EXPERT CONFERENCE – WATER QUALITY

Topic: Proposed Southland Water and Land Plan – Topic B Tranche 1 – Water Quality

Date of conference: 1 August 2022

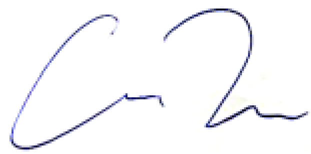
Venue: MS Teams

Facilitator: N/A

Recorder: N/A

Attendees

1 The following witnesses participated in this conference and agreed to the content of this Joint Witness Statement (**JWS**):

Name	Engaged by	Signature
Dr Ton Snelder	Southland Regional Council	
Dr Craig Depree	Dairy Interest Parties[1]	

Environment Court Practice Note

2 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.

1 Fonterra Co-operative Group Ltd and DairyNZ Ltd.

Experts' qualifications and experience

3 The qualifications of the experts are set out in their respective statements of evidence.

Purpose of expert conference

4 The purpose of this conference is for the expert witnesses to answer the questions set out in the Court's Minute dated 21 July 2022.

5 The Court has directed the experts to confer and confirm, making changes as required to Table 1. The Court has also directed the experts to complete Table 2 in the Court's Minute and comment on the Court's understanding recorded at paragraphs [5]-[6] of the Minute.

6 In addition, the Court has directed the expert witnesses to answer the following:

(a) What are the narrative descriptions for bands C and D for the macroalgal and phytoplankton attributes and for bands C/D being the minimum acceptable state (if appropriate)? If one or more of the bands are not relevant to their evidence, the expert witnesses must identify this.

(b) Are the estuaries on which the expert witnesses are not agreed, located in estuarine catchments that both experts identify as needing improvement?

(c) Were Plew's macroalgal or phytoplankton indicators used in relation to the three waterbodies identified at [9] of the Court's Minute or the NPS-FM 2020 Table 1 phytoplankton (tropic state) attribute (or both)?

(d) What concentrations for DIN and DRP did Dr Depree model i.e., did he model the Band D attribute for DRP in Table 20 of the NPS-FM 2020, and was the DIN concentration modelled > 1.0mg/L or something else? Dr Depree to also advise whether segments of waterbodies fell within the banded concentrations for DIN and DRP attributes modelled.

(e) Is it the TP or TN load (or both) that qualified the Toetoes Estuary and catchment for inclusion in Dr Snelder's maps?

Key information sources relied on

7 The experts relied on the following key sources of information:

(a) Plew, D., 2020. Models for evaluating impacts of nutrient and sediment loads to Southland Estuaries. NIWA Client Report, NIWA, Christchurch, New Zealand. NIWA Client report (datacomsphere.com.au)

(b) Plew, D.R., J.R. Zeldis, B.D. Dudley, A.L. Whitehead, L.M. Stevens, B.M. Robertson, and B.P. Robertson, 2020. Assessing the Eutrophic Susceptibility of New Zealand Estuaries. Estuaries and Coasts 43:2015–2033. Assessing the Eutrophic Susceptibility of New Zealand Estuaries (springer.com)

(c) Norton. N., Wilson. K., Rodway. E., Hodson. R. , Roberts. K. , Ward. N. , O'Connell-Milne. S. , DeSilva. N., Greer. M. (2019). Current Environmental State and the "Gap" to Draft Freshwater Objectives for Southland. Publication No 2019-12. 245 p. Current environmental state and the "gap" to draft freshwater objectives for Southland (December 2019).pdf (datacomsphere.com.au)

(d) National Policy Statement for Freshwater Management (NPS-FM 2020). National Policy Statement for Freshwater Management 2020 (environment.govt.nz)

(e) Stevens LM, Forrest BM. 2020. Macroalgal Monitoring of New River Estuary. Salt Ecology Report 054, prepared for Environment Southland, November 2020. 56p. Macroalgal and Seagrass Monitoring of New River Estuary 2019-2020.pdf

(f) Stevens LM, Forrest BM. 2020. Macroalgal Monitoring of New River Estuary. Salt Ecology Report 054, prepared for Environment Southland, November 2020. 56p. Macroalgal and Seagrass Monitoring of New River Estuary 2019-2020.pdf

Changes to Table 1

8 The experts have considered Table 1 Appended to the Court's Minute. Table 1 is correct as it appears in the Minute. Footnote 6 in the Court's minute questions the thresholds for *E. coli* in the Table 1. Our response is that for the G260 statistic, the Band D is defined by >34%. For the

G540 statistic, the Band D is defined by >20% and therefore Table 1 is correct as written.

