BEFORE THE CANTERBURY REGIONAL COUNCIL

IN THE MATTER OF	The Resource Management Act 1991 (the Act)
AND	
IN THE MATTER OF	a submission by the Department of Conservation on proposed Land and Water Regional Plan, Plan Change 4 Omnibus provisions

Evidence of MAURICE JOHN DUNCAN
for the Department of Conservation

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Introduction

1. My name is Maurice John Duncan. I am a surface water hydrologist employed by the National Institute of Water and Atmospheric Research Ltd (NIWA) based in Christchurch.

2. I hold the qualification of Master of Agricultural Science in Agricultural Engineering from Lincoln University.

3. I am a member of the New Zealand Hydrological Society, the New Zealand Freshwater Sciences Society, the New Zealand Institute of Agricultural Science and the New Zealand Soil Science Society.

4. I have been employed by the National Institute of Water and Atmospheric Research and its predecessor organisations for 45 years. I am currently employed as a Senior Scientist in the field of surface water hydrology. My recent relevant experience is with hydrodynamic modelling, the effects of hydrological flow regimes on instream values and the effects of land-use change on hydrology. I have modelled the Rangitata, Waimakariri, Hurunui and Waiau Rivers in Canterbury, the Waiapu and Mata Rivers in Gisborne District, and I have derived relationships between flow and instream values for these rivers. In most cases the work has resulted in recommendations for minimum flows and allocations. I am a co-author of "A guide to instream habitat survey methods and analysis".

5. I have previously presented evidence on the hydrology of Canterbury Rivers and on instream values for setting minimum flows and water allocations for those rivers.

6. I also have 20 years' experience of on-farm irrigation scheduling.

7. Material used in writing this evidence is listed in Appendix A.

8. I have read the Environment Court's "Code of Conduct for Expert Witnesses" and agree to abide by it. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are 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.

9. In this evidence I:

   (a) discuss the relevant considerations for setting minimum flows in small Canterbury Streams;

(b) compare the return periods of flows of 50% of mean annual low flow (7DMALF) with the return periods of droughts for small Canterbury rivers.

(c) compare the minimum flows for small Canterbury rivers with 50% of the mean annual (seven-day) low flow (7DMALF).

(d) discuss the adequacy of 50% of the 7DMALF as a minimum flow for maintaining the life supporting capacity for fish and freshwater ecosystems;

Minimum flows

10. I have been asked to give evidence about default minimum flows to be applied in small Canterbury streams. In this evidence I am considering primarily rivers with mean flows of less than 5 cubic meters per second (5 m^3/s).

11. In my evidence I will be addressing the minimum flows that would provide for the ecological values for which the Department of Conservation has responsibilities, including indigenous freshwater fisheries, recreational freshwater fisheries and freshwater fish habitats. However, I acknowledge that environmental flows also provide for recreational, cultural, amenity and natural character values.

12. A minimum flow, in this context, is the lowest flow at which any abstraction is required to cease or be reduced. In simple terms, if no minimum flow is set then all the water in a stream might be abstracted, leaving the river bed dry and so providing no habitat for freshwater fish, other in-stream life, and river bed birds, and leaving no water for other values, stock or fire-fighting.

13. Flow variability in rivers (other than spring fed rivers) provides a healthy environment for instream macro-invertebrates and fish. Floods and freshes are required to flush the drape of silt that accumulates on a river bed at low flows and to flush accumulations of periphyton from the river bed to provide a relatively clean substrate. Thin films of periphyton can then establish on the clean substrate and provide food for macro-invertebrates, which in turn provide food for fish and river birds.

14. Regular flushing flows reduce the likelihood of periphyton growth blocking water intakes and making recreational use of rivers unpleasant. Ten to twelve flushing flows per year, spread evenly throughout the year, are likely to be sufficient to avoid excessive periphyton growth.

15. Mean daily flows of more than three times the median flow are commonly regarded as being required to flush gravel river beds of silt and periphyton (Biggs 2000). Flows are

normally recorded every 15 minutes. The median flow is the median of all the 15 minute values for the whole record. Half the values in the record are greater than the median and half are less than the median. The mean daily flow is the average of the 15 minute values from midnight to midnight.

