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. I operate an ecological consultancy, Sanders Consulting Ltd, based in Lincoln. I have a Bachelor of Science with Honours in Zoology (1992) and a Doctor of Philosophy in Zoology (1997) from the University of Canterbury.

2. I have 16 years' experience as an applied ecologist, working mainly on river ecosystem management. Prior to starting my own consultancy, I worked for Boffa Miskell (Christchurch), Macquarie University (Sydney), and the Department of Conservation (Twizel).

3. I am a member of the Ornithological Society of New Zealand, the Freshwater Sciences Society of New Zealand, the New Zealand Ecological Society, and the Environment Institute of Australia and New Zealand. I am a Certified Environmental Practitioner.

4. I have conducted and supervised management and research on a range of topics, including avian and mammalian predation on braided river birds, bird breeding success, indigenous vegetation of braided rivers, weed invasion and management, and wetland construction and management. I have published two book chapters and 12 scientific papers in the peer-reviewed scientific literature, including work on the impact of avian and mammalian predators on braided river birds; aspects of aquatic invertebrate ecology and avian foraging ecology, and conservation management of rivers.

5. I am a member of the New Zealand Braided River Technical Advisory Group, which is co-ordinated by the Department of Conservation. In that role, I am currently co-writing a National Braided River Recovery Strategy.

6. During the past six years, a large part of my work has involved assessments of the potential impacts of hydroelectric power schemes on water birds throughout New Zealand, including on the Waiau River in Southland, and the Rakaia, Shotover, Waitaki, and Wairau Rivers. I have also designed and led trials on predator control and habitat enhancement on the Waitaki River and rivers of the upper Waitaki Catchment.

7. I have presented evidence in relation to braided river ecology at Council, Environment Court, and Water Conservation Order Tribunal hearings. These include Environment Court hearings relating to hydroelectric power schemes proposed by Meridian Energy for the North Bank of the Waitaki River, and by TrustPower for the Wairau River, and the recent Rakaia Water Conservation Order hearing.

8. 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

9. In my evidence I consider only the Waiau River. I assess the potential effects on braided river birds and terrestrial vegetation that could arise as a result of the proposed Hurunui and Waiau River Regional Plan (the Proposed Plan) flow and allocation regime as follows.

    a. I provide a general overview of the ecology of braided river birds;

b. I outline the methods I used in assessing the effects of the proposed Amuri Hydro Project (AHP), and hence the proposed plan flow and allocation regime;

c. I describe the bird and plant communities of the Waiau River, with particular emphasis on the Amuri Plains reach; and,

d. I assess the potential effects on braided river birds and terrestrial vegetation.

10. I understand that the proposed plan included 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.

11. Meridian Energy Limited (Meridian) and Ngai Tahu Property Limited (NTPL) have applied for the principal resource consents required for their proposed AHP on the Waiau River, as described in the evidence of Mr Jeff Page. This scheme would take water just below the Leslie Hills bridge (also known as the 'Twin Bridges'), and return it to the river, up to 29 km downstream, below Waiau township. I will refer to this section as the 'Amuri Plains reach'. I have previously assessed the effects on braided river birds and terrestrial vegetation[1] of the AHP for the purposes of the Assessment of Environmental Effects associated with Meridian and NTPL's consent applications, which were lodged in October 2011.

12. The hydrological effects of the proposed AHP, as modelled for those consent applications, are described by Mr Steven Woods in his evidence. The modelled flow regime complies with the

1 Boffa Miskell. 2011. Amuri Hydro Project: Wetlands, Birds and Terrestrial Ecology Assessment. Report prepared for Meridian Energy Ltd, September 2011.

proposed Environmental Flow and Allocation Regime for the Waiau River as set out in the Proposed Plan, except that the 2 m^3/s 'gap' between the A and B blocks proposed in the plan is not included in the model. As explained by Mr Woods, the effect of this is that the model slightly over-estimates the amount of water that the proposed AHP would take. This makes no difference because the differences are very small.

13. Mr Woods also states that in his opinion the generation flow of up to 50 m³/s represents the economic upper limit for hydropower development under the Proposed Plan, and therefore his assessment of the hydrological effects of operating the proposed AHP is equivalent to the effects of fully implementing the allocation regime in the Proposed Plan. On the basis of Mr Woods' opinion, I consider that my assessment of the proposed AHP also provides an appropriate assessment of implementing the flow and allocation regime, for the Waiau River, in the Proposed Plan.

SUMMARY OF MAIN FINDINGS

14. The Waiau River, particularly the Amuri Plains reach, provides large areas of suitable habitat for braided river birds. Recent surveys have recorded 32 species on the Waiau River. Nine '*Threatened'* or '*At Risk*' species have been recorded within the Amuri Plains reach, including breeding populations of the *Nationally Endangered* black-fronted tern and black-billed gull. In my opinion, the Waiau 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.

15. The 'active' river bed has fairly extensive areas of bare gravels, which are almost entirely devoid of native or introduced vegetation, although substantial, well-established areas of exotic woody vegetation and trees are present within the active river

bed, and along the river margins. Some native vegetation is present on more stable terraces away from the active river bed.

16. I assessed the potential effects of the proposed AHP, and hence the proposed plan flow and allocation regime, on native terrestrial plant communities arising from altered flood regimes, and on river birds arising from possible changes in habitat suitability, food supplies, and vulnerability of nests to predation and floods.

17. The risk of floods destroying nests or drowning chicks is unlikely to be affected. This is because, while lower flows may allow some birds to nest at lower, more flood-prone sites, freshes and floods at flows below 210 m^3/s would be smaller, resulting in little or no net change in flood risk to birds. At flows above 210 m^3/s, which occur eight times per annum on average, the water take for the proposed AHP would cease, and flood risk to birds would therefore be unaltered.

18. Weed invasion is likely to be exacerbated by the proposed plan flow and allocation regime resulting in a loss of suitable habitat for native plants and birds.

19. The availability of habitat for aquatic macroinvertebrates, which provide a food source for many river birds, could be reduced by approximately 15 to 22% compared with existing irrigation development in the bird breeding season. There is no evidence that food is limiting birds in braided rivers, and in my opinion, this reduction is unlikely to adversely affect the ability of birds to obtain food. Terrestrial and off-river aquatic food sources would be unaffected.

20. The loss of approximately 20% of braids as a result of the proposed plan flow and allocation regime, as demonstrated by my assessment of the proposed AHP, could make it easier for mammalian predators to reach and prey upon eggs, chicks and

adults at nests on islands. The proportion of birds affected and the increase in risk would probably be small. However, in my opinion, 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.

