# Nutrient sub-group summary

# Attribute tables

This paper presents ecosystem health attribute tables for nitrogen and phosphorus that have been developed by Adam Canning based on input from STAG and the STAG nutrient sub-group. They have been created so:

- Total nutrients are used, not dissolved;
- Ecosystem processes are included;
- Groups are weighted equally (or minimum for option 3).
- Option 3 protects for the most stringent group in each band. This is provided given as this theme has arisen a few times in STAG and we were asked how we could build in precaution.
- Bands have been harmonised with the attribute tables proposed for ASPM and IBI and existing chlorophyll a attribute (in STAG meeting papers for 16 April). We can re-calibrate the numbers if STAG changes the tables.

In each table there are three columns, each presenting a different option:

- 1. Average all groups equally, including percentile analysis.
- 2. Average all groups equally, excluding percentile analysis (as not correlated with ecosystem health metrics).
- 3. Protect for the most stringent group, excluding percentile analysis (as not correlated with ecosystem health metrics).

## Lines of evidence

- Percentile analysis: 75<sup>th</sup>, 50<sup>th</sup> and 25<sup>th</sup> percentiles of all river reaches.
- Periphyton:
  - Matheson (2016) quantile regressions. Converted DIN to TN using LAWA relationship.
  - Ton Snelder's look-up table condensed into an average for each band, weighted by river length in each class.
  - Biggs (2000) equations. Converted dissolved to totals using LAWA relationship.
- Macroinvertebrates:
  - Used national dataset 5-year averages (2012-16). Used MCI, %EPT abundance and EPT richness as these are the components of ASPM.
- Fish:
  - Used quantile regression of fish IBI data from NZFFD.
- Ecosystem processes:
  - Used dataset of GPP, ER and cotton from Joanne Clapcott. No significant relationships between GP, ER and nutrients so excluded. Cotton was included for nitrogen only (no relationship with TP) and bands were created using percentiles.

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	Value	Ecosystem healt	h			
	Freshwater Body Type	Rivers and groun	ndwater			
	Attribute	Total Nitrogen (Ecosystem Health)				
	Attribute Unit	Milligrams of Total Nitrogen per litre				
	Attribute State	Numeric Attribute State         Narrative Attribute State				
		Annual median <sup>1</sup>			Description	
		Option 1	Option 2	Option 3	C	
	A	≤ 0.25	≤ 0.26	≤ 0.07	Minimal nitrogen enrichment.	
	В	> 0.25 and ≤0.51	$> 0.26$ and $\le 0.54$	$> 0.07$ and $\le 0.47$	Mild-moderate nitrogen enrichment	
	С	> 0.51 and ≤ 1.09	$> 0.54$ and $\le 1.23$	$> 0.47$ and $\le 0.78$	Moderate-substantial nitrogen enrichment	
	National Bottom Line	1.09	1.23	0.78		
- F						
ľ	<b>D</b>	>1.09 . Based on mon	>1.23 thly monitoring.	>0.78	Severe nitrogen enrichment	
	D 1	>1.09 . Based on mon	>1.23 thly monitoring.	-0.78	Severe nitrogen enrichment	

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Value	Ecosystem health						
Freshwater Body	Rivers and groundwater						
Туре							
Attribute	Total Phosphorus (Ecosystem Health)						
Attribute Unit	Milligrams of Total Phosphorus per litre						
Attribute State	Numeric Attrib	ute State	Narrative Attribute State				
	Annual median <sup>1</sup>			Description			
	Option 1	Option 2	Option 3	0			
Α	≤ 0.012	≤ 0.012	≤ 0.006	Minimal phosphorus enrichment.			
В	> 0.012 and ≤0.026	> 0.012 and ≤0.027	> 0.006 and ≤0.025	Mild-moderate phosphorus enrichment			
С	$> 0.026 \text{ and} \le 0.041$	$> 0.027 \text{ and} \le 0.041$	$> 0.025 \text{ and } \le 0.037$	Moderate-substantial phosphorus enrichment			
National Bottom Line	0.041	0.045	0.037				
D	>0.041	>0.045	-0.037	Severe phosphorus enrichment			

0.045 20.041 20.045 1. Based on monthly monitoring.

## Meeting notes

This document also summarises the following meetings and discussions:

- On 21 March 2019, officials held a teleconference with a sub-group of STAG members to discuss a detailed scope of work to investigate the above questions.
- There was a STAG meeting on 27 March where the nutrient work was discussed and several actions were suggested.
- On 5 April, STAG members who had volunteered to conduct the nutrient work met to discuss early results of the analysis.

