Before the Hearings Commissioners
at Christchurch

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in the matter of: a submission on the proposed Hurunui and Waiau River Regional Plan and Plan Change 3 to the Natural Resources Regional Plan under the Resource Management Act 1991

to: **Environment Canterbury**

submitter: **Meridian Energy Limited**

Statement of evidence of Mark David Sanders

Dated: 12 October 2012

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QUALIFICATIONS AND EXPERIENCE

1. My full name is Mark David Sanders. My qualifications and experience are set out in my statement of evidence in relation to birds and terrestrial vegetation of the Waiau River.

2. I have read and agree to comply with the Environment Court's Code of Conduct for Expert Witnesses contained in the 2011 Practice Note. 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 that I express here.

SCOPE OF EVIDENCE

3. In this evidence I consider only the Hurunui River. I have prepared a separate statement of evidence regarding the Waiau River, in which I provide an overview of braided river bird ecology, and more detailed background of some potential effects. I do not repeat that information here, except to re-iterate that that the most important period for river birds is the nesting season (approximately September to December). My evidence is set out as follows.

    a) I outline the methods I used in assessing the effects of the proposed Balmoral Hydro Project (BHP), and hence the environmental flow and allocation regime for the Hurunui River in the Proposed Hurunui and Waiau River Regional Plan (the Proposed Plan);

    b) I describe the bird and plant communities of the Hurunui River, with particular emphasis on the Amuri reach; and,

    c) I assess the potential effects of full implementation of the flow and allocation regime, and of the development of the BHP, on braided river birds and terrestrial vegetation.

4. I understand that the Proposed Plan includes provisions that relate environmental flows and flow allocation to the breeding and feeding of riverbed nesting birds, maintaining flow variability and maintaining invertebrate food production. My evidence particularly covers the first of these matters, and in doing so touches on the others.

5. Meridian Energy Limited (Meridian) and Ngai Tahu Property Limited (NTPL) are currently preparing an application for the principal resource consents required for their proposed BHP on the north bank of Hurunui River, as described in the evidence of Mr Nick Eldred and Mr Jeff Page. My evidence is

based on the investigations that I have undertaken in relation to the BHP, and on the findings of other experts who have also made assessments in relation to the BHP, as discussed as various points throughout my evidence.

6. The proposed BHP scheme would take water from the river immediately downstream of the Mandamus River, and discharge it back to the Hurunui River about 28 km downstream, at a point 8.2 km below the SH7 bridge. I will refer to the reach between the intake and discharge as the 'Amuri reach'.

7. The hydrological effects of the proposed BHP are described in the evidence of Mr Steven Woods, who has modelled a number of flow regimes involving existing consented and potential future takes (particularly by the Hurunui Water Project). I describe the modelled flow regimes in more detail later in my evidence. The modelled flow regimes comply with the proposed Environmental Flow and Allocation Regime for the Hurunui River as set out in the Proposed Plan, except that Mr Woods has assumed that the existence of a C Block is not dependent on the development of 20 million m^3 of storage as is required in the Proposed Plan.

SUMMARY OF MAIN FINDINGS

8. The Hurunui River, particularly the Amuri reach, provides large areas of suitable habitat for braided river birds; recent surveys have recorded 27 species. Seven '*Threatened'* and seven '*At Risk*' species have been recorded on the entire river (four and six species respectively on the Amuri reach), including breeding populations of black-fronted terns and black-billed gulls, both classified as *Nationally Endangered* under the New Zealand threat classification system[1,2,3]. In my opinion, the Hurunui River as a whole, and the Amuri Plains reach on its own, are significant habitats of indigenous fauna in terms of Section 6(c) of the RMA.

9. I assessed the potential effects of the proposed BHP (on its own and in combination with proposed irrigation development), and hence the Proposed Plan flow and allocation regime, on native terrestrial plant communities arising from various potential flow regimes, and on river birds arising from possible changes in habitat suitability, food supplies, and vulnerability of nests to predation and floods.

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[1] For threat classification definitions, see Appendix D of my statement of evidence in relation to the Waiau River.

[2] Miskelly, C.M., Dowding, J.E., Elliot, G.P., Hitchmough, R.A., Powlesland, R.G., Robertson, H.A., Sagar, P.M., Scofield, R.P., Taylor, G.A. 2008. Conservation Status of New Zealand Birds. *Notornis* 55(3):117-135.

[3] Townsend, A.J.; de Lange, P.J.; Duffy, C.A.J.; Miskelly, C.M.; Molloy, J.; Norton, D.A. 2008. *New Zealand Threat Classification System Manual*. Science and Technical Publishing, Department of Conservation, Wellington, New Zealand.

10. In my opinion, implementation of the flow and allocation regime in the Proposed Plan would have negligible effects – adverse or beneficial – on the risk of floods destroying nests or drowning chicks because floods would be only slightly reduced in size by hydro, or hydro and irrigation combined.

11. Full implementation of the flow and allocation regime in the Proposed Plan is likely to exacerbate weed invasion by reducing disturbance along channel margin. This would result in a loss of suitable habitat for native plants and birds, unless weed control efforts are increased.

12. A reduction in number of flowing channels ('braids') as a result of the full implementation of the flow and allocation regime in the Proposed Plan could make it easier for mammalian predators to reach and prey upon eggs, chicks and adults at nests. The proportion of birds affected and the increase in risk would be small, in my opinion. However, any increase in predation could not be reliably mitigated because, to date, no reliable methods of reducing predation on braided river birds have been established, despite substantial work with this aim over the past 30 years.

13. The predicted small decreases and increases in availability of instream habitat of the aquatic prey of river birds are much too small to affect – adversely or beneficially – the ability of birds to obtain food, in my opinion. Terrestrial and off-river aquatic food sources will be unaffected.

14. Overall, I conclude that the flow and allocation regime in the Proposed Plan could be fully implemented while providing for appropriate management of feeding and nesting habitat of braided river birds, but it would carry a small risk of increased predation on river birds. The effects of the BHP alone are less than implementing the full flow and allocation regime.

METHODS

15. I based my assessment on reviews of existing information, field surveys of vegetation and bird habitat, and the assessments of other technical experts, as follows.

16. Information relevant to the birds and vegetation of the Hurunui River was obtained by searching the literature and a range of online sources, and from site investigations. Good information exists regarding the distribution and abundance of river birds on the Hurunui River as a result of bird surveys undertaken each year from 2006 to 2010 by Professor Ken Hughey and

volunteers[4], and Environment Canterbury (ECan), Department of Conservation (DOC), and volunteers[5]. I collated data from these surveys, and present a summary of the methods used and the data obtained in Appendix A.

17. To evaluate bird habitat and terrestrial vegetation, I surveyed the Amuri reach at low elevation from a helicopter, combined with brief ground inspections, in February, August, and December 2011. Recent aerial photography of the river is readily available on Google Earth and I used this to supplement my ground and aerial assessments.

18. I used this information, and the analyses of the following experts to evaluate the potential effects on river birds.

    a) Mr Steven Woods – Hydrology;

    b) Dr Mark Mabin – Sediment transport and braided river landforms; and

    c) Mr Ian Jowett – River hydrodynamics and in-stream habitat.

