EXPERT CONFERENCE —WATER QUALITY AND ECOLOGY (RIVERS, ESTUARIES and LAKES)

ENV-2018-CHC — 026, 29, 37, 38, 39, 40, 41, 47, 50 and Various s274 parties

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

Date of conference: 20 to 22 November 2019

Venue: Transport World Invercargill, Invercargill

Facilitator: Jim Hodges, Environment Commissioner

Recorder: Patrice Budd, Southland Regional Council

**Attendees**

1 Witnesses who participated and agreed to the content of this Joint Witness Statement (**JWS**) by signing it on 22 November.

| Name | Employed or engaged by | Signature |
|---|---|---|
| Dr Ton Snelder | Southland Regional Council | |
| Nick Ward | Southland Regional Council | |
| Dr Adam Canning | Southland Fish and Game Council | |
| Kathryn McArthur | Royal Forest and Bird Protection Society of New Zealand and Department of Conservation | |
| Dr Jane Kitson | Ngā Rūnanga[1] | |
| Dr Mark James | Meridian Energy Limited and Alliance Group Ltd | |
| Justin Kitto | DairyNZ Limited and Fonterra Co-operative Group | |
| Susan Bennett | Territorial Authorities[2] | |
| Emily Funnell | Department of Conservation | |
| Dr Greg Burrell | Southland Regional Council | |
| Ailsa Cain | Ngā Rūnanga | |

[1] Comprising Waihopai Rūnaka, Hokonui Rūnaka, Te Rūnanga o Awarua, Te Rūnanga o Ōraka Aparima, and Te Rūnanga o Ngāi Tahu.

[2] Comprising Gore District Council, Southland District Council, and Invercargill City Council.

## Purposes of the conference

2 The purposes of the conference, based on the agreed agenda, and specifically to:

(a) Finalise attributes and thresholds to be used as the basis of defining degradation on an interim basis;

(b) Identify which waterbodies are degraded and by which attributes; and

(c) Consider possible linkages to cultural indicators and Ki Uta Ki Tai and Te Mana o Te Wai, based on currently available information from cultural experts.

3 An overarching purpose of the conference is to enhance the efficiency of the Court process in accordance with Appendix 3 of the Environment Court Practice Note 2014. This describes expert conferencing as "... a process in which expert witnesses confer and attempt to reach agreement on issues, or at least to clearly identify the issues on which they cannot agree, and the reasons for that disagreement."

## Environment Court Practice Note

4 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.

## Introduction

5 This JWS records the outcomes of the third of a series of expert conferences following a facilitated meeting in Invercargill on 3 September 2019. This JWS needs to be read in conjunction with earlier JWSs recording the outcomes of expert conferences on 7 to 10 May 2019, 4 September 2019 and 14 to 16 October 2019. The October JWS provides context. This November JWS

provides a final set of attribute thresholds for rivers, lakes and estuaries and a list of degraded waterbodies in Southland using these thresholds.

6 The experts note that for the purposes of this conference, they have considered human health in addition to ecosystem health to assist the Court. Human health was not considered in the October JWS.

7 The experts have referred to FMUs and shown FMU boundaries in a limited number of assessments to provide spatial references but have not used FMUs for any other purpose.

**Linkages of indicators of ecological and human health to cultural health**

8 Ms Cain and Dr Kitson advised that their preliminary assessment is that there are commonalities in the attributes and data used in this workstream and the cultural workstream. However, the full lists of attributes used by each workstream, definitions of attributes, thresholds and methodology to determine degradation have notable variations that are not necessarily comparable or easily integrated.

9 These variations highlight the differences in world views, both professionally and culturally, and the experts do not expect one set of indicators to be used to validate the conclusions of the other. The cultural indicators are based on the attributes and related thresholds of: te ara tawhito (traditional travel routes), mahinga kai, and mauri. These were selected because they are pillars of Ngāi Tahu culture and identity. The indicators used in this JWS are based on the two compulsory values in the NPSFM 2017, ecosystem health and human health for recreation. The compulsory values are also factored into the cultural indicators.

10 The preamble to the Proposed Southland Water and land Plan (pSWLP) says that the Regional Council (**the Council**) seeks to manage water and land resources in a way that encompasses the Ngāi Tahu philosophy of "ki uta ki tai". It also says the Council 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.

11 As the processes 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 quantity, biodiversity, soil health and land use.

**Primary additional information taken into account in this JWS**

12 This remains as set out in the JWS for the 14 to 16 October 2019 conference, together with the additional references listed at the end of this JWS.

**Abbreviations used in this JWS**

13 The following abbreviations are used in this JWS:

| | |
|---|---|
| aRPD | Apparent redox potential discontinuity, which provides a visual measure for the level of oxygen in estuarine sediment |
| Chl-a | Chlorophyll *a*, which is a measure of periphyton and phytoplankton biomass |
| DIN | Dissolved inorganic nitrogen, includes ammonia, nitrite and nitrate |
| DRP | Dissolved reactive phosphorus |
| *E. coli* | *Escherichia coli*, a bacterial indicator of faecal contamination |
| EQR | Ecological quality rating, which provides an estuarine algal cover and biomass index |
| G260 | Proportion of observations that exceed 260 *E. coli* per 100 mL |
| G540 | Proportion of observations that exceed 540 *E. coli* per 100 mL |
| GEZ | Gross eutrophic zone |
| $NH_4N$ | Total ammoniacal nitrogen |
| TN | Total nitrogen |
| TOC | Total organic carbon |
| TP | Total phosphorus |

| | |
|---|---|
| WCC | Weighted composite cover, which is a combined measure of mat and filamentous periphyton cover |

**Appendices**

14 The following appendices are attached to this JWS:

Appendix 1 Grading of river sites against thresholds – an overall summary

Appendix 2 (Part 1) - State of estuary variables at the site scale

Appendix 2 (Part 2) - State of estuary variables at the estuary scale

Appendix 3 Location of estuary sites

Appendix 4 Final attributes to identify degraded waterbodies

- Table 1 rivers
- Table 2 lakes
- Table 3 estuaries

Appendix 5 Distribution of didymo in Southland

## CONFERENCE OUTCOMES - ASSESSMENT OF CURRENT STATE SOUTHLAND RIVERS AND LAKES AGAINST DEGRADED THRESHOLDS

### General background

15 The analyses used in this JWS were undertaken by Ton Snelder of LWP Ltd, Nick Ward of Environment Southland, Cathy Kilroy of NIWA and Adam Canning of Fish and Game New Zealand, for discussion at the conference. What follows reflects what is agreed and what is not agreed following the conference. The experts record that there is a high level of agreement between them, with only three matters of significance where some disagreement remains.

16 The degraded thresholds are generally as defined in the JWS 14-16 October 2019. At that time, further work was required to finalise some thresholds and finalisation occurred at the November conference. Final agreed thresholds are included in the tables for individual attributes below and in updated summary tables included in Appendix 4.

17 The above thresholds of degradation were compared to measured data. Where model predictions were available and considered fit for purpose, thresholds were also compared to model predictions of current state statistics made for all segments of the river network as determined by Whitehead (2018) and all lakes by Fraser and Snelder (2019).

### Determining what is degraded

18 The extent of effects of activities on the environment will depend on many variables that are often individually complex, and in combination highly complex. Available data to fully understand effects at a regional, catchment or sub-catchment scale are rarely, if ever, complete. However, the experts are confident that there is sufficient data to make reliable decisions for planning purposes, unless specifically noted in this JWS.

19 The experts have assessed degradation by considering:

(a) generally five years of monitoring data from more than 100 river sites for 11 attributes of ecosystem and human health.

(b) generally five years of monitoring data from seven lakes for eight attributes of ecosystem and human health.

(c) In addition, they have taken into account predictions of degradation of rivers and lakes at a regional level using national models described below.

(d) generally two years of monitoring data from six estuaries for seven attributes of ecosystem and human health.

20 The experts agree that this provides a robust identification of degraded waterbodies for regional planning purposes.

**Modelling**

21 Modelled predictions of current river water quality and MCI scores are based on the national SoE dataset comprising approximately 800 sites, which included all SoE sites in the Southland Region. The spatial framework for the model is a GIS-based digital network, which underlies the River Environment Classification (REC; Snelder and Biggs, 2002). The digital network represents Southland's rivers as 66,500 segments (bounded by upstream and downstream confluences) which have variable lengths (mean = 690m, standard deviation = 710m).

22 The number of segments and their mean lengths in each of the region's FMUs are shown in Table 0. Models for each water quality variable and MCI scores are based on regression of the SOE data against several predictor variables that describe the characteristics of the catchment of each monitoring site.

Predictions for all segments of the digital network were then made on the basis of each segment's catchment characteristics (Whitehead, 2018).

**Table 0. Number of digital network segments and their mean lengths in each of the region's FMUs.**

| FMU | Number of segments | Mean Length (Metres) |
|---|---|---|
| Aparima | 3854 | 843 |
| Fiordland and Islands | 22612 | 611 |
| Mataura | 13891 | 700 |
| Ōreti | 7817 | 811 |
| Waiau | 18099 | 703 |

23 A similar national scale model to the rivers was used to predict water quality in lakes (Fraser and Snelder, 2019). For lakes, the spatial framework was the lakes layer of the Freshwater Environments of New Zealand GIS database (FENZ; Leathwick et al., 2010). Predictions for all lakes in the Southland Region with a surface area of greater than one hectare were included in our assessments.

24 Data limitations mean predictions provided by both the river and lakes models are uncertain at the scale of individual river segments and lakes (Fraser and Snelder, 2019, Whitehead, 2018). The prediction errors for individual river segments and lakes are approximately randomly distributed such that they can be under or over-estimated. However, the models represent the broad-scale drivers of water quality; for example, they show that water quality generally decreases with decreasing elevation and increasing proportion of catchment occupied by pasture.

25 This means that the model predictions provide reasonably robust "birds-eye" views of the extent and location of degraded areas. It also means that greater confidence can be placed in the model predictions when presented in aggregate than for individual river segments or lakes. For example, the experts consider estimates of the proportion of degraded river segments within the region or FMUs are a useful indication of the extent of degradation that is reasonably robust even when there may be quite considerable uncertainties for individual river segments and lakes.

**Monitoring data**

26 For an SoE site to be included, it had to meet a minimum number of samples. These are defined by Larned, Whitehead, *et al.* (2018) for rivers and Larned, Snelder, *et al.* (2018) for lakes. Briefly, statistics that defined our thresholds comprised median, maximum, $95^{th}$ and $92^{nd}$ percentile values. The statistics were derived from samples that reflected a balance between recent data (so the statistic represents current state) and reasonable number of observations (so that the statistic is a reasonably precise estimate of the true (population) value). The assessment adopted a pragmatic approach of using time periods of five years of data, where available, which yields a sample of 60 observations, provided there are no missing observations.

27 Because monitoring data always contains missing values, the assessment included a 'filtering rule', which provided a degree of leniency to the proportion of months for which there had to be data. For river water quality data, the site and variable combinations were restricted to those where measurements were available for at least 4 of the 5 years and at least 90% of months (Larned, Whitehead, *et al.,* 2018). For lake water quality data, the lake and variable combinations were restricted to those where measurements were available for at least 4 of the 5 years and at least 80% of seasons (either 48 of 60 months, or 16 of 20 quarters; Larned, Snelder, *et al.*, 2018).

28 A breakdown of the proportion of river segments for which predicted state is degraded when compared to the thresholds is provided. A breakdown of the SoE sites analysis by FMU was not performed because it would potentially be misleading due to the uneven distribution of SoE sites over FMUs.

**Rivers**

29 As noted above, a table showing the state of the environment sites that exceed any of the applicable thresholds is included in Appendix 1. Figure 1 shows the locations of these sites.

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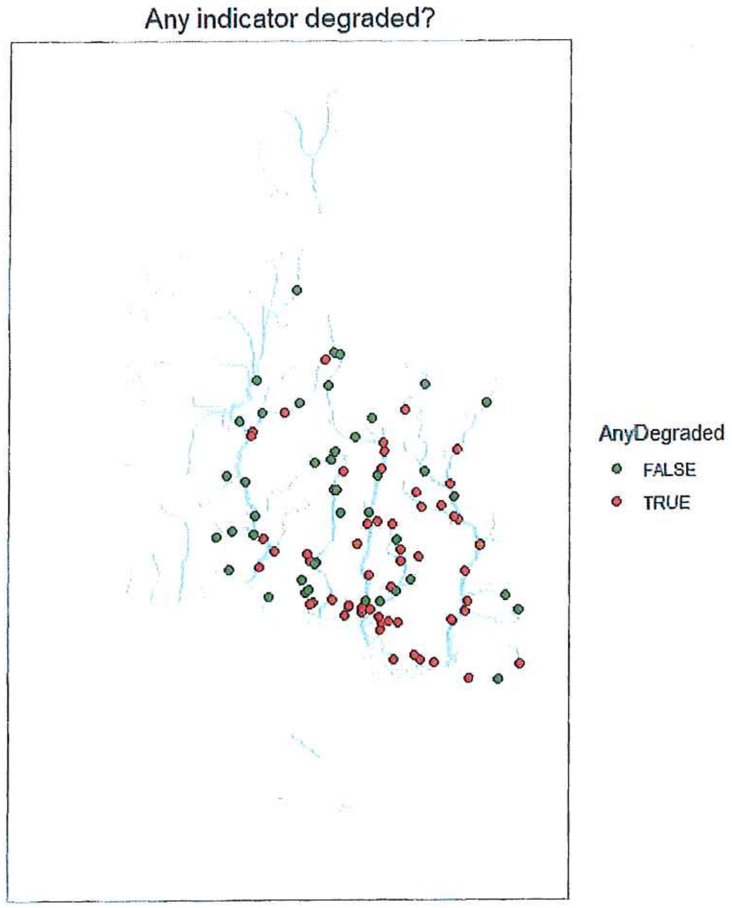



**Figure 1. State of the environment sites that exceed any of the applicable thresholds for ecosystem and human health attributes**

30 River classification inevitably involves a degree of subjectivity and judgement. The spatial framework that was used for classifying lowland and upland categories in this JWS is based on the hydrological and morphological considerations and delineated on the basis of topography. The criteria for delineating the two categories were provided in the October JWS. In some cases, the main stems are classified as upland, and as a consequence these have more stringent thresholds. It is considered these characteristics dominate the main stem of most of Southland's main stem rivers and are applied through to the coast in some cases.

