Water Quality Attributes for Healthy Rivers: Wai Ora Plan Change

TLG Summary for CSG#12

15 May 2015

Over a number of CSG meetings the important topic of which Attributes to use as measures of core values (i.e. human health, ecosystem health and mahinga kai) has been advanced through workshops and TLG input. Initial recommendations were provided by an Attributes Expert Panel back in September 2014.

A number of Attributes have been proposed to the CSG and the state of water bodies in the Waikato and Waipa catchments have been summarised with regard to some of these Attributes. However, it is recognised that the suite of Attributes used in TLG-CSG discussions and in communications with wider stakeholder groups is a sub-set of the potential Attributes that could be used to measure core values.

The purpose of this paper is to provide a set of recommendations from the TLG to the CSG on the suite of Attributes applicable to the Healthy River: Wai Ora Plan Change. In addition, we provide justification for the possible exclusion of a number of Attributes. We do this by applying a set of principles that were used in defining the National Objective Framework and it's suite of Attributes. It is hoped that application of these principles will provide the framework for CSG to confirm the suite of Attributes.

NOTE: A formal evidential report on Attribute derivation and rationale will be completed by the Attributes Expert Panel by 30 September 2015. This will be one of a series of Technical Reports overseen by the TLG that will contribute to s.32 analysis, inform policy-making and support submissions and hearings.

National Principles for Attribute Inclusion in NOF

In the process of developing the National Objectives Framework, the Ministry for the Environment defined a set of principles that were subsequently used in a logical stepwise approach to assess each potential attribute. The five principles were:

1. Does the attribute provide a measure of the value?
2. Are there agreed band thresholds, summary statistics and measurement protocols?
3. Do we know what to do to manage this attribute, do we understand the drivers and are there quantitative relationships that link the attribute state to resource use limits and/or management interventions?
4. Is there data of sufficient quality, quantity and representativeness to assess the current state of the attribute?
5. Can we assess the socio-economic implications of setting limits around this attribute?

Application of Principles to Waikato Attributes

The scope of the Healthy Rivers: Wai ora Plan Change is restricted to improving the management of N, P, sediment and faecal bacteria. This scope is considerably narrower than that covered by the

NOF. Therefore, with some minor changes the principles above can be made more relevant to the Healthy Rivers: Wai Ora process:

1. Does the attribute provide a measure of the value?

2. Measurement and band thresholds
    - Are there established protocols for measurement of the attribute?
    - Do experts agree on the summary statistic and associated time period?
    - Do experts agree on thresholds for the numerical bands and associated band descriptors?

2. Management and limits
    - Do we know what to do to manage this attribute?
    - Are the four contaminants (N, P, sediment & faecal microbes) direct drivers of this attribute?
    - Do quantitative relationships link the attribute state to limits and/or management interventions to control N, P, sediment and faecal microbes?

3. Evaluation of current state
    - Is there data of sufficient quality, quantity and representativeness to assess the current state of the attribute within Waikato FMUs?

4. Implications
    - Can the social, cultural, economic and environmental implications of setting limits be assessed?
    - Are we able to model scenarios for these attributes within the Healthy Rivers: Wai ora timeframe?

Attribute Assessment

In the Table below we set out an assessment of a wide range of Attributes discussed by CSG against the five principles defined above.

This assessment raises issues relating to a number of Attributes. Many of these issues have already been identified by CSG members and we deal with each of these below:

Clarity – In discussions and analysis to date we have been using an A-B threshold set at 4.0 m. The CSG asked that the TLG consider whether this threshold should be 3.0 m, given concerns around the width of the B band (from 4.0 m to 1.6 m). In this re-consideration we consulted with experts, in particular Dr Rob Davies-Colley from NIWA. The 4.0 m threshold reflected existing definitions of high quality waters used by WRC and in the WRISS rather than any scientifically derived value. By way of contrast, the proposed thresholds used for B-C and C-D were based on a national research project carried out in the early 1990s[1]. In that study it was found that water clarity greater than 3.0 m was considered "Eminently suitable for use" for bathing (see Fig. 1). Therefore, we propose shifting the A-B threshold from 4.0 m to 3.0 m to provide consistency in approach across the attribute. If accepted by the CSG this change would be reflected in revised State descriptions.