VALUES OF THE EXISTING ENVIRONMENT

Vegetation

19. Within the Amuri reach, the river is bounded to the north mainly by pine forest, with developed pasture in places, and to the south by developed pasture, as shown in photographs in Appendix B. The distance between these vegetation types ranges from 200 m to 1000 m, and within this 'corridor' the river flows in braided channels through a mosaic of vegetation types. The river bed vegetation is dominated by exotic species, but in some areas low-stature native plants are prominent. The width of the unvegetated or sparsely-vegetated gravel riverbed ('the fairway') ranges from 100 m to 700 m, and is typically 200 m to 400 m.

20. Exotic woody weeds (such as yellow tree lupin, gorse, broom and blackberry), are present in the Amuri reach in densities ranging from scattered individuals to dense shrublands, particularly along the river margins, but also throughout the river bed. Exotic trees, mainly crack willows but also poplars, alders and pines, are also scattered throughout the river, and in places form dense stands, often with a dense understory of woody weeds. Various exotic grasses and herbs (e.g. self-heal, stonecrop, viper bugloss, woolly mullein, sheep

[4] Hughey K.F.D. 2009. Statement of evidence of Kenneth Frederick David Hughey on behalf of the Director-General of Conservation and the Royal New Zealand Forest and Bird Society, in relation to an Application for a Water Conservation Order for the Hurunui River. 6 March 2009.

[5] DOC unpublished data.

sorrel) are common on the Hurunui River bed, as is typical of many braided rivers[6].

21. Native cushion plants (*Raoulia* species) and creeping pohuehue (*Muehlenbeckia axillaris)* are present in many places on relatively stable substrates throughout the Amuri reach (e.g. photographs 5 and 8, Appendix B). These species comprise a substantial proportion of the ground cover in places. However, exotic plants appear to be continuing to invade these areas, as can be seen in the photographs in Appendix B, and, left unchecked, it is likely that weed invasion will result in the loss of much of the remaining native vegetation, as has happened on many other braided rivers in Canterbury and elsewhere.

River Birds

22. The Hurunui River (including the river mouth) provides foraging, breeding, and roosting habitat for a diverse assemblage of birds, similar to that found on many braided rivers and coastal lagoons on the east coast of the South Island.[7,8] The river bird surveys from 2006 to 2010 recorded a total of 27 species, mainly various species of gulls, tern, waders and waterfowl (Table 1, Appendix A).

23. Of the species recorded in these surveys, spotted shags and variable oystercatchers are coastal species and were seen only at the river mouth. Similarly, most red-billed gulls, white-fronted terns, black-fronted dotterels, and pied shags were seen only at the river mouth or below SH1, although small numbers of white-fronted terns and pied shags (totals of 15 and two, respectively, over five years) were seen in the Amuri reach (Appendix A). Wrybills were seen only below SH1 and only in 2009 and 2010 (two and 10, respectively), although this species is cryptic and could easily have been present but missed during counts on other braided reaches of the Hurunui River.

24. The surveys recorded seven species classified as *Threatened* and seven species classified as *At Risk* under the New Zealand Threat Classification System[9,10,11] (Table 2). These include breeding populations of the *Threatened*

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[6] Woolmore, C. B. 2011. *The vegetation of braided rivers in the upper Waitaki basin South Canterbury, New Zealand*. Canterbury Series 0211. Department of Conservation, Christchurch, New Zealand.

[7] O'Donnell, C.F.J.; Moore, S.M. 1983. The wildlife and conservation of braided river systems in Canterbury. Fauna Survey Unit Report No. 33. NZ Wildlife Service, Wellington.

[8] O'Donnell, C.F.J. 2000. The significance of river and open water habitats for indigenous birds in Canterbury, New Zealand. Environment Canterbury *Unpublished Report* U00/37. Environment Canterbury, Christchurch.

[9] For threat classification definitions, see Appendix D of my statement of evidence in relation to the Waiau River.

[10] Miskelly, C.M., Dowding, J.E., Elliot, G.P., Hitchmough, R.A., Powlesland, R.G., Robertson, H.A., Sagar, P.M., Scofield, R.P., Taylor, G.A. 2008. Conservation Status of New Zealand Birds. *Notornis* 55(3):117-135.

(*Nationally Endangered*) black-fronted tern (range in 2006-2010 surveys: 280 – 604) and black-billed gull (16 – 1123), and the *Threatened* (*Nationally Vulnerable*) banded dotterel (205 – 450) and wrybill plover (0 – 5). Ten of the 14 *Threatened* or *At Risk* species found on the Hurunui River were recorded within the Amuri reach (Table 2).

25. The river is at its most braided in the reaches where it crosses the Amuri Plain and below State Highway 1. These two reaches provide the largest areas of suitable habitat for, and support the greatest abundance and diversity of, water birds. In other reaches the river consists almost entirely of a single channel.

26. The numbers of any given species within the Amuri reach, and indeed on the entire river, vary from year to year. Black-billed gull numbers, in particular, vary widely between years (e.g. from 16 to 1123 below Mandamus; Table 3). The abundance of this species typically varies greatly on any given river or section from year to year, apparently because birds readily move within and among rivers from year to year[12,13].

27. Nonetheless, it is clear that a substantial proportion of birds that use the Hurunui River each year occur on the Amuri reach. For example, of the 261 to 568 black-fronted terns recorded between Mandamus and the river mouth between 2006 and 2010, an average of 30% were found in the Mandamus to SH7 section (i.e. entirely within the Amuri reach), and 20% were within the SH7 to Lowry section (Table 3).

28. The river above Mandamus (upstream of the Amuri reach) also supports a diversity of species, including substantial proportions of the banded dotterels and pied oystercatchers on the Hurunui River, and smaller proportions of the black-fronted terns (Tables 3 and 4).

29. The diversity and numbers of birds present on the Hurunui River, including breeding populations of threatened species make the river as a whole a significant habitat for indigenous fauna in terms of Section 6(c) of the RMA. A similar conclusion was reached in evaluations by Dr Colin O'Donnell[14], and Professor Ken Hughey and colleagues.[15] I agree with those assessments for

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[11] Townsend, A.J.; de Lange, P.J.; Duffy, C.A.J.; Miskelly, C.M.; Molloy, J.; Norton, D.A. 2008. *New Zealand Threat Classification System Manual*. Science and Technical Publishing, Department of Conservation, Wellington, New Zealand.

[12] McClellan R.K. 2009. The ecology and management of Southland's black-billed gulls. PhD thesis, University of Otago.

[13] DOC unpublished data.

[14] O'Donnell, C.F.J. 2000. The significance of river and open water habitats for indigenous birds in Canterbury, New Zealand. Environment Canterbury *Unpublished Report* U00/37. Environment Canterbury, Christchurch.

[15] Hughey, K.; O'Donnell C.; Schmechel, F.; Grant, A.; 2009. Birdlife: Application of the River Significance Assessment Method to the Canterbury Region. Unpublished Report. Lincoln University, Lincoln.

the Hurunui River as a whole. Further, in my opinion, the Amuri reach is also a significant habitat in its own right because it includes a large proportion of the braided habitat and supports fairly large breeding populations of several threatened species.

