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: 14 to 16 October 2019

Venues: Novotel and Rydges Latimer Hotels, Christchurch

Facilitator: Jim Hodges, Environment Commissioner

Recorder: Marion Birnie

Attendees

1 Witnesses who participated and agreed to the content of this Joint Witness Statement (**JWS**) by signing it on 16 October.

Name	Employed or engaged by	Signature
Dr Ton Snelder	Southland Regional Council	
Dr Cathy Kilroy	Meridian Energy Limited – until end of rivers section	
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 Not in attendance Tuesday afternoon	
Ailsa Cain	Nga Rununga -Tuesday and Wednesday only	

For ease of reference throughout this JWS, all experts had some relevant expertise in rivers, lakes, and estuaries except the following:

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

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

(a) Ms Cain, who is a cultural policy expert;

(b) Mr Ward does not consider himself an expert in rivers.

3 It is noted that in addition to Dr Kilroy leaving the conference at the end of the rivers section, Ms Cain left before Table 3 was populated:

4 All experts reviewed the remaining content of the JWS before signing except for Dr Kilroy who had left the conference before the final review.

Purposes of the conference

5 The purposes of the conference, based on the agreed agenda, are to complete a JWS to address the tasks set out on page 3 of Table 4 of the September JWS, and specifically to:

(a) Confirm recommended classification systems for rivers, lakes and estuaries as a basis for defining degradation on an interim basis;

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

(c) Estimate levels of confidence in recommended attribute thresholds;

(d) Consider possible linkages to cultural indicators and Ki Uta Ki Tai and Te Mana o Te Wai

(e) Provide preliminary guidance on a possible methodology for linking river, estuary and lake attributes from a scientific perspective, including linkages between ground and surface water systems.

6 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

7 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

8 This JWS records the outcomes of the second 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 and 4 September 2019.

9 To provide context, the rivers conference on 7 to 9 May identified areas of the region that were degraded with respect to ecosystem and human health in terms of nitrate and ammonia concentrations, the trophic status of estuaries, MCI scores, periphyton, E coli and cyanobacteria coverage. At-risk areas of the region were also identified. There was a lakes and estuaries conference on 9 and 10 May that classified lakes and estuaries on the basis of risk but did not explicitly state which were degraded. The experts have addressed this in the current JWS and will do so further in the subsequent November one.

10 The experts noted that additional water bodies might be degraded or at risk when considered against other criteria such as nitrogen, phosphorus and other attributes relevant to periphyton, MCI and fish, but they could not agree thresholds at the time. They also noted that when further analysis is undertaken, it may be necessary to add other attributes such as temperature fish and dissolved oxygen.

11 They identified work that had been undertaken by Dr Death in relation to nitrogen, phosphorus, deposited sediment and MCI values that would provide a very helpful base for further consideration. They also identified that

Environment Southland had "undertaken significant further work that will be directly relevant to addressing the above issues."

12 In its minute dated 9 July 2019 the Court directed that further work be undertaken in relation to cultural and ecological indicators of health, and this JWS forms part of that further work process.

13 To assist the Court, the experts note that while they are familiar with the new draft National Policy Statement for Freshwater Management 2019 (NPSFM), they have not taken it into account in this JWS, because it has not been tested through a full statutory process. However, they have referred to the scientific papers and reports relied on in the preparation of the draft NPSFM.

Primary additional information taken into account in this JWS

14 The experts agree that the primary data to be used is the most up to date Environment Southland monitoring data for rivers, estuaries and lakes. This will be used in the November JWS to assess degraded state. Additional sources of information are identified in tables 1 to 3.

15 At the time of the May 2019 Rivers JWS it was intended to undertake further work in relation to Dr Death's evidence on water quality numeric thresholds, as referred to in paragraph [48] of the May 2019 Rivers JWS. Since that time the experts have considered all relevant thresholds for ecosystem health, including evidence previously presented to the Court. The experts agree that the thresholds to determine degradation to be used by the Court are those set out in this JWS and that further detailed evaluation of Dr Death's work was no longer required.

16 By way of clarification Dr Canning confirmed that the modelled water quality state Dr Death used was from Unwin and Larned 2013 (MfE model). In the current work the experts will use an updated version of the same model.

17 The assessment of degraded water bodies will be undertaken by comparing the thresholds defined in this document against data representing each attribute in waterbodies across the region. Two types of data will be used to undertake the assessment.

(a) State of environment data from the council monitoring sites (approximately 60 rivers, seven lakes, six estuaries) will be analysed to extract a value corresponding to each attribute's compliance statistic. These statistics will be compared to the relevant thresholds.

(b) Where available, spatially comprehensive predictions from the MfE model of each attribute's compliance statistic for each river segment and each lake in the region will be compared to the threshold. The assessments will be presented as maps and tables.

Other references taken into account in this JWS

18 These are listed in Appendix 1.

CONFERENCE OUTCOMES

Definitions, classification systems and clarifications

What is meant by degradation

19 In paragraphs 15 to 18 of the September JWS, the experts provided some initial comments on the definition of where ecosystem health, including water quality, is degraded, for use in interpreting Objective 6 of the proposed SWLP. They stated that the "experts have adopted the concept of the "national bottom line" (NBL) or "minimum acceptable state from the NPSFM as indicative of degraded state" and that they "will further explain this interpretation when discussing the specific attributes in later stages of the conference".

