BEFORE THE ENVIRONMENT COURT OF NEW ZEALAND
CHRISTCHURCH REGISTRY
I MUA I TE KŌTI TAIAO O AOTEAROA
KI ŌTAUUTAHI

ENV-2018-CHC-0037
ENV-2018-CHC-0050

UNDER the Resource Management Act 1991

IN THE MATTER OF an appeal under clause 14 of Schedule 1 of the RMA in relation to decisions on the Proposed Southland Water and Land Plan

BETWEEN ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND INC

Appellant

AND SOUTHLAND FISH AND GAME COUNCIL

Appellant

EVIDENCE IN CHIEF OF KATHRYN JANE MCARTHUR

Dated 20 December 2021

AND SOUTHLAND REGIONAL COUNCIL

Respondent

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INTRODUCTION

1. My full name is Kathryn (Kate) Jane McArthur. I am an independent freshwater ecologist and water quality scientist based in Kahuterawa near Palmerston North.

2. I hold a Bachelor of Science degree with Honours in Ecology and a Master of Applied Science with Honours in Natural Resource Management, both from Massey University. My post-graduate research included the influence of land use on freshwater macroinvertebrates and the interaction between policy and science in resource management, focussing on water quality objectives and limits in regional plans. I have 20 years of post-graduate experience in freshwater resource management.

3. I started my own consultancy (KM Water) in August 2020. Prior to starting KM Water, I was the Practice Leader – Water with The Catalyst Group for eight years. My work with The Catalyst Group included providing expert advice and evidence on eleven regional plans across Aotearoa New Zealand. Before this, I held the role of Senior Scientist – Water Quality with Horizons Regional Council (Manawatū-Whanganui Region). In this role I coordinated monitoring programmes for State of the Environment (SOE), periphyton, macroinvertebrate, indigenous fish, and point-source discharges, and produced expert evidence for many resource consent hearings, enforcement actions, and the Horizons 'One' Plan Council-level and Environment Court hearings (the Horizons 'One' Plan being a combined regional plan/regional policy statement).

4. I have authored and co-authored a range of reports and publications, including technical reports on water quality and aquatic biodiversity to support the Horizons One Plan and the draft Nelson Resource Management Plan. I have authored and co-authored papers in peer-reviewed journals on the relationship between flow and nutrients in rivers; nutrient limitation; methods for monitoring indigenous fish; the calculation of in-river nutrient loads and limits, and the setting of water quality objectives and limits in water policy. I have provided evidence in these topic areas before the Environment Court and in Board of Inquiry, Special Tribunal, and council hearings processes across the country.

5. I have provided ecological, water quality, and freshwater policy advice to Nelson City Council, Northland Regional Council, Ngāti Kahungunu Iwi Incorporated, Te Rōpū Taiao o Ngāti Whakatere, Te Taiwhenua o Heretaunga, Te Rūnanga o Ngāti Whātua, Te Rūnanga o Ngāti Mutunga, Ngāti Pāhauwera Development Trust, Hawke's Bay Regional Council, the national Iwi Leaders Group, the Department of Conservation, the Ministry for

the Environment, Forest & Bird, Fish and Game, Environmental Defence Society and the Biodiversity Collaborative Group. I have recently been, or am currently involved in, freshwater plan processes in Northland, Auckland, Waikato, Bay of Plenty, Hawke's Bay, Manawatū-Whanganui, Wellington, Tasman, Nelson, Canterbury, and Southland.

6. I was appointed as a member of the National Objectives Framework reference group for the National Policy Statement for Freshwater Management (2017) by the Ministry for the Environment. Since 2016, I have co-led national workshops on best practice freshwater science and policy development for the New Zealand Planning Institute. I am a guest lecturer in environmental planning, freshwater resource management practice, and science at Massey and Canterbury Universities.

7. I have been a member of the New Zealand Freshwater Sciences Society since 2001 and I have been the Society's President since 2018. I am a member of the Resource Management Law Association of New Zealand (RMLA) and was the RMLA scholarship recipient in 2010 for my master's thesis work on water quality policy and limits for the Manawatū River.

8. I am an accredited and experienced RMA hearings commissioner with a hearing chair endorsement and have been appointed by the Minister for the Environment as a Freshwater Commissioner for the new Freshwater Planning Process under the RMA amendments (2020).

9. I gave expert evidence on behalf of the Royal Forest and Bird Protection Society Incorporated of New Zealand (Forest and Bird) and the Director-General of Conservation before the Environment Court in the Topic A hearings and participated in all technical expert conferencing associated with Topic A[1] and Topic B.[2]

CODE OF CONDUCT

10. I confirm that I have read the code of conduct for expert witnesses as contained in the Environment Court's Practice Note 2014. I have complied with the Code when preparing this written statement and will do so when I give oral evidence before the Court.

[1] Joint witness statements (JWS) on water quality and aquatic ecology were produced from expert conferencing on 7 – 10 May, 4 September, 14 – 16 October and 20 – 22 November 2019. These are hereafter referred to as the May, September, October and November JWS.

[2] I participated in Topic B expert conferencing for Farm Systems, Ecology and Science in November 2021. These are hereafter referred to as the Farm Systems 2021, Ecology 2021 or Science 2021 JWS.

11. The data, information, facts, and assumptions I have considered in forming my opinions are set out in this statement to follow. The reasons for the opinions expressed are also set out in the statement to follow.