Table 1. Minimum, maximum and mean numbers of river birds recorded on the Hurunui River between the Mandamus confluence and the sea (Hughey's sections 8-12, described in Appendix A in five surveys from 2006 to 2010.[16,17] Surveys or partial surveys were also made above Mandamus in three years, but these data are not summarised here because of the variation in area and location of those surveys, as discussed in the caption to Table 4 and Appendix A.

Species	**Min**	**Max**	**Mean**
Pied oystercatcher *Haematopus finschi*	57	143	100.6
Pied stilt *Himantopus himantopus leucocephalus*	64	99	79
Banded dotterel *Charadrius bicinctus bicinctus*	199	254	220.6
Wrybill *Anarhynchus frontalis*	0	5	1.4
Black-billed gull *Larus bulleri*	16	1123	644.2
Black-fronted tern *Chlidonias albostriatus*	261	568	396.6
Black shag *Phalacrocorax carbo novaehollandiae*	17	66	37.4
Pied shag *Phalacrocorax varius varius*	0	14	7.8
Little shag *Phalacrocorax melanoleucos brevirostris*	1	22	9
Spotted shag *Stictocarbo punctatus*	0	2	0.4
White-faced heron *Ardea novaehollandiae*	21	64	37.6
Canada goose *Branta canadensis*	168	503	304
Duck species*	192	320	244
Paradise shelduck *Tadorna variegata*	99	544	241.4
Grey teal *Anas gracilis*	0	33	9.4
NZ shoveler *Anas rhynchotis*	0	2	0.4
NZ Scaup *Aythya novaeseelandiae*	0	8	3
Variable oystercatcher *Haematopus unicolor*	0	14	3.4
Black-fronted dotterel *Charadrius melanops*	0	13	5.2
Spur-winged plover *Vanellus miles novaehollandiae*	46	608	240.4
Southern black-backed gull *Larus dominicanus*	1361	2682	2101.2
Red-billed gull *Larus novaehollandiae scopulinus*	2	39	14
Caspian tern *Hydroprogne caspia*	0	2	0.8
White-fronted tern *Sterna striata striata*	0	190	81.4
Kingfisher *Todiramphus sanctus vagans*	5	10	7.2
Welcome swallow *Hirundo tahitica neoxena*	5	61	24.6
Pipit *Anthus novaeseelandiae novaeseelandiae*	0	9	2.4

*Duck species comprises mainly mallard (*Anas platyrhynchos*, and grey duck (*Anas superciliosa*), or hybrids of these species, which are difficult to differentiate in the field.

[16] Hughey K.F.D. 2009. Statement of evidence of Kenneth Frederick David Hughey on behalf of the Director-General of Conservation and the Royal New Zealand Forest and Bird Society, in relation to an Application for a Water Conservation Order for the Hurunui River. 6 March 2009.

[17] DOC unpublished data.

Table 2. Threatened and at risk species present on the Hurunui River under the New Zealand Threat Classification System[18,19,20]. CD=Conservation Dependent; DP=Data Poor; Inc=Increasing; RR=Range Restricted; SO=Secure Overseas; Sp=Sparse; TO=Threatened Overseas; De=Designated.

Species	Threat classification	Recorded in Amuri reach?
Black-fronted tern	Threatened: Nationally Endangered [DP]	Y
Black-billed gull	Threatened: Nationally Endangered [De]	Y
Wrybill plover	Threatened: Nationally Vulnerable [RR]	N
Banded dotterel	Threatened: Nationally Vulnerable [RR]	Y
Caspian tern	Threatened: Nationally Vulnerable [SO]	N
Pied shag	Threatened: Nationally Vulnerable	Y*
Red-billed gull	Threatened: Nationally Vulnerable	N*
White-fronted tern	At Risk: Declining [DP]	Y*
Pied oystercatcher	At Risk: Declining	Y
Pied stilt	At Risk: Declining [SO]	Y
New Zealand pipit	At Risk: Declining	Y
Variable oystercatcher	At Risk: Recovering	N*
Black shag	At Risk: Naturally Uncommon [SO, Sp]	Y
Little shag	At Risk: Naturally Uncommon [Inc]	Y

* Present mainly at the river mouth or on the lower reaches of the river, below SH1.

Table 3. Mean, minimum and maximum counts, of key species counted between Mandamus and the river mouth, in five surveys, from 2006 to 2010, and the percentages of these that were seen within the two sections that overlap with the Amuri reach. Data for sections above Mandamus are excluded because these sections were not surveyed consistently in all years, as explained in the caption to Table 4 and Appendix A.

	Number between Mandamus and the mouth			Mean % Mandamus to SH7	Mean % SH7 to Lowry
Species	Mean total	Minimum	Maximum		
Pied oystercatcher	100.6	57	143	32.1	14.1
Pied stilt	79.0	64	99	19.7	16.0
Banded dotterel	220.6	199	254	20.6	13.3
Wrybill	1.4	0	5	0.0	0.0
Black-billed gull	644.2	16	1123	15.8	26.3
Black-fronted tern	396.6	261	568	30.4	20.1

[18] For threat classification definitions, see Appendix D of my statement of evidence in relation to the Waiau River.

[19] Miskelly, C.M., Dowding, J.E., Elliot, G.P., Hitchmough, R.A., Powlesland, R.G., Robertson, H.A., Sagar, P.M., Scofield, R.P., Taylor, G.A. 2008. Conservation Status of New Zealand Birds. *Notornis* 55(3):117-135.

[20] Townsend, A.J.; de Lange, P.J.; Duffy, C.A.J.; Miskelly, C.M.; Molloy, J.; Norton, D.A. 2008. *New Zealand Threat Classification System Manual*. Science and Technical Publishing, Department of Conservation, Wellington, New Zealand.

Table 4. Numbers of key river bird species counted on the Hurunui River, above, within, and below the Amuri reach, during ground-based surveys in October/November from 2006 to 2010.[21,22] The Amuri reach consists of the 20.4-km Mandamus to SH7 section and the top 8.2 km of the 12.1-km long SH7 to Lowry section. For completeness, all survey data are summarised here, but note that only a subset of the bird survey sections above Mandamus was surveyed in 2006 to 2008, and none were surveyed in 2009 and or 2010 (n.s. = not surveyed). Data from partial surveys are shown in italics, and the length of river surveyed is shown for each reach and each year. More detailed data for all species are presented in Appendix A.

