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

REBUTTAL EVIDENCE OF KATHRYN JANE MCARTHUR

Dated 22 February 2022

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. My qualifications and experience are as set out in my evidence in chief dated 20 December 2021.

2. 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], providing Topic B evidence in chief dated 20 December 2021 and section 274 party evidence on 4 February 2022.

CODE OF CONDUCT

3. 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.

4. 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.

5. 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.

6. 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]

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

SCOPE

7. 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 rebuttal 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). I have not changed my opinions as expressed in prior evidence briefs or the joint witness statements arising from expert conferences I have participated in, except for the width of riparian buffers for intensive winter grazing, which I address below.

8. I have read:

   a. evidence in chief of Drs Snelder, Burrell and Monaghan and Mr McCallum-Clark on behalf of Southland Regional Council, dated 11 February 2022;

   b. s274 party evidence of Dr Kitson on behalf of Ngā Rūnanga, dated 4 February 2022;

   c. s274 party evidence of Ms Kirk on behalf of the Director-General of Conservation, dated 4 February 2022;

   d. evidence in chief (dated 20 December 2021) and s274 party evidence (dated 4 February 2022) of Dr Depree and evidence in chief of Mr Duncan (dated 4 February 2022) on behalf of the dairy interests; and

   e. draft rebuttal evidence of Dr Canning and Mr Farrell on behalf of Forest and Bird and Southland Fish and Game Council, dated 22 February 2022.

9. This statement of rebuttal evidence should be read in conjunction with my evidence in chief dated 20 December 2021 and s274 party evidence dated 4 February 2022 and covers the following themes:

   a. Approaches to determining degraded catchments;

   b. Buffer widths for Intensive winter grazing (IWG) and cultivation;

   c. Ephemeral streams and critical source areas;

   d. Content of Appendix N; and

e. Rule 78 Drain maintenance.

DETERMINING DEGRADED CATCHMENTS

Dairy interests' approach to degraded[4] catchments

10. Dr Depree proposes an assessment framework to determine which catchments are degraded or 'catchments in need of improvement' that uses a single attribute for ecosystem health and human contact values; i.e., macroinvertebrate community index (MCI) and *E. coli* respectively. Dr Depree considers[5] the biophysical ecosystem health framework that has been adopted by the National Policy Statement for Freshwater Management (NPSFM) 2020, based on the work of Clapcott et al. (2018), places greater emphasis on measures of aquatic life. I disagree, both with his single attribute approach and with the conclusions he draws about the NPSFM and Clapcott et al. (2018). Neither the NPSFM definition of ecosystem health nor the underlying framework of Clapcott et al. (2018) specify primacy of aquatic life over the other ecosystem health components.

11. Whilst I agree that macroinvertebrate biomonitoring is critical for assessing stream health that is widely used across Aotearoa New Zealand, I do not agree that the 'aquatic life' component of ecosystem health integrates the other four components as Dr Depree asserts, nor is MCI the only attribute relevant to aquatic life or specified for aquatic life in the NPSFM. In my opinion, Dr Depree's approach is an oversimplification of the complex and interrelated nature of components and attributes of ecological health. As stated in my s274 party evidence for Topic B at paragraph 27, all attributes (as determined by the experts in the October and November 2019 JWSs) are needed for the consideration of the health of an ecosystem and the assessment of that state of health is inherently holistic. I agree with Dr Snelder[6] that no one attribute has precedence or can be used as a proxy for ecosystem health.

12. I also disagree with Dr Depree that his approach is "*more consistent with concepts such as ki uta ki tai and hauora*".[7] As discussed in my s274

[4] I continue to use the term 'degraded' throughout my evidence as this was the context and wording put to the science experts by the Court for conferencing in 2019. Determining whether waterbodies are degraded was particularly relevant to understand the implications of Objective 6.
[5] Evidence in chief of Craig Depree dated 20 December 2021, paragraph 4.1(d).
[6] Evidence in chief of Dr Antonius Snelder dated 11 February 2022, paragraph 50.
[7] Evidence in chief of Craig Depree dated 20 December 2021, paragraph 4.6.

party evidence at paragraphs 26 and 27 and the s274 party evidence of Dr Kitson, the multi-attribute, interrelated approach to hauora is encapsulated by 'Principle A' of Bartlett et al. (2020)[8] and other principles, as further described by Dr Kitson.

