



Review of compatibility of Horizons One Plan targets with attributes and limits of the National Policy Statement for Freshwater Management

September 2023

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September 2023
Report No. 2023/EXT/1820
ISBN 9781991061379

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REPORT NO. 3959

**REVIEW OF COMPATIBILITY OF HORIZONS ONE
PLAN TARGETS WITH ATTRIBUTES AND LIMITS
OF THE NATIONAL POLICY STATEMENT FOR
FRESHWATER MANAGEMENT**

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REVIEW OF COMPATIBILITY OF HORIZONS ONE PLAN TARGETS WITH ATTRIBUTES AND LIMITS OF THE NATIONAL POLICY STATEMENT FOR FRESHWATER MANAGEMENT

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ISSUE DATE: 14 September 2023

RECOMMENDED CITATION: Eveleens R, Holmes R, Young R. 2023. Review of compatibility of Horizons One Plan targets with attributes and limits of the National Policy Statement for Freshwater Management. Nelson: Cawthron Institute. Cawthron Report 3959. Prepared for Horizons Regional Council.

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EXECUTIVE SUMMARY

Significant development has occurred in Aotearoa New Zealand's freshwater management policy since the Horizons Regional Council's (Horizons) One Plan became operative in 2014, including implementation of the National Policy Statement for Freshwater Management 2020 (NPS-FM). This report therefore aims to provide advice for incorporating the directives from the NPS-FM into the One Plan for rivers and streams (groundwater, lakes and coastal waters were not included in this review). Here, we review how the various freshwater values and attributes within the operative One Plan are aligned (or not) with the NPS-FM policy directives. This review expands on work already done by Horizons by providing further analysis of the attributes that comprise the One Plan targets and the NPS-FM (summarised in Table ES.1). This analysis highlights potential discrepancies between the regional and national policies. We also provide recommendations for appropriate targets within the One Plan that align with the compulsory and additional (regional) NPS-FM attribute limits, as well as a banding system for grading ecological state.

The work that Horizons has done to date means that the council is well placed to incorporate the directives from the NPS-FM into the One Plan, with general alignment between the two policies. However, continued work is needed to ensure that the One Plan fully incorporates the requirements of the NPS-FM, especially with regards to specific targets to protect freshwater values and how attributes are assessed. Since the One Plan became operative, knowledge has advanced for seven compulsory attributes, while a further three compulsory attributes that are not currently included in the One Plan and other proposed attributes still lack sufficient information to set robust targets.

For all attributes, a key starting point for implementing the NPS-FM is ensuring that data collection is appropriate and recalculating current state using the metrics assessed by NPS-FM attribute bands. Some One Plan targets directly map to NPS-FM attribute bands, but others do not, meaning that assigning targets to attribute bands will be more straightforward for some attributes than others (summarised by the traffic light colour-coding in Table ES.1). While many freshwater values will be protected by attribute targets set at the water management sub-zone level, some values will likely need further consideration to ensure targets safeguard the specific activities or species that occur within different sub-zones or river segments. In our recommendations for setting targets, we propose minimum attribute band targets and identify areas where further information is required to inform targets.

Table ES.1 Summary comparison between the compulsory NPS-FM attributes and One Plan targets for rivers and streams. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Green cells denote that the policies align and no change is required, while orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show lack of alignment, indicating that action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive table showing relevant numerical values for comparison is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Attribute	Data required	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Life Supporting Capacity	Periphyton	Common to both policies (chlorophyll-a/m ²)	The same	No % limit exceedance allowance for One Plan target thresholds. One Plan more environmentally conservative than NPS-FM	The same	None; existing thresholds validated by Matheson et al. (2016)
		Macroinvertebrates	Macroinvertebrate data common to both policies	NPS-FM A band more environmentally conservative than One Plan. Need to add Quantitative Macroinvertebrate Index (QMCI) and Average Score Per Metric (ASPM) targets to One Plan. Consider	Ensure data are collected / processed to enable QMCI and ASPM calculation (already implemented)	For MCI, One Plan minimum target is 10 points above national bottom line	Advice on MCI score interpretation (Freshwater Science and Technical Advisory Group 2019)

Compulsory NPS-FM value	Equivalent One Plan value	Attribute	Data required	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
				adding more target thresholds to align with number of NPS-FM bands			
		Visual clarity	Visual clarity data common to both policies	Not comparable due to different flow requirements and threshold definitions	Metric calculation and interpretation different due to consideration of flow and geology	Metrics not comparable	Development of national fine sediment thresholds. See Depree et al. (2018) and Franklin et al. (2019)
		Deposited sediment	Deposited sediment cover common to both	Not comparable due to protection of different freshwater values	Unclear whether changes in data collection are needed	Metrics comparable, but insufficient spatial coverage	Development of national fine sediment thresholds. See Depree et al. (2018) and Franklin et al. (2019)
		Ammoniacal nitrogen	Common to both policies (mg NH ₄ -N/L)	NPS-FM likely more stringent but incomparable	Different summary metrics used (median and 95th percentile)	NPS-FM likely more stringent	None