Location in relation to Amuri reach:	**Above**	**Entirely within**	**Partly within**	**Below**	
Description of reach	**Above Mandamus**	**Mandamus to SH7**	**SH7 to Lowry**	**Below Lowry**	**Total**
Maximum distance potentially surveyed (km):	**90.4**	**20.4**	**12.1**	**39.1**	**162**
2006 Distance surveyed (km):	***70.9***	**20.4**	**12.1**	**39.1**	**142.5**
Pied oystercatcher	*94*	33	12	98	237
Pied stilt	*9*	37	17	45	108
Banded dotterel	*196*	60	42	152	450
Wrybill	*0*	0	0	0	0
Black-billed gull	*6*	4	104	644	758
Black-fronted tern	*43*	71	274	216	604
2007 Distance surveyed (km):	***50.2***	**20.4**	**12.1**	***19***	**101.7**
Pied oystercatcher	*39*	13	14	*30*	96
Pied stilt	*0*	2	9	*76*	87
Banded dotterel	*68*	64	59	*82*	273
Wrybill	*0*	0	0	*0*	0
Black-billed gull	*0*	10	4	*2*	16
Black-fronted tern	*24*	114	19	*128*	285
2008 Distance surveyed (km):	***30.7***	**20.4**	**12.1**	**39.1**	**102.3**
Pied oystercatcher	*56*	19	12	35	122
Pied stilt	*7*	3	14	47	71
Banded dotterel	*101*	23	4	172	300
Wrybill	*0*	0	0	0	0
Black-billed gull	*0*	35	3	1085	1123
Black-fronted tern	*23*	45	26	242	336
2009 Distance surveyed (km):	**0**	**20.4**	**12.1**	**39.1**	**71.6**
Pied oystercatcher	ns	35	9	54	98
Pied stilt	ns	26	21	34	81
Banded dotterel	ns	28	18	159	205
Wrybill	ns	0	0	2	2
Black-billed gull	ns	34	1022	49	1105
Black-fronted tern	ns	154	88	326	568
2010 Distance surveyed (km):	**0**	**20.4**	**12.1**	**39.1**	**71.6**
Pied oystercatcher	ns	70	14	55	139
Pied stilt	ns	14	3	47	64
Banded dotterel	ns	55	25	160	240
Wrybill	ns	0	0	5	5
Black-billed gull	ns	22	0	203	225
Black-fronted tern	ns	152	58	70	280

[21] Hughey K.F.D. 2009. Statement of evidence of Kenneth Frederick David Hughey on behalf of the Director-General of Conservation and the Royal New Zealand Forest and Bird Society, in relation to an Application for a Water Conservation Order for the Hurunui River. 6 March 2009.

[22] DOC unpublished data.

ASSESSMENT OF EFFECTS OF THE PROPOSED SCHEME

30. Some water is currently taken from the Hurunui River for irrigation, and further irrigation is likely to be developed. In order to assess the potential hydrological effects of the BHP, Mr Woods has modelled nine flow regimes: the natural flow plus two flow regimes for each of four irrigation scenarios. For each irrigation scenario, two flow regimes were modelled: one with and one without the proposed BHP. Two of the scenarios were virtually identical and were not compared further. The seven flow regimes listed below were considered in more detail. Of these, flow regime 3b represents the greatest implementation of hydro and irrigation development under the Environmental Flow and Allocation Regime in the Proposed Plan, as explained by Mr Woods.

Flow scenarios

1. Natural flow regime

Existing irrigation scenarios

2a. Existing irrigation development (i.e. the 'status quo')

2b. Modelled existing irrigation development and hydro with 'C' block.

Full irrigation scenarios

3a. Modelled full Hurunui Water Project (HWP) irrigation development

3b. Modelled full HWP irrigation development and hydro

Stage 1 Partial irrigation development scenarios

4a. Modelled Stage 1 HWP irrigation development.

4b. Modelled Stage 1 HWP irrigation development and hydro

31. In my evidence, I focus on the potential effects of BHP, but also consider the cumulative effects of full irrigation development and the BHP. The effects of these are quite different both on a seasonal and annual basis. In particular the environmental flow and allocation regime in the Proposed Plan allows up to 49 m^3/s to be taken from the mainstem of the Hurunui River, but the BHP would only take up to 15 m^3/s of this, all of which will be returned to the river. As explained by Mr Woods, full irrigation development and the BHP represents a plausible full use of water as a result of implementing fully the flow and allocation regime for the Hurunui River in the Proposed Plan. I compare these flow regimes, with the existing irrigation development (which takes up to 6.2 m^3/s for irrigation).

32. I will refer to specific relevant hydrological effects as necessary throughout my evidence. Key points of relevance to the potential effects of the BHP, birds and terrestrial vegetation are:

    a) The BHP would affect only the Amuri Reach because all water used for hydro generation is returned to the river 8.2 km below SH7, with discharge flow varying little from intake flow.

    b) Although flow regimes 3a and 3b result in the greatest effects on flow compared to the natural flow regime and the existing irrigation development (flow regime 2a), the incremental effect of hydro is the least under flow regime 3b. The long-term average take for hydro would be 7.4 m^3/s under flow regime 3b, resulting in a 3.9 m^3/s reduction in median flow.

    c) The combined takes for hydro and irrigation would result in prolonged periods of low flows, particularly during the bird breeding season. The largest increase in duration of low flow, when compared to natural flow, occurs with modelled full irrigation development and hydro (flow regime 3b), which results in flows <30 m^3/s for 245 days per annum (66.9% of the time), a 2.7-fold increase. Of these 245 days, hydro accounts for 53 days per annum of flows < 30 m^3/s.

    d) Under all scenarios, hydro takes much of the available water that is not taken for irrigation. Consequently, all of the 'with hydro' flow regimes result in substantially lower median flows than the Natural Flow regime or the flows resulting from existing irrigation development.

    e) The pattern of fairly frequent freshes throughout the year, and especially in spring and summer, would be retained. However, the magnitude of these freshes would be substantially reduced, as can be seen from the modelled hydrographs in the evidence of Mr Woods. This effect is also reflected in a reduction in the duration of flows greater than 30 m^3/s for all flow regimes. The overall effect on freshes, in comparison with the Natural Flow regime is greatest under flow regime 3b, whilst the incremental effect of hydro is smallest under this flow regime. For example, under flow regime 3a, flow would be between 30 m^3/s and 130 m^3/s for 154 days per annum, whereas with hydro (flow regime 3b), this would reduce by 51 days to 103 days per annum.

f) The frequency and duration of larger flood flows (e.g. over 130 m³/s) will be slightly reduced under all modelled flow regimes. However the BHP will not take water for at least 48 hours if the flow exceeds 130 m³/s.

g) Because existing irrigation takes, and those for which applications have already been lodged, have priority, the incremental effects of hydro are greatest outside the irrigation season. Thus, the greatest average hydro takes of up to 15 m³/s (i.e. maximum hydro take) occur between May and December. This is reflected in the greater divergence of median flows for the two flow regimes under each scenario during these months (Figure 1).