20 This approach has generally been maintained for this JWS except as set out below. For example, with respect to deposited fine sediment and fish Index of Biotic Integrity (IBI), the experts consider region specific thresholds more appropriately define degradation in Southland than national bottom lines.

21 The experts note that there is an issue still be resolved around delineation of upland and lowland river classes for example classification of main stems of larger rivers. Some experts consider that more stringent thresholds than NBL's may need to be applied to upland catchments. This will be addressed further in the final JWS.

22 With respect to ammonia and nitrate toxicity, some experts consider more stringent thresholds than NBL's may need to be applied at regional scale. This will be addressed further in the final JWS.

23 The thresholds included in this JWS are based on the current state of the water body rather than on trends.

24 The experts have used coarse water body classifications for the purposes of defining regional thresholds of degradation. They consider that noncompliance with the thresholds clearly identifies a degraded state. Compliance with the threshold does not necessarily mean that a water body is in a state of hauora as discussed below. For example, any decline of natural state waters (ie the large

deep inland lakes and streams in the National Park) will not be identified by the thresholds established in this JWS.

25 To assist the Court, the experts note that some water bodies may not meet some of the thresholds recommended in this JWS as they are affected by natural processes that occurred before the arrival of humans. The experts request that the Regional Council provides information on where any such sites are located and reasons for concern.

26 Dr James and Dr Kilroy will provide information on sites dominated by didymo.

27 The experts confirm their previous advice that as a broad principle degradation should be based on failure against any individual attribute on threshold. However, they consider that a prudent sense check of the data should be undertaken.

Classification systems for rivers, lakes and estuaries

Rivers

28 The experts agreed a spatial framework for rivers that is a simple classification of segments of the digital river network into Lowland and Upland categories. The rationale for these classes is the recognition that the characteristics of rivers are largely determined by catchment characteristics. For example, the interaction between regional climate and catchment topography is understood to be the dominant cause of variation in hydrological and morphological characteristics of rivers at broad scales (i.e., 100 km^2). Variation in topography occurs within catchments, most obviously in the downstream direction in a pattern that is referred to as the river continuum

29 Many large river systems in Southland are dominated by the characteristics of the upper catchment, in their main stem this dominance can occur as far as the coast. This explains why in figure 1 some large rivers have main stems that classify as upland even at low elevation and in some cases as far as the coast.

30 Sections of the network that are classified as "Upland" have high elevation and steep catchments, whereas segments that are classfied as Lowland have the reverse characteristics. Segments classfied as Upland may pass through areas

where influent tributaries are classifed as Lowland. For example the Mataura river is classified as Upland in areas where it traverses the Southland plains where local streams are classified as Lowland. The classes accurately discriminate the character of the Mataura main stem (e.g., broad gravel bed river) from its local tributaries (e.g., narrow incised streams).

31 The rules for delineating the two classes are provided by Larned et al (2016). Lowland segments are defined by catchment slope <= 15 degrees and catchment elevations <=350 m asl. Upland segments are defined by catchment slope > 15 degrees and catchment elevations > 350 asl. Both criteria need to be satisfied for a segment to be classified as Upland. These rules are based on expert judgment and are arbitrarily subdividing what is in reality a continuous gradient in variation.

It is noted that this classification differs to that used by Land, Air, Water Aotearoa (LAWA), which is not network based. In the LAWA classfication, the main stem of the Mataura on the Southland plains would be classfied as a lowland river. It is also noted that the rationale described above is the same as has been adopted by the Southland Regional council to define management classes in Appendix E of its operative regional water plan.

