BEFORE COMMISSIONERS ON BEHALF OF THE CANTERBURY REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the hearing of submissions on Proposed Plan Change 3 to the Land and Water Regional Plan
BY	**OTAIO WATER USERS GROUP**
	Submitter
TO	**CANTERBURY REGIONAL COUNCIL**
	Local Authority

BRIEF OF EVIDENCE OF GREGORY IAN RYDER

Dated: 25 September 2015

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Introduction

1. My full name is Gregory Ian Ryder.

2. I hold BSc. (First Class Honours) (1984) and PhD. (1989) degrees in Zoology from the University of Otago. For both my honours dissertation and PhD. thesis I studied stream ecology with particular emphasis on sediment and benthic invertebrates.

3. I am a member of the following professional societies:

   (a) New Zealand Freshwater Society;
   (b) New Zealand Water and Wastes Association;
   (c) Royal Society of New Zealand;
   (d) Society for Freshwater Science (North America).

4. I am a Director and Environmental Scientist at Ryder Consulting Limited, a company I established 20 years ago. Prior to this, I held positions at the Otago Regional Council and the University of Otago. I work largely in the field of water quality and aquatic ecology. I have undertaken or been associated with a large number of investigations that have assessed the effects of discharges of nutrients and other contaminants on surface water ecosystems, including land use activities that produce point source and non-point source discharges. A large number of these investigations have assessed ecological responses including effects on algae and plants, benthic invertebrates and fish.

5. My work covers the whole of New Zealand, but primarily in the South Island. Private industries, utility companies, local and regional councils and government departments engage me to provide advice on a wide range of issues affecting surface waters. I have previously provided advice relating to existing and proposed irrigation schemes.

6. I presented evidence at Environment Canterbury's proposed Land and Water Regional Plan hearing and the hearings on Variation 1 (Selwyn/Te Waihora) and Variation 2 (Hinds/Hekeao Plains) to that plan.

7. Although this is a Council hearing, I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note 2014. I have complied with the Code of Conduct in preparing this evidence and I agree to comply with it while giving oral evidence before the hearing committee. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

Scope of evidence

8. Otaio Water Users Group (**OWUG**) has asked me to comment on their submission to Variation 3 in respect of the following matters:

   (a) the ecology and water quality status of the Otaio catchment;
   (b) Table 15(a) and the achievability of freshwater outcomes;
   (c) the appropriateness of the limits/targets in Table 15(c) for surface water and the linkage between these and water quality outcomes;
   (d) the ecological consequences of proposed minimum flows and allocation limits for the Otaio catchment.

9. In preparing my evidence I have read proposed Variation 3 to the proposed Land and Water Regional Plan (**pL&WRP**), the OWUG submission, and the submissions of a number of other parties. I have also reviewed technical information relating to Variation 3, including Environment Canterbury assessments of surface water quality and aquatic ecology within the South Canterbury Coast Sub-regional area, contained within appendices attached to the Norton & Robson (2015[1]) report. I have also viewed a number of supplementary documents referred to by Environment Canterbury in the SCCS limit setting process, including:

   (a) Clarke, G. & Gray, D. 2014. Environment Canterbury Memorandum. The Otaio River: An overview of ecological values, and potential impacts of a range of minimum flow and allocation regimes.

[1] Norton, N. & Robson, M. 2015. South Canterbury Coastal Streams (SCCS) limit setting process. Predicting consequences of future scenarios: Overview Report.

(b) Pattle Delmore Partners Ltd. 2015. Effects on Ecological Values of the Otaio River from changes to the B-block allocation. Prepared for Blue Cliffs Station.

(c) Ministry for the Environment. 2009. New Zealand Guidelines for Cyanobacteria in Recreational Waters: Interim guidelines.

(d) Ministry for the Environment. 2008. Proposed National Environmental Standard on Ecological Flows and Water Levels.

(e) Aitchison-Earl, P. 2014. Revised Memorandum on 'Groundwater Data to Assist the Meeting of 5 December 2014 with the Otaio Water Users Group'. Environment Canterbury Memorandum from Philippa Aitchison-Earl to Meredith Macdonald, Jo Stapleton, Ned Norton. Dated 11th December 2014.

10. I have also read relevant parts of the Officers section 42A report prepared by Fenemor *et al*. (2015).

The ecological and water quality status of the Otaio catchment

11. The Otaio catchment falls within the Northern Streams Area of the SCCS Area. For Northern streams, the Lower Waitaki South Coastal Canterbury Zone Committee's solutions package aims to improve flows and habitat over time while maintaining a protection level of 90% nitrate toxicity, and providing for development of good management practice for land use activities within the catchment. It is my understanding that this philosophy has been incorporated into Variation 3.

12. Nutrient and periphyton monitoring of the Otaio River in 2008 and 2009/10 was reported by Lessard and Norton (2011) and I have reproduced their data in Appendix One along with more recent water quality monitoring data collected by Environment Canterbury on behalf of OWUG (Appendix Two). The data from Lessard and Nortons' report confirm that nitrate concentrations in the Otaio River are well below the concentration range for nitrate toxicity (90% protection). This is not likely to be threatened under the proposed plan provisions.