12. Unless I state otherwise, this evidence is within my sphere of expertise, and I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

13. As a member of the New Zealand Freshwater Sciences Society, a constituent organisation of the Royal Society of New Zealand - Te Apārangi, I am also bound by the Royal Society of New Zealand Code of Professional Standards and Ethics in Science, Technology, and the Humanities.[3]

SCOPE

14. I have been asked by the Royal Forest and Bird Protection Society of New Zealand Inc (Forest & Bird) and the Southland Fish and Game Council (Fish and Game) to provide evidence in relation to water quality and ecosystem health with respect to the Topic B provisions of the proposed Southland Water and Land Plan (pSWLP). This statement of evidence covers the following themes:

    a. Degraded water bodies and the improvement 'gap'
    b. Consequences of delay or inaction
    c. Plan response to degradation and the 'gap'
    d. The use of physiographic zones
    e. Riparian setbacks from water bodies
    f. Intensive winter grazing
    g. Sheep grazing wetlands
    h. Ephemeral and headwater streams
    i. Drain maintenance
    j. Definitions of gravel and sediment

DEGRADED WATER BODIES AND THE IMPROVEMENT 'GAP' IN SOUTHLAND

15. Many of Southland's rivers, lakes, wetlands, lagoons and estuaries are in a poor state with respect to water quality, ecosystem health and indicators of cultural health. Shallow

[3] https://royalsociety.org.nz/assets/Uploads/Code-of-Prof-Stds-and-Ethics-1-Jan-2019-web.pdf

groundwater is also affected in many areas. The state of water quality has been declining over the last two decades, and this is largely attributable to expansion and intensification of land used for dairying, winter feeding of dairy stock and associated land management and drainage practices. Diffuse contamination of surface and groundwater is the primary source of contamination of Southland's aquatic ecosystems. Anthropogenic impacts are degrading freshwater values across multiple aquatic ecosystem types.[4]

16. Water quality in Southland is degraded by land use (human activities) and is 'over-allocated' with respect to the pervasive level of water quality degradation and the adverse effects this is having on freshwater values such as ecosystem health, human contact, drinking water, threatened species and tangata whenua cultural values, including mahinga kai. The poor state of water quality and other indicators of ecosystem and cultural health warrant an urgent and effective management response at the regional level. Southland presents a clear case for the need to improve water quality, not simply halt decline until a later plan process.[5]

17. The Science 2021 JWS (and previous 2019 JWSs) define the agreed positions of the experts on what constitutes degradation of waterways in Southland and what the specific attributes and thresholds of ecological degradation should be for regional planning purposes.[6] The experts agreed that there was sufficient data to make reliable decisions for planning purposes[7] and that degraded waterbodies can be (and have been) spatially identified.[8]

18. In the Science 2021 JWS, the experts agreed that degraded waterbodies were to be based on a combination of water quality and cultural thresholds.[9] The list of degraded waterbodies agreed by the science experts is contained in the November JWS at Appendix 1 and Appendix 2 of the Cultural Indicators of Health JWS.[10] Grading of river sites against these thresholds of degradation shows at least 62 State of the Environment (SOE) sites were degraded by one or more attribute, most sites are degraded for multiple attributes. Modelling and mapping of some attributes (where the experts agreed

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[4] Evidence in chief of K McArthur, 15 February 2019, paragraphs 16 – 18, 23 – 39 and Appendix 1. Also see evidence in chief of Mr Rodway, Mr Ward and Mr Hodson for the Council and Dr Kitson for Ngā Rūnanga and the May, September, October and November JWS (2019).
[5] Evidence in chief of K McArthur, paragraph 18.
[6] November JWS paragraphs 18 to 20 and Appendix 4.
[7] November JWS, paragraphs 18 and 20.
[8] Science 2021 JWS, response to question 7, page 11.
[9] Science 2021 JWS response to question 1, page 3.
[10] Science 2021 JWS response to question 7, page 11.

there were robust models available) to determine degradation at the river network scale (rather than discrete sites) was also included in the November JWS (2019) e.g., Figure 3 page 15 (nutrients) and Figure 5, page 18 (MCI). However, this mapping has not occurred for all attributes including cultural indicators of health and is therefore a more limited picture with respect to degraded water bodies in Southland. Additionally, the 2019 list of degraded sites did not consider the cumulative degradation of rivers and their contribution to the degradation of sensitive downstream receiving environments. An example of this approach to cumulative effects has been undertaken in more recent work by Snelder (2021).

19. Snelder (2021) has analysed and mapped Southland water bodies with respect to their compliance with a range of nutrient thresholds including the bottom of the hauora envelope (or minimum hauora state), pSWLP standards and national bottom lines.[11] These thresholds are different from those determined by the experts to describe degradation for Southland in 2019. Snelder's (2021) methods could be applied to map the network of waterbodies which have a high probability of exceeding degraded thresholds, accounting also for the critical catchment status,[12] where the models are robust (e.g., nitrogen, phosphorus, sediment, *E. coli* and MCI). The experts note[13] this is not a trivial exercise and given the list of degraded waterbodies already identified could be an extensive area of Southland.

