Expert Conference – Science / water quality - Agenda

Topic: Proposed Southland Water and Land Plan – Southland Regional Council

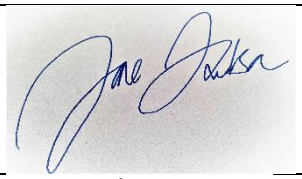
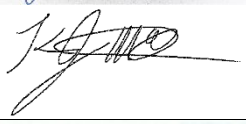
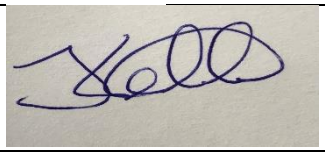
Date of conference: 24-26 November 2021

Venue: Remote AVL

Facilitator: Anne Leijnen

Recorder: Isabelle Harding

Attendees

Name	Employed or engaged by	Signature
Dr Jane Kitson (JK)	Nga Runanga	
Kathryn McArthur (KM)	Royal Forest and Bird Protection of New Zealand	
Dr Mark James (MJ)	Meridian Energy NZ	
Dr Gregory Burrell (GB)	Southland Regional Council	
Dr Ton Snelder (TS)	Southland Regional Council	
Justin Kitto (JAK)	DairyNZ/Fonterra	
~~Jim Risk~~	~~Ballance~~	

Environment Court Practice Note

1 All participants confirm that they have read the Environment Court Consolidated Practice Note 2014 and in particular Section 7 (Code of Conduct, Duty to the Court and Evidence of an expert witness) and Appendix 3 – Protocol for Expert Witness Conferences and agree to abide by it.

2 Kathryn McArthur acknowledges that as a member of the New Zealand Freshwater Sciences Society, a constituent organisation of the Royal Society of New Zealand - Te Apārangi, she is also bound by the Royal Society of New Zealand Code of Professional Standards and Ethics in Science, Technology, and the Humanities.

3 Dr Jane Kitson acknowledges that she is a member of Te Runange o Oraka-Aparima and also whakapapa to Te Runanga o Awarua and Waihopai Runaka. She notes that her expertise is partially derived from those cultural associations. She recognises that whilst she is of Ngāi Tahu descent, she is required to be impartial and unbiased in her professional opinions expressed. Jane is also a member of the New Zealand Freshwater Society so is also bound by the Royal Society of New Zealand Code of Professional Standards and Ethics in Science, Technology, and the Humanities.

Experts' qualifications and experience

4 These are set out in each experts' will say statement.

Participants

5 This JWS is limited to those Science / Water Quality experts that have an interest and took part in the discussion.

Purpose of expert conference

6 The purpose of the conference is to assist the Court by responding to a series of questions, agreed by the experts as the conference progressed, relating to science and water quality, and associated issues that the court may wish to consider when determining the appeals. For each question, the experts state matters on which they agree and on which they do not agree, with reasons.

Attachments to this JWS

7 List of questions for the Science experts

Conference outcomes

8 The Planning conferencing identified a number of technical questions to form the basis of the agenda for the Science and Water Quality experts – this is attached.

Attachment: Questions to Science/Water Quality Experts:

Given that the planning experts agree that farming that contributes contaminants to degraded water bodies should be treated differently, there is a need to clearly identify (preferably spatially per contaminant of concern) where the degraded waterbodies are and what farming areas contribute to that degradation. Specific questions include:

At the request of the experts, the planners provided the following context;
The experts have been advised by the planners that the present plan is based on halting further decline in water quality, and improving water quality where it is degraded. Based on the Overview Evidence of Matthew McCallum-Clark (para 60) Plan Change Tuatahi is proposed to be notified December 2023 and, informed by the Regional Forum process, to set out a more detailed outcomes for each FMU respectively (i.e. numeric water quality objectives), the steps to achieve them and timeframes. This includes an assessment of land and other resource use patterns and changes needed to those patterns to fully implement the NPSFM 2020.

1. What is the impact of applying ki uta ki tai to the identification of degraded water bodies? How does ki uta ki tai change what and how waterbodies are identified as degraded?