13. The 42A officer's report notes at paragraph 10.3 that the Northern Streams Area has been identified of being at risk of not meeting water

quality outcomes due in particular to periodic breaching of periphyton and cyanobacteria outcomes (as defined in Table 15(a) of Variation 3). It is my understanding from reading the Zone Committee's solution package that there would be an additional need for riparian shading to achieve this outcome. However, I do not see where this is provided for in the proposed plan change and assume this may be proposed to be addressed via some non-regulatory method. However, this approach does create an additional level of uncertainty in terms of meeting outcomes.

14. Having viewed the water quality nutrient concentration data for the Otaio catchment (attached in appendices One and Two of my evidence), it is my opinion that there is potential for nuisance periphyton and plant growths to occur. That is, nitrate and dissolved phosphorus concentrations are sufficiently elevated to promote nuisance growths, and periphyton cover has been recorded as exceeding guidelines on occasions at some sites (Appendix One), although the pattern appears quite variable down the river. Recent dissolved reactive phosphorus (DRP) levels in Esk Valley Stream, a spring-fed stream on the plains, are about 3-4 times higher than at other Otaio catchment surface water sites recently monitored on behalf of OWUG.

15. Analysis of water quality monitoring data by Norton *et al*. (2007[2]) suggests that algae (periphyton) growth in the Otaio River is phosphorus-limited and, as such, any increase in the phosphorus concentration of the water could result in further nuisance growths. I address this issue further when I discuss Table 15(c) of Variation 3 (Water Quality Limits for Rivers).

16. Lees & Wilks 2015[3] report that benthic macroinvertebrate community health in the Otaio River is generally consistent with intermittent river systems. The upper sections have greater macroinvertebrate community diversity, especially of sensitive taxa, than lower sections of the Otaio River. Invertebrate health indices are highly variable with scores at some sites on the plains indicative of 'good' to 'excellent'

[2] Norton, N., Floeder, S., and Drake, D. 2007. *Hunter Downs Irrigation Scheme: Assessment of potential effects of increased nutrients on aquatic ecology values in rivers and Wainono Lagoon.* Prepared for Meridian Energy Limited. NIWA Client Report No: CHC2007-057.

[3] Lees, P. and Wilks, T. 2015. *Effect on Ecological Values of the Otaio River from changes to the B-Block allocation.* Prepared for Blue Cliffs Station.

and others ‘poor’ to ‘fair’.

17. Gray & Clarke (2015[4]) report that 11 species of fish have been recorded in the Otaio River and its tributaries, including nine native species of which five are ranked as threatened under DoC’s threat classification system. Freshwater crayfish, or koura, have also been recorded at several sites along the lower Otaio River in 2006 and 2007.

18. In general, the ecology and water quality of the Otaio River catchment is what I would expect for an East Coast intermittent flowing river set within an agricultural catchment. Nutrient levels are elevated on the plain, but not hugely so compared to some catchments in the zone situated further south. The invertebrate and fish assemblages are typical and similar to that found elsewhere in similar sized East Coast rivers of the South Island. The number of native fish species is somewhat higher than I would have expected given the regular annual pattern of surface flow loss through the mid and lower sections of the river. It probably indicates that current mouth opening patterns are sufficient to support species with sea-going life stages (see paragraphs 54 and 61) and also that the fish community has a relatively high level of resilience to low flow events.

Table 13(a): Freshwater Outcomes for South Canterbury Coast Streams Area

19. In my Appendix Three, I have attached Table 15(a), as drafted in Variation 3 and as amended in the 42A officer’s report at paragraph 9.33 (note the section 42A report recommends no amendments to the table).

20. I have previously reviewed Table 15(a) of Variation 3 and raised a number of issues, some of which formed part of OWUG’s written submission to Environment Canterbury on the plan change. The 42A officer’s report contains responses to some, but not all, of these issues.

21. Firstly, I am in general agreement with the basis for Table 15(a). It does not differ greatly from Table 1a of the pL&WRP (Freshwater

[4] The Otaio River: *An overview of ecological values, and potential impacts of a range of minimum flow and allocation regimes*. Prepared by Environment Canterbury.

Outcomes for Canterbury Rivers), which I have previously presented evidence on largely in support of its general approach. Notwithstanding my general endorsement of Table 15(a), I have some concerns about its current wording, as outlined below, and recommend some changes.

22. For 'Periphyton Indicators' in Table 15(a), under the sub-heading row relating to cyanobacteria cover, I raised a concern that 'Cyanobacteria mat cover' should be accompanied by a minimum level of mat thickness or height to bring the outcome in line with wording used in the Ministry for the Environment's New Zealand periphyton guidelines (Biggs 2000[5]), and as has already been used for the filamentous algae outcome in Table 15(a). As it is currently worded, there is no clarification in Table 15(a) of what thickness of cyanobacteria mat the outcome refers to and, consequently, the presence of between 20 and 50% cover (depending on the river management unit) of even a very thin cyanobacteria mat (e.g. < 1mm) could be taken to mean the outcome has not been meet. I find this approach to be overly restrictive.