# Notes from nutrient sub-group meeting, 5 April 2019

Sub-group members: Adam Canning, Mike Joy, Marc Schallenberg MfE staff: Jen Price, Ton Snelder, Isaac Bain

Agenda:

- 1. Brief summary of analysis being done are we adequately covering STAG's agreed questions from the February meeting, how to stage any further work if required:
  - 1. How to weight evidence
  - 2. How and where to set bands in relation to ecological responses
  - 3. Whether attribute tables should vary spatially
  - 4. Whether TN and TP attributes for ecosystem health are more appropriate than nitrate and DRP (as per Marc's suggestion by email after the meeting)
- 2. Update on ecosystem metabolism data (Adam)
- 3. Adam's suggestion of predicting improvement in MCI based on changes in N, for impact analysis
- 4. Harmonising between attributes and how we do this when other attributes are not yet developed
- 5. Presenting to STAG on 16 April

Key points discussed:

- Based on scoping discussions with STAG and sub-groups, MfE has asked Ton to conduct a
  data analysis to inform the STAG discussion. Ton briefly outlined his methods and results. It
  was noted that Ton's analysis goes slightly further than the questions posed by STAG and
  also provides aspects of an impact analysis which is required for the policy process.
- The main areas where nutrient ecosystem health attributes would contribute to managing river ecosystem health would be in soft-bottomed rivers. It could also be helpful for highly disturbed streams where periphyton biomass rarely accrues to high levels. Both of these, and potentially other types of rivers, may be falling through the cracks.
- Attributes provide a specific mechanism for stressors to be allocated in a catchment. Managing N on its own will not be sufficient to improve ecosystem health overall.
- Collectively, attributes can go a long way towards providing for ecosystem health.
- MCI is just one of the components of ecosystem health. The suggested approach to calibrate nutrient concentrations to ecosystem impacts incorporates many ecosystem components, across multiple trophic levels.
- There is a desire to harmonise ecosystem health attributes so that bottom lines have a consistent meaning. Concerns were raised about not having enough time at the STAG meeting to discuss ecosystem health attributes in order to ensure that any N and P attribute tables would be harmonised. The sub-group is therefore recommending that nutrient ecosystem health attributes should take into account other proposed Ecosystem Health metrics but should not be delayed while other metrics are finalised.

- Weighting of multiple lines of evidence was discussed and the group concluded that weighting lines of evidence equally is the best approach because the thresholds used in the multiple lines of evidence approach come from different sources and constitute different types of relationships. Where possible, relationships will be derived using different methods (e.g. linear regression, quantile regression). Using a formal weighting process using predefined criteria is another option, but the subgroup couldn't come up with a defensible way to do this.
- The merits of using TN and TP in attribute tables were discussed. It was agreed that using TN and TP would make the limit setting process more straightforward as it would remove the need for councils to use one metric for lakes and another for rivers, and Overseer uses TN. A drawback would be in rivers with high sediment loads, as there will be a lot of sediment bound phosphorus that is not bioavailable. Also, allowing regional councils to convert from DIN to TN for nutrient accounting purposes (and thus for limit setting) could allow for arbitrary decisions to be made concerning conversion factors to use. This might not be in the best interests of ecosystem health management.
- In Agenda Item 3, Adam suggested that it would be informative to use relationships to predict improvement in ecosystem health metrics based on changes in N. This analysis could be incorporated into the impact analysis for the policy proposal. This option was discussed and the group decided not to progress it.
- The group considers that it's more critical at this stage to focus on attribute bottom lines. Lake bottom lines were aligned with ecological tipping points/regime shifts. However, this is not the case for all attributes in the NOF.
- Concerns were raised that the that Tons and Russell's analyses of N vs MCI are inconsistent because of the different datasets. The LAWA dataset has many issues including different invertebrate sampling protocols and issues with lab analyses of nutrients. Russell's data is not as broad spatially but the consistency of data collection and sample processing is much more robust. Ton will compare regional council and non-regional council data to address questions of data reliability.
- The group discussed whether it would be useful to repeat Ton's analysis on the fish IBI data that Adam and Mike provided. It was recommended that if this analysis was to proceed, a quantile regression approach would be best because fish IBI responds to multiple stressors. However, for quantile regression to be informative there needs to be a lot of data points so only climate (or FENZ) classes that have a lot of data should be used.

#### Next steps:

- The sub-group would like to ask STAG about the best approach for harmonising attributes.
- The sub-group would like to draft an agreed statement.
- Adam will put together attribute tables for STAG to consider.
- MfE is reviewing international nutrient objectives.