For the purposes of this expert conferencing, the experts took 'degraded' to be based on a *combination* of water quality and cultural thresholds (JWS refs here?).

Cultural background taken from previous JWS.

In the 4 September 2019 Rivers and Lakes JWS, Ms Cain provided the following meanings for Te Mana o te Wai and Ki Uta Ki Tai in the Southland context. (emphasis is for the purposes of this JWS)

The pSWLP seeks to manage water and land resources in a way that encompasses the Ngāi Tahu philosophy of Ki Uta Ki Tai. This approach recognises that water is important in a variety of ways and that Environment Southland is committed to managing the connections between land and all water, particularly the effects of water quality and quantity changes on the health and function of estuaries and coastal lagoons.

"Ki Uta Ki Tai is commonly referred to as 'mountains to the sea' and i**s about standing on the land and knowing the effects, both positive and negative, in every direction. This ethos reflects the mātauranga (knowledge) that all environmental elements are interconnected and must be managed as such.**

At a framework level, Ki Uta Ki Tai is similar to the RMA term 'integrated management'. The pSWLP also recognises that Te Mana o te Wai is fundamental to the integrated framework for freshwater management in Southland. Te Mana o te Wai was formally introduced to freshwater management in 2014 through the NPSFM, which states that it is nationally significant. **Upholding Te Mana o te Wai acknowledges and protects the mauri of the wate**r.

Another way of saying this is that the needs of the waterbody are put first. Te Mana o te Wai puts a korowai (cloak) over water to recognise its significance in its own right and provides an overarching principle of protection in freshwater management.

Te Mana o te Wai then moves to providing for Te Hauora o te Taiao (the health of the environment), Te Hauora o te Wai (the health of the waterbody) and Te Hauora o te Tangata (the health of the people). Hauora is not just a reference to one's health but to a state of health. Hauora is defined in English as meaning 'fit, well, healthy, vigorous, robust.' A human analogy for hauora is that you can take a knock, such as have a cold, and have the resilience to bounce back to a healthy and vigorous state.

Therefore, at a principle level, Te Mana o te Wai puts the needs of the waterbody first and provides for healthy and robust waterbodies, people and environment – not one over the other but the hauora of all three elements. **Te Mana o te Wai is encompassed in the pSWLP by Ki Uta Ki Tai that holistically integrates the application of Te Mana o te Wai from the estuaries to the headwaters and everything in-between."**

If ki uta ki tai as it is understood above is to be addressed then the experts agree the interactions between different water bodies (including upstream and downstream connections) would also need to be recognised, in order to protect and maintain the mauri of a waterbody.

In relation to water quality, the experts agree that cumulative effects in the downstream direction need to be incorporated when addressing degraded waterbodies through the Plan.

The experts agree and recognise effects that are in an upstream direction may need to be considered, particularly in relation to fish and waikakahi/freshwater mussels (that require fish as a host in part of its life cycle), when addressing degraded waterbodies through the Plan.

The experts agree they do not feel they can discuss the impacts on Mauri, and this requires a different set of experts to wananga on this matter.

Reference from JWS for Part A hearing:
Para 11 Nov JWS: "As the process to develop indicators of ecosystem and human health and cultural indicators of health have proceeded in parallel and will be completed at the same time, it has not been possible to explore linkages between the two processes in any detail at this time. When the linkages are able to be addressed, the experts consider it will be important to take a whole of catchment approach and the inter-connected and holistic philosophy of ki uta ki tai and include consideration of groundwater quantity and quality, surface water quality, biodiversity, soil health and land use."

