details of climate in the region are given in Appendix A.

Soils

179. The soils information for the property was derived from the Upper Waitaki Basin soil survey undertaken by Webb (1992) and from the NZLRI database.

180. The main soil groups over the two properties are Mackenzie, Larbreck, Edwards and Dobson series. A full description of soils is given in Appendix B.

181. The location of the various soil types on Rosehip Orchards and High Country is shown in Figure 10. Soil profile available water (PAW) is summarised in Table 10.

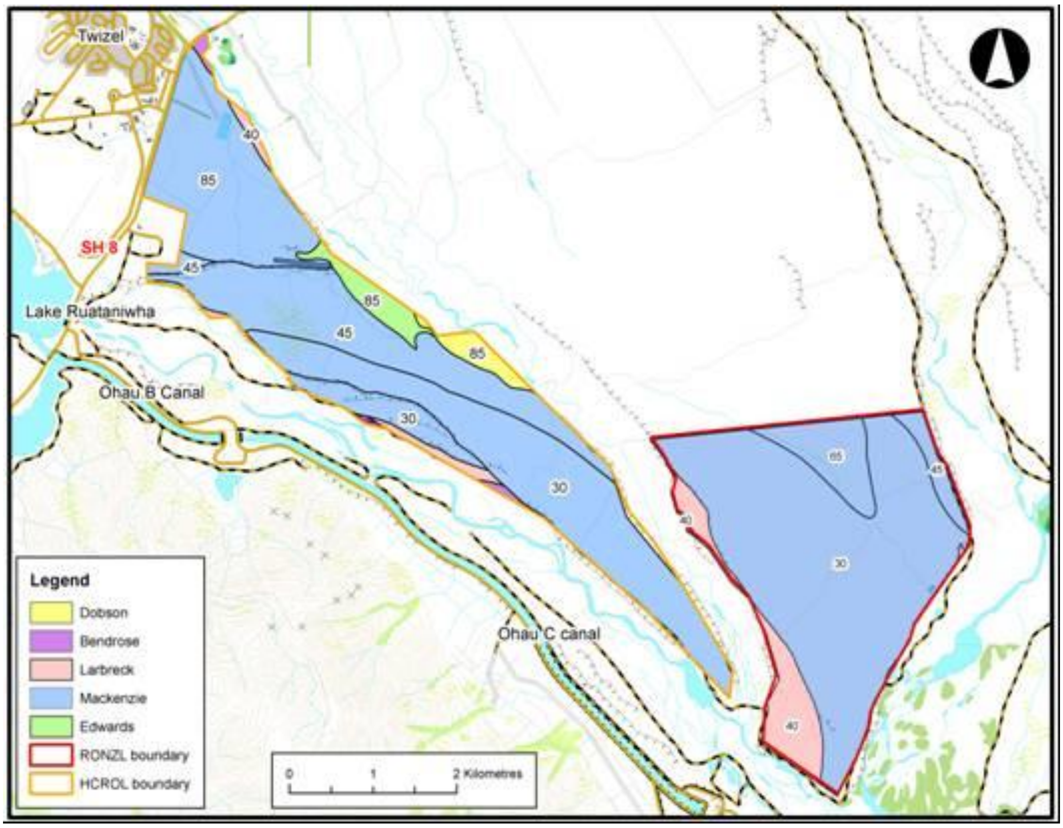

Figure 10: Plan of soils on Rosehip Orchards and High Country

Table 10: Soil profile available water

Average soil PAW (mm)	Area (ha)[i]	
	Rosehip Orchards	**High Country**
30	462	275
40	75	2
45	17	148
65	56	
80		75
Total	***610***	***500***
Note (i): Based on coverage of soils over full property area, apportioned to the proposed irrigation areas.		

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Waterways

182. The following waterways are relevant to the proposed take and use of water on Rosehip Orchards and High Country:

   a) Lake Ruataniwha
   b) Ohau B Canal
   c) Ohau C Canal
   d) Lower Tekapo River
   e) Ohau River (and Ruataniwha Wetlands)
   f) Pukaki River
   g) Twizel River (and DOC conservation area).

183. The locations of these waterways are shown in Appendix C, (Figure C3) where a description of each waterway is also provided.

Topography

184. Key topographical features relevant to the irrigation areas are the Ohau B and C canals, the Ohau, Tekapo, Pukaki and Twizel rivers (and river terraces), and Lake Benmore.

185. The properties are reasonably flat with a gentle slope in a south easterly direction. The average gradient across Rosehip Orchards ranges from approximately 6 m/km near the top of the property and 17 m/km at the southern end of the property. The average gradient across High Country ranges between approximately 5 m/km and 7 m/km. Figure 11 shows the direction of sloping land.

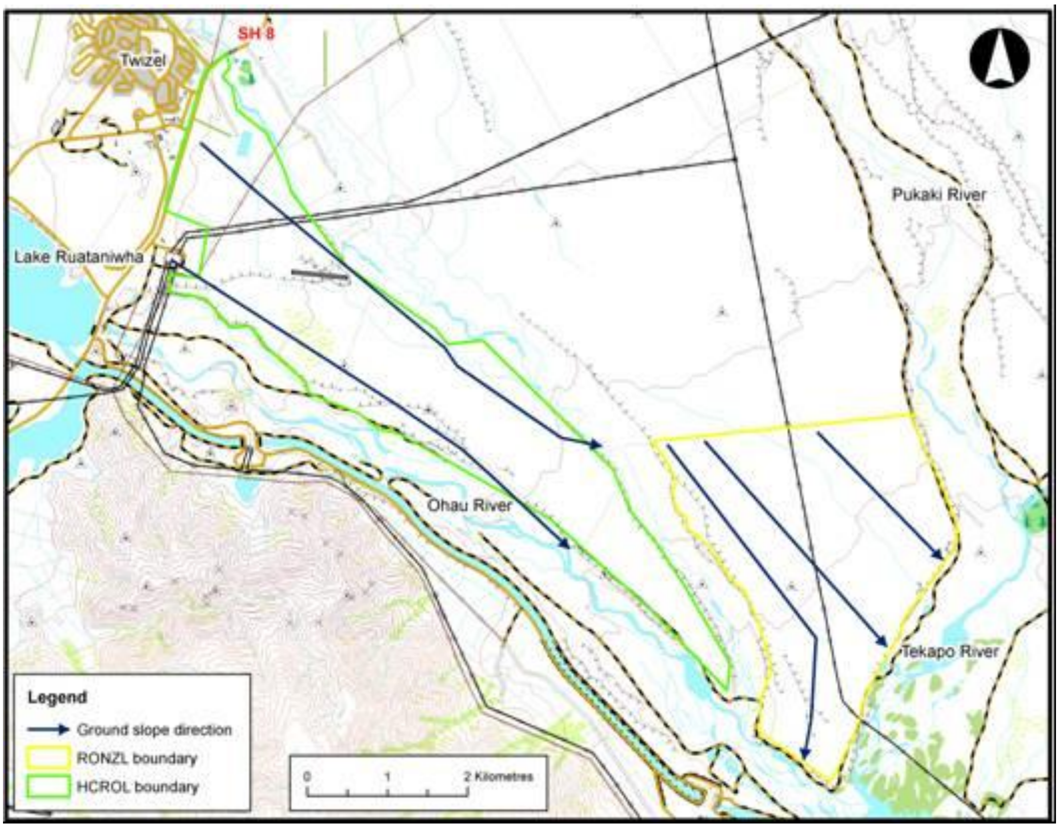

Figure 11: Direction of sloping land over Rosehip Orchards and High Country

On-farm Infrastructure

186. Both Rosehip Orchards and High Country propose to use centre-pivot irrigation systems, primarily to grow pasture and forage crops for stock grazing.

187. On-farm pipelines will be PVC pipe or similar, buried with minimum 400 mm cover. Powerlines will be installed to supply electricity to pumps and irrigators and other infrastructure on the property.

188. Rosehip Orchards proposes to use two full circle centre pivots and three part circle pivots, as shown in Figure 12. High Country proposes to use three full circle centre pivots and one half pivot. Preliminary irrigation designs indicate that the pivots will most likely range in radius from 500 m to 870 m. The pivots will not cross over any waterways.

189. The irrigation system will be designed so that pivots have the capacity to apply 6.0 mm/day over the two irrigation areas. Based on a return period of 2-5 days, the application depth will be between 12-30 mm.

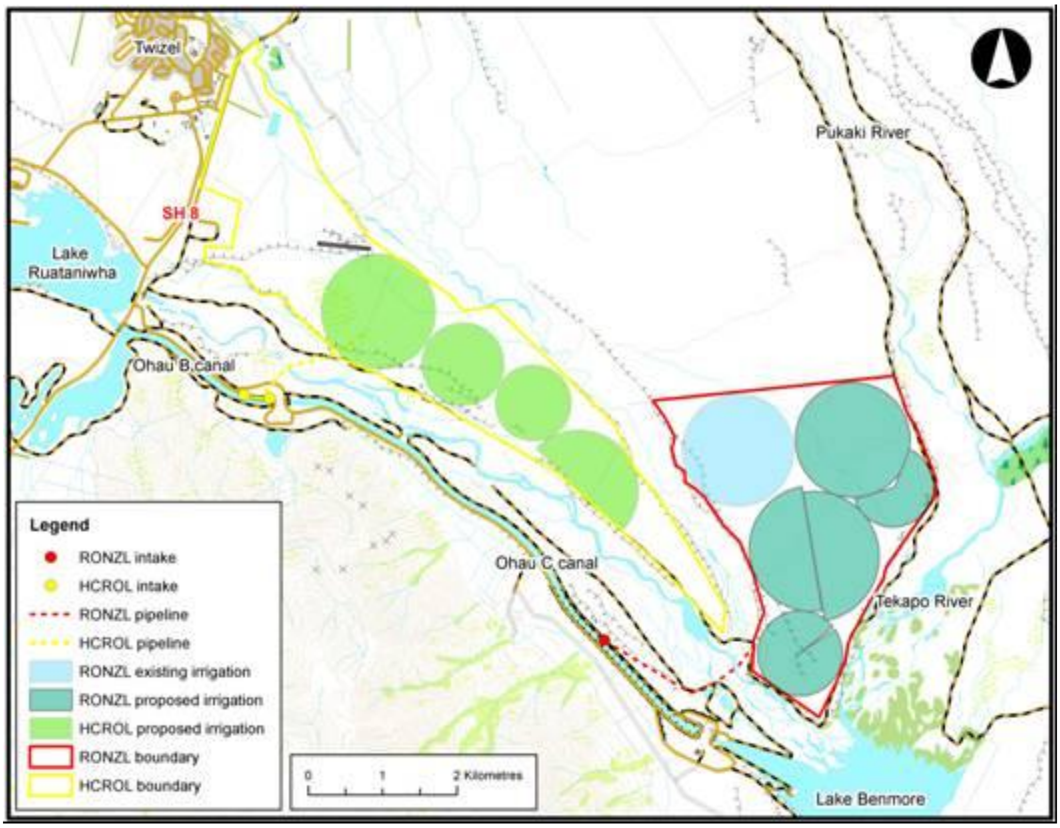

Figure 12: Rosehip Orchards and High Country irrigation infrastructure

Justification of the Proposed Take

190. I have described the issues and methodology for justifying the quantities of water requested previously in paragraphs 28 to 32.

Reasonable Use

191. Flows of 422 ℓ/s and 345 ℓ/s equate to an average system capacity of 6.0 mm/day over the 610 and 500 ha respectively.

192. The annual volumes of 3,660,000 m^3/y and 3,000,000 m^3/y applied for by Rosehip Orchards [and High Country] are based on Mackenzie Irrigation Company share allocations of 6,000 m^3/ha/year over the irrigation areas (i.e. 6,000 m^3/ha x 610 ha [or 500 ha] = 3,660,000 m^3/y [or 3,000,000 m^3/y]).

193. The results of the Irricalc modelling have been summarised in Table 11.

Table 11: Rosehip Orchards and High Country Irrigation demand modelling results summary

Average soil PAW (mm)	**Rosehip Orchards**			**High Country**		
	Irrigation demand (mm/year)	**Area (ha)**	**Irrigation demand (m^3/year)**	**Irrigation demand (mm/year)**	**Area (ha)**	**Irrigation demand (m^3/year)**
30	833	462	3,848,460	782	275	2,150,500
40	828	75	621,000	761	2	15,220
45	822	17	139,740	768	148	1,136,640
65	805	56	450,800			
80				729	75	546,750
Total	***830***	***610***	***5,060,000***	***770***	***500***	***3,849,110***

194. The results of the modelling show that an annual allocation of 5,060,000 m^3/y and 3,849,110 m^3/y for Rosehip Orchards and High Country, respectively, is required to meet full irrigation demand every eight out of ten years. This exceeds what has been allocated by the MIC shares for irrigation and what has been applied for (3,660,000 m^3/y and 3,000,000 m^3/y), and shows that the proposed takes will meet the reasonable use test.

195. The analysis indicates that the applicants may have insufficient water to fully meet demand more frequently than 20 % of the time. They will therefore have to manage the proposed irrigation system to achieve an application efficiency greater than 80 % to ensure significant yield losses do not occur in drought years.

196. Soil moisture monitoring is proposed to be carried out to ensure over-watering does not occur and maximum possible water use efficiency is achieved.

Efficient Use

197. The issues associated with efficient use and the methodologies use to assess application efficiency and irrigation runoff potential are described in paragraphs 41 - 45 and paragraph 51 above.

Application efficiency

198. The application efficiency assessments for the Mackenzie and Larbreck soils are given in Table 12 and for the Dobson and Edwards soils in Table 13 below.

199. *Table 12: Application efficiency – Mackenzie and Larbreck soils*

Return period & applied depth	Pivot length (m)	Application rate[(i)] (mm/h)	Average gross irrigation (mm)	Application efficiency (%)
5 days, 30 mm	680	49	550	78
4 days, 24 mm	680	49	522	82
4 days, 24 mm	800	57	537	79
3 days, 18 mm	800	57	489	86
Note (i): Maximum application at end of pivot.				

Table 13: Application efficiency – Dobson and Edwards soils

Return period & applied depth	Pivot length (m)	Application rate[(i)] (mm/h)	Average gross irrigation (mm)	Application efficiency (%)
2 days, 12 mm	680	49	573	59
2 days, 12 mm	800	57	575	57
Note (i): Maximum application rate at end of pivot				

200. Table 12 shows on Mackenzie and Larbreck soils, when the return period is 3 to 5 days, application efficiency will be at least 78 to 86%. Table 13 shows that, on the Edwards and Dobson soils, achieving an application efficiency of 80% will be more challenging. Applying small depths of water more frequently and having ‘boom backs’ on the pivots are techniques that can be used to improve application efficiency.