13. Dr Depree states[9] that 'experts agree' (citing a consultants' report by Greenwood et al. (2021) prepared for DairyNZ) that one of the three main stressors of macroinvertebrates is loss of riparian habitat. However, I consider this statement is incomplete, as he does not explain that fine sediment and nutrients were identified in that report as the first two key stressors. Greenwood et al. (2021) is a discussion document looking at the development of action plans under the NPSFM for macroinvertebrate attributes and contains the disclaimer at footnote 1 on page 9: "*While individual participants did not agree on all points, this report summarises the issues discussed and the majority consensus reached*." The expert panel participants were selected "*in discussion with DairyNZ*" and it is difficult to know from the text which issues the experts did in fact agree on. Notwithstanding this, the key stressors for macroinvertebrates in developed catchments identified in Greenwood et al. (2021) were listed as (in order):[10]

i. Fine sediment;

ii. Nutrients; and

iii. Removal of riparian vegetation.

14. Dr Depree goes on to express concern that habitat quality targets and remedial actions could be overlooked in favour of focussing on 'individual contaminants' in degraded catchments. The experts considered habitat and riparian restoration as attributes of relevance to improving hauora (which includes ecosystem health) in the Science 2021 JWS.[11] Riparian margins were clearly stated attributes of physical habitat providing for Te Hauora o te Taiao and Te Hauora o te Wai[12] and were included for consideration as Ngāi Tahu cultural indicators of health (Appendix 1 of Final report on Cultural indicators of health, 29/11/19 Memorandum on

[8] Bartlett et al. (2020), page 26: "*Principle A: A state of hauora will be the result of the interaction of a combination of attributes, including Ngāi Tahu Indicators of Health*." [The text of this footnote was erroneously omitted from footnote 15 to my s274 party evidence dated 4 February 2022.]
[9] Evidence in chief of Craig Depree dated 20 December 2021, paragraph 4.15.
[10] Greenwood et al. (2021) page 21.
[11] Science 2021 JWS, Table 2 Science experts' response to question 1 of farms systems expert questions, pages 9 and 10 and response to questions 4, page 7, paragraph 5.
[12] Table B, page 70 of Bartlett et al. (2020).

behalf of Ngā Rūnanga). As noted below, the experts (Science 2021 JWS) combined cultural and water quality attributes and thresholds in assessing degradation, which implicitly includes riparian margins as well as other habitat attributes, and I support reference to those matters in the pSWLP methods, including Appendix N. Of more concern, in my opinion, is the dairy interests' approach which side lines other key stressors (including fine sediment and nutrients) affecting ecosystem health. Like Dr Canning, I am of the view that habitat improvements should not be thought of as alternatives to reducing nutrient inputs to waterbodies, but complementary.

15. Further, I strongly disagree with Dr Depree[13] that his proposed approach is consistent with the expert conferencing outcomes in the May, September, October or November 2019 JWS and Science 2021 JWS; or that as experts we have taken a 'reductionist approach'[14] to determining degradation. In my opinion, the approach taken by the experts throughout the 2019 and 2021 conferencing and production of JWS was holistic, considering a wide range of attributes across multiple ecosystem types, the interactions between ecosystems, and the inclusion of both Ngāi Tahu and 'Western' sciences and knowledge. Dr Depree's approach fails to adequately consider the impact of systems on each other across the landscape (e.g., the impacts of rivers on downstream sensitive receiving environments such as estuaries or lakes, an aspect of ki uta ki tai), relies on single attributes for each of two freshwater values (ecosystem health and human contact) and has not adequately considered Ngāi Tahu cultural indicators or key concepts (i.e., hauora or ki uta ki tai).

Mapping of degraded catchments

16. Dr Snelder has provided maps of degraded waterbodies based on the thresholds from the October 2019 JWS where there was adequate and reliable monitoring and/or modelling information to enable mapping. I agree with and support Dr Snelder's evidence and the inclusion in the pSWLP of the maps he has produced based on those thresholds. I consider the methods and the maps produced to be a useful inclusion in the Plan for determining degraded catchments where improvement actions

[13] Evidence in chief of Craig Depree dated 20 December 2021, paragraph 4.1(c).
[14] Evidence in chief of Craig Depree dated 20 December 2021, paragraphs 4.5, 4.7 and footnote 5.

are needed. I also consider the approach taken by Dr Snelder to be consistent with the 2019 and 2021 science expert conferencing outcomes.

