BEFORE THE HEARING PANEL

AT HAMILTON

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the Proposed Waikato Regional Plan Change 1 Waikato and Waipā River Catchments
AND	
IN THE MATTER	of Variation 1 to the Proposed Waikato Regional Plan Change 1 Waikato and Waipā River Catchments

---

STATEMENT OF EVIDENCE IN CHIEF OF KATHRYN JANE MCARTHUR ON BEHALF OF THE DIRECTOR-GENERAL OF CONSERVATION

TOPICS: B2, B3, B4, B5

15 February 2019

Department of Conservation
Private Bag 3072
HAMILTON

Ph 07 838 5687

Email vtumai@doc.govt.nz

Counsel Acting: Victoria Tumai

Submission number: 71759

Contents

INTRODUCTION

1. My name is Kathryn (Kate) Jane McArthur.

2. I have been engaged by the Director-General of Conservation to provide evidence on freshwater management, water quality and ecosystem health, with a particular focus on streams and rivers, for the hearing on proposed Plan Change 1 for the Waikato and Waipā Rivers (PC1).

3. I am the Practice Leader – Water, at The Catalyst Group, an environmental consultancy based in Palmerston North.

QUALIFICATIONS AND EXPERIENCE

4. I hold a Bachelor of Science degree with Honours in Ecology and a Master of Applied Science with Honours in Natural Resource Management, both from Massey University. My areas of post-graduate research included the influence of land use on freshwater macroinvertebrate communities and the interaction between policy and science for improved freshwater resource management, with a focus on water quality objectives and limits in regional plans. I have 18 years post-graduate experience working in the field of freshwater resource management. I joined The Catalyst Group (an environmental consultancy based in Palmerston North) as the Practice Leader - Water in 2012.

5. Before joining The Catalyst Group, I held the role of Senior Scientist – Water Quality with Horizons Regional Council (Manawatū-Whanganui Region). Over six years with Horizons I coordinated the State of the Environment (SOE), periphyton and point-source discharge monitoring programmes for water quality and aquatic biodiversity, produced expert evidence for many resource consent hearings and enforcement actions (relating mainly to takes of, and discharges to, water). During my work on the Horizons One Plan (combined Regional Policy Statement, and Coastal and Regional Plan for Manawatū-Whanganui Region) I led the identification of Sites of Significance – Aquatic work, completed the framework of water management zones for the region, reviewed and refined the river, lake and coastal water quality targets and project managed the water quality evidence for the One Plan hearings and Environment Court proceedings.

6. I have authored and co-authored a range of reports and publications, including technical reports to support the Horizons One Plan and the draft Nelson Plan. I have also authored and co-authored papers in peer-reviewed journals on topics such as: the relationship between flow and nutrients in rivers; nutrient limitation; methods for monitoring native fish; the calculation of in-river nutrient loads and limits, and the setting of water quality objectives and limits in resource management policy. I have provided evidence in these topic areas before the Environment Court, and in Board of Inquiry and Independent Hearings Panel processes across the country.

7. I reviewed national Envirolink Tools projects to develop methods and guidelines to assess deposited sediment in rivers (Clapcott et al. 2011) and review of the New Zealand instream plant and nutrient guidelines (Matheson et al. 2012).

8. Most recently, I have provided ecological, water quality and freshwater policy advice to Nelson City Council, Northland Regional Council, Ngāti Kahungunu Iwi Incorporated, Hawkes Bay Regional Council, the national Iwi Leaders Group, the Minister of Conservation, the Ministry for the Environment water directorate, Forest and Bird and the collaborative stakeholder group tasked with preparing a draft National Policy Statement for Indigenous Biodiversity.

9. On behalf of the New Zealand Planning Institute I have co-led workshops throughout the country on best practice freshwater science and policy development with Helen Marr (Director – Perception Planning) since 2016. Participants have included: local government and industry planners, planning consultants, iwi/NGO resource managers, and the Ministry for the Environment Water Directorate staff. I was appointed as a member of the National Objectives Framework reference group for the National Policy Statement for Freshwater Management amendments by the Ministry for the Environment.

10. I have been a member of the New Zealand Freshwater Sciences Society since 2001 and I am currently the President of the Society. I have been a member of the Resource Management Law Association of New Zealand (RMLA) for nine years and was the RMLA scholarship recipient in 2010 for my work on water quality policy and limits for the Manawatū River. I have been a guest lecturer in environmental planning and

science at Massey University since 2005 and I am an accredited and experienced RMA hearings commissioner.

11. I have recently been, or am currently involved in, freshwater plan processes in Northland, Auckland, Bay of Plenty, Hawke's Bay, Manawatū-Whanganui, Wellington, Tasman, Nelson, Canterbury and Southland regions on behalf of councils, tangata whenua, the Department of Conservation or NGO stakeholders.

CODE OF CONDUCT FOR EXPERT WITNESSES

12. Although this is not an Environment Court hearing process, I have read the Environment Court "Code of conduct for expert witnesses" (2014), and I agree to abide by it. I have prepared this Statement in accordance with that Code. I confirm that my evidence is within my area of expertise. I have not omitted to consider any material facts known to me that alter or detract from the opinions I express in this Statement. I have acknowledged the material used or relied on in forming my opinions and in the preparation of this Statement.

13. As a member of the New Zealand Freshwater Sciences Society, a constituent organisation of the Royal Society of New Zealand - Te Apārangi, I also agree to be bound by the Royal Society of New Zealand Code of Professional Standards and Ethics in Science, Technology, and the Humanities[1].

SCOPE OF EVIDENCE

14. This statement of evidence was prepared for the Director-General of Conservation.

15. The scope of my evidence covers the following matters with respect to rivers in the Waikato-Waipā catchments:

a. Values and uses for the Waikato-Waipā
b. Ecosystem health and associated values in rivers
c. Biodiversity and indigenous fish values
d. Priorities for protection and FENZ fish ranking
e. Outstanding freshwater bodies
f. Water quality attributes and targets

[1] https://royalsociety.org.nz/assets/Uploads/Code-of-Prof-Stds-and-Ethics-1-Jan-2019-web.pdf

g. Relationship between values and attributes
h. Appropriate scale to identify values and apply attributes
i. Hard-bottomed streams and management of tributaries
j. Appropriate water quality attributes for PC1
k. Trophic state, nitrate, ammonia and clarity attributes – Table 3.11-1
l. *E. coli* and risks from faecal bacteria
m. Additional water quality attributes and targets for PC1
n. Cyanobacteria
o. Deposited fine sediment
p. Trophic state - periphyton
q. Dissolved oxygen
r. Temperature and pH
s. MCI
t. Sediment targets and estuarine health
u. Timeframes and timebound targets for water quality improvement

16. In preparing my evidence I have read and reviewed the following documents:
a. The National Policy Statement for Freshwater Management (2014) – 2017 amendment version (NPS-FM);
b. Waikato Regional Plan Change 1 - Waikato and Waipā River Catchments (Proposed and s42A track changes versions);
c. Section 42A report Waikato Regional Plan Change 1 Part A and Part B (McCallum-Clark et al. 2018);
a. Water Quality Attributes for Healthy Rivers: Wai Ora Plan Change (Scarsbrook 2016);
b. Restoring and protecting our water – Te Whakapaipai me tiaki i ō tātou wai: Collaborative Stakeholder Group (CSG) recommendations overview 2016;
c. Waikato River suspended sediment: loads, sources & sinks (Hughs 2015);
d. Sources of Faecal pollution in Selected Waikato Rivers - July 2015 (Moriarty 2015);
e. Nutrients and phytoplankton (chlorophyll a) in the Waikato River (Technical Leaders Group (TLG) 2015);
f. Nutrient limitation of algal biomass in the Waikato River (Verberg 2016);

g. Modelling Nutrient Loads in the Waikato and Waipa River Catchments (Semadeni-Davies et al. 2015);
h. Waikato River Water Quality Monitoring Programme: Data report 2016 (Tulangi 2017);
i. Trends in river water quality in the Waikato Region: 1993 – 2017 (Vant 2018);
j. Waikato and Waipā restoration strategy (2018);
k. Waikato River Independent Scoping Study (NIWA, 2010); and
l. The citations listed in the references section of this evidence.

ABBREVIATION LIST

Abbreviation	**Full term**
ANZECC	Australia and New Zealand Environment and Conservation Council
CSG	Collaborative Stakeholder Group
DIN	Dissolved inorganic nitrogen
DOC	Department of Conservation
DRP	Dissolved reactive phosphorous
EMU	Ecological Management Unit
FENZ	Freshwater Ecosystems of New Zealand
FMU	Freshwater Management Unit
LAWA	Land Air Water Aotearoa website www.lawa.org.nz
MCI	Macroinvertebrate Community Index
MfE	Ministry for the Environment
MoH	Ministry of Health
NGO	Non-government organisation
NOF	National Objectives Framework
NPS-FM	National Policy Statement for Freshwater Management (2014)
OFWB	Outstanding Freshwater Bodies
PeriWCC or WCC	Periphyton weighted composite cover

PC1	Proposed Plan Change 1 for the Waikato and Waipā Rivers
RMA	Resource Management Act (1991)
RMLA	Resource Management Law Association
SOE	State of the Environment
TLG	Technical Leaders Group

EXECUTIVE SUMMARY

17. Freshwater values are the foundation of freshwater policy development under the NPS-FM. They represent the full complement of intrinsic and use values of freshwater ecosystems and are critical to recognising Te Mana o te Wai and informing desired outcomes in regional freshwater planning processes. For the Waikato and Waipā catchments, freshwater values are interwoven and interpreted through Te Ture Whaimana o Te Awa o Waikato - Vision and Strategy for the Waikato River.

18. Ideally in regional plans, values are defined spatially across catchments at the Freshwater Management Unit (FMU) scale, or even at finer sub-catchment, reach or site scales where relevant. This allows for local identification of values and thereby locally suitable water quality attributes, freshwater objectives, policies, rules and other methods to be developed. Plan Change 1 diverges from a spatial approach and applies all values ubiquitously to all FMUs across the Waikato and Waipā catchments.

19. Without specific identification of the critical characteristics that comprise ecosystem health (such as biodiversity, indigenous fish and threatened species) at the relevant spatial scale across all of the FMUs, or the inclusion of relevant water quality attributes and targets specifically to support these characteristics, there is a significant risk that PC1 will not deliver water quality outcomes that will achieve 'ecosystem health' across all sub-catchments, waterbodies and freshwater ecosystems of the Waikato-Waipā catchments. This is particularly the case for the tributaries of the Waikato River, including all of the Waipā catchment.

20. The Department of Conservation (DOC) developed a method to identify priority freshwater catchments for protection and restoration across all freshwater ecosystems (rivers, lakes and wetlands). The West et al (2018) model is the best available method to determine which sub-catchment areas should be protected and/or restored to ensure ecological values and ecosystem health are safeguarded. It is also the best current indication of where water quality targets may need to be more stringent for the preservation of indigenous biodiversity at the sub-catchment level, above and beyond the targets proposed in PC1 to provide for whole of catchment water quality outcomes.

21. The top-20 river sub-catchments with the highest priority rankings for protection are identified, alongside the top-10 river sub-catchment for indigenous fish in FENZ. This type of prioritisation is not new to the Waikato and has been applied in the past using similar models by the regional council science team in collaboration with external research providers. It is not clear why this research was not used to inform the development of PC1.

22. Water quality limits and targets ideally reflect the desired state or change in state of water quality that a plan intends to achieve over time. They are the plan's numeric measures of success in providing adequate water quality to support the values. Water quality attributes and the numeric target values in Table 3.11-1 of PC1 were reviewed against the sub-catchment priorities for protection and indigneous fish rankings and revised in this evidence. Changes made to the existing water quality attributes to better reflect priority sub-catchments for indigenous biodiversity and conservation values are detailed in Appendix 1. Additional attributes and targets proposed for all sub-catchments to complement the existing attributes and better provide for ecosystem health across the full range of river and stream types are detailed in Appendix 2.

23. It is not unreasonable to expect that additional targets for improvement could be included in PC1 for implementation between the short term and 80 year water quality targets. Without the inclusion of further direction between the short term targets and the 80 year water quality attributes

states, the Vision and Strategy and provision for the values of the Waikato and Waipā Rivers is jeopardised. The approach to the period between these two timeframes in PC1 is both inappropriate and uncertain.

24. It is difficult to establish a direct link between the water quality attributes and targets the plan proposes and the ecosystem health and mahinga kai values that are a foundation of PC1. The link between the proposed attributes and the goals of the Vision and Strategy relating to healthy biodiversity, swimmability and fishability in the Waikato and Waipā Rivers are also tenuous.

25. Management of the contaminants specified in the Vision and Strategy approach (nutrients, faecals and sediment) has not been appropriately carried through into PC1 for the majority of waterways, including the whole Waipā catchment and all tributaries of the Waikato. It is difficult to imagine how management without addressing trophic state, dissolved oxygen, deposited sediment, dissolved nutrients or biological attributes, limits or targets in these waterways will make a positive contribution to water quality in the Waikato River or at the local level within the Waipā catchment and Waikato tributaries. This is particularly relevant when patterns of fish diversity are taken into account.

26. Tributaries play an important role as fish habitat, particularly those closest to the sea. Without adequate targets for water quality and addressing habitat availability in PC1, the tributaries of the Waikato and the entire Waipā catchment are unlikely to maintain or improve in terms of ecosystem health. Consequences with respect to declining or threatened fish and invertebrate species may be irreversible in the long-term.

VALUES AND USES FOR THE WAIKATO-WAIPĀ

27. Freshwater values are the foundation of freshwater policy development under the NPS-FM. They represent the full complement of intrinsic and use values of freshwater ecosystems and are critical to recognising Te Mana o te Wai and informing desired outcomes in regional freshwater planning processes. For the Waikato and Waipā catchments, freshwater

values are interwoven and interpreted through Te Ture Whaimana o Te Awa o Waikato - Vision and Strategy for the Waikato River, supported by the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010, Ngāti Tūwharetoa, Raukawa, Te Arawa River Iwi Waikato River Act 2010 and the Ngā Wai o Maniapoto (Waipā River) Act 2012, the Waikato River Authority, the Waikato River Clean-up Trust and the collaborative co-management group (CSG) that has developed Plan Change 1 to the Waikato Regional Plan for the Waikato and Waipā Rivers (PC1).

28. Ideally, values are defined spatially across catchments at the Freshwater Management Unit (FMU) scale, or even at finer sub-catchment, reach or site resolution where relevant. This allows for local identification of values and thereby suitable water quality attributes, freshwater objectives, policies, rules and other methods to be developed. Plan Change 1 diverges from a spatial approach and applies all values ubiquitously to all FMUs across the Waikato and Waipā catchments. Values are intrinsic (Mana Atua) or human use (Mana Tangata) and include the compulsory national values of Ecosystem Health and Human Health for Recreation, which must apply to all freshwater bodies in Aotearoa New Zealand under the NPS-FM.

29. The rationale for applying all values across all FMUs in the Waikato-Waipā catchments appears to be as a result of the 'ki uta ki tai' (mountains to the sea) principle underpinning the Vision and Strategy for the Waikato River. This principle is undeniably a critical component of integrated freshwater management in Aotearoa New Zealand, ensuring outcomes for the river as a whole are kept 'front of mind' through plan development processes. However, operating solely at a whole-of-river scale can mean important characteristics of overarching values such as 'ecosystem health' can be overlooked or missed in plan development. This puts intrinsic values such as ecosystem health at risk because the full representation of ecosystems, and characteristics such as threatened or at risk indigenous fish communities, spawning habitats or biodiversity priority areas are not specifically identified for protection (maintenance) or restoration (improvement). Instead preference was given to broad-scale, whole of catchment management.

30. To overcome this challenge without completely re-evaluating the spatial resolution of the values, PC1 could continue to ensure that as a minimum, overall outcomes for water quality are reflected in the sub-catchment targets, whilst also ensuring that water quality attributes in high value, priority areas (including lakes) have more stringent water quality targets where necessary, to provide for those values in the sub-catchments themselves.

31. There are no direct references to supporting or providing for the values of the Waikato and Waipā Rivers in the Objectives of PC1[2]. The values sit as policy 'orphans' within explanatory text only. If supporting and providing for the values is a key aspect of PC1 (which arguably it is with respect to the compulsory national values in the NPS-FM and the Vision and Strategy) it should be clearly stated in the objectives that supporting, providing for or achieving a desired state for the values, over time, is one of the key aims of PC1.