201. Along the full length of a pivot, average application efficiency will exceed the figures given above. I am confident that irrigation on this property can achieve 80% application efficiency overall, but there could be situations on the heavy soils where application rates and depths may have to be adjusted to improve efficiency.

Irrigation Runoff

202. The results of the irrigation runoff analysis according to the INZ Code of Practice are summarised in Table 14.

203. *Table 14: Pivot – Application rate compared to soil infiltration rate*

Irrigator type	Soil type	Return period (days)	Irrigator maximum application rate (mm/h)	Soil infiltration rate (mm/h)	Acceptable?
680 m pivot with boom backs	Mackenzie	3	49	45-62	Yes
800 m pivot with boom backs	Mackenzie	3	57	48-65	Yes
1,000 m pivot with boom backs	Mackenzie	3	72	52-72	Yes
680 m pivot with boom backs	Dobson & Edwards	2	49	18	Requires mitigation

800 m pivot with boom backs	Dobson & Edwards	2	57	19	Requires mitigation
Note (i): ‘Boom back’ added to end towers of pivots to reduce application rates.					

204. *Table 14* shows that application rate is within the soil infiltration rate for each of the proposed pivots on the Mackenzie soils, on the basis that a three day return period is adopted and boom backs are used.

205. Where irrigation is proposed over the Edwards and Dobson soils, application rates exceed the soil infiltration rates, even when the return period is reduced to two days and boom backs are used.

206. The results of the SPRINK analysis are detailed in Table 15.

Table 15: Potential irrigation redistribution at end of pivots

Soil type	**Pivot length (m)**	**Return period & applied depth**	**Application rate(i) (mm/h)**	**Average gross irrigation (mm)**	**Irrigation redistribution (mm)**
Mackenzie & Larbreck	680	5 days, 30 mm	49	550	104
Mackenzie & Larbreck	680	4 days, 24 mm	49	522	83
Mackenzie & Larbreck	800	4 days, 24 mm	57	537	113
Mackenzie & Larbreck	800	3 days, 18 mm	57	489	81
Mackenzie & Larbreck	1,000	3 days, 18 mm	72	510	125
Dobson & Edwards	680	2 days, 12 mm	49	573	384
Dobson & Edwards	800	2 days, 12 mm	57	575	399

207. Table 15 shows that the likelihood of ponding and irrigation redistribution on the Mackenzie and Larbreck soils is minimal. As Rosehip Orchards consists only of Mackenzie and Larbreck soils, ponding and redistribution is not expected to be an issue on that property.

208. Mackenzie and Larbreck soils occur adjacent to the Ohau River and the Ruataniwha Wetlands, but given irrigation runoff is very unlikely, irrigation in this area will not have any adverse effects on the river or wetlands. Figure C1 of Appendix C shows that the wetlands are located upstream of the proposed irrigation area. Also, the gradient of the land (Figure 11) means that if any runoff occurs, it will not be towards the river in the vicinity of the wetlands.

209. On High Country, there are small areas of Dobson and Edwards soils. Table 15 shows that applying smaller depths more frequently, and having ‘boom backs’ on the pivots reduces the risk of irrigation distribution, but it may still be an issue.

210. Figure 13 shows the location of the Dobson and Edwards soils relative to the proposed pivots on High Country areas and highlights the areas most at risk of irrigation redistribution.

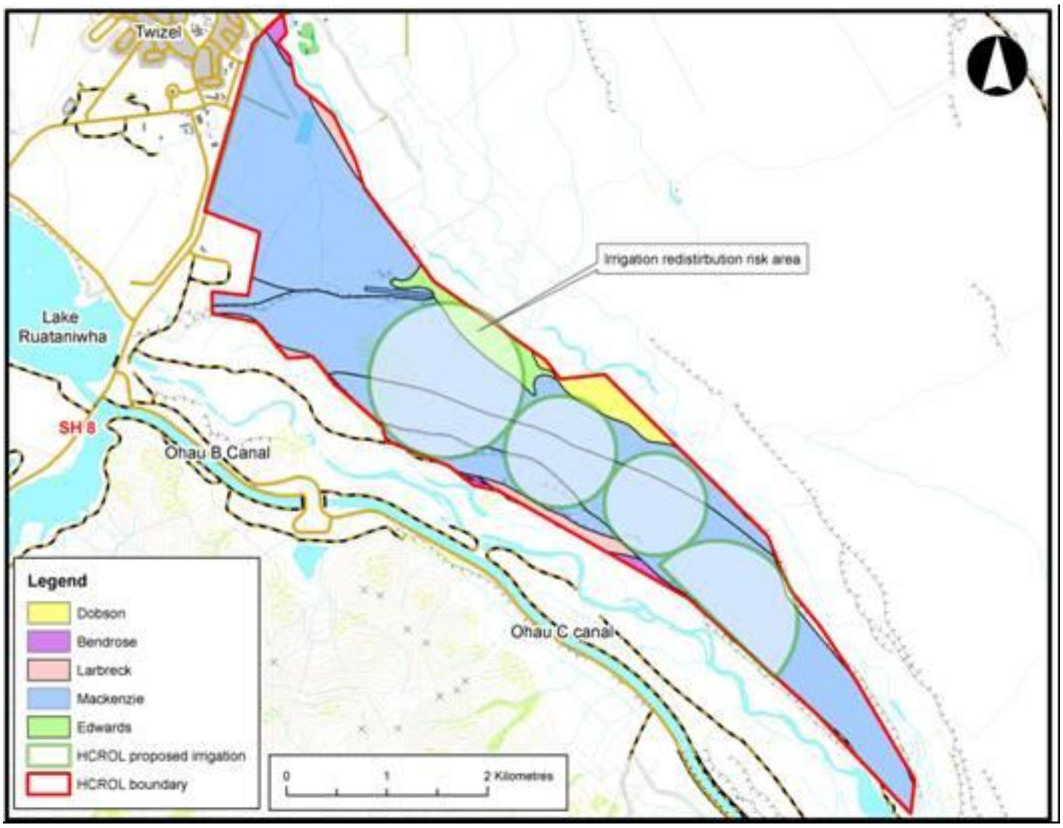

Figure 13: Plan showing areas at risk of irrigation redistribution over High Country

211. None of the Dobson soils are proposed to be irrigated at this time. A small area of Edwards soils on one pivot is planned to be irrigated. The proposed irrigated area over the Edwards soils adjoins the Twizel River and conservation area, and provides a potential risk of irrigation runoff into these areas.

212. In this area, regular observations will be made for surface ponding and runoff, and if they become an issue, mitigation measures such as extending the wetted footprint by changing sprinkler configuration, using ‘boom backs’ or fitting a variable depth irrigation system, and carefully controlling ground cover, will be taken. Variable depth sprinklers on the ends of the pivots to enable these sprinklers can be turned off while over the Edwards soils to ensure they are not excessively irrigated.

213. I recommend that the irrigation systems be designed according to the Irrigation NZ Code of Practice and Design Standards. Adherence to the Code will help to ensure that the design of the system is efficient in terms of water application, labour, energy and the use of capital.

Stockwater

214. Stockwater for Rosehip Orchards and High Country will be sourced from the Ohau C and Ohau B Canals together with the water required for irrigation.

215. The stockwater will be reticulated around the farms using polyethylene pipelines. No discharge from the stock water distribution system will occur.

216. The applicant will provide on-farm storage of water as a backup to cover for periods when the irrigation take is on restrictions.

217. Stockwater has not been included in either of consents CRC072118 or CRC072233. Separate applications will be lodged by the applicants for the take and use of water for stock and domestic supply, if the applications for irrigation water are granted and progressed by the applicants. However, until the applications are lodged and granted, the applicants will rely on provisions set out in the WWAP (Rule 1) or the Resource Management Act under Section 14(3)(b).

Assessment of Effects

Effect of Abstraction on the Ohau B and C Canals

218. The main effect of abstraction of water from either of the canals is the impact on Meridian Energy in the form of loss in power generation. A second effect relates to the abstraction of water on fish within the canals.

219. Meridian Energy has have provided derogation approval for the abstraction.

220. Fish screens will be installed on the intake in accordance with an agreed approach with Fish & Game.

Effects of Surface Water Takes on Other Water Abstractors

221. As stated in paragraph 97, all existing and proposed abstractions upstream of the Waitaki Dam for agricultural and horticultural activities comply with the 275 m^3 allocation limit as set out in Table 5 of the WWAP. These applications therefore comply with the 275 Mm^3/y allocation limit.

222. Although the proposed takes do not directly impact on Lake Ruataniwha, the applicants are proposing to comply with the minimum lake level for Lake Ruataniwha of 458 m above mean sea level set out in the WWAP.

223. Details of the relevant WWAP requirements are provided in Appendix H.

Effect of Proposed Takes on Other Users Supply Reliability

224. Aside from Meridian, other consents to abstract water from the canals are summarised in Table 16 and Table 17.

Table 16: Summary of consented users of Ohau C Canal water

Consent owner	Consent No	Consent details
Hutton Salmon Ltd	CRC040464	Take water for salmon
	CRC032103	Discharge of contaminates from salmon farm
Cairn Station Ltd	CRC921927B	Take water from Ohau-Benmore Canal, between Ohau B and C power stations.

225. Hutton Salmon Ltd is located approximately 3.6 km and Cairn Station approximately 0.8 km upstream of the proposed intake for Rosehip Orchards.

Table 17: Summary of consented users of Ohau B Canal water

Consent owner	Consent No	Consent details
Mt Cook Salmon Ltd	CRC991371	Discharge of contaminates from salmon farm
High Country Salmon Ltd	CRC960344.1	Discharge of contaminates from salmon farm
Cairn Station Ltd	CRC921927A	Take water from Ohau-Benmore Canal, above Ohau B power station via the Tomahawk Lagoon.

226. Mt Cook Salmon Ltd and High Country Salmon Ltd are located approximately 1.6 km and 1.9 km upstream of the proposed intake for High Country, respectively. The Cairn Station Ltd water take is in the vicinity of the proposed High Country take.

227. To mitigate any potential effects that the proposed takes may have on other canal users, the applicants will comply with the minimum lake level for Lake Ruataniwha of 458 m amsl. A fish screen will also be installed on the proposed intake.

228. Using water for irrigation removes some water from the Benmore/Waitaki hydrological system that could potentially be used for electricity generation and therefore potentially affects Meridian Energy.

229. Meridian Energy Ltd have provided each applicant with derogation approval for their proposed abstractions of up to 3,660,000 m^3 and 3,000,000 m^3 of water per year for irrigation from Ohau C and B canals, under resource consents CRC072118 and CRC072232.

Effect of Takes from canals on Town, Domestic and Stockwater Supplies

230. There are no abstractions of water from the Ohau B or C canals for town, domestic, or stockwater supply. On that basis, there will not be any adverse effects on surrounding community, domestic and stock water supplies.

Effects of Pipeline Crossings

231. Rosehip Orchards and High Country will need to install pipelines beneath the bed of the Ohau River to deliver water from the canals to the irrigation areas.

232. The location of the proposed Rosehip Orchards pipeline crossing is between map references H39:851-485 to H38:858-490, more or less. The High Country pipeline crossing is proposed to be between map references H39:797-528 to H38:802-530, more or less.

233. The Ohau River (upstream of the Twizel River confluence) is generally dry and only flows as a result of Meridian releasing water. Below the confluence with the Twizel River, the Ohau River flows primarily due to the contribution from the Twizel River. This is very close to Lake Benmore.

234. Potential effects from the installation of the pipelines will be temporary in nature, localised and on a small scale. The effects will therefore have a negligible effect on the natural and physical river environment.

Pipeline Construction Methodology

235. The pipeline associated with the Rosehip Orchards scheme will be installed beneath the bed of the Ohau River just below the Twizel confluence, which at that point includes

flow from the Twizel River. Flow will be diverted across to one side of the channel, a trench will be dug, the pipe laid, and the trench back-filled. The water will then be diverted across to the other side of the channel where the pipeline installation will be repeated as for the first half. Works in flowing water will be minimised as much as possible.

236. Works for High Country will only be undertaken during periods of no flow in the river (excluding the small outflow from the Ruataniwha Wetlands). The pipeline will be installed by digging a trench, laying the pipe, and back filling. As there is likely to be a small outflow from the Ruataniwha wetlands during construction, this waterway will be temporarily diverted. Once construction is completed, the waterway will be restored to its previous state.

237. The areas of excavation will be approximately 3 m wide, 3-4 m deep and will extend for approximately 700 m across the width of the Ohau River. It is intended to have minimum 2 m cover over the pipeline in the riverbed as protection against potential erosion during flood flows or spillage. Excess spoil from the works will be minimal and spread out over the river bed to represent the current state.

238. The duration of the proposed works associated with the installation of each of the pipelines beneath the river will be in the order of 1 week and will be carried out during daylight hours.

Effects on Ecosystems

239. As the works in the river bed will be carried out over a short time period (approximately 1 week), potential effects on instream values or aquatic ecosystems are expected to be minor. Fish passage will be maintained throughout the duration of the proposed works through the diversion of flow to one side of the creek. No storage of fuel or refuelling of any vehicles and machinery will occur anywhere on the bed of the river; thereby ensuring contaminants will not enter flowing water.

240. Consultation with DOC has highlighted the following concerns:

a) Effects on the DOC ponds and grasshopper monitoring sites (downstream of the Rosehip Orchards site).
b) Effects on the Ruataniwha Wetlands (upstream of the High Country site).
c) Effects on flying birds if pipeline set above ground level.
d) Timing of works during bird breeding season (August to the end of January).
e) Introduction of weeds via machinery.

241. The pipelines will be buried beneath the riverbed and will be located upstream of the DOC ponds and downstream of the Ruataniwha Wetlands (to the northeast of the Ohau C power station), which will also avoid any grasshopper monitoring sites.

242. Works will be undertaken when flows permit, and as far as practical will be undertaken outside fish spawning and bird breeding periods. Where this is unavoidable, consultation will be undertaken with DOC and Fish and Game. A condition is also proposed whereby works cannot be undertaken within 100 m of nesting birds.

243. To control the potential for the introduction of weeds to waterways during construction, machinery will be washed before moving to a new site to minimise the risk of any weed introduction. The applicant intends to follow recommended ECan and DOC guidelines.

Erosion, Flood Carrying Capacity and Essential Structures

244. In order to minimise erosion of the river bed, construction of the intake will take place during periods of low flow (for Rosehip Orchards) and no flow (for High Country), and when the risk of flooding is low.

245. Works will be undertaken to minimise the disturbance to the riverbed. Where any disturbance occurs to the banks of the river, the applicant will undertake remedial work to restore the bank stability.

246. Additionally, as the pipelines are proposed to be buried beneath the riverbed and excess materials levelled to the natural bed level, the flow of water will not be impeded and will not be deflected into the banks of the river, avoiding erosion potential.