17. Dr Snelder has modelled and mapped degraded waterbodies based on a sub-set of seven of the attributes[15] developed through the expert conferencing as set out in the November[16] 2019 Science JWS. The sub-set of attributes which Dr Snelder has modelled and mapped are:

a. Dissolved inorganic nitrogen (DIN);

b. Dissolved reactive phosphorous (DRP);

c. Visual water clarity (black disc);

d. *Escherichia coli* (*E. coli*);

e. Macroinvertebrate community index (MCI);

f. Total nitrogen (TN) loads to estuaries; and

g. Total phosphorous (TP) loads to estuaries.

18. While I am content with the subset of attributes currently being used for mapping, I consider that the other attributes of degradation identified by the experts[17] and Ngāi Tahu cultural indicators of health should also be expressed in Schedule X of the Plan alongside the degraded catchment maps (I consider that both the individual and combined maps produced by Dr Snelder should be in the Schedule). This will allow for future assessments of catchments against these thresholds to assess their degradation status if more reliable or additional data for these attributes is collected/collated in future. It will also inform on-farm mitigations focussed on attributes of concern, by providing a fuller picture of what those attributes of concern are.

Degraded estuaries

19. With respect to the degradation status of estuaries I agree with Dr Snelder's map based on modelled data and estuarine degradation status derived from Plew (2020) and I prefer his approach to that of Dr Depree.

[15] Evidence in chief of Dr Snelder dated 11 February 2022, paragraphs 34 and 35.
[16] Although I note Dr Snelder refers to the October 2019 JWS.
[17] In the November 2019 Science JWS Appendix 4 the experts identified eleven attributes for rivers (Table 1), eight attributes for lakes and ICOLLs (Table 2), and seven attributes for estuaries (Table 3) with Ngāi Tahu cultural indicators of health identified in Appendix 1 of the 29 November 2019 memorandum of counsel for Ngā Rūnanga.

Although Dr Depree uses the thresholds of degradation from the November 2019 Science JWS, Plew (2020) modelled data 'fills the gaps' in our knowledge and this updated modelling information was not available to the experts at the time of writing the November 2019 JWS.

Degraded lakes/ICOLLs[18]

20. Figure 17 of the November 2019 JWS identifies Lake Vincent and Waituna Lagoon both as degraded by total nitrogen. Waituna Lagoon is captured in the methods of Dr Snelder (through the Plew 2020 assessment of coastal lake estuaries) and in Dr Depree's degraded ICOLLs. However, Dr Depree fails to identify the catchment of Lake Vincent as degraded in his mapping methods, instead noting that lakes were assumed to be of generally good water quality.[19] It is notable that Dr Depree finds it acceptable to determine that lakes and estuaries are degraded by nitrogen, but not rivers. The experts identified Lake Vincent as degraded based on available data, noting that modelling shows degradation of lakes is likely to be more widespread.[20] Therefore, in my opinion, the catchment contributing to Lake Vincent should also be identified as degraded.

21. Dr Snelder does not identify any lake catchments as degraded because of a lack of reliable models for Southland lakes due to insufficient monitored sites (only seven of Southland's many lakes are monitored).[21] I have confirmed with Dr Snelder that although a specific lake model has not been applied to the combined map of degraded catchments in his evidence, the catchment area of Lake Vincent was already identified as 'degraded' through the other criteria applied.