9 With respect to Table 1 footnote 7 in the Court's minute. Dr Depree confirms that the correct thresholds have been used but emphasises that as fine sediment is a key driver of poor aquatic ecosystem, his riverine mapping[2] based on the macroinvertebrate community index (MCI) incorporates (i.e., integrates) both suspended and deposited fine sediment.[3]

10 Regarding the macroalgae and phytoplankton indicators for estuaries. These indicators are not attributes in the NPS-FM. Therefore, both experts have adopted the definition of minimum acceptable state defined by Plew (2020) and Plew et al. (2020) for the Estuarine Trophic Index (ETI). This is consistent with the Water Quality JWS of October 2019. Plew (2020) and Plew et al. (2020) define macroalgae and phytoplankton biomass thresholds, and descriptions of associated ecological state for ETI bands (i.e., A, B, C and D) that are equivalent to the NOF target attribute states. The ETI minimum acceptable state (i.e., C/D band threshold) is described as the transition from moderately impacted (C band) to heavily impacted ecological communities. This is consistent with trophic state narratives in the NPS-FM (e.g., Table 1 Phytoplankton – trophic state).

11 Notwithstanding the adoption of the same thresholds for the macroalgae and phytoplankton indicators, the experts differ in the methods used to assess each estuary against these thresholds. Dr Snelder used a modelling approach that first estimated TN and TP loads discharged to each estuary and then compared these estimates to maximum allowable loads to achieve the minimum acceptable state that were defined by Plew (2020). This approach has the advantage of comprehensiveness and consistency. That is, Dr Snelder was able to assign a degradation status to all the estuaries and those assignments are done on a consistent basis. In contrast, Dr Depree used and prioritised the available measurements when assigning a degradation status to all the

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[2] Refer to Dr. Depree's statement of evidence dated 20 Dec 2021 (para. 5.1, Figure 4).

[3] Refer to Figure 1 para. 4.4 in Dr. Depree's primary evidence (20 Dec 2021) which shows how macroinvertebrate health metrics (e.g., MCI) integrate multiple environmental stressors, including nutrients and sediments.

estuaries.[4] This approach has the advantage of utilising actual observations and avoids the issue of "over-protection" that is inherent in model-based criteria (see expansion of this point below). Where there was no measured macroalgal or phytoplankton state data, Dr Depree relied on the assessment of Plew (2020).

12 The experts took different approaches to interpreting the estuarine trophic states provided by Plew (2020). The physical properties of estuaries strongly influence susceptibility to macroalgae or phytoplankton blooms. The ETI uses intertidal area to determine whether it is macroalgae or phytoplankton blooms that are most likely to cause eutrophic conditions within estuaries (Plew et al. 2020).[5] Dr Depree incorporated the "determining primary indicator" identified by Dr Plew when considering the trophic status. For example, if an estuary's trophic state is most likely determined by macroalgal blooms (not phytoplankton blooms), and if the assessment indicates that estuary is 'not degraded' based on modelled macroalgal biomass but is 'degraded' based on phytoplankton – then the estuarine trophic state is determined by the relevant determining primary indicator – in this case macroalgae. Dr Depree takes the view that as the estuary is not (or less) susceptible to phytoplankton, it is irrelevant (or, at least, less relevant) in determining the estuaries trophic state. In the example, Dr Depree would conclude the estuary is 'not degraded', whereas Dr Snelder's assessment would conclude the estuary is degraded for phytoplankton (as his assessments were not influenced by the 'determining primary indicator' identified by Plew (2020)).

Completion of Table 2

13 The experts have completed Table 2 Appended to the Courts Minute. The completed table is appended to this JWS. For the avoidance of doubt, Dr Depree has included a brief description of what each of his estuarine assessments were based on (i.e., measured trophic state where available vs modelled trophic susceptibility).

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[4] This approach was consistent with the October 2019 water quality JWS – refer to para.19(d)

[5] Plew D, Zeldis J, Dudley B, Whitehead A, Stevens L, Robertson B. (2020). Assessing the eutrophic susceptibility of New Zealand estuaries. Estuaries and Coasts 43:2015–2033.

Responses to additional questions

14 With respect to question in para 7 of the Court Minute, the narrative descriptions of ecological state associated with bands C and D for the macroalgal and phytoplankton attributes are provided in Plew et al. (2020)[5] for macroalgae (Table 2) and phytoplankton (Table 4). To summarise, band C and band D defines *moderately* and *heavily* impacted ecological communities, respectively. The minimum acceptable state is the transition between moderately impacted and heavily impacted estuarine ecology (i.e., the C/D threshold). For the avoidance of doubt, estuaries that are assessed as D-band are referred to as ‘degraded’ (or ‘in need of improvement’) and estuaries that are A, B or C band were classed as ‘not degraded’. Neither expert used A/B or B/C band thresholds to map/identify ‘degraded’ estuaries.