Lake, lagoon and wetland degradation and loss

20. Waituna Lagoon and Lake Vincent are degraded ICOLL/lakes,[14] modelling shows degradation of lakes is likely to be more widespread but measured data is limited to seven lakes. Southland wetlands are also degraded, threatened by agricultural activities and drainage, and are declining in extent.[15] For example, Robertson et al. (2018) reported loss and partial drainage of wetlands in Southland of 0.5 to 1% per year since 1990 for conversion to pasture. For wetlands outside of conservation land, Ewens (2018) found a 7% reduction in total wetland extent between 2007 and 2014/15 and an 11% reduction for wetlands in the lowland areas of Southland.

[11] At two spatial exceedance settings: 20% and 30%.
[12] Snelder (2021) describes the critical catchment status as "*the load reduction that ensures loads for all receiving environments in the catchment do not exceed the maximum allowable load*". And is applicable to examining the extent of degraded waterbodies in Southland, including those that contribute to downstream degradation of sensitive receiving environments like lakes, lagoons and estuaries.
[13] Science 2021 JWS response to question 8, page 11.
[14] November JWS , Figure 17 (lakes/lagoons) and Table 25 (ICOLLs).
[15] May JWS.

Estuary degradation

21. Jacobs River Estuary (Aparima) and New River Estuary (Ōreti) are both degraded, as indicated by macroalgae growth, extensive eutrophic areas, sites with low dissolved oxygen and high organic carbon. New River Estuary is also degraded by Nickel and has elevated chlorophyll *a*.[16] Fortrose Estuary (Mataura) is close to triggering the degraded status.[17]

The gap between current state and freshwater objectives

22. The science experts agreed[18] that there was a large gap between the current state of water quality and objectives consistent with hauora (albeit the minimum hauora state or bottom of the hauora envelope). In December 2020, the Southland Regional Council and the Te Ao Marama Inc (TAMI) board approved in principle the minimum level of hauora as the draft freshwater objectives for the region (Snelder 2021). In response to question 5 from the planners, the science experts agreed[19] that "*the reductions necessary to achieve hauora are large, and reductions to achieve national bottom lines are also large*".

23. To even achieve the national bottom lines in the NPS FM (2020) for several attributes in many waterbodies, where the current state is within the red 'D band' in Figure 1 below, will still require a significant amount of improvement in the current state at the regional scale. The amount of improvement required at the site or FMU level will depend on the attribute and the location.

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[16] November JWS, Table 31, page 40.

[17] November JWS, paragraph 78: "*The macroalgae growth variable for Fortrose (0.453 EQR) is close to triggering the status of 'degraded' (<0.4 EQR). Additionally, gross eutrophic zones have been detected in the last three years where they have not previously existed in the system. The Fortrose Estuary is a well-flushed estuary and hence has lower susceptibility to eutrophication than the other monitored estuaries. Therefore, the presence of these indications of degradation in this estuary is concerning. This represents the physical expression of problem conditions that are likely to be hard to reverse*."

[18] Science 2021 JWS response to question 5, page 8.

[19] Science 2021 JWS, response to question 5, page 9.

Figure 8: Envelopes approach and numeric banding system for waterbody classes

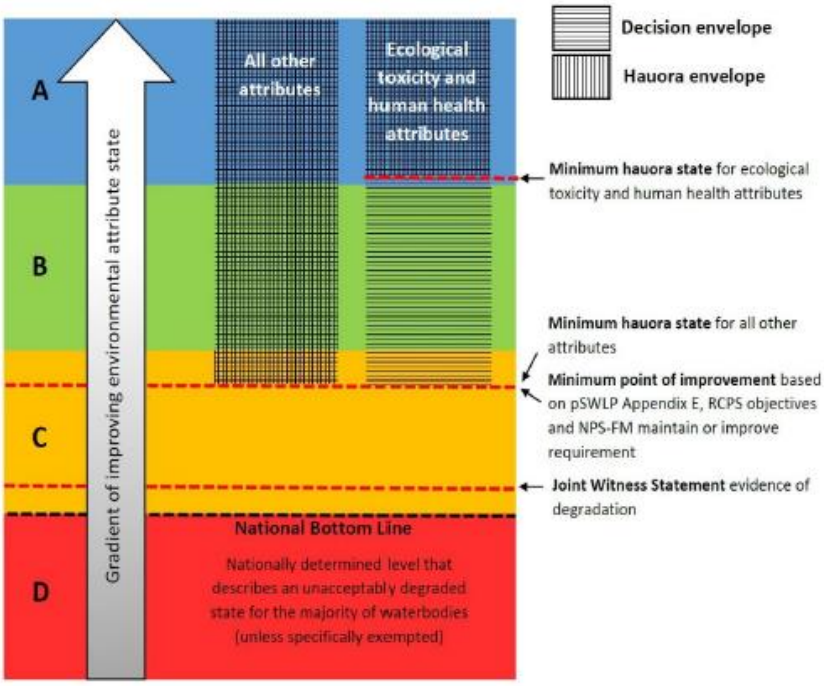

Figure 1. Conceptualisation of banding for attributes for freshwater objective envelopes (decision envelope and hauora envelope), minimum states for improvement, degradation thresholds (2019 JWS) and national bottom lines for Murihiku Southland. Reproduced from Figure 8 of Bartlett et al. (2020).[20]