31 The experts spent time discussing the appropriateness of upland and lowland classification for some attribute thresholds (refer Table 1 in October JWS). All experts agreed with the use of separate upland and lowland for tributaries and some main stems, as included in the final tables in this JWS. However, there were concerns expressed by Dr James, Mr Kitto and Ms Bennett that water quality and ecological characteristics are different in the lowland sections and

can be heavily influenced by lowland tributaries with lower water quality and changes to stream characteristics such as substrate channelling and riparian vegetation. Thus, the above experts consider it would be more appropriate to classify the lower reaches of the main stems as lowland for the purposes of periphyton and MCI attributes.

***Dissolved Inorganic Nitrogen, Dissolved reactive phosphorus, Ammoniacal nitrogen***

Thresholds

32 The thresholds to derive the site gradings are shown in

33 Table 1. In the case of Ammoniacal nitrogen ($NH_4N$), the sites were graded according to the worst outcome of either median or maximum values from the whole dataset.

**Table 1. Thresholds for degraded state for DIN, DRP, and $NH_4N$ (in mg/L). Thresholds differ by river class for DIN and DRP**

| Variable | River class | |
|---|---|---|
| | Upland | Lowland |
| DIN Median | 0.5 | 1.0 |
| DRP Median | 0.01 | 0.018 |
| $NH_4N$ Median | 1.0 (C/D band) or 0.03 (A/B band) | |
| $NH_4N$ Maximum | 2.2 (C/D band) or 0.05 (A/B band) | |

34 There is a difference of view between experts on which threshold should apply for ammonia toxicity. The experts agree that scientific understanding of the effects of toxicity is incomplete, particularly with respect to indigenous threatened species. The Southland region has a large number of at-risk and threatened indigenous species that are widely distributed across the region's waterbodies. All experts agree that C/D band threshold is clearly degraded (national bottom line). However, some experts consider a case can be made for taking a precautionary approach to toxicity with respect to risks to ecosystem health and thus the A band should be used.

***State of environment sites (measured data)***

35 Table 2 shows the number of degraded sites (true) and not degraded sites (false) with respect to DIN, DRP and $NH_4N$, based on measured data from the SoE network. The locations of the sites are shown in Figure 2. For the avoidance of doubt all reference to SoE sites is based on measured data.

**Table 2. Grading of SoE sites against DIN, DRP and $NH_4N$ thresholds by river class, where applicable. (TRUE = degraded) - Values are numbers of sites**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| DIN | 15 | 20 | 8 | 17 |
| DRP | 14 | 21 | 0 | 25 |
| $NH_4N$ (C band) | 0 | 35 | 0 | 25 |
| $NH_4N$ (A band) | 5 | 30 | 0 | 25 |

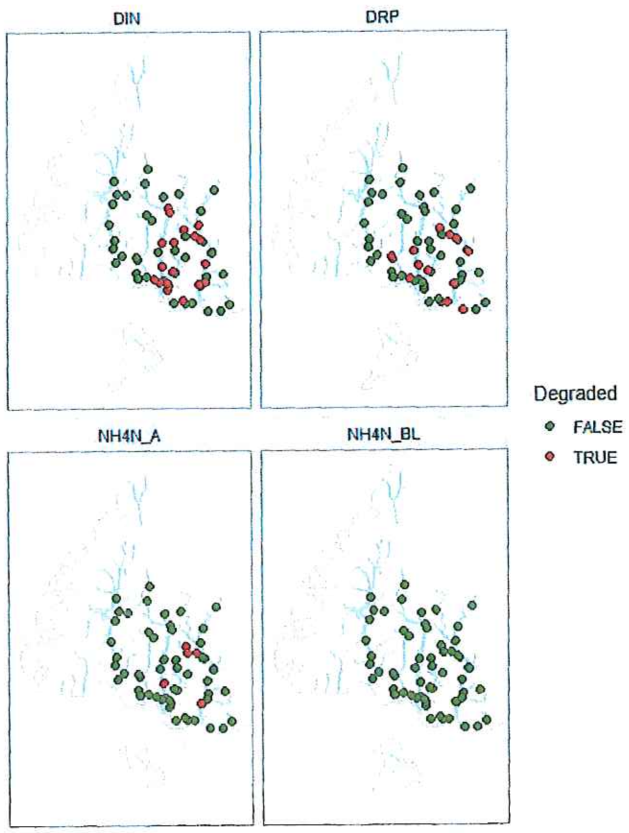



**Figure 2 Map showing SoE sites graded against DIN, DRP and $NH_4N$ thresholds**

*Modelled predictions for whole river network*

36 Table 3 shows the proportion of degraded (true) and not degraded river segments (false) with respect to DIN, DRP and $NH_4N$, based on modelled predictions. Table 4 shows the same information by FMU. The spatial distribution is shown in Figure 3. The ammonia toxicity threshold (A or C band) did not affect the number of river segments that were degraded in the modelled predictions. For the avoidance of doubt all reference to whole river network is based on modelled predictions.

**Table 3. Grading of network segments against DIN, DRP and $NH^4N$ thresholds by river class, where applicable. (TRUE = degraded). Values are proportion of segments (%)**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| DIN | 19.4 | 80.6 | 1.3 | 98.7 |
| DRP | 34.6 | 65.4 | 5.7 | 94.3 |
| $NH_4N$_A | 0 | 100 | 0 | 100 |
| $NH_4N$_BL | 0 | 100 | 0 | 100 |

**Table 4. Proportion of network segments (%) predicted to be degraded against DIN, DRP and $NH_4N$ thresholds**

| FMU | DIN | DRP | NH4N_A | NH4N_BL |
|---|---|---|---|---|
| Aparima | 18.2 | 31.5 | 0 | 0 |
| Fiordland and Islands | 0 | 0.3 | 0 | 0 |
| Mataura | 12.4 | 29.4 | 0 | 0 |
| Ōreti | 28.6 | 36.6 | 0 | 0 |
| Waiau | 1.5 | 11 | 0 | 0 |

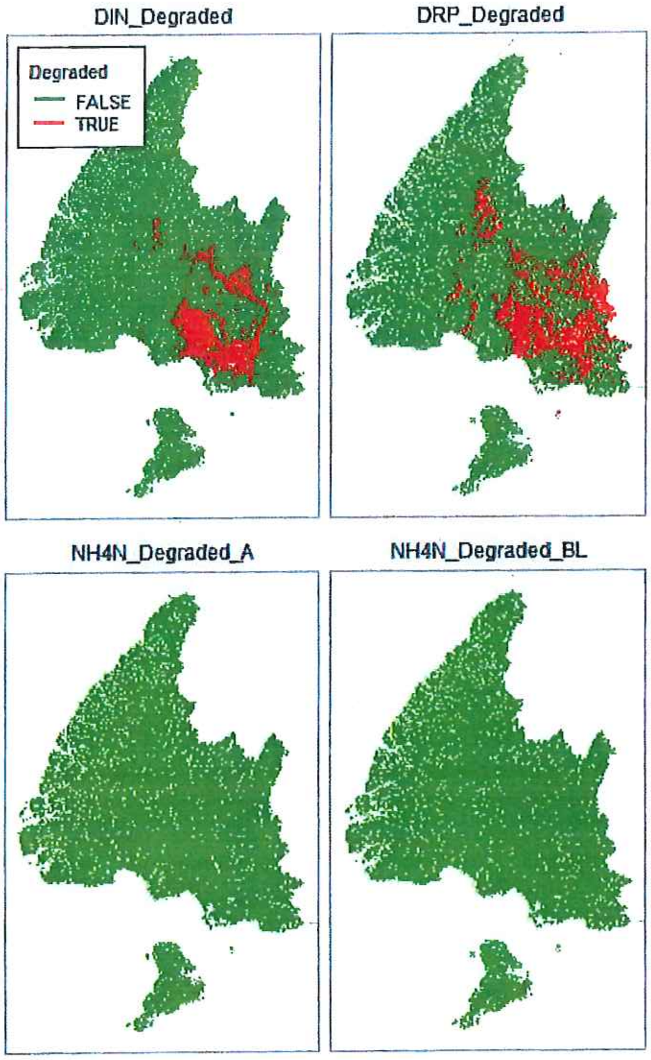



**Figure 3. Map showing predicted DIN ($NO_3N$), DRP and $NH_4N$ (adjusted) values for all river segments graded against DIN, DRP and $NH_4N$ thresholds**

***Macroinvertebrate community index***

Thresholds

37 The thresholds shown in Table 5 apply to both hard and soft bottom streams. The appropriate methodology for the substrate characteristics for any specific site should be used to determine the relevant MCI score. The experts note that there are factors that may influence MCI scores, including natural factors such as dystrophic streams affected by peat wetlands, and invasive didymo. These

factors are not considered in the analysis below but may need to be on a case-by-case basis when degradation is found, and these factors are thought to be the primary influence. If that is the case, it will need to be robustly demonstrated that MCI is below the threshold as a result of dystrophic condition, or didymo, and not some other factor.

38 For clarity, the experts note that they have considered the memorandum from Mr Hodson dated 19 November 2019 and have taken his comments into account in the above.

**Table 5. Thresholds for degraded state for MCI.**

| Variable | River class | |
|---|---|---|
| | Upland | Lowland |
| MCI Median | 100 | 90 |

State of environment sites (measured data)

39 For the avoidance of doubt, the experts note that the SoE sites all use the hard bottom MCI methodology. That is because sampling is undertaken in hard bottom habitats at all SoE sites monitored.

**Table 6. Grading of SoE sites against MCI thresholds by river class, where applicable. (TRUE = degraded). Values are numbers of sites**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| MCI | 26 | 28 | 9 | 33 |

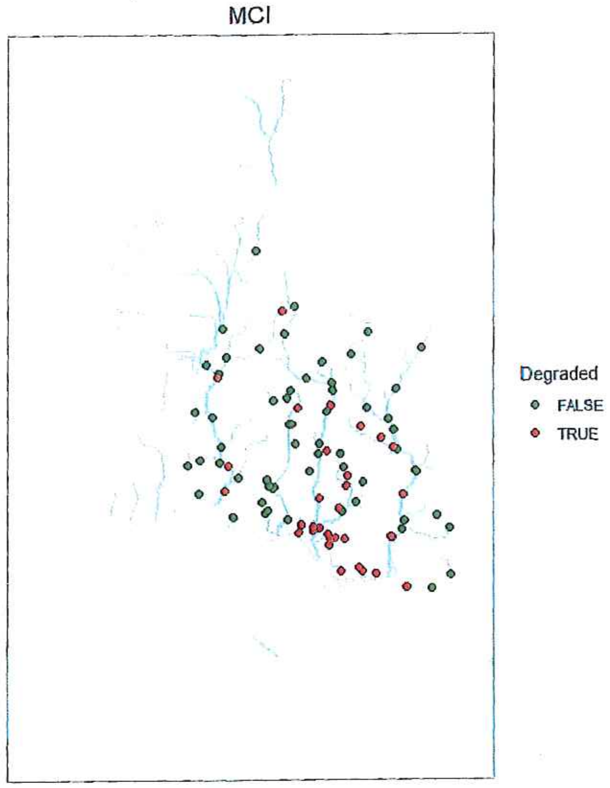



**Figure 4. Map showing SoE sites graded against MCI thresholds**

Modelled predictions for whole river network

**Table 7. Grading of network segments against MCI threshold by river class, where applicable. (TRUE = degraded). Values are proportion of segments (%)**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| MCI | 24.3 | 75.7 | 0.4 | 99.6 |

**Table 8. Proportion of network segments (%) predicted to be degraded against MCI thresholds**

| FMU | MCI degraded |
|---|---|
| Aparima | 19 |
| Fiordland and Islands | 0 |
| Mataura | 18 |
| Ōreti | 29 |
| Waiau | 1 |

MCI Network

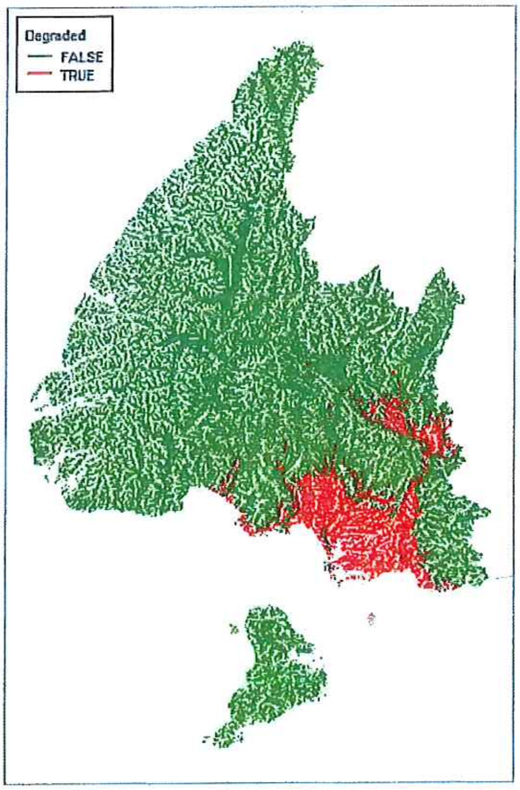



**Figure 5. Map showing predicted MCI values for all river segments graded against MCI thresholds**

### *Periphyton*

40 Periphyton data is limited, as it is only measured at a subset of the SoE sites designed to capture gradient of periphyton responses. The SoE monitoring data below is not representative of the extent of degradation due to periphyton in developed catchments and is likely to under-estimate the number of waterbodies which may be degraded. The SoE monitoring data below should not be used to determine the regional spatial extent of degradation with respect to periphyton.