15 Regarding questions posed in para. 8 of the Court’s minute. The experts do not understand what the court means by “… do not agree on the inclusion of all estuaries identified in Table 2.” For the avoidance of doubt, both experts agree on the inclusion of all 11 estuaries in the Table (note that 3 additional estuaries have been added to Table 2[6]). Disagreements relate to which of the 11 estuaries are identified as ‘degraded’ (i.e., in need of improvement). We note that the Court has made a mistake regarding the comment that “*Dr Depree identifies Jacobs River Estuary, but Dr Snelder does not*”. We assume by ‘identifies’ that the Court is referring to classifying the estuary as being degraded (i.e., in need of improvement). This is incorrect as both Dr Depree (20 Dec 2021, Figure 5) and Dr Snelder (11-Feb 2022, Figure 10) in their evidence identify the Jacobs River Estuary as being degraded based on macroalgal biomass. It has been assumed that the Court has focussed on the TP estuarine map in Dr Snelder’s evidence (11-Feb 2022, Figure 11), which does not show Jacobs River Estuary as degraded (for TP).

16 With respect to the 2nd question in para. 8 of the Court’s minute, disagreements between the experts in the assessments of the individual estuaries at the FMU scale do not result in substantial differences in the overall outcome of the degraded catchment mapping. For example, of the four major developed FMUs, the Mataura catchment is the only one

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[6] Waiau River Estuary, Waimatuku Estuary and Bluff Harbour

where Dr Snelder and Dr Depree disagree on the state of the estuary (Toetoes Estuary). However, the impact of the expert's differences in the designation of estuarine degradation status on any requirement to reduce contaminants is likely to be minimal. This is because, for riverine ecosystem health (based on MCI), Dr Depree identifies 539,780 ha (84%) of the Mataura catchment[7] as degraded and Dr Snelder identifies 100% of the catchment. Because MCI is impacted by multiple stressors, the degraded status for MCI indicates the need to reduce nitrogen, phosphorus and sediment. In addition, the human health maps of Dr Depree and Dr Snelder include 100% of the Mataura Catchment. The requirement to reduce faecal pathogens across 100% of the Mataura Catchment, which both experts agree on, would also reduce phosphorus and sediment (and possibly some nitrogen) – the benefits of which would accrue in the estuary.

17 Both Dr Snelder and Dr Depree evaluated the trophic status of the three water bodies that are defined as coastal lakes or ICOLLs[8] using national bottom line the phytoplankton (tropic state) attribute (Table 1) of the NPS-FM 2020[9].

18 With respect to the Courts question regarding the DIN and DRP threshold concentrations used in the mapping/modelling shown in Table 3 of Dr Depree's evidence dated 20-Dec. Dr Depree confirms that the DIN and DRP thresholds used to define catchment areas in need of improvement were the same as those specified in November 2019 JWS Nov 2019 (Table 1 p. 52) which specified different degradation thresholds for upland and lowland classified rivers. For DRP, the degradation thresholds used for upland rivers and lowland rivers were based on the B/C band and C/D band numeric attributes states (Table 20, NPS-FM 2020), respectively. For the avoidance of doubt, lowland and upland rivers in need of improvement were those with median DRP (modelled) concentrations >0.018 mg/L and >0.010 mg/L, respectively. With respect to DIN, lowland and upland rivers in need of improvement were those with median DIN concentrations (modelled) >1.0 mg/L and 0.5 mg/L, respectively. Note that the areas requiring improvement shown

[7] Refer to Cr Depree's statement of evidence (20-Dec 2021) para. 5.11, Figure 5 and Table 5

[8] Intermittently closed and open lakes and lagoons

[9] Table 1 (phytoplankton-trophic state) in the NPS-FM included median and maximum thresholds of phytoplankton concentrations (measured as mg/m3 of chlorophyll a). The ETI models maximum concentrations.

in Table 3 of Dr Depree's evidence dated 20-Dec 2021 include those river reaches that exceed the above DIN and DRP concentrations (i.e. 'local' exceedance), and all upstream contributed area (i.e., 'propagated' exceedance) that contribute to the downstream 'local' exceedances. The concept of 'local' and 'propagated' areas requiring improvement is illustrated in para. 4.21, Figure 4 of Dr Depree's evidence dated 20-Dec 2021.

19 The experts have responded to the Court's question regarding their respective assessment of Toetoes Estuary in detail in the following paragraphs. The expert's intention is to clarify the different approaches taken by the experts, and importantly, how these approaches result in different assessment outcomes for Toetoes Estuary (and others included in Table 2).