Compulsory NPS-FM value	Equivalent One Plan value	Attribute	Data required	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
					instead of mean and maximum)		
		Dissolved reactive phosphorus	Common to both policies (mg DRP/L)	Incomparable due to different summary metrics and flow requirements	Data collection adequate, summary metrics calculated differently	Incomparable due to different summary metrics and flow requirements	Research from Matheson et al. (2012, 2016)
		Dissolved oxygen	NPS-FM requires DO data over at least 7 consecutive days	Not comparable due to different metrics and threshold definitions	Different data types and processing methods required than for assessing One Plan	Metrics not comparable	Shift in approach to considering timing of stressful conditions – Davies-Colley et al. (2013)
	Not assigned	Nitrate (toxicity)	Common to both policies (mg NO ₃ -N/L)	Incomparable as attribute not included in One Plan	Data collection adequate, presented in reporting as specified in the NPS-FM	Incomparable as attribute not included in One Plan	Updates to guideline values (Hickey 2013)

Compulsory NPS-FM value	Equivalent One Plan value	Attribute	Data required	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
		Fish Index of Biotic Integrity (F-IBI)	Presence / absence of fish data	Incomparable as attribute not included in One Plan	Same for F-IBI, but must be assessed annually	Incomparable as attribute not included in One Plan	Addition of F-IBI as a compulsory attribute
		Ecosystem metabolism	Incomparable as attribute not included in One Plan	Incomparable as attribute not included in One Plan	Incomparable as attribute not included in One Plan	Incomparable as attribute not included in One Plan	Development of ecosystem metabolism as a compulsory attribute
Human Contact	Contact Recreation	<i>E. coli</i>	<i>E. coli</i> data common to both policies	NPS-FM has more bands than current One Plan targets. Need to set targets above current state (unless A band already achieved)	Data collection the same but flow requirements and metric calculation differ	NPS-FM bottom line of 10 <i>E. coli</i> / 100 mL is lower than One Plan secondary contact target	Update of secondary contact threshold that applies year-round
	Not assigned	Cyanobacteria (planktonic)	Incomparable as attribute not included in One Plan	Incomparable as attribute not included in One Plan	Incomparable as attribute not included in One Plan	Incomparable as attribute not included in One Plan	Addition of cyanobacteria (planktonic) as a compulsory attribute

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1. INTRODUCTION

This report provides advice for incorporating the directives from the National Policy Statement for Freshwater Management 2020 (NPS-FM; MfE 2023) into the Horizons Regional Council's (Horizons) One Plan (Horizons Regional Council 2014).

First, we review how the various freshwater values and attributes within the operative One Plan are aligned (or not) with the NPS-FM policy directives. This review expands on work already done by Horizons (Lennard et al. 2023), including our own tabular analysis of the different attributes that comprise the One Plan targets and the NPS-FM. Our analysis highlights potential discrepancies between the regional and national policies – in terms of which attributes are measured, how attribute data are collected (methods, periodicity) and what data-processing methods are used (indices, post-processing). We provide recommendations for appropriate targets within the One Plan that align with the compulsory and additional (regional) NPS-FM attribute limits, as well as the environmental limits sought by council. Finally, we propose a banding system for grading ecological state of additional regional attributes. Our review and recommendations consider only targets and attributes for rivers and streams, and do not include consideration of targets or attributes for groundwater, lakes or coastal waters.

1.1. Report purpose / scope

The following key tasks are identified within the scope of this report:

1. review the regional attributes memo (Lennard et al. 2023) to identify gaps and make recommendations,
2. review the current One Plan targets to determine whether they are still appropriate to protect the values they are linked to, including consideration of the flow, conditions and timing requirements that currently apply in the One Plan,
3. provide recommended targets for all compulsory river attributes in the NPS-FM, to protect the values they are linked to,
4. provide recommended targets for all regional (additional) river attributes, to protect the values they are linked to, and
5. provide a recommended banding system for regional (additional) river attributes for grading state.