32 A map of all river segments in Southland classified according to these criteria is shown as Figure 1.

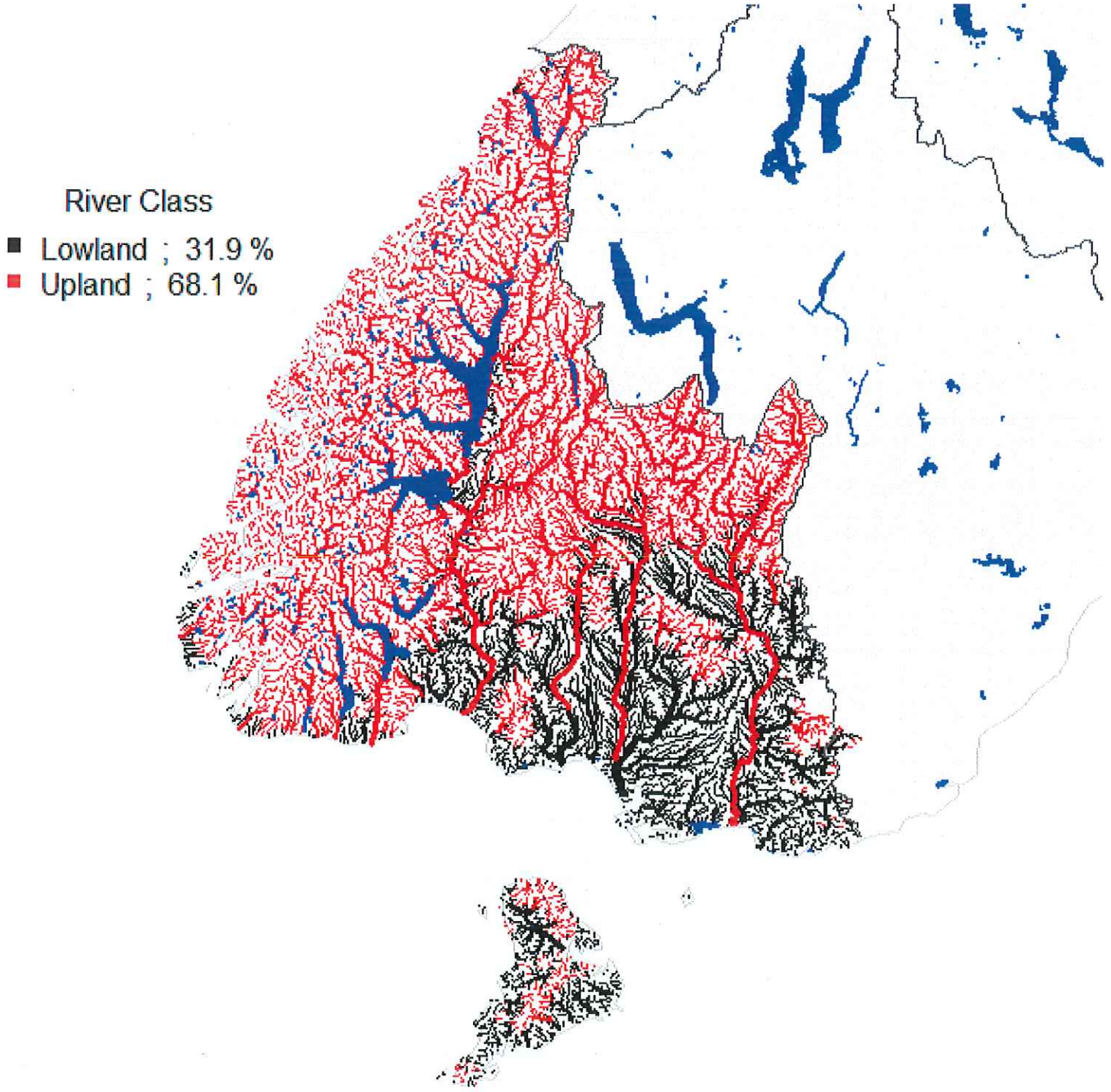

Figure 1. Map showing all river segments in Southland classified as upland and lowland. The percentages in the map legend indicate proportions of segments in each class.

Lakes

33 The experts agreed a spatial framework for lakes that is a simple classification of lakes as whole water bodies into four categories: Intermitantly Closed and Open Lakes and Lagoons (ICOLL), Deep and Shallow. The logic for these classes is described in detail by Ward (In Prep). The rules for delineating these classes were applied to the Freshwater Environments of New Zealand (FENZ; Leathwick et al. 2010) lakes database.

34 Shallow lakes are defined by lakes with an estimated maximum depth of <= 15m. Shallow freshwater lakes are the equivalent of 'polymictic' in the national objectives framework, meaning the water column is vertically mixed throughout the year.

35 Shallow freshwater lakes in good condition generally exhibit good clarity because they are dominated by aquatic macrophytes, however wind driven mixing can lead to resuspension of the sediments and turbid waters (Schallenberg 2019).

36 Shallow Lakes in Southland with monitored data available for the degradation assessment are Lake Vincent, The Reservoir and Lake George.

37 Deep lakes are defined as lakes with an estimated maximum depth of > 15m. They undergo thermal stratification in the summer (equivalent NOF category is 'stratified'). This type of stratification is persistent and results in two distinct layers; a surface layer (epilimnion) and the bottom layer (hypolimnion).

38 ICOLLs are subjectively identified based on connection to the sea. They are influenced by the marine environment when open, either directly through tidal exchange or indirectly; and can be predominantly freshwater when closed. These systems are also influenced by lake level, flushing, mixing and stratification. Some ICOLLs can experience long periods of mouth closure, during this time susceptibility to nutrient retention and eutrophication increases. Under these conditions excess phytoplankton growth and reduced macrophyte growth are characteristic of eutrophic symptoms.

39 ICOLLs behave as Lakes when closed and for management purposes need to be considered for when they are at their most susceptible, which is when

closed. In Southland, ICOLLs with monitored data available for the degradation assessment are: Waituna Lagoon and Waiau Lagoon[3].

40 A map of all lakes in Southland classified according to these criteria is shown as Figure 2. Figure 3 shows lakes with extensive monitoring data.

Estuaries

41 The classification system of Robertson et al (2016) has been adopted. For the purposes of this JWS estuaries with monitoring data available have been included only. The experts have separated monitored estuaries into two main categories.

42 The types are as follows:

(a) Tidal Lagoon

(b) Tidal River

Tidal Lagoon

43 These estuaries have extensive tidal flats which are the first areas to display symptoms of eutrophication. Fine sediment and nutrients can accumulate (particularly if loads are excessive). Excessive nutrients and sediment are deleterious to healthy growths of seagrass and saltmarsh, and fuel nuisance growths of macroalgae in at-risk habitat. Waterbodies in this class include Koreti/Waihopai (New River Estuary, Aparima (Jacobs River) Estuary, Freshwater Estuary, Waikawa Estuary and Haldane Estuary.

