Before Otago Regional Council

In the matter of	the Resource Management Act 1991
And	
In the matter of	of application RM19.151 for resource consent to take water for irrigation of 160 ha of land originally lodged on 13 May 2019

Statement of evidence by David E Whyte on behalf of submitters

Dated 8 June 2021

INTRODUCTION

1. My full name is David Edwin Whyte. I am a qualified hydrogeologist and the director of Terra Aqua Consultants Ltd, an environmental consultancy firm in Hamilton.

2. I hold a Master of Science (Hons) degree in geology (from Auckland University) and a Graduate Diploma in Hydrology (from the University of New South Wales). Since graduation, I have had 28 years of practical experience in the fields of hydrology and geology.

3. I have been involved in a wide range of groundwater resource investigations throughout New Zealand. I have undertaken many geological and hydrological investigations including for:

4. Open cast mines (New Zealand and Tasmania)

5. Hydroelectric developments (Indonesia)

6. Reservoir stabilisation measures (Clyde Power Project, Brewery Creek)

7. Water supply for various dairy factories, various town water supplies; and

8. Upgrades, tunnel dewatering, subdivision developments and many other projects in Northland, Auckland, Coromandel, Waikato, Taranaki, Bay of Plenty, Hawke Bay, Wellington and Otago.

9. I have also had experience with assessing contamination from pesticides, solvents, electro-plating, petroleum retail sites and timber treatment sites throughout New Zealand.

10. I have been engaged by Mr John Baker and Ms Bridget Steed (**Submitters**) in relation to an application to the Otago Regional Council (**ORC**) for consent by BSTGT Ltd and Trustees of the AP McQuilkin Family Trust (**Applicant**) to replace deemed permits (**Application**). This evidence is also given on behalf of Bloomsbury Stud (NZ) Ltd, a separate submitter.

11. The Application relates to the take of water from the Crown Terrace, from two points on the Upper Royal Burn North Branch and one point on the New Chums Creek (together, the **Area**) for use for irrigation and stock water on three properties (together, the **Subject Site**).

12. Prior to my engagement by the Submitters, I provided some technical advice on the Application to a number of residents of the Crown Terrace, including the Bloomsbury Stud partnership.

13. In preparing this evidence, I have read the application for consent and the amendments to the Application that have been provided by the Applicant since lodgement (dated 27 November 2020 and 3 March 2021). I have also read:

14. The submission by the Submitters and various others

15. The notification assessment prepared by Alexandra King on behalf of the Otago Regional Council (**ORC**); and

16. The section 42A report prepared by Ms King and the evidence for the Applicant.

17. I note that shortly before this evidence was to be finalised, the Applicant filed responses to queries from the Commissioner. In the time available, I have not addressed those responses in this evidence, but may do so prior to or at the hearing by way of supplementary evidence.

18. I visited the catchments on the 27 and 28 October 2020, and I describe the outcome of my observations later in my evidence.

19. In addition, I have been involved with landslide stabilisation work on the Brewery Creek Landslide as part of the Clyde Power Project so am reasonably familiar with the geology and hydrogeology in this type of terrain.

CODE OF CONDUCT

20. I am familiar with the Code of Conduct for Expert Witness contained in the Environment Court of New Zealand Practice Note 2014.

21. I confirm that I have complied with the Code in the preparation of this statement of evidence in the same way as I would if giving evidence in the Environment Court. In particular, unless I state otherwise, this evidence is within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

SCOPE OF EVIDENCE

22. My evidence addresses the following matters:

    (a) Background context and the existing environment.

(b) Comments on the Application, including effects.

(c) Comment on the section 42A report, including conditions.

(d) Comment on the Applicant's evidence.

(e) Conclusion.

EXECUTIVE SUMMARY

23. The following is a summary of the key considerations addressed in my evidence.

(a) The application does not contain adequate information to allow it to be properly assessed. In particular, there:

(i) Inadequate reliable data on current flows in the streams at relevant periods and at different points.

(ii) Inadequate information on the current state of groundwater and its relationship with surface water in the catchments.

(iii) Insufficient understanding of the lag time between losses from surface water to groundwater and the re-emergence back from groundwater to surface water.

(iv) Inadequate information on the irrigation regime, including a lack of detail on the areas to be irrigated on a daily basis and the rotation time.

(v) A lack of information on the fertilizer application rates, or what is proposed in terms of herbicides, fungicides etc.

(b) This information should have been provided with the Application, or at least available for consideration at this hearing. It is possible to obtain this information fairly efficiently. In my opinion, it would be inappropriate for consent to be granted without reliable information on these aspects.

(c) On the basis of the information that is available, my view is that the allocation sought is not sustainable, given the available quantities of water in the streams.

(d) In my view, the Applicant does not require the full allocation sought, because:

(i) Any 'base flow' will be provided by takes for stock water and/or irrigation and it is unnecessary and inefficient to provide a separate allocation just for that purpose.

(ii) The Applicant has not fully accounted for their access to water from tributaries within their properties which I understand are not currently being metered (i.e. it is water available to them which is additional to the water that would be subject to the take limits at the 3 take points). The volume should be measured accurately and completely, i.e. the total take rate from New Chums take point, plus the additional volume collected along the length of the race must be measured and the take rate at New Chums take point reduced accordingly.

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(iii) It is appropriate to calculate allocation levels at the 90th percentile, and not at 100% of stated demand.

(e) It is important that there be a substantive residual flow requirement from each point of take and that the condition securing this be clearly measurable and enforceable. A residual flow is important primarily for in-stream ecological health and to ensure downstream users are not prevented from lawfully taking water but is also relevant to providing some level of protection for the 'swamp' or wetland, and to seek to avoid unforeseen adverse effects on groundwater, noting that the relationship between surface water and groundwater is very poorly understood.

(f) In my view, any residual flow or water cut-off condition should be monitored immediately below each take point, and not immediately above the LOFTS take.

(g) Overall, it remains my view that there is inadequate information available to determine the application, and that there is a risk that granting the consent based on information available now risks there being adverse effects on the environment that are more than minor.

CONTEXT AND ENVIRONMENT

24. In terms of a description of the environment to which the Application relates, I am in general agreement with Ms King's description in Section 4.1 of the s 42A Report. I do make some further comment on this part of Ms King's report later in my evidence and note the following.

25. In relation to the Site 1 take (Upper Royal Burn take), based upon my inspection of the pipework, water flows from the chamber via pipe work and can either go into the pond, or alternatively directly down to be used for irrigation of the golf course. Ms King's report indicates that water flows into the pond before being used. This is not the case. This is important as the Applicant is not always going to be able to take water into the pond during high flows. In fact, they can only store a minimal volume of water in this pond (13,000 cubic metres).

26. In relation to the Site 2 take (Lower Royal Burn take), I note that at the time of my site visit, there were no flow control structures at this take point. I have therefore not seen the 'new' manual flow control structure. As this would have been constructed in a stream bed, I assume that it has been done under a consent granted by the ORC and as built diagrams should be available for this structure.

27. There are a number of matters discussed below which are relevant in 'setting the scene' for the assessment of the Application. In particular, I consider it is important to consider:

(a) The relevance of deemed permits.

(b) Existing water quantities within the New Chums and Royal Burn catchments.

(c) Losses to groundwater.

(d) Existing surface water takes (including what these tell us about the availability of water); and

(e) Ecological values within the catchments.

28. All of these matters are relevant to assessing the impact the proposed water takes will have on the environment, including other users.

Relevance of Deemed Permits

29. A matter which I consider important to understanding the context of the Application is the relevance of deemed permits. The historic water right permits, arising from historical mining licences, that apply to the Subject Site allow the Applicant to draw 5,266,200 cubic metres per year (m^3/year), 27,603 cubic metres per day (m^3/day), or 319 litres per second (L/s) water from the Area.

30. The deemed consents are unlike current consents in that they typically only stipulate a daily or monthly maximum take rate. They often do not have specified maximum daily take rate or volumes nor do they have set times of the year in which the maximum takes can be taken. In many cases, the volumes ostensibly authorised could not physically be taken as they exceed the volume of water available. There would seem to be few historical records of actual take rates and volumes for most of these mining consents.

31. The other issue with deemed consents is that they were issued for historical usage at a time when no real hydrological studies or data were being collected or used to determine sustainable take rates. The consents were typically issued for mining use in areas of sparse population with little or no agrarian activity. Nowadays many of the areas are farmed or cropped intensively and many are being subdivided into lifestyle blocks. This is a predominate feature of the Crown Terrace area.

32. Given this changed environment, and the climatic conditions in the Queenstown Lake District (low annual, with some as snow) the approach taken in the deemed consents is not an appropriate way to manage a valuable resource such as surface water and groundwater. In my opinion, the deemed permits cannot form any type of 'baseline' against which the Application should be assessed. They are of historic interest only.

Crown Terrace – Water Quantities Available

33. In assessing any application to take water, it is important to first ascertain how much water is theoretically available to be taken. As discussed below, this step has been omitted or underplayed and, in my view, this is a serious flaw in the Application. In this section, I discuss the available information as to the quantities of water available, and later in my evidence, I apply these to the quantities sought in the Application.

34. The Crown Terrace lies within the Dunstan Rohe which is part of the Clutha/Mata-au Freshwater Management Unit (**FMU**). The Crown Terrace covers a total area of approximately 2,913 hectares and ranges in elevation between 600 to 1,727 metres. The annual total precipitation averages between 700 to 800 mm per annum over most of this area. However, heavier falls are experienced in the higher portions. This area is effectively drained by three main streams with two of these three joined by a system of historical mining races and more modern buried pipelines.

35. The streams forming the sub-catchments are (from north to south) known as New Chums (or sometimes Bracken Creek), Royal Burn and the Swift Burn.