24. Norton et al. (2019) initially identified the 'gap' between current state and draft freshwater objectives for Southland (in a report preceding the hauora freshwater objectives defined by Bartlett et al. 2020). Key conclusions from Norton et al. (2019) at the regional scale recognise:

a. A substantial gap to close to meet freshwater objectives for faecal indicators for both groundwater drinking supply and human contact;

b. A substantial gap to close for nutrients (and nutrient affected attributes), particularly in lowland rivers, lakes and estuaries; and

[20] The decision envelope and hauora envelope are described on page 7 of Bartlett et al. (2020). In summary, the 'decision envelope' is the minimum requirement for improvement of degraded waterbodies. The decision envelope includes the range within which waterbodies are expected to provide for hauora, described as the 'hauora envelope'. The hauora envelope shares the same upper end states and most of the bottom end minimum states as the decision envelope. Where the hauora envelope has a higher requirement for improvement as a minimum state, this represents a further point for improvement to reach a state of hauora that is beyond the minimum specified in the decision envelope. This gives decision-makers some flexibility to consider timeframes and other methods to enable progress towards a state of hauora from a degraded state.

c. A substantial gap to close for sediment (and sediment related attributes), particularly in lowland rivers, lakes and estuaries.

25. Further work on reductions necessary to achieve freshwater objectives (including the minimum hauora state) has been recently completed. Snelder (2021) identified the net load reductions required for total nitrogen (TN) and total phosphorus (TP) to achieve outcomes for algal growth and nitrate toxicity for all rivers, lakes and estuaries of Southland.[21] A summary of the region-wide TN and TP load reductions required was included in the Science 2021 JWS as Table 1 (page 9)[22] and shows that to improve enough even to achieve the national bottom lines will require reductions of 47% and 21% respectively for TN and TP. To achieve pSWLP standards will require nutrient load reductions of 66% TN and 69% TP, and to reach the minimum state of hauora will require 70% TN and 70% TP reductions.

26. Snelder (2021) considered the load reduction of TN and TP to achieve proposed objectives for Southland for lakes and estuaries (as well as rivers). In some cases, the ecological needs of lakes and estuaries require greater reductions of TN and TP (where these were the more 'limiting environment') than what was needed to achieve objectives in rivers. For example, Lake Brunton, Jacobs River Estuary, Te Waewae Lagoon, Toetoes Estuary, Waikawa Estuary and Waituna Lagoon all require significantly greater reductions in TN than would be required to meet the river freshwater objectives. Lake Brunton, New River Estuary, Waikawa Estuary and Waituna Lagoon are also the 'limiting environments' requiring greater reductions in TP load than required for rivers alone.

27. Neverman et al. (2021) modelled suspended sediment load reductions required to achieve draft freshwater objectives for Southland for visual clarity and suspended fine sediment. Maximum required load reductions to achieve the bottom of the decision / hauora envelopes (Figure 1) ranged from 33% to 84% for visual clarity and 2% to 73% for suspended fine sediment depending on the reported catchment area. Regional sediment reductions were not reported.

28. Snelder and Fraser (2021) modelled *E. coli* load reductions required to achieve draft freshwater objectives for Southland. To reach the bottom of the hauora envelope in Southland will require an estimated 90% reduction from current state in *E. coli* at the

[21] Excluding the Fiordland and Islands Freshwater Management Unit (FMU).
[22] Taken from Snelder (2021).

regional scale. Reductions in *E. coli* of 87% were estimated to reach the pSWLP water quality standards at the regional scale.

29. These studies document the size of the water quality issue in Southland and inform the degree of change necessary to improve towards achieving freshwater objectives and hauora.

CONSEQUENCES OF DELAY OR INACTION

30. The consequences of inaction or delaying nutrient source reductions for New Zealand rivers, lakes and estuaries were described by Graham et al. (2020) to inform and support the government's current essential freshwater reforms including the NPS FM (2020). Graham et al. (2020) described compelling reasons not to delay nutrient reductions affecting waterbodies, including:

    a. Stocks of nutrients stored in sediment will increase as long as inputs continue, and the release of nutrients from these internal storages will continue long after inputs are reduced.

    b. Sediment deposition exacerbated by nuisance river macrophytes and nutrient storage by algae prolong recovery and become more likely with the duration of high nutrient source loading.

    c. Risks of ecological states resistant to rehabilitation (e.g., phytoplankton-dominated shallow lakes, deep lakes with high trophic levels, streams dominated by degradation-tolerant species that block re-establishment of more desirable biota) increase the longer that source reductions are delayed.

    d. Competitive exclusion of sensitive taxa by degradation-tolerant riverine biota are likely to make remediation less effective and may require additional interventions.

    e. Additional remediation options may be required that may not have been necessary if nutrient management action were taken earlier.

    f. For lakes, reductions of external loading may need to be greater, compared with loadings required to achieve outcomes if the lake had not been degraded in the first place.

g. Delays in reducing nitrogen leaching will result in increased peak loading to streams and protracted recovery for groundwater systems that have not yet responded fully to past increases in loading.

31. Delay or inaction to reduce nutrients at source has serious ecological and remediation/restoration costs across all freshwater ecosystems (Graham et al. 2020). The consequences outlined by Graham et al. (2020) are highly relevant to Southland's water bodies and should be considered when assessing the appropriateness of Council's approach, the pSWLP provisions and, as indicated in the evidence of Mr McCallum-Clark, the intention to address the majority of degradation through future plan processes.