1.1.1. Scope limitations

This report does not assess the feasibility for the region to meet the various One Plan targets or NPS-FM attribute limits. While we do consider the appropriateness of temporal aspects of monitoring requirements for attributes (such as sampling frequency or sampling periodicity in reference to a flow regime) this report does not

address the appropriateness of the current spatial extent of Horizon's monitoring framework. Finally, this report is limited to considering targets and limits as they apply to flowing waterbodies, and excludes groundwater, lakes, wetlands and estuaries.

We considered that critique of the NPS-FM or the technical advisory groups that informed the setting of attribute bands was outside the scope of this report, and therefore we regarded the NPS-FM as incontestable for the purpose of this analysis.

1.2. Background

1.2.1. *Current One Plan*

The One Plan became operative in 2014, with the most recent amendments made in 2022. Relative to other regional plans of the time, the One Plan took a progressive approach to regional freshwater resource management. It proposed a range of 'targets' that are linked with various freshwater ecosystem attributes. In turn, these attributes are linked to maintaining (or enhancing) various freshwater values. In this way, the overall structure of the One Plan is highly compatible with that of the NPS-FM. Moreover, many of the values that the One Plan manages for are also included in the NPS-FM, although there are some differences in terminology. For example, the One Plan's 'Life Supporting Capacity' value, which is consistent with terminology in the Resource Management Act 1991, is analogous to the concept of 'Ecosystem Health' in the NPS-FM in that it is a high-level value that provides for all natural components of an ecosystem.

1.2.2. *National policy context*

At the highest level, the NPS-FM can be seen as a 'line in the sand' to ensure that freshwater resources and ecosystem health are (at least) maintained or, where ecosystem components are assessed to be below bottom lines, improved. To achieve this the NPS-FM identifies 'compulsory values' that must be managed. Some compulsory values are linked to environmental bottom lines for related attributes. In this way the NPS-FM can be seen as the minimum standard to which all regional plans must adhere. Therefore, throughout this analysis we have assessed the Horizons One Plan values, attributes and targets against those present within the NPS-FM to ensure that the One Plan is inclusive of all the nationally directed minimum freshwater environmental standards (Figure 1).

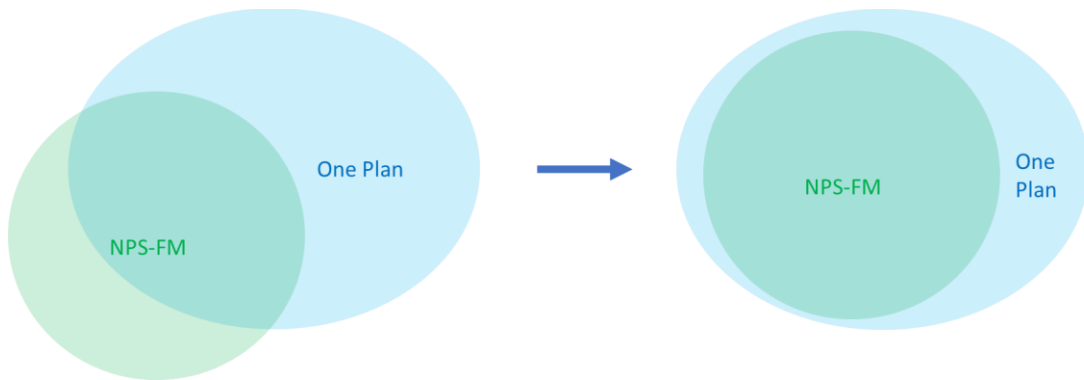


Figure 1. Schematic showing the aim of the report to ensure that the One Plan incorporates all the compulsory values, attributes and minimum standards of the NPS-FM but retains its wider scope in terms of regional freshwater management through the inclusion of non-compulsory attributes and the regionally specific concerns of the community.

2. REVIEW OF PROPOSED APPROACH TO INCORPORATING THE NPS-FM INTO THE ONE PLAN

In a memo dated 4 April 2023, Lennard et al. (2023) broadly outlines Horizons' approach to updating the One Plan and reviewing the science that underpins the targets within it. Lennard et al. (2023) further outline an approach to aligning the One Plan with the NPS-FM. In this section we provide our assessment of the proposed approach.

2.1. Alignment in principle

We support the principle that updates to the One Plan will require alignment with the compulsory values and attributes listed in the NPS-FM. The memo highlights additional regional attributes that are included in the One Plan but are not compulsory attributes in the NPS-FM.

We disagree with some of the ecosystem health subclasses that have been linked with some attributes in table 1 of the memo. These include dissolved oxygen (DO), which we would describe as an Ecosystem Health – Water Quality attribute (rather than an Ecological Processes attribute); particulate organic matter (POM), which we would also describe as an Ecosystem Health – Water Quality attribute (rather than an Aquatic Life attribute); biochemical oxygen demand ($_{sc}BOD_5$), which we would describe as an Ecosystem Health – Ecological Processes attribute (rather than an Aquatic Life attribute); and water temperature, which we would describe as an Ecosystem Health – Water Quality attribute (rather than an Aquatic Life attribute).