23. The 42A officer's report commented on this point (at paragraph 9.27), noting that the ">3mm thick" restriction sought by OWUG (following my recommendation) comes from the MfE periphyton guidelines that relate to all periphyton "mats", not just cyanobacteria, and so is a guideline for aesthetic purposes and not toxicity. While I accept this clarification, I maintain that it is appropriate that some minimum height criteria should accompany the outcome, as cyanobacteria are present in most streams and rivers, even those with good water quality. In relation to benthic cyanobacteria monitoring procedures, I note that the joint MfE and MoH guidelines document "New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters" (Wood *et al*. 2009[6]) states that cover should only be recorded if mats are greater than 1 mm thick (Appendix Five). I recommend, therefore, that the sub-heading should read "Cyanobacteria mat >1mm (%)", to be consistent with these guidelines and standard monitoring procedures.

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[5] Biggs, B.J.F. 2000. *New Zealand periphyton guideline: detecting, monitoring and managing enrichment of streams.* Ministry for the Environment, Wellington, New Zealand.

[6] Ministry for the Environment and Ministry of Health. 2009. *New Zealand Guidelines for Managing Cyanobacteria in Recreational Fresh Waters – Interim guidelines*. Prepared for the Ministry for the Environment and the Ministry of Health by S.A. Wood, D.P. Hamilton, W.J. Paul, K.A. Safi, W.M. Williamson. Wellington: Ministry for the Environment. 89 p.

24. I understand that the 42A officer's report has accepted my concern surrounding the lack of clarification regarding the percentage of samples that are required to meet the cyanobacteria outcome (paragraph 2.29). The officer's report noted that this was an omission during the drafting of Variation 3, and the percentage of samples should be the same as those used for the other periphyton attributes in Table 15(a). However, this amendment has not been carried forward in the officer's report under paragraph 9.33 (Table 15(a) included footnotes that specify the percentage of samples that are to meet the outcome for the periphyton indicators). I have included this recommended change in Appendix Four of my evidence which presents Table 15(a) with my recommended changes (marked up as track changes).

25. I expressed some reservation to OWUG about the inclusion of the cultural indicator for freshwater mahinga kai in Table 15(a). My reservation has nothing to do with having a cultural indicator *per se*, but rather the lack of a quantitative outcome, as required for all the other indicators in the outcomes table. As Table 15(a) stands, it is not clear how mahinga kai will be monitored to determine if the outcome is being achieved. This situation could create a level of uncertainty for stakeholders as to what criteria are necessary for this particular outcome to be met. I note that part of the proposed cultural indicator in Table 15(a) is already included in Policy 4.3 of the pL&WRP, which requires that "… *fish are not rendered unsuitable for human consumption by contaminants* …".

26. There are also some apparent typographical errors in Table 15(a) as drafted and retained in the 42A officer's report.

27. Firstly, in the heading row in relation to QMCI (under 'Ecological Indicators'), the sub-heading wording has been cut off ("[min" is all that appears in the PDF document). The sub-heading should read "min. 80% of samples in 5 year period". This wording is consistent with that found in Variation 1 and that proposed by Environment Canterbury in Variation 2 of the pL&WRP.

28. Secondly, in the next row adjacent to QMCI ('Dissolved oxygen'), the sub-heading wording is incorrect (written as "Dissolved oxygenin saturation] (%))". It should be written as "Dissolved oxygen [min

saturation] (%)".

29. Thirdly, in the sub-heading 'Chlorophyll a [max biomass] (mg/m^3)', the units are incorrect and apply to volumetric chlorophyll *a* sampling typically used in lake monitoring. The correct units should be mg/m^2 to reflect that the sampling relates to the biomass covering the surface area of the river bed.

30. These three corrections have been included in my amended Table 15(a) in Appendix Four.

31. OWUG asked me to comment on the achievability of freshwater outcomes listed within Table 15(a). I have focused primarily on the Otaio catchment although, where indicated, I consider my comments apply to a number of other catchments within the SCCS Area.

32. Currently, it would be difficult for the Otaio catchment to achieve all of the outcomes sought under Table 15(a). Past monitoring indicates that ecological health indicators would probably not be achieved at some sites (e.g., QMCI scores, Stark 2011[7]). An analysis of Environment Canterbury monitoring data for the Otaio River at the Gorge (2012-2013) also suggests that the cyanobacteria cover currently may not be achieved (Wood *et al*. 2013[8]).

33. The outcome for temperature is specified as a maximum and, in my experience, a maximum temperature of 20°C in hill-fed rivers is relatively low and unlikely to be met now or in the future for these types of rivers. I note that Lessard & Norton (2011[9]) recorded a maximum temperature of 21.9°C in the Otaio River at the Gorge site in February 2010.

34. In general, in my opinion, being able to achieve the Table 15(a) freshwater outcomes in the Otaio catchment in the future will be challenging and probably unlikely for some indicators. As I have noted in paragraph 14, nitrate and dissolved phosphorus concentrations are

[7] Stark, J.D. 2011. *Compilation of freshwater macroinvertebrate data from streams and rivers in the Hunter Downs Irrigation Scheme area.* Prepared for Meridian Energy Limited. Stark Environmental Report No.2011-10.

[8] Wood S.A., Mallet, R.J., and Hamilton, D.P., 2013. *Cyanobacteria band testing: Examining applicability for the National (NZ) Objectives Framework.* Environmental Research Institute Report No. 12. The University of Waikato, Hamilton.