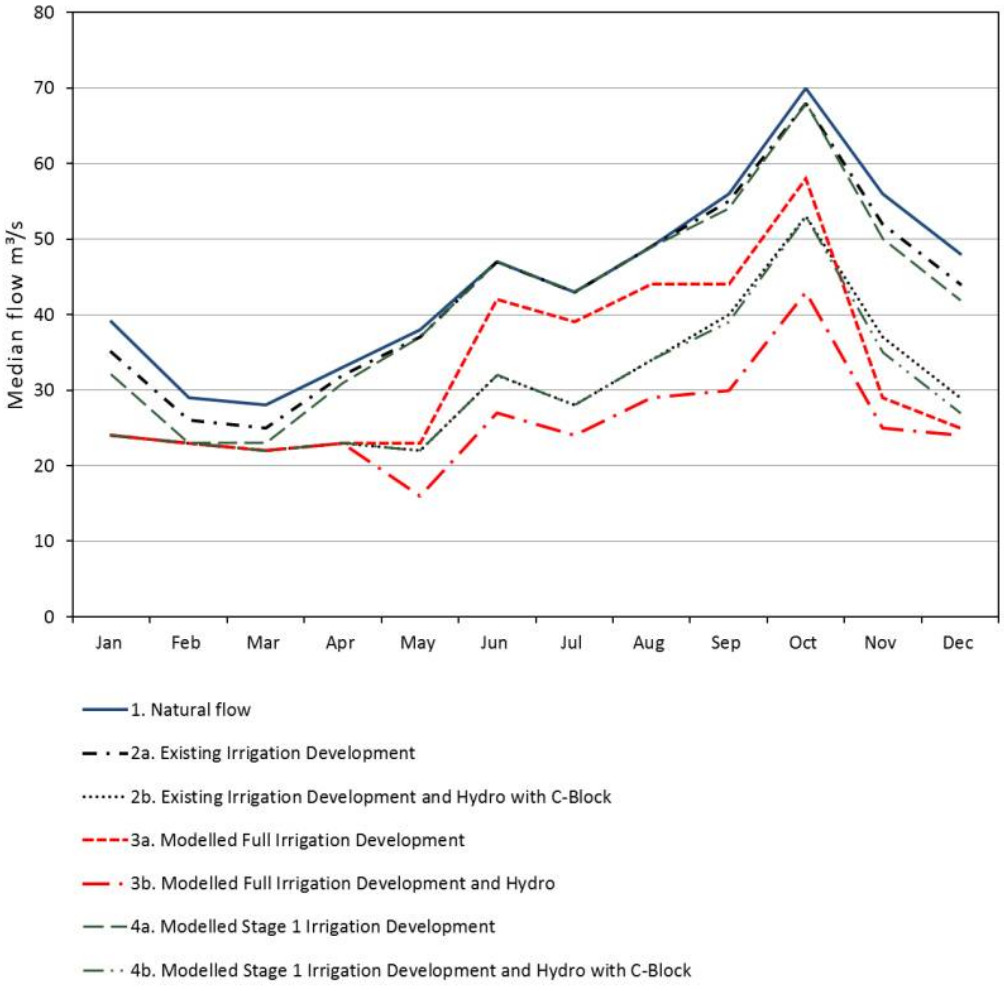

Figure 1. Monthly median flows for seven modelled flow regimes. Flow regimes 3b represents the greatest modelled implementation of irrigation and hydro. The incremental effect of hydro can be seen by comparing the relevant plots (e.g. 3b vs. 3a).

Flood risk

33. As discussed in more detail in my statement of evidence in relation to the Waiau River, reduced flows, in general, have the potential to increase flood risk

to nesting birds by allowing them to nest at lower elevation sites, and to reduce flood risk by reducing the magnitude of floods that can destroy eggs and chicks. On the Hurunui River, however, any such effects resulting from the BHP, or BHP cumulatively with irrigation, would be negligible, in my opinion. This is mainly because the main adverse impacts of floods on birds occur during large floods, and these would be only very slightly reduced by hydro, or by hydro and irrigation combined.

Bird habitat suitability and terrestrial vegetation

34. Braided river beds are readily colonised by some introduced weeds, such as broom, gorse, tree lupin, and various exotic grasses and herbs. The increases in the duration of low flows, and the reduction in magnitude of freshes and floods under all modelled flow regimes, are likely to reduce disturbance along channel margins, and so facilitate establishment of these weeds.

35. My observations of braided rivers over twenty years have been that, once established, these weeds tend to persist (at least in patches) even after large floods, and then rapidly re-establish and continue to spread. This can be seen in the Rakaia River at present, for example, following the very large 5700 m^3/s flood of December 2010. In my opinion, although large floods in the Hurunui River (the order of 400-550 m^3/s) will not be affected by the BHP, their weed-clearing effect may be reduced because weeds will have more opportunity to establish during normal flows.

36. Together, these effects will probably exacerbate weed encroachment, resulting in further loss of native plant species, and a reduction in the amount of sparsely-vegetated substrates preferred by river birds.

Predation risk

37. As discussed in more detail in my statement of evidence in relation to the Waiau River, nest survival tends to be higher on islands in rivers than on sites connected to the river, apparently because water deters some mammalian predators from gaining access to islands.

38. During the bird breeding season, the BHP could take up to 15 m^3/s when sufficient water was available. Modelling by Duncan and Shankar[23] predicts that, within the range of 10 m^3/s to 80 m^3/s, a 15 m^3/s reduction in flow would result in a decrease in wetted area (across all braids) of approximately 11%.

[23] Duncan, M.; Shankar, U. 2004. *Hurunui River habitat 2-D modelling*. NIWA Client Report CHC2004-011. Prepared for Environment Canterbury. NIWA, Christchurch.

39. Aerial photographs taken in recent years provide examples of how braiding patterns change with flow[24]. Although none show precisely the changes that the flow and allocation regime in the Proposed Plan would cause, they do provide an indication the order of magnitude of changes that could occur. For example, Figures 2 and 3 illustrate a 40 m³/s reduction in flow, over 13 days within the Amuri reach. Aerial photographs in Duncan and Shankar's report provide further examples (their Figures 7 and 8).

[24] Viewed on Google Earth. Photos are available, at various locations in the Amuri reach, at flows of 15, 17, 24, 26, 32, 55, 61, 97, & 100 m³/s.

Figure 2. Example of Hurunui River braiding pattern, 12 km upstream of SH7, at a flow of 66 m³/s (recorded at Mandamus) on 16 January 2006.

Figure 3. Example of Hurunui River braiding pattern, 12 km upstream of SH7, at a flow of 26 m³/s (recorded at Mandamus) on 29 January 2006.

40. These photographs, and Duncan and Shankar's[25] modelling, show that a 15 m³/s reduction in flow (the maximum take by the BHP) would result in small reductions in average channel width and could, in places, cause small, shallow side braids to become disconnected (i.e. not joined with other braids at both upstream and downstream ends). Overall, this would have little effect on the number or size of islands in the river. Nevertheless, it is possible that, in some places, the risk of mammalian predation on birds nesting at these sites could increase, causing a loss of breeding adults and reductions in the breeding success of threatened species.

41. The cumulative effect of hydro with irrigation would result in greater changes – between 24 m³/s and 31 m³/s reductions in median flow – during the breeding season, which would bring a higher risk of increased mammalian predation. Flows are most affected by the cumulative takes for hydro combined with irrigation in January through April (Figure 1), but river birds are less vulnerable at this time of year because nesting has finished, chicks have fledged, and many birds are beginning to migrate away from the rivers.

42. Any increases in predation on eggs, chicks, or adults could exacerbate the ongoing national declines in abundance and/or distributional range of the threatened river birds found on the Amuri Plains reach of the Hurunui River.[26,27,28,29] However, such effects would be difficult or impossible to detect and to separate from variation caused by other factors. Further, such effects could not be reliably mitigated because no reliable methods of reducing predation on braided river birds have been established, despite substantial work with this aim over the past 30 years.[30,31,32]

43. Thus, in my opinion, there is a possibility of an adverse effect on birds that could not be detected if it did occur, and could not be reliably mitigated even if it could be detected.