Regarding table 2 of the memo, there may be value in reformatting it to make the distinction between compulsory and regional attributes clearer. Compulsory attributes could be made bold or italicised to distinguish them from regional attributes, rather than attempting to distinguish them using a third column in the table. At the moment there is some confusion as some attributes are clearly compulsory NPS-FM attributes (e.g. periphyton chlorophyll-*a*), but are referred to later in the table (associated with other freshwater values) as regional attributes.

In table 2, the Threatened Species value is associated with the same list of attributes as the Ecosystem Health value. This perhaps makes sense, but there are no attributes listed that are specific to the Threatened Species value itself. We would expect that the presence or abundance of the threatened species of interest is the primary attribute of concern for this value. Similarly, for the Mahinga Kai and Fishing values, many of the attributes listed are the same as those for Ecosystem Health and there are no attributes specific to the Fishing value. As such, narrative attributes based on the New Zealand Threat Classification System (for Threatened Species) and community-defined location-specific Mahinga Kai and Fishing values may be

helpful for indicating changes in these values. Attributes relating to the presence / absence of the resource being sought and attributes relating to the ability for people to access the site and harvest and eat kai safely are also relevant.

We recognise that there may be a place for narrative attributes in the updated plan. However, in the example given for Natural State there is considerable risk of ambiguity. If Natural State is defined as the combination of Natural Form and Character and Ecosystem Health (which must both be considered independently), then is there a need to include a Natural State value?

Specific comments on table 2:

- Ecosystem Health region wide – soluble inorganic nitrogen (SIN) is not a compulsory attribute.
- Human Contact / Tauranga Waka and Transport – cyanobacteria planktonic is a compulsory attribute, but relates only to lakes and lake-fed rivers.
- Is periphyton cover also relevant for Wai Tapu?
- For Drinking Water Quality – presumably toxicants, *E. coli* and salinity are relevant alongside cyanobacteria.
- For Fishing – why does the lab measure of turbidity turn up here as an attribute?
- Note that Stock Drinking Water is called Animal Drinking Water in the NPS-FM. Why refer to indicators of faecal pollution rather than specifying the use *E.coli* or faecal coliforms?
- For Irrigation, Commercial and Industrial Use and Domestic Food Supply – why ammonia toxicity, but not nitrate toxicity? Can this be covered with just toxicants?
- For Hydro-power generation – why lab measure of turbidity?

2.2. Regional attributes

We agree with the memo recommendations that water temperature is an important attribute with relevance to several important values and deserves to remain in the updated One Plan, both as a maximum limit and as a change limit relating to point source discharges. Davies-Colley et al. (2013) provide guidance on potential statistics to use for a water temperature attribute and a framework that is consistent with the NPS-FM (see Section 4.1.5).

Similarly, we support the recommendation that toxicants are included in the updated One Plan and essentially reflect the ANZG (2018) guidelines. This will complement the nitrate toxicity and ammonia toxicity attributes that are listed as compulsory attributes in the NPS-FM (see Section 4.3.5).

We also agree with the recommendation that the interim guidelines for benthic cyanobacteria are used to develop an attribute for cyanobacteria cover related to human health where recreation occurs. However further information is required to define attribute bands and set attribute targets (see Section 4.6.5).

We support the recommendation that particulate organic matter (POM) and biological oxygen demand ($_{sc}BOD_5$) are included as regional attributes in the updated One Plan but are applicable only downstream of point source discharges (see Sections 4.5 and 4.4, respectively).

We note that dissolved / soluble inorganic nitrogen (SIN) is currently included in the One Plan, but is not a compulsory attribute in the NPS-FM. There is merit in including SIN as an attribute contributing to the management of excessive periphyton blooms, similar to the way in which periphyton blooms are potentially managed via the dissolved reactive phosphorus (DRP) compulsory attribute. Apart from table 1 in the memo, and the table near the end of the memo, there is no discussion of the SIN attribute. The latter table refers to SIN targets being derived from findings of work to address Clause 3.13 of the NPS-FM,¹ which sounds appropriate, although more details on this process would be useful in the memo.