[9] Lessard, J. and Norton, N. 2011. *Surveys of summer water quality, flow permanence and periphyton cover in rivers of the proposed Hunter Downs Irrigation Scheme area.* Prepared for Meridian Energy Limited. NIWA Client Report No: CHC2011-031.

sufficiently elevated to promote nuisance growths. DRP concentrations at most sites recently monitored are already at or above the DRP 'limits' in Table 15(c) of Variation 3. Also, as I discuss starting at paragraph 50, this conclusion in part relates to the intermittent flow character of the Otaio River, however, I do not consider that changes to the minimum flow will greatly alter this outcome.

Appropriateness of the Table 15(c) water quality limits for rivers

35. Table 15(c) (Water Quality Limits for Rivers) contains nutrient concentration 'limits' for a number of specified streams within the SCCS Area. The list is divided up into the three river management units that are found within the zone (Hill-fed upland, Hill-fed lower and Spring-fed plains). I have three concerns regarding this table.

36. Firstly, the basis for the nutrient concentration data in the table is, for some streams in the zone, based on relatively small and sometimes dated data sets. In the case of the Otaio catchment, monthly monitoring was undertaken for several years for nutrients, macrophyte and periphyton, but not always at monthly intervals, and the most recent data collected was April 2011 (Kelly 2015[10]). Given the potential ramifications for farmers in the catchment for not meeting these water quality limits, I consider the underlying data should have been more robust and up to date. This situation is highlighted by the fact that more recent (2013-14) Environment Canterbury monitoring of these surface water sites within the Otaio catchment undertaken on behalf of OWUG has indicated that DRP concentrations at most sites are likely to be at or above the water quality limits specified in Table 15(c).

37. There are significant elements of uncertainty surrounding the modelling of water quantity, water quality and ecological changes (or outcomes in Table 15(a)) associated with potential changes in land use and water availability under the proposed plan provisions. Many of these are acknowledged in the technical reports associated with the Variation 3 process. Converting modelling outputs of future changes in

[10] Kelly, D.W. 2015. *South Canterbury Coastal Streams (SCCS) limit setting process: Predicting consequences of future scenarios: surface water quality and associated values.* Environment Canterbury Report No. R15/36.

water quality concentrations and ecological indices into tables with numerical limits, in my opinion, implies a level of accuracy in outcome change far greater than should be afforded.

38. The usefulness of the ammonia concentration limits in table 15(c) is also questionable in my opinion. For some of the sites in the Otaio catchment, the annual median concentration limits are very low (e.g., 0.005 mg/L for the Otaio Gorge site and 0.003 mg/L for the Otaio at Drinnans Bridge), yet laboratory test results for the recent 2013-14 monitoring have an ammonia detection limit of 0.01 mg/L. So it is not possible to determine whether these sites are below their respective ammonia concentration limits in Table 15(c).

39. An ideal situation might have been for surface waters to have been monitored at a frequency consistent with that specified in Appendix 2 of the National Policy Statement for Freshwater Management (NPS-FM). For example, for periphyton biomass (chlorophyll *a*), the NPS-FM indicates that three years of monitoring at monthly intervals is recommended to provide a robust assessment of a stream's trophic state. In many situations in the SCCS Area, this level of sampling has not been undertaken.

40. Secondly, it remains unclear to me how Table 15(c) relates to the polices and objectives of the Variation 3 plan change. I can find no wording in the Variation 3 document that ties this table back to any specific policies and objectives. Indeed, a search of the plan change document provides only one reference to Table 15(c), and that is the table itself. In my opinion, this situation creates a significant level of uncertainty as to the purpose of this table and how it may be interpreted In the future, particularly given the nutrient concentrations within it are labelled as water quality 'limits'.

41. Thirdly, I consider it important to understand how the nutrient concentration 'limits' specified for various streams in Table 15(c) relate to the freshwater outcomes of Table 15(a) and, importantly, are they compatible.

42. I note the nutrient concentration limits in Table 15(c) are expressed as median values for annual limits, but in one of the key underlying technical reports on surface water quality (Kelly 2015) the forecasting

of nutrients concentrations under the various modelled land use scenarios uses mean concentrations. Thus, it is not possible to make comparisons and understand clearly the linkage between the analysis of effects and the nutrient water quality limits for streams that have been adopted in Variation 3.

43. I have found it difficult to determine if the nutrient concentrations limits in Table 15(c) are consistent with the periphyton indicators, particularly the chlorophyll *a* biomass indicator, in Table 15(a). Although I understand that the DRP and DIN concentration limits for streams and rivers in Table 15(c) are not there to protect these water bodies from nuisance plant and algae growths, I question their usefulness given Table 15(a) has already provided ecological indicators, a number of which will be strongly influenced by nutrient concentrations.

44. The 42A officer's report (paragraphs 10.351 – 10.354) discusses the rationale behind Table 15(c) in response to the OWUG submission, however I remain confused as to its purpose. Paragraph 10.351 of the 42A report states "*It is understood that the DIN concentrations contained in Table 15(c) are set to achieve "at least" 90% toxicity protection under the PC 3 solutions package. I understand that including a lower DIN concentration may not contribute to the achievement of the freshwater outcomes.*".