247. There are no known flood protection structures or other essential structures within the vicinity of the site.

Sediment Transport

248. Under the works proposed for the Rosehip Orchards pipeline, some sediment may be released into the Twizel river. However, the short duration of the proposed works means sediment release will only occur over a short period of time and no long term or ongoing adverse effects should arise. Undertaking the works when flows are low will minimise disturbance to the bank and reduce the risk of sediment entering the river. The effects of sediment entering the river will be minor.

249. Works will be undertaken by High Country when there is no flow in the river. Therefore, the effects of sediment release will be minor. However, the diversion of the outflow channel from the wetland area may result in the release of some sediment into the flowing water. The short duration of the proposed works means sediment release will only occur over a short period of time and no long term or ongoing adverse effects should arise. The effects of sediment entering the river will also be minor.

Effects on Other Users

250. The potential effects on other users from the proposed works relate to effects on water quality from sediment release into the river, and the timing of works. The applicant will undertake all practical measures to minimise the discharge of sediment into flowing water. Additionally, works will be carried out during daylight hours and will not be carried out on weekends or public holidays.

Effects on Amenity Values

251. The small localised scale and the reshaping and levelling of the proposed work site to resemble the natural riverbed will ensure the proposed works will result in minor, if any changes to the amenity values currently attributed to the Ohau River.

252. Additionally, the proposed locations of the pipelines are at least 2.5 km from the main road (SH8); therefore the works will not be able to be easily seen by the community or tourists.

Impact of Irrigation Overland or Quick Flow on Waterways

253. If irrigation occurs close to or over waterways, there is potential for surface runoff or quick flow to enter surface waterways. The following is proposed to mitigate those potential effects.

Twizel River and DOC Conservation Areas

254. The Twizel River and DOC conservation areas are located along the north eastern boundary of the High Country property as shown in Appendix C. The Twizel River and associated DOC conservation area also borders Rosehip Orchards on the lower western area of the property. The Twizel River flows year round.

255. As shown in Figure 14, the proposed irrigation areas are located at the top of terraces, elevated above the river and DOC reserve area. A fence has been constructed approximately 20 m from edge of the Twizel River on the High Country property.

Figure 14: Looking from High Country towards Rosehip Orchards, showing the Twizel River (in a fresh), DOC reserve and terraces (December 2008).

256. Irrigation will only occur on top of the terraces. There will be a large buffer distance between the irrigated areas and the river, within which irrigation will not occur.

257. The analysis of irrigation efficiency and the potential for surface runoff showed that the runoff (paragraph 207) was extremely unlikely on Rosehip Orchards because irrigation would be on Mackenzie and Larbreck soils, where ponding is unlikely. On High Country, the only area at risk is a small part of a pivot circle on the Edwards soils at the northern end of the block.

258. Regular inspections will be made for ponding and potential runoff and if it becomes an issue, mitigation, probably through fitting a variable depth irrigation system and if necessary turning sprinklers off when they pass over that area, will be implemented.

259. I don’t expect there to be any direct adverse effects of irrigation on the Twizel River.

Tekapo River

260. The lower Tekapo River flows along the south eastern boundary of the Rosehip Orchards property, between the confluence with the Pukaki River and Lake Benmore. The land to be irrigated is on top of a terrace, about 10 m above the river. At its closest point, the river is approximately 550 m east of the terrace base. At the base of the terrace, there are several wetlands that could be potentially affected by changes to groundwater quality (refer to Figure 15).

Figure 15: Wetland area located at the base of the terrace, Tekapo River in the distance (December 2008).

261. An existing 50-70 m wide fenced buffer strip exists between the top of the terrace edge and the proposed irrigation area, as shown in Figure 16.

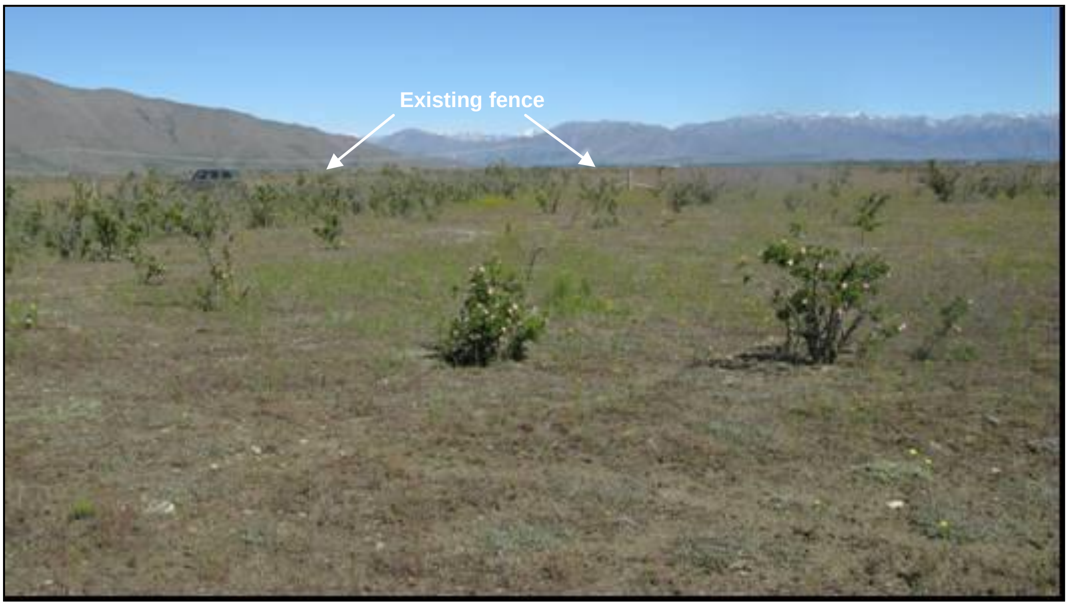

Figure 16: Existing buffer strip between terrace edge and irrigation area (December 2008)

262. As stated above, the analysis of irrigation efficiency and the potential for surface runoff showed that the runoff (paragraph 207) will be extremely unlikely on Rosehip Orchards because irrigation would be on Mackenzie and Larbreck soils, where ponding is unlikely.

Ohau River

263. The Ohau River flows along the most southern boundary of the Rosehip Orchards property, downstream of the confluence with the Twizel River, and flows along the south western boundary of the High Country property, upstream of the confluence with the Twizel River.

264. Figure 17 shows the dry Ohau riverbed adjacent to the High Country property. The river has been fenced off to prevent stock access.

Figure 17: Ohau River bed (December 2008)

265. At its closest, the main channel of the river is approximately 200 m from the property boundaries.

266. Soils along the irrigation area boundary with the Ohau River are Mackenzie series, with good infiltration characteristics. Problems with runoff are not expected.

Ruataniwha Wetlands

267. The Ruataniwha Wetlands form part of a conservation area located near the north western corner of the High Country property (Figure 18). An existing fence keeps stock out of the area.

268. As the wetlands are located up gradient of the proposed irrigation area, adverse effects relating to water quality on the wetland area from the proposed irrigation will not occur.

Figure 18: Ruataniwha Wetlands in front of the High Country property

Effects on Groundwater Quantity

269. Assuming direct runoff from irrigation is avoided or mitigated, irrigation on Rosehip Orchards and High Country has the potential to increase groundwater levels via drainage through the soil profile.

270. Currently there is no irrigation on the Ohau Flats, although there is a pivot irrigating 200 ha from groundwater on the Twizel Flats. Groundwater is likely to be sourced from a combination of :

    a) Leakage from Lake Ruataniwha,
    b) Deep groundwater flow from upland catchments,
    c) Gains from or losses to rivers and streams; permanent, intermittent and ephemeral,
    d) Rainfall recharge,
    e) Snowmelt.

271. Aqualinc (2008) estimated dryland drainage in this area to be in the order of 80-200 mm, depending on soil type. Drainage under irrigation would be expected to increase to 170-300 mm due to additional rainfall drainage and irrigation losses.

272. Taking an average of 150 mm for dryland recharge and 250 mm for irrigated recharge, an additional 100 mm of drainage could occur. This equates to 1.1 Mm^3/y of additional drainage to groundwater over the Twizel and Ohau Flats. Assuming a specific yield of 0.1 for the shallow aquifer material and assuming static conditions, groundwater levels could theoretically rise 1 m over the irrigated area. In practice, groundwater systems are to a large extent self-balancing, and water levels tend to flatten out to reach a new equilibrium, so actual changes will be significantly less than this figure.

273. In my opinion, a maximum 1 m increase in groundwater levels will have no adverse effects on groundwater in the Twizel and Ohau Flats area. There is only one bore in the area that belongs to Rosehip Orchards, which is used to supply water to the existing pivot.

Effects on Groundwater and Surface Water Quality

Twizel Flats

274. The Twizel Flats area in the MWRL study is included in the Pukaki River Basin groundwater sub-catchment. (Figure 26).

275. With the Twizel Flats area of Rosehip Orchards, the key waterways that irrigation could potentially affect are the lower Pukaki River and the lower Tekapo River – the area above the Tekapo-Pukaki confluence and the lower reach between the Tekapo-Pukaki confluence and Lake Benmore. The northern arm of Lake Benmore is in all probability the receiving environment.

276. If water drains through the soil profile under the irrigated areas, there are several pathways that the flow could take:

    a) Drain into deep groundwater, and flow underneath the Twizel River and Lower Ohau River emerging somewhere in Lake Benmore.
    b) Drain into shallow groundwater, remain in shallow groundwater and flow into the Twizel River above the Twizel-Ohau confluence.

c) Drain into deeper groundwater and emerge in the lower Ohau River above Lake Benmore.

277. GHD concluded that the majority of drainage from Twizel Flats and Ohau Flats would go into deep groundwater and emerge in Lake Benmore, i.e. essentially bypass the lower Pukaki, Tekapo and Ohau Rivers. That conclusion was based on their conceptual model of the groundwater system and the results of the Modflow modelling.

278. Simons Pass/ Simons Hill carried out additional fieldwork, including installation of shallow piezometers along the Tekapo and Pukaki Rivers, water level measurements, water chemistry tests and river gauging to confirm that the conclusions from the modelling, at least for Simons Hill and Simons Pass, are consistent with actual measurements.

279. The piezometric and groundwater chemistry measurements confirmed that shallow groundwater is closely linked to the Pukaki River in its lower reaches. The measurements show that when Meridian is spilling from Lake Pukaki, groundwater levels along the river rise, indicating a movement of water from the river into shallow groundwater and vice-versa when they are not spilling. I would assume that if Meridian spills down the Ohau River, the same effect would occur.

280. The piezometric contour map generated by GHD (Figure 14 in the groundwater report) utilised a significant number of bores in the general Ruataniwha to Ohau to Benmore area (Figure 3 in the GHD groundwater report). It shows groundwater to be moving south towards Lake Benmore. In the lower Twizel Flats, groundwater from Rosehip Orchards is shown to be moving partly in the direction of the lower Tekapo River and partly in the direction of the Twizel River or Lower Ohau River close to Lake Benmore. On High Country, groundwater appears to be moving primarily towards the Ohau River rather than the Twizel River.

281. How much of that groundwater is entering the Twizel River and Lower Ohau River is unknown. As stated earlier, the gauging of the Tekapo River commissioned by GHD and by Simons Hill/ Simons Pass did not identify any significant gaining or losing stretches between the Pukaki-Tekapo confluence and Lake Benmore. There was no measurable gain in flow. That means that contribution of groundwater to the Lower Tekapo River from the Twizel Flats is very small, despite the fact that somewhere between 3.4 and 8 cumecs of water is flowing through the Pukaki sub-catchment, as I had stated in the analysis for Simons Hill/ Simons Pass.

282. Figure 11 in the GHD groundwater report shows the Twizel River between the Pukaki Canal at Lake Poaka and the confluence with the Ohau River to be gaining flow from groundwater. What is not clear is where the gains occur and whether the river is gaining in the vicinity of Rosehip orchards or High Country Orchards. The Ohau River is not shown to be gaining flow. The Twizel River is the main contributor to the 1.5 km reach of the Ohau River above Lake Benmore.

283. I am not aware of any gaugings having been carried out to determine whether the Ohau River in its lower reach above Lake Benmore or the lower Twizel River is gaining from groundwater. Without further data, I cannot rule out the possibility that groundwater could recharge the lower Twizel and Ohau Rivers from groundwater moving from Rosehip Orchards or High Country Orchards. However, the GHD modelling and the additional fieldwork carried out for the Tekapo River reach indicates little groundwater contribution to flows in the rivers close to Lake Benmore. On that basis, it is possible

that there is little gain from groundwater in this area and that Lake Benmore is the main receiving environment . Further fieldwork is required to clarify this issue.

RECOMMENDED MITIGATION

284. Throughout the assessment of environmental effects, I have referred to recommended mitigation measures related to irrigation. They are summarised as follows.

a) Limit take to flow rates and volumes specified in the applications (monitor using flow meters).

b) Adhere to minimum water level conditions in Lake Ruataniwha.

c) Have the irrigation system designed according to the INZ Design Code of Practice.

d) Implement soil moisture monitoring and use it to operate the irrigation system as efficiently as practically possible.

e) Carry out regular visual checks for surface ponding and runoff, particularly on the Edwards soils and implement measures to avoid runoff into streams or minimise runoff in other areas.

f) Install drainage lysimeters to monitor drainage volumes and nutrient concentrations.

g) Measure and record piezometer water levels along the key waterways.

SUBMISSIONS

New Zealand Transport Agency (NZTA)

285. NZTA opposes the Simons Pass applications, in part. They are concerned with the potential effects on State Highway 8 from the proposed intake structure and pipelines that go under the road.

286. NZTA requests that the applications be declined unless sufficient information to provided to address concerns held by NZTA and conditions are applied to the consent that ensure effects on the state highway are avoided, remedied or mitigated.

287. NZTA, through MWH, has indicated they will be willing to approve the installation of such a pipeline, so long as the proposed work complies with the standard conditions for installing a pipeline This issue has been addressed by Mr Smith.

Land Information New Zealand (LINZ)

288. LINZ opposes the applications CRC082311 or CRC082304 to take water from the Pukaki Canal. LINZ have stated in their submission that if any structures proposed by the applications cross any areas of Crown Pastoral Land, an easement will be required under Section 60 of the Land Act 1948, and agreement will be required with the lessee regarding compensation.

289. If resource consents CRC082311 or CRC082304 are granted and if the proposed infrastructure including intake or pipelines crosses through any areas of Crown Pastoral Land, an easement under the Land Act 1948 will be applied for, and the applicant will obtain agreement with the lessee of the land.

290. In other general submissions, LINZ neither supports nor opposes the applications, but requests landowner consent is obtained for all proposals that affect land administered by LINZ.