Reference from Cultural Indicators of health JWS Nov 2019:
Link to ecological and human health indicators
Paragraph 59. In the 22 November 2019 Rivers, Estuaries and Lakes JWS Ms Cain and Dr Kitson highlighted that as the indicators of ecosystem and human health and

cultural indicators of health have proceeded in parallel that it has not been possible to explore linkages between the two processes in any detail. Table 1 provides limited linkages between the two and indicates if thresholds from the ecosystem and human health workstream may have been incorporated into this document. When the ecosystem and human health thresholds have been used, then it must be noted that these thresholds may not be consistent with hauora (4 September 2019 Rivers and Lakes JWS), and as such could be an underestimation of degradation in cultural health. Reported scale of Cultural degradation
Paragraph 60. This report has focused on the degradation of sites and has not included analysis of applying Ki Uta Ki Tai to understand the interconnected effects of degradation across the region. For example, if an estuary is degraded, what is the extent of that state and where if anywhere, along the conbtributing waterbodies does the state change from degradaed to hauora. The continuum of that degradation also needs to be

…For example, if an estuary is degraded, what is the extent of that state and where if anywhere, along the contributing waterbodies does the state change from degraded to hauora. The continuum of that degradation also needs to be factored into the spatial assessment.

2. ***Is the use of the monitoring and modelling of data reported in previous water quality JWS and cultural indicators of health JWS sufficient to fully inform the question of whether Southland has, or is improving towards, hauora? If not, what other information is available that might assist this question?***

No, the previous work for the water quality JWS was focussed on defining degradation rather than hauora. Bartlett et al. (2020) is a significant step towards defining this. The experts agree that the Bartlett et al (2020) framework and attributes for hauora are at the appropriate scale (regional) to advice the Court for this Plan process. J.A.K has not been able to consider Bartlett et al (2020) report in its entirety and is not able to comment at this time on this topic. This view is held for all questions where hauora is discussed.
The experts understand that there is recent work, and further work ongoing, as a part of the Council's Freshwater Planning Process under the NPSFM 2020 and has only just become available. It is understood that the Council is in the process of NPSFM implementation.

While trend analysis for water quality data is frequently undertaken and was included as part of our previous JWS, the experts don't consider that the results are useful for informing the court about movement toward or away from a target state (i.e.,hauora) without considerable extra analytical effort, which has not been undertaken. In particular, climate variability strongly influences water quality trends in complicated ways and how to account for this is poorly understood.[1]

[1] Snelder T, Fraser C, Larned S, Monaghan R, de Malmanche S, Whitehead A (2021) 'Attribution of river water-quality trends to agricultural land use and climate variability in New Zealand' Marine and Freshwater Research.

The experts have no evidence that there are any improvements towards hauora (including water quality and ecological health) in Southland and have not seen modelling that could inform the question of whether water quality and ecological health is improving.

Understanding the nature and characteristics of specific waterbodies is important, and to date most of the work and modelling has been done at the level of Environment Southland's management classes.

As the process proceeds to articulate hauora for specific waterbodies, there will be a requirement to have mechanisms to enable results from kaupapa Māori assessments of these areas. Kaupapa Māori monitoring has occurred in some catchments and a monitoring programme is about to be implemented in the coming year.

Ngāi Tahu hauora principles are described further below in the response to question 4.
Reference: Bartlett et al. 2020. Draft Murihiku Southland Freshwater Objectives: *'Providing for hauora, the health and well-being of waterbodies in Murihiku Southland,* 2020. URL: https://contentapi.datacomsphere.com.au/v1/h%3Aes/repository/libraries/id:26gi9ayo517q9stt81sd/hierarchy/document-library/reports/Values%20and%20Objectives%20reports%20-%20People%2C%20Water%20and%20Land/Draft%20Murihiku%20Southland%20freshwater%20objectives%20%28June%202020%29.pdf

3. Does taking a focus on hauora influence how to use modelling/monitoring data to determine degradation?

Models deal with single contaminants, whereas hauora needs consideration of multiple aspects as it is a holistic concept. Not all cultural indicators of health will be amenable to quantitative modelling and it may require thinking about ways of combining attributes.

To move towards hauora requires more than just numerical attributes, such as the numerical attributes in our last JWS. Therefore, there needs to be attention to narrative attributes and provisions in this Plan. Bartlett et al. (2020) highlights the importance of using narrative and numerical attributes.

These limitations mean, as currently presented, our monitoring and modelling doesn't explicitly encompass hauora. We also recognise that hauora won't necessarily be completely captured by attributes. Again, the hauora principles described in response to question 4 below provide guidance on interpreting monitoring and modelling or how monitoring and/or modelling might need to change to focus on hauora.