Tidal River

44 These estuaries are dominated by river flow so that the majority of fine sediment and nutrients are exported to the sea. This reduces their susceptibility to eutrophication compared to tidal lagoons. They can often tolerate nutrient

[3] Waiau Lagoon has two parts and the part that is monitored which the experts have classified as an ICOLL

loads an order of magnitude greater than tidal lagoons. Waterbodies in this class include Toetoes (Fortrose) Estuary.

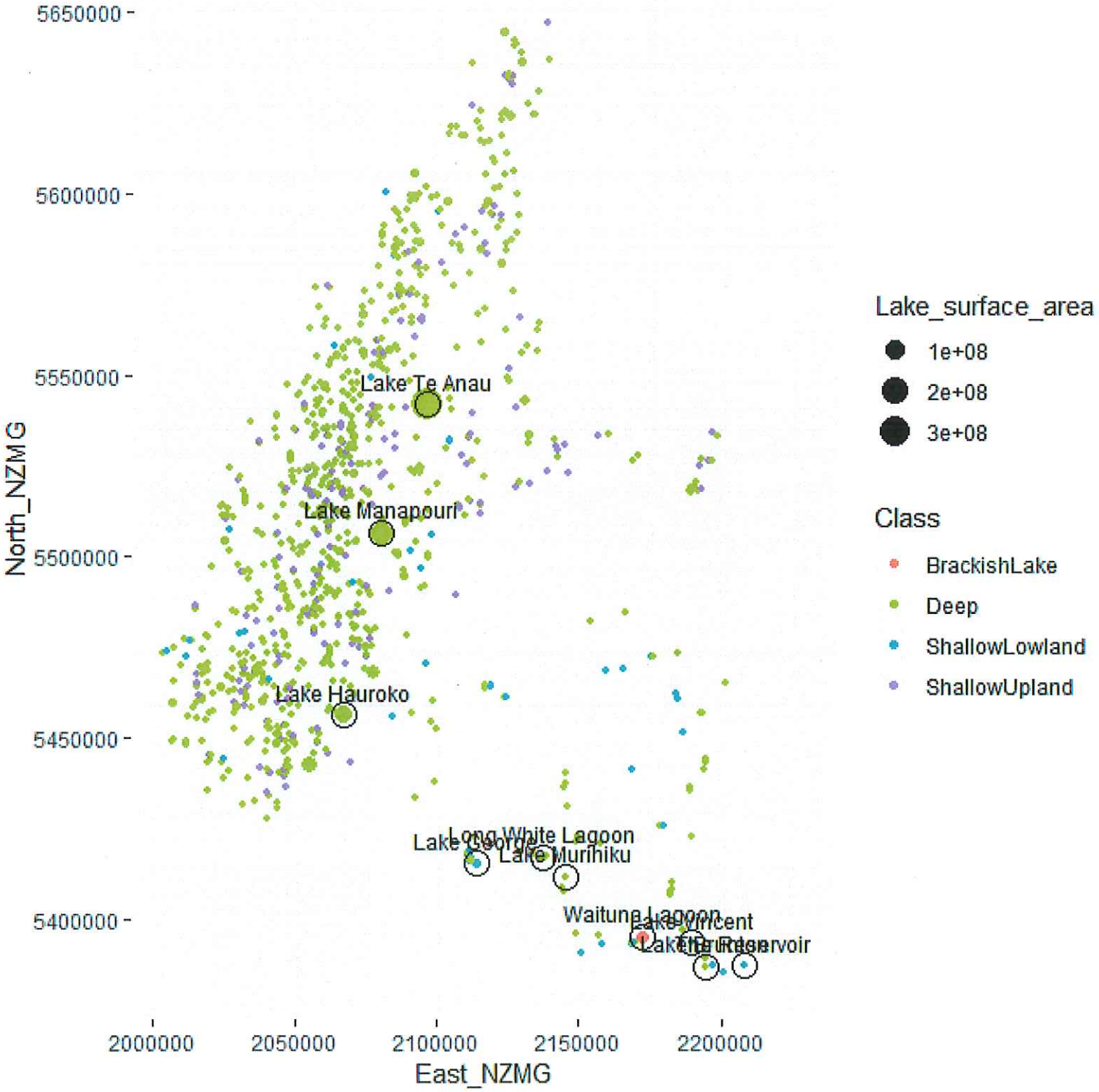

Figure 2. Map showing all lakes in Southland classified as Brackish, Deep, Shallow Lowland and Shallow Upland. Lakes with any monitoring data are indicated with a black circle and have been named. See Figure 3 for lakes with extensive monitoring data.