Ecosystem health and associated values in rivers

32. Ecosystem health is a compulsory national value under the NPS-FM and applies across all waterbodies and FMUs in the Waikato-Waipā catchments. The definition of ecosystem health in Appendix 1 of the NPS-FM states:

"*Ecosystem health – The freshwater management unit supports a healthy ecosystem appropriate to that freshwater body type (river, lake, wetland, or aquifer).*

In a healthy freshwater ecosystem ecological processes are maintained, there is a range and diversity of indigenous flora and fauna, and there is resilience to change.

Matters to take into account for a healthy freshwater ecosystem include the management of adverse effects on flora and fauna of contaminants, changes in freshwater chemistry, excessive nutrients, algal blooms, high sediment levels, high temperatures, low oxygen, invasive species, and changes in flow regime. Other matters to take into account include the

[2] In either the proposed and s42A recommendations versions, with the exception of Objective 5 which makes brief mention of tangata whenua values with respect to co-management.

essential habitat needs of flora and fauna and the connections between water bodies."

33. PC1 carries its own definition of ecosystem health, which states:

"*The Waikato and Waipā catchments support resilient freshwater ecosystems and* ***healthy freshwater populations of indigenous plants and animals****.*

- *Clean fresh water restores and protects aquatic native vegetation to provide habitat and food for native aquatic species and for human activities or needs, including swimming and drinking.*
- *Clean fresh water restores and protects* ***macroinvertebrate communities*** *for their intrinsic value and as a food source for native fish, native birds and introduced game species.*
- *Clean fresh water* ***supports native freshwater fish species****.*
- *Wetlands and floodplains provide water purification, refuge, feeding and breeding habitat for aquatic species, habitat for water fowl and other ecosystem services such as flood attenuation.*
- *Fresh water contributes to unique habitats including peat lakes, shallow riverine lakes and karst formations which all support unique biodiversity.*
- *Rivers and adjacent riparian margins have value as ecological corridors."* [emphasis added]

34. Īnanga spawning, macroinvertebrate communities, indigenous fish migration, priority biodiversity areas, threatened and at risk fish species, wetlands and lakes, indigenous vegetation and freshwater habitats, as well as downstream impacts on the coastal environment are all key characteristics of ecosystem health that are of freshwater management concern in regional planning. This evidence focuses on freshwater values of rivers and streams, particularly water quality and indigenous fish. Evidence on wetland values is provided by Dr Robertson, lakes evidence by Dr Phillips, and coastal values by Ms Kettles.

35. The components of these definitions and characteristics sit within one broad 'ecosystem health' value in PC1. Without further identification of the critical characteristics that comprise ecosystem health spatially across all of the FMUs or the inclusion of relevant water quality attributes

and targets specifically to support these characteristics, there is a significant risk that PC1 will not deliver water quality outcomes that will achieve ‘ecosystem health’ across all sub-catchments, waterbodies and freshwater ecosystems of the Waikato-Waipā catchments.

36. For example, the Komakorau Stream sub-catchment ranks first for indigenous fish and the top priority site for biodiversity protection rankings in the Waikato-Waipā[3], yet the 95th percentile nitrate toxicity targets in PC1 are proposed to be a C band in the short term, aiming for the bottom of the B band in 80 years. These targets equate to a nitrate toxicity attribute state in the short term where growth effects may be expected on up to 20% of species (mainly sensitive species such as fish), with the 80 year state allowing for some growth effects on up to 5% of species (Hickey 2016; NPS-FM 2017). Irreversible damage as a result of elevated nitrate may occur in this high priority stream and are not proposed to be managed under the PC1 framework. Such effects are inconsistent with the definition of ecosystem health in PC1.

37. Many freshwater plans developed in other regions at the inception of, or subsequent to the development of the NPS-FM have identified freshwater values at the FMU, sub-catchment or site/reach scale, depending on the relevant scale for each value of interest. Examples of this approach include: The Horizons One Plan for the Manawatū-Whanganui Region, the Proposed Natural Resources Plan for the Greater Wellington Region, and the draft Nelson Plan. It is important to note that the scale at which the values apply does not mean that FMUs or sub-catchment units have to be set at the same spatial scale.

38. The Waikato and Waipā river restoration strategy (Neilson et al. 2018) identifies a 20 year action plan to coordinate restoration activities in the Waikato-Waipā catchments to guide non-regulatory investment in restoration activities over the next 25 years. Full implementation of the strategy may provide a basis for medium term water quality targets, despite the non-regulatory nature of the strategy, particularly if the strategy is adopted as a non-regulatory method in PC1. Priority habitats

[3] Explanation and analyses of the prioritisation ranking methods are explained in paragraphs 40 to 44 below.

for indigenous fish and ecosystem health are also identified for restoration in the strategy.

BIODIVERSITY AND INDIGENOUS FISH VALUES

39. The following section identifies prioritisation methods that should be used in PC1 at the sub-catchment level to define priorities for protection of freshwater ecosystems and indigenous fish as critical components of ecosystem health.

Priorities for protection and FENZ fish ranking

40. The Department of Conservation (DOC) have recently developed a method to identify priority freshwater catchments for protection and restoration across all freshwater ecosystems (rivers, lakes and wetlands) in Aotearoa New Zealand using spatial conservation prioritisation software (West et al. 2018). This research emphasises representation of the full range of ecosystems and species, while also taking account of catchment connectivity, to align with the DOC goal of restoring freshwater ecosystems at a whole-of-catchment scale.

41. Designing a prioritisation approach at a whole-of-catchment scale (‘mountains to the sea’) while also achieving representation of a full range of ecosystems and species is particularly challenging, largely because of complications of scale, similar to the issues described above in paragraph 29. Third order sub-catchments were found to be the most suitable scale for prioritisation, capturing the most important components within the largest river catchments (West et al. 2018). Although the sub-catchments in the West et al. (2018) model are not necessarily aligned with those defined in PC1, the findings of the research support a sub-catchment approach[4] to protecting significant freshwater biodiversity values.

42. Important populations of indigenous fish (migratory and non-migratory), connectivity, catchment resource pressure, habitat barriers, invasive pest occurrence and the locations of major terrestrial conservation

[4] For clarity, this does not mean the river FMUs should be replaced with sub-catchment management units, simply that water quality targets and prioritised management actions are best applied at the sub-catchment level to ensure the values are provided for and supported at the sub-catchment scale.

projects were considered and weighted within the catchment prioritisation method to deliver maximum benefits for protection and/or restoration.

43. Figure 1 shows the prioritisation rank results for the Waikato and Waipā catchments within the PC1 FMUs. The blue shaded sub-catchments represent the prioritisation ranking for third order sub-catchments not currently within conservation protected land (shaded green in Figure 1) ranked to provide representation of a full range of river, lake and wetland ecosystems, non-migratory freshwater fish, important habitats for the maintenance of migratory indigenous fish, and intensively managed DOC Ecosystem Management Units (EMUs). Values range from 0 to 1 and are expressed as a proportion of all freshwater features in Aotearoa New Zealand so that catchments with values in the range 0–0.1 represent the top 10%, those with values in the range 0.0–0.2 represent the top 20%, and so on.

44. The prioritisation model reflects the best available method to determine which sub-catchment areas within whole catchments (mountains to the sea) should be protected and/or restored to ensure ecological values and ecosystem health are safeguarded. It is also the best available indication of where water quality targets may need to be more stringent for the preservation of indigenous biodiversity at the sub-catchment level, above and beyond the targets proposed in PC1 to provide for whole of catchment water quality outcomes.

45. Figure 2 shows the DOC priority for protection ranks averaged across each of the PC1 sub-catchments to assist in identifying which sub-catchments in the PC1 framework should be considered highest priorities for critical biodiversity and fish components of ecosystem health and therefore have more protective water quality targets assigned.

46. Top-20 river sub-catchments with the highest priority rankings for protection:

- Komakorau,
- Mangakotukutuku,
- Mangawara,

- Mangatawhiri,
- Waikato at Mercer,
- Waitawhiriwhiri,
- Waikato at Huntly-Tainui Br,
- Mangatangi,
- Kirikiriroa,
- Awaroa (Rotowaro) at Sansons Br,
- Mangakino,
- Matahuru,
- Waikato at Horotiu Br,
- Kaniwhaniwha,
- Waipā at SH23 Br Whatawhata
- Awaroa (Waiuku),
- Whangamarino at Island Block Rd,
- Waikato at Narrows,
- Mangauika, and
- Whangape.

47. Use of modelling to prioritise indigenous biodiversity areas and values is not a new approach for the Waikato Region. This type of prioritisation was applied to rivers and streams of the region by regional council science staff in collaboration with external research providers (Collier et al. 2010), using a similar modelling approach. It is not clear why this research and updates to it were not been used to inform the development of PC1 to better prioritise the plan's approach to areas of the catchment with significant biodiversity or indigenous fish values. The DOC and FENZ modelling presented above is simply an update of that earlier WRC process by Collier et al. (2010).

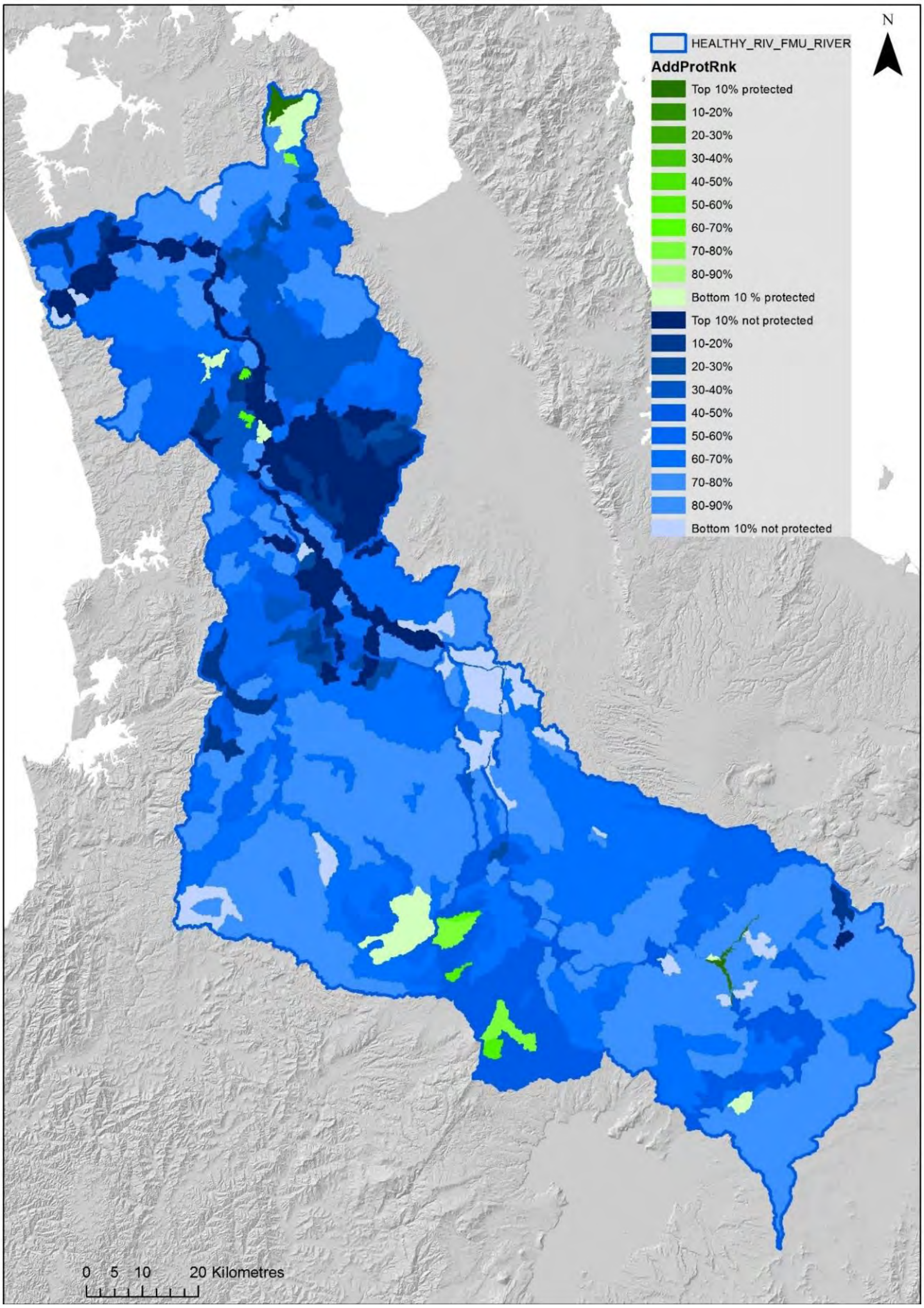

Figure 1. Conservation priority ranking of third order sub-catchments in the Waikato-Waipā Rivers for protection of freshwater ecological characteristics including: the full range of freshwater ecosystems, non-migratory fish, important habitats for migratory fish, and DOC managed EMUs (Ecological Management Units).

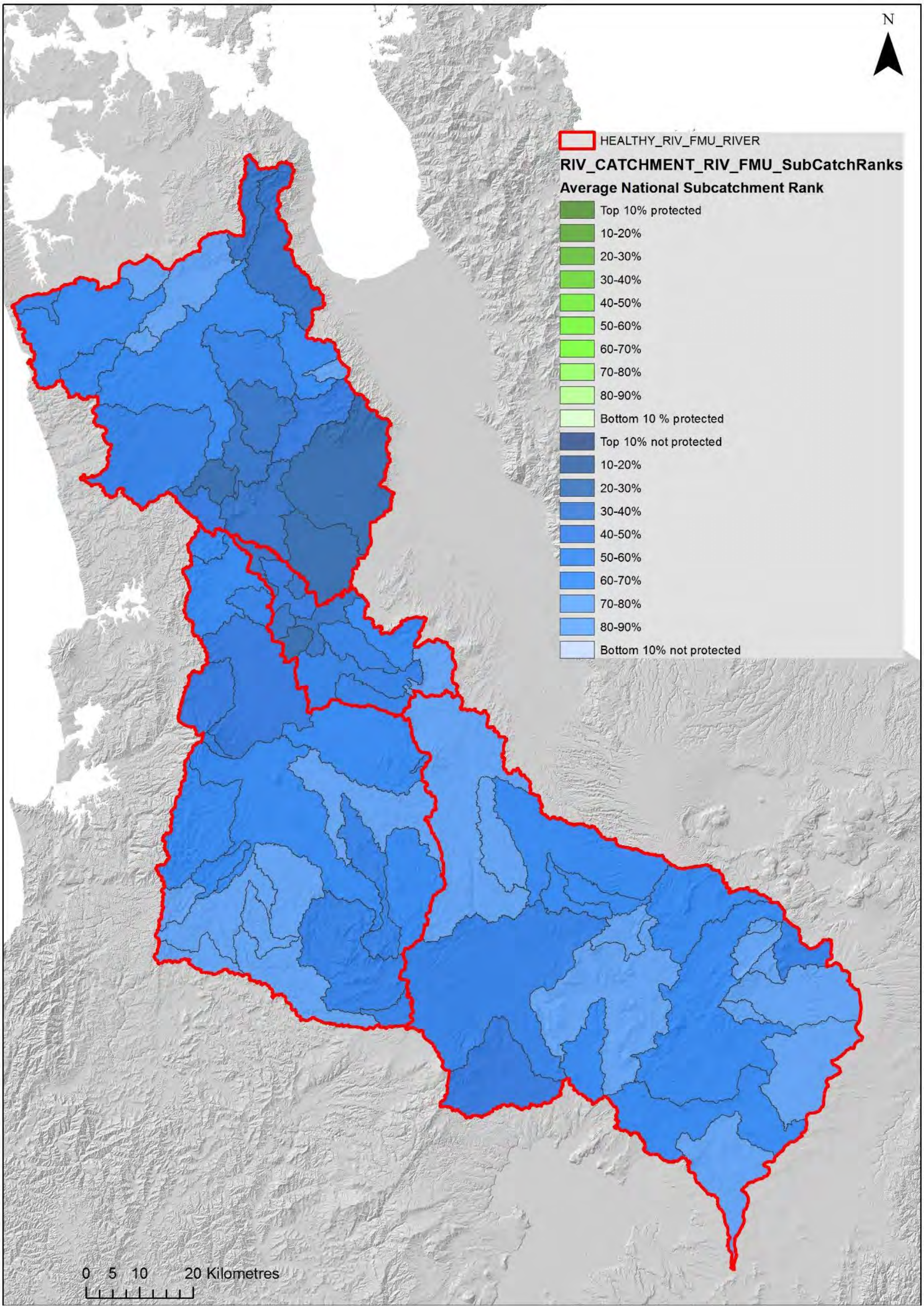

Figure 2. DOC priority for protection model ranks averaged across PC1 sub-catchments for the Waikato-Waipā River catchments.