20 Only TN (macroalgal) exceeded the maximum allowable load for Toetoes Estuary in Dr Snelder's analysis. Note that the maximum allowable load was based on the potential TN concentration for meeting the minimum acceptable state for macroalgal biomass. This means that the catchment of Toetoes Estuary (the Mataura River catchment) is assessed as degraded for TN (see Figure 10, Evidence of Dr Snelder 11 February 2022) but is assessed as not degraded for TP (see Figure 11, Evidence of Dr Snelder 11 February 2022).

21 Dr Depree's assessment of estuaries is based on prioritising the use of monitoring data for individual estuaries when it is available. In addition, Dr Depree has prioritised the *determining primary indicator* for eutrophication as defined by Plew (2020). For Toetoes estuary, the determining primary indicator is macroalgal biomass. The minimum acceptable state for macroalgal biomass (measured as an ecological quality rating, EQR) is defined as 0.4 (boundary between moderately and strongly impacted ecological communities). Through empirical relationships, Plew et al. (2020) derived a potential TN concentration value of 0.32 mg/L.[10] What this means is that for unmonitored estuaries without measured macroalgal EQR scores, it is possible to estimate an macroalgal EQR score (i.e., a modelled macroalgal susceptibility, as opposed to measured EQR state). The relevance of using the TN threshold (concentrations or loads) as a proxy for macroalgal biomass is

[10] The 95% confidence interval on the C/D threshold for TN is 0.27 to 0.41 mg/L

highly dependent on the type of estuary. Dr Depree believes that the relationship between TN and macroalgal EQR was developed for tidal lagoon estuaries (i.e., New River and Jacobs River), and is not applicable to tidal river estuaries like Toetoes which are markedly less susceptible to eutrophication than tidal lagoon estuaries. Dr Depree considers that this is the reason that the modelled macroalgal EQR susceptibility score is zero, compared to measured EQR state of >0.4 in both 2016 and 2019.[11] Dr Depree also notes that the latest macroalgal EQR state for Toetoes Estuary is 0.58 (almost a B-band). The ETI predicts nutrient susceptibility, whereas monitoring data provides an assessment of actual state. Plew et al. (2020) acknowledge the relationship between state and susceptibility can vary , stating "*the method attempts to predict the eutrophic state of estuaries; however, the predicted state or susceptibility may not match observed state for several reasons*". Dr Depree believes that where measured estuarine state data is available, then this is more robust than an estimated eutrophic susceptibility – particularly for tidal river estuaries like Toetoes that do not conform to the relationships (model) developed for more susceptible tidal lagoon estuaries.

22 Dr Depree considers that the NPS-FM (2020)[12] directs councils to use the best information available, which prioritises the use of complete and scientifically robust (measured) information over modelled data. Clause 1.6(2) states that in the absence of these data, then best information may include "information obtained from modelling". Importantly, clause 1.6(2) directs councils to prefer sources of information that "provide the greatest level of certainty" and to take all practicable steps to reduce uncertainty. Dr Depree considers that the comprehensive macroalgal and broadscale monitoring programme carried out by Environment Southland[13] is an example of 'scientifically robust data'. Dr Depree's view is that prioritising measured algal state over modelled algal

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[11] Norton et al. (2019) - Current environmental state and the "gap" to draft freshwater objectives for Southland (December 2019).pdf (datacomsphere.com.au) refer to Section 8.2, Table 77.

[12] Clause 1.6 – 'Best information', NPS-FM (2020) states it is a requirement to use, if practicable, complete and scientifically robust data. In the absence of scientifically robust data, "the best information may include information obtained from modelling, as well as partial data, local knowledge, and information obtained from other source..".

[13] Environment Southland currently have 76 reports from several estuaries assessed between 2004 and 2020 as part of their ongoing estuarine monitoring programme (refer to Estuaries - Environment Southland)

susceptibility to assess whether an estuary meets a minimum acceptable state is consistent with the intent of clause 1.6 of the NPS-FM (2020).

23 Dr Snelder's assessment of estuaries is based on analysis of all available data using models This approach uses the available observations to construct a model and then uses that model consistently. Dr Snelder considers that advantages of this approach are comprehensiveness, consistency and the ability to make assessments in situations in which there is limited or no data. Dr Snelder also points out that all monitoring data is a sample of the environmental state and is therefore an estimate of the true state. Estuarine sampling is limited in place and time and therefore Dr Snelder is cautious about privileging a limited number of observations made in one estuary.

24 The consequence of the modelling approach taken by Dr Snelder is that conclusions derived from the model will often differ from conclusions drawn by considering sites in isolation. The best way to understand this is to consider the use of a model to derive nutrient criteria depicted in Figure 1. Figure 1 is a schematic representation of observations at sites (black points) for which measurements were made of a nutrient shown on the x-axis and the biomass response shown on the y-axis. Note that the data in Figure 1 are made up for illustration purposes.