36. The dimensions of the three individual sub-catchments are given in Table 1.

37. The sub-catchments are indicated on Figure 1.

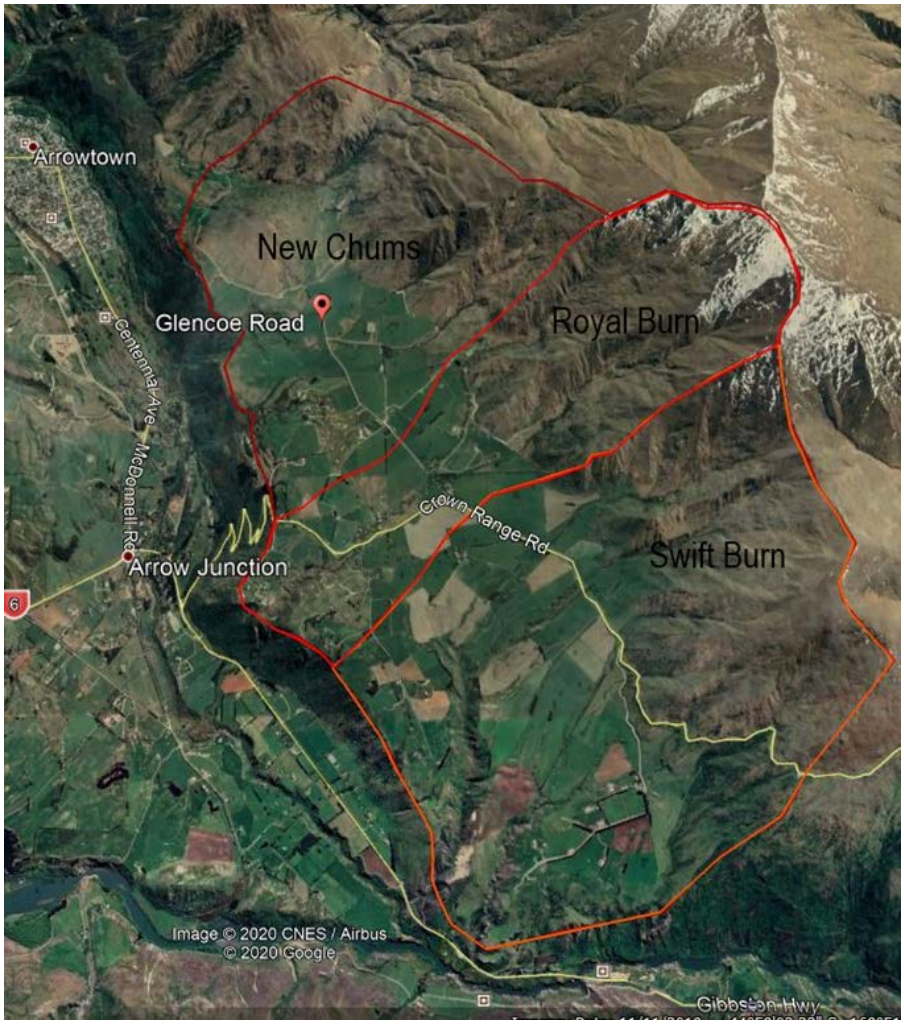

Figure 1: - Sub-Catchments in the Crown Terrace Catchment

38. Overall, the total catchment area is approximately 2,913 ha with a width of approximately 15,050 metres and maximum length of only 5,505 metres. This is a quite different dimensional situation to the neighbouring Cardrona Catchment and means that the responses to rainfall will be quite different.

Table 1 – Catchment Areas

Catchment Name	Area (ha)	Length (m)	Width (m)
New Chums	871	3,520	5,505
Royal Burn	711	5,428	1,592
Swift	1,331	5,505	7,953
TOTAL	**2,913**	**NA**	**NA**

Notes: - NA denotes not applicable

39. By knowing the surface area and the annual rainfall, it is possible to calculate the potential maximum volume of water able to be collected by that catchment. Ideally, there would be several rain gauges spread across the catchment to provide a better

understanding of the rainfall patterns and provide historical records to permit an assessment of minimum rainfall years in terms of frequency of occurrence and total rainfall.

40. The calculation of how much stream flow is generated from melting snow is a difficult one, given that the depth of snow that falls each year is variable. Available records from the Cardrona Skifield show that over the last three years the snow depth is variable (https://nz.j2ski.com/snow_forecast/New_Zealand/Cardrona_snow_history.html).

41. However, as an example, an area of one hectare with 28 centimetres of snow will produce 168,240 L of water and this will be released over a period, rather than all at once as during rainfall. It is well known that with climate change, snow drop is changing and data from the local ski fields indicate that the snow drop is showing a decreasing trend.

New Chums / Bracken Creek

42. As discussed below, a difficulty with the Application is the lack of monitoring of flows. There is a flume located on the New Chums Race, however due to its location it is only measuring half the flow that is being collected by this race and conveyed to a central collection point. It therefore does not provide useful data to enable consideration of the water quantities available.

43. Ignoring any losses via infiltration (to groundwater which could be up to 25% or more[1]) or evapo-transpiration, New Chums can collect an annual total of between 609,700 and 696,800 cubic metres. However, if 25% is lost to groundwater, this volume decreases to between 457,275 to 522,600 m^3/year (or an average volume of between 1,253 and 1,432 m^3/day). This equates to an annualised continuous mean flow rate of between 14 and 16.5 L/s.

44. An annualised continuous mean flow rate means that the total collected is averaged and assumed to flow 24-hours a day for 365 days of the year. This calculation does not include the inter-catchment flow that this historical mining race collects from the neighbouring catchment.

45. The historical race that originates within New Chums and channels water from there via pipeline and race currently re-directs more than 95% of the water away from New Chums Creek and into the pipeline which is then connected to the race. The race does not simply catch water from one extraction point of New Chums Creek, but also collects almost 100% of up to four permanent tributaries which previously had flowed across the race. Now they are simply collected by the race, like a roof gutter, and incorporated into the flow within the race. There is no longer any material flow in these natural creek beds, and the water flow is directed to two storage ponds and then the central water storage system for the golf course. In my opinion, from an environmental perspective, this is irresponsible and unacceptable.

46. Neither rainfall nor snowfall is measured in the head waters of these streams. It is anticipated that climate change will have an impact on both the timing and amount of rainfall and snowfall. The snow fall on the local ski fields is indicating changes. This, in turn, then has an impact on both aquifer recharge and stream flows.

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[1] Table 3 page 22 in Investigation of Wakatipu Basin Aquifers, July 2014. Otago Regional Council Report.

47. The Ministry for the Environment (MfE) has a web site which purports to contain accurate data on stream flows for all streams in New Zealand (https://data.mfe.govt.nz/layer/53309-river-flows/). For the New Chums catchment, the site has a MALF of 0.00468 cumecs (or cubic metres per second or 4.8 L/s) and a mean flow of 0.0198 cumecs. This equates to a mean flow of 19.8 L/s, or slightly greater than the mean annual flow I have calculated based upon rainfall of 14 to 16.5 L/s.

48. I discuss below the fact that the maximum take rates sought by the Applicant is unlikely to be able to be accommodated given these existing volumes.

Royal Burn Upper and Lower

49. In the Royal Burn catchment, the maximum annual rainfall collection is calculated at between 497,700 and 568,800 cubic metres. This figure represents the entire catchment take, not just the relevant part of the catchment area from which the upper and lower take points will draw.

50. Given the position of the upper take point, approximately halfway down the catchment, the rainfall collected is likely to represent approximately 50% of the total catchment collection volume. This means that the upper take point is likely to be receiving a maximum annual rainfall volume of between 248,850 and 284,400 cubic metres. However, if the loss to groundwater is also 25% this reduces further to between 186,638 and 213,300 m^3/year (or 511 to 584 m^3/day) or an annualised continuous mean flow rate of between 5.9 and 6.8 L/s.

51. For the lower take point, the additional catchment area is small and will not significantly increase the rainfall capture volume. I would therefore expect the annualised continuous mean flow rate at the lower take point to be approximately between 6 and 7 L/s. This assumes no water was being taken from the upper take point if it was, that amount would be deducted from the flow available at the lower point, with perhaps a very minor increase from ground or rainwater between the two take points.

52. For the two branches of the Royal Burn at Glencoe Road, the MfE website shows the MALF's as 0.0108 and 0.0107 cumecs (or 10.8 and 10.7 L/s) respectively. The mean flow is estimated at 0.0319 and 0.0336 cumecs, respectively. These flows are significantly greater than the mean annual flow I have calculated from rainfall on the catchment of between 5.9 and 6.8 L/s.

53. The question is why, with two catchments with the same geology, elevation, vegetation, aspect, rainfall, and similar surface area, does the MfE calculate such different mean and low flow figures. This suggests to me that MfE have overestimated the flow in the Royal Burn. The difference in flows may also be explained by the approach in calculations. The MfE calculation is for the end of the stream reach, so its figures relate to the stream flow at Glencoe Road, whereas my calculations are at the points of take. The MfE figures also do not mean that the indicated flow is available over the entire length of the reach, as at the top of the reach the flow is zero and increases as you move down the reach.

54. Regardless of which estimate is more accurate, both estimated rates of flow are too low to sustain the take rates and volumes that the Applicant is seeking.

55. Thus, even with a mean flow at Glencoe Road of 31.9 L/s there is insufficient water flowing for the Applicant to take the daily maximum for most of the year.

Groundwater

56. Overall groundwater flow direction can only be accurately determined from observation bores that have been surveyed for both location and elevation. By and large the groundwater flow is typically in a similar direction as surface water flows. Hence it can be inferred that the general groundwater flow is essentially in an easterly to westerly direction (from the highest points to the lowest point in the catchment).

57. However, examination of the seepage areas across the Crown Terrace suggests that in localised areas this pattern is not followed. There is a large area of seepage evident between Glencoe Road and the escarpment, and northwest of the Crown Range Road where groundwater flow is directed more in a north-west to southeast direction. This large seepage area eventually discharges groundwater flow towards a small tributary to the Royal Burn. This area is indicated on Figure 3.

58. A search of the ORC databases indicates that there are few consented groundwater bores in the Crown Terrace. From speaking with various landowners there are several 'wells', but these are just large diameter holes for collecting water for pumping to tanks for storage rather than a drilled groundwater well.

59. There are numerous areas of seepage across the entire Crown Terrace. This suggests that groundwater flow is a significant component of the overall hydrology of the area. Due to the lack of stream flow data, it is unclear how much water is being lost to or regained from the groundwater aquifer. The large seepage area below Glencoe Road mentioned above indicates significant loss to groundwater from at least between the historic deemed consents (RM14.364.01, 3073B, 97029.V1, 97402) offtake locations and a point below Glencoe Road. Large areas of seepage appear below Glencoe Road, and this indicates that groundwater is being gained by the surface water system at these points.

60. Similarly, in an area west of the intersection with Crown Range Road and Glencoe Road there is an area of seepage that is sustained from infiltration from both the Royal Burn and the Swift Burn catchments. This area of seepage is evident on both sides of the Crown Range Road and the flow direction is more east to west. This area is indicated on Figure 3. This area is also discharging groundwater to the Royal Burn.

61. This means that if large volumes of surface water are taken from the streams above the areas of stream bed that are losing water to groundwater, the amount of groundwater recharge will ultimately decline, resulting in less water within the aquifer and less loss from groundwater back into the stream from surface seepage. Delineating the groundwater flow direction is important to accurately characterise where any contamination or run off from the golf course may be carried, as discussed later.

62. In terms of groundwater allocation, the Crown Terrace aquifer(s) does not appear on any listing within the Council's "Regional Plan: Water". Consequently, there is no defined allocation volume. However, in line with the Council's own default groundwater allocation provisions, the allocable groundwater resource should be defined on the basis of rainfall-recharge calculation of 50% of MAR (Mean Annual Rainfall), as stated in the groundwater-surface-water allocation policies and rules in the Water Plan [i.e. 6.4.1A(b) and 6.4.1A(c)][2].

[2] Otago Regional Council. 2012. Regional Plan: Water for Otago.

63. If this is enacted, this will have a significant effect on the volume of water that can be sustainably allocated for use from the surface water streams.

Existing Surface Water Takes

64. A search of the ORC data bases shows the following surface water consents are current. The consented takes are listed in Table 4. In Table 4 if the consent does not have a mining privilege number it is not a deemed consent. Table 5 summarises the take locations and application take rates requested. Table 6 summarises the maximum recorded instantaneous take rate at each location from data recorded at hourly intervals.