48. Lake Waikare ranked ninth in the prioritisation ranking by sub-catchment but was removed to determine the top-20 river sub-catchments. Lake priorities are discussed in the evidence of Dr Phillips.

49. The FENZ geodatabase (Freshwater Ecosystems of New Zealand; Leathwick et al. (2012)) consists of a large set of spatial data layers and supporting information on rivers, lakes and wetlands in Aotearoa New Zealand. It contains data gathered from a wide variety of sources and can be used to objectively map and quantify various aspects of New Zealand's freshwater ecosystems, providing:

- "*Comprehensive descriptions of the physical environment and biological character.*
- *Classifications that group together rivers and streams, lakes and wetlands having similar ecological character.*
- *Estimates of human pressures and impacts on biodiversity status.*
- *Rankings of biodiversity value that indicate a minimum set of sites that would provide representative protection of a full range of freshwater ecosystems while taking account of both human pressures and connectivity*" (DOC 2010).

50. Figure 3 shows the indigenous fish ranking from the FENZ geodatabase averaged across the PC1 sub-catchments.

51. PC1 river sub-catchments with the top-ten best average indigenous fish rankings from FENZ include: Komakorau, Mangawara, Kirikiriroa, Awaroa (Waiuku), Matahuru, Awaroa (Rotowaro), Waitomo at Tumutumu, Waipā at Otorohanga, Waikato at Mercer (Rangiriri), and Ohote. Lake Waikare was ranked second for fish over all ecosystem types but was again removed to define the top-10 ranked river systems. Eight of the top-ten river sub-catchments identified for fish also sit within the 20 highest ranked sub-catchments using the averaged priority for protection ranks (Figure 2). The rankings indicate, as a minimum, where specific water quality attributes and targets should be set in PC1 to protect indigenous fish values over and above the water quality targets set for the whole of river water quality and broad ecosystem health value.

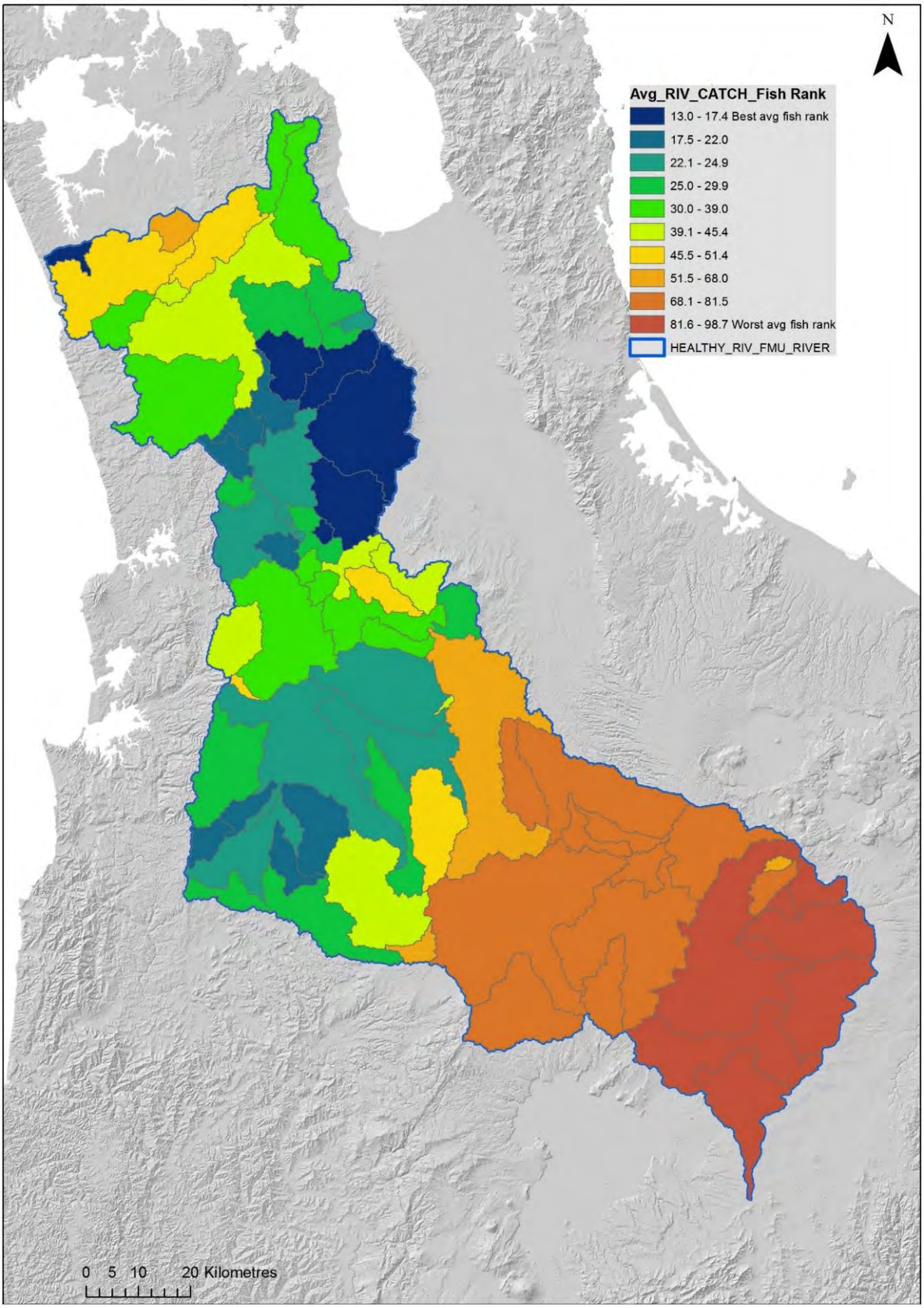

Figure 3. FENZ (Freshwater Ecosystems of New Zealand) priority indigenous fish rankings for the Waikato-Waipā River catchments.

Indigenous fish conservation threat status

52. The New Zealand Freshwater Fish Database, administered by NIWA, holds 11,930 fish survey records for the Waikato and Waipā River catchments from 1908 to 2018. To reflect the most recent fish occurrence, records from November 1998 to November 2018 were examined (8,629 records). The species recorded and their conservation threat status are listed in Table 1. There are sixteen species of indigenous fish found over the last twenty years in the Waikato and Waipā catchments. Twelve exotic species were found, a number of which are listed pest fish in the Waikato Region.

53. Of the sixteen indigenous fish, nine species have a conservation threat status of At Risk (six species Declining and one Naturally Uncommon) and two are Threatened and Nationally Vulnerable (shortjaw kōkopu and lamprey). There are a large number of relict (non-migratory) mudfish populations, which are not associated with riverine systems (B David - Waikato Regional Council Scientist, pers. comm.). Although usually diadromous (migratory), some of the large Galaxids and in some cases īnanga, have developed non-diadromous populations within the Waikato River catchment (David et al. 2018). Lake Waahi is an important site for non-diadromous recruitment of giant and banded kōkopu into the Waikato River, in combination with the high ranking for Lake Waikare and the occurrence of At Risk mudfish populations in many Waikato wetlands, highlights the need to consider connectivity of freshwater ecosystems to support ecosystem health and biodiversity values.

54. Sub-catchments closer to the coast and at lower elevation typically have higher priority rankings for indigenous fish because of the influence of the largely diadromous (migratory) New Zealand fish fauna (Jowett and Richardson 1996).

55. The New Zealand Threat Classification System uses nationally understood, consistent categories and criteria to assess the risk of extinction for all New Zealand species (Figure 4). Nationally, 74% of species in the indigenous freshwater fish fauna have an assigned threat status, this is considerably worse than the global average of 37% (Joy et al. 2018). The proportion of species classified as threatened or at risk of

extinction has been increasing over time in New Zealand, and negative trends in species occurrence were found in ~75% of freshwater fish species, 65% of these were significant declines and more species were declining in pasture sites than in natural cover sites, indicating that declines are primarily associated with land use and human activities (Joy 2009; Joy et al. 2018).

56. A recent international assessment of our freshwater flora and fauna concluded that New Zealand has "*one of the most endangered freshwater habitats in the world*"[5]. The increase in the number of species listed as threatened with, or at risk of extinction over the past 25 years gives some indication of the recent decline in fish occurrence and diversity nationally. Declines are now indicated in species that were once common, like longfin eel and īnanga. Allibone at el. (2010) warn that:

"*More serious effort is now required to reverse the decline in native freshwater fishes and to manage the instrumental causes of their decline that are ongoing, and in some cases increasing, if the extinction of further freshwater fish is to be prevented.*"

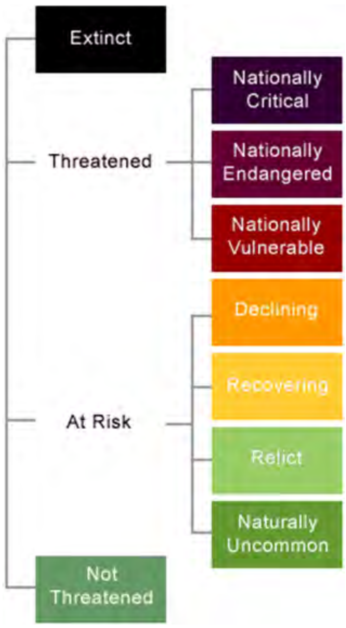

Figure 4. New Zealand Threat Classification System categories. Source: Department of Conservation.

[5] Freshwater Fish Specialist Group (2012). '2012 Annual Report.' (IUCN: Chester, UK.).

57. The leading causes of decline in indigenous fish in Aotearoa New Zealand have been identified as: degrading water quality, nutrient enrichment, water abstraction, invasive and exotic fish species, loss of habitat via land use, downstream barriers to migration, loss of riparian vegetation and river modification (Allibone et al. 2010; Joy et al. 2018; Canning 2018). Globally, the drivers of declines in fish diversity and abundance are human induced and include eutrophication (nutrient enrichment), habitat loss and population isolation through damming of rivers, flow alteration, habitat destruction, exotic species invasion, over-harvesting and climate change (Joy et al. 2018). The New Zealand fish fauna is under threat from these same global drivers.

58. Torrentfish, present in the Waikato and Waipā catchments, are the only member of their genus (*Cheimarrichthys*) world-wide and the only member of the family Pinguipedidae to inhabit freshwater globally. Thus, they have unique, intrinsic biodiversity value. There is mounting evidence in the freshwater fish database that torrentfish are declining in some large river systems, including the Manawatū River (*Dr R. Allibone; pers. comm.*).

59. Two species of kākahi (freshwater mussel) have been recorded in the Waikato-Waipā catchments:

- *Echyridella aucklandica* (Threatened - Nationally Vulnerable) in the Waikato River catchment but not the Waipā.
- *Echyridella menziesii* (At Risk - Declining) in both catchments.

60. There are also three other species of macroinvertebrates that are listed as Threatened - Nationally Vulnerable, one Threatened - Nationally Critical, and ten At Risk and Data Deficient (Grainger et al. 2014).

61. Given the state of indigenous fish nationally and poor fish diversity and threat status compared to global trends, remaining habitats with high diversity (species richness), intact indigenous fish communities are of significant biodiversity value in New Zealand.

Table 1. Freshwater fish and large invertebrate taxa found in New Zealand Freshwater Fish Database records for the Waikato and Waipā River catchments between 1998 and 2018, conservation threat status (Dunn et al. 2018; Grainger et al. 2014) and migration strategy[6].

Common name	Taxonomic name	Conservation threat status	Migrate?
Indigenous fish			
Banded kōkopu	*Galaxias fasciatus*	Not threatened	Y
Black mudfish	*Neochanna diversus*	At risk, declining	N
Common bully	*Gobiomorphus cotidianus*	Not threatened	Y
Cran's bully	*Gobiomorphus basalis*	Not threatened	N
Giant bully	*Gobiomorphus gobioides*	At risk, naturally uncommon	Y
Giant kōkopu	*Galaxias argenteus*	At risk, declining	Y
Grey mullet	*Mugil cephalus*	Not threatened	Marine
Īnanga	*Galaxias maculatus*	At risk, declining	Y
Kōaro	*Glaxias brevipinnis*	At risk, declining	Y
Lamprey	*Geotria australis*	Threatened, nationally vulnerable	Y
Longfin eel	*Anguilla dieffenbachii*	At risk, declining	Y
Redfin bully	*Gobiomorphus huttoni*	Not threatened	Y
Shortfin eel	*Anguilla australis*	Not threatened	Y

[6] A number of usually migratory fish have established non-diadromous, self-sustaining populations in the Waikato catchment, e.g. large Galaxids and īnanga (David et al. 2018).

Shortjaw kōkopu	*Galaxias postvectis*	Threatened, nationally vulnerable	Y
Torrentfish	*Cheimarrichthys fosteri*	At risk, declining	Y
Yelloweye Mullet	*Aldrichetta forsteri*	Not threatened	Marine
Indigenous invertebrates			
Freshwater shrimp	*Paratya curvirostris*	Not threatened	
Kākahi	*Echyridella menziesi*	At risk, declining	
	Echyridella aucklandica	Threatened, nationally vulnerable	
Kōura	*Paranephrops planifrons*	Not threatened	
Exotic fish (some of which are listed as pest species in the Waikato Region)			
Brook char	*Salvelinus fontinalis*	Introduced and naturalised	
Brown bullhead catfish	*Amiurus nebulosus*	Introduced and naturalised	
Brown trout	*Salmo trutta*	Introduced and naturalised	
European carp	*Cyprinus carpio*	Introduced and naturalised	
Gambusia	*Gambusia affinis*	Introduced and naturalised	
Goldfish	*Carassius auratus*	Introduced and naturalised	
Grass carp	*Ctenopharyngodon idella*	Introduced and naturalised	
Guppy	*Poecilia reticulata*	Introduced and naturalised	
Perch	*Perca fluviatilis*	Introduced and naturalised	

Rainbow trout	*Oncorhynchus mykiss*	Introduced and naturalised	
Rudd	*Scardinius erythrophthalmus*	Introduced and naturalised	
Tench	*Tinca tinca*	Introduced and naturalised	

Outstanding freshwater bodies

62. The submission of the Director-General identifies some waterbodies in the Waikato-Waipā catchments that should be considered outstanding under the NPS-FM framework. Outstanding freshwater bodies and the management of their water quality requires that the significant values of these waterbodies are identified, so that they can be protected through regional plans.

63. The Director-General's submission identifies the Waikato River, river mouth and delta, Whangamarino Wetland, the Waitomo River/caves Karst system, the Waikato Peat Lakes and Lake Rotokotuku as outstanding freshwater bodies. The Whangamarino wetland is covered in the evidence of Dr Robertson, while Dr Phillips' evidence discusses the Waikato Peat Lakes and Lake Rotokotuku.

64. With respect to the river systems identified in the submission as outstanding freshwater bodies, the Waikato River, river mouth and delta are identified for cultural, historic and aesthetic values as well as a high diversity of freshwater and estuarine indigenous species. The Waitomo karst system values are identified in the submission as nationally rare systems, karst system caves and cracks are also classified as 'nationally threatened' uncommon ecosystems by Holdaway et al. (2012) as they are subject to local threats from agricultural water pollution and recreational activities. The Waitomo River sub-catchment upstream of Tumutumu ranks highly for indigenous fish values in the FENZ assessment.

65. There is no standardised method for determining whether a river is 'outstanding' in New Zealand. Water Conservation Orders provide some guidance on 'outstandingness' in freshwater systems. Furthermore,

there are no objective or recognised criteria to assist in determining whether specific ecological values such as indigenous fish populations, communities or habitats are outstanding or significant. However, recent research on the state of indigenous fish communities at the national level (Canning 2018; Joy et al. 2018) and the significant national declines in fish diversity and community 'intactness' reported by Joy et al. (2018) lead to the conclusion that representation of the full range of freshwater ecosystems, fish community intactness and priority for protection and/or restoration are relevant criteria for considering whether particular waterbodies can be considered 'outstanding' in the regional or national context and whether these values are significant, requiring protection.