25 In Figure 1, the model is indicated by the blue line. This model can be regarded as statistical line of "best fit" (a regression line). Because the line of best fit goes through the middle of the available data, some sites (i.e., black points) are above the blue line, and some are below.

26 A criterion is derived from this model by nominating a biomass threshold. In Figure 1 a nominated biomass threshold of 60 mg m^{-3} is indicated by the red arrow. The criterion is derived from the model as the point on the x-axis that is consistent with the biomass threshold (i.e., the nutrient concentration of 534 mg m^{-3}), which is indicated by the green arrow.

27 There is always uncertainty in the criteria, which is indicated in Figure 1 by the scatter of observations around the regression line. This uncertainty leads to two types of risk associated with any criteria. First, there is a risk that the biomass threshold at some sites will be exceeded even if the stressor is held at or below the derived criterion. This risk is called "under-protection risk" and is indicated in Figure 1 by points that

lie above the regression line. Second, there is a risk that at some sites the biomass threshold can be achieved at higher (more lenient) levels of nutrient than indicated by the criterion. This risk is called "over-protection risk" and is indicated in Figure 1 by points that lie below the regression line. It is noted that if the line of best fit goes through the middle of the available data, we are "even-handed" about these two types of risk. That is, a site drawn at random has the same level of risk that it is over- or under-protected by the criteria.

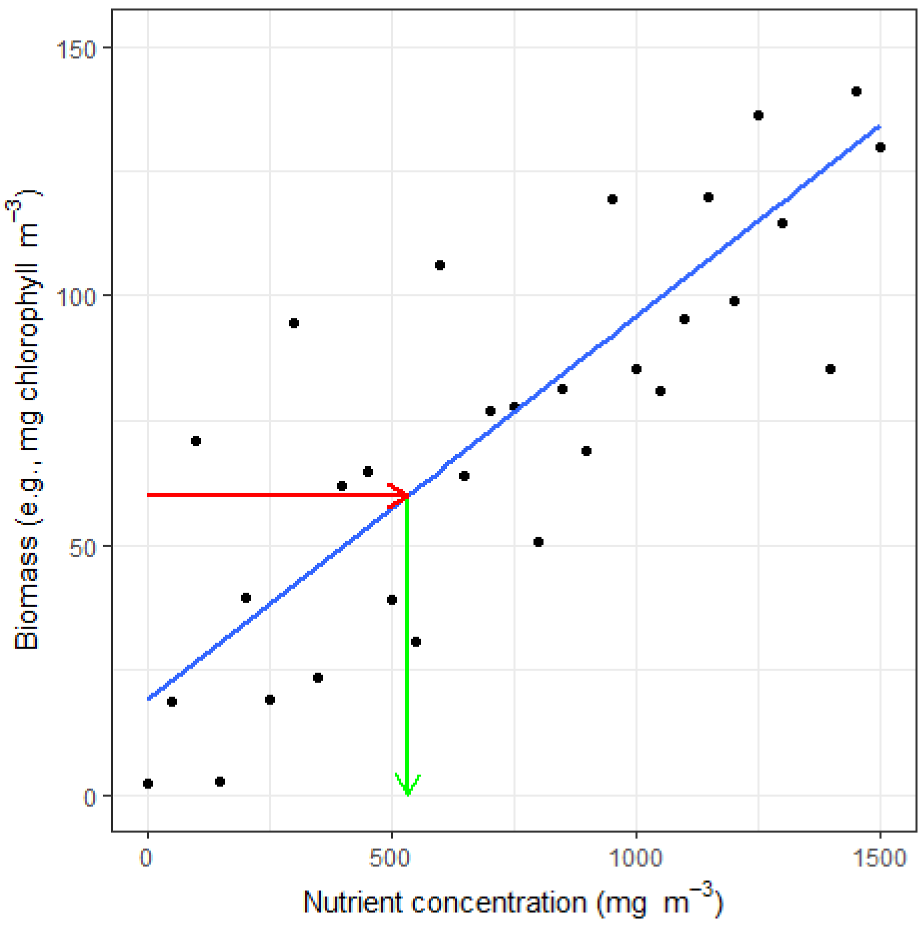


Figure 1. Schematic representation of derivation of criteria based on a stressor-response model. This figure is based on MFE (2022)[14]

28 It is important to emphasise that these two types of risk are always associated with environmental, and other, criteria. In addition, the probability that any site is perfectly represented by the model (i.e., lies perfectly on the blue regression line in Figure 1) is low. Therefore, Dr Snelder's view is that when making broad-scale assessments (i.e., over

[14] MFE, 2022. Guidance on Look-up Tables for Setting Nutrient Targets for Periphyton: Second Edition. Ministry for the Environment., Wellington, New Zealand.

many sites, such as in the identification of degraded catchments in Southland) it is problematic to choose to prioritise observations for some sites and modelled criteria for other sites. To do so introduces subjectivity and means that the assessment is not being even-handed with respect to the two types of risk described above.