Table 2 – Surface Water Takes

Consents ID	Deemed Maximum Daily Take (L/s)	Catchment	Mining Privilege Number
99477	83.3	Not recorded	WR415B
95696	83.3	New Chum	WR1032AR
2006.256	36	Royal Burn	NDC
96264 #	13.9	Royal Burn	WR1348AR
96285 # 1	13.88	Royal Burn	WR1351AR
RM14.364.01	55.6	Royal Burn	NDC
3073B	111.1	Royal Burn North Branch	WR1347AR
97029.V1	55.6	Royal Burn North Branch	WR1347AR
97402	83.33	Royal Burn	WR1346AR
2000.263	27.76	Swift Burn	WR1031AR
96265	55.54	Swift Burn	WR1349AR
RM18.034.01	33	Swift Burn	NDC
98457	13.88	Swift Burn	WR1415AR

Note: According to the data base all the take points are fitted with measuring devices.
NDC denotes not deemed consent.
1 Consent conditions indicates that not more than one half of the flow of the Royal Burn North Branch shall be taken under this permit.
Consent conditions preclude 96285 and 96284 being taken at the same time. This condition was imposed to prevent either of the RBNB or the RBSB to have all the flow taken and prevent downstream users and the flora and fauna from having no water. It also suggests that the flows in both branches are similar in magnitude and not likely to have dried up.

Table 3 – Surface Water Take Locations and Application Take Rates

Consent ID	Maximum Daily Take (L/s)	Catchment	Map Reference (NZMS260)
95696	24.5	New Chum	F41:846-768
96285	15	Upper Royal Burn North Branch	F41:856-747
RM14.364.01			
3073B	50	Lower Royal Burn North Branch	F41:856-741
97029.V1			

Table 4 – Applicant's Historical Surface Water Take Recorded Maximum

Consents ID	Flow Measurement ID	Average Flow (L/s)	Instantaneous Maximum Flow (L/s)	Date of Maximum Flow (dd/mm/yyyy)
95696	WM0733 (WEX0184)	11.9 [1]	76.28	21/07/2020
96285	WM1202	5.58 [2]	27.58	28/06/2020
RM14.364.01				
3073B	WM0503 (WEX0129)	1.48 [3]	19.92	26/08/2017
97029.V1	WM0385	7.77 [4]	107.9	20/11/2017

Note:
Designations starting with WEX are meters installed by BSTGT Ltd and A P McQuilkin Family Trust.
[1] Period of record is 3 June 2015 until 10 November 2020.
[2] Period of record is 30 March 2016 until 10 November 2020.
[3] Period of record is 9 October 2013 until 10 November 2020.
[4] Period of record is 1 December 2009 until 28 October 2020.

65. Several of the take locations listed in Table 5 service more than a single domestic dwelling or lifestyle property. In addition, there is at least one property that is in the process of installing a water wheel to generate electricity from the Royal Burn stream flow.

66. The Applicant's recorded usage amounts to a maximum instantaneous take rate of 259.26 L/s, with the total instantaneous take (for all users) being potentially 652.3 L/s. The indicated maximum takes typically represent a very short period of take which may coincide with a rainstorm event since they typically appear in the winter months (June to August) with only one in November.

67. For WM0733, which is measuring flow in the New Chums Race, the data set shows that there are 4,518 points out of 44,070 where the flow rate is greater than 24.5 L/s. This represents 10.3% of the entire record with data collected every hour since 3rd June 2015 till 10th November 2020.

68. For the period of record for WM0385 (Lower RBNB take) this shows that out of the 95,617 recorded data points, only 228 points have flows greater than 50 L/s, or only 0.23% of the recorded data set. Data is recorded hourly over this time. This meter is also measuring the volume that was used by McQuilkin Family take water (3073B) and this take is monitored by WEX0129[3]. The ORC have a data set labelled as WM0503 which appears to correspond with WEX0129. For the period of record this data set reports no flows greater than 20 L/s, and only 127 points out of 62,149 points being more than 10 L/s. This represents less than 0.2% of the data set with data collected at hourly intervals.

69. Similarly, for WM1202 (Upper RBNB take) this shows that out of the 40,457 data points only 518 are greater than 15 L/s or put another way less than 1.3% of the recorded data points. Data is collected on hourly intervals over this time.

70. This data shows that the deemed consented take volumes were not being exercised, and that the Applicant's desired take rates are not physically possible. It also shows that the Applicant's historical usage (prior to 10 November 2020) averages 26.7 L/s (2,309.5 m^3/day or 842,957 m^3/year).

71. The mean annual flow rate (calculated from the maximum annual rainfall on the catchment area) totals only between 48.8 to 55.5 L/s. This means that for 50% of the year it is less than that and 50% it is more.

My investigation and observations

72. I visited the catchments on 27 and 28 October 2020. There was rainfall on the evenings of 26 and 27 October 2020.

73. I walked almost the full length of the New Chums and Royal Burn stream network and collected data at certain points (usually at either races or culverts) to assess the flows occurring on that day. Given the time of year (end of spring) the flows should have been representative of above average flows, certainly not close to mean annual low flows (MALF).

74. I observed that there are several flow measuring (or monitoring) devices within the races and streams as well as with pipework on private property. I have obtained flow data from ORC for most of these measurement points and discuss these data later in the report.

75. There is a Parshall Flume located within the mining race in the New Chums Catchment. The flow on the day (in 2020) I was there ranged between 22 and 24 L/s. This is slightly greater than the mean flow estimated for the catchment on the Ministry for the Environment River Flow web site. Even at this flow rate there was minimal flow escaping the off-take point and continuing down the New Chums Creek.

[3] 1st Paragraph under Figure 3 in application document.

Figure 2: Flow Measurement on 28 October 2020 Parshall Flume

76. The bulk of this flow in the race at this point is from inter-catchment flow originating from the New Chums into the Brackens Creek Catchment.

Points of Take and Flow Measurements

77. The locations of the known off-take points within the New Chums and Royal Burn Catchment are indicated on Figure 3. The locations of flow measurements made and calculated from the data collected over the 27 and 28 October 2020 are also shown on Figure 3.

78. Calculations of the flow measurements made are presented in full in **Appendix A**.

79. Flow measurements are summarised in Table 7.

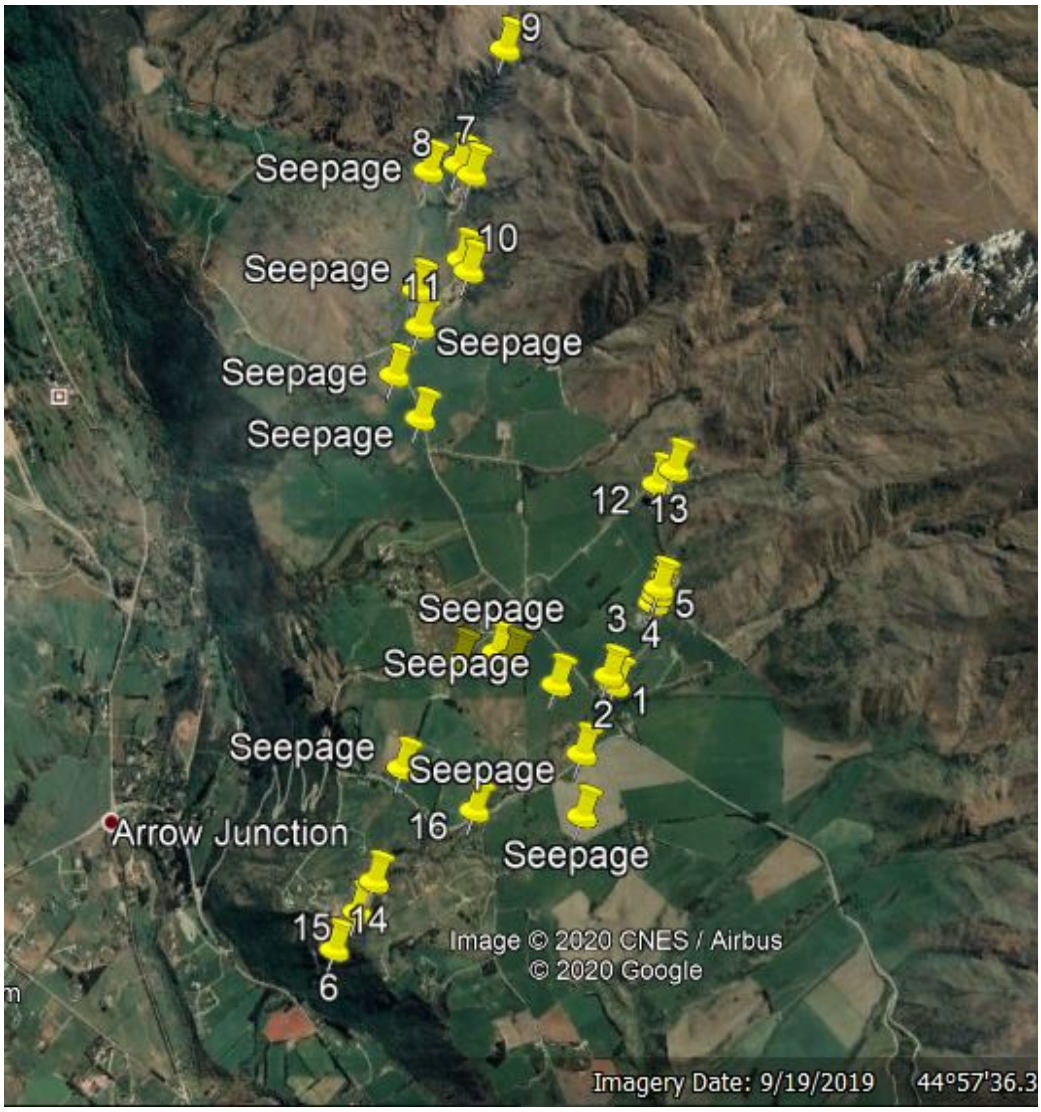

Figure 2: Features of Interest in Hydrology of Crown Terrace

80. The pins in Figure 2 indicate the following locations:

1	Refers to Royal Burn at Glencoe Road (South Branch).
2	Refers to Royal Burn at Glencoe Road (North Branch).
3	Refers to the begining of the open Brodie Race.
4	Is the location of the weir Monitoring flow down Brodie Race.
5	Is the Lower take above the culvert on the Royal Burn (Northern Branch).
6	Refers to the take for four houses after the waterfall on the Royal Burn (John and Bridget's take 97402)
7	Refers to take at New Chums (not from the specified locations).
8	Refers to point where a Parshall Flume is located in the New Chums Race (this does not monitor flow from the take Point at 7).

9 Refers to off take point at Start of the pipeline in New Chums Creek (specified locations in Application).

10 Refers to the discharge point into two New Chums Ponds (7,500 cubic metres of Storage paragraph 7 of Mr McQuilken's Evidence).

11 Refers to a tributary that is not collected by the mining race.

12 Refers to the Royal Burn Pond (13,000 cubic metres of Storage paragraph 11 in Mr McQuilken's Evidence).Where flow from Royal Burn upper take can be stored or bypassed.