OVERVIEW OF BRAIDED RIVER BIRD ECOLOGY

21. New Zealand's braided rivers provide habitat for a diversity of birds, with more than 80 species recorded on these habitats[2]. Around 30 species are commonly found on braided rivers, mainly comprising various species of gulls, terns, waders, waterfowl, and cormorants ('shags'). Many of these species are endemic to New Zealand, and several are threatened. Braided rivers are the main breeding habitats for many of these species and are therefore important for their long-term survival.

22. Bird use of braided rivers varies with season. The general pattern is for gulls, terns and waders to begin arriving on these rivers in late winter, nest between September and December, and then migrate downstream toward the coast, often congregating at estuaries and lagoons. Many then fly north during January to March to spend autumn to winter on coastal habitats in the North Island.

23. There is considerable variation in this pattern among species and from year to year. Many birds continue to use the rivers year-round, although rivers are most important for birds during the breeding season. During the non-breeding season, conditions away from the river, such as on wintering habitats and along migratory routes, are also likely to influence bird population size.

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2 O'Donnell, C. 2004. River bird communities Pp. 18.1 – 18.19. In: Harding, J.S.; Mosley, M.P.; Pearson, C.P.; and Sorrel, B.K. (editors) Freshwaters of New Zealand. New Zealand Hydrological Society Inc. and New Zealand Limnological Society Inc. Christchurch, New Zealand.

24. The birds vary greatly in the extent to which they depend on braided river habitats. The most specialised species, the wrybill, nests only on braided rivers, whereas others, such as black-fronted terns and black-billed gulls, sometimes nest and feed on other habitats, such as adjacent terraces, pasture, or wetlands. For others, such as waterfowl and cormorants, braided rivers are one of a wider range of habitats commonly used.

25. Almost all of these species nest on the ground, and prefer open expanses of bare or sparsely-vegetated substrates. Eggs and chicks are vulnerable to floods and predators, both mammalian and avian, and these factors typically result in high rates of mortality (often >75% egg loss).[3,4,5,6] Research using video cameras, DNA analysis, and direct observations has shown that cats, ferrets, hedgehogs, and stoats are the main mammalian predators, and harriers and southern black-backed gulls the main avian predators at river bird nests.[6, 7, 8, 9]

26. Birds that nest on islands tend to enjoy slightly higher nest success rates, on average, than those on river banks or 'mainland' sites because water – even very low flow – appears to deter some mammalian predators from accessing islands.[3,4,10,11] However, this effect is weak and highly variable; predation by mammals is still very common on islands.

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3 Boffa Miskell. 2007. Black-fronted tern trial: effects of flow and predator control on breeding success. Unpublished report prepared for Meridian Energy by Boffa Miskell Limited in conjunction with Urtica Consulting, April 2007.

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

5 Keedwell, R.J. 2005: Breeding biology of Black-fronted Terns (Sterna albostriata) and the effects of predation. Emu 105: 39-47.

6 Keedwell, R.J.; Sanders, M.D.; Alley, M.; Twentyman, C. 2002: Causes of mortality of black-fronted terns Sterna albostriata on the Ohau River, South Island, New Zealand. Pacific Conservation Biology 8: 170-176.

7 Steffens K.E., Sanders M.D., Gleeson D.M., Pullen K.M., & Stowe C.J. 2012. Identification of predators at black-fronted tern *Chlidonias albostriatus* nests using mtDNA analysis and digital video recorders. *New Zealand Journal of Ecology* 2012 (36)1: 48-55.

8 Sanders, M. D. & Maloney R.F. (2002). Causes of mortality at nests of ground-nesting birds in the Upper Waitaki Basin, New Zealand: a five-year video study. *Biological Conservation*, 106(2), 225-236.

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

10 Pierce, R.J. 1987: Predators in the Mackenzie Basin: their diet, population dynamics and impact on birds in relation to the abundance and availability of their main prey (rabbits). Unpublished Wildlife Service Report, Wellington, New Zealand.

27. Braided river birds feed, to varying extents, on fish, aquatic and terrestrial invertebrates, and plants.[12] Foraging habitat requirements vary. For example, wading birds such as wrybills, stilts and oystercatchers forage, at various depths according to species, along the edges of channels or pools, and in wet substrates. In contrast, black-fronted terns feed on drifting or emerging insects and fish at or near the water surface, and flying insects, terrestrial invertebrates, and sometimes skinks.

METHODS

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

29. I surveyed the vegetation of the river bed and riparian margins during aerial observations and inspections on the ground in May, August, and December 2011, at a number of locations along the Amuri Plains reach. I was assisted in the vegetation survey of August 2011 by Ms Carol Jensen, who is an experienced botanist. I relied on Ms Jensen for identification of some plant species.

30. Birds on the Waiau River were surveyed in 2008, 2009, and 2010 by the Department of Conservation (DOC), Environment Canterbury (ECan), and volunteers.[13] I collated the data from these surveys, and supplemented them with a helicopter survey of key bird species which I made with two other experienced bird surveyors on 13 December 2011. The DOC and ECan surveys covered the river from the mouth to Waterfall Creek (101 km).

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11 Rebergen, A.; Keedwell, R.; Moller, H.; Maloney, R. 1998: Breeding success and predation at nests of banded dotterel (Charadrius bicinctus) on braided riverbeds in the central South Island, New Zealand. New Zealand Journal of Ecology 22(1): 33-41.

12 Heather, B.; Robertson, H. 1996: Field guide to the birds of New Zealand. Viking, Auckland, New Zealand.

13 Schmechel F. 2008. Braided River Bird Surveys of the Waiau River and Eight Smaller Canterbury Rivers, Spring 2008. Environment Canterbury Report.

The helicopter survey covered the same area plus an additional 25 km upstream, to Windy Point on the Hope River. Details of the bird survey methods are presented in Appendix A.

31. The data from these surveys provide a good picture of the bird species that are present on the Waiau River and their distribution and abundance, and, in my view, form a sound basis for my assessment.

32. I assessed the suitability of the Waiau River as bird habitat from observations during my aerial survey, from aerial photography, and from on-ground habitat inspections in the Amuri Plains reach in May, August, and December 2011.

33. I then 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.

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

    d) Dr Dean Olsen – In-stream aquatic invertebrates.

VALUES OF THE EXISTING ENVIRONMENT

Vegetation

34. The river margins are in places densely lined with trees, mainly crack willows but also occasional poplars, alders, pines and kanuka. Exotic woody weeds (yellow tree lupin, gorse, broom, blackberry) are also common throughout the Amuri Plains reach and in places form a dense understory. Various exotic grasses

and herbs[14] are common on the Waiau River bed, as is typical of many braided rivers[15].

35. The 'active' river bed has fairly extensive areas of bare gravels, which are almost entirely devoid of native or introduced vegetation, although substantial, well-established areas of exotic woody vegetation and trees are also present in places within the active river bed, as can be seen in photographs in Appendix E.