66. Further to this, in developing criteria for outstanding ecological values in freshwater bodies, Maseyk et al. (2018)[7] considered the following in their advice to Bay of Plenty Regional Council on identifying outstanding freshwater bodies under the NPS-FM (Objective A2) framework:

"Harper (2017) states that it is inappropriate to identify an [Outstanding Fresh Water Body] OFWB based on the presence of significant values. We do not share this view because in some circumstances the presence of significant values would be adequate to pass an 'outstanding' test. However, we acknowledge that this would only apply to some significant values, and most significant values would not automatically equate to 'outstandingness' in isolation from other considerations.

For example, were a freshwater body to possess any of the following significant ecological values, it should also be considered outstanding: intact indigenous fish communities; habitat for 'threatened – nationally vulnerable' indigenous fish; intact submerged aquatic plant communities; naturally uncommon ecosystems that are critically endangered or endangered. These important ecological values identify an OFWB because:

- *They comprise whole freshwater communities, habitats, and ecosystems, and the majority of critical ecological components to provide for the value as a whole.*

[7] I am a co-author of this work.

- *They warrant protection due to their important ecological contribution to freshwater values nationally (they are regionally rare and/or threatened nationally).*
- *Without identifying OFWBs that contain these values,* ***the national range and breadth of freshwater ecological values will be irreparably diminished****."* [emphasis added]

67. The contribution of a particular waterbody to regional or national ecological values and the potential for the regional or national range and breadth of ecological values to be "irreparably diminished" if the values in a waterbody are not protected is particularly relevant to considering 'outstandingness' under the NPS-FM objectives (A2 and B4).

68. In the case of the Waikato and Waipā Rivers, there is clear evidence of sub-catchments with intact indigenous fish communities (high FENZ indigenous fish rankings), with high priority for protection of the full range of freshwater ecosystems nationally, and unique and distinctive biodiversity characteristics, including species with assigned conservation threat status. In my opinion, these criteria lead me to the conclusion that some areas of the Waikato-Waipā catchments can be considered outstanding freshwater bodies for ecological values and that these values can also be considered significant.

69. Identification of OFWB within the Waikato-Waipā catchments is an important consideration for PC1 because of the NPS-FM objective A2 specifically requiring the maintenance and improvement of water quality to *protect* the significant values of OFWB and wetlands. Because PC1 addresses water quality across the Waikato-Waipā catchments, some of which can be considered outstanding, mechanisms to protect those significant values are needed in PC1 to ensure water quality targets are consistent with the objective in the NPS-FM to 'protect' those values. Without identifying OFWB in the PC1 catchments there is a risk that water quality targets may not be adequate to *protect* significant ecological values.

70. This is particularly relevant because significant ecological characteristics (sitting under the overarching value of ecosystem health) have not been identified or provided for in the proposed PC1 approach to water quality.

71. The Waikato River delta and mouth are significant habitats for the ecological health and integrity of the Waikato River as a whole as they are critical to the spawning success of īnanga and recruitment into the wider Waikato catchment, and as juvenile habitat and migratory pathways for all diadromous fish inhabiting the whole catchment (Table 1).

72. Īnanga are a key freshwater fish species that are at risk and declining in population nationally (Dunn et al. 2018). They comprise the largest proportion of the five indigenous fish which make up the whitebait catch in New Zealand (and in the Waikato), and thus have high cultural value as mahinga kai species in addition to their intrinsic ecological value. Īnanga are obligate estuarine spawners in most cases (although see David et al. 2018). Adult īnanga migrate into lower river and estuarine habitats to lay eggs on inundated marginal vegetation during high spring tides (Photo 1). Eggs mature in humid conditions within vegetation and larvae are washed out to sea to develop into whitebait on subsequent spring tides.

73. Threats to īnanga spawning habitats include stock access to riparian vegetation, physical alteration of inundated margins, sedimentation of spawning sites, predation and poor water quality, affecting adult, larval and juvenile life-stages. To protect this significant value, spawning habitats require stock exclusion, adequate riparian vegetation, natural bank and inundation profiles and good water quality in the lower river, mouth and delta.

74. Good water quality and low sedimentation is also needed to provide for juvenile habitat and migration values of indigenous fish into and through the lower river, mouth and delta, in order to sustain populations of diadromous freshwater fish (and thereby ecosystem health values) throughout the Waikato and Waipā River catchments. Ecological values in the river and estuary are inextricably connected.

75. Outstanding freshwater bodies require a more stringent level of water quality than that provided for by the PC1 targets, in order to protect their significant values.

Photo 1. Īnanga eggs spawned within riparian vegetation. *Science Learning Hub, University of Canterbury.*

WATER QUALITY ATTRIBUTES LIMITS AND TARGETS

Relationship between values and attributes

76. The setting of freshwater objectives and water quality limits and targets are one method available for Plans to protect (in outstanding freshwater bodies), maintain (where they are currently in a good state) or improve (where degraded) freshwater values, and in the case of PC1 to assist in achieving the goals of the Vision and Strategy for a healthy, swimmable, and fishable Waikato River. Water quality limits and targets ideally should reflect the desired state or change in state of water quality which a Plan intends to achieve over time. They are the plan's numerical measures of success in providing adequate water quality to support the values.

77. The s42A report amendment to the original explanatory note for Table 3.11-1 states: "The values and uses set out below apply to all FMU's unless explicitly stated, and provide *background* to the freshwater

objectives, and the attributes and attribute states outlined in Table 3.11-1.' [emphasis added]. It is best practice to ensure that the linkage between values and freshwater objectives/attributes is clear and explicit in freshwater plans, not contextual 'background' information.

78. In my view, the page of explanatory notes[8] for Table 3.11-1 is unnecessary and should be removed from PC1. Whilst the explanations of water quality may appear to provide some useful context with respect to Table 3.11-1, the text gives only limited examples and does not comprehensively describe the variability in water quality across the Waikato-Waipā catchments. The explanatory notes are of limited benefit for technical or planning interpretation of Table 3.11-1. It is usual practice for this type of explanatory information to sit within an external technical report which specifically addresses and details the use of the attributes and targets in a comprehensive manner across all sub-catchments, not within the plan document.

79. There is a natural progression of steps detailed in the NPS-FM flowing from defining FMUs, identifying values (including spatial identification) and setting of objectives, limits and targets. Water quality attributes, limits and targets need to be set at levels which will achieve the desired state of the values (Figure 5) and will guide the plan's methods (policies, rules and non-regulatory methods). In my view the Vision and Strategy and the NPS-FM process are not mutually exclusive and are well-aligned with respect to values. The NPS-FM provides current national guidance on freshwater plan development. Following the NPS-FM process does not undermine the Vision and Strategy, rather it enables a robust process, consistent with achieving freshwater values over time.

[8] Page 15 of the s42A recommended track changes version of PC1.

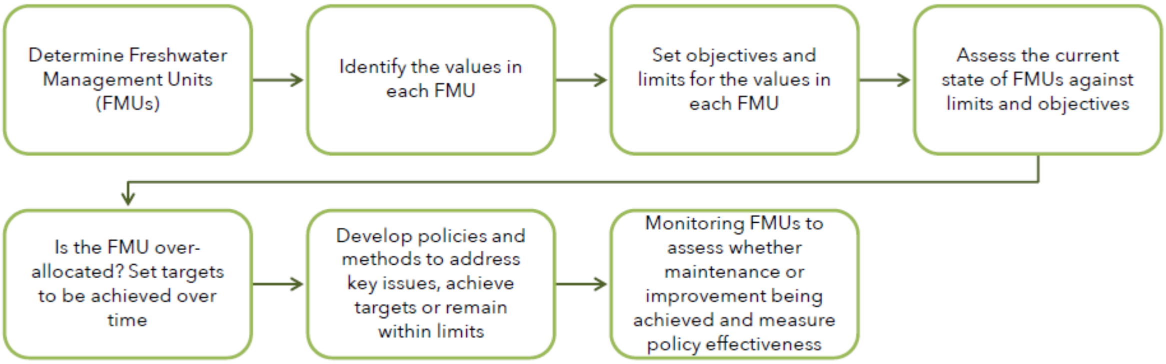

Figure 5. Summary of the steps required to follow the NPS-FM process in regional plans.

Appropriate scale to identify values and apply attributes

80. Water quality attributes, limits and targets cannot be set to achieve values without specific consideration of the critical needs of those values and the spatial location of where they apply in catchments. Identifying values at the general 'whole of catchment' level and then setting general water quality limits and targets at that same scale carries a significant risk that critical values will not be provided for at the sub-catchment or tributary scale and is inconsistent with Objective CA1(b) of the NPS-FM to recognise regional and *local* circumstances and the subsequent associated policies.

81. The section 42A report[9] notes that the development of attributes was undertaken in "general accordance with policy CA2 of the NPS-FM". The s42A report goes on to attempt to describe the Collaborative Stakeholder Group (CSG) setting of attributes in relation to the compulsory national values (ecosystem health and human health for recreation) but the paragraph and justification in the following sections are incomprehensible.

82. In developing water quality attributes, the Technical Leaders Group (TLG) and an expert panel convened for the development of attributes, applied five principles[10] developed by MfE officials and the NOF Reference Group to assess the suitability of attributes for the National

[9] Paragraph 529.
[10] These principles are outlined on pages 9-10 of Scarsbrook (2016) Water Quality Attributes for Healthy Rivers: Wai Ora Plan Change.

Objectives Framework (NOF) in the NPS-FM (2014). The principles were drafted specifically for attribute development in *national* policy[11].

83. Principle 5, the ability to model the social, cultural and economic outcomes, has significantly hampered development of a suitable suite of environmental bottom lines in the NOF across the attributes critically associated with ecosystem health. Criticism was raised (including from within the NOF Reference Group itself) that testing attributes through these 'gateways' meant ecosystem health was not adequately provided for across the group of attributes that made 'the cut'. The application of Principle 5 has been *ad hoc* in the NOF process (author's own observation), with some attributes not modelled included in the NOF anyway and others abandoned because the modelling was deemed too difficult.

84. Use of principles developed specifically for national policy instruments, instead of applying the NPS-FM section CA process, appears to have also hampered a full assessment of the attributes needed to maintain or improve ecosystem health values in the Waikato-Waipā.

85. In the development of PC1 the critical characteristics of the values at the sub-catchment scale were not taken into account when determining a suitable set of attributes for water quality and specific management of the tributaries for these values was excluded. Rather, a catchment-wide or broad river-type context was used which reflects outcomes for the Waikato mainstem. As a result, attributes that could be highly relevant to supporting the values at the finer sub-catchment scale have not been included in Table 3.11-1, and in many cases the water quality attributes and targets set (both short term and long term) are inadequate to provide for a good state of ecosystem health and thereby the full range of freshwater ecosystems, sustainable populations and communities of indigenous fish and threatened species in the tributaries themselves.

[11] Section 32 of the RMA requires evaluation and examination of whether a proposed approach is the most appropriate way to achieve the purposes of the Act or to meet the objectives, and assessing the scale and significance of the environmental, economic, social, and cultural effects that are anticipated from the implementation of a proposal. In the author's view such an evaluation is appropriate to apply to assess the plan's methods, not to 'gate-keep' the application of water quality attributes.

86. Changes to the water quality attributes and targets are recommended in the following sections. The recommended changes to existing attributes in Table 3.11-1 were based on analysis of the top-twenty priority ranked sub-catchments (from West et al. 2018), top-ten ranked sub-catchments for indigenous fish (FENZ) and better alignment with *E. coli* attributes from the 2017 amendments to the NOF. Recommended changes to existing attributes are found in Appendix 1.

87. Further attributes are recommended for all sub-catchments to support ecosystem health, recreational and mahinga kai safety with respect to cyanobacteria risk (Appendix 2). Consideration was given to including attributes specific to sub-catchments and tributaries with hard-bottomed streams, susceptible to nuisance periphyton growth, deposited sediment and associated water quality stressors. Species protection levels for metals, metalloids and other toxicants are also recommended for sub-catchments affected by urban and industrial contaminants to provide for critical ecological values and a baseline level of ecosystem health in these waterbodies. These protection levels were sourced from the ANZECC (2000) guidelines.

Hard-bottomed streams and management of tributaries

88. The 'whole of catchment' approach taken to setting water quality attributes assumes that broadly all waterbodies in the Waikato-Waipā catchments are soft-bottomed. This approach excludes adequate consideration of the following factors: nuisance periphyton, benthic cyanobacteria, deposited sediment and associated water quality stressor effects on benthic macroinvertebrates, ecosystem health and other values in those waterbodies which are not soft-bottomed and may be adversely affected by poor water quality for these attributes.

89. Naturally hard-bottomed waterbodies need to be identified in order to better ensure ecosystem health and associated recreational and cultural values are supported in all tributary waterways in the Waikato-Waipā Rivers. Suitable water quality attributes and targets for these waterbodies are recommended below at Appendix 2.

90. In the Waikato-Waipā catchments there are numerous waterbodies that are not naturally soft-bottomed systems. Tributaries of the Waikato River are often hard-bottomed, including:

- upper Waiotapu,
- upper Kawaunui,
- Otomakokore,
- Whirinaki,
- Tuhunaatara,
- upper Makino,
- Whakauru,
- Pokaiwhenua,
- Little Waipa,
- Mangawhero,
- Mangaohoi,
- Mangaonua,
- Mangatangi,
- Mangatawhiri,
- Whakapipi,
- Opuatia,
- Waipā mainstem upstream of Pirongia,
- Mangaokewa,
- Mangatutu,
- Mangaohoi, and
- Manguika.

91. Nuisance benthic periphyton may proliferate in these waterbodies[12] if dissolved nutrient contaminants are not managed, resulting in adverse effects on ecosystem health via direct physical changes to instream habitat and macroinvertebrate community health, or changes to critical stressors such as diurnal fluctuation in dissolved oxygen and pH. In soft-bottomed streams, elevated nutrients may also contribute to the proliferation of nuisance macrophytes, with similar adverse outcomes for habitat, flow, dissolved oxygen and other stressors.

[12] Nuisance periphyton is noted to affect some of the above listed sites in the LAWA database.

92. Of particular concern is the lack of management of water quality in the tributaries of the Waikato River, including the whole Waipā catchment. Values apply to all waterbodies in all FMUs of the catchment, however water quality is significantly degraded in many tributaries and will not be maintained or improved to support the values in the tributaries themselves. Tributary ecosystem health values have been essentially excluded by the PC1 approach. This does not appear to be consistent with the Vision and Strategy or the NPS-FM.

93. In addition to permissive management of nitrate and ammonia toxicity effects (discussed below), the trophic state of all of the tributaries and management of the nutrients, which contribute to deteriorating trophic state and stressors such as dissolved oxygen have not been included in the targets or the management actions of PC1. Furthermore, species protection levels have not been considered for toxicity attributes and targets for metals, metalloids and other toxicants. In areas affected by urban or industrial contaminants (diffuse and point source), toxicity from contaminants other than nitrate and ammonia can cause significant adverse effects on ecosystem health values.

94. Indicators of ecosystem health such as MCI are also useful attributes for inclusion in PC1. The NPS-FM now requires Regional Councils to develop methods to address waterbodies where MCI is less than 80 or there is a degrading trend. A number of waterbodies in the Waikato catchment have poor MCI (<80) and/or declining trends.

95. The PC1 approach fails to manage the potential for nuisance periphyton or macrophytes in tributary waterways and the whole of the Waipā catchment and thus the only attributes associated with ecosystem health are nitrate and ammonia toxicity in these waters. It is unclear how this approach will provide for indigenous species or ecosystem processes across the full range of ecosystem types or for cumulative effects on downstream receiving environments such as the river mouth and delta. This is a key concern given the plan's definitions of ecosystem health and mahinga kai values specifically reference indigenous fish and other indigenous species for their intrinsic and human use values, and these values apply to all waterbodies.

96. In order to achieve the goals of the Vision and Strategy and the NPS-FM (and arguably the RMA itself) for healthy biodiversity, swimmability and fishability in the Waikato and Waipā Rivers, further attributes, targets and methods need to be included in PC1 for all tributaries.