32. Similarly, failure to reduce inputs of sediment and toxicants (e.g., metals) will have synergistic and multi-stressor adverse effects on ecosystem health that also become more difficult and more expensive to remedy the longer action is delayed.

33. Recent research shows that degraded stream macroinvertebrate communities in Aotearoa New Zealand can be highly resistant and resilient, making restoration difficult (Barrett et al. 2021). Macroinvertebrate communities in degraded streams become dominated by hyper-tolerant species, preventing recolonisation of more sensitive species, even after water quality improvement.

34. As discussed in depth in my Topic A evidence in chief[23] the indigenous fish fauna of Southland is diverse (species rich) and contains many populations of threatened species, some of which are on the brink of extinction. Protection and restoration of water quality, habitat and flows will be critical to conserving the diversity of indigenous fish and freshwater taonga species in Southland and maintaining the contribution the Southland fauna makes to national and global biodiversity values.

PLAN RESPONSE TO DEGRADATION AND THE 'GAP'

35. Generally, in Southland, water quality decreases with decreasing elevation and increasing proportion of the catchment in pasture (November JWS para 24).

36. To counter the pervasive effects of intensive agricultural land use (including winter grazing) on the ecosystem health of water bodies in Southland a multi-faceted response to reducing contaminant inputs is needed. Whilst we do not (and will likely never) have

[23] Evidence in chief of Kathryn McArthur, dated 15 February 2019, paragraphs 40 to 57.

perfect information, there is good and reliable information to support the need for remedial actions and a plan response now, including:

a. The degree of degradation of various waterbodies and ecosystem types
b. Where degraded waterbodies are located
c. The specific contaminants of concern
d. The physiographic nature of the landscape
e. The risk pathways for contaminant transport (both by physiographic zone and from drainage and overland flow variants)
f. The likely causes of degradation
g. How various activities can be mitigated to reduce effects and improve ecosystem health and water quality.

37. We also know that delaying action will have ecological and economic costs and will make future restoration more difficult and expensive (Graham et al. 2020; Barrett et al. 2021).

38. The science experts agreed[24] that Appendix N is unlikely to significantly narrow the gap between the current state and a state that is above the thresholds of degradation (as described in the November JWS) or the multiple attributes of hauora. Furthermore, the experts agreed that to close the gap a significant change to management of land and freshwater is needed (beyond current management practices). The experts agreed[25] the proposed plan (including Appendix N) should contain a rigorous requirement to reduce contaminant losses and asked the Farm Systems experts to consider what other options were available and what would be required based on existing technology.

39. The Farm Systems experts responded[26] that "*Appendix N does not list specific mitigations but requires landowners to meet specific objectives (part B section 5 of Appendix N). In order to strengthen Appendix N to better achieve hauora, additional objectives in Table 2 of the Science JWS [2021] could be added to Appendix N that specifically relate to ecological and cultural health.*" ... "*Appendix N in itself cannot achieve a state of hauora as it only deals with farm management practices and is not intended to bring about land use change. It is designed to reduce the environmental*

[24] Science 2021 JWS - response to question 4, page 7 and response to question 5, page 8.
[25] Science 2021 JWS – response to question 5, page 9.
[26] Farm Systems second JWS 6 December 2021, page 8.

footprint of a current land use by adopting good farming principles, efficiency, gains and mitigations. BUT it certainly can make progress towards a less degraded state."

40. I support the inclusion of cultural and ecological objectives in Appendix N (as described in the Science 2021 JWS Table 2) as this will better align the objectives of Appendix N with the five-component framework of ecosystem health (Clapcott et al. 2018) from the NPS FM (2020) and with improvement towards hauora. However, the 'B5 Planning conference outcomes' dated 10 December 2021 do not seem to have included any further objectives for Appendix N.

41. The implementation of Appendix N (alongside the rules for consented farming activities) is unlikely to significantly shift the required improvements in water quality above national bottom lines or the degraded thresholds for Southland (ecological and cultural) and thereby begin to 'close the gap'. This is particularly the case with respect to the management of nitrogen through FEMPs, but also applies to limitations on improvement in sediment, phosphorus and faecal contaminant loads. Further intensification must be avoided to prevent losses from intensification from offsetting any improvements in water quality (particularly nitrogen) that may be provided by mitigations on existing farms (Monaghan et al. 2020). I support the provisions in Rule 20 which seek to halt intensification. However, as noted above, halting decline does not go far enough towards achieving objectives and improving beyond degradation. A clear and certain framework is needed in the Plan that is capable of directing the required contaminant reductions for existing farms to address degradation and move towards hauora. To achieve hauora, such a framework might also eventually require landscape-scale changes to farms, such as the exclusion of stock from all headwater/ephemeral streams[27] (discussed further below).

PHYSIOGRAPHIC ZONES

42. The physiographic zones and application of the overland flow and artificial drainage variants is an excellent and parsimonious[28] 'model' of water quality risk for Southland. Physiographic zones provide a useful tool to inform future FMU processes, appropriate and effective on-farm mitigations in Farm Environmental Management Plans (FEMP) and

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[27] By headwater streams here I mean the channels (stream orders 1-3), many of which are ephemeral/intermittent, that capture water and are the source of the surface water hydrological network. Such channels occur extensively across the catchment landscape, including in lowland areas and plains.