Thresholds

41 The compliance statistics are different to those in Table 1 of the October JWS. The experts agree that it should be 92nd percentile over at least three years

during monthly sampling. The assessment performed in this JWS is based on five years data.

**Table 9. Thresholds for degraded state for Periphyton**

| Variable | River class | |
|---|---|---|
| | Upland | Lowland |
| Chl-a 92nd percentile ($mg/m^2$) | >120 | >200 |
| WCC 92nd percentile (%) | >40 | >55 |

State of environment sites (measured data)

42 The experts note that didymo may influence periphyton communities. Didymo is not considered in the analysis below but may need to be on a case-by-case basis when degradation is found and didymo is shown to be the primary influence. If this is the case it will need to be robustly demonstrated that periphyton is above the threshold as a result of didymo.

**Table 10. Grading of SoE sites against periphyton chlorophyll-a and WCC thresholds by river class, where applicable. (TRUE = degraded). Values are numbers of sites**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| Chlorophyll | 2 | 13 | 2 | 13 |
| WCC | 3 | 12 | 2 | 13 |

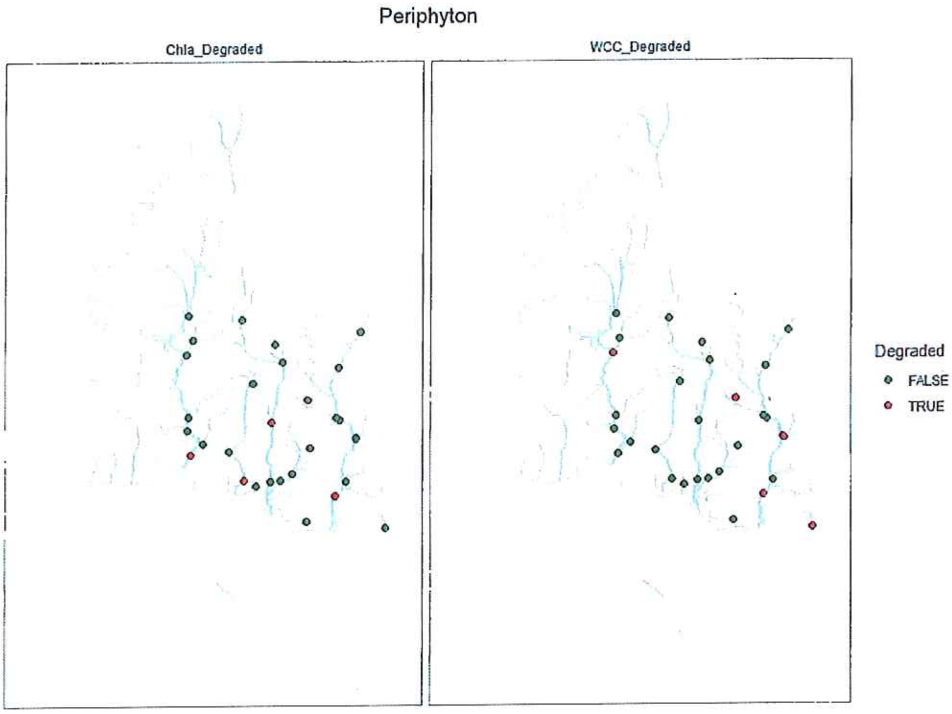



**Figure 6. Map showing SoE sites graded against periphyton chlorophyll-a and WCC thresholds**

Modelled predictions of periphyton for whole river network

43 The analysis, shown in Figures 7 and 8, compares predicted (i.e., modelled) concentrations of TN and DRP with criteria for these two nutrients that will achieve the periphyton chlorophyll *a* biomass thresholds for upland and lowland classes of rivers. This has involved the further analysis of the MfE modelled predictions presented earlier for nutrients. This extended interpretation of the modelled predictions should be regarded as indicative only.

44 The assessment in this JWS is based on nutrient concentration criteria provided by Snelder et al. (2019) and uses the same methods that are described in MFE (2019). In the MFE (2019) analysis, river segments that are predicted to have soft bottoms were excluded on the basis that they are not expected to support high periphyton biomass. The assessment in this JWS has not excluded soft bottoms from the analysis.

45 The predictions are based on each nutrient (i.e., TN and DRP) analysed separately.

46 The proportion of each FMU that is predicted to be degraded (i.e., where predicted concentrations exceed the criteria) is shown in Table 11.

**Table 11. Proportion of each FMU that is predicted to be degraded based on modelling as described above**

| FMU | TN (Periphyton) | DRP (Periphyton) |
|---|---|---|
| Aparima | 53 | 47 |
| Fiordland and Islands | 0 | 3 |
| Mataura | 42 | 45 |
| Ōreti | 58 | 57 |
| Waiau | 10 | 11 |

**Predicted degraded based on Periphyton TN criteria**

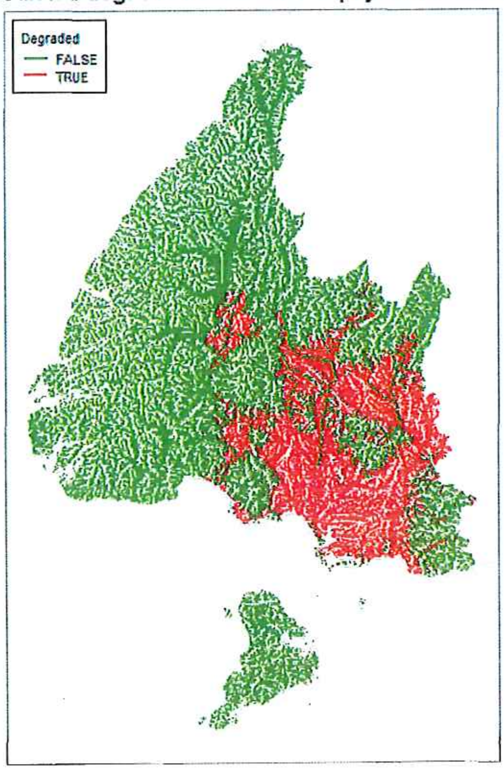



**Figure 1. Map showing degraded river segments based on periphyton TN criteria**

Predicted degraded based on Periphyton DRP criteria

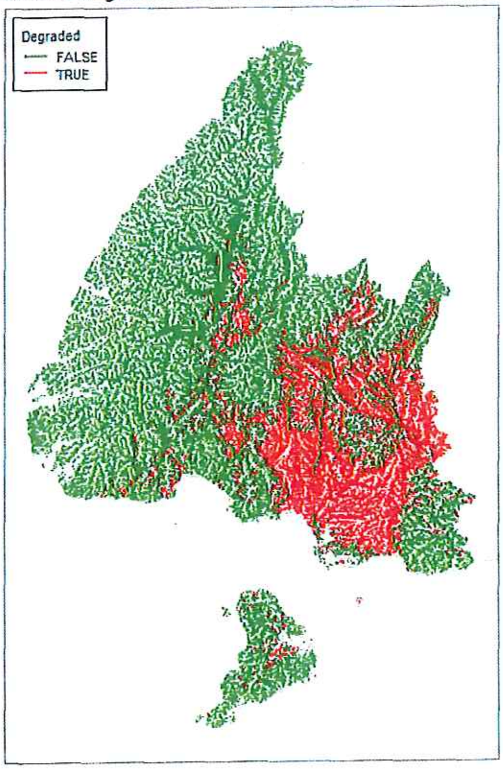



**Figure 8. Map showing degraded river segments based on periphyton DRP criteria**

***Deposited fine sediment***

Thresholds

47 The mean of observed sediment cover over all sample occasions at each site was compared to the thresholds shown in Table 12. The experts identified an error in the compliance statistic reported in Table 1 of the October JWS for deposited fine sediment and have corrected this in the final table of thresholds included in Appendix 1.

**Table 12. Thresholds for degraded state for deposited fine sediment (%)**

| Variable | River class | |
|---|---|---|
| | **Upland** | **Lowland** |
| Mean deposited sediment | >20 | >30 |

State of environment sites (measured data)

48 Deposited fine sediment data is limited, as it is only measured at a subset of the SoE sites designed to capture gradient of deposited fine sediment. The data is not representative of the extent of degradation due to deposited fine sediment in developed catchments and is likely to under-estimate the number of waterbodies which may be degraded. The SoE deposited fine sediment monitoring data cannot be used to infer the regional spatial extent of degradation.

**Table 13. Grading of SoE sites against deposited fine sediment thresholds by river class, where applicable. (TRUE = degraded). Values are numbers of sites**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| Deposited sediment | 0 | 15 | 2 | 16 |

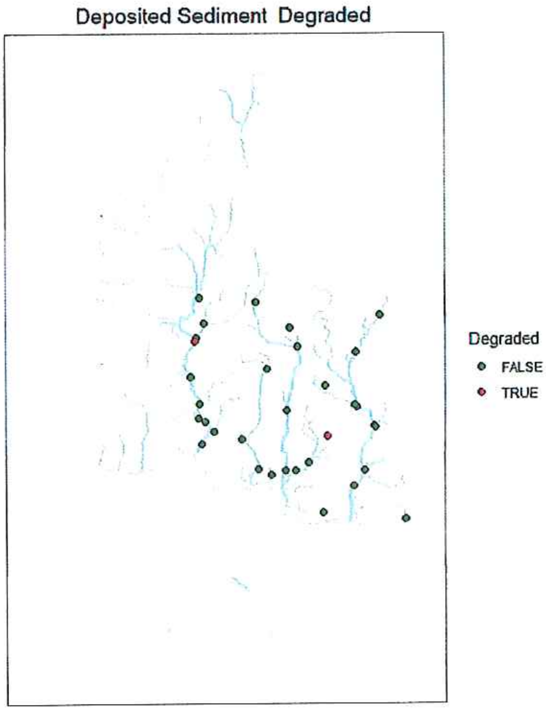



**Figure 9. Map showing SoE sites graded against deposited fine sediment thresholds**

Whole of network predictions

49 A model that incorporates Southland's SoE data is not available for deposited fine sediment.

***Suspended sediment***

50 The experts have used turbidity as the measure of suspended sediment to be consistent with the approach adopted in the draft NPSFM (MfE 2019).

Thresholds

51 The median of observed turbidity over all sample occasions at each site was compared to the thresholds shown in Table 14 (based on Franklin et al. 2019). The experts have concerns about the appropriateness of these thresholds, which are yet to be finalised at a national level. As part of the Topic B process, this could be further revisited for this attribute only.

**Table 14. Thresholds for degraded state for suspended sediment (turbidity)**

| Variable | Suspended sediment class | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3 | 4 | 7 | 8 | 9 | 11 | 12 |
| Turbidity (NTU/FNU) | 2 | 4.8 | 3.3 | 6.4 | 1.6 | 1.5 | 3.1 |

State of environment sites (measured data)

52 For the sake of clarity, turbidity is based on monthly SoE sampling, not continuous monitoring data.

**Table 15. Grading of SoE sites against turbidity (suspended sediment) thresholds by river class, where applicable. (TRUE = degraded). Values are numbers of sites**

| **Variable** | **Lowland** | | **Upland** | |
|---|---|---|---|---|
| | **TRUE** | **FALSE** | **TRUE** | **FALSE** |
| Turbidity (NTU) | 17 | 18 | 6 | 19 |

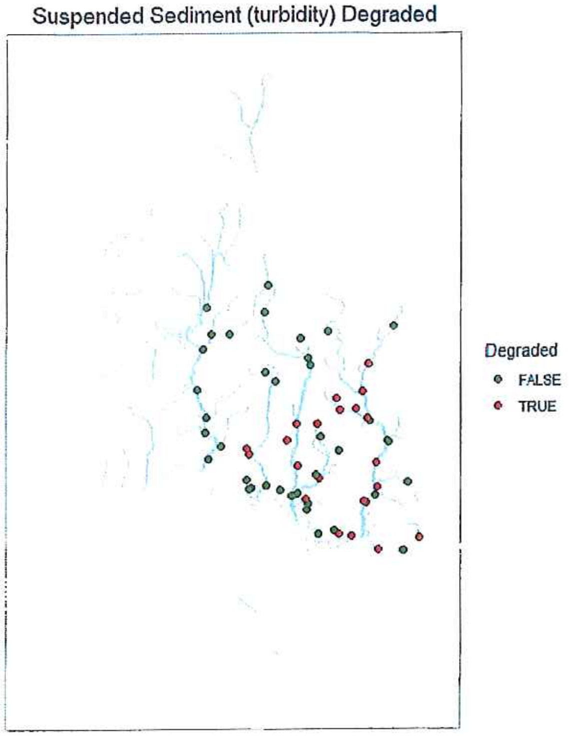



**Figure 10. Map showing SoE sites graded against suspended sediment (turbidity) thresholds**

Modelled predictions for whole river network

53 The experts note that because of the complexity of the thresholds with the particular classes and the uncertainty of the model predictions, some anomalies appear in Figure 11, which indicates degradation in Fiordland, Stewart Island/Rakiura and offshore islands. These anomalies are minor when viewed at the regional scale, as indicated at Table 16.