[1] Smith, D. G., Davies-Colley, R. J. (1992). Perception of water clarity and colour in terms of suitability for recreational use. Journal of Environmental Management 36: 225-235.

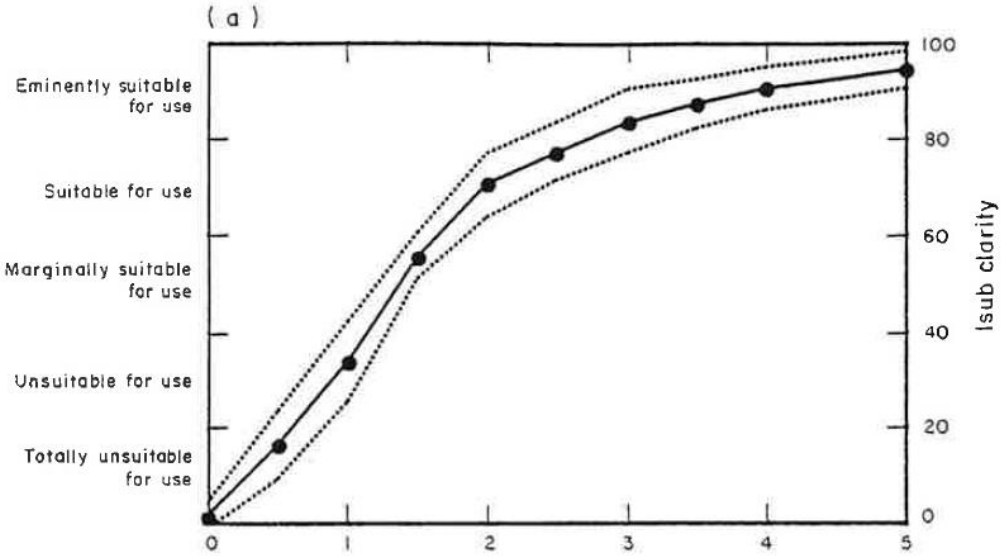

Figure 1. Clarity response curves for bathing. Note: X-axis is Black disc range (m). Reproduced from Smith & Davies-Colley (1992).

Cyanobacteria (planktonic) – The proliferation of cyanobacteria in a water body is usually undesirable, although it can occur in even relatively pristine waters. Of particular concern is the potential for some species to produce toxins at certain times. These toxins can have adverse effects on human health (e.g. skin irritations). Assessment of this Attribute against the principles in Table 1 indicate issues with the extent of monitoring across the Waikato-Waipa and the level of knowledge about links between N, P, sediment and faecal contaminants and management of nuisance cyanobacteria. As a result, it is unlikely that scenario modelling of socio-economic implications and environmental outcomes will be possible within the Healthy Rivers timeframe. There is reasonable levels of information for the Shallow Lakes FMU and this Attribute is most relevant there.

TN & TP – There has been discussion around extending the TN and TP Attribute to tributaries. At the national scale the bands for TN and TP were developed to relate to levels of eutrophication in lakes. The TLG has recommended extending the use of these bands to the Waikato River main stem, a lake-fed river with impoundments that increase residence time and provide the opportunity for algal growth. TN and TP are not relevant for tributaries and the Waipa due to their short residence times. However, within an FMU it is possible to identify which tributary catchments are "hot-spots" for contributing nitrogen and phosphorus loads to the main stem. This knowledge will be incorporated into the scenario modelling so as to target mitigation actions to achieve the desired Attribute states with respect to TN and TP in the main stem. Therefore we recommend that TN and TP levels in tributaries be used as indicators, but not Attributes.