[28] A parsimonious model is a model that accomplishes a desired level of explanation or prediction with as few predictor variables as possible.

can inform resource consents for land use.[29] In my view it is useful for these maps to be included within the pSWLP and for physiographic zones (and associated variants) to be referenced in the management of contaminant losses from farms (through FEMPs and other plan provisions).

43. The Topic A evidence of Mr Rodway describes the physiographic zones and provides significant detail on the risks associated with various combinations of contaminant type, physiographic zone and variants, risk pathway, land use type, mitigation options and farming practices.[30] The risk frameworks set out in Mr Rodway's evidence provide an approach by which Council staff (assuming a consenting regime) or persons preparing a FEMP could understand the risks of contaminant losses and available mitigation options for an existing farm, given the physiographic nature of the farm area and any variants.

RIPARIAN SETBACKS

44. Cultivation (and grazing) of land adjacent to waterways exacerbates and accelerates the transport of sediment and phosphorus to water (Basher et al. 1997). If cultivated land adjacent to waterbodies is used for grazing of fodder crops *in situ,* microbial pathogens also become problematic contaminants of water.

45. Cultivation, stock access or earthworks on land adjacent to waterways can impact on riparian spawning habitat through direct disturbance of spawning areas and eggs, sedimentation, and removal of vegetation.

46. Setback distances and vegetated riparian margins can alleviate or reduce many of the effects of cultivation and grazing adjacent to waterbodies on water quality. They contribute to reducing the influx of sediment to water from the largest load contributors: pastoral agriculture and streambank erosion (which is exacerbated by stock trampling).

47. Good riparian management (including stock exclusion, vegetated buffers and setbacks) has multiple benefits for water quality, including: nutrient, microbial and sediment interception and processing, shading, input of wood and leaves to freshwater ecosystems, and enhanced fish, spawning and invertebrate habitat (Parkyn 2004;

[29] Evidence in chief of K McArthur, 15 February 2019, paragraphs 20 and 90.
[30] Evidence in Chief of Ewan Rodway for Southland Regional Council, 14 December 2018, pages 36 to 47.

McKergow et al. 2016). Stock exclusion and riparian fencing may result in an 80% net reduction in suspended sediment load from bank erosion (Dymond et al. 2016).

48. Setbacks from water for sediment generating activities are a key method to avoid or reduce the adverse effects on water quality, ecosystem health and critical spawning habitats. Wider margins also have significant concomitant benefits for reducing other contaminants associated with cultivation, arable cropping and grazing, particularly nitrogen and microbial pathogens.

49. The ideal width required for trapping of particulate contaminants in surface runoff differs because the effectiveness of riparian buffer width varies as a function of slope, soils, drainage/hydrology, vegetation, rainfall and mode of contaminant transport (Collier et al. 1995; Parkyn 2004; Liu et al. 2008; McKergow et al. 2016).

50. There are key conclusions that can be drawn from the literature on riparian management and buffers: slope is an important factor – steeper land requires wider buffers (Liu et al. 2008; Zhang et al. 2010), small headwater streams also require setbacks and buffers as they are important for ecosystem health (Greenwood et al. 2012) and for nutrient contaminant reductions at the catchment scale (McDowell et al. 2017), and wider is usually better for effective contaminant removal (Parkyn 2004). Generally, buffer widths need to widen as the slope length, angle, and clay content of the adjacent land increase and as soil drainage decreases (Collier et al. 1995; Quinn and McKergow 2007).

51. Parkyn (2004) reviewed the New Zealand and international literature on the effectiveness of riparian buffer zones, reporting that in studies of perennial ryegrass filter strips the first five metres were critical for removal of larger particles of sediment and that 20 metre filter strips were able to remove 90% of sediment along with sediment-bound and particulate nutrients due to increased infiltration within the wider buffer. Liu et al. (2008) reported an optimal buffer width of 10 metres for sediment removal and that sediment removal did not appreciably increase beyond 10 metre wide filter strips. However, many authors note the effectiveness of even a 10 metre strip may be reduced because of clogging by fine sediment (whereby the capacity of the vegetation to filter sediment is overwhelmed over time if the flux of sediment from the landscape is not managed).

52. Smith (1989) in a New Zealand study, found removal of more than 80% of fine (suspended) sediment and particulate nutrients for vegetated filter strips of 10-13 metres. Infiltration capacity was improved through root structures of vegetation in buffer zones.

53. Parkyn's (2004) review also reported sediment and total phosphorus removal rates increase (between 53% and 98%) with increasing buffer width (4.6 metres to 27 metres). Critically, most large sediment particles will be removed within five metres of grass buffer, but 10 metres was needed to remove finer particles and will capture up to 95% of total sediment. These fine particles create poor water clarity in suspension and contribute significantly to fine sediment deposition. However, few studies specifically examined the effectiveness of riparian buffers at slopes greater than 10 degrees and most studies looked specifically at reducing sediment inputs from general pastoral grazing as opposed to farming activities which include periods of exposed bare or heavily pugged soils (e.g., cultivation or intensive winter grazing).