Snelder TH, Larned ST, Fraser C, De Malmanche S (2021) 'Effect of climate variability on water quality trends in New Zealand rivers' Marine and Freshwater Research.

4. What are the linkages between the indicators of ecosystem and human health, and cultural indicators of health? Within these linkages, are there any differences in consideration of hauora?

The Cultural indicators of health (CIH) and the science JWSs Nov 2019 were completed in parallel. As such, exploration of linkages between indicators of ecosystem and human health, and cultural indicators of health was not possible. The CIH JWS did provide limited linkages in Table 1 and noted in paragraph 59 that ecosystem and human health thresholds may not be consistent with hauora and as such could be an underestimation of degradation in cultural health.
Further work has occurred between the Council and Ngai Tahu ki Murihiku, which has described Freshwater Water Objectives for Murihiku Southland around hauora for Environment Southland water management classes (Bartlett et al. 2020).

Hauora, or healthy resilience, is identified as both a state and part of a continuum that includes degradation and permanent loss. There is a gradient when it comes to levels of degradation, and therefore the extent of any actions required to restore waterbodies, is also a gradient (Hauora envelope) within the state of hauora that accommodates natural variability.

To describe hauora requires a comprehensive set of attributes of waterbodies to be assembled and organised based on interdependent components that provide for te hauora o te taiao, te hauora o te wai and te hauora o te tangata.

In developing freshwater objectives (FWO) for hauora, Bartlett et al. 2020 utilised mātauranga and the latest environmental science. Qualities of water bodies are captured in a suite of draft freshwater objectives that, in combination, are expected to be able to provide for hauora over time. Analysis resulted in an expanded set of options for draft freshwater objectives, consisting of a combination of both numerics and narratives, and including both compulsory (nationally directed) and regionally developed attributes alongside Ngāi Tahu Indicators of Health.

As shown within the tables in Appendix 1 (of Bartlett et al. 2020) and within the draft narrative freshwater objectives in Section 6.1 (of Bartlett et al. 2020), a state of hauora (described by the hauora envelope) must be considered holistically, thinking about interdependent components and associated attributes. In this way, the hauora envelope incorporates both draft numeric freshwater objectives and qualities described in the draft narrative freshwater objectives. Recognising the wider dimensions of hauora included within the narratives and the tables in Appendix 1 will lead to particular methods of supporting draft objectives, through actions that improve not just water quality and in-stream conditions but also riparian margins and the extent of indigenous vegetation on connected lands, for example.

As identified in this JWS (in response to question 5) Appendix N is unlikely to significantly narrow the gap between the current state to beyond the threshold of degradation (as described by the science JWS November 2019) or the multiple attributes of hauora. However, it could be viewed as a stepping stone to reduce contamination loss and to broaden the thinking to looking at on-farm actions to improve some attributes of hauora and to enable water users avenues to provide for hauora.

Providing for hauora is akin to Ngāi Tahu ki Murihiku understanding of utu or reciprocity, which involves an expectation that as much is given as is being received. In other words, actions of the water user should be equally beneficial to the waterbody,

not just to the water user. This is relevant to considering how to improve waterbodies that are outside the hauora envelope, and also how to maintain those that are found to be healthy and resilient. Bartlett et al. (2020) pg. 32

The draft FWO (Bartlett et al. 2020) was based on the following hauora principles:

- Principle A: A state of hauora will be the result of the interaction of a combination of attributes, including Ngāi Tahu Indicators of Health.
- Principle B The nature and behaviour of particular waterbodies is important to understand when considering attributes.
- Principle C Nationally directed attributes alone cannot describe a state of hauora for waterbodies, so additional measures are needed, including assessing against Ngāi Tahu Indicators of Health.
- Principle D Where a water quality attribute is associated with risk of people getting sick, this risk will be reduced to the lowest possible level.
- Principle E Where a water quality attribute is assessing levels of toxicity or aspects of harm to aquatic species, in order to avoid harm to these species this risk will be reduced to the lowest possible level.
- Principle F Hauora is most likely to be provided for when waterbodies are closest to their natural condition, so an understanding of natural state or reference state is needed to help decision-makers.