13 Refers to the off-take point (upper) on the Royal Burn.

14 Refers to the point where trout where spotted in the Royal Burn.

15 Refers to off take point.

16 Refers to another off take point.

Table 5 – Calculated Flows at Indicated Locations

Location	Flow Value (Ls^{-1})	Catchment
Royal Burn South Branch at Glencoe Road	56	Royal Burn
Royal Burn North Branch at Glencoe Road	48	Royal Burn
Rectangular Weir on Royal Burn North Branch	13	Royal Burn
Main Stem below Culvert on Royal Burn North Branch	15	Royal Burn
Brodies Race (downstream of weir)	16	Royal Burn

Water Harvesting

81. In theory, there is a good argument for the harvesting of high stream flows to store and use in periods of low flow. This is an idea that should be encouraged. However, to achieve it requires some specific information on stream flows that, in this case, either has not been collected or has not been provided. Flow data made available by the ORC only relate to how much water is taken from streams, not recording the flow within the stream, or how much is left behind after the take. These data do however show, that for the existing deemed consents, there are relatively short periods where large quantities are taken (but seldom at the deem consented maxima) which indicate short periods of high flows.

82. It may well be that the high recorded takes (recorded by flow measurement in pipeline or race) may be taking a significant proportion of the actual stream flow. It is theoretically possible that the high flow taken may in fact be leaving the stream with a flow that is close to or below the MALF.

83. Another important factor in determining if harvesting is a feasible practice is to model (in a spreadsheet format) how the storage and stream flow are going to operate. Given the long dry summer/autumn season in this area the volume of

storage to make it practical to harvest high flows for use through the low flow periods may be large and make this option impossible to operate.

Storage Loss due to Evaporation

84. Currently there appears to be little accurate data on actual evaporation losses from large pond surfaces in the Crown Terrace. In the adjacent Wakatipu Basin annual potential evapo-transpiration is estimated at 950 mm[4] per year or approximately 150 to 250 mm more being lost than delivered by rainfall. Up to 70 to 75% of the total loss (665 to 713 mm) is likely to occur between January to March. This represents an average daily evaporation rate of 7 to 8 mm.

85. From the Crown Terrace we have some evidence from a recently constructed pond (New Chums Pond). This was full of water on the 27 September 2020 (Figure 3) and when revisited on 28 October 2020 the water level in the pond had dropped considerably (Figure 4). I have estimated that the loss is at least 1,600 cubic meters or 1,600,000 litres. I note that the smaller pond, into which the observed pond would ordinarily flow, was dry and in need of repair, so therefore presumably the water was not otherwise being actively removed.

Figure 3: Photo taken 27 September 2020 of pond being filled from New Chums Race.

[4] Table 3 page 22 in Investigation of Wakatipu Basin Aquifers, July 2014. Otago Regional Council Report.

Figure 4: Photo taken 28 October 2020 of same pond.

86. We do not know exactly how many days it took to reach this point, but assuming that the water was lost gradually over the full 31 days between these two dates then the rate of loss is 0.6 L/s if it occurred as either seepage (since the pond appears to be unlined) or evaporation.

87. This minimum rate of loss equates to a drop in water level of 80 mm per day and represents a daily volume of 48 cubic metres. This is relevant as the Application does not seem to factor in evaporation losses at all.

Ecological Values

88. Ecologically, the most critical times for stream flora and fauna are the low flow periods and unfortunately these often coincide with the time of most demand for water to be withdrawn from the stream system for irrigation.

89. On my site visit on 27 and 28 October 2020, while walking down the Royal Burn I observed at least five mature trout and numerous younger trout swimming in the clear water. Given that the area is also often frequented by shags, kingfishers, and other aquatic birds, it would seem logical to expect it also is home to a range of other smaller aquatic fauna. This is consistent with the evidence of the ecologists. Particularly Mr Hickey (paragraph 37).

90. Unfortunately, in the New Chums catchment, most of the water has been directed away from the natural water courses. This has completely changed the ecology of these catchment areas, with most of the streams being run dry. It is hard to understand whether koura might live there because most of the water capacity has been depleted some time ago.

COMMENT ON THE APPLICATION

Adequacy of base information

91. As noted above, the Application seeks new water permits for irrigation and stock water from two take points on the Royal Burn North Branch and one on New Chums Creek. The original volumes sought have been incrementally reduced since lodgement, and the total quantity now applied for is 1,214,683 m^3/year.

92. As a general comment, the original Application did not contain adequate information to allow it to be properly assessed. Even with the supplementary material provided since lodgement, I still consider that further information is required in order to allow a full assessment.

93. The greatest data gap is accurate low flow data for the streams in the area. There do not seem to be any publicly available data sets on stream gauging or flow measurement on the ORC web site. This is concerning since it is imperative to have this information to allow meaningful management of surface and groundwater resources within this area.

94. It is a relatively simple matter to install a few instream weirs to collect flow data above and below each take point from the three streams. By collating the flow data from the streams with the flows being taken it is then easily calculated what percentage of the stream flow is being taken. These do not need to be complex in design (a regular rectangular weir or even a stepped weir to allow for higher flows in winter is all that is required) nor do they need to be in place to record the high winter flows (although it would be useful to have that information as well). These can easily be automated with data telemetered.

95. The average annual rainfall figure often given for the Crown Terrace is between 700 and 800 mm. This is probably true for the lower section of the terrace itself but is unlikely to be correct for the steeper and higher areas forming the Crown Range. The higher areas will have more precipitation in the form of both rainfall and snowfall and this may have a significant effect on the total possible catchment yield and the timing of high flows in the streams. I have commented earlier in my evidence on what I consider to be appropriate estimated flow rates considering known levels of rainfall.

96. Ideally, there should be rain gauges at several points within each catchment. These can also be automated and, to save on establishment costs, I would suggest installing these at the same locations that the weirs are being installed.

97. Another aspect on which there is missing information is the relationship between surface water and groundwater. There is no real data presented by the Applicant to help assess where water may be being lost or gained by streams. There is no information presented on any lag time between the loss of water from the stream and its re-emergence from the groundwater system. There is no data provided by the Applicant showing that any losses or gains are relatively constant throughout the year or if they change between seasons.

98. My comments that follow are based on the information that is currently available, which, as noted, is incomplete.

Sustainability of allocation sought

99. The actual quantities said to be required for the Subject Site given in the latest amendment (3 March 2021) to the Application are:

- Farm irrigation (139.2 ha) – 1,074,608 m^3/year
- Golf course irrigation (20 ha) – 38,989 m^3/year
- Baseflow for New Chums and Brodie races – 315,360 m^3/year.

100. The Application also indicates a requirement for stock water of 1,296 m^3/year (Ms Lennox's evidence at para 101 clarifies that no water is sought for domestic use as this is apparently provided from water permit 97184.V1 which authorises the abstraction of 36,000 L/day from bore F41/0176 of which the Applicant holds a $1/12^{th}$ share (or 3,000 L/day) In her evidence at paragraph 119 Ms Lennox provides a revised stock water usage figure of 45 m^3/day or an annual volume of 16,425 m^3 which seems a rather large increase.

101. Together, this amounts to 1,430,253 m^3/year, however 1,214,683 m^3/year is sought to reflect apparent maximum historical l use (last six years).[5] A daily volume of 7,732 m^3/day is proposed and 239,716 m^3/month (which is slightly greater than a 31-day month at the maximum daily rate). The Applicant proposes to take at the maximum daily rate each day they are exercising the consent.

102. This means that the annual take volume equates to a five-month period of take (excluding any volume for maintenance flow in two races and stock takes). The Application does not define its irrigation season in terms of months. In Ms King's evidence she indicates the Application is for 100-percentile demand (paragraph 3 page 41).

103. In Ms Lennox's evidence at paragraph 122, she has attempted to discuss the need for maintenance flows totalling 10 L/s for the New Chums and Brodie Races. She presents a table which is difficult to interpret. Ms Lennox indicates three date ranges, May to August (121 days, which presumably is not the irrigation season), then September to August (123 days which does not make sense, unless she means August to September also not likely to be irrigation season, but this does not give you 123 days). Ms Lennox's evidence (paragraph 147) gives a monthly figure of 210,361 m^3/month which equates to 6,786 m^3/day for a 31-day month. This does not match the volumes requested in the Application.

104. This means that the annual take volume equates to a five-month period of take (excluding any volume for maintenance flow in two races and stock takes). This is confirmed in Ms Lennox's evidence (although in her paragraph 147 she gives a monthly figure of 210,361 m^3/month which equates to 6,786 m^3/day for a 31-day month).

105. The maximum rate of take is proposed as follows:

- New Chums – 24.5 L/s
- Royal Burn North Branch – upper take – 15 L/s

[5] Ahika Consulting, letter dated 3 March 2021.

- Royal Burn North Branch – lower take – 50 L/s.

106. In my opinion, the quantities sought do not fit comfortably with the quantities actually available in the rivers. Comparing the available quantities calculated in the previous section of my evidence with what has been applied for, I note:

107. At New Chums, the annualised continuous mean flow rate is calculated to be between 14 and 16.5 L/s, which is below the proposed rate of take of 24.5 L/s. It is difficult to see how the Applicant's total maximum take rate can be achieved during the dry summer and autumn seasons when this is when they will be wanting to take the maximum irrigation and stock volumes totalling 7,732 m^3/day (or Ms Lennox's 6,786 m^3/day).

108. At the Royal Burn North Branch upper take point, the annualised continuous mean flow rate is calculated to be between 5.9 and 6.8 L/s, while the MfE calculation is just below 11 L/s. The proposed rate of take, at 15 L/s (1,296 m^3/day or 1,296,000 L/d), exceeds either volume.

109. At the Royal Burn North Branch lower take point, the annualised continuous mean flow rate is calculated to be between 6 and 7 L/s, while the MfE calculation is just below 11 L/s. The Applicant is proposing to take at a maximum rate of 50 L/s (4,320 m^3/day or 4,320,000 L/day) from this lower take point. It is physically impossible for the Applicant to take water at a rate of 50 L/s from this point for most of the year.

110. The proposed volumes of take are extremely problematic. For large portions of the time, predominantly in the irrigation season, the flow will be less than the calculated mean value, yet this is presumably when the Applicant will be seeking to take the maximum quantities. The main difficulty that I can see with the Application is that the Applicant has not provided any hydrological evidence to demonstrate that what they are asking for is feasible.

111. I note that there is an existing consent condition for the deemed consent 96285 requiring that only 50% of the flow in the RBNB can be taken. Even back in the mining days there was concern about maintaining residual flow within this portion of the stream. It is not clear whether this condition has been complied with historically. If the applicant is to take 50 L/s at this point and still comply with that original consent condition the flow in the stream would need to be greater than 100 L/s.

112. The issues are particularly pronounced at the lower take point, where the proposed rate of take will be physically impossible at most times. The Applicant has now presented some photographic evidence[6] and one gauging[7] that this take point is frequently 'dry' with no flowing water from early in January, particularly if the Upper Take is being used. The issue here is that this lower take is extracting water from the Royal Burn which has already had considerable water taken from it by the Upper Royal Burn North Branch take. Based upon the NIWA gauging (although Ms Lennox refers to another gauging in her evidence paragraph 91) if the Applicant was exercising their take on the day of the gauging, there would have been no water flowing down the RBNB. This is unacceptable since it will result in longer periods of 'no flow' with subsequent effects on other downstream users and possibly groundwater uses as well.

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6 Figure 3 Intake structure at Lower RBNB point of take (97029 & 3037B) in application document.

7 NIWA, letter dated 26 February 2021.

113. In this regard, I consider a condition for residual flow to be critical, not only for a stream health reasons but to alleviate effects on downstream users (potential or existing). The larger the residual flow the better. I discuss this further below.