54. Given the scale of the sediment issue in Southland and the reductions required to achieve objectives in some catchment areas (Neverman et al. 2021), I recommend a minimum 10 metre minimum buffer width is needed to reduce fine sediment and nutrient inputs to water bodies through overland flow. Furthermore, wider buffers are needed where land slope increases above 10 degrees, sediment generating activities are adjacent to sensitive receiving waters, or the flux of sediment from the contributing landscape is likely to be severe (i.e., intensive winter grazing).

55. The greater the slope the higher the erosion potential where soil is exposed by land use activities. Therefore, wider buffers (i.e., 20 metres or greater) will be needed to reduce the potential for fine sediment to enter water from exposed soils on steep land and I recommend 20 metre buffers apply to cultivation at slopes greater than 10 degrees. Sensitive receiving waters that have a longer residence time than rivers (i.e., wetlands, lakes, springs, lagoons and estuaries) should have greater buffers to protect these waterbodies from excess sediment due to the potential for increased adverse effects over the long term that are more difficult to remediate.[31] I recommend a 20 metre buffer from cultivation should apply to these waterbodies.

56. Stock should be excluded from any setback or buffer, including those associated with ephemeral or intermittent streams. Ideally, buffer widths discussed above would apply to

[31] As agreed by the experts in the Science 2021 JWS page 15.

all grazing systems adjacent to waterbodies in Southland as this would contribute to significantly reducing the load of contaminants reaching water via overland flow. Buffers specific to intensive winter grazing are discussed further below.

INTENSIVE WINTER GRAZING

57. The Topic A evidence of Mr Rodway[32] identifies some of the risks associated with winter grazing (any stock type). Mr Rodway considers the nutrient losses from *in situ* grazing of forage crops between May to August make a disproportionately large contribution to nutrient losses from the total farm system. Whilst Mr Rodway differentiates the greater nutrient losses from winter grazing on forage crops from grazed dairy pasture, it is not clear if his use of the term ‘grazed dairy pasture’ includes dairy pasture grazing or break-feeding of pasture that occurs during winter and thus may result in pugging and exposure of bare soils.

58. According to Mr Rodway[33] suspended sediment losses from dairy winter grazing land are estimated to be approximately 550% greater than those from dairy pasture grazing (again, it is not clear if this includes winter dairy pasture grazing) with losses of 330 kg/ha/y coming from dairy winter grazing (compared to 60 kg/ha/y from dairy pasture grazing). Sediment losses of 60 kg/ha/y are not insignificant.

59. Neverman et al. (2021) identified areas of winter forage cropping provided by Environment Southland to model sediment losses. The report noted winter forage cropping would create a sediment generation risk due to having bare ground for what they assumed was approximately three months of the year because of double soil exposure from initial cultivation and subsequent grazing. In their analysis of sediment load reductions required to meet freshwater objectives Neverman et al. (2021) found a 2.9% (Waiau) to 9.7% (Aparima) increase in sediment loads depending on the FMU from winter forage cropping.

60. The existing definition of intensive winter grazing is limited to grazing forage crops. Amendments discussed by the planners included controlling break feeding on pasture only between 1 June and 31 July (through Appendix N). I am not aware of any evidence which shows that break feeding on pasture generates significantly less sediment than intensive winter grazing generally, therefore the potential effects of these activities on

[32] Evidence in chief of Ewen Rodway for Southland Regional Council dated 14 December 2018, paragraphs 103 to 110.
[33] Evidence in chief of Ewen Rodway paragraph 106.

water quality should be managed in the same way. Likewise, I am not aware of effects only occurring or occurring predominantly in the period 1 June to 31 July and do not understand there to be any effects-based reason for identifying land utilised for these purposes only during that period. My understanding is that excess sediment can be generated through erosion of bare soils across much of the year when animals are fed in this manner. I support provisions to manage intensive winter grazing on pasture throughout winter.

61. Given the significant risk of severe sediment flux from land that is intensively grazed in winter overwhelming riparian buffer strips I recommend a 20 metre buffer strip for waterbodies that are adjacent to intensive winter grazing.

SHEEP GRAZING WETLANDS

62. I understand that stock exclusion from wetlands is agreed, with the exception of sheep. The Ecology experts agree[34] that wetlands are ecologically, and culturally important ecosystems and their extent is greatly diminished in Southland with ongoing loss. Therefore, the risk of adverse effects on natural wetlands should be avoided wherever possible and where it cannot be avoided should be carefully managed. Given the high values of remaining natural wetlands and the risks posed to them by sheep grazing (as identified in the Ecology 2021 JWS), allowing sheep (or any grazing stock) into natural wetlands is unlikely to adequately protect the extent and values of natural wetlands in Southland.

EPHEMERAL AND HEADWATER STREAMS

63. Small, headwater streams are important for ecosystem health (Storey et al. 2011; Greenwood et al. 2012) and are critical areas for determining catchment water quality (McDowell et al. 2017). As discussed previously, headwater streams occur throughout the landscape, including in lowland areas, and they capture run-off that is the source of the wider stream and river network.

64. Headwater streams (including ephemeral streams with isolated pools and intermittent streams) are known to contain as many or more invertebrates (both in density and species richness) as perennial streams (Storey et al. 2011). Headwater streams are

[34] Ecology 2021 JWS response to question 1, page 3.

also considered crucial for sustaining the structure, function, productivity, and biodiversity of downstream ecosystems (Wipfli et al. 2007; Freeman et al. 2007).