BUFFER WIDTHS

22. I maintain my opinion (as set out in evidence in chief and further elaborated in s274 party evidence) that a minimum 10-metre riparian buffer should apply to all rivers and streams at slopes less than 10 degrees to effectively reduce the adverse effects of sediment from activities such as cultivation. Ideally, this buffer would apply to all land in pastoral farming adjacent to waterways as the diffuse run-off of sediment from pastoral land

[18] Intermittently closed and open lake and lagoons (ICOLLs).
[19] Evidence in chief of Craig Depree dated 20 December 2021, paragraph 4.23 and footnote 18.
[20] November JWS 2019, paragraph 20.
[21] Evidence in chief of Dr Antonius Snelder dated 11 February 2022, paragraph 36.

constitutes 40% of sediment in rivers nationally[22] and 39% in Southland (extrapolated from Neverman et al., 2021). Mr Duncan is incorrect in assuming[23] that there are not significant sources of sediment available for transport in pasture-based farming systems. Pastoral farming is the primary anthropogenic source of sediment loss in Aotearoa New Zealand and contributes a significantly greater proportion of diffuse sediment lost to river catchments and the ocean than other land uses, including production forestry.

23. On cultivated land with a slope of 10 degrees or greater, in rivers adjacent to IWG, or for cultivation/IWG adjacent to lakes, wetlands or estuaries (lentic or non-flowing waterbodies), in the absence of specific management of sediment sources or erosion and sediment controls, a 20-metre buffer would better reduce the risk of sediment reaching waterbodies and protect ecological values.[24] My reasoning for this is set out in evidence as noted above. To briefly reiterate:

a. Increased slope is related to erodibility and soil loss risk[25] and decreased buffer effectiveness;

b. IWG is a high risk activity for generating seasonally high loads of sediment under elevated rainfall conditions which may result in lesser buffers being rapidly overwhelmed by sediment and rendered ineffective; and

c. Lakes, wetlands and estuaries are often low or non-flowing environments with long residence times, inputs of sediment can have greater adverse effects over time within these waterbodies.

24. Dr Depree[26] ascribes my recommendations for wider buffers as relating to the additional width needed for nutrient removal, citing paragraph 54 of my evidence in chief. This is an incorrect interpretation of paragraph 54 of my evidence and all remaining discussion of buffer widths

[22] New Zealand is a highly erodible land mass, contributing ~1.7% of sediment received by the world's oceans annually, despite being only 0.2% of global land area. https://niwa.co.nz/news/reducing-sedimentation
[23] Evidence in chief of Craig Duncan dated 4 February 2022, paragraphs 57 and 58.
[24] When buffer widths are considered holistically with respect to improving ecosystem health outcomes, rather than simply as sediment controls, 20-metre buffers can provide multiple benefits with respect to maintaining self-sustaining indigenous vegetation and associated terrestrial and aquatic biodiversity values, including protection of indigenous fish spawning habitats, which often occur in the vegetation of riparian margins. There are cultural values associated with riparian buffers which should also be acknowledged in setting buffer widths.
[25] Evidence in chief of Dr Ross Monaghan dated 11 February 2022, paragraphs 25 to 31.
[26] Section 274 party evidence of Craig Depree dated 4 February 2022, paragraph 4.3.

throughout my evidence. Whilst I note in evidence where the reviewed literature identifies some concomitant benefits for nutrient removal, I do not assert this as a reason for wider buffers. The premise on which I recommend wider buffers is that they will slow sediment transport from land to waterways and assist in reducing the risk of buffers being overwhelmed from seasonally high flux of sediment co-occurring with elevated winter rainfall or snowmelt (i.e., IWG) and which may also be justified by the risks of cultivation at elevated slope, or proximity to sensitive receiving environments (e.g., lakes, wetland, lagoons).

25. Mr Duncan identifies[27] studies (reviewed and summarised by the Ministry for the Environment) showing significantly reduced sediment removal efficiencies beyond 10 metres. Having reviewed most of these studies in my evidence in chief and during expert conferencing for the Science 2021 JWS, I observe these studies do not specifically assess buffer effectiveness at slopes greater than 10 degrees. Although the buffer effectiveness reduces between 10 and 20 metres width, there is still more sediment removal occurring in the wider buffers, and for steeper slopes the experts agree a wider buffer is likely to be more effective[28] and it may be appropriate to have a wider buffer where highly effective sediment removal is needed (e.g., sensitive receiving environments).

26. Notwithstanding this, I agree with Drs Monaghan and Depree that management of critical source areas (CSAs) (which potentially include riparian margins if poorly managed) and adoption of other erosion and sediment control principles and practices is important in reducing sediment and overland contaminant transport to water.