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[25] Duncan, M.; Shankar, U. 2004. *Hurunui River habitat 2-D modelling*. NIWA Client Report CHC2004-011. Prepared for Environment Canterbury. NIWA, Christchurch.

[26] Riegen, A .C. & Dowding, J.E. 2003. The Wrybill *Anarhynchus frontalis*: a brief review of status threats and work in progress. Wader Study Group Bull. 100: 20-24.

[27] O'Donnell, C.; Hoare, J.M. 2011. Meta-analysis of status and trends in breeding populations of black-fronted terns *Chlidonias albostriatus*, 1962-2008. New Zealand Journal of Ecology. 35 (1) 30 – 43.

[28] Miskelly, C.M., Dowding, J.E., Elliot, G.P., Hitchmough, R.A., Powlesland, R.G., Robertson, H.A., Sagar, P.M., Scofield, R.P., Taylor, G.A. 2008. Conservation Status of New Zealand Birds. *Notornis* 55(3):117-135.

[29] McClellan R.K. 2009. The ecology and management of Southland's black-billed gulls. PhD thesis, University of Otago.

[30] Keedwell, R.J.; Maloney, R.F.; Murray, D.P. 2002a: Predator control for protecting kaki (*Himantopus novaezelandiae*) – lessons from 20 years of management. Biological Conservation 105: 369-374.

[31] Gaze, P., Steffens, K. 2012. A review of seven years of black-fronted tern management on the Wairau with recommendations for the future. Unpublished Report, Department of Conservation, Nelson.

[32] Cleland, S.; Aitcheson, S.; Barr, T.; Currall, G.; Burke, C.; Guilford, P.; Fairhall, M.; Murray, D.; Nelson D.; Maloney, R. 2010. Predator Control Project Report for Kaki Recovery Programme A: Tasman Valley B: Ahuriri Valley March 200 – February 2010 Kaki Project Internal Report 10/04, Department of Conservation, Twizel.

Effects on food supplies/foraging habitat

44. As discussed in more detail in my statement of evidence in relation to the Waiau River, most birds on braided rivers feed – to varying degrees – on a combination of aquatic prey and terrestrial prey and plants, from both on-river and off-river food sources. An adequate food supply is clearly essential for birds, although there is no evidence that in-stream food supplies are a limiting factor for braided river birds.

45. Mr Jowett has modelled the effects of flow on in-stream habitat availability in the Amuri reach, and considers in his evidence how this might affect in-stream biota, some of which form part of the diet of river birds. Mr Jowett concludes that, under the proposed BHP and irrigation flow regimes, between 89% and 100% of habitat for the mayfly *Deleatidium* (the main aquatic invertebrate prey of river birds) would be retained during the bird nesting season. He also predicts that the area of the more general 'food producing' habitat would either remain the same or increase slightly.

46. In my opinion, these small potential effects are very unlikely to affect the ability of river birds to obtain food, particularly given that other food sources are also used, and numerous other factors also influence foraging efficiency and food availability (e.g. prey behaviour, weather, recent floods, and substrate).

CONCLUSIONS

47. In my opinion, the diversity and numbers of birds present, including breeding populations of threatened species, make the Hurunui River as a whole, and the Amuri reach on its own, significant habitats of indigenous fauna in terms of Section 6(c) of the RMA.

48. The full implementation of the flow and allocation regime in the Proposed Plan would have negligible effect on the risk of floods destroying nests or drowning chicks because floods would be only very slightly reduced by hydro, or hydro and irrigation combined.

49. The full implementation of the flow and allocation regime in the Proposed Plan is likely to exacerbate weed invasion by reducing disturbance along channel margins, resulting in a loss of suitable habitat for native plants and birds unless weed control efforts are increased. The effects of the BHP alone will be less than this.

50. The reduction in number of braids as a result of the full implementation of the flow and allocation regime in the Proposed Plan could make it easier for

mammalian predators to reach and prey upon eggs, chicks and adults at nests. The proportion of birds affected and the increase in risk would be small, in my opinion. However, any increase in predation could not be reliably mitigated because, to date, no reliable methods of reducing predation on braided river birds have been established, despite substantial work with this aim over the past 30 years.

51. The predicted small decreases and increases in availability of instream habitat of the aquatic prey of river birds are very unlikely to adversely or beneficially affect the ability of birds to obtain food. Terrestrial and off-river aquatic food sources will be unaffected.

52. Overall, I conclude that the flow and allocation regime in the Proposed Plan could be fully implemented while providing for appropriate management of feeding and nesting habitat of braided river birds, but it would carry a small risk of increased predation on river birds. The effects of the BHP alone are less than implementing the full flow and allocation regime.

Mark David Sanders

12 October 2012

APPENDIX A. Bird surveys

Birds on the Hurunui River, were surveyed each year from 2006 to 2010 by Professor Ken Hughey and volunteers[33], and Environment Canterbury (ECan), Department of Conservation (DOC), and volunteers.[34] The river was divided into 11 (DOC) or 12 (Hughey) sections (Table A1) for the purposes of river bird counts, and the number of each species was recorded separately for each section.

The Amuri reach was surveyed in all five years, but not all sections of the river above Mandamus were surveyed in all years, and one section below the Amuri reach (Lowry to SH1) was not surveyed in 2007, as follows. In 2006, Hughey's Section 7 was not surveyed. In 2007, Hughey's sections 3,4,5,7, and 10 were not surveyed. In 2008, sections 3,4,5,6,7, were not surveyed. In 2009 and 2010, only the river from Mandamus to the mouth was surveyed.

Table A1. River sections as used in surveys by Hughey[33] and DOC[34].

Hughey's section numbers	DOC section numbers	Section length (km)	Section description	Location in relation to the Amuri reach
1	1	12.6	MHI to Lake Mason outlet stream (South branch)	Above
2	2	18.1	Lake Mason outlet stream to Gorge (South branch)	Above
3/4	3	20.6	Upper North Branch to Lake Sumner	Above
5	4	14.9	North branch from Lake outlet to South Branch confluence	Above
6	5	4.7	Confluence to Maori Gully	Above
7	6	19.5	Maori Gully to Mandamus	Above
8	7	20.4	Mandamus to SH7	Entirely within Amuri reach..
9	8	12.1	SH7 to Lowry	Top 8.2 km is within Amuri reach
10	9	20.1	Lowry to SH1	Below
11	10	16.7	SH1 to River mouth	Below
12	10	2.3	River mouth	Below
Total length:		162		

[33] Hughey K.F.D. 2009. Statement of evidence of Kenneth Frederick David Hughey on behalf of the Director-General of Conservation and the Royal New Zealand Forest and Bird Society, in relation to an Application for a Water Conservation Order for the Hurunui River. 6 March 2009.

[34] DOC unpublished data.