**Table 16. Grading of network segments against suspended sediment (turbidity) threshold. (TRUE = degraded). Values are proportion of segments (%)**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| Turbidity | 34.7 | 65.3 | 8.0 | 92 |

**Table 17. Proportion of network segments (%) predicted to be degraded against suspended sediment threshold**

| FMU | Suspended sediment (Turbidity) degraded |
|---|---|
| Aparima | 19 |
| Fiordland and Islands | 0 |
| Mataura | 18 |
| Ōreti | 29 |
| Waiau | 1 |

Suspended sediment Network

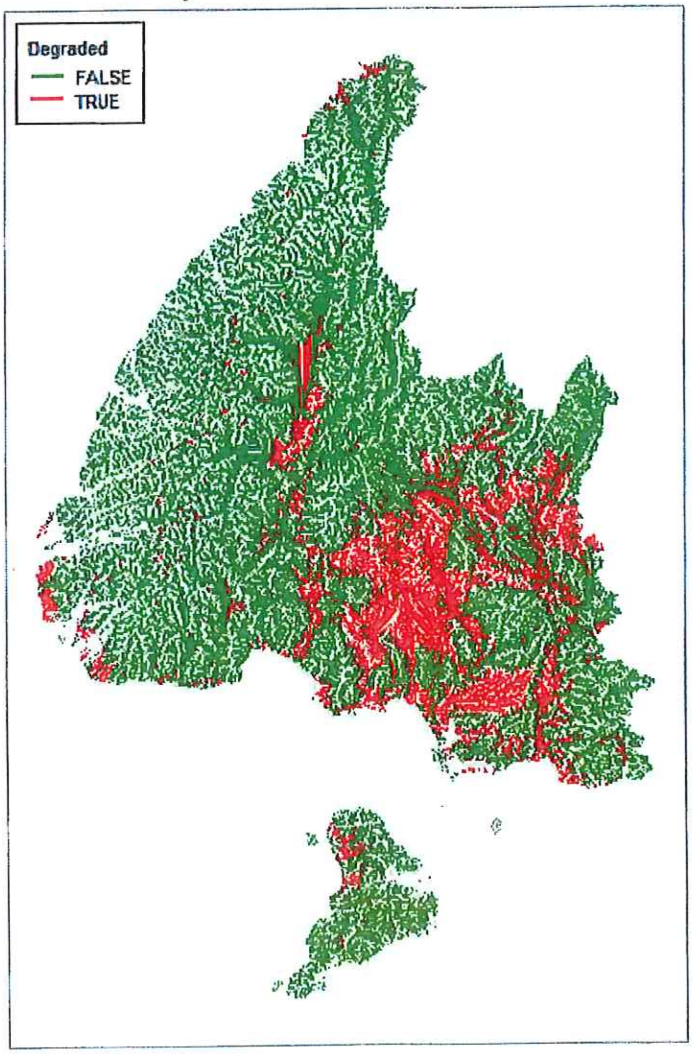



**Figure 11. Map showing predicted suspended sediment (turbidity) values for all river segments graded against thresholds**

***Didymo***

54 Figure 12 was prepared by NIWA to show the sites where didymo potentially dominates (black dots) and would need to be investigated further if thresholds for periphyton or MCI indicate degradation. The didymo sites are where didymo has been recorded and not just for SoE sites.

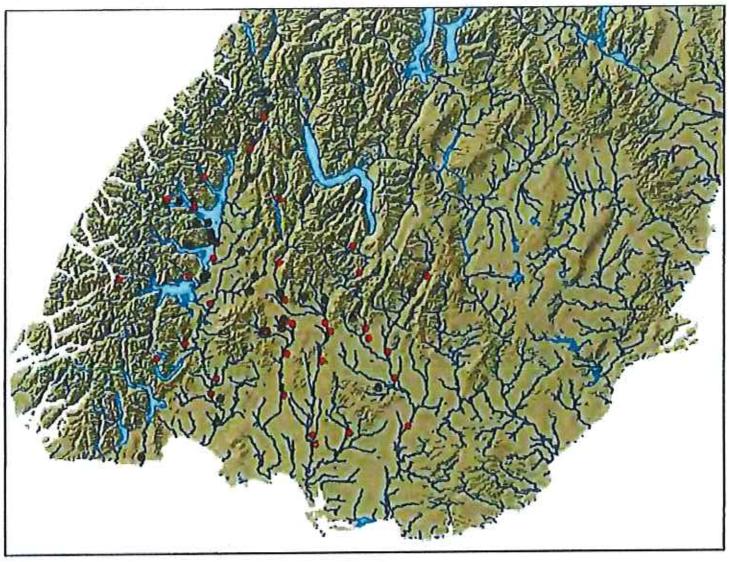


**Figure 12. Locations in Southland from which algae samples have returned a positive ID for didymo.** Data from the MPI didymo samples database. Note that there may have been one or two new locations in Fiordland since about 2014. Black dots indicate visible didymo (i.e., potential nuisance growths). Red dots indicate presence of cells only or unknown. Stewart Island/Rakiura not shown. There have been no records of didymo from Stewart Island/Rakiura.

***Fish Index of Biotic Integrity (IBI)***

Thresholds

55 The mean of fish IBI over all sample occasions at each site was compared to the fish IBI threshold of <23.

State of environment sites (measured data)

56 Table 18 is based on SoE data from 2012 to 2017. The surveys were not conducted in every year over this period. Assessment was performed for the latest three surveys. The sites that identified as degraded are shown in Figure 13.

**Table 18. Grading of SoE sites against fish IBI thresholds by river class, where applicable. (TRUE = degraded). Values are numbers of sites**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| Fish IBI | 6 | 31 | 4 | 9 |

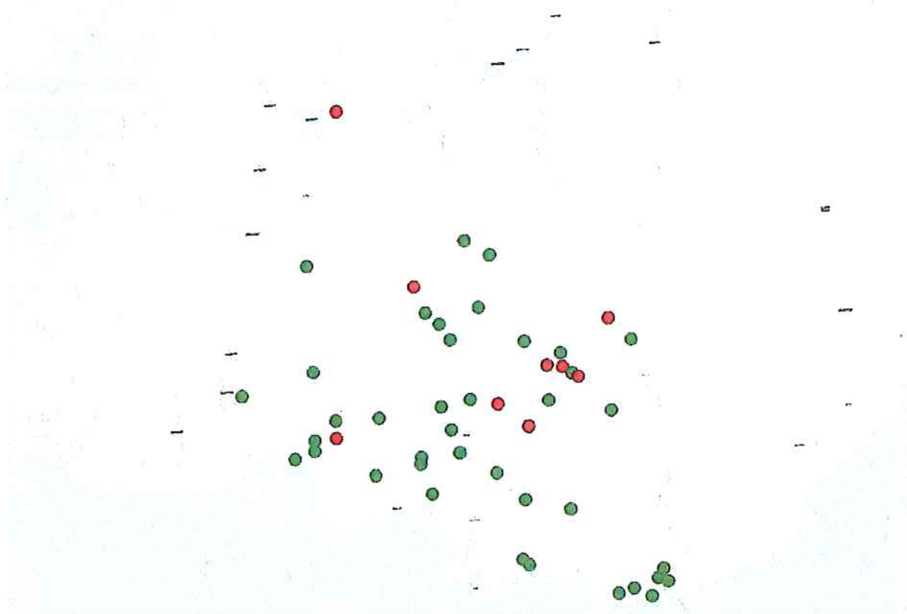


**Figure 13. Compliance of fish IBI, using the average score of up to the last three years surveys between 2012-2017 (not all years sampled). Green=not degraded, red=degraded.**

Modelled predictions for whole river network

57 A model that incorporates Southland's SoE data is not available for fish IBI.

***Human Health – E. coli***

Thresholds

58 The thresholds for *E. coli* have been derived from the NPSFM (2017) human health recreation value. This attribute is based on four statistics that are derived from *E. coli* observations; median, 95th percentile, G540 and G260. Each of these statistics is associated with a band from A (best) to E (worst) and the site is allocated a band based on the "worst" of the four statistics. Thus, if median, 95th percentile, and G540 are in the B band, but G260 is in the C band, the final grade is C. Sites were assigned as degraded if the band was D or E – these grades having unacceptable risks of infection from pathogens for primary contact with freshwater. This threshold would also apply to lakes.

59 In some cases, further analysis at specific sites may be appropriate using a quantitative microbial risk assessment to more accurately determine the level of risk to human health from pathogens.

State of environment sites (measured data)

60 The assessment in Table 19 has been done on the monthly SoE data. The NPSFM (2017) includes a requirement that there must be 60 samples within the five-year period of assessment. This is extremely onerous as it means that there must be no missing values over a five-year period if sampling is on a monthly basis. This requirement was relaxed to be consistent with the other river variables (i.e., graded sites were restricted to those where measurements were available for at least four of the five years and at least 90% of months; Larned, Whitehead, *et al.*, 2018). The experts note this does not include the data gathered in the Council's recreational bathing programme, which covers seven freshwater sites.

**Table 19. Grading of SoE sites against human health (E. coli) thresholds by river class, where applicable. (TRUE = degraded). Values are numbers of sites**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| *E. coli* | 31 | 2 | 13 | 11 |

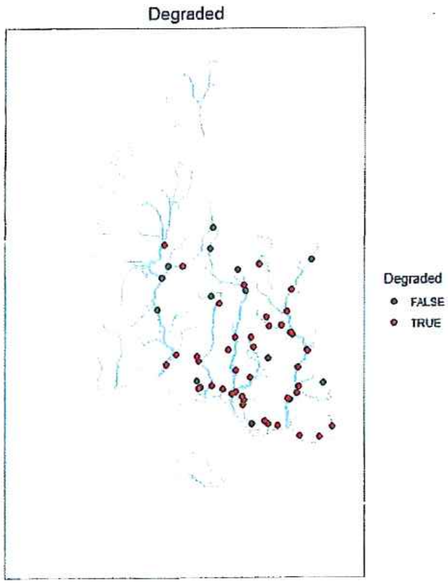



**Figure 14. Map showing SoE sites graded against human health threshold (*E. coli*)**

Modelled predictions for whole river network

**Table 20. Grading of network segments against human health (*E. coli*) by river class, where applicable. (TRUE = degraded). Values are proportion of segments (%)**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| *E. coli* | 72.2 | 27.8 | 7.2 | 92.8 |

**Table 21. Proportion of network segments (%) predicted to be degraded against human health (*E. coli*) thresholds**

| FMU | *E. coli* |
|---|---|
| Aparima | 65 |
| Fiordland and Islands | 0 |
| Mataura | 59 |
| Ōreti | 68 |
| Waiau | 18 |

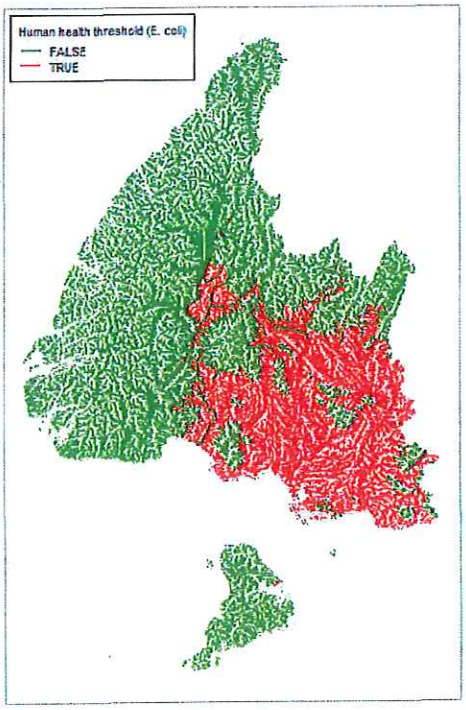



**Figure 15. Map showing predicted exceedances of human health threshold (*E. coli*) for all river segments**

***Human health – Benthic Cyanobacteria***

Thresholds

61 Assessments of benthic cyanobacteria were undertaken using a threshold that was based on the alert threshold suggested in the New Zealand Guidelines for

Managing Cyanobacteria in Recreational Fresh Waters (Wood et al., 2009). The Guidelines suggest a benthic cyanobacteria threshold of less than 20% coverage of the riverbed substrate by potentially toxigenic cyanobacteria.

62 The experts did not consider the observations of detaching mats in their analysis. Wood et al., (2013) demonstrated that detaching mats were common even when percentage coverage was low, and inclusion of the detached component in the assessment of state is therefore inappropriate.