291. If any of the resource consent applications proposed by the applicant are granted, and if the proposed infrastructure including intakes, canals or pipelines cross through any areas of Crown Pastoral Land, a licence to occupy or an easement under the Land Act 1948 will be applied for.

Fish and Game

292. Fish and Game opposes all applications. The concerns raised in their submission, that are relevant to the matters addressed in my evidence, are:

    a) Environmental flow regimes
    b) Efficiency of use;
    c) Metering of takes;
    d) Fish screening provisions;
    e) Timing of in-stream works.

293. All applications addressed in this report will comply with the relevant environmental flow regimes and lake levels specified under the WWAP.

294. Standard metering conditions are proposed to form part of each of the resource consent applications to take water, as agreed to in the common MIC consent conditions, and detailed in the conditions described by Mr Kyle.

295. Fish screening/exclusion measures are proposed as part of each of the resource consent applications to take and use water. The indications from preliminary discussions with Fish & Game are that issues related to fish screening will be resolved.

296. Works within natural waterways (Lake Pukaki, Pukaki River and Ohau River) will preferentially be undertaken when the risk to nesting birds and to salmon spawning is low. When this is not possible, consultation will be undertaken with Fish and Game prior to the commencement of works to agree on an appropriate procedure.

297. The Pukaki and Ohau rivers generally only flow when Meridian is spilling water from the lakes. Construction will not occur during times when spilling is occurring.

Royal Forest and Bird Protection Society of NZ Inc (Forest and Bird)

298. The relevant concern held by Forest and Bird relates to whether the minimum flow regimes specified in the WWAP will be adhered to.

299. These applicants are not proposing to take water from any streams. Applications CRC062867 and CRC062842 will not comply with Table 5 of the WWAP, in regards to the allocation of 8 Mm^3 set for upstream of the Lake Pukaki outlet. Although the volumetric limits will be exceeded under these options, allowable lake water levels will not be altered by the proposed takes for reasons outlined in paragraphs 72 to 76 of my evidence. The applicants will comply with lake water level restrictions.

Department of Conservation

300. DOC has concerns regarding whether the applications are meeting the minimum flow requirements and allocation limits set in the WWAP.

301. All applications addressed in this report, will comply with the overall annual allocation limit set down by the WWAP, and the lake levels specified under the WWAP. The proposed take from Lake Pukaki will not comply with the 8 Mm^3/y allocation limit, but the impacts on lake levels will be less than minor.

Waitaki First Incorporated

302. Waitaki First Incorporated oppose all the applications to take and use water for stockwater and/or irrigation purposes, unless any consents granted meet provisions of the WWAP and includes several conditions summarised below:

    a) Water is to be applied by spray or drippers only;
    b) Soil moisture levels are to be reported monthly to the Regional Council;
    c) Aquaflex data logger system is to be installed to record soil moisture levels;
    d) Farm management plan to be completed and approved by the Regional Council specifying the range of soil moisture levels at which irrigation will be applied and cease and when nitrogen inhibitors will be applied.

303. The applicant is proposing the following as part of their resource consent applications:

    a) To use only spray irrigation for the application of water.

    b) Soil moisture monitoring will be undertaken on each property (refer to the sections on reasonable use). My recommendation to the applicants is to use a method such as Aquaflex and to log the data, but the actual methodology is yet to be finalised. Soil moisture levels will not be reported monthly to the Regional Council.

c) Farm Environmental Management Plans have been completed by Ms Robson for each of the properties, and form part of the on-farm evidence.

Gottlieb and Anne Braun-Elwert

304. A and G Braun-Elwert oppose the applications. Their submission requests that all irrigation water is to be piped and that all water takes are to be measured.

305. All irrigation takes are proposed to be piped by Rosehip Orchards and High Country. The Tekapo Canal water supply option for Simons Hill and Simons Pass will also be piped.

306. The Pukaki Canal and Lake Pukaki water supply option for Simons Hill and Simons Pass will be a combination of canals and pipe. All reasonable care will be taken to minimise leakage from the canals to ensure that the maximum amount of water that can be taken will be used productively.

307. Standard metering conditions are proposed to form part of each of the resource consent applications to take water, as agreed to in the common MIC consent conditions, and described in the conditions proposed by Mr Kyle.

RJ Blackmore

308. RJ Blackmore, regarding submissions relevant to my evidence, requests that any abstraction from any stream does not exceed one third of the five year mean low flow, that irrigation methods are specified to ensure maximum efficiency of use, and that offsite storage is made compulsory.

309. Simons Hill, Simons Pass, Rosehip Orchards and High Country are not proposing to take water from any streams. Takes will be from canals or Lake Pukaki.

310. Irrigation methods will be centre-pivots, which will be designed and managed to be as efficient as is practically possible. Annual allocation limits, which I have shown in my evidence to be reasonable, will prevent wastage and ensure efficient use.

311. Off-site storage is unnecessary where the water sources for irrigation are already storage-based due to the presence of several lakes, whose levels are controlled by Meridian Energy for power generation. The applicants will comply with statutory lake level conditions.

RESPONSE TO ECAN S42A REPORTS

312. ECan have raised several matters within their S42a reports that according to them have not been previously addressed by the applicants. The matters raised in the S42a reports relevant to my evidence are addressed in the following sections.

ECan Report 33A and 34A: CRC062842, CRC062867

Effects of Granting Over the Lake Pukaki Allocation Limit

313. The Officer (para 23, 24) states that the applicant has not provided any assessment of effects of granting an application over the allocation limits on entitlements to other activities. The Officer is referring to the 8 Mm^3/y limit from Lake Pukaki, which would be exceeded by the proposed Simons Hill and Simons Pass take, if that water supply option is chosen.

314. My evidence shows that the proposed take, despite exceeding the Lake Pukaki allocation limit, will not impact significantly on Lake Pukaki water levels. The lake will continue to operate in its normal water level range. The take will impact on Meridian's ability to generate electricity, but Meridian has provided derogation approval for the activity.

315. The 8 Mm^3/y allocation limit is included in the 275 Mm^3/y allocation limit in Table 5 of the WWAP for the Upper Waitaki basin, so I can't see how there is any effect on granting an application over the allocation limits on entitlements to other activities. Either the water comes from Lake Pukaki or it comes from somewhere else. The impact on the 275 Mm^3/y allocation limit is the same.

Fish Screening

316. Fish screening/exclusion measures are proposed as part of each of the resource consent applications to take and use water. The indications from preliminary discussions that the applicant has had with Fish & Game representatives are that the applicant expects to resolve any issues related to fish screening.

Didymo

317. The ECan Officer (para 44/43 –table) has identified in the reports that Didymo has been detected in the Tekapo Canal. The Officer has raised the issue that if it reaches the intake, it could challenge the performance of the intake and fish screening structures, and the proposed water race system could provide a vehicle for further spread.

318. If Didymo is currently in the Tekapo Canal, it will also be or eventually be, in all waterways downstream of the Tekapo Canal. If any water is discharged from the proposed irrigation, it will also be into waterways downstream of the Tekapo Canal and will therefore not be exposing waterways to Didymo where that exposure does not already exist.

319. With respect to the intake, from an engineering perspective, Didymo could partially block the intake. If it does, it will not adversely affect fish screening structures, but will compromise the taking of water. That is a problem that the applicants will have to address as it will be them that will be affected, not the ability of the structure to screen fish. Details of intakes are given in evidence by Mr Smith.

Efficient Use

320. The Officer (para 44/43 –table) was not satisfied that the annual volume being sought by the applicant under CRC062867 would be reasonable, however agrees that the volume applied for under CRC062842 is reasonable.

321. Issues surrounding the reasonable and efficient use of water under CRC062867 have been addressed in paragraphs 28 to 40. I have used water balance modelling to establish that the volume of water required to meet irrigation demand according to reasonable and efficient use criteria exceeds that applied for.

322. Either water balance modelling or NRRP Schedule WQN9 v2 method can be used to determine reasonable volumes. I have used water balance modelling, while CRC has used Schedule WQN9. A summary of the data used for my analysis is included in this evidence. Full details of the water balance modelling have also been provided to CRC. Similar inputs have been used for both methods. The difference in assessments between water balance modelling and the WQN9 method relate to the methodology, rather than the inputs used.

323. The Officer (para 44/43 –table) also raised concerns regarding the efficiency of the proposed delivery system proposed under consent CRC062867 and CRC062842, whereby water will be delivered from the intake to the irrigation area via an open race. The Officer makes the point that under such a system, significant losses are likely to occur.

324. I disagree with the officer on this issue. The canals will be constructed to minimise losses and those losses are included in the annual allocations for irrigation. Any water lost from the system is water lost to irrigation, which is not in the applicants' interests.

325. Where significant leakage is likely, races will be lined with clay or an artificial liner to minimise losses. If necessary, some sections could be piped.

326. It should also be noted that the applicants have proposed an alternative intake location that would involve a fully pipe delivery system under CRC082304 and CRC082311.

Water Quality

327. The Officer (para 44/43 –table) considers the effects on groundwater and surface water quality may be more than minor as a result of the proposed irrigation.

328. I have provided an assessment of effects within my evidence of the proposed irrigation with respect to potential surface runoff and drainage to groundwater on both groundwater and surface water resources. My assessment quantifies the effects on water quantity from the proposed irrigation. I have stated that the predicted changes in water quantity (groundwater levels and changes in stream/ river flows) will be no more than minor. The impacts of changes in water quality are addressed by other experts.

ECan Reports 33B and 34B: CRC062843, CRC062869

Flood Carrying Capacity and Erosion

329. The Officer (para 25 – table) identifies that no design plans of the proposed erosion protection works were provided with the application. These have since been completed and are included within the evidence. (see Figure 7).

Water Quality

330. The Officer (para 25 – table) has identified that there is the opportunity for water conveyed through the open race system to be contaminated, and when discharged potentially affect the quality of the receiving water. This matter has been addressed in paragraphs 86 to 88 of my evidence.

331. The ECan Officer has also stated that the proposed discharge of surplus water to non-irrigated land at a rate of between 25 and 250 ℓ/s could have the effect of saturating the soils at the point of discharge resulting in the potential for contaminants to be transported into groundwater. The officer has recommended that buffer storage is created at the ends of each branch of the race system to avoid the discharge. This matter has been addressed in paragraphs 85 to 93 of my evidence.

ECan Reports 33C and 34C: CRC082304, CRC082311

Fish Screening

332. Fish screening/exclusion measures are proposed as part of each of the resource consent applications to take and use water. The results of preliminary discussions with Fish & Game are that issues related to fish screening will be resolved.

Didymo

333. The ECan Officer has identified in the reports that Didymo has been detected in the Tekapo Canal. The Officer has raised the issue that if it reaches the intake it could challenge the performance of the intake and fish screening structures.

334. This issue has been addressed in paragraphs 317 to 319 above.

Efficient Use

335. The Officer (para 39 – table) was not satisfied that the annual volume being sought by the applicant under CRC082311 would be reasonable, however agrees that the volume applied for under CRC082304 is reasonable.

336. This issue has been addressed in paragraphs 320 to 326 above. I am fully satisfied that the annual volume sought by the applicant under CRC082311 is reasonable.

Water Quality

337. The Officer (para 39 & table) considers the effects on groundwater and surface water quality may be more than minor as a result of the proposed irrigation.

338. I have provided evidence describing the impact that the proposed irrigation could have on groundwater levels and flows in streams and rivers. In conjunction with the MWRL evidence, I have identified the likely pathways for water flow and concluded that the overall flow impact on waterways is likely to be small.

339. Other experts have presented evidence on the impact of water quality changes on the environment.

ECan Report 32A: CRC072118

Minimum Lake Levels

340. The Officer (para 22) considers the proposed abstraction should be subject to the Lake Ohau and Lake Pukaki minimum lake levels.

341. Resource consent CRC072118 refers to the take and use for water from Ohau C Canal, which is controlled by water released from Ohau B canal. Taking of water from this location has no direct impact on any of the upstream lakes. The closest upstream lake is Ruataniwha. Although the proposed abstraction will not have an adverse effect on the levels of Lake Ruataniwha, the applicant is proposing to comply with the minimum lake level for Lake Ruataniwha of 458 m above mean sea level.

342. Given the distance of the proposed take from Lakes Pukaki and Ohau, and the presence of Lake Ruataniwha, restricting the take based on the levels in lakes Pukaki and Ohau is not appropriate because the levels within lakes Pukaki and Ohau are controlled by Meridian, not by downstream abstractions. Meridian are required to maintain the lakes between set operating levels, and the proposed abstraction from the Ohau C canal will not change that.

Transpower

343. The Officer (para 44-47) identifies that there are existing Transpower structures and electrical conductor lines over the irrigation area that may be adversely affected by the proposed irrigation.

344. Transpower lines run from the Twizel substation and pass across Pukaki Flats and the lower Mary Burn. Pivot layout is designed to avoid power pylons.

345. The applicant will have no difficulty in complying with condition WP13 proposed by Environment Canterbury to mitigate the potential effects on Transpower structures as follows:

> *The consent holder shall, in relation to any Transpower Structures or Transpower transmission lines:*
>
> *(a) Prevent the spray of water onto conductors by adjusting nozzles, turning jets off when the irrigator boom passes by the towers and keeping the irrigator boom away from conductors.*
>
> *(b) Ensure the placement of structures, buildings, tree plantings or encroaching vegetation comply with the set back distances described in the NZ Electrical Code of Practice for Electrical Safe Distances (NZCEP 34:2001).*

Water Quality

346. The Officer (para 34 –table) considers the effects on groundwater and surface water quality may be more than minor as a result of the proposed irrigation.

347. This is addressed in paragraphs 338 to 339 above.

ECan Report 32B: CRC072117

Flood Carrying Capacity and Erosion

348. The Officer (para 27 – table) is not satisfied that the effects on the flood carrying capacity of the Ohau river will be minor. The Officer states that while the river is generally dry, Meridian occasionally release flow into the river via the labyrinth weir. If the proposed works were to coincide with release of water, the Officer is unsure of what the effects of this would be.

349. As discussed in Appendix C, water is only released into the river via the labyrinth weir from the Ohau B Canal or from Lake Ruataniwha as an emergency overflow. The

applicant will not undertake works in the Ohau riverbed when this is occurring. The works within the riverbed proposed by the applicant are expected to take approximately one week to complete. Prior to the commencement of works, the applicant will consult with Meridian regarding the possibility of such a release of water.

Other Structures and River Bank Stability

350. The Officer (para 27 – table) considers the proposed works may have an effect on the river terraces and roadways.

351. The proposed pipeline will need to cross under the existing canal road (McAughtries Road), which is privately owned by Meridian. Prior to the commencement of the works, the applicant will obtain permission from Meridian to undertake the road crossing.