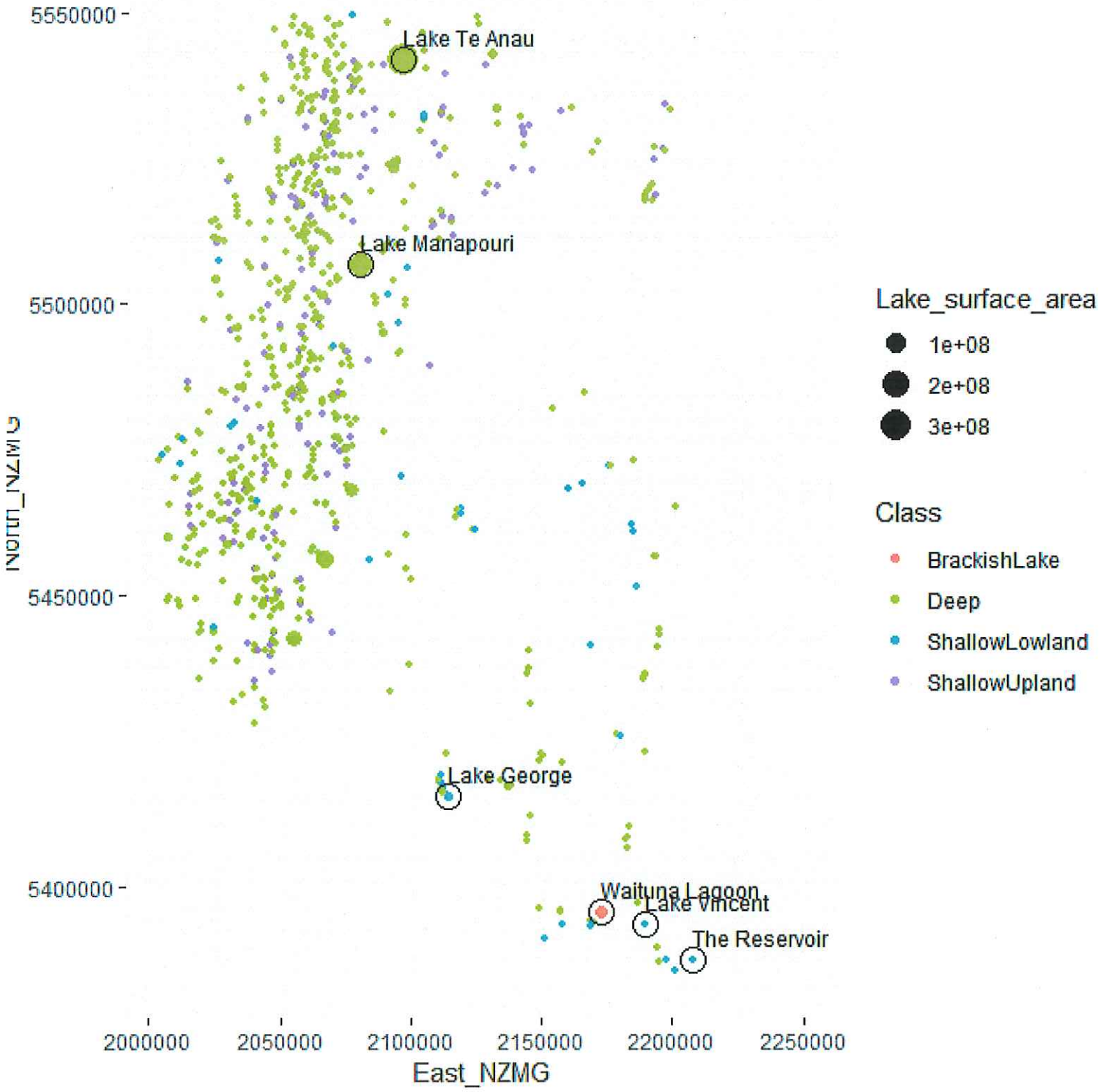

Figure 3. Map showing lakes in Southland classified as Brackish, Deep, Shallow Lowland and Shallow Upland. Lakes with extensive monitoring data are indicated with a black circle and have been named.

Other definitions

45 To assist the Court, the experts agree that for the purposes of this JWS:

Attribute means a measurable characteristic of fresh water, including physical, chemical and biological properties which supports particular values (NPSFM 2017).

Classification means to categorise things that have some property or attribute in common and are differentiated from others by kind, type or quality (Oxford Dictionary definition).

National Bottom Line or NBL means where specified, the minimum acceptable state for the compulsory values as specified in Appendix 2 of the NPSFM (2017).

Threshold means the numeric value indicating degradation (defined by the experts).

Clarifications

Ecosystem health

46 As recorded in the JWS dated 4 September 2019, JWS the experts have interpreted ecological health to include water quality, habitat quality, aquatic life and ecosystem processes.

Levels of confidence in recommended attribute thresholds

47 The experts were asked to address levels of confidence that could be placed in the thresholds developed. They acknowledge it is not possible to remove all uncertainty but consider the thresholds applied in this JWS represent the best available assessments based on currently available data and research.

Indigenous biodiversity and threatened species

48 In paragraph 18 of the September JWS, the experts stated that "When assessing attribute state, the experts will consider indigenous biodiversity and threatened species"

49 Dr Kitson, Ms McArthur and Ms Funnell have considered priority habitats for indigenous biodiversity and threatened species in their evidence. They consider that there is a broad distribution of these habitats and species across Southland.

50 In developing attributes and thresholds for degradation in rivers (Table 1) the experts have considered indigenous biodiversity and threatened species as part of the following attributes:

(a) Fish IBI

(b) MCI

(c) Deposited fine sediment

(d) Ammonia and Nitrate toxicity. The more stringent thresholds that are being tested as identified in Table 1 are based on the protection of indigenous biodiversity and threatened species.

51 In developing attributes and thresholds for degradation in lakes (Table 2) the experts have considered indigenous biodiversity and threatened species as part of the following attributes:

(a) Macrophyte cover and slime algae for ICOLL's.