5. In the context of farming, do you think there needs to be any changes to the plan provisions to better achieve hauora, from your point of view? For instance, Appendix N?

New work being undertaken by ES shows there is a large gap between the objectives that are consistent with hauora and current water quality state. There is also work (currently being undertaken) that considers how far mitigations consistent with Appendix N will go towards those outcomes. We understand from Dr Snelder that current management practices on farm show they may not be able to entirely close the gap. This is consistent with the literature and the experts' work in other regions. For some attributes, even the gap between current state and degraded thresholds is large. Therefore, to achieve hauora, Appendix N would require management objectives beyond those specified in Section 5. To close the gaps identified above, a significant change to management of land and freshwater is needed.

Table 1 shows the net load reductions that are required for TN and TP to achieve outcomes for algal growth and toxicity for all rivers, lakes and estuaries of Southland except the Fiordland and Islands Freshwater Management Unit (FMU). The reductions are shown for three sets of outcomes that are consistent with Hauora [2], the Land Plan water quality standards (pSWLP) and national bottom lines (NBL). Note that these do not represent the specification of degradation as per the 2019 JWS. While not all of the experts are familiar with the model and associated technical report behind Table 1, the general magnitude of reductions are consistent with the experts' expectations.

The net load reduction is the sum of the reductions that are necessary to achieve the outcomes in the individual rivers, lakes and estuaries that were represented in the modelling process (see Snelder 2021 for details). The load reductions are expressed

[2] Bartlett, M.; Kitson, J.; Norton, N.; Wilson, K. *Draft Murihiku Southland Freshwater Objectives: Providing for Hauora, the Health and Well-Being of Waterbodies in Murihiku Southland*; Environment Southland and Te Ao Marama Inc: Invercargill, New Zealand, 2020.

as proportions of the current load and the values shown in parentheses are the 5th and 95th confidence limits for the reported values (i.e., the range is the 90% confidence interval).

Table 1. Net load reductions required for TN and TP to achieve outcomes for algal growth and toxicity for all rivers, lakes and estuaries of Southland except the Fiordland and Islands Freshwater Management Unit (FMU).

Outcomes	TN reduction (%)	TP reduction (%)
Hauora*	70 (61-78)	70 (62-77)
pSWLP	66 (58-74)	69 (59-77)
NBL (C/D)	47 (33 – 61)	21 (13 -33)

Snelder T (2021) Assessment of Nutrient Load Reductions to Achieve Freshwater Objectives in the Rivers, Lakes and Estuaries of Southland. To inform the Southland Regional Forum process. LWP Client Report 2020–13. LWP Ltd, Christchurch, New Zealand.

*The hauora outcomes used in the modelling are for the bottom of the hauora envelope and therefore, the modelled outcomes represent what could be considered a minimum acceptable level for single attributes.

From this table, it is clear that reductions necessary to achieve hauora are large, and reductions to achieve national bottom lines are also large. There has not been an assessment of what implementation of the proposed Plan would achieve, which is technically possible but would require considerable technical/modelling effort. In relation to the proposed Plan (including Appendix N), the experts agree it should contain a rigorous requirement to reduce contaminant losses. The experts recommend the farm systems experts consider what other options are available and what would be required based on existing technology.

Hauora is not only about contaminants, there are other actions that can contribute to hauora (see table below) and these can be focussed on by landowners.

Question from farm systems expert conferencing
To what extent will there be water quality improvements achieved by farming in accordance with farm environmental management plans prepared and implemented under Appendix N?

A question arose out of the farm systems expert conferencing, we have discussed contaminant management aspects in the above response to question five. The previous version of the table below (within the farm systems expert's response to question one) was focussed on water quality. The science experts have identified other attributes of relevance to improving hauora including ecosystem health in Table 2.

We recognise some attributes we have listed in Table 2 may not all fit well within Appendix N; however, we have included them for consideration within the Plan provisions more generally.