As noted in the memo, pH interacts with, or is affected by, several other physico-chemical and biological parameters, and influences the toxicity of some contaminants such as ammonia and heavy metals. Given its importance, we consider that pH should remain as an attribute in the updated One Plan and therefore do not support the recommendation in the memo that pH is not listed as an attribute but should continue to be measured. We acknowledge that pH varies on a diel basis and single spot measurements have somewhat limited value. Ideally, pH should be measured continuously (i.e. high temporal frequency), as is recommended for water temperature and dissolved oxygen (DO). Davies-Colley et al. (2013) proposed a framework for pH, including potential attribute band numerical values, that would align with the NPS-FM. This could be adopted for the updated version of the One Plan (see Section 4.10.5.).

2.3. Linking with compulsory NPS-FM attributes

We support the memo recommendation that periphyton cover targets for both filamentous algae and diatoms / mats are combined into a periphyton weighted composite cover attribute in the updated One Plan. We also recommend that there should be some consideration of the need for both periphyton cover and periphyton biomass attributes, as while periphyton biomass is included as a compulsory attribute in the NPS-FM, periphyton cover also relates strongly to ecosystem health (Matheson

¹ Clause 3.13 of the NPS-FM details how targets should be set for nutrient attributes and any attributes affected by nutrients, including the forms of each nutrient to set targets for and giving consideration to downstream environments.

et al. 2016) (see Section 4.2.5). The NPS-FM notes that visual estimates of periphyton cover could be conducted at low-risk sites instead of biomass monitoring. We support the adoption of the compulsory deposited fine sediment attribute as a measure of the physical habitat component of ecosystem health. There is value in considering the adoption of more broad physical habitat indices, but we agree that there is some uncertainty about their efficacy as attributes. With longer datasets now available for the Rapid Habitat Assessment (RHA) protocol, this indicator appears to have most promise as an attribute, and we recommend caution in dropping the RHA from further consideration in favour of other related indices.

The memo focuses on river water quality attributes, but rightly notes that water quantity needs to be considered alongside water quality in efforts to maintain ecosystem health and other freshwater values that are specified in the NPS-FM and / or the One Plan. However, no water quantity attributes are specifically listed in appendix 2 of the NPS-FM, and councils must set environmental flows and take limits as specified in sections 3.16 and 3.17 of the NPS-FM. Conceivably, environmental flows and take limits could be considered as attributes and included in attribute tables alongside water clarity, DO, etc. However, the NPS-FM signals that environmental flows and take limits should be included as rules in regional plans. Exactly where water quantity rules and attributes should sit in the revised plan is outside our expertise, but we agree that both are critically important and need to be represented in the revised One Plan.

2.4. Other matters to consider

The focus of the memo on rivers potentially means that lakes might be overlooked. Ideally, lakes and rivers should be considered together, especially since some attributes are relevant to both waterbody types. It is worth noting that some attributes mentioned in the memo (e.g. total nitrogen [TN], total phosphorus [TP], planktonic cyanobacteria) are compulsory only for lakes and do not need to be measured for rivers.

2.5. Concluding review comments

Overall, the memo outlining Horizons' approach to updating the One Plan (Lennard et al. 2023) is a very useful document and highlights the need for alignment of the One Plan with the compulsory values and attributes listed in the NPS-FM. The memo also identifies additional regional attributes that are included in the One Plan but are not compulsory attributes in the NPS-FM. We support most of the recommendations of the memo, although we consider that pH should remain as an attribute in the updated One Plan. The memo rightly notes the importance of considering both water quantity and water quality in efforts to maintain ecosystem health and other freshwater values

that are specified in the NPS-FM and / or the One Plan, and we agree that both are critically important and need to be represented in the revised One Plan. In the remainder of this report, we examine each of the compulsory and regional attributes in detail and recommend changes and bands to facilitate alignment of the revised One Plan with the NPS-FM.

3. COMPARISON OF ONE PLAN TARGETS WITH COMPULSORY NPS-FM ATTRIBUTES

The NPS-FM specifies 12 compulsory Ecosystem Health attributes and two compulsory Human Contact attributes related to rivers and streams. Here, compulsory attributes are compared to the targets currently specified within the One Plan and key differences are identified. Differences include that the limits in the NPS-FM often specify percentiles to provide allowances for natural variability such as variation in river flows, while some One Plan targets specify the flow conditions at which targets apply for the same purpose.

Alongside differences in the metrics assessed, the way in which the level of protection is specified differs. In the current One Plan, many targets related to the value of 'Life Supporting Capacity' have been set in relation to the geology of water management sub-zones, with consideration also given to the species present in different ecosystem types (Death 2006). The same attribute targets have been set for sub-zones with the same geology classes, with the classes defined as Hill Mixed, Hill Soft Sedimentary, Lowland Mixed, Lowland Sand Upland Hard Sedimentary, Upland Limestone, Upland Volcanic Acidic and Upland Volcanic Mixed. In contrast, the NPS-FM explicitly specifies the level of protection through which an attribute band is set as the target and thresholds are split to account for geology where required.