97. Nutrient, stressor and biological attributes, limits or targets need to be set for all waterways to make a positive contribution to water quality in the Waikato River and to support values at the *local* level within the Waipā catchment and Waikato tributaries themselves. This is particularly relevant, for example, when patterns of fish diversity are taken into account. Tributaries play an important role as fish habitat, particularly those closest to the sea. Without adequate water quality and habitat availability the tributaries of the Waikato and the entire Waipā catchment are unlikely to maintain or improve in terms of ecosystem health. Consequences with respect to declining or threatened fish and invertebrate species may be irreversible in the long-term if the effects of water quality on population health and viability of these species are not considered.

Appropriate water quality attributes for PC1

Trophic state, nitrate, ammonia and clarity attributes – Table 3.11-1

98. The mainstem of the Waikato River is critical to sustaining ecosystem health and associated values for the whole of the catchment (Pingham et al. 2012a, 2012b; Pingham 2014; Pingham et al. 2014). Water quality in the mainstem is compromised by elevated sediment loads, nitrogen and phosphorous, planktonic algae, and in the mid to lower reaches faecal contaminants. Nutrient enrichment contributes to elevated phytoplankton biomass (algae). Nitrate and ammonia concentrations in the mainstem are generally not of direct toxicity concern. However, tributaries contribute large loads of these contaminants which cumulatively affect the Waikato River mainstem ecosystems, as well as degrading water quality and affecting ecosystem health within the tributaries themselves.

99. Long term trends in water quality (Vant 2018) show increasing turbidity at three sites (Taupō Gates, Ohaaki and Mercer) and deteriorating total nitrogen at nine out of ten sites on the mainstem (all except Taupō

Gates) and two-thirds of all sites in the catchment, particularly in the upper catchment tributaries. Ammonia trends all showed improvement[13]. Six sites on the mainstem (downstream of Waipapa) showed improvement in chlorophyll *a* (measure of phytoplankton biomass). Faecal contaminants and water clarity showed improving and deteriorating trends depending on the site. Slight deterioration in dissolved oxygen was observed by Vant (2018) at five out of six sites.

100. Planktonic algae, total nitrogen and total phosphorus are managed in the mainstem of the Waikato using the lake-fed attributes from the NOF. Some of these are set in Table 3.11-1 for maintenance of current water quality, while others are targeted for improvement.

101. Clarity targets are also set for all mainstem sites. While the relationship between sediment load, turbidity and clarity is not direct, improvement in turbidity and reduction in sediment load should contribute indirectly to improvements in clarity (Dupree 2017). Clarity targets were set based on the work of Smith and Davies-Colley (1992).

102. In many of the tributaries of the Waikato and Waipā Rivers nitrate, ammonia, faecal contaminants and water clarity all need significant improvement from the current state (Tulagi 2017; Vant 2018; LAWA 2019). At some sites, ammonia and nitrate are already at levels that can cause toxicity effects on some species and the species protection level associated with the proposed nitrate and ammonia targets in PC1 are not adequate to support healthy, diverse freshwater ecosystems or prevent further deterioration in threatened or at risk fish.

103. Despite the poor current state, some sub-catchment sites have permissive nitrate and/or ammonia targets and do not appear to be planned for substantial improvement over that period. While the small improvements anticipated by tributary sub-catchment targets for nitrate and ammonia toxicity may assist with reducing concentrations in the Waikato River mainstem, it is unlikely to result in positive outcomes for ecosystem health or mahinga kai values in the tributaries themselves.

[13] However, improvements were offset by increasing trends in nitrate nitrogen and contributing to total nitrogen increases.

104. There are inconsistencies in the desired state (short term and 80 year targets) for nitrate and ammonia toxicity between the annual medians and 95th percentiles/annual maximums respectively. To ensure certain outcomes for ecosystem health and a known level of toxicity effect, median and 95th percentile or maximum values should represent the same 'band' from the NOF attribute framework for these contaminants, to ensure a consistent level of species protection. For example, nitrate improvements required for Kawaunui and Mangamingi Streams are not consistent (i.e. median requires improvement to a NOF B band state and 95th percentile requires improvement to an A band state). To ensure ecosystem health values are provided for I recommend both attribute measures are improved to an "A" state by changing the 80-year target for nitrate (median) to 1.0 mg/m^3. The same type of inconsistency applies to ammonia toxicity targets in the Waiotapu, Mangaone, Waitawhiriwhiri, Komakorau, and Whakapipi Streams and should be rectified in Table 3.11-1.

105. Inconsistencies in the targets for total nitrogen, total phosphorous and trophic state attributes are also found in the Waikato FMUs. For the Waikato at Narrows and Waikato at Horotiu the trophic state, total nitrogen and total phosphorus attributes aim for B band while toxicity attributes are aiming for an A band. Trophic state targets should be consistent with toxicity targets to achieve an "A" state of Ecosystem Health. For the Waikato at Huntly, Mercer and Tūākau the trophic state is also inconsistent with toxicity band states. Chlorophyll *a*, total nitrogen and total phosphorus 80-year targets should aim for the lower threshold of the A band, rather than the B band for trophic state.

106. In some cases, short term improvements are unlikely to result in outcomes which support ecosystem health values. For example, in the upper Waikato FMU, Waiotapu and Mangamingi sub-catchment ammonia and nitrate toxicity targets allow for acute and chronic toxicity effects on growth of 5-20% of species (particularly sensitive species such as fish).

107. Some sites do not have attribute targets applied for each sub-catchment. For example, in the upper Waikato FMU there is no short term target for trophic state (chlorophyll *a*) for the Waikato River at

Whakamaru and there are no clarity targets for the Torepatutahi or Waiotapu sub-catchments. There is no clarity target for the Waikato River at Mercer. Targets need to be set for these sub-catchments, even in the absence of current data, to ensure the values are provided for in these waterbodies over the short and 80 year terms.

E. coli and risks from faecal bacteria

108. *E. coli* targets are also set in Table 3.11-1 for the Waikato mainstem sites. These targets have been superseded by the amendments to the NOF in 2017 and should be reviewed to ensure they are consistent with national policy direction for regional and national swimmability targets.

109. Water quality in the lower Waikato River below Ngāruawāhia was given a C- grade in the Waikato River Authority Report Card in 2016, indicating that "people are exposed to a moderate risk of infection (less than 5 per cent risk) from contact with water during activities with occasional immersion and some ingestion (such as wading and boating)". Within the tributaries an overall D grade was given to water quality, indicating the risk of infection is greater than 5 per cent (Williamson et al. 2016). These risks are associated with secondary contact with water, whilst the values for recreation and mahinga kai relate to primary contact (full immersion), consistent with the 2017 amendments to the NOF to improve 'swimmability'.

110. To ensure safe recreational and cultural use values, and to align microbiological outcomes with national 'swimmability' targets, the minimum *E. coli* attribute states for the yellow band from the 2017 amendments to the NOF are recommended to replace the *E. coli* targets in Table 3.11-1.

111. In the Waipā River and Waikato tributaries, long-term (80-year) *E. coli* targets are not consistent with safe primary contact recreation in tributary waterbodies. Long-term clarity targets for the Waipā catchment and all Waikato tributaries are often within the range considered "unsuitable for bathing use" by Smith and Davies-Colley (1992) and may adversely affect aquatic life, reducing the ability for some fish to site feed.

112. Appendix 1 of my evidence contains changes to existing water quality attributes states and targets by sub-catchment for Table 3.11-1 which better reflects a healthy state for ecological values and recreational or mahinga kai use values at the sub-catchment scale.

Additional water quality attributes and targets for PC1

113. By focusing on only four contaminants (nitrogen, phosphorous, sediment and *E. coli*) Table 3.11-1 excludes additional water quality attributes that are critical to providing for ecosystem health and recreational and cultural values such as mahinga kai. The exclusion of critical water quality attributes undermines the ability of PC1 to ensure all freshwater values are adequately provided for. In my view it is more consistent with the Vision and Strategy and the NPS-FM to set the attribute scope to support the values. Attributes are the means by which the values are achieved, they are not an outcome in and of themselves.

114. The following sections discuss additional water quality attributes and targets that I recommend be addressed in PC1 and Table 3.11-1. These proposed attributes and targets are contained in Appendix 2 of my evidence.

Cyanobacteria

115. Potentially-toxic blue-green algae (cyanobacteria), which can dominate the phytoplankton assemblage in the lower Waikato River during summer months, may pose a risk to public health when biomass is high (Waikato Regional Council, 2017). High cyanobacteria biomass in the lower river originates mostly from blooms in the upstream hydro lakes or shallow riverine lakes (Neilson et al. 2018). Inclusion of the NOF planktonic cyanobacteria attribute and targets for cyanobacteria are recommended for inclusion in the mainstem of the Waikato River to provide for safe recreational and mahinga kai use values. Likewise, benthic cyanobacteria may proliferate and cause toxic effects in hard bottomed streams. Recommended targets from the national guidelines (MfE/MoH 2009) are included in Appendix 2.

Deposited fine sediment

116. Despite being a priority in the vision and strategy, sediment limits or methods are not proposed in Table 3.11-1. Clarity attributes are proposed as outcomes although it is unclear how these will be met.

117. Deposited fine sediment is critical to the ecosystem health in many stream types. It is the fine sediment (<2mm diameter sands and silts) that drops out of suspension and deposits on, or in, the coarser bed sediments of naturally hard-bottomed streams. Deposited sediment can have aesthetic, cultural and recreational effects. It is also of considerable ecological interest because deposited sediment smothers benthic macroinvertebrates; clogs the gills of fish and invertebrates; and reduces the ability of fish to feed, find refuge or spawn within the gravels of river beds. Sedimentation in pasture streams also reduces available stream width and habitat (Davies-Colley 1997).

118. Indigenous fish and macroinvertebrates need access to the hyporheic zone, the zone beneath the bed of rivers where shallow groundwater flows. The hyporheic zone provides refuge to indigenous fish during droughts and floods. Indigenous fish have been found to burrow deep into the gravels of river beds, receiving essential dissolved oxygen from flow through the gravels at the surface (McEwan and Joy 2011; McEwan and Joy 2013a, b and c). Deposited sediment is the greatest threat to species that inhabit or utilise gravels (e.g., *Gobiomorphus spp.* bullies and shortjaw kōkopu) as it blocks the interstitial spaces (the spaces between the gravel particles), reducing flow, dissolved oxygen, macroinvertebrate food sources and habitat.

119. Clapcott et al. (2011) developed a guideline for fine deposited sediment in rivers, based on a large body of international and New Zealand literature and national data. The guideline applies only to naturally hard-bottomed rivers and streams and is the basis for the recommended deposited sediment attribute in Appendix 2.

Trophic state - periphyton

120. The trophic state of hard-bottomed streams and rivers is assessed using the periphyton biomass attribute in the NOF. Periphyton attributes

from the NOF and associated dissolved nutrient[14] limits and targets to achieve the periphyton attribute states are recommended in Appendix 2.

121. Dissolved nutrient attributes are needed along with deposited fine sediment because PC1 fails to adequately address the fundamental source and largest predictor of macroinvertebrate community composition and ecosystem health — land use (Clapcott and Goodwin 2014). In my opinion, this undermines the ecosystem health value in tributaries and thereby the Vision and Strategy and direction from the NPS-FM. Dissolved nutrients are the key factor (following flood frequency) controlling periphyton growth in nutrient enriched streams (Suren et al. 2003).

122. I have designed periphyton monitoring programmes, analysed data, and measured periphyton in many rivers for state of the environment and consent/compliance monitoring purposes across the central North Island and Nelson. There are two commonly used and complementary methods to determine the state of periphyton in rivers. The first is periphyton biomass, which is a measure of the amount of chlorophyll *a* (photosynthetic pigment) per unit area of the river bed. The second is periphyton cover, which assesses the type of periphyton (e.g., filamentous and mat algae) and proportion of cover of the bed of a river by type.

123. Chlorophyll *a* is measured in the laboratory and requires collection of rock scrapings of periphyton for analysis. Chlorophyll *a* has been used in many studies (both in New Zealand and internationally) to determine the effects of periphyton biomass on ecological communities. The disadvantages of measuring periphyton biomass include: the potential for bias in the collection of substrate scrapings (although there are standard protocols to address this); it is time consuming to collect in the field; samples need to be shipped to a laboratory on ice or frozen; laboratory testing adds costs to monitoring; and the return time for results can be weeks or months. The advantage of periphyton biomass is the

[14] Dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorous (DRP). The note for the nitrate toxicity attribute in the NOF states that dissolved nutrients will need to be more stringent to manage nitrate effects on trophic state (periphyton biomass).

more quantitative nature of the data and the ability to relate the results to the NOF and the science literature.

124. Periphyton cover is measured by in-stream visual observation in the field across measured transects, using standard protocols (Biggs and Kilroy 2000; Kilroy et al. 2008). There is some potential for between-observer bias, particularly if observers are not well trained. However, this bias has been shown to be much lower than expected (Kilroy et al. 2013) and periphyton percent cover is a scientifically supported, and recommended[15] alternative or complimentary method to periphyton biomass in New Zealand rivers, that is readily available to councils and others monitoring rivers.

125. The advantages of measuring periphyton cover include: it is easily collected in the field; observations of periphyton cover can be efficiently measured at the same time as fine deposited sediment and benthic cyanobacteria cover (i.e., *Phormidium autumnale*); there are no transport logistics for samples; there are no laboratory costs; if appropriate training is provided it can be used by tangata whenua and stakeholders to monitor their own rivers; and the results are almost instantaneous. Additionally, because the costs are significantly less than biomass monitoring, more sites can be included in periphyton cover assessments and it can be monitored more frequently at low cost. The disadvantage is that it is a semi-quantitative measure that cannot be directly related to the NOF trophic state attribute. However, both methods (biomass and cover), are complementary.

126. Matheson et al. (2012) developed provisional guidelines for periphyton cover in New Zealand rivers, associated with freshwater macroinvertebrate metrics (as a proxy for ecological condition), using the weighted composite cover method to classify states of ecological condition at sites where other stressors are minimal (Table 2). These guidelines update the MfE (2000) periphyton guidelines as they incorporate both mat and filamentous cover into one combined measure, the method was further confirmed by Matheson et al. (2016). This is a preferable approach to the MfE (2000) guidelines, as periphyton communities are often a mixture of mat and filamentous growth (Photo

[15] Periphyton cover is included in the MfE guidance on monitoring the NOF periphyton attribute.

2). Differentiating between the two types of cover to determine if guidelines are exceeded is difficult and impractical.

Table 2: Matheson et al. (2012) provisional guidelines for periphyton weighted composite cover percentage (periWCC) for classes of ecological condition in New Zealand rivers.

PeriWCC	Ecological condition
<20%	Excellent
20 – 39%	Good
40 – 55%	Fair
>55%	Poor

127. Managing periphyton is important because high biomass and cover of periphyton causes diurnal fluctuations in dissolved oxygen and pH due to the continued oxygen demand of cellular respiration throughout the night when oxygen-producing photosynthesis ceases (Photo 2). Low dissolved oxygen causes avoidance behaviour (fish will not enter low oxygen habitats), hypoxia (suffocation), and growth effects in fish (Richardson et al. 2001). Managing the maximum biomass and/or cover of periphyton and subsequent reductions in dissolved oxygen is needed to avoid hypoxic effects on indigenous aquatic life.