Table 2. Science experts' response to question 1 of farm systems expert questions.

Mitigation change/improvement potential	***Attribute***	***commentary***
Catchment context	• Knowing what species might be present • Understand the current state of cultural and environmental health • Understanding deposited sediment in farm waterways and changes through time • Best practice for drain maintenance • Retaining instream debris for habitat • Restoring of riparian vegetation with consideration of biodiversity • Consideration for taonga and mahinga kai species • Identifying ephemeral head water streams, springs and other waterbodies, e.g., wetlands, on farm and the linkages between them. • Identification and management of spawning habitat. • Avoiding reductions in natural form of your waterway for example, keeping natural winding shape and variations in depth and velocity. • Remove fish passage barriers with the exception of barriers introduced for protecting native fish. • Avoid piping of waterways.	Some aspects of the catchment context are currently included in Appendix N part B and others will need to be added. For FEMPs to successfully identify and manage these attributes, farmers and rural professionals will need ready access to user friendly information and monitoring methods such as, locations of spawning habitat, knowledge of which species are present and their habitat needs, state of environment data, cultural health and mahinga kai information. Rural professionals will also need sufficient training to address these requirements.
Human health aspects	• Reduce faecal contamination (*E. coli*) to the lowest possible level. • Protecting human and cultural health. • Avoiding human faecal contamination of water.	The experts agree that faecal contaminants should also be listed alongside nutrients and sediment in Clause 5 (c) of Appendix N.

The FEMP should also identify objectives in relation to the journey towards hauora (including ecological health).

6. ***Does defining degraded conversely also define hauora? (See for example, Bartlett M, Kitson J, Norton N, Wilson K (2020) Draft Murihiku Southland Freshwater Objectives: Providing for hauora, the health and well-being of***

waterbodies in Murihiku Southland. Environment Southland and Te Ao Marama Inc, Invercargill, New Zealand.)

The experts agree that the work in the previous topic A JWS processes is still relevant and important information to inform the plan process before the Court. Whilst it does not describe what is needed to achieve hauora, it is clear in setting out the nature, scale and location of the issue across Southland's waterbodies with respect to degradation.

It is agreed that defining degraded (as has been done in previous JWSs) does not conversely define hauora. Hauora is closer to a natural state whereas we consider a degraded state is far from natural.

7. Can degraded water bodies be spatially identified?

Yes, we can identify degraded water bodies that have monitoring data. For sites that lack monitoring data, models have been produced that predict current state and these could be used to identify degraded water bodies. While there is monitoring data that includes Ngai Tahu indicators of cultural health, not all of these indicators have been modelled. Therefore, identification of degraded state based on modelling is restricted to a small number of indicators.

Models are useful for providing an overview of water quality and ecological state at the regional and subregional scale but have large uncertainty a local or river reach scale. The use of monitoring data and modelling to display degradation was discussed in the JWS dated 22 November 2019:

The experts have spatially identified degraded sites, based on available monitoring and modelling data in the following;
Appendix 2 in JWS for cultural indicators of health
Appendix 1 from November water quality JWS

8. Should the catchments above degraded waterbodies that contribute to that contamination (even though they themselves may not be degraded) be identified and managed? If so, can these be spatially identified?

Yes, in order to manage cumulative impacts. All resource users within catchments upstream of degraded sites and/or waterbodies should be managed to an extent that considers cumulative impacts, contaminant loss risk, and amount of contaminant loss. The experts recognise a linkage in the downstream direction between cumulative effects of contaminant loss and degradation and also linkages in the upstream direction. Degradation can have impacts in the upstream direction for example, by interfering with fish passage, spawning habitat and impacts on mauri.

Yes, these catchments can be spatially identified but it is not a trivial thing to do. An example is provided in the nutrient report by Snelder (2021).

Catchments upstream of sites and waterbodies that are identified as degraded, could be delineated by indicator and maps could be produced. This would provide clarity

about where mitigations in Appendix N may apply. Given the list of degraded waterbodies we have identified, this could be an extensive area outside of Fiordland and Stewart Island.