Macrophytes (LakeSPI) – The condition and species composition of macrophytes in lakes is monitored in a number of shallow lakes in the region[2]. However, the drivers of macrophyte communities in shallow lakes are complex and a number of these drivers fall outside the scope of Healthy Rivers (e.g. pest fish). Furthermore, the relationship between Ecosystem Health and macrophyte biomass is not linear. Extensive beds of native macrophytes can indicate healthy

[2] Edwards, T., de Winton, M., Clayton, J. (2010). Assessment of the Ecological Condition of lakes in the Waikato Region using LakeSPI – 2010. Prepared by NIWA for Waikato Regional Council. Environment Waikato Technical Report 2010/24.

conditions, whereas similarly extensive beds of introduced and nuisance species may indicate degraded conditions. Therefore we recommend that Macrophytes are not included as an Attribute.

Periphyton – Periphyton biomass is recognised as an important Attribute for Ecosystem Health in rivers. However, development of this Attribute for the NOF has focussed solely on hard-bottomed streams and rivers (i.e., where substrate is suitable for attached algae)[3]. Many waterways in the Waikato-Waipa catchment have beds comprised of fine sediments (mud, silt and sand) that provide unsuitable habitat for attached algae. However, there are areas within the catchment where substrates in streams are suitable for periphyton (e.g. Upper Waipa and its tributaries). Periphyton biomass is not currently monitored quantitatively by WRC, although percentage cover of various types is monitored annually to 3 yearly in the Regional Environmental Monitoring (REMS) surveys. This monitoring indicates limited issues with periphyton at monitored sites – only 2 samples out of a total 146 samples showed periphyton cover greater than 55% (cut-off for nuisance growth levels). The vast majority of samples (90%) had periphyton cover less than 20% (indicative of high quality). In smaller streams in the Waipa catchment (e.g., <6 m wide) stream shade is an effective mitigation method to reduce the incidence of summer blooms, where these occur[4]. We conclude that periphyton is of limited relevance as a measure of Ecosystem Health in Waikato-Waipa and recommend it not be included as an Attribute.

Dissolved oxygen – This is included in the NOF as an attribute for sites below point source discharges. The Attribute relies on intensive continuous monitoring during the summer period to calculate required compliance statistics. This level of monitoring is not realistic across the regional State of the Environment monitoring network, although it would be prudent for WRC to begin such intensive monitoring in "at risk" waterways. Links to the four contaminants of interest are indirect – the greater the plant/algal biomass the greater the potential for dissolved oxygen issues, but this will be modified by site-specific conditions such as flow, mixing and temperature. We recommend that Dissolved Oxygen be included as an Attribute for reaches below point source discharges, but not for general application across the catchment.

Temperature – Another important Attribute for Ecosystem Health, but outside of the scope of Healthy Rivers: Wai Ora, as it is not related to the four contaminants.

pH – Can be an important Attribute for Ecosystem Health, but outside of the scope of Healthy Rivers: Wai Ora, as it is not directly related to the four contaminants (is influenced by growth of aquatic plants and algae).

Deposited sediment – In stony-bottomed streams the deposition of fine sediment can have significant adverse effects on Ecosystem Health and other values (e.g. trout fishery). While some thresholds have been proposed nationally[5] there is currently insufficient monitoring data to describe current state and this Attribute remains in the development stage. We recommend that deposited sediment not be included as an Attribute.

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[3] Snelder, T., Biggs, B., Kilroy, C., Booker, D. (2013). National Objective Framework for periphyton. NIWA Client Report CHC2013-122. Prepared for Ministry for the Environment, Wellington. 39 p.