45. The officer's report further states (paragraph 10.353) that, rather than adopt a blanket nitrate toxicity threshold, a conscious decision was made to include the predicted output nitrogen concentrations for each individual river from modelling the Zone Committee's Solutions Package to avoid allowing rivers with low predicted nitrate concentrations to deteriorate up to the 90% toxicity threshold (about 5.6 mg/L). I note that the modelling referred to above is related primarily to predictions for groundwater nitrate-nitrite-nitrogen concentrations, with the assumption that the per cent increase expected in surface water would be the same as the per cent increase predicted for groundwater, and that it would not differ between hill-fed and spring-fed sites.

46. I understand the need to protect against the potential for ammonia and nitrate toxicity, however many of the DIN limits in Table 15(c) are well

within nitrate toxicity guidelines for New Zealand rivers and I consider it would have been more appropriate to follow the NPS-FM approach for setting appropriate ammonia and nitrate toxicity attributes states for specific rivers or river management units within the SCCS Area. The numeric attribute states used for ammonia and nitrate toxicity in the NPS-FM at least have some technical rationale behind them.

47. While the officer's report has commented on the rationale behind the DIN limits in Table 15(c), it has not commented on the DRP limits. These are not related to toxicity protection and so the arguments presented in paragraphs 10.351 – 10.354 of the officer's report are not valid in my opinion. For some river sites listed under Table 15(c), the ammonia and DRP limits appear to be exceeded already. This appears to be the case for the Otaio River and some of its tributaries (Appendix Two), although further monitoring is required to produce robust annual median data. I see no reasonable ecological justification for including the ammonia and DRP concentration limits in Table 15(c).

48. Further, the stated ecological outcomes for periphyton in river management units under Table 15(a) do not appear to be compatible with some of the nutrient concentration limits in Table 15(c). As such, I consider it may be prudent to remove Table 15(c) and replace it with a table specifically for nitrate and ammonia toxicity (although ammonia is highly unlikely to be an issue with respect to toxicity in SCCS streams), based on the criteria used in the NPS-FM. I made a similar recommendation in evidence presented at the pL&WRP Variation 2 hearing. However, at that hearing, I suggested nitrate toxicity outcomes would sit comfortably under the 'Ecological health indicators' sub-heading of Table 13(a) (equivalent to Table 15(a)).

49. I do not see a shift to adopting the NPS-FM nitrate toxicity limits as allowing nitrate concentrations to deteriorate upwards, as suggested in the 42A officer's report. Aside from protection against toxicity effects, nitrate in abundance can stimulate excessive algae and plant growth. But protection against these outcomes is already provided for in Table 15(a) via the numerical indicators for macrophyte and periphyton. These indicators, if met, should signal that nitrate and phosphorus concentrations are within acceptable ranges for the

various streams and rivers within the zone.

Effects of low flows and abstractions on instream ecology

50. The Otaio River drains foothills of the Hunter Hills. Surface flow in the upper catchment is permanent, but loses to gravels as the river crosses the Canterbury Plains result in frequent dewatering and dry sections particularly during summer. Mr de Joux's evidence on behalf of OWUG provides more detail on the river's hydrology, flow variability, flow connectivity and relationships between ground and surface waters.

51. The river is described as an intermittent river system due to its frequent loss of surface flow in its mid and lower reaches. Mr de Joux notes (paragraph 11 of his evidence in chief) that the river dries up under natural conditions and, at or below the median flow of 306 L/sec at the Gorge recorder site (as it exists the hill country), the downstream river becomes disconnected for considerable distances, which increase as the flow at the Gorge continues to decrease. I understand that this loss of surface flow occurs regardless of whether irrigation abstractions are occurring.

52. The dynamics of the relationship between surface flow and groundwater levels have been investigated by Environment Canterbury (Aitchison-Earl 2014[11]; Aitchison-Earl 2015[12]). My understanding from these investigations is that while river water is lost to shallow groundwater, much of this resurfaces as flow in springs arising on the south bank, and as re-emergent flow in the Otaio River downstream of McAlwees crossing (situated approximately 18-19km upstream of the mouth), as shown in Figure 2 of Mr de Joux's evidence.

53. Loss of surface flow has obvious potential ecological ramifications for aquatic fauna and flora and these have been described for the Otaio River in several reviews (Gray & Clarke 2015; Lees & Wilks 2015;

[11] Aitchison-Earl, P. 2014. Revised Memorandum on 'Groundwater Data to Assist the Meeting of 5 December 2014 with the Otaio Water Users Group'. Environment Canterbury Memorandum from Philippa Aitchison-Earl to Meredith Macdonald, Jo Stapleton, Ned Norton. Dated 11th December 2014.

[12] Aitchison-Earl, P. 2015. South Canterbury Coastal Streams (SCCS) limit setting process. Predicting consequences of future scenarios: groundwater quantity. Report No. R15/40.

Lessard & Norton 2011). The key potential effects relate to; i) reduction in habitat availability for resident species, ii) changes in habitat that favour less desirable stream communities (e.g., development of nuisance periphyton cover), iii) loss of connectivity of surface flow to allow passage (e.g., for migratory species), and iv) changes in water quality that favour species more tolerant of poor water quality (e.g., those adapted to higher water temperatures, lower dissolved oxygen levels and large daily swings in pH).