36. Native plants are present, although rarely dominant, within the various vegetation types along the river and its margins. I found occasional cabbage trees, harakeke (New Zealand 'flax'), tutu and toe toe in places along the riparian margins, and regenerating kanuka in various places along the edge of developed farmland on both banks of the Amuri Plains reach. I also saw scattered matagouri, kowhai, and porcupine scrub on the south bank. On some stable gravel terraces, not within the active river 'fairway', low stature native plants are common; during the August survey, Ms Jensen and I found creeping pohuehue, *Hebe traversii*, and five species of native scabweeds[16] on stable terraces on the northern side of the river.

River Birds

37. The birdlife of the Waiau River is concentrated in three wide, braided reaches within the Hanmer Plains, the Amuri Plains, and around State Highway 1. These reaches provide the largest areas of suitable habitat and support the greatest number and diversity of water birds. The assemblage of birds found on the river is typical of braided rivers on the east coast of the South Island.

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14 e.g. self-heal, stonecrop, procumbent pearlwort, viper bugloss, woolly mullein, sheep sorrel.

15 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.

16 *Raoulia australis, R. tenuicaulis, R. subsericea, R. haastii* and *R. monroi*

38. In the recent surveys, 32 species were recorded. The results of these surveys are summarised in Appendices B and C, where I have separated counts within, below, and above the Amuri Plains reach of the river, for each year surveyed. The species recorded include seven species classified as *Threatened* and eight as *At Risk* under the New Zealand Threat Classification System (Appendix D).[17,18] Of these 15 species, nine species were sighted within the Amuri Plains reach, and four were sighted only at the river mouth or on the lower reaches of the river (Table 1).

39. In Table 2, I present the counts from the recent on-river surveys of five key species: pied oystercatcher, banded dotterel, wrybill plover, black-billed gull, and black-fronted tern. I have chosen to focus on these five species because, in my opinion, they are of the greatest value from a conservation perspective because of their threat status and/or numbers present on the Waiau River. They are highly-dependent on braided rivers for breeding, foraging, and roosting habitat, and the factors that affect these species are also likely to affect other, less vulnerable bird species.

40. Table 2 shows the number of each of these five species counted in the 2008, 2009, and 2010 surveys, separated according to whether they were seen above, within, or below the Amuri Plains reach. This table shows that the Amuri Plains reach supports a relatively large proportion of these birds counted on the Waiau River in recent surveys, although numbers vary from year to year. For example, the Amuri Plains reach supported 93% of the 2035 black-billed gulls counted on the river in 2008, but only 12% of the 734 counted in 2010. This variability is

17 Townsend, A.J.;de lange, P.J.; Duffy, C.A.J.; Mickelly, C.M.; Molloy, J.; Norton, D.A. 2008. New Zealand Threat Classification System Manual. Science and Technical Publishing, Department of Conservatrion, Wellington, New Zealand.

18 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.

typical of black-billed gulls which move about within and between rivers from year to year.[19,20] Numbers and proportions of black-fronted terns and banded dotterels were more stable, with between 44% and 51% of both species counted within the Amuri Plains reach over the three on-river surveys. The helicopter surveys yielded similar results to the on-river surveys (Appendix C).

41. During the helicopter survey, eight black-fronted tern colonies were found: five above the Amuri Plains reach (259 individuals), two within (514 individuals), and one below (32 individuals). During this survey, most terns (84%) nesting in colonies on the river were located on islands. The terns on islands might have had some partial protection from mammalian predators (but not avian predators) compared to those nesting on 'mainland' or bank sites, although some of the islands were likely to support their own predator populations. For example, one of the two black-fronted terns colonies within the Amuri Plains reach was located on a large island with established scrub and willow forest (Photos 1 & 2; Appendix E), which would provide suitable habitat for mammalian predators.

42. In my opinion, the diversity and numbers of birds present, including breeding populations of threatened species, make the Waiau River as a whole, and the Amuri Plains reach on its own, significant habitat in terms of Section 6(c) of the RMA. A similar conclusion was reached by O'Donnell in an assessment undertaken for ECan in 2000, of the significance of river and open water habitats for indigenous birds in Canterbury.[21]

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19 Boffa Miskell Ltd. 2011. North Bank Tunnel: Waitaki River Bird Surveys, 2010. Report prepared for Meridian Energy Ltd, April 2011.

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

21 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.

Table 1. Threatened and at risk species present on the Waiau River, following Miskelly *et al*.[22] under the New Zealand Threat Classification System.[23] CD=Conservation Dependent; DP=Data Poor; Inc=Increasing; RR=Range Restricted; SO=Secure Overseas; Sp=Sparse; TO=Threatened Overseas; De = Designated. See Appendix D for further details.

Species	Threat Classification	Recorded in Amuri Plains reach
Black-fronted tern	Threatened: Nationally Endangered [DP]	Y
Black-billed gull	Threatened: Nationally Endangered [De]	Y
Wrybill plover	Threatened: Nationally Vulnerable [RR]	Y
Banded dotterel	Threatened: Nationally Vulnerable [RR]	Y
Caspian tern	Threatened: Nationally Vulnerable [SO]	N
Pied shag*	Threatened: Nationally Vulnerable	N
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]	N
Royal spoonbill*	At Risk: Naturally Uncommon [Inc RR SO Sp]	N

* Present only at the river mouth or on the lower reaches of the river (except for one red-billed gull near Waiau Ferry bridge).

22 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.

23 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 Conservatrion, Wellington, New Zealand.

Table 2. Numbers of five key river bird species counted on the Waiau River, above, within, and below the Amuri Plains reach, during ground-based surveys in October/November 2008, 2009, and 2010 (Data source: Schmechel 2008[24] and DOC unpublished data). See Appendix B for data for all species.

Species	Above Amuri Plains reach [a]	Within Amuri Plains reach [b]	Below Amuri Plains reach [c]	Total
2008				
Pied oystercatcher	52	62	30	144
Banded dotterel	119	208	124	451
Wrybill	4	2	5	11
Black-billed gull	50	1909	76	2035
Black-fronted tern	195	264	61	520
2009	Above	Within	Below	Total
Pied oystercatcher	39	125	19	183
Banded dotterel	81	237	213	531
Wrybill	1	7	9	17
Black-billed gull	3	75	229	307
Black-fronted tern	235	375	213	823
2010	Above	Within	Below	Total
Pied oystercatcher	51	69	29	149
Banded dotterel	122	269	219	610
Wrybill	2	3	10	15
Black-billed gull	458	85	191	734
Black-fronted tern	198	274	157	629

[a] Waterfall stream to Twin Bridges; [b] Twin Bridges to Sandersons Road; [c] Sandersons Road to mouth.