Table A2. Bird survey data. Data source: Hughey[35] and DOC.[36]

	2006				
Species	Above Mandamus	Mandamus - SH7	SH7 - Lowry	Below Lowry	Total
Pied oystercatcher *Haematopus finschi*	94	33	12	98	237
Pied stilt *Himantopus himantopus leucocephalus*	9	37	17	45	108
Banded dotterel *Charadrius bicinctus bicinctus*	196	60	42	152	450
Wrybill *Anarhynchus frontalis*	0	0	0	0	0
Black-billed gull *Larus bulleri*	6	4	104	644	758
Black-fronted tern *Chlidonias albostriatus*	43	71	274	216	604
Black shag *Phalacrocorax carbo novaehollandiae*	13	3	8	35	59
Pied shag *Phalacrocorax varius varius*	0	0	0	11	11
Little shag *Phalacrocorax melanoleucos brevirostris*	0	2	0	3	5
Spotted shag *Stictocarbo punctatus*	0	0	0	0	0
White-faced heron *Ardea novaehollandiae*	0	8	3	43	54
Canada goose *Branta canadensis*	71	71	14	83	239
Duck species	23	85	35	150	293
Paradise shelduck *Tadorna variegata*	258	105	202	237	802
Grey teal *Anas gracilis*	1	0	0	0	1
NZ shoveler *Anas rhynchotis*	2	0	0	0	2
NZ Scaup *Aythya novaeseelandiae*	0	0	0	0	0
Variable oystercatcher *Haematopus unicolor*	0	0	0	2	2
Black-fronted dotterel *Charadrius melanops*	0	0	0	13	13
Spur-winged plover *Vanellus miles novaehollandiae*	101	132	116	360	709
Southern black-backed gull *Larus dominicanus*	267	1228	350	454	2299
Red-billed gull *Larus novaehollandiae scopulinus*	0	0	0	39	39
Caspian tern *Hydroprogne caspia*	0	0	0	0	0
White-fronted tern *Sterna striata striata*	0	0	0	190	190
Kingfisher *Todiramphus sanctus vagans*	0	3	1	3	7
Welcome swallow *Hirundo tahitica neoxena*	5	0	0	61	66
Pipit *Anthus novaeseelandiae novaeseelandiae*	32	4	1	4	41

[35] Hughey K.F.D. 2009. Statement of evidence of Kenneth Frederick David Hughey on behalf of the Director-General of Conservation and the Royal New Zealand Forest and Bird Society, in relation to an Application for a Water Conservation Order for the Hurunui River. 6 March 2009.

[36] DOC unpublished data.

Table A2 continued.

	2007				
Species	Above Mandamus	Mandamus-SH7	SH7-Lowry	Below Lowry	Total
Pied oystercatcher *Haematopus finschi*	39	13	14	30	96
Pied stilt *Himantopus himantopus leucocephalus*	0	2	9	76	87
Banded dotterel *Charadrius bicinctus bicinctus*	68	64	59	82	273
Wrybill *Anarhynchus frontalis*	0	0	0	0	0
Black-billed gull *Larus bulleri*	0	10	4	2	16
Black-fronted tern *Chlidonias albostriatus*	24	114	19	128	285
Black shag *Phalacrocorax carbo novaehollandiae*	3	15	36	15	69
Pied shag *Phalacrocorax varius varius*	0	0	0	1	1
Little shag *Phalacrocorax melanoleucos brevirostris*	0	1	0	0	1
Spotted shag *Stictocarbo punctatus*	0	0	0	2	2
White-faced heron *Ardea novaehollandiae*	0	7	8	11	26
Canada goose *Branta canadensis*	56	159	91	16	322
Duck species	3	67	114	56	240
Paradise shelduck *Tadorna variegata*	56	42	55	2	155
Grey teal *Anas gracilis*	0	0	0	2	2
NZ shoveler *Anas rhynchotis*	0	0	0	2	2
NZ Scaup *Aythya novaeseelandiae*	0	0	0	1	1
Variable oystercatcher *Haematopus unicolor*	0	0	0	14	14
Black-fronted dotterel *Charadrius melanops*	0	0	0	11	11
Spur-winged plover *Vanellus miles novaehollandiae*	29	7	23	16	75
Southern black-backed gull *Larus dominicanus*	248	695	336	330	1609
Red-billed gull *Larus novaehollandiae scopulinus*	0	0	0	4	4
Caspian tern *Hydroprogne caspia*	0	0	0	0	0
White-fronted tern *Sterna striata striata*	0	0	0	0	0
Kingfisher *Todiramphus sanctus vagans*	0	0	0	6	6
Welcome swallow *Hirundo tahitica neoxena*	7	2	8	1	18
Pipit *Anthus novaeseelandiae novaeseelandiae*	0	0	0	0	0

Table A2 continued.

	2008				
Species	Above Mandamus	Mandamus-SH7	SH7-Lowry	Below Lowry	Total
Pied oystercatcher *Haematopus finschi*	56	19	12	35	122
Pied stilt *Himantopus himantopus leucocephalus*	7	3	14	47	71
Banded dotterel *Charadrius bicinctus bicinctus*	101	23	4	172	300
Wrybill *Anarhynchus frontalis*	0	0	0	0	0
Black-billed gull *Larus bulleri*	0	35	3	1085	1123
Black-fronted tern *Chlidonias albostriatus*	23	45	26	242	336
Black shag *Phalacrocorax carbo novaehollandiae*	7	5	6	6	24
Pied shag *Phalacrocorax varius varius*	0	2	0	11	13
Little shag *Phalacrocorax melanoleucos brevirostris*	0	0	2	8	10
Spotted shag *Stictocarbo punctatus*	0	0	0	0	0
White-faced heron *Ardea novaehollandiae*	4	13	5	5	27
Canada goose *Branta canadensis*	14	179	54	127	374
Duck species	13	40	34	118	205
Paradise shelduck *Tadorna variegata*	77	29	22	75	203
Grey teal *Anas gracilis*	0	2	0	8	10
NZ shoveler *Anas rhynchotis*	0	0	0	0	0
NZ Scaup *Aythya novaeseelandiae*	0	0	0	6	6
Variable oystercatcher *Haematopus unicolor*	0	0	0	1	1
Black-fronted dotterel *Charadrius melanops*	0	0	0	1	1
Spur-winged plover *Vanellus miles novaehollandiae*	21	9	8	115	153
Southern black-backed gull *Larus dominicanus*	139	1270	280	599	2288
Red-billed gull *Larus novaehollandiae scopulinus*	0	0	0	5	5
Caspian tern *Hydroprogne caspia*	0	0	0	0	0
White-fronted tern *Sterna striata striata*	0	12	1	131	144
Kingfisher *Todiramphus sanctus vagans*	0	0	3	2	5
Welcome swallow *Hirundo tahitica neoxena*	0	2	0	28	30
Pipit *Anthus novaeseelandiae novaeseelandiae*	0	1	0	0	1

Table A2 continued.