(b) Discussion of the large deep lakes as given in paragraph 24.

(c) Ammonia and Nitrate toxicity as per rivers.

52 In developing attributes and thresholds for degradation in estuaries (Table 3) the experts have considered indigenous biodiversity and threatened species as part of the following attributes

(a) Seagrass cover

(b) Metal toxicity in sediment

(c) Gross eutrophic zone

Preliminary commentary on a possible methodology for linking river, estuary and lake attributes

53 Ki Uta Ki Tai is the framework to be used in the pSWLP for linking river, estuary and lake attributes. In accordance with Te Mana o te Wai, it will be necessary to prioritise the needs of the water body first. This framework and approach is described briefly in paragraph 12 of the September JWS.

54 Expert conferencing to date on topic A of the pSWLP has been limited to defining thresholds for degradation and identifying individual sites or water bodies that are degraded. In order to give effect to Ki Uta Ki Tai and Te Mana o te Wai, future catchment wide scientific work will need to consider the following matters:

(a) Source, transport and fate of contaminant loads including nutrients and sediment from mountains to the sea, including groundwater.

(b) Continuity and regime of flow to provide for habitat and passage of aquatic life.

(c) Human health considerations, including the source, transport and fate of pathogens and toxicants through the network.

(d) Land use and other human activities contributions to the above, including catchment modifications.

(e) Implications of climate change.

Attributes and recommended thresholds

55 These are shown in Tables 1, 2 and 3 for rivers, lakes and estuaries respectively.

56 In all tables, the data used in the JWS is SOE monitoring data and MfE model data unless stated otherwise.

57 For lakes in Table 2, the determination of degradation is based on the lowest ranked of all monitoring sites in the lake.

58 For lakes and lagoons that are intermittently open to the sea, monitoring data should be analysed separately for closed periods and open periods.

Table 1: Preliminary attributes and associated spatial scale to identify degraded rivers

Attribute	Spatial Area	Metric	Numeric Threshold	Compliance Statistic	Data Used in JWS[4]	Component of ecosystem health framework[5]	Explanation/Reference
Dissolved inorganic nitrogen (DIN) (nutrient)[6]	Upland To be confirmed[7]	DIN	>0.5mg/L	5 year median		Water quality	Matheson et al 2016 Snelder et al 2019 Bottom of Band B of MFE 2019
	Region[8]	DIN	>1.0mg/L	5 year median		Water quality	Matheson et al 2016 Snelder et al 2019 Bottom of Band C and national bottom line of MFE 2019
Dissolved Reactive Phosphorus (DRP) (nutrient)	Upland To be confirmed[7]	DRP	>0.01mg/L	5 year median		Water quality	Matheson et al 2016 Snelder et al 2019 Bottom of Band B of MFE 2019
	Region	DRP	>0.018mg/L	5 year median		Water quality	Matheson et al 2016 Snelder et al 2019 Bottom of Band C and national bottom line of MFE 2019

[4] State of the Environment data and MfE model unless stated otherwise

[5] As Clapcott et al 2018

[6] In the first JWS, ammonia and nitrate were assessed separately for nutrient effect. On further consideration, the experts consider that these should be combined as DIN for this JWS.

[7] There is a difference of view between the experts and relates to whether there should be a more stringent standard for upland areas. If such a standard is to be used, some of the experts suggest that it would be based on the information in the rest of this row. This will become clearer with evaluation of the data.

[8] Mr Kitto and Dr Snelder were of the view that where rivers do not have plant growth issues, restricting DIN to less than 1mg/L is not justified and the operative NPS nitrate toxicity attribute is more appropriate.

Table 1: Preliminary attributes and associated spatial scale to identify degraded rivers

Attribute	Spatial Area	Metric	Numeric Threshold	Compliance Statistic	Data Used in JWS[4]	Component of ecosystem health framework[5]	Explanation/Reference
Ammonia-N (toxicity) Less stringent standard	Region To be confirmed[9]	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 as that is higher than the DIN value)
			>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 To be confirmed[10]	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			Bottom of Band A of NPSFM 2017 – no observed toxicity effect on any species tested

[9] There is a difference of view between the experts and relates to whether there should be a more stringent standard. If such a standard is to be used, some of the experts suggest that it would be based on the information in the rest of this row. This will become clearer with evaluation of the data. Note that there are two limits that apply leading to the four rows

[10] There is a difference of view between the experts and relates to whether there should be a more stringent standard. If such a standard is to be used, some of the experts suggest that it would be based on the information in the rest of this row. This will become clearer with evaluation of the data. Note that there are two limits that apply leading to the four rows

Table 1: Preliminary attributes and associated spatial scale to identify degraded rivers

Attribute	Spatial Area	Metric	Numeric Threshold	Compliance Statistic	Data Used in JWS[4]	Component of ecosystem health framework[5]	Explanation/Reference
Nitrate-N (toxicity)	Region	Nitrate-N					See footnote[11]
Macroinvertebrates[12]	Upland	MCI	<100	5 year mean		Aquatic life	Appendix E – hill category and Mataura 2 & 3 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 Clapcott et al 2017 used for hard and soft bottomed rivers as appropriate
Periphyton[12]	Upland – To be confirmed[13]	Chlorophyll-a	>120mg/m^2	92%ile over 3 years for monthly sampling		Aquatic life	Snelder et al 2019 Snelder et al 2013 Bottom of Band B NPSFM 2017

[11] The experts agree that other ecosystem health effects are manifested at lower concentration than toxic effects. In general managing for ecosystem health will address toxic effects for Nitrate.