114. I discuss the storage ponds below. In Mr McQuilkin's evidence he discusses the ponds that are in the system. He describes the following:

- New Chum Pond - 7,500 cubic metres (above Glencoe Road)
- Royal Burn Pond - 13,00 cubic metres (below Upper Take point, above Glencoe Road)
- Brodie Pond - 5,000 cubic metres (below Glencoe Road)
- McQuilkin Pond - 400 cubic metres (below Glencoe Road)

115. This equates to 25,900 cubic metres not the 25,500 cubic metres mentioned in other Application evidence. In either case the storage volume for the purported storage of flood high flows is very slim.

116. The inability of the Applicant to take at 50 L/s from the lower take location is confirmed by flow gauging done on their behalf by NIWA. This information shows that on 21 February 2021 there was insufficient flow at the Brodie Race take point even with no take occurring at the upper take location. NIWA present their data in a table which I have partially reproduced here, and to which I have added the last 2 columns.

Table 6 – NIWA Gauging Royal Burn

Site Number	Site Name	Flow (L/sec)	Applicant's proposed Take (L/s)	Residual Flow After Take (L/s)
100	Royal Burn at SH6	25.5		
200	Royal Burn at Crown Road Bridge	44.3		
300	Royal Burn at Swamp	12.4		
400	RBNB below Glencoe Road	9		
500	RBSB Above Glencoe Road	8.8		
600	RBNB below Brodie Race	16.8		
700	RBNB Above Brodie Race	25.4	50	-24.6
800	RBNB below Top take	20		4.2
900	RBNB above Top Take	19.2	15	19.2

Note: RBNB refers to Royal Burn North Branch
RBSB refers to Royal Burn South Branch

117. This information shows that on 21 February 2021 there was insufficient flow at the Brodie Race take point even with no take occurring at the upper take location.

118. A problem with this information is that there is no reference in the NIWA report as to whether the Applicant was operating their system at the time the flow measuring was done. This is of concern for two reasons. First, it is not clear if the apparent loss between stations 600 and 700, (Lower Take point to Brodies Race is between these points), is a real 'loss' or a 'loss' due to water flowing down Brodies Race. Presumably, the Applicant was taking at least their "*maintenance flow*" (of at least 10 L/s) from the New Chums and Brodies Races at that time and no information is given as to what was happening to this volume of water.

119. I believe it is a 'loss' due to flow being diverted down Brodies Race at a rate of 8.6 L/s.

120. Secondly the large 'gain' between stations 300 and 200 needs more investigation to be fully understood. The NIWA data show us that above the convergence point of the RBNB and RBSB the flows in each separate branch are 9 and 8.8 L/s respectively. This gives a total flow of 17.8 L/s, yet at the next location gauged the flow is reported to be only 12.4 L/s, a loss of 5.4 L/s. So, descending the RBNB there is initially a reach that is constant (within the measurement errors) and then there appears to be a short reach that gains 5.4 L/s (down to Lower Take Point). There is an apparent loss at that point, but this is water taken by Brodies Race. The next section of reach loses (16.8 –9) 7.8 L/s with the next reach losing an additional 5.4 L/s (17.8 – 12.4 L/s). The losses recorded on that day from the RBNB total 13.2 L/s and while this is contributing to the 'gain' reported in the next reach of 31.9 L/s it does not explain the total gain. So where is this additional 18.7 L/s being 'gained' from?

121. The gain indicated at the Bridge at Crown Range Road is not just from the area of 'swamp' indicated below the Royal Burn but includes water seeping from sources within the New Chum, Royal Burn and Swift Burn Catchments. Neither the Application nor the Council report mentions this fact or discusses the much larger 'swamp' which runs from the golf course southward towards the Royal Burn and includes the overflow from the New Chums and Brodie Races which forms a small tributary to the Royal Burn (as confirmed in Mr McQuilkin's evidence at paragraph 18).

122. This is shown very well in Mr Hickey's Figure 1. There are two very green arches visible to the right of the Royal Burn and extending up towards the golf course area. This is a very large area of 'swamp' in fact much larger than the 'swamp' immediately below Glencoe Road and which others believe is contributing to the gain of the Royal Burn. There is also a water course/stream that runs (or did at least up until after my visit to the site in October 2020) from the end of the Brodie Canal around on the western edge of this 'swamp' which also contributes flow if the applicant releases it. There is also a small stream that runs from the 'swamp' past Patrick and Lisa Garceau's property. On the day of my site visit this stream was not flowing past Mr Garceau's property.

123. There is evidence provided in submissions by downstream users that at times the Royal Burn has not run at all in recent years due to the Applicant's activities[8, 9]. This is consistent with my observation that the Applicant's desired flows are at such a

[8] Paragraph 16, page 2. John Baker and Bridget Steed Submission.

[9] Second sentence of Patrick & Lisa Garceau Submission.

level that the water takes would take all available water, leaving the river dry. This also suggests that the 'gain' from groundwater may well be less than suggested by the NIWA gauging data.

124. As an overall comment, I consider the takes proposed in the Application are not sustainable.

Storage Ponds

125. The Applicant has indicated in the Application that the intention is to take high winter/spring flows and store these for use in the dry summer and autumn seasons. Initially the Application only indicated a storage volume of 13,000 cubic metres. The Application has been changed and in the Council's s 42 report there is mention of total volume of storage of 25,000 cubic metres in three ponds. Now in Mr McQuilkin's evidence we have four ponds totalling 25,900 cubic metres. Existing consents indicate insufficient storage space to execute such a management plan.

126. The details initially available were as follows.

127. Pond storage is mentioned in the Application as being 13,000 cubic metres for the pond supplied from the Upper Royal Burn North Branch (Royal Burn Pond - McQuilkin evidence). From measuring the area of the pond surface (from Google Earth Pro) the pond area is determined to be 2,450 square metres (approximately)

128. From these facts we can calculate an average depth of the pond, assuming that the sides are vertical (not an unacceptable assumption given the ground conditions at the location). So, dividing the volume by the surface area gives the average water depth. The calculated depth for this pond is therefore approximately 5.3 metres. This pond volume provides a maximum of 1.5 days of maximum irrigation and stock, water use. If water is taken from this pond at the maximum daily take rate of 6,772 cubic metres (since the rest is being taken from New Chums/Bracken Creek) and being refilled at a rate of 15 L/s (since it cannot be refilled by the Lower Take), it will take only two days of irrigation take to drain the pond. Calculations are presented in Table 3.

Table 7 – Upper Pond

	Storage Volume (m^3)	Irrigation Take (m^3)	Refilling @ 15 Ls^{-1}
Day 1	13,000	6772	1296
Day 2	6,228		
Day 3	-544		

129. Examination of the Google Earth pro image reveals two other large ponds located close to existing races and likely to be used to store water (New Chum Pond 7,500 cubic metres). These are to store water from the New Chums/Bracken Creek flows. The two ponds have surface areas of 545 and 1,063 square meters, respectively. Assuming the same pond construction is followed, these provide a possible storage for approximately 8,522 cubic metres (assuming a water depth of 5.3 metres in each pond). So, my estimate is generous based upon Mr McQuilkin's evidence.

130. In combination the New Chum Pond provide a total of 12,500 cubic metres of storage, less than two day's storage at the maximum daily rate sought by the

Applicant, bringing into question the proposed methodology for water management.

131. Ms Lennox in her evidence (paragraph 105), makes comment about the daily maximum take. The Application states that that the daily maximum take rate is required every day of the five months of the irrigation season. This is also confirmed in Ms King's report as her understanding of the application. In Ms Lennox's evidence she refers to *"210,361 m^3/month"* which equates to a daily maximum take volume of 6,786 m^3/day which is less than the daily maximum take rate sought.

Irrigation Infrastructure

132. Given that much of the indicated 160 ha of land to be irrigated is immediately below the two identified storage ponds, it is rather unusual that the Applicant has buried pipelines extending from the storage ponds to a single central location[10]. Mr McQuilkin states in his evidence that gravity feed is sufficient to irrigate the farm pasture area. Given that parts of the farm are close to the elevation of the ponds from which the water is being delivered from this seems unlikely. Unless they are not actually intending to irrigate all the 160 ha stated.

Golf Course

133. While the original Application did not specifically mention the golf course or turf business, it is now well known that these are at issue. There is clearly activity on the Subject Site that shows irrigation of these two areas is occurring already and this is addressed in the Applicant's evidence.

134. The average 18-hole golf course covers an area of approximately 30 ha of maintained turf, although the area can be greater. In this case the course apparently involves 20 ha of irrigated land. It is interesting in Mr Howard's evidence at paragraph 11 he gives the percentage of golf course area that is typically irrigated as 40-60%, with a typical 18-hole course covering 50 to 60 ha. In this case, the irrigated area is 20 out of 30 hectares or 66%. I understand the Applicant's golf course makes multiple use of the same green, i.e. several tees end up at the same green. This should mean that the Applicant requires less water to irrigate fewer greens.

135. While the concentrations of contaminants may be in a similar order of magnitude to those generated under many pastoral farming areas, the area of application of the pesticides, herbicides and fertilizers is much less and applications likely to be more frequent.

136. There is a body of scientific evidence from both within New Zealand and overseas[11,12] that confirms that golf courses can and do act as significant point sources of contamination, via both runoff to surface waters and infiltration to groundwater. The main contaminants of concern include pesticides, herbicides, and fertilizers. Given the special character of the Crown Terrace and the fact that it drains into the larger Wakatipu Basin any contamination of these waters will ultimately influence a much wider environment and larger population.

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10 Figure 1 Scheme Plan page 2 in Resource consent application to replace various deemed permits.

11 Groundwater Impacts of Golf Course Development in Cape Cod. Technical Note #27 from Watershed Protection Techniques. 1(2): 86-88.

12 Effect of Golf Course Turfgrass Management on Water Quality of Non-tidal Streams in the Chesapeake Bay Watershed. Wilson, C. M; PhD Thesis, 2015.

137. While it is possible to say that these issues can be managed by changing management practices, this is seldom achieved. This can be seen in the Wakatipu Basin with the pollution of Lake Hayes following the development of golf courses and decline in pastoral farming, which should have resulted in a decline in Total N, nitrate-N, ammonium-N, phosphate-phosphorus (P), in surface water and Lake Hayes in particular, rather than the observed increase.

138. The Application does not provide any information on fertilizer application rates, or what herbicides, pesticides or fungicides are to be used on the golf course. The turf witness, Mr Howard, does not discuss anything about fertilizer application rates, fungicide or herbicide usage. He mainly discusses water use and the need to not over water a golf course.

139. As a golf course is being developed in the centre of the Crown Terrace (and currently does not appear to have any monitoring bores in place), it may be necessary for the Council to declare this a Nitrogen Sensitive Zone (NSZ) as defined in the Proposed Plan Change 6A (Water Quality). If this is enacted, then any groundwater contribution must be kept below 10 kgN/Ha/y. The only way to accurately measure and monitor this is by installing a ring of groundwater monitoring bores that encircle the boundary edge of the golf course, plus a further series of bores some distance away from that boundary in the direction of the groundwater gradient. In addition, some bores will need to be installed upgradient of the golf course to ensure that background levels can be monitored to compare with those within the golf course area of influence.