63 The Guidelines suggest that a single observation that exceeds the threshold should trigger a series of management actions. However, this is not an appropriate method for determining a grade that represents the longer-term human health risk posed by benthic cyanobacteria at a specific site. In this JWS, the experts followed the recommendations of Wood et al. (2014), as implemented in Snelder et al. (2014) and used the 90$^{th}$ percentile of monthly observations to assign a grade for benthic cyanobacteria. They then assigned sites as degraded if the 90$^{th}$ percentile of the observations exceeded the 20 percent cover threshold. This method of assigning sites is a change from the method used in the May JWS for human health at paragraph 45, which was based on a single exceedance, as the full dataset was not available at that time.

64 Benthic cyanobacteria observations were available for differing numbers of occasions for the five-year period ending 2018. The experts did not apply the filtering rule that was used for the other variables and simply made the assessment based on all available samples. This resulted in the grading statistic (i.e., the 90$^{th}$ percentile) being assessed from between 5 and 46 samples (median = 31). This was done because of the limited data available at some sites.

State of environment sites (measured data)

65 Benthic cyanobacteria data is limited, as it is only measured at a subset of the SoE sites designed to capture a gradient of responses. The data is not representative of the extent of degradation due to benthic cyanobacteria in developed catchments and is likely to under-estimate the number of

waterbodies which may be degraded. The data should not be used to determine the regional spatial extent of degradation with respect to benthic cyanobacteria.

**Table 22. Grading of SoE sites against human health (benthic cyanobacteria) thresholds by river class, where applicable. (TRUE = degraded). Values are numbers of sites**

| Variable | Lowland | | Upland | |
|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE |
| Benthic Cyanobacteria | 1 | 14 | 0 | 18 |

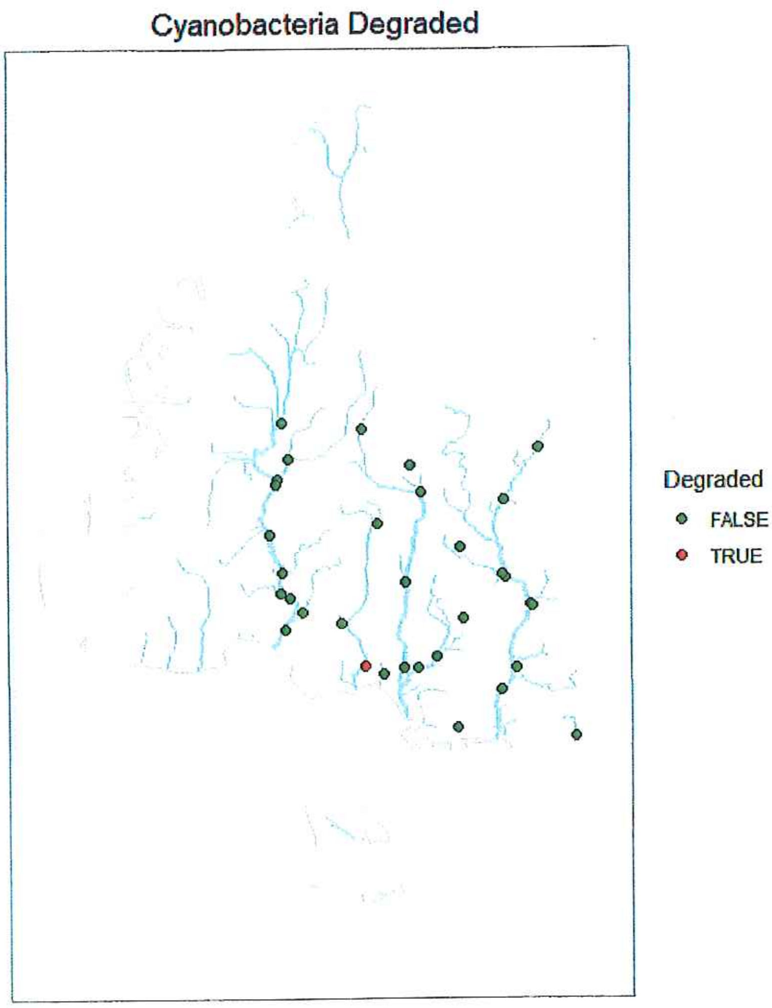



**Figure 16. Map showing SoE sites graded against human health threshold (benthic cyanobacteria)**

Modelled predictions for whole river network

66 A model that incorporates Southland's SoE data is not available for benthic cyanobacteria.

**Lakes and ICOLLs**

Thresholds

67 The thresholds to derive the lake gradings are shown in Tables 23 and 25.

**Table 23. Thresholds for degraded state**

| Variable | Lake class | | |
|---|---|---|---|
| | Deep | Shallow | ICOLLs |
| TN Median (mg/L) | 0.8 | 0.75 | 0.75 |
| TP Median (mg/L) | 0.05 | | |
| CHLA Median (mg/m$^3$) | 12 | | |
| CHLA Maximum (mg/m$^3$) | 60 | | |
| Dissolved Oxygen at bottom of water column Minimum (mg/L) | 0.5 | | |
| Ammonia toxicity Median (mg/L) | 1.0 (C/D band) or 0.03 (A/B band) | | |
| Ammonia toxicity Maximum (mg/L) | 2.2 (C/D band) or 0.05 (A/B band) | | |

State of environment lakes (measured data)

68 There are seven lakes in the region with sufficient data (Figure 17). The ammonia toxicity threshold (A or C band) did not affect the number of SoE sites

that were degraded. Lake Murihiku only has data for 2013, which is outside of the period used for this assessment.

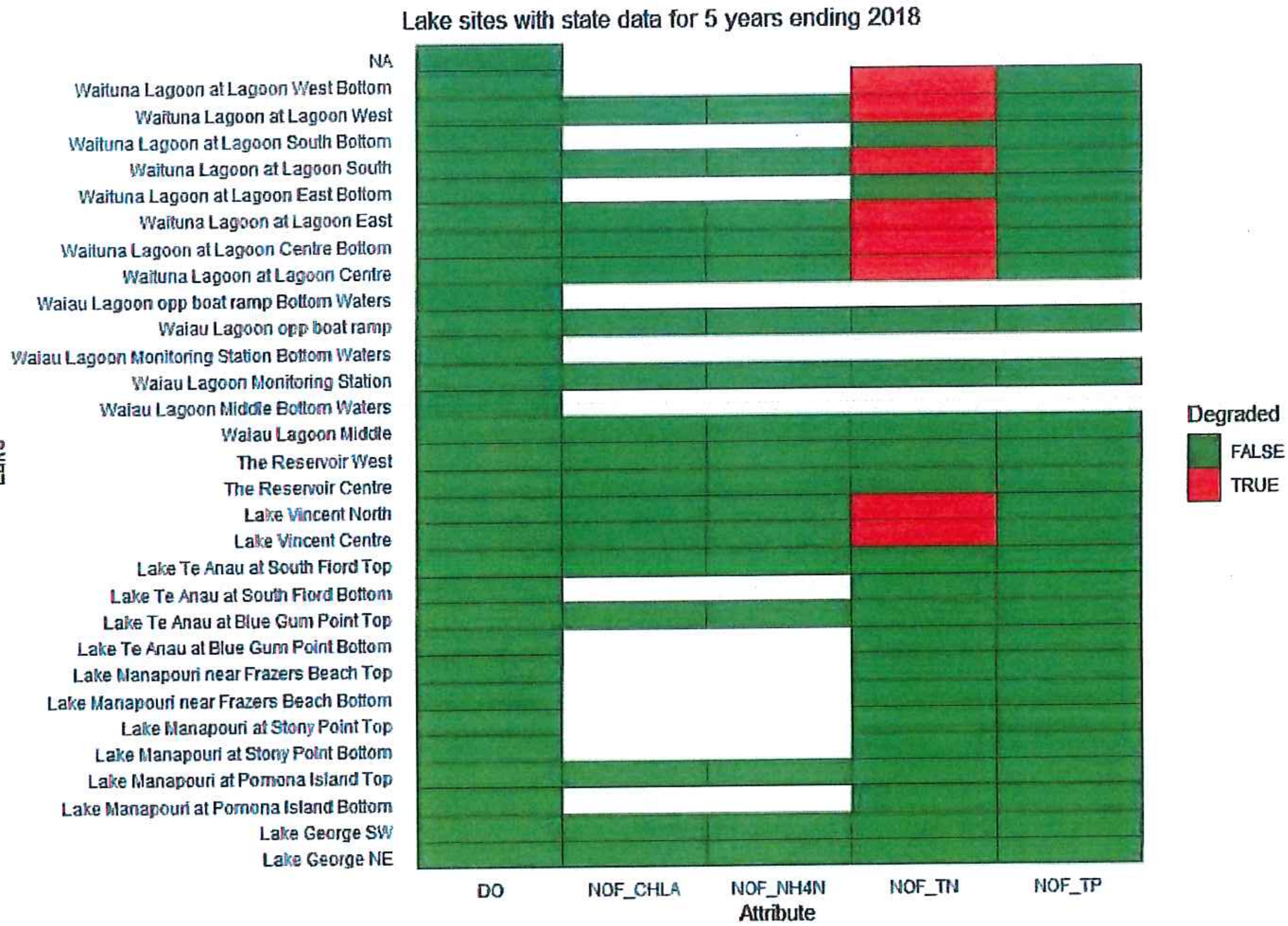



**Figure 17. Plot indicating SoE lakes graded against DO, $NH_4N$, TN, TP and CHL-a degraded thresholds**

Modelled predictions for all lakes

69 Predictions were derived from Fraser and Snelder (2019). The proportion of lakes that are predicted to be degraded are shown in Table 24 and Figure 18. The limitations of the lake predictions are described by Fraser and Snelder (2019). The predictions of degraded lakes for TN and TP in the north west of the region (i.e., northern Fiordland) are likely due to the poor representation of catchment land cover in the lake models (i.e., the predictions are unlikely to be accurate). There are no modelled predictions for bottom dissolved oxygen or ammonia.

**Table 24. Grading of network segments against lake water quality threshold. (TRUE = degraded). Values are proportion of segments (%)**

| Variable | Deep | | Shallow Lowland | | Shallow Upland | |
|---|---|---|---|---|---|---|
| | TRUE | FALSE | TRUE | FALSE | TRUE | FALSE |
| TN | 7.3 | 92.7 | 28.6 | 71.4 | 0 | 100 |
| TP | 0.4 | 99.6 | 0 | 100 | 0 | 100 |
| CHLA | 0 | 100 | 0 | 100 | 0 | 100 |

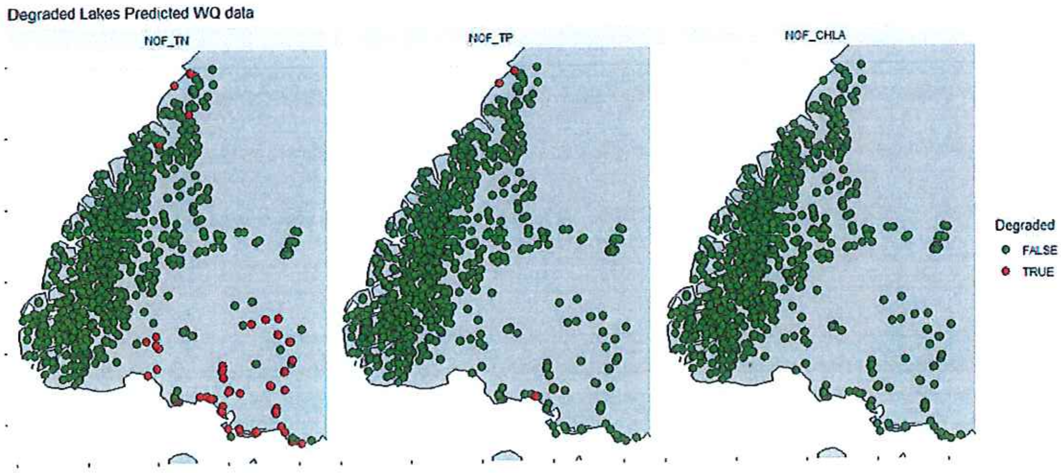



**Figure 18. Map showing all lakes graded against thresholds based on predicted TN, TP and CHLA values**

### *Human health*

70 There is insufficient data to adequately assess against the thresholds for *E. coli* and planktonic cyanobacteria.

### *ICOLL (Intermittently closed and open lakes and lagoons)*

71 There are three ICOLLs specific attributes (Table 25). These attributes were assessed against the five-year average of the DOC annual monitoring data for Waituna Lagoon. There is no data for these attributes for Lake Brunton and Waiau Lagoon.

**Table 25. ICOLLs specific threshold assessment (TRUE = degraded)**

| Attribute | Macrophtye % cover | Slime algae % cover in permanently wetted sites | Lagoon aquatic plant biomass index (cover % x height (cm)) |
|---|---|---|---|
| **Threshold** | <30% | >10% | <1000 |
| Waituna Lagoon | TRUE | TRUE | FALSE |

**Estuaries**

***Site Level Sediment Quality***

Total Metals in Sediment

72 The thresholds to derive the estuary gradings for metals are set out in Table 26.

**Table 26. Thresholds for degraded state for Metals at site level (ANZECC, 2000)**

| Variable | Applies to all Estuary classes |
|---|---|
| Total Arsenic (mg/Kg dry weight) | >20 |
| Total Cadmium (mg/Kg dry weight) | >1.5 |
| Total Chromium (mg/Kg dry weight) | >80 |
| Total Copper (mg/Kg dry weight) | >65 |
| Total Mercury (mg/Kg dry weight) | >0.15 |
| Total Nickel (mg/Kg dry weight) | >21 |
| Total Lead (mg/Kg dry weight) | >50 |
| Total Zinc (mg/Kg dry weight) | >200 |

Total organic carbon in Sediment

73 The thresholds to derive the estuary gradings for total organic carbon are set out in Table 27.

**Table 27. Thresholds for degraded state for Total organic carbon and mud content at site level (refer to October JWS)**

| Variable | Applies to intertidal areas of tidal lagoon and tidal river Estuary classes |
|---|---|
| Total organic carbon (% dry weight) | >1.2* |

*For sites with >25% mud content.