ASSESSMENT OF EFFECTS OF THE PROPOSED SCHEME

Hydrological effects

43. Mr Woods has modelled the hydrological effects of four flow scenarios, including the AHP, for the Amuri Plains reach. Mr Woods describes these scenarios in detail in his evidence. They are, in brief:

    a) The Natural Flow. This is the flow at the Marble Point flow recorder, above the current and proposed takes.

24 Schmechel F. 2008. Braided River Bird Surveys of the Waiau River and Eight Smaller Canterbury Rivers, Spring 2008. Environment Canterbury Report.

b) The Status Quo. This is the 'existing environment', that is, the current flow regime including existing irrigation takes (i.e. The A block with the current monthly minimum flows).

c) Modelled Full Irrigation Development. This is predicted future irrigation only, and does not include any take for hydroelectric power generation (i.e. the A+B Block).

d) The Modelled Proposal, which I refer to as the proposed AHP. This consists of full irrigation development and additional take for hydroelectric power generation (i.e the A+B+C Block).

44. In my evidence, I compare the proposed AHP (or 'modelled proposal') with the status quo because, as I mentioned earlier, and as also explained by Mr Woods, this represents a plausible outcome of implementing the flow and allocation regime for the Waiau River in the Proposed Plan. Thus, in this evidence, I am presenting my assessment of the cumulative effects of takes for a scenario using the A, B and C allocation blocks in the proposed plan.

45. I will refer to specific relevant hydrological effects as necessary throughout my evidence; the main points of relevance to birds are that there will be prolonged periods of low flows, particularly during the bird breeding season, and that larger flood flows will be unaffected if the C Block is used by the proposed AHP.

Flood risk

46. The braided river bird nesting season corresponds with the period when floods are most frequent. It generally takes from seven to nine weeks for riverbed birds to develop to fledglings from the time eggs are laid, and during this period, nests and pre-fledgling chicks are vulnerable to floods. In seasons with large and/or frequent floods, floods can cause very high rates of

nest and chick mortality. Braided river birds typically re-nest rapidly after losing nests to floods, and can therefore still breed successfully. Nonetheless, floods still represent a major cause of mortality in many years.

47. The risk of flooding of river bird nests and chicks could be affected by the modelled proposal flow regime in two main ways, one adverse and one beneficial. First, the increased duration of low flows, particularly during the bird nesting season, could allow some birds to nest at lower elevation sites, where they could be more vulnerable to floods. Flow during the nesting season (September to December) would be reduced by up to 50 m^3/s for much of the time as a result of implementing the AHP.[25] This would result in a reduction in channel depth and width, and it is possible that some birds might nest on or close to the substrate that would otherwise have been inundated.

48. However, from detailed field measurements at one black-fronted tern colony; observations and photographs of other colonies and habitat availability on the Waiau River; Mr Jowett's modelling of flow, depth and wetted width; and my experience of other species on other rivers, it is my opinion that few birds would nest on or near this newly-exposed substrate. This is mainly because it would be frequently flooded which tends to deter birds in the first place, and large areas of other suitable habitat are available on this river (although weed encroachment could be an issue, as I will discuss next). Thus, few birds would be exposed to increased flood risk, in my opinion.

49. Second, and conversely, reductions in the magnitude or frequency of floods would result in a decreased risk that nests would be flooded or chicks drowned. Whilst floods greater than 210 m^3/s would not be affected by the AHP, which would shut

[25] MWH (2011). Amuri Hydro Project Hydrology Summary. Appendix 4 to *Resource Consent Application: Amuri Hydro Project*, Meridian Energy Ltd and Ngai Tahu Property, October 2011.

down during such flows, the magnitude of floods or freshes up to 210 m³/s would be reduced, as explained by Mr Woods. In other words, the AHP would essentially 'cut off' the peaks of these mid-range floods. Floods in this range occur frequently during the nesting season, and probably destroy some nests when they occur. However, in my opinion, any benefits of a reduction in the size of such floods would be small because the reduction in wetted width would be relatively small, and most nests would be located on higher ground, beyond the reach of these floods.

50. It is likely, in my opinion, that the net effect of these two effects would be to reduce the risk of nests being flooded, but overall any benefits from this would be negligible because only a small proportion of nests would be affected.

Bird habitat suitability and terrestrial vegetation

51. Braided river beds are readily colonised by some introduced weeds, such as broom, gorse, tree lupin, and various exotic grasses and herbs. Floods play a role in clearing weeds and maintaining bare substrates, and reducing the magnitude or frequency of floods can reduce their weed-clearing effects. This in turn can exacerbate weed encroachment, resulting in loss of native plant species, and a reduction in the amount of sparsely-vegetated substrates preferred by river birds. The AHP will not take water when flow is greater than 210 m³/s, which occurs eight times per annum, on average. Thus, the vegetation clearance effects of larger floods would not be directly affected.

52. However, floods or 'freshes' less than 210 m³/s would be reduced in size, and the river would be held at low flows for longer periods of time. This would result in a reduction in bed movement and lateral erosion, and would facilitate

establishment of weeds such as broom,[26] which is abundant in the river. River bed weeds often grow rapidly and once established, are not easily removed by floods. Thus, in my opinion, it is likely that the allocation of the C Block water in particular would exacerbate weed encroachment.[26] This would reduce the availability of suitable habitat for native plants and birds, and provide more suitable habitat for mammalian predators. However, any such increase in the spread of weeds could, if deemed necessary, be mitigated using established weed control techniques. Further, if some freshes less than 210 m³/s were allowed to pass down the river unimpeded for a time (12 h – 24 h) this might also have a benefit in limiting the establishment of exotic weeds on the river bed.

Predation risk

53. Generally, reducing flow in braided rivers results in fewer flowing braids, and therefore a reduction in the area and number of islands available as habitat for river birds[27]. Whilst non-island habitat may be physically suitable for birds, nests that are not on islands are, on average more likely to be preyed upon by mammalian predators than nest on islands, as I mentioned earlier. Avian predation risk is not affected by whether nests are on islands.

54. On the Waiau River, the modelled proposal would result in a reduction in the number of braids, as discussed by Mr Jowett in his evidence. Mr Jowett found that 18 of 88 braids (20%) that he surveyed that were flowing at 49.5 m³/s were no longer flowing at 15.1 m³/s, and another six had flows of <0.01 m³/s. He also found that the average number of braids reduced from 5.5 at

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26 Snelder, T.; Booker, D.; Jellyman, D.; Bonnett, M.; Duncan, M. 2011. Waiau River mid-range flows evaluation. Report prepared for Environment Canterbury, June 2011.