This could be done for nitrogen, phosphorus, sediment, and *E. coli*, and macroinvertebrates (MCI) and this could be done for monitoring sites and for modelled data for all locations. The resulting degraded areas could be used to trigger part B clause 6(b) of Appendix N requiring reductions in contaminants on farms.

The experts note the predictions based on models are always uncertain. The uncertainties can be assessed and used to present the information in terms of probability. For example, it is possible to make maps that indicate the probability that locations are degraded. The uncertainties will also generally vary between contaminants. This occurs because attributes vary in the strength of their association with the environmental drivers that are used as predictors in the models and also because there may be differing numbers of sites for which data is available.

Note – Appendix N Planners JWS version

9. Are there any other outstanding matters or policy decisions that need to be resolved in order to determine what to map? Why are these outstanding? For example, classification of river type (upland, lowland).

Classification of larger rivers remains unresolved with Mark James of the opinion that the Waiau River in particular should be divided into upland and lowland (paragraph 30 in the November 2019 JWS). It is also noted by Mark James that rivers dominated by didymo need to be considered as special cases for biological thresholds (paragraph 42). Based on the five variables described above, these will not be material to the mapping described in response to question 8. These sites are identified in Appendix 5.

Disagreement between experts on the degraded threshold for ammonia and nitrate toxicity remains as set out in the November JWS paragraph 80(b) but for the purposes of mapping described above it is not relevant.

Disagreement between experts as noted in paragraph 80(c) still exists but is not relevant to the mapping exercise as it can't be mapped.

Policy 18 (2a) refers to 'managing sheep in catchments where E. coli levels could preclude contact recreation': For the purposes of Policy 18:

10. Can the experts please specify the E. coli levels that could preclude contact recreation, including the E. coli limits necessary to support safe immersion in freshwater bodies for example, for the purposes of bathing, fishing, mahinga kai (below which contact recreation would be considered to be precluded)? And

The experts discussed this in the November 2019 JWS and agreed to use the *E. coli* thresholds from the NPSFM 2017 (these are the same as Table 9 in the NPSFM

2020). Bands D and E were considered unsuitable for human contact and sites below the C Band threshold are identified in Appendix 1 of that JWS.

The Cultural Indicators of Health JWS applied several attributes in relation to human contact and used the same *E. coli* thresholds as one of its indicators and these sites are identified in Table 2 of Appendix 2 of that JWS.

For *E. coli,* the two sets of identified degraded sites (in the water quality and cultural indicators JWS's) are the same. Shellfish faecal contamination has been identified in the Cultural Indicators of Health JWS.

The experts identify that aside from shellfish there are no reliable indicators of faecal contamination for safe consumption of other mahinga kai or sports fish.

11. Can the catchments where E. coli levels could preclude contact recreation (as defined in answer to (10) above) be mapped spatially? And

Yes, we have done this in the November 2019 JWS (Figure 14 mapped sites and Figure 15 predicted river segments) page 30-31.

Based on *E. coli* as an indicator, the threshold used in the November 2019 JWS to define degraded (C/D) is generally considered by the experts to be an unacceptable level of risk for human contact because at least 50% of the time the median value is greater than 130/100 ml.

T.S advises that similar but more up to date work has recently been carried out and available on the ES website. This can be found at, https://waterandland.es.govt.nz/science-and-economics/science-modelling/contaminants-and-numbers and the citations for this reference is as follows:

Snelder, T., Fraser, C. Assessment of Escherichia coli Load Reductions to Achieve Draft Freshwater Objectives in the Rivers of Southland Murihiku, 2021.

12. If the answer to (10) or (11) is 'no', what further work (by whom) is necessary to enable those questions to be answered?

Not applicable.

13. What (if any) is the science to support mandating portable feeders or other methods of preventing stock from trampling supplementary feed?

There may well be, but the group does not feel that they have the expertise to answer this question. We suggest it may be better directed towards the Farm Systems experts.