29 Dr Snelder performed his assessment using criteria derived from the model of Plew (2020). The details of that model differ slightly from Figure 1 in that the nutrient criteria were expressed as mean annual loads of TN and TP discharged to the estuary. Dr Snelder determined if each estuary was degraded by estimating the current load of TN and TP discharged to the estuary using another regional nutrient load model. Then he compared those estimated current loads to the criteria to achieve the C/D band for macroalgae and phytoplankton derived by Plew (2020). If the estimated current loads exceeded these criteria, the estuary status was designated as degraded.

30 Dr Snelder is unwilling to accept the assessment of Dr Depree because of the subjectivity associated with the choosing to prioritise the individual observations for the Toetoes estuary over the assessment produced with his modelling approach. However, Dr Snelder does concede that Toetoes estuary is poorly represented by the model of Plew (2022) (i.e., the data point pertaining to Toetoes estuary would lie far from the regression line were it represented on Figure 1). Dr Snelder is not an expert in estuary modelling, and simply used the results of Plew (2020) to map degradation status of catchments. He is therefore unwilling to suggest that the poor representation of Toetoes estuary in the model of Pew (2020) is grounds for choosing to prioritise the observations over the assessment produced with the model.

Areas Resolved

31 As per the previous joint witness statement, the purpose of conferencing has been to provide additional clarification to the Court around the methods used by the experts for mapping degraded catchments. Except for Toetoes Estuary, the experts have not been directed to resolve their differences – but rather to explain / clarify them for the understanding of the court. As explained, the differences result from differences in approach regarding the use of measured state data vs modelled susceptibility, and the recognition of *determining primary indicators* identified by Plew (2020) for Southland estuaries (i.e., whether the

eutrophic susceptibility is most likely due to macroalgal or phytoplankton blooms).

Areas Not Resolved

32 As discussed, there are two main factors accounting for the differences in the conclusions drawn by Dr Depree and Dr Snelder – these are:

(a) Dr Depree believes there are considerable advantages in using multi-year estuarine monitoring data that provides measured trophic state for several estuaries. The strength of the ETI is that it enables resource managers to estimate the potential susceptibility of estuaries that have no monitoring data. Dr Depree believes that using a mixture of measured trophic state (or monitored estuaries) and modelled susceptibility (of unmonitored estuaries) is more robust than relying on modelled susceptibilities for all estuaries. Moreover, he believes this approach is more consistent with the intent of clause 1.6 of the NPS-FM (2020) that prioritise the use of scientifically robust data that provides the greatest level of certainty.

(b) In contrast, Dr Snelder believes that the model-based assessment has the benefit of comprehensiveness, consistency and the ability to make assessments in situations in which there is limited or no data. Dr Snelder does concede that Toetoes estuary is poorly represented by the model of Plew (2022). However, he is unwilling to make subjective decisions to prioritise the individual observations for one estuary over the assessment produced using the model.

Table 2

	Dr T Snelder			**Dr C Depree**[15]		
Estuary	**Macroalgal biomass**	**Phytoplankton biomass**		**Macroalgal biomass**	Phytoplankton biomass	"Determining primary indicator" for estuarine eutrophication (Plew 2020)[16]
	Estuarine trophic status based on TN load[17]	**Estuarine trophic status based on TN load**[17]	**Estuarine trophic status based on TP load**[17]	**estuarine trophic state based on measured EQR or TN concentration**	**Estuarine trophic state based on measured (LAWA) or modelled (Plew 2020) phytoplankton concentrations**	

[15] Dr Depree emphasizes that algal biomass (and nutrient thresholds related to minimum acceptable states of biomass) are used as a proxy for estuarine 'ecosystem health'. In addition to nutrients (and eutrophication), southland estuaries are also impacted by fine sediment (which are an important aspect of the overall estuarine trophic indicator, ETI score). As such, estuaries that are below a minimum acceptable state for algal biomass (micro or macro), then the entire catchment is identified for reducing nutrients and sediment contaminants – not just the nutrient that is considered most responsible for the algal biomass exceedance. In other words, exceedance of macroalgal biomass threshold (i.e. <0.4 EQR score) is not interpreted as the estuary being over-allocated in just nitrogen, but rather the ecosystem health of the estuary needs improvement via reductions in all key contaminants (i.e., N, P and sediment).