[4] i) Quinn, J. M., Cooper, A. B., Stroud, M. J., Burrell, G. P. (1997). Shade effects on stream periphyton and invertebrates: An experiment in streamside channels. New Zealand Journal of Marine & Freshwater Research 31: 665-683.

ii)Davies-Colley RJ, Quinn JM (1998). Stream lighting in five regions of North Island, New Zealand: control by channel size and riparian vegetation. New Zealand Journal of Marine and Freshwater Research 32: 591-605.

[5] Clapcott J, Young R, Harding J, Matthaei C, Quinn J, Death R (2011). Sediment assessment methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Nelson, Cawthron Institute. 105 p.

Fish – There has been a significant body of research over the last decade on the use of fish as biological indicators of Ecosystem Health. However, fish communities in New Zealand are a mixture of native and introduced species, with many of the natives being migratory. Barriers to fish passage, physical habitat quality, competition and predation by introduced species, human harvest and water quality all influence the distribution of fish. As a result of these complex interactions, indicators based on fish communities generally perform poorly when compared with other indicators (e.g. nutrient concentrations, macroinvertebrates), particularly when assessing land use effects. We recommend that indicators of fish communities not be included as Attributes.

Invertebrates – New Zealand has a long history of using macroinvertebrates as biological indicators. The most commonly used index (Macroinvertebrate Community Index; MCI) has been shown to be an effective indicator of a range of pressure gradients, including land use. There are nationally-accepted thresholds for A-D bands[6]. WRC monitors MCI at 62 sites throughout the Waikato-Waipa catchment. This includes both hard-bottomed and soft-bottomed sites. 44% of these sites fall in the 'A' band, 24% in the 'B' band, 13% in the 'C' band and 19% in the 'D' band. By FMU, the average MCI in the Upper Waikato is 122 (A), Mid Waikato is 80 (C-D boundary), Waipa is 115 (B) and Lower Waikato is 86 (C).

The main issue with MCI as an Attribute under the NPS-FM is the range of drivers that influence it[7]. In general MCI tends to decline with increasing land use intensity, whereas contaminant levels tend to increase. However, improvements in MCI may not occur simply from improving management of contaminant levels (i.e., the causative link is weak or non-existent). Physical habitat structure, temperature and flow conditions are all important drivers. There are also complex interactions between drivers. Therefore, it is not possible at this stage to predict the effectiveness of controls on N, P, sediment and *E. coli* alone on MCI outcomes. This severely limits our ability to undertake cost-benefit analysis for use of MCI as an Attribute either at the national scale or within the Waikato. We recommend that MCI not be included as an Attribute.

E coli (Mahinga kai) - For food species that are thoroughly washed and cooked prior to eating we consider it would be appropriate to use the same *E. coli* Attribute bands as for primary contact recreation (i.e. swimming).

Faecal coliforms (Mahinga kai) – There are nationally accepted standards for assessing estuarine water quality relating to shellfish-gathering, but this Attribute has been outside the scope of the NPS-FM and NOF. To our knowledge these Standards have not been applied to freshwater shellfish-gathering, and we do not know what the extent of freshwater shell-fish gathering for food is in the Waikato. Waikato Regional Council does monitor Faecal Coliforms at freshwater sites. Only four monitored sites achieve the "Satisfactory" level defined by WRC (see table below). These sites are Taupo Control Gates, Ohakuri tailrace, Whakamaru tailrace and Waiotapu Stream at Campbells Rd.

Without knowledge of the extent of freshwater shellfish gathering and the associated practices (e.g. are they consumed raw or cooked?) we are not able to make a firm recommendation on the inclusion of Faecal Coliforms as an Attribute for Mahinga kai. However, it is clear that very few sites (and no sites in the lower river) would meet satisfactory levels.

[6] MCI score ≥120 is 'A', 'B' is 100-119, 'C' is 80-99 and 'D' is <80.

[7] Clapcott, J., Goodwin, E. (2014). Relationships between Macroinvertebrate Community Index and environmental drivers. Cawthron Report No. 2507. Prepared for Ministry for the Environment, Wellington. 21 p.