352. The works will involve installing the pipeline within the river terraces. However, where any disturbance occurs to the banks of the river, works will be undertaken to restore bank stability and to return the works area to a state consistent with the surrounding environment.

Diversion of Water During Works

353. The Officer (para 27 – table) has stated that the applicant may require consent to divert water as a result of the proposed pipeline installation.

354. As explained in Paragraph 235, the pipeline will be installed by diverting flow across to one side of the riverbed, digging a trench, laying the pipe and back filling. Water will then be diverted across to the other side of the riverbed where the pipeline installation will be repeated as for the first half. Excavated material will be used to build a temporary wall around which flow will be diverted. If this is not practical, water may be temporarily diverted into another existing river channel.

355. The diversion will only be temporary in nature for the purpose installing and maintaining the pipeline. The diversion will only be over a length of the bed of a maximum of perhaps 25 metres between H39:851-485 and H38:858-490 and will not impede fish passage or cause the stranding of fish in pools or channels. All water will remain within the natural riverbed.

Instream Ecosystems

356. The Officer (para 27 – table) has raised a concern regarding the introduction and spread of weeds within the river from the proposed works. To mitigate this effect the applicant is proposing the following condition form part of the resource consent:

> *Machinery shall be free of plants and plant seeds prior to use in the river.*

People, Community and Amenity Values

357. The Officer (para 27 – table) has concerns regarding the potential effects of the works on recreational users of the river. To mitigate this, the applicant will only undertake works during daylight hours and no works will be undertaken on weekends or public holidays.

ECan Report 19A: CRC072233

Minimum Lake Levels

358. The Officer (para 19) considers the proposed abstraction should be subject to the Lake Ohau and Lake Pukaki minimum lake levels.

359. This issue has been addressed in paragraphs 340 to 342 above.

Efficient Use

360. The Officer (para 30 – table) was not satisfied that the annual volume being sought by the applicant under CRC072233 would be reasonable.

361. Issues surrounding the reasonable and efficient use of water under CRC072232 have been addressed in paragraphs 191 to 196. I have used water balance modelling to establish that the volume of water required to meet irrigation demand is reasonable.

Water Quality

362. The Officer (para 30 –table) considers the effects on groundwater and surface water quality may be more than minor as a result of the proposed irrigation.

363. This has been addressed in paragraphs 338 to 339, in my evidence and in the evidence of other experts.

ECan Report 19B: CRC072232

Flood Carrying Capacity and Erosion

364. The Officer (para 22 – table) is not satisfied that the effects on the flood carrying capacity of the river will be minor. The Officer states that while the river is generally dry, Meridian occasionally release flow into the river via the labyrinth weir. If the proposed works were to coincide with release of water, the Officer is unsure of what the effects of this would be.

365. As discussed in Appendix C, water is only released into the river via the labyrinth weir as an emergency overflow. The proposed works in the riverbed are located upstream of the weir and therefore the flood carrying capacity of the river will not be affected in any way by the works.

Other Structures and River Bank Stability

366. The Officer (para 22 – table) considers the proposed works may have an effect on the river terraces and roadways.

367. As with the pipeline for Rosehip Orchards, the proposed pipeline will need to cross under the existing canal road (McAughtries Road), which is privately owned by Meridian. Prior to the commencement of the works the applicant will obtain permission from Meridian to undertake the road crossing.

368. The works will involve installing the pipeline within the river terraces. However, where any disturbance occurs to the banks of the river, works will be undertaken to restore bank stability and to return the works area to a state consistent with the surrounding environment.

Diversion of Water During Works

369. The Officer (para 22 – table) has stated that the applicant my require consent to divert water released from the Ruataniwha Wetlands as a result of the proposed pipeline installation.

370. The pipeline will be installed by diverting flow across to one side of the channel, digging a trench, laying the pipe and back filling. Water will then be diverted across to the other side of the channel where the pipeline installation will be repeated as for the first half. Excavated material will be used to build a temporary wall around which flow will be diverted. If this is not practical water may be temporarily diverted into another existing river channel.

371. The diversion will only be temporary in nature for the purpose installing and maintaining the pipeline. Additionally, the diversion will only be over a minimal bed width as the stream is small. The diversion will not impede fish passage or cause the stranding of fish in pools or channels

Instream Ecosystems

372. The Officer (para 22 – table) has raised a concern regarding the introduction and spread of weeds within the river from the proposed works. To mitigate this effect the applicant is proposing the following condition form part of the resource consent:

> *Machinery shall be free of plants and plant seeds prior to use in the river.*

Ian McIndoe

18 November 2009

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Appendix A: Climate Description

Simons Pass Station, Simons Hill Station, Rosehip Orchards, and High Country Rosehip Orchards are located near the southern end of the Mackenzie Country in the Upper Waitaki valley. The Mackenzie Country lies in an inter-montane basin, experiencing hot summers and cold winters.

Rainfall

The nearest climate station with long-term rainfall records is Twizel (stations 4995/4996/4997).

In any analysis involving rainfall, daily rainfall for the period 1972 to 2002 has been used. Twizel has a mean annual rainfall of 600 mm but varies from 318 mm to 874 mm. The amount of precipitation is generally evenly spread throughout the year, although in summer high evapotranspiration rates often results in a soil moisture deficit between September and April.

Evapotranspiration

There are no full climate stations in the vicinity of the applicant's property with long-term potential evapotranspiration (PET) records. Tara Hills, near Omarama, is the closest with a long-term record (Stations 5211/5212). The stations are at 488 m amsl, which is broadly same elevation as the applicant's property (440-550 m amsl).

Tara Hills has an average annual PET$_o$ of 808 mm, which is typical of PET in Canterbury. The area is subject to hot summers and high radiation, driving daily ET values up, but seasonal ET is tempered by a shorter growing season than coastal areas in Canterbury.

Average annual rainfall records for Twizel and PET records for Tara Hills are summarised in Figure A1.

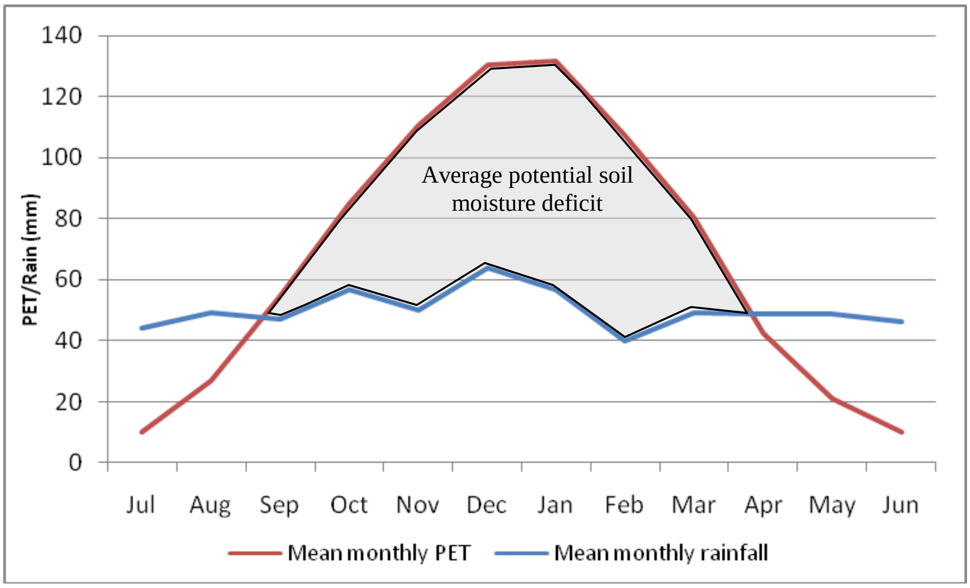

Figure A1: Mean monthly rainfall for Twizel and evapotranspiration for Tara Hills

Appendix B: Soil Descriptions

Mackenzie Series

Soils of the Mackenzie Series are typically shallow, stony, excessively drained soils formed from sandy fluvio-glacial gravels overlain by varying thicknesses of alluvium. This soil is characterised by 5-18 cm sandy loam to very stony loamy sand topsoils with weakly developed crumb and granular structure. The B horizon is a sandy loam to very stony loamy sand, which grades to a structureless very stony sand C horizon. The soil profile has a very friable consistence and is also characterised by rapid permeability.

Tekapo Series

Soils of the Tekapo Series are typically well-drained, shallow to deep soils formed from loess or loess over till and occupy moraines in the moist subhumid region. This soil is characterised by 18-30 cm fine sandy loam top soil with moderately developed nut and crumb structure. The B horizon is a fine sandy loam. A structureless C horizon exists below 50 cm. Average clay content of less than 18% in the clay upper 45 cm. The soil profile has a very friable, although underlying till is usually very firm.

Pukaki Series

Soils of the Pukaki Series are well-drained formed from shallow to moderately deep deposits of loess with a high content of fine sand. The soil is characterised by 18-25 cm fine sandy loam to loamy fine sand top soils with weakly to moderately developed crumb structure. The B horizon is a fine sandy loam to loamy fine sand. Weakly structured C horizon below 50 cm. Stones commonly occur above 80 cm. The soil profile has a very friable consistence and is also characterised by rapid permeability.

Grampian Series

Soils of the Grampian Series are moderately well-drained soils formed from loess deposits on piedmont fans in the dry subhumid region. The soil is characterised by 15-20 cm fine sandy loam to silt loam topsoils. The upper B horizon is weakly developed. Lower B horizon is a loamy fine sand to silt loam with weakly developed structure. A firm massive silt loam to clay loam fragipan with abundant clay skins (horizon perches water). Depth to fragipan varies from 30 to 80 cm. Moderate permeability above fragipan and slow permeability through fragipan.

Simon Series

Soils of the Simon Series are well-drained soils formed from loess deposits occurring on old fans and terraces in the dry subhumid region. The soil is characterised by 15-25 cm silt loam to fine sandy loam topsoils. The B horizon is a silt loam to fine sandy loam. There is an average clay content of more than 18 percent in the upper 45 cm. Depth to gravels varies from 45 to 150 cm. In deeper profiles, a firm incipient fragipan occurs below 50 cm. Permeability is moderate above the gravels and fragipan.

Larbreck Series

Soils of the Larbreck Series are typically shallow and stony, excessively drained soils formed from alluvium on young terraces in the subhumid region. This soil is characterised by 5-12 cm sandy loam to very stony loamy sand topsoils with weakly developed crumb and or single-grain structure. The B horizon is a very stony loamy sand. The C horizon very stony sand. The soil is a friable consistence with rapid permeability.

Edwards Series

Soils of the Edwards Series are well to moderately well drained, moderately deep to deep soils derived from silty alluvium on older flood plains in the sub humid region. The soil is characterised by 15-25 cm silt loam topsoils with weakly to moderately developed nut, granular, and crumb structure. The upper B horizon is silt loam to fine sandy loam and has a weakly to moderately developed nut and block structure. There are faint to distinct mottles in the lower B horizon. The C horizon is a silt loam to very stony loamy sand.

Dobson Series

Soils of the Dobson Series are poorly drained, shallow to deep soils formed from recent alluvium. They occur in younger plains and in small hollows adjacent to streams. The soil is characterised by 15-40 cm silt loam to loamy sand topsoils. The B horizon is a silt loam to loamy sand. Dobson soils are also characterised by water logging of whole profiles, and subsoils that are commonly ‘mucky’.

Appendix C: Description of waterways and sensitive areas

Lake Pukaki

Lake Pukaki is the largest of three roughly parallel alpine lakes running north-south along the northern edge of the Mackenzie Basin. Lake Pukaki covers an area of about 168 km², and has a catchment area of 1413 km^2. The surface elevation of the lake normally ranges from 518.2 to 532 metres above sea level.

The lake has been raised twice to increase storage capacity (9 m in the 1940,s, and 37 m in the 1970's). The current lake has an operating range of 13.8 m (the level within which it can be artificially raised or lowered), giving it an energy storage capacity of 1,595 GWh and an additional storage volume of 5500-6000 Mm^3/y.

Major natural inflows come from the Tasman, Jollie and Hooker Rivers. Total inflow from these rivers is in the order of 128 m^3/s on average (ECan, 2004). Several minor streams also discharge into Lake Pukaki. The other major inflow is discharge from the Tekapo B Power Canal, which is controlled by Meridian Energy, subject to electricity generation requirements and resource consent conditions. Flow from the Tekapo Canal into the lake may be as high as 115 m^3/s.

Outflows and lake levels are primarily determined by Meridian Energy, with most of the water being taken through the Pukaki Canal into the Ohau Canal system. Water will be released over the Pukaki spillway at times when lake levels are high, for flood dissipation or for other operational reasons.

Lake Pukaki, therefore, is a highly modified water resource in terms of inflows, outflows and lake levels.

The Tekapo Canal

This is a major power canal operated by Meridian Energy Ltd that takes water from the outlet of the Tekapo A power station and discharges it through Tekapo B power station into Lake Pukaki. It has a mean flow of 75.6 m^3/s but flow can vary from about 20 m^3/s up to a peak flow of 115 m^3/s (ECan 2004).

The Pukaki Canal

This is also a major power canal operated by Meridian Energy Ltd that takes water from Lake Pukaki to the Ohau A canal, west of Twizel. The combined flow discharges through Ohau A power station into Lake Ruataniwha.

The flow through Pukaki Canal is primarily determined by Meridian Energy, subject to electricity generation requirements. The flow of the Pukaki Canal ranges from 91 to 231 m^3/s with an average over the year of approximately 183 m^3/s (CRC, 2004). The lower than average flows typically occur in October through to January, with the average to higher than average flows occurring February through to September.

The Pukaki River

The Pukaki River was once a natural river that flowed southwest for 15 km from the outlet of Lake Pukaki to the Tekapo River, about 5 km upstream of Lake Benmore. The river was dammed at Lake Pukaki to raise the level of Lake Pukaki and water diverted into the Pukaki Canal for power generation. Since it was dammed and diverted, the Pukaki River is dry most of the time.

Flows in the Pukaki River are determined by Meridian. Water can be spilled over the Lake Pukaki spillway and flows can be as high as 1000 m^3/s or more. For that reason, the river is subject to rapid flooding. Average release flow rate is about 180 m^3/s. Meridian, under resource consent CRC905325.1 can release up to 0.56 m^3/s into the Pukaki River via the Spill Channel.

The Tekapo River

The Tekapo River is a natural river that runs between Lake Tekapo and Lake Benmore. Originally, the river flowed southwest for 50 kilometres from the southern end of Lake Tekapo before joining with the Pukaki River and flowing into the northern end of Lake Benmore.