# Actions from STAG meeting, 27 March

Actions:	For:
Investigation of spatial variation in relation to where "unders and overs"	Nutrient sub-
might occur in relation to other existing nutrient attributes and MCI scores	group
Provide a worked example of a catchment to show how the different	Nutrient sub-
attributes relating to nutrients would fit together.	group
Provide advice on how uncertainty is taken into account in NOF attributes: 1.	MfE, STAG
In the face of uncertainty how much of a margin are we giving to the	
environment, and 2. How confident are we that the number will provide the	
intended level of protection (may be qualitative).	
Develop principles on uncertainty for attributes	STAG

Communicate uncertainty in attribute tables (may be qualitative).
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## Notes from nutrient sub-group meeting, 21 March 2019

Attendees: Adam Canning, Clive Howard-Williams, Ian Hawes, Jenny Webster-Brown, Joanne Clapcott, Ken Taylor, Mike Joy

MfE officials: Jen Price, Jo Burton, Nik Andic, Isaac Bain, Ton Snelder

Apologies: Marc Schallenberg, Jon Roygard, Tanira Kingi, Ra Smith, Russell Death (attempted to join meeting but was unable to due to technical issues)

#### Question 1

-There was discussion around the questions: What was the rationale behind the multipliers in Russell's work? How are direct and indirect linkages defined and weighted?

-There are two steps to weighting - the first is to agree whether the components should be weighted equally. -The next step is to consider how individual components are incorporated into the attribute, this depends on -the nature and spread of the data.

-Other variables that could be used include regional and national datasets on organic matter processing (measured using cotton strip decomposition), gross primary productivity and productivity/respiration.

<u>Key points</u>: the group prefers equal weighting of each ecosystem component. The sub-group will source additional data and assess its suitability to include in the analysis.

#### Meeting notes:

#### Questions 2 and 3

-There are two approaches - one would be to set bottom lines consistent with known effects thresholds (e.g. a particular MCI score) and one would be to estimate reference condition and calculate the deviation from that.

-For example the sediment attribute development work used deviation from reference state. -The difficulty with this approach is that there are not reference sites available for all river classes, and modelling is used to estimate reference condition in many cases. This is based on a regression and the error around the reference state estimate can be calculated.

-It was suggested that the attribute tables being developed as part of this work could be used in a similar way to the "trigger values" under the former ANZECC guidelines, to indicate where further investigation is required. This view was not shared by all participants, some were of the view that this attribute should have the same requirements as the other existing Appendix 2 attributes where there is a requirement to set objectives above the bottom line.

-The REC captures land use variability as well as climate and source of flow, because areas of intensive agriculture, for example, are highly correlated with certain environment types.

-Some participants were of the view that separating analyses by REC classes would introduce bias because of the tendency for certain REC classes to be impacted by land use to a greater degree than others.

-There was a suggestion that instead of REC classes, a division between east, west, north and south could be trialled. It was pointed out that there would be greater uncertainties in such a classification, compared to using REC classes.

-Ton has done an initial investigation comparing MCI scores with nitrate in different REC classes. Some classes have been aggregated so that there is enough data for analysis. In some REC classes the relationship between the two variables is less strong. It was pointed out that this may have been due to the limited data available in those classes and hence the full spectrum of land use intensity is not represented.

-Communicating the uncertainty in this work is very important. One group member expressed

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concern about the levels of uncertainty involved in this work. -Using multiple lines of evidence is a way of ensuring robust outcomes.

# Initial email invite and notes contained within

-----Original Appointment-----From: Jennifer Price Sent: Thursday, 14 March 2019 11:15 AM To: (STAG members and MfE officials) Subject: Teleconference to plan further work on proposed nutrient attributes When: Thursday, 21 March 2019 1:00 PM-2:30 PM (UTC+12:00) Auckland, Wellington. Where: Meeting room 2A, or by Skype (meeting link in text below)

Kia ora koutou,

Arohamai, I know this time will not suit everyone but it was the most popular choice. Hopefully we can get this done within an hour.

The aim of this teleconference will be to <u>put a plan into place</u> to address the following questions in relation to Russell Death's proposed nutrient attribute tables:

- 1. How to weight evidence
- 2. How and where to set bands in relation to ecological responses
- 3. Whether attribute tables should vary spatially
- 4. Whether TN and TP attributes for ecosystem health are appropriate (as per Marc's suggestion by email)

In relation to the questions above it might be helpful to think of the following:

- 1. What approach do we need to use to answer this question?
- 2. Who can do the work?
- 3. What resources or data do we need?

Please get back to me if you have any comments/questions, or if you can't make it but would like to contribute.