140. These bores should be in place and have a history of monitoring data collected prior to there being approval for water take to irrigate the golf course, in order to provide sufficient certainty that there will be no adverse effects on water quality. I do not consider it appropriate to leave this to a post event report to the Council as proposed in the conditions by Ms King.

Conditions proposed as part of the Application

141. I note that the Application has recently been amended to provide that water will not be abstracted from the Royal Burn North Branch take points when flows drop below 5 L/s at NZTM2000 1274996E 5011547N. This location is shown in Mr Veendrick's Figure 1 in his evidence. The location is immediately above the LOFTS take and is below the confluence of the RBNB and RBSB. At this point, the stream (according to the NIWA gauging data is still in a losing reach, so while 5 L/s might be measured here, that does not mean that volume will be available at the LOFTS take, or further down the river. in my view it makes no sense to measure the flow here.

142. The NIWA gauging data show that on the day of measurement, flows of 9 and 8.8 L/s respectively were observed in the North and South branches. By having the monitoring point on the reach that has this combined flow, the Applicant could potentially take water from the RBNB even when the flow on that Branch is less than 5 L/s (or the Council proposed 10 L/s).

143. The imposition of low flow cut off values serves two purposes. The first is to help maintain the stream wellbeing and the second is to ensure that flow is still available to other downstream users. If the monitoring point is also measuring flow from another source (stream) how is it to be determined that the applicant is maintaining the required level of flow down the RBNB? This can only be achieved if both branches of the Royal Burn are also independently monitored. It would be simpler

and less complicated to simply measure the flow in the RBNB above the point of confluence.

144. The Applicant now also proposes a residual flow condition requiring that water not be abstracted from a point of take where a continuous residual flow extending 50 metres downstream from that point of take cannot be maintained.

145. In my opinion, such a condition is impractical and impossible to monitor, measure or enforce. It also does nothing to maintain or improve the health of the stream.

COMMENTS ON EVIDENCE FOR THE APPLICANT

146. I make the following comments on the evidence filed for the Applicant. I note that I have not necessarily identified every paragraph I disagree with, and it will be apparent from my evidence to date that I do not accept a significant part of the Applicant's position. However, my comments below focus on aspects on which I consider further response or elaboration is required.

Matt Hickey

147. Mr Hickey makes statements concerning the sections of the Royal Burn North Branch as to whether they are perennial (flow year-round) or ephemeral (flow intermittently).[13] However, the section marked in yellow on Mr Hickey's Figure 1 as permanent flow is not permanent since the Application includes photographs and comment concerning the 'dryness' of the Royal Burn North Branch above the off take for Brodies Race. This is seen in the original application document in the paragraph above Figure 3 Intake structure at Lower RBNB take point (97029 and 3037B) which states:

> The other point of take is located further downstream on the RBNB (referred to hereon in as the "Lower RBNB" take). This is where 97029 and 3073B are exercised. At the point of take, there is a small channel that diverts part of the flow down a flume on the true right-hand side of the creek to where the water meter is located. At the time of the site visit early 2018, the creek was completely dry (see pictures below). There is no screening at this point of take.

148. At paragraph 27, Mr Hickey states that the NIWA gauging indicates that the reach between the Lower North Branch Take and Glencoe Road would naturally run dry in most years. The gauging data do not suggest that at all. To make that statement would require many more gaugings over a period of time. That is the type of information that should have been provided by the Applicant to support the Application. In my opinion, the fact that it runs dry is likely to be an effect of the Applicant's two takes from the Royal Burn North Branch, rather than being a 'natural' yearly occurrence. On the day the gauging was done, the NIWA report does not record if the Applicant was using their takes in part or in total. I have done that in my Table 2 on page 10.

149. At paragraph 39 Mr Hickey states "… *the fact that we captured brown trout in the gaining reach indicates that the flows are most likely permanent*". Mr Hickey does not comment on whether the Applicant was operating their system to collect water in full, partially or not at all at the time of the electric fishing survey in January 2019.

[13] Figure 1 in his evidence on page 8 of 15.

150. Other submitters (Bridget Steed and Garceau) state in their submissions that when the Applicant is operating their system and collecting water from the Royal Burn, the stream sometimes dries completely, even below the Crown Range Road Bridge.

151. Mr Hickey does not discuss the high degree of interconnection between the surface water and groundwater in this setting and what effect removing a large volume of surface water from the losing reaches of streams will have on recharge to the groundwater system.

152. At paragraph 43 Mr Hickey comments: -

> (a) In terms of ecological outcomes, the Royal Burn below the lower take is naturally intermittent and this controls the life supporting capacity of the water body at that point. Provision for a visible surface water flow past the point of take will reduce the extent of drying that could occur and allow some water to pass the take that while going to ground likely re-emerges in the gaining reach downstream.
>
> (b) At the point above the LOFTS scheme take, 5l/s will provide adequate habitat for the freshwater ecological values present in that perennial gaining reach.

153. A residual flow that disappears into the ground after or within 50 metres is not doing anything to maintain or enhance the life supporting capacity of the stream reach. Even under the deemed consents this was recognised as an important factor and hence the condition that at the Lower Take Point not more than 50% of the flow could be taken. Mr Hickey does not provide any reason why the 5 L/s provides "*adequate habitat for the freshwater ecological values in that perennial gaining reach"*.

154. In paragraphs 44 and 45 Mr Hickey discusses the reliability of water supply for downstream users, however he refers to the LOFTS scheme. There are, of course, several other downstream users, including Mr Baker and Ms Steed. To be certain of the reliability of a surface water supply you need to have some actual reliable data in the form of gauging to be able to make comment on the reliability and to determine if 5 L/s is an appropriate level to ensure 100% continuous supply for stream health, domestic and stock takes. Mr Hickey does not discuss whether this figure of 5 L/s allows for any possible future users who may want to take water from the Royal Burn.

Antony McQuilkin

155. I have read Mr McQuilkin's evidence and make the following comments.

156. At paragraph 8, Mr McQuilkin refers to there being an automated control structure at New Chums but this was not the case when I visited the area. It would be useful to have evidence of this system to understand when it was installed and its specifications in order for me to comment on it. In my opinion it would make more sense to have an orifice weir installed within the pipe work to restrict the maximum flow able to be taken and a shut off valve down at the New Chum Pond to shut off flow when it is not needed.

157. At paragraph 10, he notes that the upper point of take on the RBNB is subject to manual control only. There is apparently no method of measuring residual flow. In my opinion it would make more sense to have an orifice weir installed within the

pipe work to restrict the maximum flow able to be taken and a shut off valve down at either the RB Pond or further down the pipeline ot wards the golf course.

158. Paragraph 15 again refers to manual control. I assume this is intended to be installed rather than in place at present. The photographs in Ms King's evidence confirm that there is no control structure at the Lower Take point.

159. At paragraph 18 Mr McQuilkin discusses the Brodie Pond. He states:

> Prior to construction of the Brodie Pond, some water would flow unused through the Barley Station property, through downstream neighbouring properties, and then eventually drop back into the Royal Burn. The pond has been designed to capture and store this water so that it can be used more efficiently on the Barley Station property.

160. This raises questions about what happens to the 'maintenance flows' of 864 m^3/day taken during the non-irrigation periods once the Brodie Pond is full. It does not appear that this water is required by the Applicant but is being removed from the available water resource that might be used by downstream users.

Hilary Lennox

161. At paragraph 28 Ms Lennox states "Ms Millers recommended flow regime (of 10 L/s residual flow) will protect the wetland swamp habitat, even though there isn't any."

162. I discuss below my view that the swamp area likely falls within the definition of a 'natural inland wetland' within the meaning of the NPS-FM, so I disagree that there is no wetland swamp habitat to be protected. As discussed below, there is considerable room for debate about whether the *"wet patches in the paddock"* are swamps or not. What is not in debate is that these areas are important in the hydrology of the Crown Terrace. All the hydrological experts appear to be in agreement that the situation is very complex and poorly understood. To be making decisions without the full knowledge of the relationship and interaction between surface water and groundwater would seem to me to be irresponsible.

163. At paragraph 33, Ms Lennox comments that 5 L/s would quickly be lost to ground however I am not aware of any scientific evidence to support that statement. She refers anecdotally to a dry January 2018, but I am not aware of any gauging data from that period that would substantiate her assertion.

164. Ms Lennox in her paragraph 47 states

> During a phone call on 14 May 2021, Ms Miller advised that she had been unable to locate the wetted area in the piggery paddock (aka the 'swamp'[14]) during her site visit the day before. Ms Miller has not, therefore, seen the area in question.

165. If this statement is correct this is of concern since this is the area of significant groundwater upwelling and the area in which the losses of surface water from the Royal Burn North Branch are meant to be re-emerging. If it is dry in May, this means

[14] Note that the term "swamp" is used casually to describe a damp patch in the piggery paddock dominated by willow, exotic pasture, bull rushes and other weeds, but is not a swamp as ecologically defined. This footnote is Ms Lennox not mine.

that the recharge to groundwater had been declining for some considerable time for this 'swamp' to dry up and not be apparent.

166. At paragraph 55, Ms Lennox accepts that the situation with surface water and ground water is complex and not fully understood yet. This is consistent with my evidence above. In my view the appropriate approach in the face of uncertain information is not to 'assume' that downstream users will not be adversely affected, but to acquire all available information upfront, and, if appropriate, put in place very careful monitoring requirements after that.

167. At paragraph 59, Ms Lennox discusses Dr Olsen's evidence and accepts that his evidence is that water quality has not been affected. I do not consider this conclusion can properly be drawn from Dr Olsen's evidence. His evidence on water quality is that water quality in the lower Arrow River indicates a low level of nutrient enrichment. The monitoring point is a significant distance from the point of application, and in my view, does not tell us anything useful about whether application of fertiliser, herbicide, fungicide etc used on the golf course and subject to irrigation would have an adverse effect on water quality closer to source. From a hydrological perspective, I would expect there would be such effects, and certainly further information is required before concluding any such effects would be acceptable.

168. At paragraph 63, Ms Lennox again claims there is no evidence of adverse effects on water quality. As I understand it, the golf course is not yet fully developed. More importantly, there is currently no monitoring of any possible effects being undertaken.

169. At paragraph 80, Ms Lennox states that the Applicant's abstraction in 2016/2017 was 60% of the next 2 years, and therefore *"it seems unlikely"* that the Applicant's use of water was the sole cause of the reduced annual abstraction by Baker et al. That is too simplistic an analysis in my view. Rainfall levels would have an impact on flows and the interplay between surface and groundwater is also relevant. If rainfall levels were low, even a reduced take by the Applicant would have reduced the available flow further downstream, both by removing otherwise-available surface water and by removing water that would otherwise be available to recharge groundwater sources, which would emerge further downstream. I have no difficulty in accepting the submitter's observations that their ability to abstract would be directly affected by upstream sources, including that by the Applicant.

170. For the same reason, I do not entirely agree with her at para 81 that there is no pattern to suggest the annual volume taken by the Applicant influences the Baker take. This will be influenced by rainfall and groundwater availability, as noted above.

171. Ms Lennox in paragraph 83 mentions the failed pipeline limiting the ability to take water however this seems only to apply to the 2019/2020 year. Apart from that year the percentage of flow taken by the Steed consortium range between 18.2 to 34.6% of that taken by BSTGT Limited. This can be explained by variation in crops grown etc.