[16] Plew D. (2020). Models for evaluating impacts of nutrient and sediment loads to Southland Estuaries. To inform the Southland Regional Forum process. NIWA Client Report 2020216CH prepared for Environment Southland. 57 p. NIWA Client report (datacomsphere.com.au)

[17] Trophic status is defined as 'not degraded' where current state nutrient load is less than threshold nutrient loads that corresponds to the minimum acceptable state for macroalgal biomass or phytoplankton biomass. Conversely, when the current state load is less than the threshold load (for TN or TP), then the estuarine state is consider 'not degraded'. This assessment does not consider the 'determining primary indicator' (i.e. whether the estuary is most susceptible to eutrophication by macroalgae or phytoplankton blooms).

					phytoplankton concentrations[18,]	
Waikawa Harbour	Not degraded	Degraded	Degraded	Not degraded (based on measured macroalgal EQR score >0.4)[19]	NA (estuary susceptible to macroalgae)	macroalgae
Haldane Estuary	Not degraded	Not degraded	Degraded	Not degraded (based on measured macroalgal EQR score >0.4)[20]	NA (estuary susceptible to macroalgae)	macroalgae
Lake Brunton (closed)	Degraded	Degraded	Not degraded	NA (estuary susceptible to phytoplankton)	Not degraded (based on modelled phytoplankton susceptibility <60 ug/L)[21]	phytoplankton
Lake Brunton (open)	Not assessed	Not assessed	Not assessed	Degraded (based on modelled macroalgal EQR susceptibility <0.4)[22]	NA (estuary susceptible to macroalgae)	macroalgae

[18] Note Dr Depree's phytoplankton assessments were only applied to those estuaries identified phytoplankton as the "determining primary indicator. Refer to Table 3-2 (p. 30) in Plew (2020)[16]. Estuaries where phytoplankton was the 'determining primary indicator' were low salinity coastal lakes where the minimum acceptable state for phytoplankton was the national bottom-line (Table 1, NPS-FM) for the annual maximum (i.e. 60 mg/m^3 of chla)

[19] Assessed as degraded by Dr Depree (Rebuttal evidence 22nd Feb 2022, para. 7.8, Figure 3) based on potential TN concentration for this estuary being 0.332 mg/L, which only just exceeded the threshold TN value of 0.32 mg/L. However, during preparation for expert conferencing, Dr Depree noted that the Environment Southland "gap analysis report" (Norton et al 2019) A-band (2010) and B-band (2016) shows that this estuary (where the determining primary indicator is macroalgae) the measured macroalgal EQR scores were A-band and B-band, respectively, in 2010 and 2016 (Norton et al. 2019) – refer to Table 77 (Appendix 1)

[20] Measured ecological quality rating (EQR) = A-band: (2010 and 2016 monitored data reported by ES, Norton et al. 2019) – refer to Table 77 (Appendix 1)

[21] Plew (2020) modelled phytoplankton susceptibility = 49 ug/L of chla (B-band; Table 1 NPS-FM).

[22] Plew (2020) modelled macroalgal EQR score = 0 (D-band)

Toetoes (Fortrose) Estuary	Degraded	Not degraded	Not degraded	Not degraded (based on measured macroalgal EQR score >0.4)[23]	NA (estuary susceptible to macroalgae)	macroalgae
Waituna Lagoon	Not degraded	Degraded	Not degraded	NA (estuary susceptible to phytoplankton)	Degraded (based on measured phytoplankton and TN)[24]	phytoplankton
Bluff Harbour	Not degraded	Not degraded	Not degraded	Not degraded (based on modelled EQR susceptibility value >0.4)[25]	NA (estuary susceptible to macroalgae)	macroalgae
New River (Oreti) Estuary	Degraded	Degraded	Degraded	Degraded (based on measured EQR scores <0.4 in 2016 and 2019)[26]	NA (estuary susceptible to macroalgae)	macroalgae
Waimatuku Estuary	Not degraded	Not degraded	Not degraded	Not degraded (based on modelled EQR susceptibility >0.4)[27]	NA (estuary susceptible to macroalgae)	macroalgae
Jacobs River Estuary	Degraded	Not degraded	Not degraded	Degraded (based on measured EQR scores <0.4 in 2016 and 2019)	NA (estuary susceptible to macroalgae)	macroalgae

[23] Meased ecological quality rating (EQR) = C-band (>0.4) for 2016 and 2019 reported by ES)[11] – refer to Table 77 (Appendix 1). Note that the latest 2020 monitoring of Toetoes Estuary showed an EQR score of 0.58 (well over the minimum acceptable state). Refer to Fortrose (Toetoes) Estuary 2019_2020 Macroalgal Mapping.pdf