16. An environmental flow regime consists of a minimum flow and an allocation. The LWRP provides for an allocation of 20% of the 7DMALF. In my opinion, an allocation of this level is unlikely to compromise ecological and other values.

Relevant considerations for setting a default minimum flow.

17. Minimum flows have an effect on the habitat of fish and invertebrates in Canterbury streams including upland bully, alpine galaxias, Canterbury galaxias, torrent fish, juvenile and adult brown trout, longfin eel, black-fronted tern, and mayfly nymphs.

18. For those species, what is important is the way that the amount of physical habitat changes with reductions on flow. If minimum flows are set too low, in-stream habitat starts to decline rapidly.

19. In addition to maintaining sufficient naturally occurring physical habitat for most species, particularly those species that are nationally critical, endangered or vulnerable, there are three factors that are relevant in determining a minimum flow:

    (a) The minimum flow required to keep a river mouth open, which is important for diadromous fish;

    (b) The minimum flows that allow sufficient depth for passage of trout and salmon over all downstream locations. Some rivers loose water to the groundwater downstream of the minimum flow site. So the minimum flow needs to be set at a level that allows trout passage throughout the river.

    (c) Low natural variability in the flow of spring-fed rivers. With spring-fed streams a flow of 50% of the 7DMALF would provide flows much less than the lowest recorded flow. For example in the Avon River at Gloucester Street the lowest recorded flow is 0.964 m^3/s for the 30 years of record, and the 7DMALF is 1.352 m^3/s. At 50% of the 7DMALF, flows can be reduced to 0.676 m^3/s which is 30% less than the lowest recorded minimum flow.

Historical flow methods

20. Minimum flow regimes can be determined by prescribing a proportion of measured natural flows. This method is known as a "historical flow method".

21. Generally, the aim of a historical flow method is to set a minimum flow which is within the observed historical flow range, in order to avoid a flow regime which deviates largely from the natural flow regime. It is assumed that the ecosystem is adapted to the natural flow regime and that a reduction in flow which deviates too much from the natural regime will cause degradation in the biological state of the river (Richter 2010).

22. I am aware that in 2008 the Ministry for the Environment (MfE) prepared a proposed National Environmental Standard on Ecological Flows and Water Level (proposed NES) which, for rivers and streams with mean flows less than or equal to 5 m^3/s (cubic metres per second, or cumecs), specified minimum flows at 90% of the mean annual (seven-day) low flow (7DMALF) in the absence of existing minimum flows (MfE 2008).

23. The proposed NES document had input, including peer review, from 24 leading scientists and administrators from regional councils, environmental organisations, recreationalists, water users, government departments, tangata whenua and environmental scientists. It was a very well-considered proposal (MfE 2008).

24. In my opinion, setting minimum flows at 90% 7DMALF, consistent with the proposed NES would be appropriate because that would avoid adverse effects on ecological values.

25. The Selwyn River can be used as an example of the type of small river to which the proposed NES was intended to apply. It is a typical Canterbury foothills fed river with a mean flow of less than or equal to 5 m^3/s.

26. I am aware that a specific flow regime applies for the Selwyn River, but I have chosen that river as an example to illustrate how different flow regimes would apply because there are good data available for it has been monitored, at Whitecliffs, since 1964.

27. Data for the Selwyn River at Whitecliffs from 1964 and 2014 show that the river has a recorded mean flow of 3.24 m^3/s and the 7DMALF is 0.782 m^3/s. The proposed NES regime, at 90% of 7DMALF, equates to a mean flow 0.704 m^3/s. Under the regime in the Land and Water Plan the minimum flow may go as low as 0.391 m^3/s.

28. To put those flows into context it is worth observing that in over 50 years of records the lowest flow recorded was 0.417 m^3/s and the mean instantaneous annual low flow is 0.708 m^3/s. Therefore, if it applied to the Selwyn River, the default "50%" regime in the Plan would set a minimum flow which is significantly lower than the lowest recorded flow. The resultant flow would be outside the historical flow range, and outside the parameters that would be contemplated under the historical flow method.

29. Figure 1 on the next page illustrates the flow levels I have discussed in relation to the Selwyn River at Whitecliffs, and the large difference in flow levels that would apply at 90% of 7DMALF and 50% of 7DMALF.