27 Duncan, M.J.; Hughey, K.F.D.; Cochrane C.H.; Bind J. 2008. River modelling to better manage mammalian predator access to islands in braided rivers. Pp. 487–492. *In*: *Sustainable Hydrology for the 21st Century. Proceedings of the 10th BHS National Hydrology Symposium, Exeter.*

50 m³/s to 4.4 at 15.1 m³/s. The reductions in channel size with decreasing flow are also illustrated by the series of photographs taken from the Waiau township bridge, presented by Ms Pflüger in her evidence. The greatest reductions in flow would occur throughout the bird nesting season, with monthly median reductions of up to 50 m³/s, from September to December, when compared with the status quo.

55. During the December 2011 aerial surveys, I found that 84% of black-fronted terns nesting on the Waiau River, and all of those nesting within the Amuri Plains reach, were nesting on islands. It is likely that most other breeding river birds within the affected reach would also be nesting on islands, given the wide, braided nature of the river and the predominance of island habitat.

56. With the AHP, the river would still provide a large number of islands, and a large area of island habitat. However, it is possible that some birds that would have been nesting on islands under the existing flow regime, would nest on 'mainland' or 'bank' habitat under the modelled proposal, as a result of the reduction in the number of braids. If so, eggs, chicks and incubating adults at those nests could be more vulnerable to mammalian predation.

57. Our current understanding of predator and prey behaviour in relation to flow is not sufficient to quantify this potential increase in predation risk. In my opinion, the proportion of birds affected is likely to be small given that the river would still retain most of its islands under the modelled proposal. The increase in the probability of predation is also likely to be small for three reasons: first, the protective effect of water is weak and variable (as I mentioned earlier); second, many of the islands in the river will already support mammalian predator populations because they have substantial areas of suitable predator habitat in the

form of shrub and willow forest (see the photographs in Appendix E); and third, avian predation would not be affected.

58. Nonetheless, any increases in predation on eggs, chicks, or adults could exacerbate the apparent ongoing declines in abundance and distributional range of the threatened river birds found on the Amuri Plains reach of the Waiau River. However, such effects would be difficult or impossible to detect and separate from variation due to other causes. 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.[28,29,30]

59. Thus, in my opinion, there is a possibility of a probably small 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.

Food supplies

60. Birds generally have high metabolic rates and limited fat stores, and need to feed frequently. Nutritional requirements are particularly high during the breeding season, because of the need to produce and incubate eggs, and, for some species, to feed chicks. The most important months are September to December, when most birds are nesting, although food supplies leading up to and following this period are also likely to be important.

61. Aquatic invertebrates and fish provide food for many river bird species, although the birds vary in the extent to which they

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28 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.

29 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 fo Conservation, Nelson.

30 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.

depend on these items. Some species, such as wrybills, are mainly aquatic feeders, whereas most others also feed on terrestrial prey and plants.[31] Most birds found on braided rivers also forage on off-river food sources, such as wetlands (e.g. waterfowl) and ploughed or irrigated pasture (e.g. black-billed gulls, black-fronted terns, pied oystercatchers). Birds appear to respond opportunistically to the availability of food, often congregating at sites of high food abundance.[32,33,34,35] The relative importance to birds of different food sources, such as terrestrial sources on and off-river and instream sources, is not well-understood.

62. Changes in flow regimes can reduce or increase the biomass and species composition of aquatic invertebrates and fish, and may also influence the availability of these as food for birds (e.g. by changing foraging conditions such as depth). However, while an adequate food supply is clearly essential for birds, there is no evidence that in-stream food supplies are a limiting factor for braided river birds. Nonetheless, I have considered potential impacts on the in-stream component of bird food supplies because large reductions could be a cause for concern.

63. Dr Olsen and his colleagues at the Cawthron Institute modelled monthly changes in *Deleatidium* spp. habitat availability under the proposed AHP, and a 'modelled full irrigation development scenario', relative to Natural Flow, for a representative average, wet, and dry year. The mayfly *Deleatidium* dominates the macro-invertebrate community in the Waiau River, and is likely to provide the main aquatic food source for birds.

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31 Heather, B.; Robertson, H. 1996: Field guide to the birds of New Zealand. Viking, Auckland, New Zealand.

32 Hay, J.R. 1984. The behavioural ecology of the wrybill plover. Unpublished PhD thesis. University of Auckland, Auckland.

33 Hughey, K.F.D. 1997. The diet of the wrybill (Anarynchus frontalis) and the banded dotterel (Charadrius bicinctus) on two braided rivers in Canterbury, New Zealand. Notornis 44: 185-193.

34 Lalas, C. 1977. Food and feeding behaviour of the black-fronted tern, Chlidonias hybrida albostriatus. Unpublished MSc thesis, University of Otago, Dunedin.

35 Sanders, M. D. (1999) Effect of changes in water level on numbers of black stilts (Himantopus novaezelandiae) using deltas of Lake Benmore. New Zealand Journal of Zoology, 26, 155-163.

64. I have summarised Dr Olsen's BITHABSIM[36] results for the bird breeding season (September to December), in Table 3. This shows that most *Deleatidium* habitat would be retained during the bird breeding season with the AHP. In the 'average year' the AHP was predicted to retain 76% of the habitat available with the existing environment, and 71% and 79% of that available with naturalised flow and a full irrigation without hydro scenario, respectively. Habitat retention was predicted to be higher in the modelled dry and wet years.

65. In my opinion, these changes are unlikely to adversely affect the ability of birds to obtain food; a similar range and amount of in-stream food would continue to be available, and terrestrial food sources and off-river aquatic food sources such as ponds, wet pasture, and irrigation channels would be unaffected by the AHP.

Table 3. Modelled mean *Deleatidium* habitat retention for the bird breeding season (September – December). Data provided by Dr Olsen, see also Table 10 of Dr Olsen's evidence. Three comparisons are presented.

Comparison	Dry year	Average year	Wet year
Modelled proposal (A+B+C Blocks) vs Natural flow	84%	71%	73%
Modelled proposal vs Existing environment ('status quo' – A Block with existing minimum flows)	86%	76%	79%
Modelled proposal vs full irrigation (A+B Block).	87%	79%	81%

CONCLUSIONS

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

[36] Benthic Invertebrate Time Series Habitat Simulation

67. The risk of floods destroying nests or drowning chicks might decrease slightly with the implementation of the flow and allocation regime in the proposed plan but this is unlikely to be a significant benefit.

68. Weed invasion is likely to be exacerbated by the implementation of the flow and allocation regime in the proposed plan resulting in a loss of suitable habitat for native plants and birds, unless weed control efforts are increased.

69. The relatively small reductions in instream habitat availability are unlikely to adversely affect the ability of birds to obtain food. Terrestrial and off-river aquatic food sources will be unaffected.

70. The reduction in number of braids as a result of the 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. Any such 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.