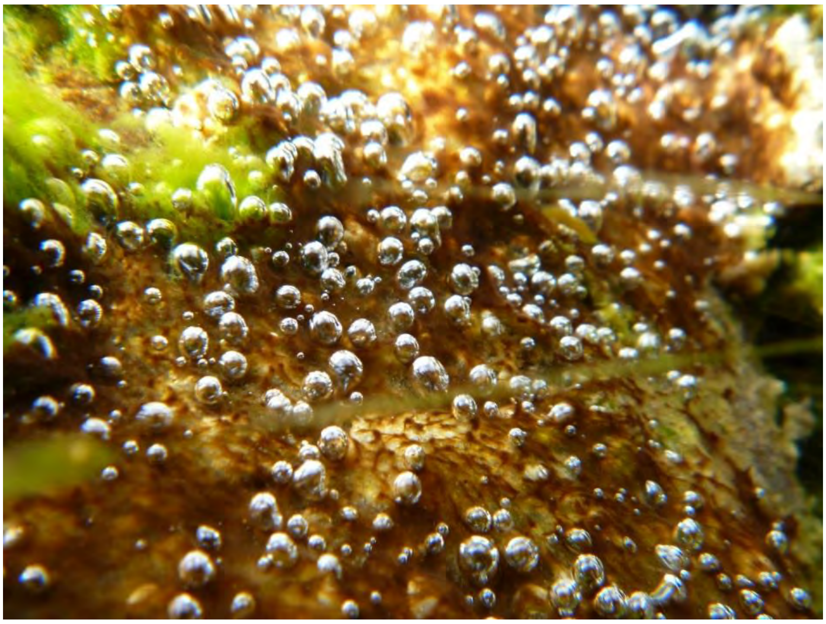

Photo 2: Mixed filamentous algae and cyanobacteria (mat) periphyton community giving off oxygen during photosynthesis. Kate McArthur - Wairere Stream, Whakapapa, 2014.

Dissolved oxygen

128. Dissolved oxygen is critical to aquatic life and is an attribute included in the NOF (albeit downstream of point source discharges at this stage[16]). Davies-Colley et al. (2013) reviewed the international and New Zealand literature and provided recommendations on stressors (dissolved oxygen, temperature and pH) to support varying levels of ecosystem health. This work is the most current and thorough assessment of these attributes relevant to water quality in New Zealand to ensure health, growth and survival of aquatic life in freshwater in Aotearoa New Zealand.

129. Appendix 2 contains recommended dissolved oxygen targets for all sub-catchments in the Waikato-Waipā Rivers for inclusion in PC1 to provide for ecosystem health values, consistent with the NOF approach in the NPS-FM and the recommendations of Davies-Colley et al. (2013). As a minimum these targets should apply to all sites on the Waikato River mainstem, although preferably sub-catchments should also have dissolved oxygen targets. Short term targets should as a minimum be above the national bottom line for dissolved oxygen to avoid direct anoxia and mortality of aquatic life.

Temperature and pH

130. Davies-Colley et al. (2013) developed thresholds for temperature and pH alongside dissolved oxygen. This work is the basis for the temperature and pH attributes recommended in Appendix 2.

Macroinvertebrate community index

131. Macroinvertebrate community structure is an important biotic component of ecosystem health and is required for consideration by councils in the NPS-FM (2017) under Policy CB1(ii) and Policy CB3. The macroinvertebrate community index known as MCI (Stark 1985), is a tool commonly used to indicate the health of macroinvertebrate communities in wadable rivers, as impacted by organic enrichment and other stressors such as periphyton, habitat, temperature and deposited

[16] The NOF Reference Group have consistently requested the dissolved oxygen attribute in the NOF apply to all waterbodies, not just those downstream of point sources, as is currently the approach within the NOF. Further work is underway to include this attribute more generally.

sediment. There are hard and soft bottomed variants of the index (Stark and Maxted 2007a) that can be applied depending on river type (Stark and Maxted 2007b), which are relevant to wadable rivers in the Waikato-Waipā catchments. The degradation or quality classes within the index provide a banding system consistent with the NPS-FM approach (Collier et al. 2014) and are recommended for inclusion as attributes in PC1.

Sediment targets and estuarine health

132. In setting water quality targets, consideration is also needed of the downstream receiving environment. This approach is supported by several requirements in the NPS-FM, including: Policy A1(iii), Objective C1, Policy C1(a), Policy C2(b), and the notes for use of the trophic state (periphyton) attributes in Appendix 2 of the NOF. Consideration of estuarine and coastal water quality is also implicit within the ki uta ki tai (mountains to the sea) principle. PC1 makes no mention of the health of estuarine or coastal ecosystems, which are a critical part of the river system as a whole.

133. Estuarine systems (including the Waikato River mouth and delta) are sensitive to nutrient and sediment loads from upstream catchments. The ecological values of the delta and river mouth are high, given they are critical habitats for spawning of īnanga, passage of migratory fish, habitats for juvenile freshwater species and habitats for resident or migratory estuarine and coastal species. The Director-General's submission identifies these habitats as outstanding freshwater bodies. The values of the Waikato River mouth and delta and the impact of sedimentation on estuaries are covered in the evidence of Ms Kettles.

134. In order to avoid, remedy or mitigate the adverse effects of nutrient and sediment on the river mouth and delta, consideration needs to be given to the capacity of the mouth and delta to receive nutrient and sediment loads and to reduce these loads if the capacity of the mouth and delta are exceeded. Further work is needed to ensure PC1 outcomes for sediment and nutrient loads to the river mouth and delta are managed for ecosystem health and other significant values.

Timeframes and timebound targets for water quality improvement

135. According to the s42A report[17] the short term 'targets' for water quality in Table 3.11-1 are not intended to align with a 10% improvement in water quality within a ten-year timeframe (i.e. by 2026). Rather, it is the management actions in the sub-catchments which are intended to be achieved in the ten-year 'short term' timeframe. This approach means that the short term 'targets' do not actually operate as targets in the PC1 framework as they are not timebound. Both the short term and the 80 year targets have now been reframed as attribute states in the s42A report recommendations (via changes to Objectives 1 and 3). The removal of the reference to water quality 'targets' further erodes certainty in the timing of outcomes for water quality.

136. As a result of this 'non-target' approach, a significant difficulty also arises in measuring the success of management actions, particularly in the short term. Questions arise from the approach, including: when will the short term 'targets' be achieved? How will we know when we 'get there' without specific, measurable and timebound water quality targets? Critically, it is unclear how it will be known if the management actions in PC1 are effective at changing the state of water quality in the short term. Good policy effectiveness monitoring requires development of measures of success at the outset of a planning cycle (Norton et al. 2010) to inform the next planning cycle that will be needed to continue to work towards the 80 year targets. Ideally, the water quality short term 'targets' would be a key measure of success of PC1.

137. However, the s42A recommended changes to the list of tables and explanatory notes to Table 3.11-1[18] further confuse the issue by using the terms 'limits' and 'targets' with respect to the short term water quality attributes. It is difficult to determine whether the short term attributes *are* limits and targets when trying to reconcile the explanatory text with the s42A report narrative and recommended changes to Objectives 1 and 3. If the short term water quality attributes are targets (which in my view they should be), they must be timebound, so that water quality changes from management actions are measurable at a defined time in the future.

[17] Section 42A report, paragraph 557.

[18] Page 15 of the recommended s42A track changes version of PC1.

138. If the intent of the short term approach in PC1 is a 10% improvement in water quality in the first ten years, the water quality targets should apply at a ten-year interval from the implementation of management actions within each sub-catchment, and at the latest by 2030. This gives a defined and timebound target for water quality that is certain and provides the ability to measure the success of the management actions that can be tested after ten years and for further actions to be evaluated and anticipated for the next Plan process to come.

139. It is not therefore unreasonable to expect that additional targets for improvement could be included in PC1 now, for implementation between the short term and 80 year water quality targets/attribute states. Without the inclusion of further direction between the short term targets and the 80 year water quality attributes states, a future that achieves the Vision and Strategy and provides for the values of the Waikato River as set out in PC1 is in jeopardy. The PC1 approach takes a 'miracle happens here' approach to the period between these two timeframes which is both inappropriate and uncertain.

140. Given this uncertainty it is also not unreasonable to expect that the short term targets should be stringent enough, and clearly linked to the values to ensure that irreversible damage will not occur in the short term. This is particularly critical with respect to ecosystem health, and as identified in the Director-General's submission, ensuring that values should include maintaining the representation of the full range of intact ecosystems, ensuring that threatened and at risk species continue to be sustained within the catchment and that the remaining intact indigenous fish communities are not imperilled by further water quality degradation.

CONCLUSION

141. It is difficult to establish a direct link between the water quality attributes and targets the plan proposes and the ecosystem health and mahinga kai values that are a foundation of PC1. The link between the proposed attributes and the goals of the Vision and Strategy relating to healthy biodiversity, swimmability and fishability in the Waikato and Waipā Rivers are also tenuous.

142. Management of the contaminants specified in the Vision and Strategy approach (nutrients, faecals and sediment) has not been appropriately carried through into PC1 for the majority of waterways, including the whole Waipā catchment and all tributaries of the Waikato. It is difficult to imagine how management without addressing trophic state, dissolved oxygen, deposited sediment, dissolved nutrient or biological attributes, limits or targets in these waterways will make a positive contribution to water quality in the Waikato River or at the local level within the Waipā catchment and Waikato tributaries. This is particularly relevant when patterns of fish diversity are taken into account. Tributaries play an important role as fish habitat, particularly those closest to the sea. Without adequate targets for water quality and addressing habitat availability in PC1, the tributaries of the Waikato and the entire Waipā catchment are unlikely to maintain or improve in terms of ecosystem health. Consequences with respect to declining or threatened fish and invertebrate species may be irreversible in the long-term.

Kate McArthur

15 February 2019

References

Allibone R, David B, Hitchmough R, Jellyman D, Ling N, Ravenscroft P, Waters J 2010. Conservation status of New Zealand freshwater fish, 2009. *New Zealand Journal of Marine and Freshwater Research 44*: 271 287.

ANZECC, ARMCANZ 2000. The Guidelines. Australia and New Zealand guidelines for fresh and marine water quality. http://www.environment.gov.au/system/files/resources/53cda9ea-7ec2-49d4-af29-d1dde09e96ef/files/nwqms-guidelines-4-vol1.pdf

Biggs BJF, Kilroy C 2000. Stream periphyton monitoring manual. Prepared for Ministry of the Environment. NIWA, Christchurch.

Canning AD. 2018. Predicting New Zealand riverine fish reference assemblages. PeerJ 6:e4890 https://doi.org/10.7717/peerj.4890

Clapcott JE, Young RG, Harding JS, Matthaei CD, Quinn JM, Death RG 2011. Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Cawthron Institute, Nelson, New Zealand.

Clapcott JE, Goodwin E 2014. Relationships between macroinvertebrate community index and environmental drivers. Report prepared for the Ministry for the Environment. Cawthron Institute Report No. 2507. Pp. 29.

Collier K, Clements B, David B, Lake M, Leathwick J 2010. Significant natural areas of the Waikato region: streams and rivers - Methodology and draft list of priority sites. Environment Waikato Technical Report 2010/19. Document #: 1480934.

Collier K, Clapcott J, Neale M 2014. A macroinvertebrate attribute to assess ecosystem health for New Zealand waterways for the national objectives framework – Issues and options. Environmental Research Institute report 36, University of Waikato, Hamilton. Pp. 32.

David BO, Jarvis M, Ozkundakci D, Collier KJ, Hicks AS, Reid M 2018. To sea or not to sea? Multiple lines of evidence reveal the contribution of non-diadromous recruitment for supporting endemic fish populations within New Zealand's longest river. *Aquatic Conservation: Marine and Freshwater Ecosystems* 2018:1–15 (*in press*).

Davies-Colley RJ 1997. Stream channels are narrower in pasture than in forest. *New Zealand Journal of Marine and Freshwater Research 31:* 599-608.

Davies-Colley R, Franklin P, Wilcock B, Clearwater S, Hickey C 2013. National Objectives Framework: Temperature, Dissolved Oxygen & pH Proposed thresholds for discussion. NIWA Client Report No: HAM2013-056. Prepared for the Ministry of the Environment.

Department of Conservation 2010. Freshwater Ecosystems of New Zealand. Department of Conservation, Wellington. http://www.doc.govt.nz/our-work/freshwater-ecosystems-of-new-zealand/

Dunn NR, Allibone RM, Closs GP, Crow SK, David BO, Goodman JM, Griffiths M, Jack DC, Ling N, Waters JM, Rolfe JR 2018. Conservation status of New Zealand freshwater fishes, 2017. *New Zealand Threat Classification Series 24*. Department of Conservation, Wellington. 11 p.

Dupree C 2017. Sediment Attribute Stage 1b Proposed classification for suspended sediment Prepared for Ministry for the Environment. NIWA Client Report No. 2017076HN.

Grainger N, Collier K, Hitchmough R, Harding J, Smith B, Sutherland D 2014. Conservation status of New Zealand freshwater invertebrates, 2013. New Zealand Threat Classification Series 8. Department of Conservation, Wellington. 28 p.

Hickey CW 2016. Guidelines for the protection of aquatic ecosystems, toxicant trigger values: nitrate – freshwater. Australian and New Zealand guidelines for fresh and marine water quality. Draft August 2016. Council of Australian Governments Standing Council on Environment and Water, Canberra, ACT, Australia. 26 pp.

Holdaway RJ, Wiser SK, Williams PA 2012. Status assessment of New Zealand's naturally uncommon ecosystems. Conservation Biology 26(4):619–629.

Jowett IG, Richardson J 1996. Distribution and abundance of freshwater fish in New Zealand rivers. *New Zealand Journal of Marine and Freshwater Research 30*: 239-255.

Joy, MK 2009. Temporal and land-cover trends in freshwater fish communities in New Zealand's rivers: an analysis of data from the New Zealand Freshwater Fish Database – 1970 – 2007. Prepared for the Ministry for the Environment, Wellington, 17 p.

Joy MK, Foote KJ, McNie P, Piria M 2018. Decline in New Zealand's freshwater fish fauna: effect of land use. Marine and Freshwater Research https://doi.org/10.1071/MF18028. CSIRO Publishing.

Kilroy C, Biggs B, Death R 2008. A periphyton monitoring plan for the Manawatu-Wanganui Region. Report prepared for Horizons Regional Council. NIWA Client Report CHC2008-03.

Kilroy C, Booker DJ, Drummond L, Wech JA, Snelder TH 2013. Estimating periphyton standing crop in streams: A comparison of chlorophyll a sampling and visual assessments. *New Zealand Journal of Marine and Freshwater Research 47(2):* 208–224.

Leathwick JR, West DW, Moilanen A, Chadderton WL 2012. Development of a Systematic, Information-Based Approach to the Identification of High Value Sites for River Conservation in New Zealand. River Conservation and Management, John Wiley & Sons, Ltd: 183-191.

Maseyk F, Brown M, McArthur K, Beveridge A 2018. Significant Values of Wetlands and Outstanding Freshwater Bodies: Policy options and draft plan provisions. Report prepared by The Catalyst Group for Bay of Plenty Regional Council. Report no. 2018/143. Pp. 64.

Matheson F, Quinn J, Hickey C 2012. Review of the New Zealand instream plant and nutrient guidelines and development of an extended decision-making framework: Phases 1 and 2 final report. Prepared for the Ministry of Science & Innovation Envirolink Fund. NIWA Client Report No: HAM2012-081.

Matheson F, Quinn JM, Unwin M 2016. Instream plant and nutrient guidelines. Review and development of an extended decision-making framework Phase 3, HAM2015-064: 118.

McEwan AJ, Joy MK 2011. Monitoring a New Zealand freshwater fish community using passive integrated transponder (PIT) technology: lessons learned and recommendations for future use. New Zealand Journal of Marine and Freshwater Research 45: 121-133;

McEwan AJ, Joy MK 2013a. Responses of three PIT-tagged native fish species to floods in a small, upland stream in New Zealand. New Zealand Journal of Marine and Freshwater Research 47: 225- 234;

McEwan AJ, Joy MK 2013b. Habitat use of redfin bullies (Gobiomorphus huttoni) in a small upland stream in Manawatu, New Zealand. Environmental Biology of Fishes 97: 121-132;

McEwan AJ, Joy MK 2013c. Diel habitat use of two sympatric galaxiid stream fishes at two spatial scales a small upland stream in Manawatu, New Zealand. Environmental Biology of Fishes 97: 897- 907.

Ministry for the Environment 2000. New Zealand Periphyton Guideline: Detecting, monitoring and managing enrichment of streams. Prepared for the Ministry for the Environment. NIWA, Christchurch.

Ministry for the Environment and Ministry of Health. 2009. New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters – Interim Guidelines. Prepared for the Ministry for the Environment and the Ministry of Health by SA Wood, DP Hamilton, WJ Paul, KA Safi and WM Williamson. Wellington: Ministry for the Environment.

Neilson K, Hodges M, Williams J, Bradly N 2018. Waikato and Waipā River restoration strategy. Volume 1: Report and references. Waikato Regional Council Technical Report 2018/08. Document #: 12385432.