30. Because there is a specific regime for the Selwyn River at Whitecliffs, the minimum flow that applies for the Selwyn River at Whitecliffs, A Permits, is 0.55 m^3/s. It will change to 0.638 m^3/s from 1 July 2025 as is shown on Figure 1 on the next page.

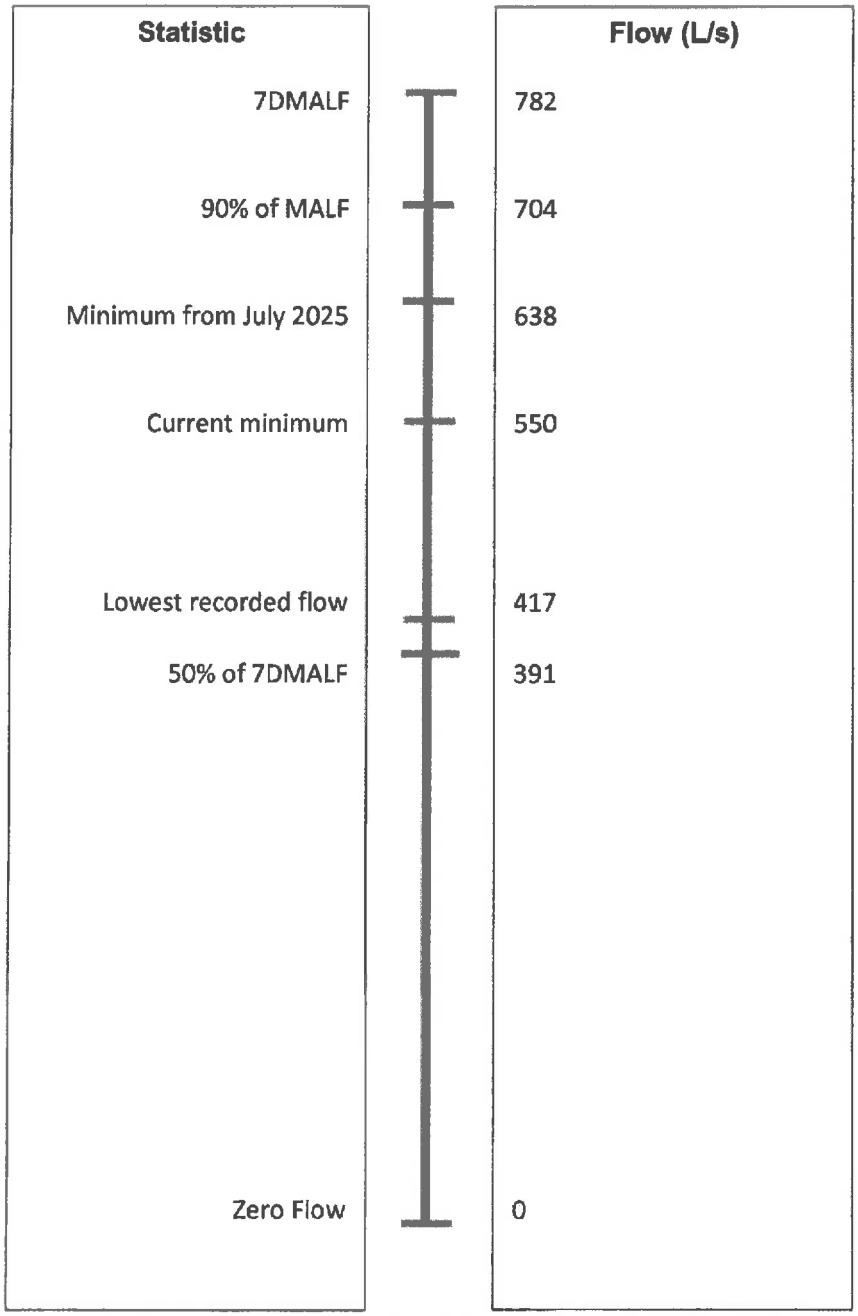

Figure 1. Flow statistics for the Selwyn River at Whitecliffs. Note that 50% of the 7DMALF is less than the lowest recorded flow.