71. Overall, I conclude that the flow and allocation regime in the proposed plan could be 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.

Mark David Sanders

12 October 2012

APPENDIX A. BIRD SURVEY METHODS

Walk-through surveys

Braided river birds on the Waiau River, were surveyed in late October/early November in 2008[37], and 2009 and 2010 (Department of Conservation [DOC] unpublished data), by Environment Canterbury (ECan), DOC. These surveys covered the Waiau River from Waterfall Stream to the mouth (101 km), and were undertaken over several non-consecutive days by observers walking or jet-boating downstream and counting all birds seen[37]. The river was divided into 15 sections (Table 1; Figure 1) for the purposes of these counts, and the number of each species was recorded separately for each section.

Table 1. River sections used in river bird surveys. Sections 4 to 18 correspond to sections 1 to 15 in recent DOC and Ecan surveys. Sections 1 to 3 are additional (further upstream) to those of recent surveys, and were covered in helicopter surveys. NZ Map Grid (1949) co-ordinates of the upstream boundary of each section are shown.

Section	Easting	Northing	Length (km)
1. Windy Point	2458630	5846682	7.3
2. Hope Bridge	2465120	5846412	9.0
3. Waiau Confluence	2473900	5846064	9.1
4. Waterfall Stream	2481586	5848207	11.7
5. Waiau Ferry Bridge	2492190	5846982	8.6
6. Marble Point Water Gauge	2490794	5838149	7.3
7. Twin Bridges	2493703	5835267	6.3
8. Powerline	2499596	5834405	7.4
9. Pass Stream	2504667	5837148	4.5
10. Murray Down	2509341	5839933	4.1
11. Waiau Bridge	2512814	5839102	6.4
12. Sandersons Road	2516873	5835608	3.7
13. Cheddar Valley	2521360	5837899	17.9
14. Hematite Stream	2524920	5831184	2.7
15. Leamington Road	2527925	5831551	5.7
16. SH1 Bridge	2533293	5831746	4.5
17. Spotswood Access	2536546	5828954	7.0
18. River Mouth	2540572	5825759	3.2

Helicopter surveys

On 13 December 2011, an aerial survey was made of birds on the river. Mean flow at Marble Point on this day was 86 m³/s. This survey covered 126 km of the river: the 101 km reach of river covered by the on-river surveys mentioned above and an additional 25 km of river immediately upstream of Waterfall Stream, i.e. the Hope River from Windy Point to the Hope-Waiau confluence, and the Waiau River from the confluence to Waterfall Stream. Three additional sections were established for the river above Waterfall Stream (Figure 1; Table 1). The aerial survey used methods developed on the Waiau River in Marlborough and the Waitaki River: One 'navigator/spotter' and two observers were flown down the river in a small helicopter at low altitude and low speed, counting and recording locations

37 Schmechel F. 2008. Braided River Bird Surveys of the Waiau River and Eight Smaller Canterbury Rivers, Spring 2008. Environment Canterbury Report.

of colonies or flocks of key species, and recording notes on habitat conditions (especially whether colonies were located on islands or 'mainland' sites). The focus of the survey was on black-fronted terns and black-billed gulls. Numbers of birds on the river were relatively low, and we were also able to count other bird species where this did not detract from counting the key species.

During the aerial survey, high resolution digital photographs were taken of flocks or colonies of black-billed gulls and black-fronted terns and surrounding habitat. These were later used to assess habitat conditions and to obtaining independents count of birds, following the methods of McClellan[38]. Sites within the Amuri Plains reach where colonies or flocks of black-fronted terns and black-billed gulls had been recorded were visited on the ground immediately after the aerial survey to make more detailed on-ground observations of habitat conditions, and nest locations.

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

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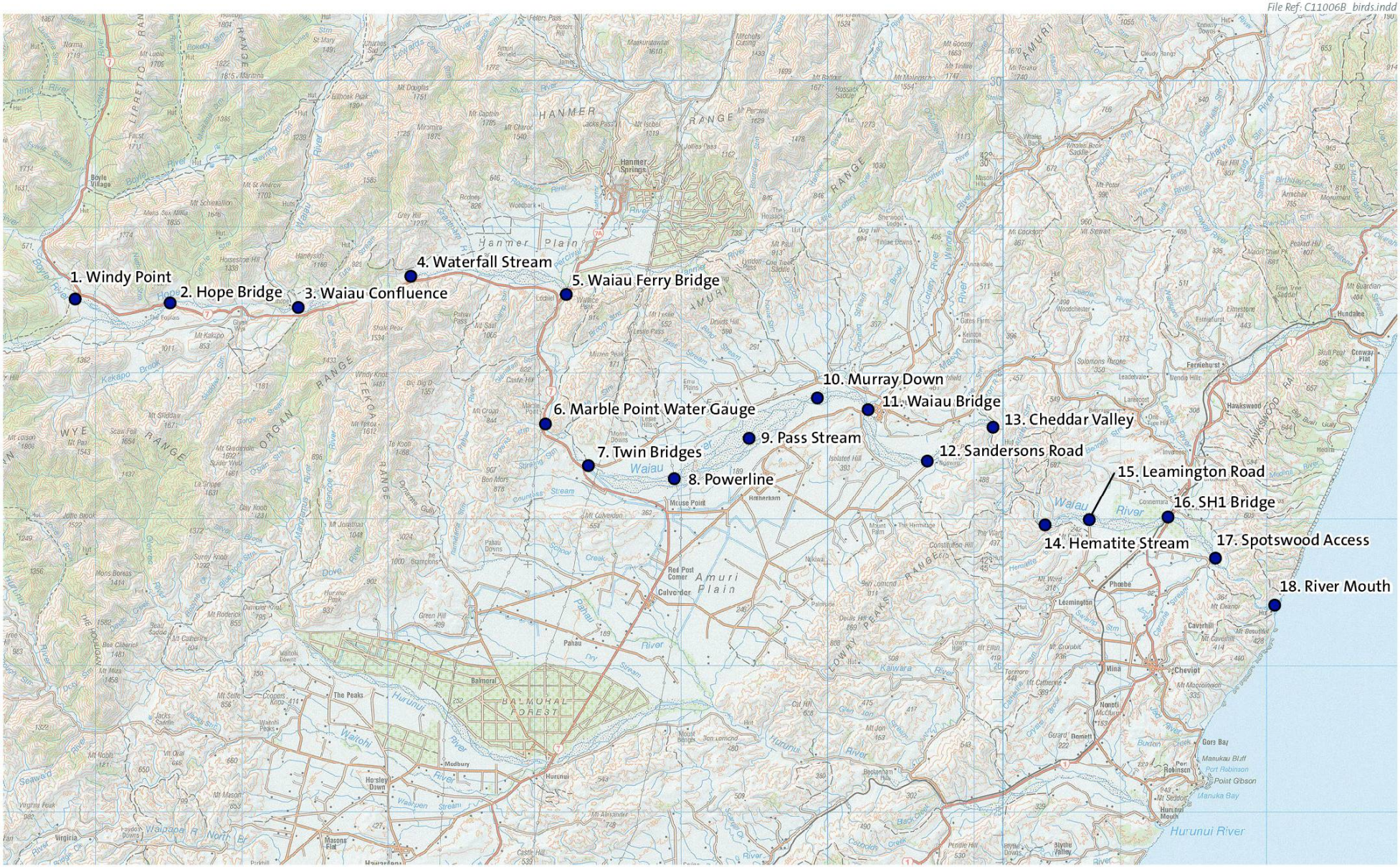

Boffa Miskell
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Data Sources: Topo map sourced from LINZ, Crown copyright reserved.