27. With respect to buffers for IWG, having reflected further on Dr Monaghan's evidence I agree that if good management of CSAs is fully implemented in the manner described by Dr Monaghan,[29] a 10-metre buffer may suffice as an effective sediment management measure in most cases.[30] A wider buffer may be necessary for protection of ecosystem health and cultural values, as discussed by Dr Burrell.[31] The necessity for

[27] Evidence in chief of Craig Duncan dated 4 February 2022, paragraph 64 and Figure 5.
[28] Science 2021 JWS, response to question 7, pages 14 and 15.
[29] Evidence in Chief of Dr Ross Monaghan dated 11 February 2022, paragraph 14(b).
[30] Noting that a wider buffer may be necessary for protection of ecosystem health and cultural values, as discussed by Dr Burrell in his evidence in chief dated 11 February 2022, paragraph 20.
[31] Evidence in chief of Dr Burrell dated 11 February 2022, paragraph 20

wider IWG buffers for these purposes should be identified within and required by FEMPs in appropriate locations.

28. With respect to cultivation, I agree with Dr Burrell[32] and I continue to recommend a 10-metre buffer for slopes of less than 10 degrees and a 20-metre buffer at slopes 10 degrees or greater. A 20-metre buffer will be particularly important as a management measure where the cultivation at slope activity is adjacent to sensitive receiving environments such as lakes, wetlands, lagoons or estuaries, which take long time periods to recover from sedimentation.

EPHEMERAL STREAMS AND CRITICAL SOURCE AREAS

29. Whilst Mr Duncan[33] and others identify ephemeral rivers/waterbodies as flow paths only, devoid of river or aquatic ecological features, I reiterate the view stated in my evidence in chief[34] that streams in pasture invariably narrow, become incised, gather sediment and grow pastural ('terrestrial') vegetation on their former beds (Davies-Colley 1997), rendering them outside the pSWLP definition of intermittent river.[35] These features would be better described as 'intermittent streams without clear, defined beds' (noting that this does not fit within the current definitions of the pSWLP), but as I have expressed in previous evidence,[36] the nature of river flow occurs across a hydrological continuum, and it is not as clear-cut as Dr Depree suggests.[37]

30. Mr Duncan does not substantiate his observation[38] that contaminant losses through ephemeral flow paths are not normally derived from animals standing in these areas and I am unaware of any literature that supports this premise. Cattle are well-documented as attracted to stand and defecate in water (e.g., Collins et al. (2007) and others). Ephemeral streams are subject to both diffuse and direct (Photo 1) contaminant inputs and therefore there are significant potential benefits to downstream water quality in excluding stock from these areas.

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[32] Evidence in chief of Dr Greg Burrell dated 11 February 2022, paragraphs 21 and 23.
[33] Evidence in chief of Craig Duncan dated 4 February 2022, paragraph 32.
[34] Evidence in chief of Kathryn McArthur dated 20 December 2021, paragraph 66.
[35] "*Intermittent river means a river which does not contain permanently flowing or standing water and where the bed is predominantly devoid of terrestrial vegetation and comprises sand, gravel, boulders, or similar material or aquatic vegetation*."
[36] Evidence in chief of Kathryn McArthur dated 20 December 2021, paragraph 66.
[37] S274 party evidence of Craig Depree dated 4 February 2022, paragraph 5.8.
[38] S274 party evidence of Craig Duncan dated 4 February 2022, paragraph 46.