3.1. Periphyton

3.1.1. *Metrics / indices used to measure attribute*

The NPS-FM includes **milligrams of chlorophyll-a (chl-a) per square metre** as the metric for assessing the compulsory 'periphyton (trophic state)' attribute. The One Plan also uses chl-a to assess periphyton targets. The One Plan has additional (regional) periphyton targets associated with filamentous cover and diatom or cyanobacteria cover – these periphyton cover targets are considered in Section 4.2.

3.1.2. *Current NPS-FM limits and One Plan targets*

The chl-a attribute bands for periphyton in the NPS-FM are shown in Table 1. Also shown is the (maximum) national bottom line of 200 mg chl-a/m².

Table 1. Periphyton chlorophyll-*a* (chl-*a*) attribute bands specified within the NPS-FM. The NPS-FM allows for no more than 17% of samples to exceed band limits at sites classed as 'productive', or otherwise no more than 8% of samples can exceed band limits, with bands assessed using a minimum 3-year period of monthly monitoring.

Band	Periphyton biomass (mg chl-<i>a</i>/m²)
A	≤ 50
B	> 50 to ≤ 120
C	> 120 to ≤ 200
<i>National bottom line</i>	200
D	> 200

The A band represents conditions where periphyton blooms are rare, reflecting negligible nutrient enrichment and / or alteration of the natural flow regime or habitat. At the other end of the scale, the D band represents regular or extended nuisance blooms, signifying high nutrient enrichment and / or significant alteration of natural conditions.

The chl-*a* targets in the One Plan are matched to different geology classes.² The target numeric values for each geological class align directly with the attribute band thresholds specified in the NPS-FM. This is because both the One Plan targets and NPS-FM attribute bands for chl-*a* are underpinned by the New Zealand Periphyton Guidelines (Biggs 2000). The 50 mg chl-*a*/m² target value is intended to protect aquatic biodiversity for streams and rivers where invertebrate biodiversity is high (Ausseil and Clark 2007). Likewise, the 120 mg chl-*a*/m² target was set to protect angling, aesthetic / recreation values and biodiversity values in slightly enriched systems. Finally, the 200 mg chl-*a*/m² target was set for tertiary soft-sedimentary geology and lowland areas to protect biodiversity values in catchments where natural conditions (such as natural sources of DRP, high sediment loads, and / or very low summer flows) can drive high periphyton biomass.

3.1.3. *Temporal / flow-linked monitoring requirements*

Both the NPS-FM attribute bands and the One Plan targets apply year-round and during all flows. Horizons already monitor periphyton monthly as part of their state of the environment (SoE) monitoring programme (Horizons Regional Council 2019), so no change in data collection is required to comply with the monitoring requirements of the NPS-FM.

² The One Plan targets are for a biomass of ≤ 50 mg chl-*a*/m² for Upland Hard Sedimentary and Upland Volcanic Acidic classes; ≤ 120 mg chl-*a*/m² for Hill Mixed, Upland Limestone and Upland Volcanic Mixed classes; and ≤ 200 mg chl-*a*/m² for Hill Soft Sedimentary, Lowland Mixed and Lowland Sand classes (equivalent to the NPS-FM national bottom line).

3.1.4. Data processing and interpretation

The metric, targets and attribute bands, as well as the data collection methods used to assess periphyton biomass, are the same for both the One Plan and the NPS-FM. However, the two policies calculate compliance with band thresholds differently. The NPS-FM allows up to 17% or 8% of samples to exceed band limits based on whether sites are classed as 'productive' or not. The productive class is defined, using the River Environment Classification (REC), as the combination of 'Dry' Climate categories (i.e. Warm-Dry and Cool-Dry) and Geology categories that have naturally high levels of nutrient enrichment (i.e. Soft-Sedimentary, Volcanic Acidic and Volcanic Basic). The default class is applied to all other sites. In contrast, the One Plan targets are defined as a maximum threshold, with no percent exceedance allowance for any samples. The NPS-FM also requires a minimum of a 3-year dataset to determine attribute bands, meaning a long-term dataset is required for defining current state.

3.1.5. New information since implementation of One Plan that should be considered

Both the One Plan targets and NPS-FM attribute bands for periphyton were based on the New Zealand Periphyton Guidelines (Biggs 2000). To our knowledge there is no new information that would warrant changing the target numeric values in the One Plan, as work conducted on the relationship between nutrient concentrations, periphyton and freshwater values since the development of the One Plan (see Matheson et al. 2016) has validated the thresholds set by Biggs (2000).