[24] Four measured sites (LAWA) – one site exceeded 60 ug/L chla (NBL for phytoplankton annual maximum – Table 1 NPS-FM, and one site is exceeding the TN national bottom line of 0.75 mg/L, Table 3, NPS-FM). Plew (2020) modelled phytoplankton susceptibility was >60 ug/L (chla)

[25] Plew (2020) - modelled macroalgal EQR score = 0.8

[26] The 2020 measured macroalgal EQR score for the New River Estuary was 0.48 (C-band) (Macroalgal and Seagrass Monitoring of New River Estuary 2019-2020.pdf)

[27] Plew (2020) - modelled macroalgal EQR score = 0.89 – high potential TN concentration, but macroalgal growth limited by low salinity

Waiau River	Not degraded	Not degraded	Not degraded	NA (estuary susceptible to phytoplankton)	Not degraded (based on modelled phytoplankton susceptibility)[28]	phytoplankton
Te Waewae Lagoon	Not degraded	Degraded	Degraded	NA (estuary susceptible to phytoplankton)	Not degraded (based on measured phytoplankton)[29]	phytoplankton

[28] Phytoplankton growth limited by the rapid flushing time of the estuary (i.e., no time for nutrients to be taken up by phytoplankton) – modelled susceptibility = A band

[29] Three measured sites in the lagoon (LAWA website) – B band for phytoplankton (Table 1, NPS-FM); Plew (2020) modelled phytoplankton susceptibility C-band

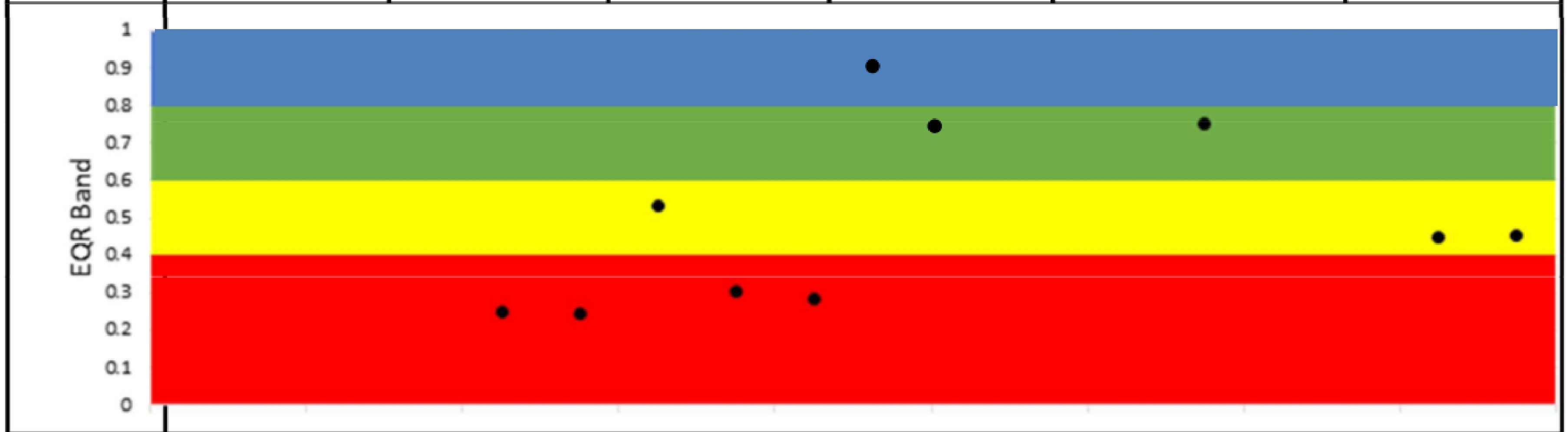
Appendix

Measured macroalgal trophic state (EQR band) for selected Southland monitored estuaries

8.2 Estuary results tables

Table 77: Macroalgae state (as measured by the EQR index) for monitored estuaries within each estuary class.

FMU	Fiordland and Islands	Aparima	Oreti	Mataura		
Class	SIDE	SIDE	SIDE	SIDE	SIDE	SSRTRE
Estuary	Freshwater Estuary	Jacobs River Estuary	New River Estuary	Waikawa Estuary	Haldane Estuary	Fortrose Estuary
Objective state	NA	NA	NA	NA	NA	NA



Baseline year	2010	2016	2019	2010	2016	2019	2010	2016	2019	2010	2016	2019	2010	2016	2019	2010	2016	2019
	ND	ND	ND	ND	D	D	C	D	D	A	B	ND	A	A	ND	A	C	C