Norton N, Snelder T, Rouse H 2010. Technical and Scientific Considerations When Setting Measurable Objectives and Limits for Water Management. Report prepared for the Ministry for the Environment. NIWA Client Report: CHC2010-060.

Pingram MA 2014. *Food webs in the lower Waikato River and the role of hydrogeomorphic complexity.* (Doctor of Philosophy (PhD Thesis)), University of Waikato. Retrieved from http://hdl.handle.net/10289/8529

Pingram MA, Collier KJ, Hamilton DP, David BO, Hicks BJ 2012a. Carbon Sources Supporting Large River Food Webs: A Review of Ecological Theories and Evidence from Stable Isotopes. *Freshwater Reviews 5*(2): 85-103. doi:10.1608/FRJ-5.2.476

Pingram MA, Collier KJ, Hamilton DP, Hicks BJ, David BO 2012b. Spatial and temporal patterns of carbon flow in a temperate, large river food web. *Hydrobiologia 729*(1): 107-131. doi:10.1007/s10750-012-1408-2

Pingram MA, Collier KJ, Hamilton DP, David BO, Hicks BJ 2014. Use of high-intensity data to define large river management units: A case study on the lower Waikato River, New Zealand. *River Systems*. doi:http://dx.doi.org/10.1127/rs/2014/0076

Richardson J, Williams EK, Hickey CW 2001. Avoidance behaviour of freshwater fish and shrimp exposed to ammonia and low dissolved oxygen separately and in combination. New Zealand Journal of Marine and Freshwater Research 35: 625-633.

Smith DG, Davies-Colley RJ 1992. Perception of water clarity and colour in terms of suitability for recreational use. Journal of Environmental Management 36: 225-235.

Stark JD 1985. A macroinvertebrate community index of water quality for stony streams. Water & Soil Miscellaneous Publication 87: 53 p. (National Water and Soil Conservation Authority, Wellington, New Zealand).

Stark JD, Maxted JR 2007a. A biotic index for New Zealand's soft-bottomed streams. New Zealand Journal of Marine and Freshwater Research 41:1 43-61.

Stark JD, Maxted JR 2007b. A User Guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No. 1166. Pp. 66.

Suren AM, Biggs BJF, Kilroy C, Bergey L 2003. Benthic community dynamics during summer low-flows in two rivers of contrasting enrichment 1. Periphyton. *New Zealand Journal of Marine and Freshwater Research 37(1)*: 53-70.

Tulagi A 2017. Waikato River water quality monitoring programme: data report 2016. Waikato Regional Council Technical Report 2017/14. Document #: 10492663.

Vant B 2018. Trends in river water quality in the Waikato region, 1993-2017. Waikato Regional Council Technical Report 2018/30. Document #: 11951194.

Waikato Regional Council 2017. How Clean is the Waikato River? https://www.waikatoregion.govt.nz/Environment/Naturalresources/Water/Rivers/Waikato-River/How-clean-is-the-Waikato-River/

West DW, Leathwick JR, Dean-Speirs TL 2018. Approaches to the Selection of a Network of Freshwater Ecosystems within NZ for Conservation. Aquatic Conservation: Marine and Freshwater Ecosystems, in press.

Williamson, B., Quinn, J., Williams, E., & van Schravendijk-Goodman, C. 2016, *2016 Pilot Waikato River Report Card: Methods and Technical Summary*, prepared for Waikato River Authority, Client Report No. HAM2016-011, NIWA, Hamilton.

WWF 2018. Living Planet Report - 2018: Aiming Higher. Grooten M. Almond REA (Eds). WWF, Gland, Switzerland. 148 p.

Appendix 1

Table 1. Recommended changes to existing water quality short term targets and 80 year attribute states for sub-catchments in the Waikato-Waipā Rivers to account for conservation protection priority (P) and/or indigenous fish (F). Additions underlined and highlighted, deletions ~~struck through~~. *N.B. where the current attribute state for a sub-catchment or waterbody reflects better water quality than the short term or 80 year targets, water quality shall be maintained in the current state, the current state operates as an NPS-FM limit and water quality shall not be allowed to degrade towards the target.*

Site	Protection priority (P) or fish (F) ranking	Annual Median Chlorophyll a (mg/m^3)		Annual Maximum Chlorophyll a (mg/m^3)		Annual Median Total Nitrogen (mg/m^3)		Annual Median Total Phosphorus (mg/m^3)		Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO_3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E. coli/100mL*) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Waikato River Ohaaki Br		1.5	1.5	13	13	134	134	10	10	0.039	0.039	0.062	0.062	0.002	0.002	0.013	0.013	~~70~~ C	~~70~~ B	3.8	3.8
Waikato River Ohakuri Tailrace Br		3.2	3.2	11	11	206	160	17	17	0.084	0.084	0.172	0.172	0.003	0.003	0.017	0.017	~~15~~ C	~~15~~ B	3.4	3.4
Waikato River Whakamaru Tailrace			5		25	260	160	20	20	0.101	0.101	0.230	0.230	0.003	0.003	0.010	0.010	~~60~~ C	~~60~~ B	2.0	3.0
Waikato River Waipapa Tailrace		4.1	4.1	25	25	318	160	25	20	0.164	0.164	0.320	0.320	0.007	0.007	0.017	0.017	~~162~~ C	~~162~~ B	2.0	3.0
Pueto Stm Broadlands Rd Br										0.450	0.450	0.530	0.530	0.003	0.003	0.009	0.009	~~92~~ C	~~92~~ B	1.8	3.0
Torepatutahi Stm Vaile Rd Br										0.500	0.500	0.800	0.800	0.002	0.002	0.011	0.011	~~216~~ C	~~216~~ B	1.0	1.6
Waiotapu Stm Homestead Rd Br										1.257	1.0	1.563	1.5	0.112	0.03	0.176	0.05	~~281~~ C	~~281~~ B	1.0	1.6

Site	Protection priority (P) or fish (F) ranking	Annual Median Chlorophyll a (mg/m³)		Annual Maximum Chlorophyll a (mg/m³)		Annual Median Total Nitrogen (mg/m³)		Annual Median Total Phosphorus (mg/m³)		Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO_3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E. coli*/100mL) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Mangakara Stm (Reporoa) SH5										1.270	1.0	1.590	1.5	0.008	0.008	0.062	0.05	~~1584~~ C	~~540~~ B	0.9	1.0
Kawaunui Stm SH5 Br										2.580	2.4	2.850	1.5	0.006	0.006	0.079	0.05	~~2335~~ C	~~540~~ B	1.4	1.6
Waiotapu Stm Campbell Rd Br										0.915	0.915	1.100	1.100	0.291	0.24	0.315	0.05	~~18~~ C	~~18~~ B	1.2	1.6
Otamakokore Stm Hossack Rd										0.740	0.740	1.190	1.190	0.006	0.006	0.024	0.024	~~680~~ C	~~540~~ B	1.2	1.6
Whirinaki Stm Corbett Rd										0.770	0.770	0.870	0.870	0.002	0.002	0.012	0.012	~~98~~ C	~~98~~ B	2.7	3.0
Tahunaatara Stm Ohakuri Rd										0.555	0.555	0.830	0.830	0.003	0.003	0.015	0.015	~~783~~ C	~~540~~ B	1.3	1.6
Mangaharakeke Stm SH30 (Off Jct SH1)										0.525	0.525	0.750	0.750	0.003	0.003	0.015	0.015	~~684~~ C	~~540~~ B	1.1	1.6
Waipapa Stm (Mokai) Tirohanga Rd Br										1.189	1.0	1.500	1.5	0.003	0.003	0.005	0.005	~~1147~~ C	~~540~~ B	1.2	1.6
Mangakino Stm Sandel Rd	**P**									0.650	0.650	0.860	0.860	0.003	0.003	0.012	0.012	~~251~~ C	~~251~~ B	1.8	3.0

Site	Protection priority (P) or fish (F) ranking	Annual Median Chlorophyll a (mg/m^3)		Annual Maximum Chlorophyll a (mg/m^3)		Annual Median Total Nitrogen (mg/m^3)		Annual Median Total Phosphorus (mg/m^3)		Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E. coli*/100mL) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Whakauru Stm SH1 Br										0.260	0.260	0.450	0.450	0.003	0.003	0.033	0.033	~~2106~~ C	~~540~~ B	0.8	1.0
Mangamingi Stm Paraonui Rd Br										2.760	2.4	3.12	1.5	0.091	0.03	0.296	0.05	~~2151~~ C	~~540~~ B	0.8	1.0
Pokaiwhenua Stm Arapuni - Putaruru Rd										1.680	1.0	2.040	1.5	0.002	0.002	0.020	0.020	~~1363~~ C	~~540~~ B	1.3	1.6
Little Waipa Stm Arapuni - Putaruru Rd										1.522	1.0	2.040	1.5	0.002	0.002	0.085	0.05	~~1377~~ C	~~540~~ B	1.5	1.6

Site	Protection priority (P) or fish (F) ranking	Annual Median Chlorophyll a (mg/m^3)		Annual Maximum Chlorophyll a (mg/m^3)		Annual Median Total Nitrogen (mg/m^3)		Annual Median Total Phosphorus (mg/m^3)		Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO_3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E. coli*/ 100mL) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Waikato River Narrows Boat Ramp	**P**	5.5	5	23	23	404	350	28	20	0.235	0.235	0.500	0.500	0.009	0.009	0.018	0.018	~~340~~ C	~~260~~ B	1.7	1.7
Waikato River Horotiu Br	**P**	6.1	5	23	23	432	350	34	20	0.260	0.260	0.530	0.530	0.007	0.007	0.029	0.029	~~774~~ C	~~540~~ B	1.4	1.6
Karapiro Stm Hickey Rd Bridge										0.520	0.520	1.689	1.5	0.008	0.008	0.031	0.031	~~4518~~ C	~~540~~ B	0.9	1.0
Mangawhero Stm Cambridge-Ohaupo Rd										1.990	1.0	2.490	1.5	0.041	0.03	0.072	0.05	~~2920~~ C	~~540~~ B	0.3	1.0
Mangaonua Stm Hoeka Rd										1.455	1.0	1.878	1.5	0.036	0.03	0.051	0.05	~~6372~~ C	~~540~~ B	1.0	1.0
Mangaone Stm Annebrooke Rd Br										2.580	2.4	2.940	1.5	0.009	0.009	0.02	0.02	~~2052~~ C	~~540~~ B	0.9	1.0
Mangakotukutuku Stm Peacockes Rd	**P**									0.800	0.800	1.788	1.5	0.077	0.03	0.132	0.05	~~11394~~ C	~~540~~ B	0.5	1.0

Site	Protection priority (P) or fish (F) ranking	Annual Median Chlorophyll a (mg/m³)		Annual Maximum Chlorophyll a (mg/m³)		Annual Median Total Nitrogen (mg/m³)		Annual Median Total Phosphorus (mg/m³)		Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO_3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E.coli*/100mL) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Waitawhiriwhiri Stm Edgecumbe Street	**P**									0.880	0.880	1.240	1.24	~~0.256~~ 0.24	~~0.24~~ 0.03	0.318	0.05	~~5922~~ C	~~540~~ B	~~0.4~~ 0.5	1.0
Kirikiriroa Stm Tauhara Dr	**P & F**									0.815	0.815	1.572	1.5	0.096	0.03	0.183	0.05	~~2124~~ C	~~540~~ B	0.5	1.0

Site	Protec-tion priority (P) or fish (F) ranking	Annual Median Chlorophyll a (mg/m³)		Annual Maximum Chlorophyll a (mg/m³)		Annual Median Total Nitrogen (mg/m³)		Annual Median Total Phosphorus (mg/m³)		Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO_3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E.coli*/100mL) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Waikato River Huntly-Tainui Br	**P**	5.9	5	19	19	562	350	43	20	0.365	0.365	0.900	0.900	0.005	0.005	0.015	0.015	~~1944~~ C	~~540~~ B	0.9	1.0
Waikato River Mercer Br (Rangiriri)	**P & F**	10.0	5	30	25	631	350	49	20	0.365	0.365	0.870	0.870	0.003	0.003	0.010	0.010	~~1494~~ C	~~540~~ B	0.9	1.0
Waikato River Tuakau Br		11.3	5	37	25	571	350	50	20	0.325	0.325	0.880	0.880	0.003	0.003	0.008	0.008	~~1584~~ C	~~540~~ B	0.7	1.0
Komakorau Stm Henry Rd	**P & F**									1.279	1.0	~~4.40~~ 3.5	~~3.5~~ 1.5	~~0.25~~ 0.24	0.24 0.03	~~0.419~~ 0.40	~~0.40~~ 0.05	~~3474~~ C	~~540~~ B	~~0.3~~ 0.5	1.0
Mangawara Stm Rutherford Rd Br	**P & F**									0.765	0.765	2.760	1.5	0.103	0.03	0.172	0.05	~~4955~~ C	~~540~~ B	~~0.3~~ 0.5	1.0

Site	Protection priority (P) or fish (F) ranking	Annual Median Chlorophyll a (mg/m³)		Annual Maximum Chlorophyll a (mg/m³)		Annual Median Total Nitrogen (mg/m³)		Annual Median Total Phosphorus (mg/m³)		Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO_3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E.coli*/ 100mL) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Awaroa Stm (Rotowaro) Sansons Br @ Rotowaro-Huntly Rd	P & F									0.700	0.700	1.190	1.190	0.021	0.021	0.089	0.05	~~1800~~ C	~~540~~ B	0.8	1.0
Matahuru Stm Waiterimu Road Below Confluence	P & F									0.715	0.715	1.689	1.5	0.016	0.016	0.059	0.05	~~6147~~ C	~~540~~ B	~~0.4~~ 0.5	1.0
Whangape Stm Rangiriri-Glen Murray Rd	P									0.004	0.004	0.690	0.690	0.006	0.006	0.134	0.05	~~584~~ C	~~540~~ B	~~0.3~~ 0.5	1.0
Waerenga Stm SH2 Maramarua										0.820	0.820	1.410	1.410	0.005	0.005	0.022	0.022	~~5098~~ C	~~540~~ B	0.9	1.0
Whangamarino River Jefferies Rd Br										0.625	0.625	1.842	1.5	0.012	0.012	0.147	0.05	~~4712~~ C	~~540~~ B	0.6	1.0
Mangatangi River SH2 Maramarua	P									0.110	0.110	1.120	1.120	0.005	0.005	0.038	0.038	~~5567~~ C	~~540~~ B	0.5	1.0
Mangatawhiri River Lyons Rd Buckingham Br	P									0.013	0.013	0.370	0.370	0.003	0.003	0.011	0.011	~~5108~~ C	~~540~~ B	1.6	1.6
Whangamarino River Island Block Rd	P									0.075	0.075	0.700	0.700	0.011	0.011	0.054	0.05	~~655~~ C	~~540~~ B	~~0.3~~ 0.5	1.0

Site	Protec-tion priority (P) or fish (F) ranking	Annual Median Chlorophyll a (mg/m³)		Annual Maximum Chlorophyll a (mg/m³)		Annual Median Total Nitrogen (mg/m³)		Annual Median Total Phosphorus (mg/m³)		Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO_3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E.coli*/100mL) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Whakapipi Stm SH22 Br										3.390	2.4	5.120	3.5	0.006	0.006	0.081	0.05	~~1773~~ C	~~540~~ B	1.1	1.1
Ohaeroa Stm SH22 Br										1.473	1.0	1.806	1.5	0.003	0.003	0.015	0.015	~~4667~~ C	~~540~~ B	0.8	1.0
Opuatia Stm Ponganui Rd										0.740	0.740	1.060	1.060	0.005	0.005	0.016	0.016	~~2898~~ C	~~540~~ B	0.6	1.0
Awaroa River (Waiuku) Otaua Rd Br Moseley Rd	**P & F**									1.369	1.0	2.310	1.5	0.021	0.021	0.135	0.05	~~1017~~ C	~~540~~ B	~~0.4~~ 0.5	1.0