Oxygen levels in Sediment

74 The thresholds to derive the estuary gradings for oxygen levels are set out in sediment in Table 28.

**Table 28. Thresholds for degraded state for oxygen levels in sediment (see October JWS).**

| Variable | Applies to intertidal areas of tidal lagoon and tidal river Estuary classes |
|---|---|
| Depth to apparent redox discontinuity potential (aRPD) | <10mm |

***Site Level Water quality***

Chlorophyll-a concentration in water

75 The thresholds to derive the estuary gradings for planktonic Chlorophyll-a are set out in Table 29.

**Table 29. Thresholds for degraded state for Chlorophyll-a at site level.**

| Variable | Salinity >30ppt | Salinity <30ppt |
|---|---|---|
| Chlorophyll-a* (µg/l) | >12 | >16 |

*Data only available for New River Estuary.

### *Estuary scale measures*

The thresholds to derive the estuary gradings at estuary scale are set out in Table 30

76 Tabl. Assessment was based on the latest survey.

**Table 30. Thresholds for degraded state of estuary.**

| **Variable** | **Applies to intertidal areas of tidal lagoon and tidal river Estuary classes** |
|---|---|
| Macroalgae cover and biomass (EQR rating*) | <0.4 |
| Gross eutrophic zone (% or Ha cover of intertidal area) | >10%; >20Ha |
| Seagrass cover (loss from baseline measure) | >15% |

*EQR rating from the Opportunistic Macroalgal Blooming Tool (OMBT - WFD-UKTAG 2014)

State of environment Estuaries

77 There are seven estuaries in the region with sufficient data, which are shown in Figure 19 and the degradation status is summarised in Table 32. They are represented in Appendix 3 at the site scale and estuary scale.

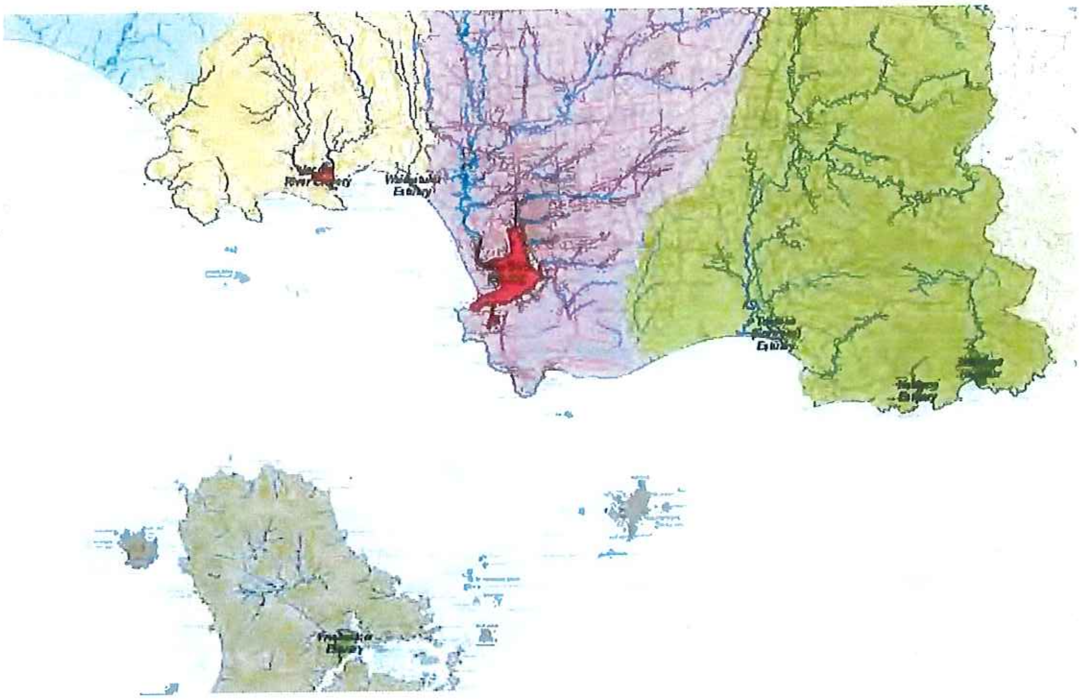


**Figure 19. Location of Southland monitored estuaries.**

**Table 31. State assessment of monitored estuaries in Southland. Red indicates 'degraded estuaries'.**

| Estuary | State | FMU | Reasons |
|---|---|---|---|
| Fortrose Estuary | Degradation state unclear | Mataura | See paragraph 66. |
| Freshwater Estuary | Not degraded | Fiordland and Islands | |
| Haldane Estuary | Not degraded | Mataura | |
| Jacobs River Estuary | Degraded | Aparima | Macroalgae growth (Low EQR rating); extensive eutrophic areas (high GEZ); 3 sites low oxygen levels (aRPD) and 1 high in organic carbon (TOC). |
| New River Estuary | Degraded | Ōreti | Macroalgae growth (Low EQR rating); extensive eutrophic areas (high GEZ); 2 sites low oxygen levels (aRPD) and high in organic carbon (TOC). 1 site also high in Nickel. 1 Site high in Chlorophyll-a*. |

| Estuary | State | FMU | Reasons |
|---|---|---|---|
| Waikawa Estuary | Not degraded | Mataura | |
| Waimatuku Estuary | Degradation state unclear | Aparima | Insufficient data |

*Additional site at Ōreti Beach has high chlorophyll-a concentrations. The beach is influenced by estuary outflow but is not within the estuary.

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.

***Human health***

79 The assessment has not been done for recreational bathing sites, which include some estuary and coastal sites.

**Summary of issues not agreed**

80 The remaining points of disagreement between experts are:

(a) Whether it would be more appropriate to classify the lower reaches of the main stems of rivers as Lowland for the purposes of periphyton and MCI attributes (paragraph 31).

(b) All experts agree that C/D band threshold for ammonia and nitrate toxicity is clearly degraded (national bottom line). However, some experts consider a case can be made for taking a precautionary approach to toxicity with respect to risks to ecosystem health and thus the A band should be used (paragraph 33).

(c) There is disagreement as to whether a waterbody is degraded on the basis of it failing only on DIN and/or DRP when it is not degraded on the basis of aquatic life indicators such as periphyton, MCI or fish IBI.

## Appendix 1

## Grading of river sites against thresholds

## Appendix 1: Grading of river sites against thresholds

| Site | FMU | DIN | DRP | NH4N_A | NH4N_BL | ECOLI | Chla_Degraded | WCC_Degraded | DepSediment | SuspendedSediment | Cyanobacteria | MCI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aparima River at Thornbury | APARIMA | FALSE | FALSE | FALSE | FALSE | TRUE | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE |
| Hamilton Burn at Affleck Road | APARIMA | FALSE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE |
| Opouriki Stream at Tweedie Road | APARIMA | TRUE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | |
| Otautau Stream at Otautau-Tuatapere Road | APARIMA | FALSE | TRUE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE |
| Otautau Stream at Waikouro | APARIMA | FALSE | TRUE | FALSE | FALSE | TRUE | | | | TRUE | | FALSE |
| Pourakino River at Traill Road | APARIMA | FALSE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | |
| Waimatuku at Waimatuku Township Road | APARIMA | | | | | | FALSE | FALSE | FALSE | | FALSE | TRUE |
| Waimatuku Stream at Lorneville Riverton Hwy | APARIMA | TRUE | TRUE | FALSE | FALSE | TRUE | | | | FALSE | | TRUE |
| Waimatuku Stream at Rance Road | APARIMA | | | | | | | | | | | TRUE |
| Carran Creek at Waituna Lagoon Road | MATAURA | FALSE | TRUE | FALSE | FALSE | TRUE | | | | TRUE | | TRUE |
| Longridge Stream at Sandstone | MATAURA | TRUE | TRUE | TRUE | FALSE | TRUE | FALSE | TRUE | FALSE | TRUE | FALSE | TRUE |
| Mataura River 200m d/s Mataura Bridge | MATAURA | TRUE | FALSE | FALSE | FALSE | TRUE | | | | TRUE | | TRUE |
| Mataura River at Gore | MATAURA | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | TRUE |
| Mataura River at Mataura Island Bridge | MATAURA | TRUE | FALSE | FALSE | FALSE | TRUE | TRUE | TRUE | FALSE | TRUE | FALSE | TRUE |
| Mataura River at Parawa | MATAURA | FALSE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | FALSE |
| Mimihau Stream at Wyndham | MATAURA | FALSE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE |
| Moffat Creek at Moffat Road | MATAURA | FALSE | TRUE | FALSE | FALSE | TRUE | | | | TRUE | | TRUE |
| Mokoreta River at Wyndham River Road | MATAURA | TRUE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | FALSE |
| North Peak Stream at Waimea Valley Road | MATAURA | FALSE | FALSE | TRUE | FALSE | TRUE | | | | TRUE | | |
| Otamita Stream at Mandeville | MATAURA | FALSE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE |
| Oteramika Stream at Seaward Downs | MATAURA | TRUE | TRUE | TRUE | FALSE | TRUE | | | | TRUE | | TRUE |
| Sandstone Stream at Kingston Crossing Rd | MATAURA | TRUE | TRUE | TRUE | FALSE | TRUE | | | | TRUE | | TRUE |
| Tokanui River at Fortrose Otara Road | MATAURA | FALSE | TRUE | FALSE | FALSE | TRUE | | | | TRUE | | TRUE |
| Waikaia River at Waikaia | MATAURA | FALSE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE |
| Waikaia River at Waipounamu Bridge Road | MATAURA | TRUE | FALSE | FALSE | FALSE | TRUE | | | | TRUE | | FALSE |
| Waikaka Stream at Gore | MATAURA | FALSE | TRUE | FALSE | FALSE | TRUE | FALSE | TRUE | FALSE | FALSE | FALSE | FALSE |
| Waikawa River at Progress Valley | MATAURA | FALSE | FALSE | FALSE | FALSE | TRUE | FALSE | TRUE | FALSE | TRUE | FALSE | FALSE |
| Waikopikopiko Stream at Haldane CurioBay | MATAURA | FALSE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | |
| Waimea Stream at Mandeville | MATAURA | TRUE | TRUE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | TRUE |
| Waituna Creek at Marshall Road | MATAURA | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE |
| Bog Burn d/s Hundred Line Road | ŌRETI | FALSE | TRUE | FALSE | FALSE | TRUE | | | | TRUE | | FALSE |
| Dipton Stream at South Hillend-Dipton Road | ŌRETI | TRUE | FALSE | FALSE | FALSE | TRUE | TRUE | FALSE | FALSE | TRUE | FALSE | FALSE |
| Dunsdale Stream at Dunsdale Reserve | ŌRETI | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE |
| Hedgehope Stream 20m u/s Makarewa Confl | ŌRETI | FALSE | FALSE | FALSE | FALSE | | FALSE | FALSE | FALSE | TRUE | FALSE | TRUE |
| Irthing Stream at Ellis Road | ŌRETI | TRUE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE |
| Makarewa River at King Road | ŌRETI | | | | | | | | | | | TRUE |
| Makarewa River at Lora Gorge Road | ŌRETI | FALSE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | FALSE |
| Makarewa River at Wallacetown | ŌRETI | TRUE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | TRUE |
| Mokotua Stream at Awarua | ŌRETI | FALSE | FALSE | FALSE | FALSE | FALSE | | | | FALSE | | TRUE |
| Murray Creek at Double Road | ŌRETI | | | | | | | | | | | TRUE |
| Ōreti River at Lumsden Bridge | ŌRETI | TRUE | FALSE | FALSE | FALSE | FALSE | | | | FALSE | | FALSE |
| Ōreti River at Wallacetown | ŌRETI | TRUE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | TRUE |
| Otapiri Stream at Anderson Road | ŌRETI | | | | | | | | | | | TRUE |
| Otapiri Stream at Otapiri Gorge | ŌRETI | TRUE | FALSE | FALSE | FALSE | TRUE | | | | TRUE | | FALSE |
| Otepuni Creek at Nith Street | ŌRETI | TRUE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | TRUE |

| Site | FMU | DIN | DRP | NH4N_A | NH4N_BL | ECOLI | Chla_Degraded | WCC_Degraded | DepSediment | SuspendedSediment | Cyanobacteria | MCI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tussock Creek at Cooper Road | ŌRETI | TRUE | TRUE | FALSE | FALSE | TRUE | | | | FALSE | | TRUE |
| Waianiwa Creek 1 at Lornville Riverton Highway | ŌRETI | | | | | | | | | | | TRUE |
| Waihopai River at Kennington Road | ŌRETI | | | | | | | | | | | TRUE |
| Waihopai River at Waihopai Dam | ŌRETI | | | | | | | | | | | TRUE |
| Waihopai River u/s Queens Drive | ŌRETI | TRUE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | TRUE |
| Waikiwi Stream at North Road | ŌRETI | TRUE | FALSE | FALSE | FALSE | TRUE | | | | TRUE | | TRUE |
| Winton Stream at Benmore - Otapiri Road | ŌRETI | | | | | | | | | | | TRUE |
| Winton Stream at Lochiel | ŌRETI | TRUE | TRUE | TRUE | FALSE | TRUE | | | | TRUE | | TRUE |
| Mararoa River at Kiwiburn | WAIAU | | | | | | | | | | | TRUE |
| Mararoa River at The Key | WAIAU | FALSE | FALSE | FALSE | FALSE | TRUE | | | | FALSE | | |
| Mararoa River at Weir Road | WAIAU | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | FALSE |
| Orauea River at Orawia Pukemaori Road | WAIAU | FALSE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE |
| Upukerora River at Te Au Milford Road | WAIAU | FALSE | FALSE | FALSE | FALSE | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE | |
| Waiau River 100m u/s Clifden Bridge | WAIAU | | | | | | | | FALSE | | FALSE | TRUE |
| Waiau River at Duncraigen Road | WAIAU | | | | | | | | | | | TRUE |
| Waiau River at Tuatapere | WAIAU | FALSE | FALSE | FALSE | FALSE | TRUE | TRUE | FALSE | FALSE | FALSE | FALSE | TRUE |
| Waiau River us Excelsior Creek | WAIAU | | | | | | | | TRUE | | FALSE | |