The water from Lake Tekapo is now diverted via a canal to Lake Pukaki as part of the Waitaki Hydroelectric scheme. It only flows in the upper reaches to any extent when Meridian spills water from either the dam or canal back into the riverbed. This can occur after particularly heavy snow melt or rainfall when Lake Tekapo is full, or if the power stations or canal need servicing.

Large spills can clean out and reshape the riverbed.

A number of key tributaries run into the Tekapo River, including Forks River (mean flow 3.2 m^3/s), Grays River, Stony Creek, Irishman Creek (mean flow 1.3 m^3/s) and Mary Burn (mean flow 0.6 m^3/s). These form most of the flow in the lower reaches when water is not being spilled.

Mary Burn

The Mary Burn begins near the base of the Gammack range and flows in a southerly direction towards the Tekapo River, along the eastern side of the Mary Range. The Mary Burn typically flows year round and has a gravelly substrate. The stream has an average channel width of 2 m, streambed width of 4 m, average depth of 0.5 m, and is known for its trout fishery and spawning area (LINZ, 2002).

The mean flow of the Mary Burn at Mt McDonald is about 0.6 m^3/s, with a MALF of about 0.3 m^3/s. Lowest flows generally occur from February through to May and the highest flows in winter and spring.

In the general area of the proposed irrigation east of the Mary Range, there is evidence of old dry stream beds or depressions that only run after high rainfall, or more commonly snow thaw events. The frequency of flow in these old stream beds ranges from a 1 in 2 year event to a 1 in 10 year event.

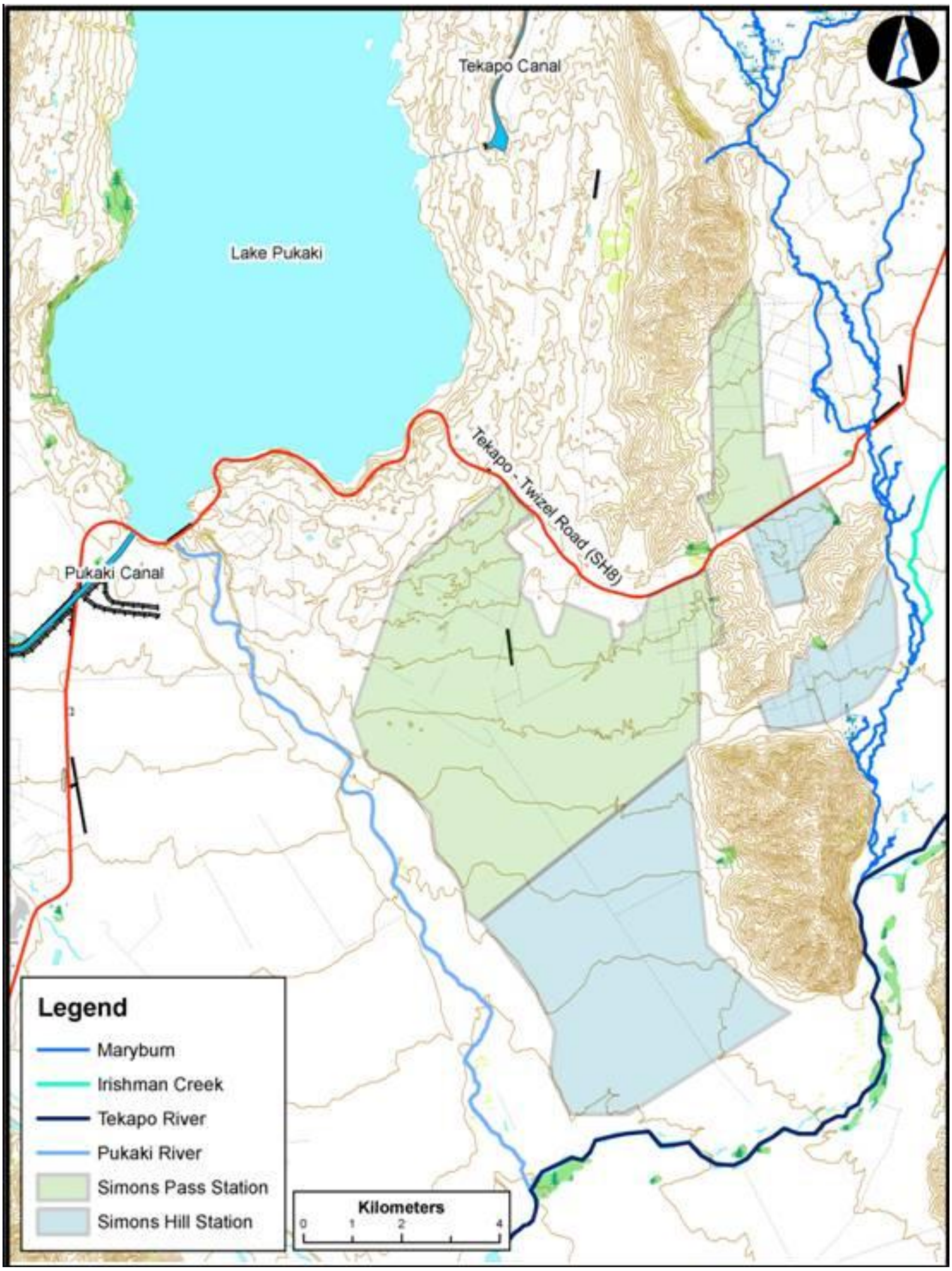

Figure C1: Waterways

Lake Ruataniwha

Lake Ruataniwha is a man-made lake built between 1978 and 1981, covering an area of approximately 490 ha. It was built for the purposes of contributing towards power generation. The lake is fed from the Ohau River and also water sourced from Lake Ohau and Lake Pukaki via the Pukaki/Tekapo canals. Meridian under resource consent CRC905336.1 can release up to 1,740 m^3/s into the Ohau River via the Lake Ruataniwha control structure, at the Ruataniwha dam, that leads into the Ohau River.

Lake Ruataniwha is popular with visitors and is also known for its international-standard rowing course.

Ohau B and C Canals

The Ohau B and Ohau C Canals are man-made structures, linking Lake Ruataniwha and Lake Benmore. Meridian Energy owns and operates the canals, and primarily the flow within the canals is subject to electricity generation requirements.

The mean flow of the Ohau A Canal ranges from 42 to 114 m^3/s with an average over the year of approximately 73 m^3/s. After joining with the Pukaki Canal, flow increases to an average of about 260 m^3/s. Lower than average flows typically occur in April through to September, with the average to higher than average flows occurring October through to March

Lower Ohau River

The lower Ohau River is located downstream of the Lake Ruataniwha between the Dam and Lake Benmore. Approximately 1.5 km before entering Lake Benmore, the Twizel River flows into the Ohau River. Above the Ohau River/Twizel River confluence the Ohau River is generally a dry riverbed. The Ohau River only has regular flows in the lower reaches due to the contribution from the Twizel River. Above the confluence the River typically only flows following releases of excess water by Meridian from either the Lake Ruataniwha spillway or from the Ohau B Canal.

Meridian, under resource consents CRC905336.1 and CRC905341.1, can release up to 1,740 m^3/s and 560 m^3/s into the Ohau River from Lake Ruataniwha or the Ohau B Canal, respectively. The outlet from the Ohau B canal consists of a zig zag or labyrinth weir located downstream of the abstraction proposed by High Country. The flow in the lower river is therefore generally controlled by Meridian and is prone to rapid flooding.

Previous discussions between IR Solutions (the previous consultant for High Country and Rosehip Orchards) and Meridian Energy identified that Meridian is required to test the dam gates monthly in consultation with DOC. This monthly flow rarely goes very far down the river, and it has been estimated that only on five occasions in the last ten years has the flow been great enough to enter Lake Benmore.

As the Ohau River (before the confluence of the Twizel River) is typically dry, it is unlikely that this stretch has much recreational value. After the Twizel confluence however the Ohau River is used for fishing, 4WD, swimming, and jet boating.

Ruataniwha wetlands and black stilt reserve

Ruataniwha Wetlands was created in 1993 (Sanders, M. Brown, K and Keedweel: 2007). This wetland is approximately 39 ha and consists of seven main ponds.

In 1998, Ruataniwha Wetlands was extended (lower wetlands) as part of the Project River Recovery, with the addition of two ponds. Two more ponds were added in 2000, bringing the total area of the lower wetlands to 40 ha. Stop log weirs control the water levels in the ponds. In winter, water levels are typically higher, with water levels lowered in spring and summer to expose nesting and feeding habitat.

The main wetland birds present are banded dotterels, pied stilts, black-fronted terns, Finsch's oystercatchers, spur-winged plovers and various waterfowl.

The original wetlands are fenced with the lower wetlands being unfenced.

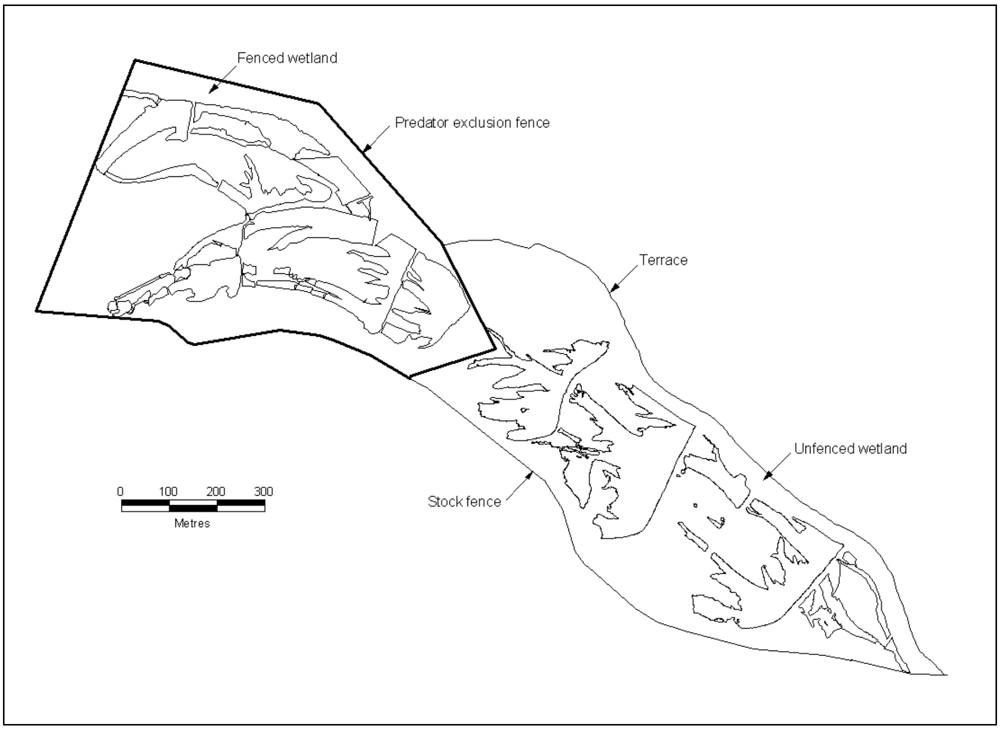

Figure C2: Fenced and unfenced sites at Ruataniwha Wetlands, showing locations of fences, ponds, and terrace. [Source: (Sanders, M. Brown, K and Keedweel: 2007)][2].

The DOC black stilt captive breeding centre is located at the base of the Lake Ruataniwha dam, just above the Ruataniwha Wetland reserve area. This is a recognized conservation area, providing habitat for black stilts and other waterfowl, aquatic fauna and terrestrial fauna.

Twizel River and DOC conservation areas

The Lower Twizel River typically flows throughout the year. The flow of the Twizel River at Lake Poaka typically ranges from 1.5 to 4.3 m^3/s with a mean flow of approximately 2.6 m^3/s (CRC, 2004). The lowest flows typically occur in February to April, and in August presumably when waterways are frozen. Average to higher than average flows occur in October through to January, and in March.

The Twizel River at the confluence of the old Ohau River channel has an estimated mean of flow of 6 m^3/s and a mean low flow of around 2 m^3/s (LINZ, 2003)[3].

Two native lizards, the common gecko and McCann’s skink, are found on the river flats.

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[2] Sanders, M. Brown, K. and Keedweel, R. (2007). Testing the effects of a predator-exclusion fence on predator abundance and wetland bird breeding success at Ruataniwha wetland, Twizel

[3] LINZ (2003): Crown Pastoral Land Tenure Review. Lease name: Omahau Downs. Lease number Pt 092. Fish and Game report.

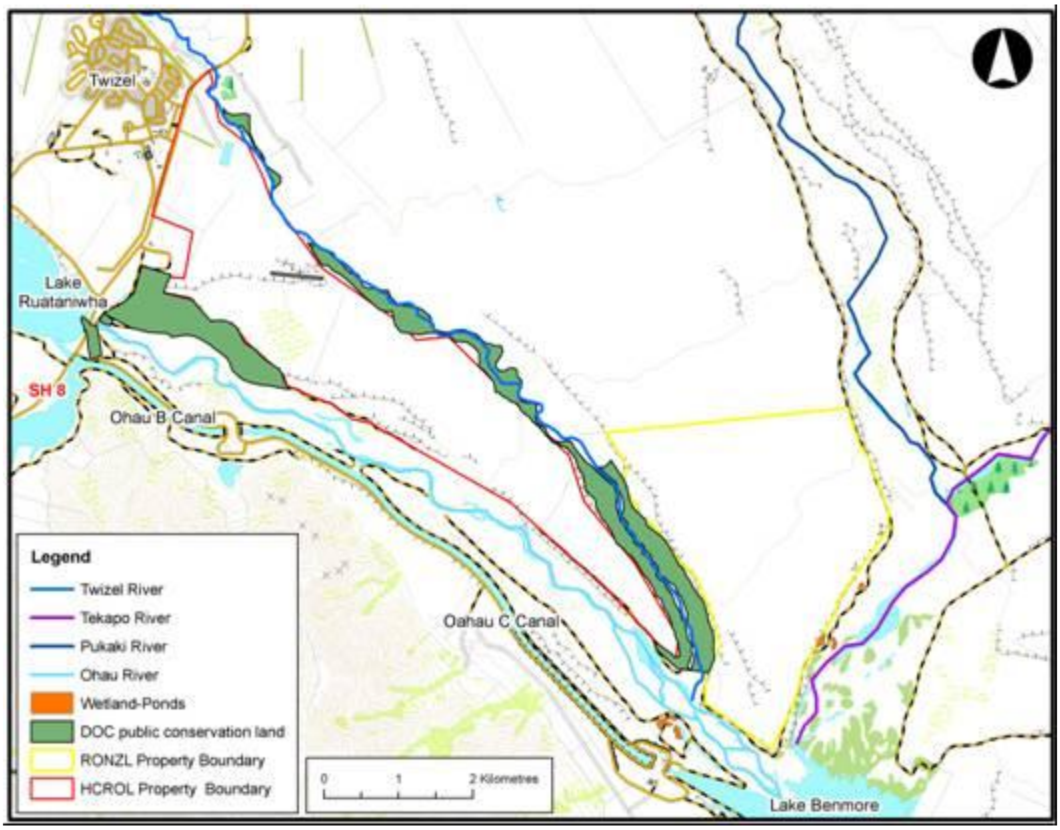

Figure C3: Waterways

Appendix D: Description of the groundwater environment

Geology

The Simons Pass/Simons Hill stations are located within the Twizel sub-basin as defined by Cooksey (2008). There are no bore logs within the Simons Pass/ Simons Hill areas, and the following is a generalised stratigraphy adapted from Cooksey (2008).