3.1.6. Comparison summary and recommendations

The structure of the NPS-FM attribute bands and the One Plan targets match in terms of chl-a values and band thresholds. However, the NPS-FM is more lenient than the current One Plan targets because it allows a limited percentage of samples (i.e. six samples out of 36 over 3 years in productive classes) to exceed the band thresholds. **We recommend that the structure of the One Plan chl-a targets is changed to match the NPS-FM.** This change serves to accommodate natural variability during summer low-flows and ensures consistency with national policy direction. While introducing a percent sample exceedance allowance to the target thresholds does risk allowing some decline where current targets are already being met (and so could conflict with the overarching objective of the NPS-FM of allowing no further decline in freshwater health), it will prevent sites from unnecessarily failing targets based on a small number of exceedances during summer low-flows.

Overall, modifying the One Plan chl-a/m² targets ensures consistency with the NPS-FM periphyton attribute and remains appropriate to protect the linked freshwater values in the One Plan. Table 2 summarises the One Plan targets and NPS-FM comparative analysis for the compulsory periphyton (trophic state) attribute.

Table 2. Summary comparison between the periphyton One Plan targets and compulsory NPS-FM periphyton (trophic state) attribute (for chl-*a*/m²). A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Green cells denote that the policies align and no is change required, while orange cells signal that changes to the One Plan should be considered. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Life Supporting Capacity	Common to both policies (chl- <i>a</i> /m ²)	The same	No % limit exceedance allowance for One Plan target thresholds. One Plan more environmentally conservative than NPS-FM	The same	None; existing thresholds validated by Matheson et al. (2016)

3.2. Macroinvertebrates

3.2.1. Metrics / indices used to measure attribute

The NPS-FM includes three metrics for the compulsory macroinvertebrate attribute, including the **Macroinvertebrate Community Index (MCI)**, **Quantitative Macroinvertebrate Community Index (QMCI)** and **Average Score Per Metric (ASPM)**. The ASPM (Collier 2008) is calculated from three metrics, the MCI, EPT³ taxon richness and %EPT abundance. Only MCI and QMCI are included as attributes within the One Plan, with the QMCI target set only to assess the effects of specific activities (e.g. the effect of point source discharges on aquatic macroinvertebrate communities).

3.2.2. Current NPS-FM limits and One Plan targets

The NPS-FM attribute bands and national bottom lines for each macroinvertebrate metric are shown in Table 3. It is important to note that the One Plan only defines two thresholds for MCI scores in relation to Life Supporting Capacity (which equates to the Ecosystem Health value in the NPS-FM). In contrast, a four-band system is used in the NPS-FM.

³ EPT = Ephemeroptera, Plecoptera, Trichoptera.

Table 3. Macroinvertebrate attribute bands specified within the NPS-FM. Bands are assessed against a 5-year median from annual monitoring.

Band	MCI	QMCI	ASPM
A	≥ 130	≥ 6.5	≥ 0.6
B	≥ 110 and < 130	≥ 5.5 and < 6.5	≥ 0.4 and < 0.6
C	≥ 90 and < 110	≥ 4.5 and < 5.5	≥ 0.3 and < 0.4
<i>National bottom line</i>	90	4.5	0.3
D	< 90	< 4.5	< 0.3

The most environmentally conservative target set for the MCI in the One Plan is > 120, while the target for most sub-zones is set at > 100. These targets do not align with the thresholds for MCI attribute bands set in the NPS-FM. Specifically, the most environmentally conservative One Plan target is 10 points lower than the NPS-FM A-band threshold and sits in the middle of the NPS-FM B band (Table 3). In contrast, the lowest MCI One Plan target is 10 points higher than the NPS-FM national bottom line of 90 (and sits in the middle of the C band).

Furthermore, the QMCI One Plan target is set as a maximum allowable change of 20% between matched upstream and downstream habitats (and is limited to apply only to specific activities such as discharges). As such, the One Plan QMCI target does not align with the NPS-FM QMCI attribute bands. Notably, a 20% decrease would result in a decline in attribute band, and so would conflict with the NPS-FM objective of allowing no further decline.

3.2.3. Temporal / flow-linked monitoring requirements

The NPS-FM prescribes that macroinvertebrates are monitored annually, with samples taken between 1 November and 30 April, and that the NPS-FM attribute grading is based on the median value from 5 years of monitoring. Horizons already monitor macroinvertebrates annually (Horizons Regional Council 2019), so provided that sampling dates are within the summer period, no changes in the monitoring timing or periodicity are required. A requirement for stable antecedent flows is well established in national sampling protocols (e.g. Stark and Maxted 2007; NEMS Working Group 2022) and this will be common to sampling methods used in both the NPS-FM and the One Plan.