54. Despite the above potential effects, 11 species of fish, including nine native species, have been recorded in the Otaio river and its tributaries. Six of these species require access to/from the sea to complete their life cycle. The presence of these species is evidence that the mouth is open often enough to allow inward migration.

55. Mr de Joux notes in his evidence (paragraph 12) that a flow of 8000 L/sec will open the mouth and, depending on beach barrier conditions, a flow of 2000 L/s could maintain an open mouth. It has been estimated that the mouth can be expected to open on average 3 times per year, and remain open for between 3 and 5 days. I note that these mouth openings have occurred under the current situation of no minimum flow for the river. Mr de Joux notes that abstractions for irrigation purposes do not affect the frequency or duration of river mouth opening, nor will the application of the minimum flow.

56. Currently there is no minimum flow for the Otaio River and under Variation 3 it is proposed to adopt a minimum flow of 90 L/sec measured at the Gorge recorder site. It is my understanding from the hydrological evidence that this increase in the minimum flow is unlikely to provide surface flow connectivity in the mid and lower reaches of the river. This is because significantly higher flows at or around the median flow (306 L/sec) are required for connectivity to be achieved.

57. I can find no information that robustly quantifies the ecological benefits of the proposed 90 L/sec minimum flow for the Otaio River or the hapua. A ‘default’ minimum flow of 90% of the 7DMALF, is recommended in the proposed National Environmental Standard for ecological flows and water levels for rivers and streams with mean flows less than or equal to 5 m^3/s. The proposed 90 L/sec minimum flow in Variation 3 is slightly less than this standard. However, I

question the ecological benefits of this minimum flow condition for the Otaio River given its intermittent flow in the mid reaches and that the river disconnects when flows at the gorge are less than about 300 L/sec. There is a risk that one ecological outcome from increasing the minimum may be to create more slow flowing or ponding habitat over the summer months that will simply heat up and harbour nuisance algal growths.

58. It may be that the proposed minimum flow will provide additional habitat and/or protection for the invertebrate fauna that inhabits the interstitial spaces beneath and around the river channel (often referred to as the hyporheic community). This community can be important as a population source for recolonising the river invertebrate community. However, it would appear that these may be affected well before the flow of 90 L/sec is reached.

59. Gray & Clarke (2015) state that while the precise relationship between flow at the Otaio Gorge, groundwater levels and flow in the lower Otaio River is poorly understood, abstraction of shallow groundwater in the catchment will continue to effect flow, habitat and water quality in the lower reaches and hapua (lagoon). Thus, a higher minimum flow minimizes these effects. While it seems that the greatest benefit of having a minimum flow and reducing the A-block allocation over time will be to increasing river flow in the lower reaches and the depth of water in the hapua, the relationships between the magnitude of the minimum flow and the change in habitat size and quality in the lower river and hapua are unknown for this river system. However, it does seem certain that the minimum flow has no bearing on the state of the hapua in terms of it being closed or open to the sea. Mouth openings are influenced by much higher flows.

60. Abstraction at higher flows has potential to alter flow events that influence channel shape, bed transport and river mouth opening. In addition to these physical effects, higher flows help maintain the ecological health of the river through the removal of excessive algae and plant growths. The effects of B-block allocation water have been assessed by various parties (de Joux 2015[13]; Lees & Wilks 2015; and

[13] de Joux, R. 2015. Modelling the impact of "A" and "B" abstractions on the residual flow of the Otaio River.
Prepared for the Otaio Water Users Group.

Environment Canterbury). Mr de Joux has summarized some of these findings in his evidence in chief (paragraphs 37 – 43).

61. It seems there is a general consensus that a B-block allocation of up to 1,000 L/sec, accompanied by a minimum flow of 780 L/sec at the Gorge recorder, will have no more than minor effects on higher flows that influence the river system's ecological integrity. That is, the frequency and duration of annual mouth openings would not be affected, fish migration along the river channel would not be affected, and the frequency and magnitude of flow events sufficient to remove periphyton build-up is largely unaffected.

Conclusion

62. Predicted water quality and ecological outcomes for the Otaio catchment under the provisions of Variation 3 are, in my opinion, uncertain. While the move to a set a minimum flow for the river and significantly reduce the A-block allocation over time should result in more water in the lower reaches of the river and in the hapua, significant ecological benefits are not guaranteed.

63. Achieving the freshwater outcomes under Table 15(a) will, I expect, be highly site-specific and variable throughout the river system. The intermittent nature of the river in its mid reaches is likely to remain so, making it highly likely that some outcomes will not be achieved.

64. In my opinion, Table 15(c) should be replaced with a table specifically for nitrate and ammonia toxicity based on recognised New Zealand guidelines. I see no reasonable ecological justification for including the existing ammonia and DRP concentration limits in Table 15(c).

65. The proposed B-block allocation appears to be set at a sufficiently high minimum and of a magnitude such that effects on flow events that have ecological significance (e.g., flows that scour nuisance periphyton growths, channel maintenance flows, mouth opening flows, etc) will not be adversely affected.