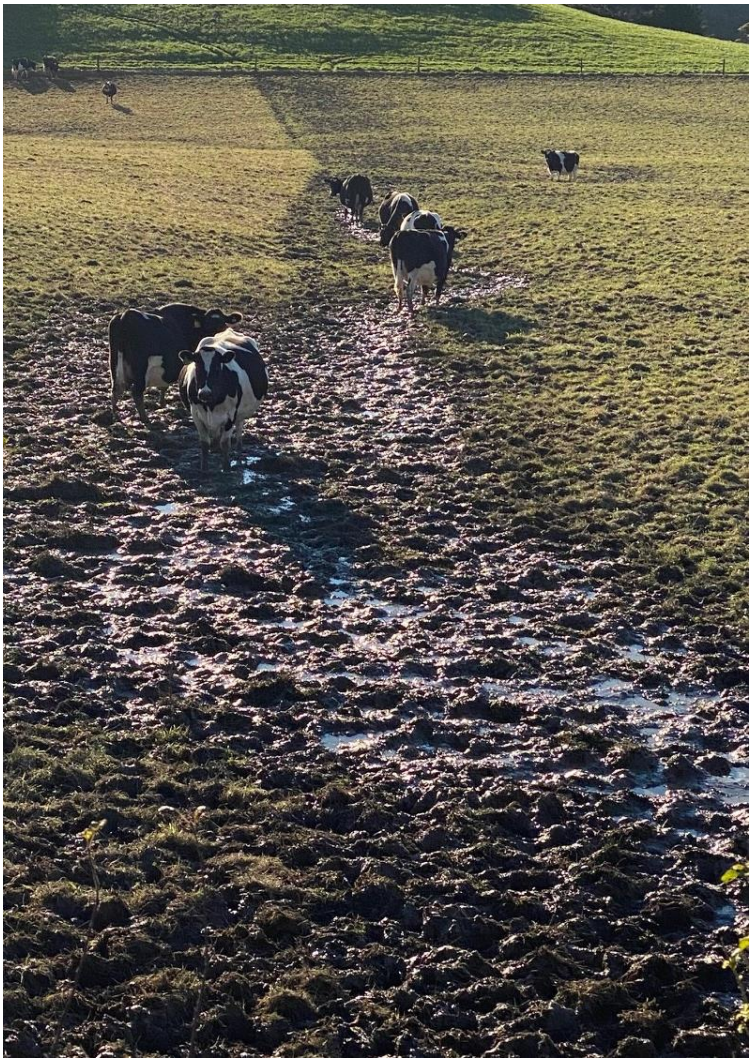

Photo 1. Wintering dairy cattle in an ephemeral waterbody, K McArthur, July 2021.

31. Regardless of what they are called in the Plan, I support the identification and management of ephemeral streams/waterbodies (*c.f.* flow paths) as CSAs and acknowledge that in future, further steps to protect their ecological values and reduce their contribution to degraded water quality (including via stock exclusion and setbacks) may be required 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. In this I agree with Mr McCallum-Clark.[39]

[39] Evidence in chief of Matthew McCallum-Clark dated 11 February 2022, paragraph 41.

APPENDIX N

32. I have reviewed the proposed changes to Appendix N now recommended by Mr Farrell.[40] These additional considerations stem from the recommendations of the experts in the Science 2021 JWS.[41] Here the experts identified other attributes of relevance to improving hauora (which by inference includes ecosystem health) either through FEMPs or the Plan provisions more widely. I support their inclusion in the Plan as per the expert agreement in the Science 2021 JWS.

33. I note there were some minor differences between what the experts suggested in the Science 2021 JWS and the amendments to Appendix N previously recommended in Mr Farell's evidence in chief. To remedy this, I recommended Mr Farrell include 'faecal contaminants' to be listed alongside nutrients and sediment in Clause 5(c) of Appendix N (as recommended in the 'commentary' column of Table 2 in relation to Human health aspects).[42] Further, the attributes (three bullets alongside Human health aspects in Table 2) should also be added to Appendix N or elsewhere in the Plan (I leave the matter of where they best sit to the planning experts).

'DRAIN' MAINTENANCE – RULE 78

34. I have considered the evidence in chief of Mr McCallum-Clark and s274 party evidence of Ms Kirk with regards to Rule 78 and exclusions from the rule for threatened non-diadromous galaxiid fish. Although I have discussed the matter further with some of the planners and ecologists involved in this topic, I have not changed my views previously expressed in evidence and the Ecology 2021 JWS. In my opinion, none of the changes suggested adequately address the significant adverse effects of the activity on indigenous aquatic life, including other threatened[43] and taonga species.

[40] Rebuttal evidence of Ben Farrell dated 22 February 2022, Appendix 1.
[41] Science 2021 JWS response to the question to the Farm Systems experts, pages 9 and 10 and Table 2.
[42] Science 2021 JWS, page 10.
[43] i.e., other than some habitats of threatened non-diadromous galaxiids.

Kathryn Jane McArthur
22 February 2022

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