14. What (if any) is the science to support a 120 cattle/250 deer limit to mob size for intensive winter grazing?

The group does not feel that they have the expertise to answer this question. We suggest it may be better directed towards the Farm Systems experts.

Questions arising from the Farm Systems Experts conference:

Setbacks for cultivation

7 Rule 25 (cultivation) regarding effectiveness of setback differences: how much more effective at reducing sediment and nutrient runoff would it be to have 10m for 4-16 degree slopes and 20m above 16 degree slopes than the current suggestion of 5m up to 10 degree slopes and 10m between 10 and 20 degree slopes?

Cultivation near waterbodies is a high-risk activity for generating sediment because of the exposed soil. Therefore, it needs to be managed appropriately given the sediment issues for waterways in Southland.

Research on rank grass buffer effectiveness has demonstrated variable effectiveness depending on buffer width, slope, slope length, rainfall and clay content, drainage, and hydrology. As the width of the buffer is increased, (at slopes between 0 – 10 degrees) sediment removal effectiveness increases at a lesser rate to a point before it flatlines at 20 metres. This relationship may differ for nutrient run-off. The research does not tend to specifically address cultivation but sediment from agricultural run-off in general. Therefore, while there may be benefits in increasing buffer width in relation to mitigating sediment and nutrient loss, the magnitude of these benefits is uncertain.

The effectiveness of a buffer 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).

The experts question the use of 4-16 degree and 16-degree slope categories in the first part of the question and note that cut offs around 10 degrees are more relevant to consider given the experts have data on the effectiveness of buffer widths between 0-10 degrees.

The experts agree that in terms of removal of fine sediment through riparian buffer strips 10 metres will provide greater removal than the currently suggested 5 metre buffer for slopes 10 degrees or less. For steeper slopes a wider buffer is likely to be more effective. Refer to the table below as an example of how sediment removal effectiveness varies with buffer width and slope. The optimal buffer width will depend on how much sediment removal is desired.

Table 3. Reproduced from memo from Roger Hodson to Clair Jordan dated 19/12/2016.

Table 1.0: Predicted removal efficiency (%) for sediment at different slopes and setback widths, adapted from Zhang et al 2010.

Slope (degrees)	Setback (m)				
	3	5	10	20	30
1	*51%*	***61%***	*70%*	*72%*	*72%*
3	*57%*	**67%**	76%	78%	78%
4	*61%*	***71%***	*80%*	*82%*	*82%*
6	*67%*	**77%**	86%	88%	88%
7	*58%*	***69%***	*77%*	*79%*	*79%*
8	*51%*	***62%***	*71%*	*72%*	*73%*
9	*48%*	**58%**	67%	68%	68%

NOTE:Italicised text was calculated using the formula provided in the Zhang et al 2010. Extrapolation beyond 9 degrees and below 1 degree was not undertaken as there was no empirical data beyond these slopes. The predicted sediment removal percentages are for riparian margins vegetated with mixed grass and trees (this is the most conservative vegetation type for sediment removal). Greyed box's and bolded text shows the removal efficiency at 5 m setbacks.

It is K.M's view that given the scale of the sediment problem, Plan provisions including Rule 25 should seek a high degree of sediment removal effectiveness. A 20m buffer may be more appropriate for slopes greater than 10 degrees, although there is little literature that has directly tested the effectiveness of buffers on slopes greater than 10m.

The experts agree when rank grass buffers are used in conjunction with other erosion and sediment controls the total effectiveness is improved.

Due to longer residence time, the experts agree that lakes, wetlands and springs should have a higher degree of protection through wider buffer widths because of the residence time of sediment within these ecosystems and the potential for increased adverse effects over the long-term that are more difficult to remediate.

K.M recommends 20 metres for these waterbodies.

While the question is implicit in managing contaminant run-off as a result of cultivation, the experts note that there are additional cultural and ecological benefits when managing riparian margins, especially if they are vegetated. These include:

- Protection of riparian spawning habitat,
- Instream shade,
- Provision of woody debris and leaf matter providing food and refuge to aquatic life,
- Mahinga kai and taonga species restoration,
- Biodiversity,
- Wildlife corridors.