Ngā mihi

Jen

From: Jennifer Price
Sent: Thursday, 21 March 2019 10:38 AM
To: (STAG members and MfE officials)
Subject: Teleconference 1pm today: starter for discussions and Skype instructions
Importance: High

Hi all,

For this afternoon's teleconference, we will be discussing Option 2 from the Minutes of the last meeting ie: "Incorporate Russell Death's nitrate and DRP attributes into NPS-FM, with further work to answer outstanding questions"

Please refer to the list of questions below. I have collated STAG's comments from the email discussions under each question.

It would be great if we could use these as a starting point to narrow down the scope.

My understanding from the STAG discussion is that the group agreed that the periphyton attribute, its note and supporting guidance should remain. Attribute tables in guidance under the NOF Periphyton Note is a separate exercise (and a separate scope of work).

Please find attached instructions for Skyping in – the link is in the Outlook invite and also below. If

you've not used Skype for Business before you may need to install a plugin, which can take a few minutes.

Thanks very much, Jen

## Questions

## 1. How to weight evidence

-Compare RD's approach to that used in sediment attribute development work -Approach needs to be defensible and transparent

- The analogy of the TLI in lakes is that variables that are correlated, and all linked to eutrophication, are weighted equally – but can be interpreted separately. I would favour one periphyton relationship, one invertebrate and one fish and would have to be convinced that they should be weighted differently.

- Not all metrics lend themselves well to being weighted by strength of correlation, so a broader interpretation should apply. Though for clarity, the original weighting we based the analysis on does include strength. Below is a quote from the methods section of Smith & Tran (2010): *"We combined the results of each line of evidence in a weighted mean to define final nutrient criteria. Weights were assigned on the basis of strength and significance of the analysis, confidence in the data, and best professional judgment (BPJ). The multiple lines of evidence used were percentiles, metrics that yielded significant changepoints, and cluster analyses. Results from metrics established specifically for or directly related to nutrients in the water were weighted more heavily than those associated with general pollution or, in the case of the percentile analysis, had no connection with biological responses. To reduce the subjectivity of applying weights to individual results and to provide a more reproducible* 

method, analyses were placed on a scale of increasing connection with biological response to nutrients. The scale ranged from 1 to 2. Analyses with no connection to biological assemblages (percentiles) received a weight of 1, analyses that provided an indirect evaluation of response to nutrients (BCA) received a weight of 1.5, and analyses of direct or

threshold responses to gradients (nCPA) received a weight of 2."

Smith, A. J., & Tran, C. P. (2010). A weight-of-evidence approach to define nutrient criteria protective of aquatic life in large rivers. *Journal of the North American Benthological Society*, 29(3), 875-891.

## 2. How and where to set bands in relation to ecological responses

-Explore a deviation from reference approach be explored given that the work presented as well as other work (e.g. McDowell et al 2013) demonstrate variance in reference conditions in nutrients and ecological metrics across river classes.

- Bands will be TN/TP concentrations that best correlate with a high probability of a system meeting the desired status. I am comfortable that this could be O/E, thought this enhances uncertainty and would encourage precautionary value setting.

- Marc also suggested at the end comparing percentile approach to band delineation with those that may be identified by thresholds. We can try this where appropriate, though we have tried change-point analysis before and it wasn't overly informative.

- We have already carried out nonparametric changepoint analysis (nCPA) and are now doing this on data normalised by reference condition MCI (as per Jo's suggestion). We can provide the R outputs soon and incorporate where significant.

- So I wonder if we could have one last look at the evidence underlying the 0.89 threshold specifically. Could I ask you to provide a summary of the different lines of evidence that support your proposed bottom line of 0.89? I wonder if we could arrive at a collective expression of confidence in the bottom line numbers?

## 3. Whether attribute tables should vary spatially

-REC is a good starting point to explore whether ecological relationships (intercept and slope) vary among river classes

- I would suggest that we look at Ton's spatially resolved TN and TP "predictions" and base the periphyton index on these (potentially reducing the group number to six). -North and South Island, particularly for P

- We have also began looking at whether these relationships vary with climate classes, source of flow, island and geology, and can also provide these soon too.

#### 4. Whether TN and TP attributes for ecosystem health are appropriate

-Compare TN and TP patterns to nitrate and DRP – both nationally and among river classes - The ratios at any site are relatively constant and the variability in the ratios of DIN:TN and DRP:TP in any region will probably not have wide error bars. So, for the (few) sites that dont measure TN and TP we could probably convert using a regional (or river class) ratio. We can interrogate LAWA for this (or Ton may have done this already)be aggregated (perhaps into five or s classes).

#### **Suggested reviewers**

denies de la compara de la compa compara de la compara de Scott Larned (NIWA), Roger Young (Cawthron) and (externally) David Hamilton (who is now at the