AMURI HYDRO

Waiau River sections - bird surveys

Date: 11 April 2012

Plan prepared for Meridian Energy by Boffa Miskell Limited

Author: **gary.white@boffamiskell.co.nz** | *Checked:* DRo

Figure 1

APPENDIX B. ON-RIVER BIRD SURVEY DATA, 2008-2010

Data source: Schmechel[39], and Department of Conservation (unpublished data; 2009 & 2010). *Above: Waterfall stream to Twin Bridges; Within: Twin Bridges to Sandersons Road; Below: Sanderson's Road to mouth.

	2008				2009				2010			
Species	Above	Within	Below	Total	Above	Within	Below	Total	Above	Within	Below	Total
Black shag *Phalacrocorax carbo novaehollandiae*	6	40	22	68	2	6	5	13	1	11	19	31
Pied shag *Phalacrocorax varius varius*	0	0	15	15	0	0	18	18	0	0	21	21
Little shag *Phalacrocorax melanoleucos brevirostris*	0	0	5	5	0	0	1	1	1	0	0	1
White-faced heron *Ardea novaehollandiae*	1	4	3	8	0	2	4	6	2	18	1	21
Royal spoonbill *Platalea regia*	0	0	0	0	0	0	1	1	0	0	0	0
Black swan *Cygnus atratus*	0	0	1	1	0	0	8	8	0	0	0	0
Canada goose *Branta canadensis*	245	72	15	332	102	170	45	317	117	141	33	291
Duck species	6	70	61	137	0	49	19	68	1	42	20	63
Paradise shelduck *Tadorna variegata*	3	30	47	80	4	28	53	85	9	27	30	66
Mallard *Anas platyrhynchos*	0	0	0	0	3	32	15	50	17	33	22	72
NZ shoveler *Anas rhynchotis*	0	0	0	0	0	0	0	0	0	0	0	0
NZ Scaup *Aythya novaeseelandiae*	0	0	14	14	0	0	13	13	0	0	0	0
Harrier *Circus approximans*	0	8	3	11	0	4	3	7	0	0	0	0
Pukeko *Porphyrio melanotus*	0	1	0	1	0	0	0	0	0	0	0	0
Pied oystercatcher *Haematopus finschi*	52	62	30	144	39	125	19	183	51	69	29	149
Variable oystercatcher *Haematopus unicolor*	0	0	4	4	0	0	6	6	0	0	4	4
Pied stilt *Himantopus himantopus leucocephalus*	39	27	27	93	24	120	91	235	8	39	26	73
Banded dotterel *Charadrius bicinctus bicinctus*	119	208	124	451	81	237	213	531	122	269	219	610
Black-fronted dotterel *Charadrius melanops*	0	0	0	0	0	0	0	0	0	0	0	0
Wrybill *Anarhynchus frontalis*	4	2	5	11	1	7	9	17	2	3	10	15
Spur-winged plover *Vanellus miles novaehollandiae*	47	75	89	211	10	42	110	162	83	339	98	520
Skua	0	0	0	0	0	0	1	1	0	0	0	0
Southern black-backed gull *Larus dominicanus*	334	1101	673	2108	594	1715	487	2796	435	1583	227	2245
Red-billed gull *Larus novaehollandiae scopulinus*	1	0	16	17	0	0	4	4	0	0	28	28
Black-billed gull *Larus bulleri*	50	1909	76	2035	3	75	229	307	458	85	191	734
Black-fronted tern *Chlidonias albostriatus*	195	264	61	520	235	375	213	823	198	274	157	629
Caspian tern *Hydroprogne caspia*	0	0	6	6	1	0	0	1	0	0	1	1
White-fronted tern *Sterna striata striata*	0	1	65	66	0	0	80	80	0	1	41	42
Common tern *Sterna hirundo longipennis*	0	0	0	0	0	0	0	0	0	0	0	0
Kingfisher *Todiramphus sanctus vagans*	0	2	4	6	0	2	1	3	0	0	0	0
Welcome swallow *Hirundo tahitica neoxena*	0	1	0	1	0	0	0	0	0	0	0	0
NZ pipit *Anthus novaeseelandiae novaeseelandiae*	3	0	0	3	8	3	0	11	6	3	0	9

39 Schmechel F. 2008. Braided River Bird Surveys of the Waiau River and Eight Smaller Canterbury Rivers, Spring 2008. Environment Canterbury Report.