[12] Didymo dominated systems will need special consideration when interpreting Macroinvertebrates and Periphyton data – refer paragraph 66 &67 of May rivers JWS.

[13] There is a difference of view between the experts and relates to whether there should be a more stringent standard for upland areas. If such a standard is to be used, some of the experts suggest that it would be based on the information in the rest of this row. This will become clearer with evaluation of the data.

Table 1: Preliminary attributes and associated spatial scale to identify degraded rivers

Attribute	Spatial Area	Metric	Numeric Threshold	Compliance Statistic	Data Used in JWS[4]	Component of ecosystem health framework[5]	Explanation/Reference
		% weighted composited cover (Peri WCC)	>40%	92%ile over 3 years for monthly sampling	SOE data	Aquatic life	Matheson et al 2012 threshold between good and fair ecological condition
	Region	Chlorophyll-a	>200mg/m^2	92%ile over 3 years for monthly sampling		Aquatic life	Snelder et al 2019 Snelder et al 2013 Bottom of Band C (national bottom line) NPSFM 2017
		% weighted composited cover (Peri WCC)	>55%	92%ile over 3 years for monthly sampling	SOE data	Aquatic life	Matheson et al 2012
Macrophytes	Region	% cover					While important there is insufficient information available to assess this attribute against the Matheson et al 2012
Deposited fine sediment	Upland	% cover	>20%	3 year mean over 2 years for monthly sampling	SOE data	Physical habitat	Clapcott et al 2011 Burdon et al 2013 STAG 2019

Table 1. Preliminary attributes and associated spatial scale to identify degraded rivers

Attribute	Spatial Area	Metric	Numeric Threshold	Compliance Statistic	Data Used in JWS[4]	Component of ecosystem health framework[5]	Explanation/Reference
	Lowland	% cover	>30%	Median over 2 years for monthly sampling	SOE data	Physical habitat	Clapcott et al 2011 Burdon et al 2013 STAG 2019
Stream and riparian habitat							While important there is insufficient information available to establish a threshold
Temperature	Region	°C					While important there is insufficient information available to assess this attribute against the Davies Colley et al 2013 thresholds
Fish	Region	Index of Biotic Integrity (IBI)	<23	Site Average of the latest up to three surveys	SOE and NZ Freshwater Fish Database	Aquatic life	Joy and Death 2004[14]. Joy 2010 (Southland specific)

[14] Trout is treated neutral as per STAG 2019 report. For clarification IBI is calculated as per Joy and Death 2004 report but with a regional derived bottom line as per Joy 2010 report.

Table 1: Preliminary attributes and associated spatial scale to identify degraded rivers

Attribute	Spatial Area	Metric	Numeric Threshold	Compliance Statistic	Data Used in JWS[4]	Component of ecosystem health framework[5]	Explanation/Reference
					(since 2010)		
Dissolved oxygen	Region	mg/L					While important there is limited information available to assess this attribute
Turbidity (suspended sediment)	Region	NTU	As per table 1.2 as per the national bottom line of Franklin et al 2019			Water quality	MfE guideline[15] New NPSFM
Ecosystem metabolism	Upland	Gross primary production (GPP) and Ecosystem Respiration (ER)					While important there is limited information available to assess this attribute and potentially to set the threshold
	Lowland						While important there is limited information available to assess this attribute and potentially to set the threshold
Metals and other contaminants							While important there is limited information available to assess this attribute and potentially to set the threshold

[15] Reference for MfE guideline

Table 1: Preliminary attributes and associated spatial scale to identify degraded rivers

Attribute	Spatial Area	Metric	Numeric Threshold	Compliance Statistic	Data Used in JWS[4]	Component of ecosystem health framework[5]	Explanation/Reference
E. coli (human health)	Region	cfu/100mL	Bands D and E or Median >130				Experts understand this is not part of ecosystem health and in any event remains as per the May JWS
Benthic Cyanobacteria (human health)	Region	% cover					Experts understand this is not part of ecosystem health and in any event remains as per the May JWS

Table 2: Preliminary attributes and associated spatial scale to identify degraded Lakes and ICOLLs

Attribute	Metric	Numeric Threshold			Compliance Statistic	Data Used in JWS	Component of ecosystem health framework[16]	Explanation/ Reference
		Shallow	Deep	ICOLL				
Sedimentation Rate								While important there is limited information available to assess this attribute.
Sediment muddiness								While important there is limited information available to assess this attribute and potentially to set the threshold
Sediment metals								While important there is limited information available to assess this attribute
Total Nitrogen in water	mg/ m^3 TN	>800	>750	>750	Annual median		Water quality	NPSFM 2014 (amended 2017)[17]

[16] As Clapcott et al 2018

[17] The lagoon technical guidelines for 2013 for Waituna Lagoon (ICOLL) are set at moderate health rather than degraded state and hence has not been adopted here