172. At paragraph 98, Ms Lennox refers to the minimum flow monitoring point as being outside the losing reach. This is not correct. Based upon the NIWA flow gauging data the monitoring location is still within the losing reach, so available flow may continue to decrease after this point and before it is subject to the LOFTS take.

173. Paragraph 105 refers to Mr Veendrick's evidence that there is less than 4 days' storage available – I make the same observation earlier in my evidence. Ms Lennox tries to differentiate between the rate of take and the rate of use. I consider this to be a spurious argument. The months of take are not clearly stated in the Application. An irrigation season is referred to but not defined. At maximum daily take rates, the quantities sought equate to 5.8 months use. Council's evidence refers to about 8 months (allowing for lower takes and use at the beginning and end of the irrigation season. In my opinion, the irrigation season needs to be defined to allow for a proper assessment of potential effects.

174. Ms Lennox's paragraph 107 states that the maximum annual take volume in the past five years is 1,214,683.04 m^3. As she does not give the actual number of days that water was taken on, I can only proceed on the basis that water was taken every day in each year. This maximum annual take is made up from 278,581.8 m^3 from the RBNB Upper take, 377,662.7 m^3 from the RBNB Lower Take and 558,438.5 m^3 from New Chums. These figures translate into average daily takes of 763.3, 1,034.7 and 1,529.9 m^3 respectively. If these takes were being taken year-round, they represent 8.8 L/s, 11.9 L/s and 17.7 L/s. These rates are significantly lower than presented in the Application. For groundwater takes it is common, especially for frost protection requirements where much larger volumes of water are required for short periods of time, for storage ponds to be constructed. Unlike a surface water take groundwater is often restricted due to the transmissivity of the aquifer and also the avaliable drawdown. Perhaps in this case the Applicant could be taking at these lower rates year-round to meet the water use desired.

175. Ms Lennox's comments on the storage available are also not correct. Her own evidence is that during summer the Royal Burn cannot sustain the take rate applied for and that the storage volume is inadequate to store more than 4 days maximal use at once. In any summer there will be more than 4 days where the maximum irrigation take will be required and the storage will be depleted within that time.

176. In Ms Lennox's section entitled Historical Use, she includes Table 3 which gives annual volumes.

177. At the moment the flow from New Chum's is not being accurately recorded and reported to the Council. The Parshall flume that is monitoring the flow in the New Chum Race, unless it has been repositioned since my visit in 2020 is not placed to monitor the total flow being taken by the Applicant. This is confirmed in Mr McQuilkin's evidence in paragraph 8 "*A meter and telemetry measures are in place near the start of the race*". The Applicant should have a flow measuring device installed at the inlet to New Chums Pond and also one on the outlet and one monitoring any flow that bypasses the pond and goes directly into Brodie Race.

178. At paragraph 112, Ms Lennox states that the area of farmland being irrigated is 139.2 ha. The Application referred to 160 ha. I assume the difference is due to the golf course originally being identified as 'farmland' rather than for its actual use, but this remains unclear to me.

179. At paragraph 116, Ms Lennox states she does not agree that 90th percentile limits should be used. In my experience, the 90th percentile is very commonly used by other Councils and has recently been adopted in other recent deemed permit replacement applications for ORC. This is a sensible approach. I am not aware of any Council that allocates water based on 100% of stated demand.

180. At paragraph 128, Ms Lennox refers to it being inappropriate to have two different levels of take, because water might be taken in winter and stored. This is exactly what the Application states that they are going to take "*flood flows*" and store them. However, I do not consider there is much likelihood of winter flood flows being harvested when the available storage is so limited. Storage would be full within 3-4 days of maximum rate of take. No evidence is presented to show that the storage provided is sufficient to do what the Applicant claims. I agree with Ms King in this regard.

181. Paragraph 147 Ms Lennox gives a monthly figure of 210,361 cubic metres. This equates to a maximum daily take of 6,786 m^3. Yet the Applicant seems to be arguing for a higher daily maximum take elsewhere in the Application. At the indicated daily take and annual volume in this paragraph the annual volume sought equates to 5.8 months of irrigation at the maximum daily rate. It is not clear if this is the length of the Applicant's irrigation season or whether it is proposed to be spread over the entire year. In Ms Kings evidence she breaks the year into 'irrigation' and 'non-irrigation' periods, which I support. There is no need for higher levels in the winter months.

182. At paragraphs 148 to 151, Ms Lennox proposes that a visual flow for 50 metres be a condition of granting the consent. I disagree with that as an appropriate condition. The problem I have with it is that is not measurable, timely nor enforceable. Is Ms Lennox suggesting that someone is at the sites night and day to observe and photograph this 'residual flow' and then provide photographic evidence to the Council in a timely fashion?

183. The residual flow needs to be a physical amount that can be physically measured at 15-minute intervals and reported as it happens. This is possible to do, and it can all be telemetered. This will require up to three flow measurement points per take. One measuring the flow above the take point, one measuring the flow taken and one measuring the residual flow.

184. If the instream values are such that the upper take has to supply a residual flow of 10 L/s then this should also be applied to the lower take as well. It does not make sense to treat connected stream reaches in such a different manner. If the Applicant is sure that the system works as they describe then the difference between 5 L/s and 10 L/s should not make any difference to how the Applicant can operate the system.]

COMMENTS ON EVIDENCE FOR THE ORC

Section 42A Report

185. I make the following comments on Ms King's Report. I note that her report draws on advice from other authors, which I comment on separately below. Again, I have not identified every paragraph that I agree or disagree with, but rather have addressed those parts which I consider require further consideration.

Section 4.1 Description of Site and Surrounding Environment

186. Figure 1 presented in the report shows the irrigation infrastructure in place in the northern most portion of farmland to be irrigated. This is shown as a thin line representing a buried pipeline running down from the ponds to Glencoe Road. No details are provided with the Application as to how water is taken from this pipeline and used to irrigate areas of land that are topographically higher in elevation than

the pipeline. The area to the southeast of the New Chums Pond is a long way from the single pipeline.

187. Ms King's report does not discuss the collection of water from points other than the take point specified for the New Chums. By walking along the race from the specified take point to the ponds it is obvious that several tributaries (which do not flow into the New Chum creek) are being collected by the Applicant and would be available to them in addition to the volumes sought to be authorised by the Application. There is also a large volume of water (equivalent to the flow being measured by the flume (so 22 to 24 L/s) which is not being metered at all by the Applicant.

Section 4.2 Description of the Water Body

188. I agree with much of what Ms King states in this section of her report. However, her Figure 7 is not accurate. The location of Water Permit 97402 (Steed and Baker) is not indicated and nor is it listed as a take in the preceding paragraphs. Byron Pretorius report cited by Ms King, does not include this point of take at all. The report shows a take point on the true right bank of the Royal Burn much lower than that operated by Steed and Baker. 97402 is located on the true left bank of the Royal Burn. Ms King states "Here, a pipe in the Royal Burn conveys water to a small sized header drum. A pipe approximately 50mm in diameter takes water from the header drum down gradient toward the state highway." In fact, the pipe size is much larger and reduces to 100 mm pressure pipe.

Section 4.5 Regional Significant Wetlands and Natural Inland Wetlands

189. This section of Ms King's report refers to some discussion about the nature of the 'swamp'. I am not able to comment on this in detail but note there are many ways to define a swamp, fen or bog. I think that all the technical experts can agree however that this area (like many more across the Terrace) is more than a 'wet patch in the paddock' as described by the Applicant. The fact that this 'wet patch in the paddock' is a major source of recharge to the surface water means that his should be afforded some protection to help preserve the water quality of this recharging water.

190. Having regard to the definition of 'Natural Inland Wetland' in the NPS Freshwater Management 2020, I consider the 'swamp' would fall within the definition, because:

    (a) It is a permanently or intermittently wet area, that supports a natural ecosystem of plants that are adapted to wet conditions (definition of 'wetland' in s 2 RMA).

    (b) It was not constructed artificially and is not a geothermal wetland (definition of 'natural wetland' parts (a) and (b), cl 3.21 NPS-FM).

    (c) It does not appear to be 'improved pasture' and there is no evidence it is subject to rain derived water pooling (definition of 'natural wetland' parts (c), cl 3.21 NPS-FM).

    (d) It is not in the coastal marine area (definition of 'natural inland wetland', cl 3.21 NPS-FM).

191. Given the focus of the NPS-FM on protecting natural wetlands, I consider it is useful to recognise the 'swamp' as being important, even if it is not listed as regionally

significant. I would have expected more information and analysis of the impacts of the proposed take on the 'swamp'.

192. If the surface water is removed from the losing section of the RBNB then there will be less water recharging the groundwater. This is agreed by Ms Lough and Mr Veendrick for Council. This will result in a lowering of the water table and therefore a reduction in the surface area of the 'swamp'. This will in turn result in a decreased amount of water available to be gained back to surface water. At present no one has any idea what percentage reduction in area and hence flow that this will be. To date, there has not been any data or evidence addressing this in a satisfactory manner. I would expect that there are already adverse effects on the wetland as a result of the Applicant's current takes, but that these have not been appropriately recognised.

193. The current level of take is significantly less that the maximum takes proposed by the Applicant. This is shown by the average take rates not the maximum peak rates. In Ms Lennox's Table 3 the annual take volumes range between 245,570 and 656,245 cubic metres. These figures represent no more than 50% of the Applicant's annual take volume and there is anecdotal evidence that at times they have dried the entire RB down to 97402 take point.

194. The variation in take volume today is also interesting as this covers the period when the Applicant was enlarging their golf course from nine holes to 15 holes. Yet the least volume of water was taken in the 2019/2020 year. I would have expected the usage to increase over that time. Also, the Applicant is claiming that they are irrigating the pasture already and if they were you would expect the annual usage to be a more consistent or an increasing volume as they install and use more irrigation water.

Section 6.2 Effects Assessment

195. The report has some discussion on residual flows. It focusses on the value of the residual flow but pays little attention to how it will be monitored and measured. The report seems to approach this monitoring and measurement using a single flow meter. This will not be enough. At all points of take there are three things that need to be monitored. First the upstream flow prior to any take. Then the actual take rate and thirdly the residual flow. While the residual flow maybe provided via a pipe of a specified diameter this flow also has to be measured, monitored and reported to Council daily.

196. At the Lower Take Point where it is suggested a 50:50 sharing regime be put in place, it will also require three monitoring points. Again, above the take point, the flow being taken, and flow being left to go down the natural stream channel. Without this information how is the 50:50 share going to be monitored by Council?

197. If the consent is granted with the monitoring conditions imposed as discussed above, then I think that a residual flow of at least 10 L/s from the lower take point would most probably result in less than minor effects on downstream users of the Royal Burn. This condition can be reviewed and changed as required.

Effects on other users

198. The report also then describes effects on other users as less than minor without having all the information or fully understanding how the surface and groundwater

system are inter-related. A residual flow of 10 L/s is clearly a better option than a residual flow of 5 L/s.

199. To date the Applicant's takes have had some effects on the downstream users. Ms Lennox refers to these as 'short-term' effects. I agree that those effects were short term (and avoidable), however the large and continuous consumption of surface water from these catchments may have long term effects that are only now starting to become apparent. No one has any data on the effect these takes will have on the groundwater levels nor on the water quality in the 'swamp' as no one has been looking or collecting information. This does not mean that there is no effect or that the effect is less than minor.