The Torlesse Supergroup forms the basement, outcropping in the ranges within the area. It is predominantly very well indurated, unweathered greywacke (hard, poorly sorted sandstone), at places interbedded with argillite (mudstone), with weathering and fracturing of the upper part. It is generally impermeable to groundwater, but fractures can provide pathways for shallow groundwater movement, leading to bedrock springs. The structural highs form barriers to groundwater flow.

Overlying the basement are Tertiary deposits of the Kowai Formation (locally known as the Glentanner Formation). The Formation is relatively impermeable, consisting of weathered greywacke, interbedded with very compacted sand, silts and silty clays. This Formation is effectively the hydrogeological basement.

Quaternary deposits are represented by the Wolds Formation, overlain by an interglacial unit, followed by the Balmoral Formation, Mount John Formation and Tekapo Formation. These glacial deposits are overlain by post glacial alluvial gravels. These deposits form the main hydrogeological units within the area.

The Wolds Formation is a moderately to highly weathered sandy gravel, with the matrix between clasts filled with silty clay. It forms a compact, low permeability formation.

A thin inter-glacial unit overlies the Wolds Formation. This unit is a thin sandy silt layer. It was observed in the Twizel area, and its extent further afield is unknown

The Balmoral Formation comprises till and outwash gravels. The till is chaotic, poorly sorted, and has a high silt and clay content. The outwash gravels are sandy gravels, with the matrix filled with silt and clay. There are rare layers of well sorted gravels, providing limited opportunity for groundwater flow. Overall, the formation has a higher fines content than overlying formations, and is therefore less permeable.

The overlying Mount John Formation is a till, but with occasional lenses of sandy outwash gravel. The gravels are well sorted fine to coarse gravels with some sand, showing sub-horizontal bedding, cross-bedded in-filled channels, sand lenses, and well-sorted openwork gravels. Channel structures are common and have been observed in the terraces along the Pukaki River, although the inter-connection between channels is unknown. Groundwater is thought to flow preferentially through the outwash gravels.

The Tekapo gravels are mainly sandy gravels with rare silt. The Tekapo Formation forms a thin surface veneer up to 5m thick. The surface has many well-defined, abandoned, braided channels which can be observed on the land surface.

There is somewhat less silt and clay compared with the Mount John Formation, but otherwise the two formations are very similar and difficult to separate, and probably function as a single hydrogeological unit.

Post glacial alluvial gravels overlie the Tekapo Formation. These are sandy gravels with lenses of well-sorted gravels and sands. They occur within and around the present day river systems. It has been observed that he lower gravels have a relatively high silt content and therefore may provide a barrier to downwards infiltration of shallow groundwater (Read, 1974). However, they are generally highly permeable.

Depth to basement beneath the younger Formations appears quite variable across the area. Oborn estimated depth to basement to range from 300 to 1000 m. More recent studies (Long et al, 2003) suggest the basement may be as deep as 2000 m at the deepest point. Based on a gravity survey, Cooksey (2008) suggests there is a bedrock high beneath the Tekapo River, although it is not clear which section of the Tekapo River this is beneath, or exactly how close to surface the bedrock high is thought to be.

Geomorphology

The topography of the area is dominated by glacial landforms, with moraine areas and outwash plains associated with the major ice advances in the area. The geomorphology that can be observed at surface indicates the complex system that is present at depth. Older deposits have been reworked, re-deposited, and subsequently buried by subsequent glacial advances and retreats.

The major rivers that drain the area are all incised into the glacial outwash surfaces, and the present-day alluvial gravels are all degradational surfaces, at a lower level than the glacial outwash surfaces.

The proximity of the outwash gravels to the terminal moraines plays a part in the hydraulic conductivity of the formation. Close to the moraine ridge, the gravels are likely to be larger, angular and less sorted. More distant from the ridge, the gravels will be more rounded and more sorted, with a higher sand and silt content. The poor sorting of the proximal gravels results in a reduced amount of pore space, and poor interconnection between pores, and therefore lower permeabilities compared to outwash gravels that are more distal.

Hydrogeology

There is very limited information on the hydrogeology of the Simons Pass/ Simons Hill area due to the lack of bores and other data across these areas. Various studies have been carried out over a wider area, and some of the information can be used as a basis for understanding the hydrogeology within this area.

According to Cooksey (2008), the Glentanner Formation forms the general hydrogeological basement, with the inliers of bedrock creating impermeable boundaries within the Simons Hill/ Simons Pass area. It is suggested that the older Wolds and Balmoral formations are less permeable than the younger, overlying ones (Mt John and Tekapo). Permeability reduces both with depth and with proximity to terminal moraines, although the deposits are complex, and this is a generalisation. Cooksey suggested that the younger formations are cleaner and better sorted, with more openwork gravel lenses, therefore providing more opportunity for groundwater flow. The most recent, post-glacial alluvium is also likely to have a lower silt and clay content, and therefore be more permeable.

GHD (2008), suggest that the aquifer system contains mainly shallow groundwater (less than 30 m bgl), with some areas of deeper groundwater (greater than 30 m bgl). Shallow groundwater representing the water table most likely occurs within the Tekapo Formation and post-glacial alluvial gravels. The post-glacial alluvial gravels occur adjacent to the modern day rivers, and are where the majority of the highest yielding shallow bores are located. Shallow bores near Fraser Stream (near Twizel) have transmissivities ranging from 3,000 to 7,000 m^2/day and yields of more than 60 ℓ/s (GHD, 2008). This would suggest that the post-glacial alluvial gravels, which occur adjacent to the Pukaki River and lower reach of the Tekapo River, could also support a highly productive shallow aquifer. Aqualinc staff observed during installation of the shallow piezometers that the greatest inflows of groundwater in the holes were adjacent to the Tekapo River.

The Mt John Formation and potentially older and deeper formations may contain deep groundwater in usable quantities. However, the general view is that permeability and subsequent aquifer yields decrease with depth. There are two deep bores (I38/0012 and I38/0015) located to the east of the Mary Range and one deep bore (H38/0035) located 3 km to the west of the Pukaki River.

Bore H38/0035 was drilled to a depth of 118 m bgl and had an estimated transmissivity of approximately 500 m^2/day.

Within the smaller proposed irrigated areas, bore I38/0012 is screened from 95 to 105 m bgl, and had a transmissivity of approximately 250 m^2/day. Bore I38/0015 is screened from 75 to 81 m bgl, and had a transmissivity of 50 m^2/day. Cooksey (2008) interpreted bore I38/0015 to be screened within older Balmoral outwash gravels. The shallower, 24 m deep bore I38/0014, had an estimated transmissivity of 3,500 m^2/day (based on specific capacity data), which is relatively high and within the range of values found near Fraser Stream around Twizel.

Based on the relatively small amount of specific capacity data, the shallow aquifer is likely to be significantly more permeable than deeper aquifers. This is in agreement with Cooksey's view that older and deeper gravel formations are less permeable than younger gravel formations. The limited amount of data also suggests that relatively good quantities of water can sometimes be obtained from deeper aquifers, but that yields can be highly variable and site specific. Drilling of bores would be required to prove or disprove this.

There is limited evidence for the existence of multiple aquifers. Some shallower bores are reported to have a different water level to deeper bores, but differences could be due to elevation changes. More data from different depths would be required to investigate this properly. Unfortunately, there are no bores in Pukaki Flats (west of the Mary Range) to determine whether separate aquifer systems exist.

To the east of the Mary Range, in the northern part of the area, bore I38/0012 has the greatest depth to water recorded at around 33 to 35m bgl. However, the elevation of the piezometric surface is not very different to the shallower bores to the south (I38/0014 and I38/0015), suggesting this change in depth to water is just a reflection of the topography, as outlined above, rather than evidence for the existence of stratification of gravel layers.

Groundwater Flow Direction

Regional

Regionally, the direction of groundwater flow is towards Lake Benmore and the Tekapo River (Heller et al, 2004; GHD 2008; Cooksey, 2008). The Mary Range sub-divides groundwater flow across the Simons Pass/ Simons Hill area. The Mary Range brings groundwater flow towards the surface, as is shown by wetlands and springs near the base of the range.

Within the two irrigated areas east of the Mary Range, Cooksey (2008) and Heller at al, (2004) show that groundwater flows in a south westerly direction towards the Mary Range. They also show that, within the upper of the two irrigated areas, groundwater flowing in a south westerly direction would appear to be trapped within a basin that is defined by the

Mary Range. In my view, that is not possible, and in reality, groundwater must flow to the north and then east, around House Hill.

Within the main proposed irrigation area (to the west of the Mary Range), the gradient of the piezometric contours created by Heller et al (2004) reduce with increasing distance down-gradient of the Lake Pukaki. Heller suggests that this could be due to increased permeability of the aquifer sediments. Given the absence of bores in this area, it is difficult to say whether that is correct or not.

One problem with the results of the three referenced studies is that the direction of groundwater flow within the main irrigated area (Pukaki Flats) was made without groundwater level data (as there were no bores present). Another problem is that there was no differentiation between the water levels in shallow bores and those in deep bores, and therefore the contours could be misleading.

Local shallow groundwater

Sixteen shallow piezometers were installed by Simons Hill and Simons Pass to provide more detailed information on the direction of groundwater flow in the Simons Pass/ Simons Hill area (refer to Figure D1). Based on this, it can be seen that, although the regional groundwater flow direction is to the south west, locally this is very much influenced by the bedrock inliers, with flow being towards the rivers, and diverted around the Mary Burn Range and House Hill.

Depth to Groundwater

Groundwater was found at shallow depths in the shallow piezometers installed close to the streams and rivers. Further away from the surface water courses, shallow groundwater was generally not observed (within the installed piezometers at around 7m depth). This will be due to the fact that the water table, generally, is a subdued reflection of the topography, and depth to water would be expected to be greater beneath topographic highs.

Springs

Cooksey (2008) describes three main types of springs in the Mackenzie Basin: depression, fracture, and contact springs. Depression springs occur where the water table intersects the ground surface. Such springs were located close to the Tekapo River and Mary Burn confluence, where they emerge from the terrace on the north side of the river. Cooksey (2008) suggests these represent a discharge point for water flowing from the north beneath the Tekapo Outwash Gravels, although doesn’t provide any reasoning for this. Cooksey (2008) also identified depression springs along the western side of the Mary Range within the Simon’s Pass area.

Fracture springs occur in most bedrock areas, including the Mary Range. Cooksey (2008) identifies several springs along the edge of the Mary Range in the Simon’s Pass area. Cooksey (2008) also describes contact springs where groundwater is perched above a lower permeability layer, emerging for example at a terrace. In this case, the perched groundwater would be moving through the system rapidly, with little infiltration downwards. This type of spring was not observed in this area, although could occur. The significance is that the lower permeability horizons, such as the Mount John Outwash Gravels can be sufficiently impermeable that shallow groundwater can be perched.

The spring near the Tekapo Twizel Road is located within, or near, a 5 hectare wetland (Environment Canterbury Online GIS, February 2009). This wetland area occurs between the base of a terrace, and the eastern side of the Mary Burn.

From a field visit in February 2009, a spring was observed at the base of this terrace, and the water level in bore I38/0054, located at the top of this terrace (approximately 50 m away from the spring), and adjacent to the wetland area, was 3.52 meters below ground level. Groundwater that discharges into this wetland area would probably enter the Mary Burn.

Both the wetland near the Tekapo Twizel Road and the DOC reserve near the confluence of the Mary Burn and Tekapo River are all listed as land areas of national significance (Environment Canterbury Online GIS, February 2009). From both of these areas, irrigation drainage water has the potential to discharge into the Mary Burn.

Groundwater Quality

Cooksey (2008) stated that groundwater type is predominantly Ca-Na-HCO3, typical of relatively young groundwater. Further sampling in 2009 by Aqualinc confirmed this general conclusion, with water to the east of the Mary Range also having a more dominant magnesium component.

Nitrate and chloride levels overall were generally low, and Cooksey (2007) suggested they could be used as a baseline for monitoring future changes in water quality. However, three samples from the east side of the Mary Range showed elevated nitrates (the highest being 6.9 mg/l (NO3-N and NO2-N)), and higher TDS overall, probably reflecting land use inputs to the groundwater, but also reflecting possibly longer groundwater residence times.

The groundwater quality sampling indicates that there is likely to be interaction between groundwater and surface waters in the Lower Pukaki and the Tekapo Rivers. The direction of flow is likely to be head dependent, with flow from the Tekapo to groundwater at times of low groundwater head, and reversed when groundwater heads are higher. The existence of flow in the Lower Pukaki, and the relatively high TDS compared to the lake and river waters in the September 2009 sampling supports this concept.

Groundwater- Surface water Connection

Tekapo and Pukaki rivers

Previous work by Gabites Porter and Partners (1982) stated that both the Tekapo and Pukaki Rivers appear to flow on perched water tables, meaning that the rivers would be disconnected from shallow groundwater. If this is true (and the perched aquifer is associated with the alluvial deposits) then shallow groundwater (containing nitrate in the drainage water from irrigation) would not be expected to enter these rivers. However there is no evidence supporting that conclusion.

Halstead (pers comm., in White et al, 2004) stated that there is evidence for groundwater discharge into the Pukaki River, and into the lower reach of the Tekapo River near Grays Hills.

Field work has been carried out by Aqualinc at the request of Simons Hill and Simons Pass Stations to assess the actual likelihood of surface water/groundwater interaction. This has included the installation of shallow piezometers, concurrent flow gaugings, and water quality sampling.

Tekapo River

Heller et al (2004) identified the lower reach of the Tekapo River as an area of groundwater discharge. The shallow piezometers installed by Aqualinc along the Tekapo River from the Mary Range down to the confluence with the Pukaki River, show water levels above the bed of the river, with a hydraulic gradient towards the river, and potential for groundwater to discharge into the river. Further evidence for the contribution of groundwater to surface water flow is given by the existence of features such as a permanent spring-fed stream downstream from piezometer I38/0090, and a groundwater-supported pond near I38/0091.

Concurrent gauging was carried out on 4 March 2009, 25 March 2009 and again on 15 September 2009 by Boraman Consultants at the request of Aqualinc. The results are shown in Table D1 below.