Note: Coliforms are bacteria that live in the intestines of warm-blooded animals (humans, pets, farm animals, and wildlife). Faecal coliform bacteria are a kind of coliform associated with human or animal wastes. Escherichia coli (E. coli) is part of the group of faecal coliforms.

WRC guidelines and standards used to assess estuarine water quality for shellfish-gathering.

Water quality variable (units)	Relevance	Categories		
		Excellent	Satisfactory	Unsatisfactory
Shellfish-gathering				
Faecal coliforms, median (no./100 mL)	Human health	<2	2 – 14	>14
Faecal coliforms, 90 percentile (no./100 mL)	Human health	<6	6 - 43	>43

http://www.waikatoregion.govt.nz/Environment/Environmental-information/Environmental-indicators/Coasts/Coastal-water-quality/Estuarine-water-quality-techinfo/#guidelines

Cyanobacteria (Mahinga kai) – The bands for primary contact recreation (Cyanobacteria planktonic) are appropriate for this value.

Table 1. Proposed Attributes for Waikato Objectives Framework and assessment against five principles. Those Attributes highlighted in yellow are discussed in the text.

Value	Attribute	Link to Value	Thresholds	Management	Evaluation of State	Implications
Human Health	*E. coli*	Yes	Yes	Yes	Yes	Yes
	Clarity	Yes	Yes*	Yes	Yes	Yes
	Cyanobacteria (planktonic)	Yes	Yes	Limited	Limited	No
	Cyanobacteria (benthic)	Yes	No	Limited	No	No
Ecosystem Health	Phytoplankton (lakes)	Yes	Yes	Yes	Yes	Yes
	TN	Yes	Yes	Yes	Yes	Yes
	TP	Yes	Yes	Yes	Yes	Yes
	Nitrate	Yes	Yes	Yes	Yes	Yes
	Ammonia	Yes	Yes	Yes	Yes	Yes
	Macrophytes (Lake SPI)	Yes	Yes	No	Limited	No
	Periphyton (rivers)	Yes	Yes	Yes	No	Yes
	Dissolved Oxygen	Yes	Yes	No	No	No
	Temperature	Yes	Yes	No	No	No
	pH	Yes	No	No	No	No
	Deposited sediment	Yes	No	Yes	No	No
	Fish	Yes	No	No	Yes	No
	Invertebrates (MCI)	Yes	Yes	No	Yes	No
Mahinga Kai	*E. coli*	Yes	Yes	Yes	Yes	Yes
	Faecal coliforms	Yes	Yes	Yes?	Yes	Yes
	Catch-per-unit-effort	Yes	No	No	No	No
	Cyanobacteria	Yes	Yes	No	Limited	No

Summary

The table below summarises TLG recommendations to the CSG on status of potential Attributes for use in the Healthy Rivers:Wai Ora process.

Value	Attribute	TLG recommendation
Human Health	*E. coli*	Include as previously recommended
	Clarity	Include with modified A-B threshold
	Cyanobacteria (planktonic)	Include in Shallow Lakes FMU only
Ecosystem Health	Phytoplankton (lakes)	Include as previously recommended
	TN	Include as previously recommended. Do not extend to tributaries
	TP	Include as previously recommended. Do not extend to tributaries
	Nitrate	Include as previously recommended
	Ammonia	Include as previously recommended
	Macrophytes (Lake SPI)	Do not include
	Periphyton (rivers)	Do not include
	Dissolved Oxygen	Include as previously recommended (below point source discharges)
	Temperature	Do not include
	pH	Do not include
	Deposited sediment	Do not include
	Fish	Do not include
	Invertebrates (MCI)	Do not include
Mahinga kai	*E. coli*	Apply as for Human Health above
	Faecal coliforms	Do not include (at this stage)
	Catch-per-unit-effort	Do not include
	Cyanobacteria (planktonic)	Apply as for Human Health above

Summary of CSG workshops on attributes CSG8-CSG10

Individual attributes	Comments on current state/ bands to aim for	Additional comments on applying or defining bands	Questions/ requests for more info

E. coli	**Upper**
	Main stem ok but tributaries not, and may contribute to problems further down
	
	Other parts of river
	Need to improve – need to be A or B to meet Vision and Strategy.
	