31. Canterbury Regional Council (CRC) has analysed the frequency of naturally occurring low flows for long term sites with flows less than 5 m^3/s, as shown in Table 1 below. I have compared that data with the approximate return periods for minimum flows of 50% of 7DMALF in the last column of Table 1. Table 1 shows that, at all the sites monitored, the return periods of the 50% minimum flows in the Land and Water Regional Plan (LWRP) are 5 years of more. Over half of the sites have return periods of 100 years or more.

32. These data confirm that, under a regime that sets the minimum flow at 50% of 7DMALF, at every site monitored, flows could be consistently reduced below levels that would be experienced during a 5 year drought. At 50% of the sites that have been monitored, flows could be reduced to below levels that would occur in a 100 year drought. In my opinion these return periods indicate that a minimum flow of 50% of 7DMALF is too low in comparison with the historical flow record.

Table 1. Return period estimates with minimum flows at 50% 7 DMALF for long term CRC sites with mean flows less than 5 m^3/s.

River	Site	7DMALF (m^3/s)	7 day low flow 5 year return period (m^3/s)	7 day low flow 10 year return period (m^3/s)	7 day low flow 100 year return period (m^3/s)	LWRP minimum (m^3/s)	Return period of LWRP minimum
Rosy Morn	Weir	0.0034	0.0026	0.0023	0.0016	0.002	~ 100 y
Camp Stream	Craigieburn	0.011		0.006	0.004	0.006	10 y
Huka Huka	Lathams Rd	0.033	0.0218	0.02	0.016	0.017	~ 100 y
Rocky Gully	Rockburn	0.077	0.064	0.059	0.05	0.039	> 100 y
Stanton	Cheddar Valley	0.013		0	0	0.007	?
Kakahu	Mulvihills Mt	0.034		0.009	0.004	0.017	?
Maryburn	MacDonald	0.278	0.228	0.209	0.172	0.139	> 100 y
Kaituna	Kaituna Vly Rd	0.031	0.015	0.010	0.0025	0.016	~5 y
Heathcote	Buxton Tce	0.535	0.461	0.429	0.358	0.268	> 100 y
Cust	Threlkelds Rd	0.325	0.183	0.147	0.089	0.163	> 5 y
Omarama	Above Tara Hills	0.521		0.400	0.289	0.261	> 100 y
Avon	Gloucester St	1.389	1.248	1.215	1.153	0.695	> 100 y
Bealey	Arthurs Pass	0.51	0.42	0.38	0.31	0.255	> 100y
Twizel	Lake Poaka	0.25		0.07	0.02	0.126	~5 y ?
Waipara	White Gorge	0.102	0.049	0.037	0.019	0.051	~5 y
Maerewhenua	Kellys Gully	0.61	0.43	0.38	0.28	0.305	> 10y
Selwyn	Coe's Ford	0.562	0.316	0.205	0.107	0.281	> 5 y
Selwyn	Whitecliffs	0.782	0.616	0.575	0.497	0.391	> 100 y
Forks	Balmoral	1.262	1.040	0.965	0.818	0.631	> 100y
Pareora	Huts	0.498	0.340	0.309	0.259	0.249	> 100 y
Waihao	McCullochs	0.347	0.207	0.170	0.109	0.174	~ 10 y
Tengawai	Picnic Gds	0.562	0.291	0.251	0.189	0.281	> 5 y
Ashley	Lees Valley	0.747	0.559	0.497	0.385	0.374	> 100 y
Okuku	Fox Creek	0.55	0.402	0.325	0.17	0.275	> 100 y

Comparison with current minimum flows

33. Using sites for which CRC keeps data I have obtained long term flow statistics for sites with mean flows less than 5 m^3/s (CRC long term flow sites). I assumed "Band 1 restriction flows" were the minimum flows. I then calculated 90% and 50% 7DMALF minimum flows and the Band 1 restriction flows as a percentage of the 7DMALF

flows. The results are shown in Table 2. The right hand column presents the Band 1 flows as a percentage of the 7DMALF flows. The data shows:

(a) Three rivers out of 14 have minimum flows less than 50% 7DMALF.

(b) Seven of the rivers have minimum flows greater than 90% 7DMALF and two more have minimum flows very close to that standard.

(c) Excluding the Kaituna River the mean minimum flow is 91% of the 7DMALF. (The Kaituna River was excluded as the Band 1 restriction flow seems inordinately high in relation to the mean and 7DMALF statistics).