**Appendix 2 (Part 1)**

**State of estuary variables at the site scale**

| | Arsenic | Cadimum | Chromium | Copper | Mercury | Nickel | Lead | Zinc | % mud content | TOC | aRPD 2019 | Chlorophyll-a in water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Threshold | >20 | >1.5 | >80 | >65 | >0.15 | >21 | >50 | >200 | NA* | >1.2% | <10 | >10.5; >16 |
| Sites | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Annual Mean | $90^{th}$ Percentile |
| Fortrose Estuary Site A | 1.7 | 0.02 | 8.2 | 2.6 | 0.01 | 3.5 | 2.5 | 16.0 | 5.8 | | 33.2 | |
| Fortrose Estuary Site B | 2.1 | 0.0075 | 3.9 | 1.5 | 0.01 | 2.5 | 1.5 | 10.9 | 4.2 | | 24.9 | |
| Freshwater Estuary Site A | | | 2.8 | 1.3 | | 3.4 | | 5.7 | 1.6 | | 30 | |
| Freshwater Estuary Site B | | | 4.1 | 1.6 | 0.01 | 2.8 | 0.8 | 7.4 | 0.9 | | 80 | |
| Freshwater Estuary Site C | | | 3.3 | 1.5 | 0.01 | 2.9 | 0.8 | 6.3 | | | | |
| Haldane Estuary Site A1 | 4.0 | 0.016667 | 3.7 | 4.0 | 0.01 | 6.2 | 2.2 | 25.0 | **29.5** | 0.2 | 35.2 | |
| Haldane Estuary Site B | 3.9 | 0.005 | 5.1 | 1.9 | 0.01 | 2.9 | 1.2 | 11.0 | 7.9 | | 14 | |
| Haldane Estuary Site C | | 0.019 | 10.6 | 5.3 | 0.01 | 7.3 | 2.5 | 26.1 | | | 20.0 | |
| Jacobs River Estuary Site A | 4.8 | 0.056667 | 11.7 | 22.5 | 0.02 | 13.0 | 3.5 | 32.0 | 1.2 | | 22.5 | |
| Jacobs River Estuary Site B | 4.6 | 0.023333 | 8.7 | 9.4 | 0.01 | 7.3 | 2.2 | 26.4 | 8.0 | | 14.7 | |
| Jacobs River Estuary Site C | 6.0 | 0.013333 | 7.7 | 5.2 | 0.02 | 5.3 | 1.7 | 18.4 | 7.2 | | 4.7 | |
| Jacobs River Estuary Site D | 6.6 | 0.071667 | 17.6 | 19.1 | 0.03 | 12.4 | 4.9 | 48.3 | **67.1** | 2.8 | 0.84 | |
| Jacobs River Estuary Site E | 5.4 | 0.08 | 15.0 | 25.2 | 0.02 | 13.7 | 4.6 | 62.2 | **57.3** | 0.7 | 2.6 | |
| New River Estuary Site B | 4.6 | 0.015 | 7.7 | 3.2 | 0.01 | 5.0 | 1.4 | 15.8 | 1.8 | | 24.8 | |
| New River Estuary Site C | 5.1 | 0.02 | 11.8 | 4.2 | 0.01 | [illegible] | 2.1 | 20.9 | 7.0 | | 33.5 | |
| New River Estuary Site D | 5.0 | 0.02 | 7.8 | 3.0 | 0.01 | 5.1 | 1.7 | 16.1 | 3.7 | | 22.9 | |
| New River Estuary Site E | 6.0 | 0.075 | 19.1 | 9.2 | 0.02 | 12.9 | 4.5 | 43.5 | **45.7** | 1.2 | 0 | |
| New River Estuary Site F | 10.1 | 0.148333 | 36.8 | 23.0 | 0.06 | 30.7 | 13.6 | 119.7 | **88.0** | 2.9 | 1.4 | |
| Waikawa Estuary Site A | 5.4 | 0.013333 | 7.6 | 2.7 | 0.01 | 4.2 | 1.8 | 14.7 | 16.6 | | 10 | |
| Waikawa Estuary Site B | 5.3 | 0.016667 | 6.9 | 2.0 | 0.01 | 3.4 | 1.4 | 11.4 | 3.8 | | 17.1 | |
| Waikawa Estuary Site C | | 0.042 | 15.0 | 8.9 | 0.02 | 9.8 | 5.4 | 38.3 | | | 10 | |
| Waikawa Estuary Site C1 | 5.9 | 0.02 | 13.2 | 6.7 | 0.02 | 7.8 | 4.7 | 42.3 | **71.0** | 1.0 | 21.6 | |
| Waimatuku Estuary Site D | 3.9 | 0.11 | 11.6 | 9.4 | 0.01 | 7.4 | 3.1 | 36.0 | NA | | NA | |
| Waimatuku Estuary Site E | 3.9 | 0.08 | 10.3 | 8.5 | 0.01 | 7.7 | 2.5 | 34.0 | NA | | NA | |
| Waimatuku Estuary Site G | 6.5 | 0.06 | 13.0 | 8.9 | 0.01 | 9.0 | 3.2 | 32.0 | NA | | NA | |
| New River Estuary Ōmāui Beach | | | | | | | | | | | | 3.8 |
| New River Estuary Awarua Farm | | | | | | | | | | | | 7.6 |

| | Arsenic | Cadimum | Chromium | Copper | Mercury | Nickel | Lead | Zinc | % mud content | TOC | aRPD 2019 | Chlorophyll-a in water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Threshold | >20 | >1.5 | >80 | >65 | >0.15 | >21 | >50 | >200 | NA* | >1.2% | <10 | >10.5; >16 |
| Sites | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Mean (up to 3 years) | Annual Mean | 90th Percentile |
| New River Estuary Lagoon tip outlet | | | | | | | | | | | | 9.9 |
| New River Estuary Stead Street | | | | | | | | | | | | 18.9 |
| New River Estuary Dunns Road | | | | | | | | | | | | 6.6 |
| Oreti Beach | | | | | | | | | | | | 31.4 |
| New River Estuary Ski club | | | | | | | | | | | | 5.1 |
| New River Estuary Mcoys Beach | | | | | | | | | | | | 6.0 |
| New River Estuary Sandy Point | | | | | | | | | | | | 4.6 |

**Note that Total organic carbon (TOC) requires the prerequisite of muddy i.e. >25% mud content. Mud concentrations above 25% are bolded in the table.*

**Appendix 2 (Part 2)**

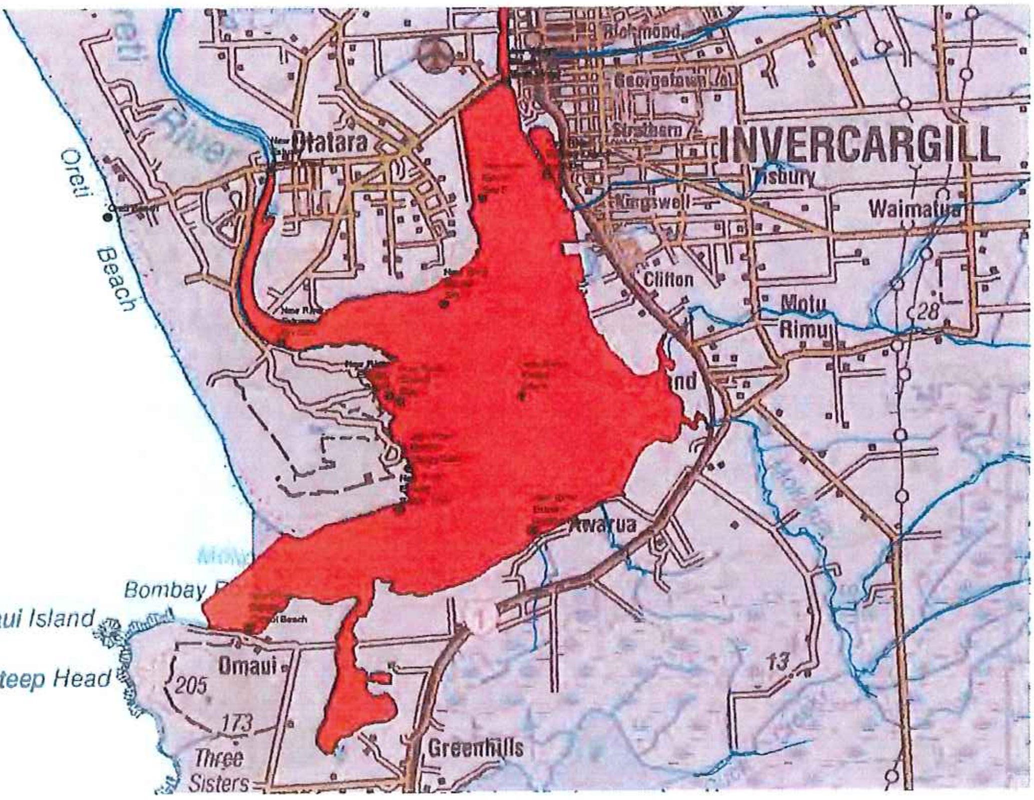
**State of estuary variables at the estuary scale**

| | Macroalgae (EQR) | GEZ | | Seagrass loss | |
|---|---|---|---|---|---|
| Threshold | <0.4 | >20Ha | >10% | Ha | >15% loss from baseline |
| Estuary | Annual assessment | Annual assessment | | Annual assessment | |
| Fortrose Estuary | 0.453 | 9.0 | 3.7 | 0.1 | 33% |
| Freshwater Estuary | | No symptoms | | 6.4 | 2% |
| Haldane Estuary | 0.9 | 0.0 | 0.0 | 0 | 0 |
| Jacobs River Estuary | 0.245 | 144.0 | 29.0 | -5.9 | -19% |
| New River Estuary | 0.284 | 428.0 | 15.0 | -38 | -40% |
| Waikawa Estuary | 0.75 | 0.7 | <1 | 4.1 | 61% |

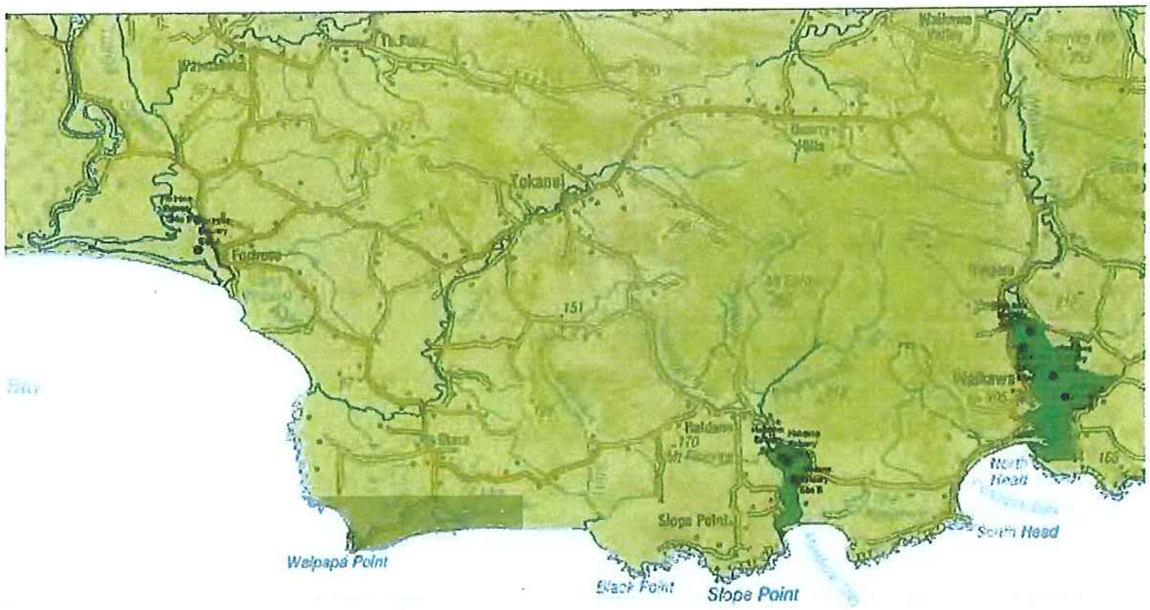
**Appendix 3**

**Location of estuary sites**


*Aparima FMU*




*Ōreti FMU*


Tokanui
Fortrose
Slope Point
Waipapa Point
Black Point
Slope Point
North Head
South Head
Waikawa

Mataura FMU


THE SEAL OF THE ENVIRONMENT COURT OF NEW ZEALAND

## Appendix 4

## Final attributes to identify degraded waterbodies

**Table 1 rivers**

**Table 2 lakes**

**Table 3 estuaries**

**Table 1:** Final attributes and associated spatial scale to identify degraded rivers.

| Attribute | Spatial Area | Metric | Numeric Threshold | Compliance Statistic | Component of ecosystem health framework | Explanation/Reference |
|---|---|---|---|---|---|---|
| Dissolved inorganic nitrogen (DIN[3]) (nutrient)[4] | Upland | DIN | >0.5mg/L | 5 year median | Water quality | Matheson et al 2016<br>Snelder et al 2019<br>Bottom of Band B of MFE 2019 |
| | Lowland | DIN | >1.0mg/L | 5 year median | Water quality | Matheson et al 2016<br>Snelder et al 2019<br>Bottom of Band C and national bottom line of MFE 2019 |
| Dissolved Reactive Phosphorus (DRP[3]) (nutrient) | Upland | DRP | >0.01mg/L | 5 year median | Water quality | Matheson et al 2016<br>Snelder et al 2019<br>Bottom of Band B of MFE 2019 |
| | Lowland | DRP | >0.018mg/L | 5 year median | Water quality | Matheson et al 2016<br>Snelder et al 2019<br>Bottom of Band C and national bottom line of MFE 2019 |

[3] Note: discussion of disagreement at paragraph 79(c).