Site	Protection priority (P) or fish (F) ranking	Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO_3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E.coli*/100mL) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Waipā River Mangaokewa Rd		0.380	0.380	0.600	0.600	0.003	0.003	0.017	0.017	~~2417~~ C	~~540~~ B	1.5	1.6
Waipā River Otewa		0.228	0.228	0.502	0.502	0.003	0.003	0.008	0.008	~~2036~~ C	~~540~~ B	2.1	2.1
Waipā River SH3 Otorohanga	**F**	0.370	0.370	1.050	1.050	0.004	0.004	0.020	0.020	~~3289~~ C	~~540~~ B	1.2	1.6
Waipā River Pirongia-Ngutunui Rd Br		0.565	0.565	1.270	1.270	0.008	0.008	0.023	0.023	~~4441~~ C	~~540~~ B	0.7	1.0
Waipā River Whatawhata Bridge	**P**	0.673	0.673	1.319	1.319	0.009	0.009	0.026	0.026	~~3657~~ C	~~540~~ B	0.6	1.0
Ohote Stm Whatawhata/Horotiu Rd	**F**	0.495	0.495	1.370	1.370	0.023	0.023	0.052	0.05	~~2142~~ C	~~540~~ B	0.6	1.0
Kaniwhaniwha Stm Wright Rd	**P**	0.350	0.350	0.890	0.890	0.007	0.007	0.022	0.022	~~1917~~ C	~~540~~ B	0.9	1.0
Mangapiko Bowman Rd Stm		1.369	1.0	2.490	1.5	0.022	0.022	0.076	0.03	~~7074~~ C	~~540~~ B	0.6	1.0
Mangaohoi Stm South Branch Maru Rd		0.230	0.230	0.390	0.390	0.003	0.003	0.008	0.008	~~943~~ C	~~540~~ B	1.6	1.6
Mangauika Stm Te Awamutu Borough W/S Intake	**P**	0.210	0.210	0.280	0.280	0.002	0.002	0.003	0.003	~~1008~~ C	~~540~~ B	3.3	3.3

Site	Protection priority (P) or fish (F) ranking	Annual Median Nitrate (mg NO_3-N/L)		Annual 95th percentile Nitrate (mg NO_3-N/L)		Annual Median Ammonia (mg NH_4-N/L)		Annual Maximum Ammonia (mg NH_4-N/L)		~~95th percentile~~ *E. coli* (*E.coli*/100mL) NOF Band		Clarity (m)	
		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Puniu River Bartons Corner Rd Br		0.650	0.650	1.280	1.280	0.007	0.007	0.029	0.029	~~2790~~ C	~~540~~ B	0.9	1.0
Mangatutu Stm Walker Rd Br		0.380	0.380	0.880	0.880	0.003	0.003	0.012	0.012	~~738~~ C	~~540~~ B	1.5	1.6
Waitomo Stm SH31 Otorohanga		0.520	0.520	0.830	0.830	0.008	0.008	0.025	0.025	~~1453~~ C	~~540~~ B	0.6	1.0
Mangapu River Otorohanga		0.860	0.860	1.360	1.360	0.015	0.015	0.057	0.05	~~4284~~ C	~~540~~ B	0.7	1.0
Waitomo Stm Tumutumu Rd	**F**	0.630	0.630	0.800	0.800	0.004	0.004	0.013	0.013	~~2241~~ C	~~540~~ B	1.1	1.6
Mangaokewa Stm Lawrence Street Br		0.530	0.530	0.980	0.980	0.004	0.004	0.013	0.013	~~6224~~ C	~~540~~ B	1.4	1.6

Appendix 2.

Table 1. Additional water quality short term and 80 year targets for sub-catchments in the Waikato-Waipā Rivers to account for hard-bottomed stream types, and provide for conservation protection priorities (P), indigenous fish (F), ecosystem health and recreation and mahinga kai values. *N.B. where the current attribute state for a sub-catchment or waterbody reflects better water quality than the short term or 80 year targets, water quality shall be maintained in the current state, the current state operates as an NPS-FM limit and water quality shall not be allowed to degrade towards the target.*

Protection priority or fish rank : P/F		Periphyton biomass (NOF band)[1]		Periphyton %WCC[2]		DIN (mg/L)[3]		DRP (mg/L)[3]		Cyano-bacteria (NOF band/ % benthic)[4]		Fine deposited sediment % cover[5]		Dissolved oxygen (NOF band)[6]		Temperature max.[7]		pH range[7]		Toxicants / metals % species protection[8]		MCI[9]	
Hard-bottomed stream type: HB		**short term**	**80 year**	**short term**	**80 year**	**Short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**
Waikato River Ohaaki Br						0.8	0.4	0.015	0.01	B	B			B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waikato River Ohakuri Tailrace Br						0.8	0.4	0.015	0.01	B	B			B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waikato River Whakamaru Tailrace						0.8	0.4	0.015	0.01	B	B			B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waikato River Waipapa Tailrace						0.8	0.4	0.015	0.01	B	B			B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Pueto Stm Broadlands Rd Br						0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Torepatutahi Stm Vaile Rd Br						0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waiotapu Stm Homestead Rd Br	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100

Protection priority or fish rank: P/F		Periphyton biomass (NOF band)[1]		Periphyton %WCC[2]		DIN (mg/L)[3]		DRP (mg/L)[3]		Cyano-bacteria (NOF band/ % benthic)[4]		Fine deposited sediment % cover[5]		Dissolved oxygen (NOF band)[6]		Temperature max.[7]		pH range[7]		Toxicants / metals % species protection[8]		MCI[9]	
Hard-bottomed stream type: HB		**short term**	**80 year**	**short term**	**80 year**	**Short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**
Mangakara Stm (Reporoa) SH5						0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Kawaunui Stm SH5 Br	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waiotapu Stm Campbell Rd Br						0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Otamakokore Stm Hossack Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Whirinaki Stm Corbett Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Tahunaatara Stm Ohakuri Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangaharakeke Stm SH30 (Off Jct SH1)						0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waipapa Stm (Mokai) Tirohanga Rd Br						0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangakino Stm Sandel Rd	**HB P**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100

Protection priority or fish rank: P/F		Periphyton biomass (NOF band)[1]		Periphyton %WCC[2]		DIN (mg/L)[3]		DRP (mg/L)[3]		Cyano-bacteria (NOF band/ % benthic)[4]		Fine deposited sediment % cover[5]		Dissolved oxygen (NOF band)[6]		Temperature max.[7]		pH range[7]		Toxicants / metals % species protection[8]		MCI[9]	
Hard-bottomed stream type: HB		**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**Short term**	**80 year**
Whakauru Stm SH1 Br	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangamingi Stm Paraonui Rd Br						0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Pokaiwhenua Stm Arapuni - Putaruru Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Little Waipa Stm Arapuni - Putaruru Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100

Protection priority or fish rank: P/F		Periphyton biomass (NOF band)[1]		Periphyton %WCC[2]		DIN (mg/L)[3]		DRP (mg/L)[3]		Cyano-bacteria (NOF band/ % benthic)[4]		Fine deposited sediment % cover[5]		Dissolved oxygen (NOF band)[6]		Temperature max.[7]		pH range[7]		Toxicants / metals % species protection[8]		MCI[9]	
Hard-bottomed stream type: HB		**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**Short term**	**80 year**
Waikato River Narrows Boat Ramp	**P**					0.8	0.4	0.015	0.01	B	B			B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waikato River Horotiu Br	**P**					0.8	0.4	0.015	0.01	B	B			B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Karapiro Stm Hickey Rd Bridge						0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangawhero Stm Cambridge-Ohaupo Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangaonua Stm Hoeka Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangaone Stm Annebrooke Rd Br						0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangakotukutuku Stm Peacockes Rd	**P**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100

Protection priority or fish rank: P/F		Periphyton biomass (NOF band)[1]		Periphyton %WCC[2]		DIN (mg/L)[3]		DRP (mg/L)[3]		Cyano-bacteria (NOF band/ % benthic)[4]		Fine deposited sediment % cover[5]		Dissolved oxygen (NOF band)[6]		Temperature max.[7]		pH range[7]		Toxicants / metals % species protection[8]		MCI[9]	
Hard-bottomed stream type: HB		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	Short term	80 year
Waitawhiriwhiri Stm Edgecumbe Street	P					0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Kirikiriroa Stm Tauhara Dr	P & F					0.8	0.4	0.015	0.01					B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100

Protection priority or fish rank: P/F		Periphyton biomass (NOF band)[1]		Periphyton %WCC[2]		DIN (mg/L)[3]		DRP (mg/L)[3]		Cyano-bacteria (NOF band/ % benthic)[4]		Fine deposited sediment % cover[5]		Dissolved oxygen (NOF band)[6]		Temperature max[7]		pH range[7]		Toxicants / metals % species protection[8]		MCI[9]	
Hard-bottomed stream type: HB		**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**Short term**	**80 year**
Waikato River Huntly-Tainui Br	**P**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	B	B	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waikato River Mercer Br	**P & F**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	B	B	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waikato River Tuakau Br		N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	B	B	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Komakorau Stm Henry Rd	**P & F**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangawara Stm Rutherford Rd Br	**P & F**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100

Protection priority or fish rank: P/F		Periphyton biomass (NOF band)[1]		Periphyton %WCC[2]		DIN (mg/L)[3]		DRP (mg/L)[3]		Cyano-bacteria (NOF band/ % benthic)[4]		Fine deposited sediment % cover[5]		Dissolved oxygen (NOF band)[6]		Temperature max.[7]		pH range[7]		Toxicants / metals % species protection[8]		MCI[9]	
Hard-bottomed stream type: HB		**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**Short term**	**80 year**
Awaroa Stm (Rotowaro) Sansons Br @ Rotowaro-Huntly Rd	**P & F**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Matahuru Stm Waiterimu Road Below Confluence	**P & F**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Whangape Stm Rangiriri-Glen Murray Rd	**P**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waerenga Stm SH2 Maramarua		N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Whangamarino River Jefferies Rd Br		N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangatangi River SH2 Maramarua	**P HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangatawhiri River Lyons Rd Buckingham Br	**P HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Whangamarino River Island Block Rd	**P**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100

Protection priority or fish rank: P/F		Periphyton biomass (NOF band)[1]		Periphyton %WCC[2]		DIN (mg/L)[3]		DRP (mg/L)[3]		Cyano-bacteria (NOF band/ % benthic)[4]		Fine deposited sediment % cover[5]		Dissolved oxygen (NOF band)[6]		Temperature max.[7]		pH range[7]		Toxicants / metals % species protection[8]		MCI[9]	
Hard-bottomed stream type: HB		**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**Short term**	**80 year**
Whakapipi Stm SH22 Br	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Ohaeroa Stm SH22 Br		N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Opuatia Stm Ponganui Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Awaroa River (Waiuku) Otaua Rd Br Moseley Rd	**P & F**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100

Protection priority or fish rank: P/F		Periphyton biomass (NOF band)[1]		Periphyton %WCC[2]		DIN (mg/L)[3]		DRP (mg/L)[3]		Cyano-bacteria (NOF band/ % benthic)[4]		Fine deposited sediment % cover[5]		Dissolved oxygen (NOF band)[6]		Temperature max.[7]		pH range[7]		Toxicants / metals % species protection[8]		MCI[9]	
Hard-bottomed stream type: HB		short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year	short term	80 year
Waipā River Mangaokewa Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waipā River Otewa	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waipā River SH3 Otorohanga	**HB F**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waipā River Pirongia-Ngutunui Rd Br		N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waipā River Whatawhata Bridge	**P**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Ohote Stm Whatawhata/Horotiu Rd	**F**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Kaniwhaniwha Stm Wright Rd	**P**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangapiko Bowman Rd Stm		N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangaohoi Stm South Branch Maru Rd	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangauika Stm Te Awamutu Borough W/S Intake	**HB P**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100

Protection priority or fish rank: P/F		**Periphyton biomass (NOF band)[1]**		**Periphyton %WCC[2]**		**DIN (mg/L)[3]**		**DRP (mg/L)[3]**		**Cyano-bacteria (NOF band/ % benthic)[4]**		**Fine deposited sediment % cover[5]**		**Dissolved oxygen (NOF band)[6]**		**Temperature max.[7]**		**pH range[7]**		**Toxicants / metals % species protection[8]**		**MCI[9]**	
Hard-bottomed stream type: HB		**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**	**short term**	**80 year**
Puniu River Bartons Corner Rd Br		N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangatutu Stm Walker Rd Br	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Waitomo Stm SH31 Otorohanga		N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	80	100
Mangapu River Otorohanga		N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	100	100
Waitomo Stm Tumutumu Rd	**F**	N/A	N/A	N/A	N/A	0.8	0.4	0.015	0.01	N/A	N/A	N/A	N/A	B	B	24	20	6 - 9	6.5 - 8.5	95	95	100	100
Mangaokewa Stm Lawrence Street Br	**HB**	B	B	40	30	0.8	0.4	0.015	0.01	20%	20%	25	20	B	B	24	20	6 - 9	6.5 - 8.5	95	95	100	100

Key to attributes	Periphyton biomass (NOF band)[19]	Periphyton %WCC[20]	DIN (mg/L)[21]	DRP (mg/L)[3]	Cyano-bacteria (NOF band/ % benthic)[22]	Fine deposited sediment % cover[23]	Dissolved oxygen (NOF band)[24]	Temperature max.[25]	pH range[7]	Toxicants / metals % species protection [26]	MCI[27]

[19] Trophic state for rivers (periphyton biomass) is a compulsory attribute under the NPS-FM and must apply wherever there are hard-bottomed streams in the Waikato-Waipā catchments, to manage for ecosystem health values. Many hard-bottomed streams are identified by sub-catchment in Table 1, some streams have become heavily sedimented over time due to pastoral development with encroachment of grasses and weeds (Davies-Colley 1997), and a lack of riparian vegetation. Some of these catchments may be restored to a more hard-bottomed state over time if sediment, riparian margins and nutrients are managed appropriately. Periphyton can also grow on sand, plant and wood substrates within streams where nutrient and flow conditions are suitable.

[20] Periphyton cover is relevant for hard-bottomed streams. Numeric cover values are from the weighted composite cover (WCC) percent thresholds from Matheson et al. (2012) for ecological condition (40% as the bottom of the 'good' band as a short term target). The 80 year attribute state is set at the recreation threshold of 30%WCC.

[21] Dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) targets were based on collation of multiple, similar, nutrient thresholds considered appropriate to manage the risk of periphyton exceeding the NOF biomass attribute or the %WCC attributes recommended from Matheson et al. (2012). Similar dissolved nutrient limits are recommended by Dr Canning in evidence for Fish and Game to provide for ecosystem health values and have been implemented in Regional Plans including: Plan Change 6: Tukituki catchment, Hawkes Bay; Plan change 6a: Otago Region; and the One Plan Schedule E targets, Manawatū-Whanganui Region. The limits/targets are the best approximation of nutrient concentrations appropriate to control periphyton biomass/cover and to lessen the dissolved nutrient contribution to growth of nuisance aquatic macrophytes in soft-bottomed streams.

[22] Cyanobacteria is a risk to people and animals and can proliferate on the bed of hard-bottomed streams as benthic growth, potentially becoming toxic. Thresholds from the MoH/MfE (2009) guidelines are recommended to safe-guard recreational and mahinga kai values in benthic systems. Systems susceptible to planktonic cyanobacteria have the NOF B band (green) applied.

[23] Deposited fine sediment is a critical attribute for ecosystem health in hard-bottomed streams. Short term targets are for recreational and aesthetic values, with 80 year targets set to provide for biodiversity and fish spawning aspects of ecosystem health.

[24] Dissolved oxygen is a critical attribute for all freshwater life and ecosystem health values. The NOF requires dissolved oxygen as an attribute below point sources, however, this is inadequate to provide for ecosystem health or aquatic life in all freshwater systems and the dissolved oxygen attribute should apply to all waterbodies.

[25] Based on Davies-Colley et al. (2012) recommended temperature, pH and dissolved oxygen attributes for the NOF. Temperature thresholds is the summer-period measurement of the Cox-Rutherford Index (CRI), averaged over the five (5) hottest days (from inspection of a continuous temperature record). pH range does not apply to naturally acid or humic stained streams.

[26] Excludes nitrate and ammonia toxicity and applies to relevant metal and toxicant concentrations associated with the species protection levels as derived from the ANZECC (2000) guidelines or any updates to those guidelines. Particularly important to support ecosystem health in waterbodies affected by urban or industrial contaminants (point-sourced or diffuse).

[27] Based on Collier et al. (2014) macroinvertebrate attribute for the NOF and in response to the 2017 amendments to the NPS-FM requiring methods to address MCI <80 or sites showing a degrading trend.