	2009				
Species	Above Mandamus	Mandamus-SH7	SH7-Lowry	Below Lowry	Total
Pied oystercatcher *Haematopus finschi*	ns	35	9	54	98
Pied stilt *Himantopus himantopus leucocephalus*	ns	26	21	34	81
Banded dotterel *Charadrius bicinctus bicinctus*	ns	28	18	159	205
Wrybill *Anarhynchus frontalis*	ns	0	0	2	2
Black-billed gull *Larus bulleri*	ns	34	1022	49	1105
Black-fronted tern *Chlidonias albostriatus*	ns	154	88	326	568
Black shag *Phalacrocorax carbo novaehollandiae*	ns	4	12	2	18
Pied shag *Phalacrocorax varius varius*	ns	0	0	14	14
Little shag *Phalacrocorax melanoleucos brevirostris*	ns	5	0	2	7
Spotted shag *Stictocarbo punctatus*	0	0	0	0	0
White-faced heron *Ardea novaehollandiae*	ns	0	3	18	21
Canada goose *Branta canadensis*	ns	121	80	22	223
Duck species	ns	66	71	64	201
Paradise shelduck *Tadorna variegata*	ns	107	52	87	246
Grey teal *Anas gracilis*	ns	3	18	12	33
NZ shoveler *Anas rhynchotis*	0	0	0	0	0
NZ Scaup *Aythya novaeseelandiae*	ns	0	0	8	8
Variable oystercatcher *Haematopus unicolor*	ns	0	0	0	0
Black-fronted dotterel *Charadrius melanops*	ns	1	0	0	1
Spur-winged plover *Vanellus miles novaehollandiae*	ns	30	13	151	194
Southern black-backed gull *Larus dominicanus*	ns	1024	891	367	2282
Red-billed gull *Larus novaehollandiae scopulinus*	ns	0	0	20	20
Caspian tern *Hydroprogne caspia*	ns	0	0	2	2
White-fronted tern *Sterna striata striata*	ns	2	0	68	70
Kingfisher *Todiramphus sanctus vagans*	ns	4	2	2	8
Welcome swallow *Hirundo tahitica neoxena*	ns	0	4	12	16
Pipit *Anthus novaeseelandiae novaeseelandiae*	ns	2	0	0	2

Table A2 continued.

	2010				
Species	Above Mandamus	Mandamus-SH7	SH7-Lowry	Below Lowry	Total
Pied oystercatcher *Haematopus finschi*	ns	70	14	55	139
Pied stilt *Himantopus himantopus leucocephalus*	ns	14	3	47	64
Banded dotterel *Charadrius bicinctus bicinctus*	ns	55	25	160	240
Wrybill *Anarhynchus frontalis*	ns	0	0	5	5
Black-billed gull *Larus bulleri*	ns	22	0	203	225
Black-fronted tern *Chlidonias albostriatus*	ns	152	58	70	280
Black shag *Phalacrocorax carbo novaehollandiae*	ns	10	7	23	40
Pied shag *Phalacrocorax varius varius*	ns	0	0	0	0
Little shag *Phalacrocorax melanoleucos brevirostris*	ns	0	0	22	22
Spotted shag *Stictocarbo punctatus*	0	0	0	0	0
White-faced heron *Ardea novaehollandiae*	ns	22	15	27	64
Canada goose *Branta canadensis*	ns	224	176	103	503
Duck species	ns	108	54	158	320
Paradise shelduck *Tadorna variegata*	ns	72	10	110	192
Grey teal *Anas gracilis*	ns	0	0	2	2
NZ shoveler *Anas rhynchotis*	0	0	0	0	0
NZ Scaup *Aythya novaeseelandiae*	ns	0	0	0	0
Variable oystercatcher *Haematopus unicolor*	ns	0	0	0	0
Black-fronted dotterel *Charadrius melanops*	ns	0	0	0	0
Spur-winged plover *Vanellus miles novaehollandiae*	ns	88	35	99	222
Southern black-backed gull *Larus dominicanus*	ns	1665	763	254	2682
Red-billed gull *Larus novaehollandiae scopulinus*	ns	0	0	2	2
Caspian tern *Hydroprogne caspia*	ns	0	0	2	2
White-fronted tern *Sterna striata striata*	ns	0	0	3	3
Kingfisher *Todiramphus sanctus vagans*	ns	4	2	4	10
Welcome swallow *Hirundo tahitica neoxena*	ns	0	0	5	5
Pipit *Anthus novaeseelandiae novaeseelandiae*	ns	0	0	0	0

APPENDIX B. Representative photographs of the Hurunui River.

Photo 1. Hurunui River approximately 17 km upstream of the Mandamus River confluence. This is within DOC bird survey section 6.

Photo 2. Hurunui River 11 km above the Mandamus confluence.

Photo 3. Hurunui River just above Mandamus, at lower end of gorge.

Photo 4. Hurunui River, Amuri Plains reach, near The Peaks.

Photo 5. Hurunui River: Stable terrace vegetation on Amuri Plains reach.

Photo 6. Amuri Plains reach on Hurunui River, looking downstream, and showing pine plantation on the north bank.

Photo 7. Narrow riparian strip of willows on the south banks of Amuri Plains reach of the Hurunui River.

Photo 8. Sparse vegetation including native *Raoulia* species within the Amuri reach of the Hurunui River.

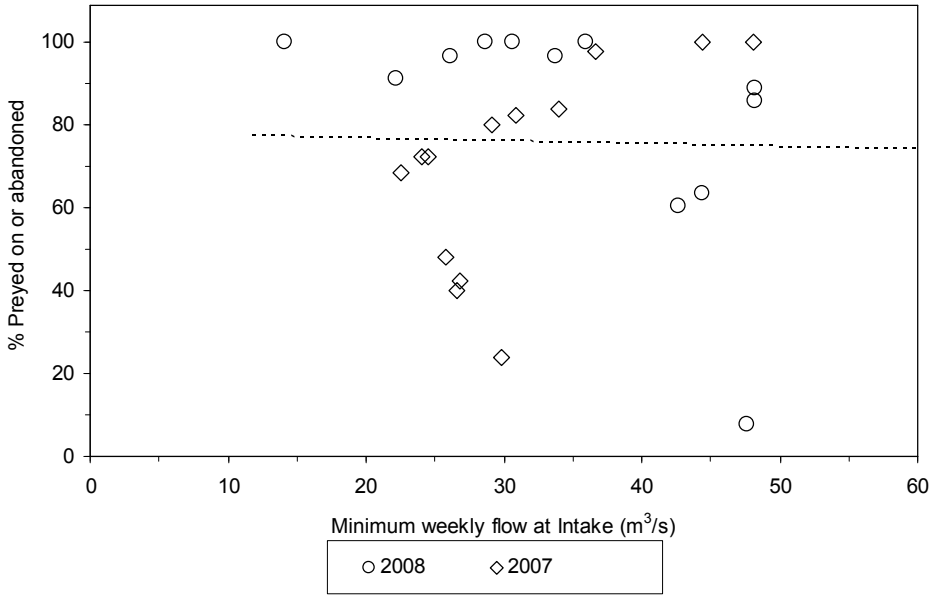
Photo 9. Aerial photograph of the Amuri reach of the Hurunui River
(Photo: Google Earth)

Photo 10. Hurunui River passing through the Lowry Peaks range.

Photo 11. Old bridge over Hurunui River, approximately 6.6 km above SH1.

Photo 12. Hurunui River mouth, looking north.

APPENDIX C. Relationship between flow and predation rate on Wairau River, Marlborough



Relationship between combined depredation and abandonment rate of black-fronted tern nests on the Wairau River, and flow, on a weekly basis, over the 2007 (diamonds; 929 nests over 13 weeks) and 2008 (circles; 561 nests over 12 weeks) breeding seasons. Abandoned nests are included because terns often abandon in response to predation on nearby nests. Flooded nests are excluded. Dashed line is the line of best fit to all data (using the least squares method). Source: Sanders 2009.