Gregory Ian Ryder

25th September 2015

APPENDIX ONE: Mean nutrient concentrations and periphyton (% cover) stream sites from surveys conducted in 2008 and 2009/10. An * denotes missing data. (adapted from Lessard and Norton 2011).

Otaio River site (summer 2008)	DRP mg/m^3	DIN mg/m^3	NH_4-N mg/m^3	NO_3-N mg/m^3	Periphyton long % cover
SH1 Bridge	0.006	0.521	0.009	0.512	0
Grays Crossing Ford	0.005	0.110	0.005	0.105	10
Church Hill Rd. (trib.)	0.145	0.119	0.089	0.030	30
Esk Bank Rd. (trib.)	0.005	0.277	0.014	0.263	30
Drinnans Bridge	0.004	0.245	0.010	0.235	60
Esk Valley Rd Cnr Hendrys Rd.	0.042	0.035	0.022	0.013	90
Backline Rd. – Cnr Esk Valley Rd.	0.016	0.046	0.016	0.030	*
Blue Cliffs School Rd.	0.004	0.090	0.007	0.083	0
Otaio Gorge	0.010	0.058	0.008	0.050	10

Otaio River site (summer 09/10)	DRP mg/m^3	DIN mg/m^3	NH_4-N mg/m^3	NO_3-N mg/m^3	Periphyton long % cover
SH1 Bridge	0.006	0.199	0.002	0.197	14
Grays Crossing Ford	0.004	0.117	0.003	0.114	99
Church Hill Rd. (trib.)	0.015	0.066	0.066	0.000	98
Esk Bank Rd. (trib.)	0.006	0.175	0.011	0.164	0
Drinnans Bridge	0.005	0.136	0.002	0.134	0
Esk Valley Rd Cnr Hendrys Rd.	0.011	0.020	0.015	0.006	74
Backline Rd. – Cnr Esk Valley Rd.	0.302	0.080	0.030	0.050	*
Blue Cliffs School Rd.	0.005	0.067	0.004	0.063	0
Otaio Gorge	0.005	0.036	0.005	0.031	0

APPENDIX TWO: Recent (2013-14) nutrient and *E. coli* concentration data for Otaio catchment sites. Sampling undertaken on behalf of the Otaio Water Users Group.

Site	Nutrient		March 13/03/2014	October 17/10/2014	December 23/12/2014
Otaio @ Gorge	DIN	mg/L	0.021	0.04	0.055
	DRP	mg/L	0.006	0.008	0.004
	E coli	MPN/100 mL	36	12	64
Otaio @ Blue Cliffs	DIN	mg/L	0.022	0.13	Dry
	DRP	mg/L	0.005	0.008	Dry
	E coli	MPN/100 mL	23	45	Dry
Esk Valley Stream (spring fed)	DIN	mg/L	not sampled	0.04	Dry
	DRP	mg/L	not sampled	0.022	Dry
	E coli	MPN/100 mL	not sampled	921	Dry
Esk Bank Stream Ford	DIN	mg/L	0.22	0.24	Dry
	DRP	mg/L	0.004	0.008	Dry
	E coli	MPN/100 mL	81	25	Dry
Otaio @ SH 1	DIN	mg/L	0.24	0.54	Dry
	DRP	mg/L	0.009	0.012	Dry
	E coli	MPN/100 mL	11	31	Dry
Spring @ Blue Cliff Rd Culvert	DIN	mg/L	0.131	0.51	Dry
	DRP	mg/L	0.006	0.004	Dry
	E coli	MPN/100 mL	1733	579	Dry

APPENDIX THREE: Table 15(a) as drafted in Variation 3 and in the 42A officer's report.

Table 15(a) Freshwater Outcomes for South Coastal Canterbury Area Rivers to be achieved by 2030.

Management Unit	River	Ecological health indicators			Macrophyte indicators		Periphyton indicators			Siltation indicator	Microbial indicator		Cultural Indicator
		QMCI [min	Dissolved oxygenin saturation] (%)	Temperature [max] (^{o}c)	Emergent Macrophytes [max cover of bed] (%)	Total Macrophytes [max cover of bed] (%)	Chlorophyll *a* [max biomass] (mg/m^{3})	Filamentous algae >20mm [max cover of bed] (%)	Cyanobacteria mat cover (%)	Fine sediment <2 mm diameter [max cover of bed] (%)	Suitability for contact recreation [SFRG]	*E.coli* [number of *E.coli* per 100 millilitres] [annual median]	
Hill-fed – upland	Hook R. Waimate Ck. Horseshoe Bend Ck. Kohika R. Makikihi R Otaio R. Waihao R. Buchanans Ck. Hook Dn. Merrys Stm. Sir Charles Ck. Waituna Stm.	6	90	20	No value set	No value set	50[a]	10[a]	20	15	Good	<260[d]	Freshwater mahinga kai species are sufficiently abundant for customary gathering, water quality is suitable for their safe harvesting, and they are safe to eat.
Hill-fed - lower	Hook R. Waimate Ck. Horseshoe Bend Ck. Kohika R. Makikihi R Otaio R. Waihao R. Buchanans Ck. Hook Dn. Merrys Stm. Sir Charles Ck. Waituna Stm.	6	90	20	No value set	No value set	200[bc]	30[bc]	50	15	Good to Fair	<260[d]	
Spring-fed plains	Hook R. Waimate Ck. Horseshoe Bend Ck. Kohika R. Makikihi R Otaio R. Waihao R. Buchanans Ck. Hook Dn. Merrys Stm. Sir Charles Ck. Waituna Stm.	5	70	20	30	50	No value set	30[bc]	50	20	No value set	<260[d]	