Table D1: Tekapo River flow gauging results

	Discharge (m^3/s)		
Site	**04/03/2009**	**25/03/2009**	**15/10/2009**
Tekapo River at Iron Bridge	9.84	6.89	10.01
Tekapo River at above Greys Hills Station	5.83(i)	7.58	10.25
Tekapo River below Mary Burn Confluence	9.95	7.50	10.89
Note (i): This gauging was done at requested location but was found to only have a portion of the main flow. The site was changed for the second series of measurements.			

There is consistently a minor decrease in flow evident between the Mary Burn confluence and Iron Bridge, suggesting an overall loss to groundwater in the area below Pukaki Flats. However, the piezometric data suggests that the river should be gaining water from groundwater along parts of this reach. The groundwater chemistry data supports a connection between groundwater and surface water in this area. It is possible that there are gaining and losing stretches along the reach, with the amount and direction of exchange of water depending on relative groundwater and surface water levels.

My view is that the Tekapo is losing water to groundwater about piezometer SH11. That water flows through the gravels in the lower Pukaki Flats in a general direction parallel to the Tekapo River and reappears down towards the confluence with the Pukaki River. It is also possible that the Tekapo River is losing some water to groundwater on the southern side of the river.

Pukaki River

At the boundary of Simons Pass and Simons Hill stations (about halfway down the Pukaki River), the water table was significantly below the base of the riverbed in May 2009. Moving south along the river, the water table gradually rises relative to the river bed, and close to the confluence, there is wetland vegetation and some evidence of surface water, indicating that the water table was at or close to the surface at that point. In September 2009, sampling and the flowing water in the lower reaches of the river suggests it was gaining from groundwater at this time.

It was also apparent that while Meridian was spilling water down the Pukaki River, significant rises in groundwater levels were seen in the piezometers along the river. That would indicate that groundwater moves freely to and from the river, depending on flows and relative groundwater levels. At times, flows in the lower Pukaki River will be coming from bank storage along the river that was recharged during spill events. That was most likely the case in September 2009.

Mary Burn

The Mary Burn flows on the eastern side of the two smaller proposed irrigated areas (on the eastern side of the Mary Range). Concurrent gauging at three locations on this stream was carried out by Cooksey (2008). The stream was gauged immediately upstream of the Tekapo Canal, at State-Highway 8 and upstream of the confluence with the Tekapo River. Cooksey (2008) showed a sharp increase in flow between these two sites on all three gaugings, and concluded the increase was likely to be due to a combination of springs, surface flow from the southeast, and groundwater, the later rising to the surface near the bedrock high in the south of the area.

Flow in the Mary Burn may increase if water from depression springs near the southern end of the irrigated area flow into the stream. Based on the direction of groundwater flow from previous studies, it would seem that any springs flowing into the Mary Burn would be fed by shallow groundwater to the north east of the stream, as opposed to shallow groundwater from within the irrigated areas south of House Hill, although as stated above, there is doubt about the validity of the piezometric contours used to conclude this.

The piezometric data from the recent Aqualinc investigations also suggest this is not the case. The direction of groundwater flow from this work was to the south east, with water levels being within a metre of the bed of the stream. Water levels, even in the deeper bores, were higher than the level of the Mary Burn. Downgradient of SH13, the water table intercepts the surface in a wetland area (DOC reserve), with springs observed bubbling out of the ground within the DOC reserve, and within Simons Hill Station near the boundary with the DOC reserve (Denis Fastier pers comm., 2009).

Together with the fact that with water levels are just below the level of the bed of the stream, at SH13 and SH15, there appears to be considerable potential for groundwater contribution to the stream along the reach south east of House Hill. The Mary Burn then flows into the Tekapo River near Grays Hill.

Lower Tekapo River between Pukaki Confluence and Lake Benmore

Concurrent gauging was carried out on 15 September 2009 by Boraman Consultants at Aqualinc's request to determine whether there was any significant change in flow in the Lower Tekapo River between the Iron Bridge and Lake Benmore. The results are shown in Table D2 below.

Table D2: Lower Tekapo River flow gauging results

	Discharge (m^3/s)
Site	**15/10/2009**
Tekapo River at Iron Bridge	10.01
Tekapo River above Lake Benmore	10.21
Pukaki River above Tekapo confluence	0.05-0.34

It is possible that the Tekapo River is gaining a small amount of flow between the Iron Bridge and Lake Benmore, although the differences in flow are well within normal gauging error. There is a small contribution from the Pukaki River, which could easily account for the possible small increase in flow.

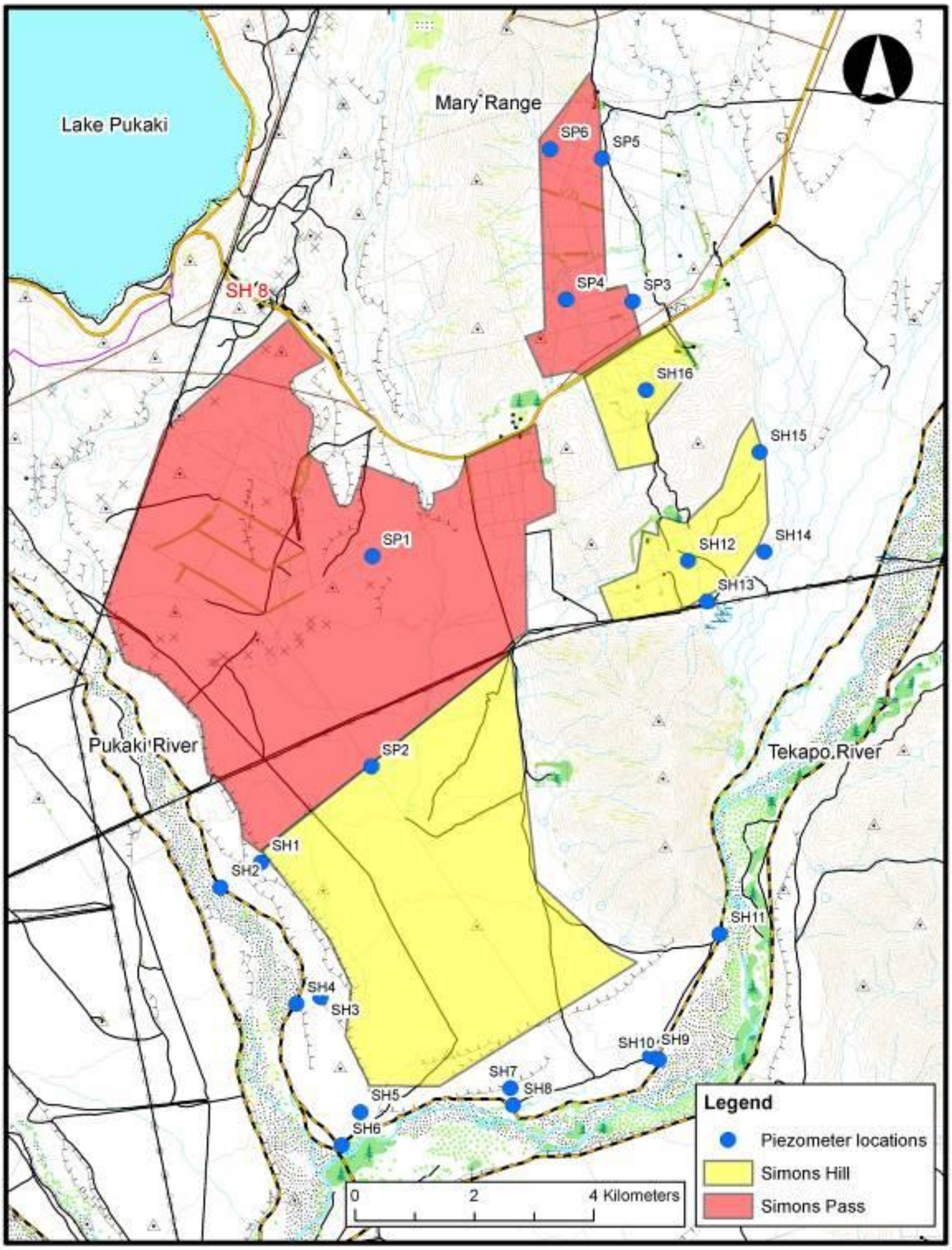

Figure D1: Piezometer locations

Appendix E: Water balance modelling

The IrriCalc model, developed by Aqualinc Research Limited, simulates the variable use of water in agriculture with differing crops, agricultural soil types, historical daily climatic conditions, and irrigation strategies. The basis of the model is a daily soil moisture balance with an irrigation scheduling component. A full description of the model is given in my MWRL evidence (Appendix A).

A summary of the inputs to the model are summarised in Table E1:

Table E1: Summary of irrigation demand model inputs

Description	**Simons Pass/Simons Hill & Rosehip Orchards/ High Country**
Period modelled	1973-2008
Rainfall and PET data	NIWA 5 km gridded data
Crop type	Pasture
Rooting depth	0.5 m
Average Soil PAW	25-180 mm (see Table 2)
Allowable soil moisture deficit	50%
Application efficiency	80%
Application depth of water	Equal to (or less than) the soil moisture deficit (i.e. ≤50% of the PAW)
Design system capacity	Up to 0.8 ℓ/s/ha (6.9 mm/day)
Return Interval	Equal to the application depth (mm)/6.9 mm/day
Christiansen's uniformity coefficient	85% (for a centre-pivot)

The modelling was undertaken in a manner that ensured consistency with the policies of the Waitaki Catchment Water Allocation Regional Plan (WWAP) and the proposed Natural Resources Regional Plan (NRRP) was achieved. This included meeting the requirements of Policy 16 of the WWAP, which specifies annual volumes are to be based on soil moisture measurements, local rainfall and evapotranspiration modelling for eight-in-ten year reliability and achievement of irrigation application efficiency of at least 80 %, and the NRRP which specifies an irrigation system capacity of a maximum of 0.8 ℓ/s/ha (or 6.9 mm/day).

The model was used to assess the volume of water that would have been required each season, for the period 1973-2008, from which the 80th percentile was calculated.

Appendix F: Efficiency assessments

I propose that the irrigation systems are designed according to the Irrigation NZ Code of Practice and Design Standards. Adherence to the Code will help to ensure that the design of the systems are efficient in terms of water application, labour, energy and the use of capital.

Although application efficiency has been assumed to be 80% as per Policy 16 of the WWAP, irrigation application efficiency depends on several site specific factors such as irrigator length, irrigation system capacity, sprinkler type and depth of application.

Application efficiency changes along the length of pivots. In general, the longer the pivot, the lower the application efficiency, because of higher application rates at the end of the pivot.

The SPRINK[4] irrigation model has been used to calculate average irrigation application efficiency for each of the proposed irrigation systems.

Irrigation Runoff

Irrigation runoff typically occurs when the irrigation system application rate exceeds the soil infiltration rate on sloping land, water ponds and redistributes on the surface. It is not normally a significant problem on flat ground.

The concern is that irrigation run-off may collect contaminants (sediments, fertilisers and pesticides) from the land and transport them to nearby waterways to the detriment of its water quality.

Two methods have been used to check application rates - The Code of Practice and Irrigation Design Standards (March, 2007), and the SPRINK model. The Code of Practice provides guidance on maximum application rates for different soil types, and different land slopes and allows the proposed application rate to be compared to the estimated soil infiltration rate.

The SPRINK model was used to assess the amount of irrigation redistribution, when varying the return period, applied depth and application rate. In general, applying les water more frequently improved application efficiency and reduced the potential for surface redistribution of water.

The analysis examines application rates compared to soil infiltration rates and suggests a return period and applied depth to minimise deep drainage, macropore flow and runoff, and to maximise irrigation application efficiency.

Excess application rates result in irrigation redistribution, which is one of the potential causes of low efficiency. Redistribution cannot be completely eliminated, but should be minimised within reason. A value less than 10% of the applied water over a season is a useful target.

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[4] SPRINK – a stochastic irrigation efficiency model developed at Winchmore Irrigation Research Station , Canterbury by Dr Marshall English, Oregon State University, USA, modified by Aqualinc for efficiency and runoff assessments.

Appendix G: Stockwater

Rule 1 of the Waitaki Catchment Water Allocation Regional Plan (WARP) authorises water to be taken at a rate not exceeding 5 litres per second with a volume not exceeding 10 cubic meters per day, per property subject to Rules 9 and 10.

Section 14(3)(b) of the Resource Management Act states the following:

> *A person is not prohibited by subsection (1) from taking, using, damming, or diverting any water, heat, or energy if—*
>
> *(b) In the case of fresh water, the water, heat, or energy is required to be taken or used for—*
> *(i) An individual's reasonable domestic needs; or*
> *(ii) The reasonable needs of an individual's animals for drinking water,—*
>
> *And the taking or use does not, or is not likely to, have an adverse effect on the environment.*

Therefore Section 14(3)(B) of the Act authorises the taking and use of water for reasonable domestic and stockwater needs, where there is no adverse effect on the environment.

Appendix H: WWAP

Waitaki Catchment Water Allocation Regional Plan (WWAP)

The WWAP is the regional plan for allocation of water in that part of the catchment that is within the Canterbury Region. The following rules apply to the applications proposed by Simons Hill Station Ltd, Simons Pass Station, Rosehip Orchards, and High Country.

The primary control in regards to water allocation in the region is through Rules 2, 3 and 6 of the WWAP. Rules 2 and 3 require that the taking, damming, diverting, and using of water is within the allocation limit for the particular water body and is subject to any minimum flow or lake level, flow sharing regime and flushing flow specified in Table 3 of the plan or minimum lake levels specified in Table 4.

Table 3 of the plan does not refer to Lake Pukaki or the canals, however Annex 1 of the WWAP, number 127 states that "... The Board considered that taking water from the hydro-electricity canals should not be exempt from the minimum lake levels ...”

Table 4 of the plan is relevant to the application by Simons Hill and Simons Pass Stations. The Ohau B and C canals are located just downstream of Lake Ruataniwha, the minimum lake levels for which have been specified in Table 3 of the WWAP.

The relevant aspects of Tables 3 and 4 of the WWAP have been summarised in the Table F1 below.

Table F1: Minimum lake level for Lake Pukaki (source: Table s 3 & 4 WWAP)

Water Bodies	Environmental Flow Regimes / Minimum Lake Levels
Lake Pukaki	A minimum lake level of 518 metres a.m.s.l
Lake Ruataniwha	A minimum lake level of 458 metres a.m.s.l

The applicants are proposing to comply with the minimum lake level set out in the WWAP.

Rule 6 requires that takes are within the annual allocations expressed in Table 5 of the WWAP. The applicable limit is the 275 Mm^3/y allocation for agricultural and horticultural activities.