	Lower and Waipa might have interim target to get to 'C' band but long term objective still has to be 'B'.
		Apply to all seasons of the year because taking of food may occur at any time	• Info on sources/origins/how to allocate responsibility
			• Sources: point and non point contributions, natural sources, farm level
			• Origins: stock, birds, other animals, human – epidemiology – risk of illness.
			• Sources in different parts of catchment:
			  ○ Waipa: - Why upper and lower Waipa seem high
			  ○ Mid: What is the role of HCC wastewater plant vs other urban sources?
			  ○ Lower: How much comes from Waipa/upstream and how much generated locally? (Relates to cumulative effect and die-off)
			• Trends and long term records? Is it different for a longer (10 year) period, due to recent droughts. Is there a trend (especially relation to changing land use)
			• What is the appropriate standard for 'safe to take food?' – fish, watercress might be OK at recreational standard but shellfish standard is more stringent.

Clarity	**Upper** A – main stem [at least to Ohakuri] B – incl. tributaries [and below Ohakuri] Provisos: • No further degradation within band/ from current state • Will be clearer as we know costs • Are geothermal tribs different?	Bands CSG mostly comfortable with where bands set with provisos: • Want to know percentage of people who found 1 metre acceptable • Wonder if 3m not 4m for 'A' Some members don't like the term 'marginally acceptable'. Preferred narrative description:	• Clarity effects in geothermal tributaries • What is the cumulative effect of Waipa and Upper Waikato on Lower (vs lower tribs) • More info on state of tributaries and sources of sediment in tributaries • Actions that can mitigate • How many years' samplings are used to assess? • Compare with other rivers nationally

	Middle B – Karapiro to Ngaruawahia (may need time) **Waipa** C (realistic) **Lower Waikato** C (cumulative effect) **Lakes** Special / individual case – what's realistic?	A: Excellent clarity for swimming B: Good clarity for swimming C: Acceptable clarity for swimming [but see proviso above – want to know who thinks 1m is acceptable before we can call it acceptable at 1m] D: Unacceptable clarity for swimming Further info needed on bands: • From source study: % of people who found 1 metre acceptable • 'A' band threshold [3m/4m] – what was basis for decision?	• Source paper [CSG want to see national clarity study]
Phytoplankton	**Upper** B, with no further degradation of A areas, possibly expanding A areas, keeping Narrows at high B **Middle** B **Lower** B (may take longer timeframe) **Lakes** Individually, complement catchment plans	Bands cover broad range, don't want to see further degradation within bands	• Further understanding of nutrient dynamics in plankton growth, and access to reports
N and P	**P** Maintain where already A, and raise to a B throughout – timeframe is the question. **N** Initial target – no degradation. Then aim to raise to a 'B' (with no degradation of A areas), but acknowledge it may be at a slower rate than for P.	Relativity of N and P important – need to understand more. But risky to rely on controlling P so need to look at both. Noting this is aspirational. Considering legacy effects (groundwater lags) and current land use changes that need to be taken into account Earlier comment – do we need to apply Total N and Total P limits on tributaries and Waipa, as well as main stem?	• As above – nutrient effects on algae • Why does the colour change in between sites 5 and 6? • How much of total tonnes N is surface versus groundwater?
Ammonia and Nitrate	• Lift C sites to a B • Might need some B sites to lift also – depending on effects on species	Not enough information on effects on sensitive species	• If we deal with total N will this take care of it? • Need more info on where vulnerable/ threatened species are