Key:
QMCI = Quantitative macro invertebrate community index
SFRG = Suitability for Recreation Grade from Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas 2003
[a] Exceeded in no more than 8% of samples (1 in 12)
[b] Exceeded in no more than 17% of samples (2 in 12)
[c] Exceeded in no more than 33% of samples (4 in 12) for Waihao River from Forks to SH1
[d] Annual median less than 260 E.coli per 100 millilitres is the threshold for meeting Band A under the National Objectives Framework.

APPENDIX FOUR: Table 15(a) with recommended changes marked up as track changes.

Table 15(a) Freshwater Outcomes for South Coastal Canterbury Area Rivers to be achieved by 2030.

Management Unit	River	Ecological health indicators			Macrophyte indicators		Periphyton indicators			Siltation indicator	Microbial indicator		Cultural Indicator
		QMCI [min 80% of samples in 5 year period]	Dissolved oxygen [min saturation] (%)	Temperature [max] (^{o}c)	Emergent Macrophytes [max cover of bed] (%)	Total Macrophytes [max cover of bed] (%)	Chlorophyll a [max biomass] (mg/m^2)	Filamentous algae >20mm [max cover of bed] (%)	Cyanobacteria mat >1mm cover (%)	Fine sediment <2 mm diameter [max cover of bed] (%)	Suitability for contact recreation [SFRG]	*E.coli* [number of *E.coli* per 100 millilitres] [annual median]	
Hill-fed – upland	Hook R. Waimate Ck. Horseshoe Bend Ck. Kohika R. Makikihi R Otaio R. Waihao R. Buchanans Ck. Hook Dn. Merrys Stm. Sir Charles Ck. Waituna Stm.	6	90	20	No value set	No value set	50[a]	10[a]	20[a]	15	Good	<260[d]	Freshwater mahinga kai species are sufficiently abundant for customary gathering, water quality is suitable for their safe harvesting, and they are safe to eat.
Hill-fed - lower	Hook R. Waimate Ck. Horseshoe Bend Ck. Kohika R. Makikihi R Otaio R. Waihao R. Buchanans Ck. Hook Dn. Merrys Stm. Sir Charles Ck. Waituna Stm.	6	90	20	No value set	No value set	200[bc]	30[bc]	50[bc]	15	Good to Fair	<260[d]	
Spring-fed plains	Hook R. Waimate Ck. Horseshoe Bend Ck. Kohika R. Makikihi R Otaio R. Waihao R. Buchanans Ck. Hook Dn. Merrys Stm. Sir Charles Ck. Waituna Stm.	5	70	20	30	50	No value set	30[bc]	50[bc]	20	No value set	<260[d]	

Key:
QMCI = Quantitative macro invertebrate community index
SFRG = Suitability for Recreation Grade from Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas 2003
[a] Exceeded in no more than 8% of samples (1 in 12)
[b] Exceeded in no more than 17% of samples (2 in 12)
[c] Exceeded in no more than 33% of samples (4 in 12) for Waihao River from Forks to SH1
[d] Annual median less than 260 E.coli per 100 millilitres is the threshold for meeting Band A under the National Objectives Framework.

APPENDIX FIVE: **Excerpt (Appendix 13) from MfE and MoH guidelines for managing cyanobacteria in recreational fresh waters (interim guidelines).**

Appendix 13: Example field sampling sheet for benthic cyanobacteria

Contact Information:

Name of sampler: ..... Ph: ..... Fax: .....

Email: ..... Address: .....

Sample Information:

Date: ...../...../.....Time: ..... Bank of river: TLB TRB

Sample location (please be as detailed as possible): .....

Method:

- Select an area of river bed (40–60 m long) suitable for 4 transects. It should include areas of riffle and run.
- Take each transect across the river, or to a maximum depth of **0.6 m** for larger, deeper rivers.
- Start at the most downstream transect and work upstream to avoid disturbance to areas not yet surveyed.
- Divide transect into 5 points. To do this, estimate the distance between viewing points by counting paces across the river, or to 0.6 m depth, then dividing by 5; work back to your starting point.
- Estimate % cover occupied by benthic cyanobacterial mats at each viewing point. Only record mats if they are greater than 1 mm thick
- Note presence or absence of detached or detaching mats on each transect and exposed mats on the river bed.
- Note bed substrate type (cobbles, gravels, sand-silt, macrophytes).

	Transect 1	Transect 2	Transect 3	Transect 4	Comments
Transect length					
Riffle or run?					
Substrate					
Detached or detaching mats?					
Exposed mats on river's edge?					
Sample taken?					
% cover by benthic cyanobacteria (to nearest 5%)					
View 1					
View 2					
View 3					
View 4					
View 5					
Mean % cover/ transect					Average % cover at site