65. Studies of stream macroinvertebrates in Aotearoa New Zealand indicate that headwaters have high biodiversity values (Storey and Quinn 2008). Intermittent and ephemeral headwater habitats can have high biodiversity even where there is only a thin film of water and may also harbour headwater specialist or endemic species (Collier and Smith 2006).

66. There is no clear ecological definition of an ephemeral stream vs an intermittent stream, ecologically they occur on a hydrological continuum, there are however definitions in many regional plans around the country. Like the pSWLP definition, many regional plans define intermittent streams as having an established bed, whereas ephemeral streams are often considered not to have a definitive 'bed'. These types of definitions are problematic ecologically and particularly in the pastural landscape. Streams in pasture invariably narrow, become incised, gather sediment and grow pastural ('terrestrial') vegetation on their former beds (Davies-Colley 1997).

67. The inclusion of small waterways (including headwater, intermittent and ephemeral streams) in farming rules (including intensive winter grazing, cultivation, stock exclusion and fertiliser discharge provisions) is critical to ensure impacts on freshwater ecosystem health and water quality are reduced or avoided not just within the streams themselves, but also in downstream catchments (Storey et al. 2011; Greenwood et al. 2012; McKergow et al. 2016; McDowell et al. 2017). I support the removal of provisions from the pSWLP which sought to exclude ephemeral streams from protection. I see this as an important first step in recognising the importance of these ecosystems and their contribution to water quality and ecosystem health.

68. Ephemeral and intermittent streams require setbacks and riparian buffers to reduce contaminant transport from land to water and direct avoidance of the discharge of fertiliser. Small streams contribute 77% of the national contaminant load of nitrogen and phosphorous in lowland areas (McDowell et al. 2017). Management of small headwater streams to reduce contaminant transport is therefore a critical component of any regulatory plan that seeks to reduce contaminant loads across the catchment.

69. Ephemeral streams are critical sources of contaminant transport from the land to water and should be identified on-farm within FEMPs and included in rules to mitigate the

impacts of farming activities on water bodies. I support their recognition in the Plan as critical source areas (CSAs) where intensive winter grazing may not occur, and which must be identified and "managed" through FEMPs.

70. I am concerned however that the important ecological values of ephemeral streams are not identified in the plan provisions (including Appendix N and the definitions) and these values will not be protected through addressing ephemeral streams only as critical source areas and applying subsequent mitigations. Further steps to permanently exclude stock from ephemeral and small headwater streams may be required in future to realise the significant reductions in contaminants needed in Southland to achieve freshwater objectives, to provide for the ecosystem health of these waterbodies and to give effect to Te Mana o te Wai.

DRAIN MAINTENANCE

71. Rule 78 of the pSWLP allows weed and sediment removal for drain maintenance as a permitted activity subject to conditions. The Ecology experts agree[35] that the proposed permitted conditions are not sufficient to avoid or minimise effects on indigenous and taonga species because the permitted rule still allows for high levels of disturbance to waterways that are inhabited by indigenous species. The affected drainage network is extensive across Southland and includes the habitats of most of Southland's freshwater indigenous species, including threatened species. A higher level of protection is required, and the proposed permitted activity does not address many of the effects identified by the experts.[36]

72. The experts have identified[37] that a longer term view needs to be taken, rather than simply relying on best management practices to reduce impacts (which cannot avoid significant residual effects on indigenous and taonga species). The experts consider there is a hierarchy of actions that can be taken with the first priority being the prevention of weed and sediment accumulation, before contemplating mitigation of drain clearance practices. The experts have identified some mitigation practices in Table 1 on page 6 of the Ecology 2021 JWS, but stress throughout that effects will still be significant and that taonga and indigenous species will not be adequately protected through mitigation alone and that this is inconsistent with the pSWLP Objective 15 and Policy 3 provisions for

[35] Ecology 2021 JWS response to question 2, page 4.
[36] Ecology 2021 JWS response to question 2, page 5.
[37] Ecology 2021 JWS response to question 3, pages 6 and 7.

taonga species. Given the destructive nature of drain maintenance activities, the experts agreed that effects on threatened species should be avoided.[38]

73. Whilst restricting drain maintenance from the mapped habitats of threatened species may reduce the impact on some populations and individuals within mapped areas, the experts recognise[39] that unmapped (and unmonitored) habitats will still be at risk. Some species, such as kanakana (lamprey) and waikakahi (freshwater mussels), are very difficult to map as these species are rarely detected using standard freshwater survey methods. Adding to the uncertainty in mapping threatened species habitats (where drain maintenance could be more restricted) is the patchy nature of our monitoring of indigenous freshwater species and the quality and quantity of data contained in the New Zealand Freshwater Fish Database. Mapping may reduce the spatial extent of permitted drain maintenance, but will not avoid significant adverse effects on some habitats of threatened and taonga species.

GRAVEL AND SEDIMENT DEFINITIONS

74. Fine sediment is defined in the national guidelines and sediment assessment protocols by Clapcott et al. (2011) as silts or sands <2 mm in diameter. Coarser particles (i.e., >2mm) can be termed 'gravel' through a range of particle size classes depending on the scale used. Gravel is generally used as the term for all particles larger than 2mm diameter.

Kathryn Jane McArthur
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[38] Ecology 2021 JWS response to question 2, page 4.
[39] Ecology 2021 JWS response to question 5, page 8.

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