Total Phosphorus in water	mg/ m^3 TP	>50 annual median			Annual median	Water quality	NPSFM 2014 (amended 2017)[17]
Nitrate (Toxicity)							Refer to Table 1 for relevant thresholds for Nitrate toxicity
Ammonia-N (toxicity)							Refer to Table 1 for relevant thresholds for Ammonia toxicity
Phytoplankton	mg chl-a/m^3	>12 annual median; >60 annual maximum			Annual median and annual Maximum	Aquatic life	NPSFM 2014 (amended 2017)[18]
Cyanobacteria planktonic							No thresholds available for ecosystem health
Clarity							While important there is limited information available to assess this attribute and potentially to set the threshold
Trophic Level Index (TLI)							Components of the TLI3 are already being individually addressed

[18] The lagoon technical guidelines for 2013 for Waituna Lagoon (ICOLL) are set at moderate health rather than degraded state and hence has not been adopted here

Macrophytes cover	% cover of available habitat (area of the lake suitable for plant growth)			<30%	Annual lagoon average	DOC annual monitoring	Aquatic life	Lagoon Technical Group (LTG) guidelines 2013
Lake submerged plant indicators (SPI)								While important there is limited information available to assess this attribute.
Slime Algae	% cover of permanently wetted sites			>10%	Lagoon annual mean	DOC annual monitoring	Aquatic life	Lagoon Technical Group Guidelines 2013
Aquatic plant biomass index	Cover % x height (cm)			<1000	Lagoon annual mean	DOC annual monitoring	Aquatic life	Lagoon Technical Group Guidelines 2013
Dissolved oxygen in lake bottom water	mg/L	<0.5			Annual minimum	SOE for shallow lakes only	Water quality	STAG report 2019
Marginal Habitat								While important there is limited information available to assess this attribute and potentially to set the threshold
Temperature								While important there is limited information available to assess

								this attribute and potentially to set the threshold
pH								Other attributes drive pH variation

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
			Tidal Lagoon	Tidal River			
Sedimentation Rate	Sites are representative of deposition area.						This is important but we are not confident that the variability can be captured by current methods.
Sediment muddiness							This is important but this requires detailed research on how to apply the published thresholds in Robertson et al 2015.
Metals (Toxicity in sediment)	Lowest site takes precedence [wording from Lakes]	mg/Kg Dry Weight of sediment (total recoverable metal) (Arsenic -As, Cadmium - Cd, Chromium - Cr, Copper - Cu, Mercury -Hg, Nickel - Ni,	>ANZECC lower trigger limit.		Mean for up to the last 3 years if available		ANZECC guidelines 2000 / 2018

		Lead - Pb and Zinc - Zn)				
Phytoplankton	Per Site/sampling station	µg/L (micrograms chlorophyll-a litre)	>12 (salinity >30 ppt) >16 (salinity <30 ppt)	Annual 90th percentile	ICC data	Revilla et al. (2010) Will depend on ability to access Invercargill City Council data
Marginal Habitat						No obviously applicable thresholds. No criteria available.
Area of soft mud						This is important but there are no obviously applicable thresholds
Intertidal Coverage of Seagrass cover						Seagrass is a critically important indicator of estuarine health. The experts were unable to confirm how best to address this in the time available but will give it further consideration in the final JWS.
Total Nitrogen in water		Load and / or concentration				The experts were unable to confirm how best to address this in the time available but will give it further consideration in the final JWS.
Total Phosphorus in water		Load and / or concentration				The experts were unable to confirm how best to address this in the time available but will give it further consideration in the final JWS.

Macroalgae cover	Intertidal area	Ecological Quality rating (dimensionless)	<0.4 EQR index score	<0.4 EQR index score)	Annual peak growth measures.	SOE	As per recommendation in Robertson et al. 2016. Opportunistic macroalgae blooming tool.
Sediment oxygen	Individual sites.	mm (depth to apparent Redox Potential Discontinuity) (aRPD))	<10mm depth	<10mm depth	Annual measurement, site mean.	SOE	aRPD based on Based on Coastal and Marine Ecological Classification Standard Marine and Coastal Spatial Data Subcommittee Federal Geographic Data Committee June, 2012
Sediment nutrients	Per site intertidal.	% Total organic carbon (TOC)	1.25% dry weight, where mud >25%		Mean for up to the last 3 years if available	SOE	No criteria available to set thresholds for TN and TP. Info available for TOC. Robertson et al (2015) Robertson et al (2016)
Gross Eutrophic Zone	Over intertidal area	% of intertidal area	Presence 19	Presence	Annual during peak growth.		MfE 2018 Gross eutrophic zones are identified areas where: Mud content >25% Shallow aRPD <1cm High macroalgal growth >50%

Estuary invertebrates	Per site						This is important but there are no obviously applicable indices and thresholds.
Estuary eutrophication risk	Per estuary		D Band, very high risk				The experts were unable to confirm how best to address this in the time available but will give it further consideration in the final JWS.

[19] GEZ are symptoms of seriously degraded systems. They represent the physical expression of problem conditions that are likely to be hard to reverse and may become self-reinforcing due to feedback loops promoting anoxic release of sediment bound nutrients so are ideally characterised early and limited to very small areas.

Outline of remaining work programmes

59 The following work remains to be completed:

(a) Identification of which existing waterbodies are degraded and by which attribute?

(b) To be confirmed by experts

(c)

Other matters

60

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Appendix 1

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