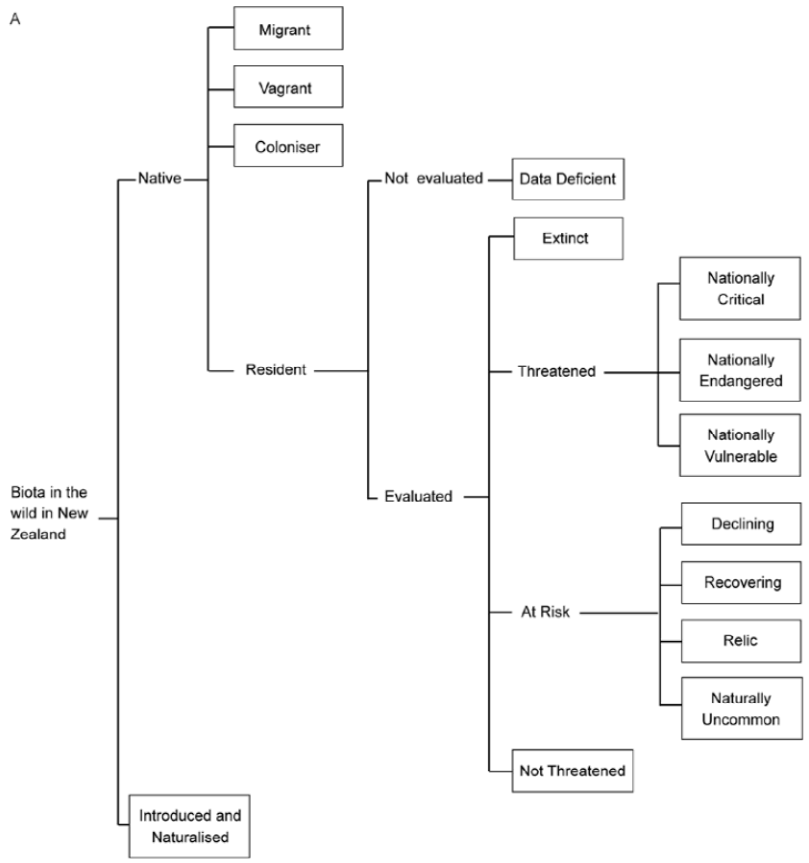
APPENDIX C. AERIAL BIRD SURVEY DATA

Aerial surveys of the Waiau and part of the Hope River were undertaken on 13 December 2011. Note that only conspicuous species can be reasonably reliably counted with this method (see main text for details), and the absence of a species does not indicate that it was not present on the river. In particular, no data are shown for banded dotterel, wrybill, pipit, red-billed gull, variable oystercatcher, southern black-backed gull because these species could not be reliably counted in this survey. As with on-river surveys, counts should be treated as minimum estimates because some individuals are likely to have been missed. Data are not directly comparable with the results of on-river surveys because of the different methods used. Data are separated according to whether the birds were counted above, within, or below the Amuri Plain Reaches (APR).

Species	Additional *	Above APR	Within APR	Below APR	Total
Australasian harrier	1	3	4	5	13
Black shag	1	0	6	7	14
Black-billed gull	0	0	449	452	901
Black-fronted tern	152	155	549	78	934
Canada goose	40	0	13	36	89
Caspian tern	0	0	0	2	2
Grey teal	0	0	6	1	7
Little shag	0	0	0	2	2
Mallard/Grey duck	0	2	62	83	147
Paradise duck	24	6	141	70	241
Pied oystercatcher	0	9	59	31	99
Pied stilt	2	5	116	23	146
White-faced heron	3	4	14	8	29

*Additional: Windy Point to Waterfall Stream; Above: Waterfall stream to Twin Bridges; Within: Twin Bridges to Sandersons Road; Below: Sanderson's Road to mouth.

APPENDIX D. NEW ZEALAND THREAT CLASSIFICATION SYSTEM[40]



Qualifiers are an integral part of the New Zealand Threat Classification System and must be cited in publications referring to the threat status of taxa listed under this system. Qualifiers provide critical additional information about a taxon's listing, status and management. When a taxon is listed, all of the qualifiers that apply to it are recorded in alphabetical order as subscripts after the threat category. For example:

Anzybas carsei 'Nationally Critical $_{CD, EF, OL, RF}$'

The qualifiers (abbreviations in brackets) and their full definitions are listed below:

Conservation Dependent (CD)

The taxon is likely to move to a higher threat category if current management ceases.

Data Poor (DP)

Confidence in the listing is low due to there being only poor data available for assessment.

Designated (De)

A taxon that does not fit within the criteria provided, and which the Expert Panel has designated to the most appropriate listing without full application of the criteria. For example, a commercial fish stock that is being fished down to Biomass Maximum Sustainable Yield (BMSY) may meet criteria for 'Declining'; however, it could be designated as 'Not Threatened' if the Expert Panel believes that this better describes the taxon's risk of extinction.

40 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 Conservatrion, Wellington, New Zealand.

Extinct in the Wild (EW)

The taxon is known only in cultivation or captivity.

Extreme Fluctuations (EF)

The taxon experiences extreme unnatural population fluctuations, or natural fluctuations overlaying human-induced declines, that increase the threat of extinction. When ranking taxa with extreme fluctuations, the lowest number of mature individuals should be used for determining population size, as a precautionary measure.

Increasing (Inc)

There is an ongoing or predicted increase of > 10% in the total population, taken over the next 10 years or three generations, whichever is longer. Note that this qualifier is redundant for taxa ranked as 'Recovering'.

Island Endemic (IE)

A taxon whose natural distribution is restricted to one island archipelago (e.g. Auckland Islands) and is not part of the North or South Islands or Stewart Island/Rakiura.

One Location (OL)

Found at one location (geographically or ecologically distinct area) of less than 1000 km2 (100 000 ha), in which a single event (e.g. a predator irruption) could easily affect all individuals of the taxon, e.g. L'Esperance Rock groundsel (*Senecio lautus* var. *esperensis*) and Open Bay Island leech (*Hirudobdella antipodum*). Taxa with restricted distributions but where it is unlikely that all sub-populations would be threatened by a single event (e.g. because water gaps within an archipelago are larger than known rodent swimming distances) should be qualified as 'Range Restricted' (RR). 'OL' can apply to all 'Threatened' and 'At Risk' taxa, regardless of whether their restricted distribution is natural or human-induced.

Partial Decline (PD)

Taxa undergoing decline over the majority of their range, but with one or more secure populations (such as on offshore islands). Partial decline taxa (e.g. North Island kaka *Nestor meridionalis septentrionalis* and Pacific gecko *Hoplodactylus pacificus*) are declining towards 'Relict' status rather than towards extinction.

Range Restricted (RR)

Taxa confined to specific substrates, habitats or geographic areas of less than 1000 km2 (100 000 ha); this is assessed by taking into account the area of occupied habitat of all sub-populations (and summing the areas of habitat if there is more than one sub-population), e.g. Chatham Island forget-me-not (*Myosotidium hortensia*) and Auckland Island snipe (*Coenocorypha aucklandica aucklandica*). This qualifier can apply to all 'Threatened' and 'At Risk' taxa regardless of whether their restricted distribution is natural or human-induced, but is redundant if a taxon is confined to 'One Location' (OL).

Recruitment Failure (RF)

The taxon's current population may appear stable but the age structure is such that catastrophic declines are likely in the future.

Secure Overseas (SO)

The taxon is secure in other parts of its natural range outside New Zealand.

Sparse (Sp)

Taxa that occur within typically small and widely scattered populations.

Stable (St)

The total population is stable (± 10%), taken over the last 10 years or three generations, whichever is longer.

Threatened Overseas (TO)

The taxon is threatened in those parts of its natural range outside New Zealand.

APPENDIX E. PHOTOGRAPHS

Photo 1. Location of a black-fronted tern (circled) on a large island within the Amuri Plains reach. Note nearby vegetation.

Photo 2. River bed to true left of the black-fronted tern colony (indicated by arrow) shown in Photo 1. Much of the vegetation, including part of the willow forest at the rear left is on the island; another channel, located further to the left and not visible here, separates this large island from the river margins.