34. Given that all these sites had minimum flows that were well considered and were an average of 91% of the 7MALF, it seems incongruous that the default minimum flow should be 50% of the 7DMALF, to be applied when no minimum flow has been set in Sections 6 to 15 of the Land and Water Regional Plan.

Table 2. Comparison of prescribed minimum flows and proposed NES and LWRP - minimum flows for CRC long term flow sites.

River	Site	Mean flow (m^3/s)	7DMALF (m^3/s)	90% 7 DMALF minimum (m^3/s)	50% 7 DMALF minimum (m^3/s)	Irrigation Restriction Band 1 (m^3/s)	Restriction as % of 7DMALF (%)
Avon	Gloucester St	1.8	1.389	1.250	0.695	1.29	93
Forks	Balmoral	3.2	1.262	1.136	0.631	1.100	87
Cust	Threlkelds Rd	1.5	0.325	0.293	0.163	0.614	189
Maerewhenua	Kellys Gully	2.8	0.61	0.549	0.305	0.60	98
Selwyn	Coes Ford	3	0.562	0.506	0.281	0.600	107
Selwyn	Whitecliffs	3.2	0.782	0.704	0.391	0.550	70
Okuku	Fox Ck	4.4	0.55	0.495	0.275	0.535	97
Waihao	McCullochs	3.5	0.347	0.312	0.174	0.600	173
Tengawai	Picnic Gds	3.8	0.562	0.506	0.281	0.500	89
Kaituna	Kaituna Vly Rd	0.6	0.031	0.028	0.016	0.325	1048
Pareora	Huts	3.5	0.498	0.448	0.249	0.290	58
Omarama	Above Tara Hills	1.5	0.521	0.469	0.261	0.250	48
Waipara	Teviotdale		0.425	0.383	0.213	0.11	26
Waipara	White Gorge	2.8	0.102	0.092	0.051	0.05	49
					Mean (all)		**160**
					Mean (less Kaituna)		**91**

Summary

35. Minimum flows are required to provide for, and to preserve so far as is practicable, all indigenous freshwater fisheries and to protect recreational freshwater fisheries and freshwater fish habitats as well as other values.

36. Currently the LWRP assigns rivers with no minimum flow a minimum flow of 50% of the 7DMALF.

37. Most of the rivers without minimum flows will have mean flows less than 5 m^3/s.

38. The LWRP default minimum flows are significantly less than the minimum flows proposed in the well-considered, Ministry for the Environment's proposed National Environmental Standard of 90% of the 7DMALF, for rivers with mean flows less than 5 m^3/s.

39. The use of a prescribed proportion of a flow statistic as a minimum flow, is classified as a historical flow method, which should aim to maintain the flow within the historical flow range.

40. For most rivers, having 50% of 7DMALF as a minimum flow would provide a flow less than the 100 year return period low flow. Thus having a minimum flow of 50% of 7DMALF is unlikely to maintain the flow within the historical flow range for most rivers.

41. CRC long term flow sites, where minimum flows have been set by CRC have an average minimum flow of 91% of 7DMALF.

42. My accumulated evidence and professional experience suggests that the default LWRP minimum flows are too low and that 90% of the 7DMALF would more be likely to preserve indigenous freshwater fisheries, protect recreational freshwater fisheries and be more aligned with minimum flows currently in place in Canterbury rivers.

Maurice Duncan

January 2016

Appendix A. References

Selwyn River at Whitecliffs irrigation restrictions: http://ecan.govt.nz/SERVICES/ONLINE-SERVICES/MONITORING/IRRIGATION-RESTRICTIONS/Pages/irrigation-restriction.aspx?AreaID=6

Biggs, B.J.F. 2000. Eutrophication of streams and rivers: dissolved nutrient chlorophyll relationships for benthic algae. Journal of the North American Benthological Society 19:17-31.

Ministry for the Environment. 2008. Proposed National Environmental Standard on Ecological Flows and Water Levels. MfE publication ME 868. ISBN 978-0-478-30212-4.

Richter, B.D. 2010. Re-thinking environmental flows: from allocations and reserves to sustainability boundaries. River Research and Applications 26: 1052-1063.