[4] In the May 2019 JWS, ammonia and nitrate were assessed separately for their nutrient effect on Ecosystem Health. The experts have since combined these as a single DIN attribute.

**Table 1:** Final attributes and associated spatial scale to identify degraded rivers.

| Attribute | Spatial Area | Metric | Numeric Threshold | Compliance Statistic | Component of ecosystem health framework | Explanation/Reference |
|---|---|---|---|---|---|---|
| Ammonia-N (toxicity) Less stringent standard[5] | Region | Amm-N | >1.0mg/L | Annual median | Water quality | Bottom of Band C of NPSFM 2017 – identified in NPSFM as 80% species protection level (rounded down from the national bottom line of 1.3 mg/L as that is higher than the DIN threshold) |
| | | | >2.2mg/L | Annual maximum | Water quality | Bottom of Band C of NPSFM 2017 – identified in NPSFM as 80% species protection level |
| Ammonia-N (toxicity) More stringent standard | Region | Amm-N | >0.03mg/L | Annual median | Water quality | Bottom of Band A of NPSFM 2017 – no observed toxicity effect on any species tested |
| | | | >0.05mg/L | Annual maximum | Water quality | Bottom of Band A of NPSFM 2017 – no observed toxicity effect on any species tested |
| Nitrate-N (toxicity) | Region | Nitrate-N | | | | See footnote[6] |
| Macroinvertebrates[7] | Upland[8] | MCI | <100 | 5 year mean | Aquatic life | Appendix E – hill category |

[5] Note: discussion of disagreement at paragraph 79(b).

[6] Most experts agree that other ecosystem health effects are manifested at lower concentration than toxic effects. However, some experts are of a different view that it is appropriate in some situations for DIN to exceed 1 mg/L, provided there are no nuisance periphyton/plant growth issues.

[7] Note: see paragraph 36 for exceptions.

[8] Note: discussion of disagreement at paragraph 79(a) and paragraph 31.

**Table 1:** Final attributes and associated spatial scale to identify degraded rivers.

| Attribute | Spatial Area | Metric | Numeric Threshold | Compliance Statistic | Component of ecosystem health framework | Explanation/Reference |
|---|---|---|---|---|---|---|
| | | | | | | Clapcott et al 2017 used for hard and soft bottomed rivers as appropriate |
| | Lowland | MCI | <90 | 5 year mean | Aquatic life | Appendix E – lake fed, spring fed, lowland hard bed<br>Clapcott et al 2017 used for hard and soft bottomed rivers as appropriate |
| Periphyton[9] | Upland[8] | Chlorophyll-*a* | >120mg/m$^2$ | 92%ile over at least 3 years monthly sampling | Aquatic life | Snelder et al 2019<br>Snelder et al 2013<br>Bottom of Band B NPSFM 2017 |
| | | % weighted composite cover (Peri WCC) | >40% | 92%ile over at least 3 years monthly sampling | Aquatic life | Matheson et al 2012 threshold between good and fair ecological condition |

[9] Note: see paragraph 41 with respect to didymo.

**Table 1:** Final attributes and associated spatial scale to identify degraded rivers.

| Attribute | Spatial Area | Metric | Numeric Threshold | Compliance Statistic | Component of ecosystem health framework | Explanation/Reference |
|---|---|---|---|---|---|---|
| | Lowland | Chlorophyll-*a* | >200mg/m$^2$ | 92%ile over at least 3 years monthly sampling | Aquatic life | Snelder et al 2019<br>Snelder et al 2013<br>Bottom of Band C (national bottom line)<br>NPSFM 2017 |
| | | % weighted composite cover (Peri WCC) | >55% | 92%ile over at least 3 years monthly sampling | Aquatic life | Matheson et al 2012 threshold between fair and poor ecological condition |
| Deposited fine sediment | Upland | % cover | >20% | Median over at least 2 years monthly sampling | Physical habitat | Clapcott et al 2011<br>Burdon et al 2013 |
| | Lowland | % cover | >30% | Median over at least 2 years | Physical habitat | Clapcott et al 2011<br>Burdon et al 2013 |

**Table 1:** Final attributes and associated spatial scale to identify degraded rivers.

| Attribute | Spatial Area | Metric | Numeric Threshold | Compliance Statistic | Component of ecosystem health framework | Explanation/Reference |
|---|---|---|---|---|---|---|
| | | | | monthly sampling . | | |
| Fish | Region | Index of Biotic Integrity (IBI) | <23 | Site Average of the latest up to three surveys | Aquatic life | Joy and Death 2004[10]<br>Joy 2010 (Southland specific) |
| Turbidity (suspended sediment) | Region | NTU/FNU | As per table 1.2 national bottom line of Franklin et al 2019 | Median over at least 2 years monthly sampling | Water quality | Franklin et al 2019[11]<br>STAG 2019 |
| *E. coli* (Human health) | Region | *E. coli* /100mL | Bands D and E | Four compliance statistics to determine | n/a | NPS FM 2017 |

[10] Trout are treated neutral as per STAG 2019 report.

[11] Technical guidance from Franklin et al (2019) to MfE on fine sediment attribute thresholds for the draft NPSFM, MfE (2019).

**Table 1:** Final attributes and associated spatial scale to identify degraded rivers.

| Attribute | Spatial Area | Metric | Numeric Threshold | Compliance Statistic | Component of ecosystem health framework | Explanation/Reference |
|---|---|---|---|---|---|---|
| | | | | attribute state | | |
| Benthic cyanobacteria (Human health) | Region | % cover | >20 | $90^{th}$ %ile of 5 years of monthly sampling | n/a | Wood et al 2009<br>Wood et al 2014 |

**Table 2.** Final attributes, thresholds and associated spatial scale to define degraded lakes and ICOLLs.

| Attribute | Metric | Numeric threshold | | | Compliance Statistic | Data Used in JWS | Component of ecosystem health framework | Explanation/ Reference |
|---|---|---|---|---|---|---|---|---|
| | | Shallow | Deep | ICOLL | | | | |
| Ammonia-N (toxicity) Less stringent standard[12] | mg/L Amm-N | >1.3 | | | Annual median | SOE data | Water quality | Bottom of Band C of NPSFM 2017 – identified in NPSFM as 80% species protection level |
| | mg/L Amm-N | >2.2 | | | Annual maximum | SOE data | Water quality | |
| Ammonia-N (toxicity) More stringent standard | mg/L Amm-N | >0.03 | | | Annual median | SOE data | Water quality | Bottom of Band A NPSFM 2017 – 99% species protection |
| | mg/L Amm-N | >0.05 | | | Annual maximum | SOE data | Water quality | |
| Total nitrogen | mg/ $m^3$ TN | >800 | >750 | >750 | Annual median | SOE data | Water quality | NPSFM 2017 |
| Total phosphorus | mg/ $m^3$ TP | >50 annual median | | | Annual median | SOE data | Water quality | NPSFM 2017 |

[12] Note: discussion of disagreement at paragraphs 33 and 79(b).

| Attribute | Metric | Numeric threshold | | | Compliance Statistic | Data Used in JWS | Component of ecosystem health framework | Explanation/ Reference |
|---|---|---|---|---|---|---|---|---|
| | | Shallow | Deep | ICOLL | | | | |
| Phytoplankton | mg chl-a/m³ | >12 | | | Annual median | SOE data | Aquatic life | NPSFM 2017 |
| | | >60 | | | Annual maximum | | | |
| Dissolved oxygen in lake bottom water | mg/L | <0.5 | | | Minimum over five years | SOE for shallow lakes only | Aquatic life | STAG 2019 |
| Macrophyte cover | % cover of available habitat | | | <30% | Lagoon annual average over 5 years | DOC annual monitoring | Aquatic life | Lagoon Technical Group (LTG) guidelines 2013<br>de Winton 2019 |
| Aquatic plant biomass index | Cover % x height (cm) | | | <1000 | Lagoon annual average over 5 years | DOC annual monitoring | Aquatic life | Lagoon Technical Group (LTG) guidelines 2013<br>de Winton 2019 |

| Attribute | Metric | Numeric threshold | | | Compliance Statistic | Data Used in JWS | Component of ecosystem health framework | Explanation/ Reference |
|---|---|---|---|---|---|---|---|---|
| | | Shallow | Deep | ICOLL | | | | |
| *E. coli* (Human health) | *E. coli*/100ml | Bands D and E | | | Four compliance statistics to determine attribute state | n/a[13] | n/a | NPSFM 2017 |

[13] Insufficient data (paragraph 69), threshold relevant to assess degradation when future data collected.

Table 3: Preliminary attributes and associated spatial scale to identify degraded estuaries.

| Attribute | Spatial Area | Metric | Numeric Threshold | Compliance Statistic | Data Used in JWS | Explanation/Reference |
|---|---|---|---|---|---|---|
| Metals toxicity in sediment | Per site | mg/Kg Dry Weight of sediment (total recoverable metal)<br>(Arsenic -As, Cadmium - Cd, Chromium - Cr, Copper - Cu, Mercury - Hg, Nickel - Ni, Lead - Pb and Zinc - Zn) | >ANZECC lower trigger limit.<br>Mean for up to the last 3 years if available | Mean for up to the last 3 years if available | ES data | ANZECC guidelines 2000 / 2018 |
| Sediment nutrients | Per site intertidal. | % Total organic carbon (TOC) | 1.2 % dry weight, where mud >25% | Mean for up to the last 3 years if available | ES SOE | Info available for TOC.<br>Robertson et al (2015)<br>Robertson et al (2016a) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sediment oxygen | Individual sites. | mm (depth to apparent Redox Potential Discontinuity) (aRPD)) | <10mm depth | Latest annual measurement site mean. | ES SOE | aRPD based on Based on Coastal and Marine Ecological Classification Standard Marine and Coastal Spatial Data Subcommittee Federal Geographic Data Committee June, 2012 |
| Phytoplankton | Per Site/sampling station | µg/L (micrograms chlorophyll-a litre) | >12 (salinity >30 ppt) >16 (salinity <30 ppt) | $90^{th}$ percentile 3 years | ICC data | Revilla et al. 2010 |
| Macroalgae cover and biomass | Intertidal area | Ecological Quality rating (dimensionless) | <0.4 EQR index score | Latest annual assessment | ES SOE | WFD-UKTAG 2014 |
| Gross Eutrophic Zone | Intertidal area | % of intertidal area | >10% and >20ha | Latest annual assessment | ES SOE | Robertson et al. 2017 |
| Seagrass | Intertidal area | % loss from baseline measure | >15% | Latest annual assessment | ES SOE | Robertson et al. 2016b |

## Appendix 5

### Distribution of didymo in Southland

### Environment Southland (ES) monitoring sites

Visual assessments of periphyton cover on the stream bed carried out in the ES periphyton monitoring programme (Hodson and De Silva 2018) indicate the extent and severity of didymo at the monitoring sites.

**TABLE 1. List of ES periphyton monitoring sites showing the seven sites where didymo was observed particularly frequently and which had particularly high frequency of cover and mean cover. Data from December 2014 to January 2018.**

| River and site | Percentage of surveys where didymo was observed | Mean percentage cover |
|---|---|---|
| Mararoa River at Weir Road | 38 | 24.6 |
| Waiau River at Tuatapere | 44 | 24.4 |
| Ōreti River at Three Kings | 79 | 17.5 |
| Cromel Stream at Selbie Road | 49 | 9.5 |
| Lill Burn at Lill Burn-Monowai Road | 38 | 8.8 |
| Upukerora River at Te Anau Milford Road | 41 | 4.2 |
| Whitestone River d/s Manapōuri -Hillside | 26 | 3.9 |

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