Effects on Water Quality

200. The Applicant has not provided any information on fertilizer application rates, nor any detail on herbicide, fungicide or pesticide use. I do not agree that the effects on water quality can properly be described as minor without that information. I have discussed above my expectation that there is a risk of groundwater being contaminated as a result of irrigation of the golf course.

Effects on Groundwater

201. The Council claims *"no known aquifer on the Crown Terrace"* however there are a number of identified bores on the terrace some of which must have required Council consents to drill. The Council has engaged two external experts to make comment about groundwater and there is plenty of evidence that groundwater is significant hydrologically on the Terrace.

202. The Council acknowledges that the provision of residual flows "would decrease the risk of adverse effects on the nearby bores" but it does not have any information to quantify this. The lack of information on the interaction between surface water and groundwater (and particularly the interflows between them) means that it is very unclear what the 'effects' maybe long term on existing bore uses and other downstream users.

203. Without accurate information (flow rates, lag time, etc) I can only make general comments on what I think the effects may be. One thing that is certain is that removal of large volumes of surface water from all the streams in this area will result in a significant reduction in groundwater recharge and also to the volume then potentially re-entering to surface water from groundwater. If the groundwater table is lowered (and it only needs to be by a metre or so) then the gaining reaches in the Royal Burn may no longer be gaining, or if they remain gaining the volume gained will be greatly decreased.

Section 6.3.1 Historical Water Access

204. There appear to be some typographical errors in this section on page 37 paragraph 2. The heading is Upper Royal Burn, but the text refers to the Lower Burn – I assume the first section refers to the upper and the second to the lower.

205. The method used to 'prove' the historical use (Method 10A.4) is interesting. From my reading this is a method to present a consent holder's annual usage in a report to Council to prove it has not used more than the consented volume. I do not believe it is meant to be a method to prove a consented volume can be taken from a stream, since the take is not related back to any actual stream flow data. The Council report

lists various maximum flows (daily, monthly and annual) for a period of time. It does not identify the date of the daily maximum nor the month of monthly maximum.

206. The daily maximum probably coincides with a winter high flow. The monthly maximum probably coincides with a month outside the irrigation season.

207. The report states the monthly maximum takes at the three take points as New Chum (83,100 m^3/month) or 31 L/s, Upper Royal Burn (35,100 m^3/month) 13.1 L/s and Royal Burn Lower (99,700 m^3/month) or 37.2 L/s.

208. Given these are maximum historical takes for a month it is hard to see how the Application for take rates of 50 L/s can be granted for the Royal Burn Lower or the take rate of 15 L/s at the Royal Burn Upper.

Hilary Lough

209. I agree with Ms Lough in general however I disagree with her comment that the no mitigation is necessary. Evidence has been presented that some downstream users have lost their water supply for periods of time. This is without the Applicant taking more than 50% of their application volume in any one of the past five years (Ms Lennox Table 3). I do not consider that being without drinking water and stock water is a less than minor effect.

210. I agree that the interaction between surface water and groundwater is complex, but this needs to be fully understood before the consent is granted.

Bas Veendrick

211. I largely agree with Mr Veendrick's comments and support his comments about the complex nature of the groundwater and surface water interaction. I do not support his comment that the effects will be less than minor on downstream users.

CONCLUSIONS AND RECOMMENDATIONS

212. Given the lack of hydrological data currently available for the Crown Terrace and the apparent high demand for surface water for irrigation it is important that some real time data be collected as soon as possible. The first thing to do is to install weirs above and below the main off takes as identified for the deemed consents. This information in association with the flow data currently being collected by the ORC will provide good information upon which to determine if the current or proposed new RMA consents are sustainable and comply with the applicable provision in the current Regional Plan.

213. Based on what we do know, the maximum average flow as calculated from the catchment area and the average rainfall indicates that that the deemed consent maximum take rate sought is unlikely to be able to be taken given the size of the catchments and the annual rainfall.

214. Given the low gradients of the mining races, sizes of the intake pipes and the limited evidence of high winter flows it is also considered unlikely that this figure could be taken during the winter months when the streams are flowing at higher levels.

215. In my opinion, installation of groundwater monitoring bores around the golf course and elsewhere should be implemented prior to any consents being granted. This is to ensure the following:

(a) To enable monitoring of water levels and any aquifer contamination.

(b) Establish baseline of water level and water quality data.

(c) Establish any correlation of influences (recharge levels, pumping, irrigation and takes from surface waters).

216. Unless this information is collected now, then the opportunity to accurately define both the groundwater levels and surface water and groundwater quality will be lost.

217. In the absence of this information, it is my opinion that there is insufficient information available to provide any confidence that the implementation of the consents sought will not have potentially significant adverse effects on the environment, specifically on the availability of groundwater, stream and wetland health and on availability of water for downstream users.

David Whyte
8 June 2021

Appendix A

Flow Calculations

CALCULATING AREA OF SEGMENT IN PIPE

Date of Gauging	27/10/2020
Location	Royal Burn Glencoe Road Ist Culvert

Data Input	Units	Value
Radius of Pipe	m	0.263
Depth of Water	m	0.240
Length of Travel	m	13
Time of Travel	s	18
Number of Pipes		1

Ratio Cross-section to Wetted Area

Input Parameter	Units	Value
Manning Coefficient		0.012
Slope	m per m	0.001

CALCULATIONS

Area	m^2	0.0964			Cross-sectional Area	m^2	0.0964
Surface Velocity	$m.s^{-1}$	0.722			Wetted Perimeter	m	0.735
					R		0.13125
Average Velocity for Water Column (0.8)	$m.s^{-1}$	0.578			Velocity	$m.s^{-1}$	0.015

		1 Pipe	2 Pipes	3 Pipes
Flow Volume per pipe	$m^3.s^{-1}$	0.0557	0.111	0.167
	$m^3.h^{-1}$	200.6	401.2	601.8
	$m^3.d^{-1}$	4,814.3	9,628.5	14,442.8

CALCULATING AREA OF SEGMENT IN PIPE

Date of Gauging	27/10/2020
Location	Royal Burn at 30 Glencoe Road 2nd Culvert (RBNB)

Data Input	Units	Value
Radius of Pipe	m	0.410
Depth of Water	m	0.175
Length of Travel	m	13
Time of Travel	s	18
Number of Pipes		1

Ratio Cross-section to Wetted Area

Input Parameter	Units	Value
Manning Coefficient		0.012
Slope	m per m	0.001

CALCULATIONS

Area	m^2	0.0825			Cross-sectional Area	m^2	0.0825
Surface Velocity	$m.s^{-1}$	0.722			Wetted Perimeter	m	0.402
					R		0.205
Average Velocity for Water Column (0.8)	$m.s^{-1}$	0.578			Velocity	$m.s^{-1}$	0.037

		1 Pipe	2 Pipes	3 Pipes
Flow Volume per pipe	$m^3.s^{-1}$	0.0477	0.095	0.143
	$m^3.h^{-1}$	171.6	343.2	514.8
	$m^3.d^{-1}$	4,118.2	8,236.3	12,354.5

CALCULATING AREA OF SEGMENT IN PIPE

Date of Gauging	27/10/2020
Location	Royal Burn at Mining Race down stream from rectangular weir

Data Input	Units	Value
Radius of Pipe	m	0.105
Depth of Water	m	0.060
Length of Travel	m	10
Time of Travel	s	10
Number of Pipes		2

Ratio Cross-section to Wetted Area

Input Parameter	Units	Value
Manning Coefficient		0.012
Slope	m per m	0.001

CALCULATIONS

Area	m^2	0.0082			Cross-sectional Area	m^2	0.0082
Surface Velocity	$m.s^{-1}$	1.000			Wetted Perimeter	m	0.156
					R		0.0525
Average Velocity for Water Column (0.8)	$m.s^{-1}$	0.800			Velocity	$m.s^{-1}$	0.002

		1 Pipe	2 Pipes	3 Pipes
Flow Volume per pipe	$m^3.s^{-1}$	0.0065	0.013	0.020
	$m^3.h^{-1}$	23.5	47.0	70.6
	$m^3.d^{-1}$	564.4	1,128.8	1,693.3

APPENDIX B

Photographs

Photographs are in three sections – the first is the New Chum inlet and race, then the Upper Royal Burn North Branch take and then the Lower Royal Burn North Branch take point.

Photograph 1: View of intake dam at New Chums Creek. Black corrugated pipeline is new and the old, abandoned iron pipeline is supporting the person. As can be seen the downstream face of the "dam" is lined with plastic sheeting to prevent as much water as possible to be directed down the pipeline. New Chums Creek bed is evident on the right-hand side of photograph but has minimal flow down it at the time the photograph was take.

Photograph 2: View of seepage and surface flow from a small tributary that is not being picked up by the New Chums Race since in this area the “race” is buried and consists of pipe. There are several other features like this where the race is acting as a roof gutter and collecting all this seepage/flow.

Photograph 3: View of a small tributary captured by the New Chums race. Race is in foreground with flow moving left to right.

Photograph 4: View looking at discharge from New Chums Creek at point downstream from the Parshall Flume shown in Figure 2. Pipe is 280 mm in diameter.

Photograph 5: View looking at discharge from another stream into New Chums Race situated to the right of the discharge shown in Photograph 10. This flow is not monitored by the Parshall Flume.

Photograph 6: View looking at intake structure of the Upper Take location on the Royal Burn North Branch. Flow is collected via a large diameter pipe, then flows through a large chamber (to the right of the pipe) before flowing down a pipeline and then either into the storage pond, or down to the central collection point below Glencoe Road. Pipe is less than half submerged, and in chamber (see below) it is fully submerged.

Photograph 7: View looking at collection chamber with inlet pipe on the left-hand side and the outlet pipe at the top. Flow is controlled using a movable plate which is inset in the outlet pipe. No flow measurement is done at this point, so any adjustments require at least two people to do accurately. This chamber is only slightly above the water level when the photographs were taken so the flow cannot be much more than this at any time during the year.

Photograph 8: View of downstream exit of culvert under Glencoe Road for the Royal Burn South Branch. Culvert is 545 mm in diameter. As can be seen from the heavy iron staining and the moss on the inside of the culvert, the flow is seldom much greater than this. This is Location 1 on Figure 3.

Photograph 9: View of downstream exit of second culvert under Glencoe Road carrying flow from Royal Burn North Branch. Location 2 on Figure 3. Culvert is 545 mm in diameter. As can be seen by the iron staining and moss growth on the sides of the culvert, the flow is seldom greater that that shown.

Photograph 10: View of Royal Burn North Branch looking upstream towards the Lower take point, situated slightly upstream from this culvert. Maximum flow depth in culvert was 175 mm. On the left-hand side of photograph is the rectangular weir which measures flow in Brodies Race. On the day (27th October 2020) the photograph was taken approximately 50% of the flow at this point was going down Brodies Race.

Photograph 11: View of rectangular weir. Weir crest is 500 mm wide.

Photograph 12: View looking downstream from above the point that the Royal Burn North Branch flow is split at the Lower take point. Note that there are no flow control devices at all at this take point. Also note that this flow represents 50% of the approximated 50% of the already taken flow at the upper Royal Burn take.