3.2.4. Data processing and interpretation

The NPS-FM uses 5-year medians to determine attribute bands, meaning that a long-term dataset is required for defining current state. While MCI can be calculated from macroinvertebrate presence / abundance data, QMCI and ASPM require quantitative count data collection and processing methods (NEMS Working Group 2022; see also Stark 1985; Collier 2008). As Horizons' macroinvertebrate sampling and processing methods are already aligned to NEMS (Maree Patterson, Horizons, pers. comm.,

21 August 2023), no changes will be required to enable calculation of quantitative macroinvertebrate community indices.

3.2.5. *New information since implementation of One Plan that should be considered*

Since the One Plan targets were developed, interpretation of MCI scores has become more environmentally conservative, at least within the context of the NPS-FM. Relative to the previous score interpretation bands provided by Stark and Maxted (2007), the thresholds for each NPS-FM attribute band have been increased by 10 points. The national bottom line is set above an MCI score that would indicate 'possible severe pollution' under the Stark and Maxted (2007) interpretation bands (Freshwater Science and Technical Advisory Group 2019).

3.2.6. *Comparison summary and recommendations*

The NPS-FM macroinvertebrate attribute bands do not align with the One Plan targets for MCI or QMCI. Moreover, compared to previous interpretations of the MCI scores (Stark and Maxted 2007), the NPS-FM has raised the score thresholds for pristine / near-pristine sites by 10 index points (to > 130; see Freshwater Science and Technical Advisory Group 2019). Therefore, **we recommend that the upper MCI target is raised by 10 to correspond with a pristine state (MCI ≥ 130) as defined in the NPS-FM.** Consideration should be given to adding intermediate target thresholds to align with the four NPS-FM bands (i.e. A–D). These thresholds could be applied spatially to the different geology classes in a similar manner to the four periphyton chl-*a* target thresholds in the One Plan (see Section 3.1.).

The NPS-FM also adds additional indices for macroinvertebrates. Given there are no zone-wide targets for QMCI and no targets for ASPM in the One Plan, **we recommend that targets be set for ASPM and QMCI within the One Plan.**

Table 4 summarises the One Plan targets and NPS-FM comparative analysis for the compulsory macroinvertebrate attribute.

Table 4. Summary comparison between the macroinvertebrate One Plan targets and compulsory NPS-FM macroinvertebrates attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Green cells denote that the policies align and no is change required, while orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Life Supporting Capacity	Macro-invertebrate data common to both policies	NPS-FM A band more environmentally conservative than One Plan. Need to add QMCI and ASPM targets to One Plan. Consider adding more target thresholds to align with number of NPS-FM bands	Ensure data is collected / processed to enable QMCI and ASPM calculation (already implemented)	For MCI, minimum target is 10 points above national bottom line	Advice on MCI score interpretation (Freshwater Science and Technical Advisory Group 2019)

3.3. Visual clarity (suspended sediment)

3.3.1. Metrics / indices used to measure attribute

The NPS-FM includes **visual clarity per metre** as the metric for assessing the compulsory 'suspended fine sediment' attribute. The One Plan targets also assess visual clarity using the same methodology.

3.3.2. Current NPS-FM limits and One Plan targets

The visual clarity attribute bands in the NPS-FM are shown in Table 5. Also shown is the (median) national bottom line, which ranges between 0.61 m and 2.22 m depending on suspended sediment class. Suspended sediment class is based on the REC for each individual river segment, determined by climate, topography (source of flow) and geology (table 23 and table 26 in the NPS-FM). All four suspended sediment classes occur within the Horizons region (Figure 2).

Table 5. Visual clarity attribute bands specified within the NPS-FM. Bands are assessed against a 5-year median from monthly monitoring.

Band	Visual clarity (m) by suspended sediment class			
	1	2	3	4
A	≥ 1.78	≥ 0.93	≥ 2.95	≥ 1.38
B	< 1.78 and ≥ 1.55	< 0.93 and ≥ 0.76	< 2.95 and ≥ 2.57	< 1.38 and ≥ 1.17
C	< 1.55 and ≥ 1.34	< 0.76 and ≥ 0.61	< 2.57 and ≥ 2.22	< 1.17 and ≥ 0.98
<i>National bottom line</i>	1.34	0.61	2.22	0.98
D	< 1.34	< 0.61	< 2.22	< 0.98

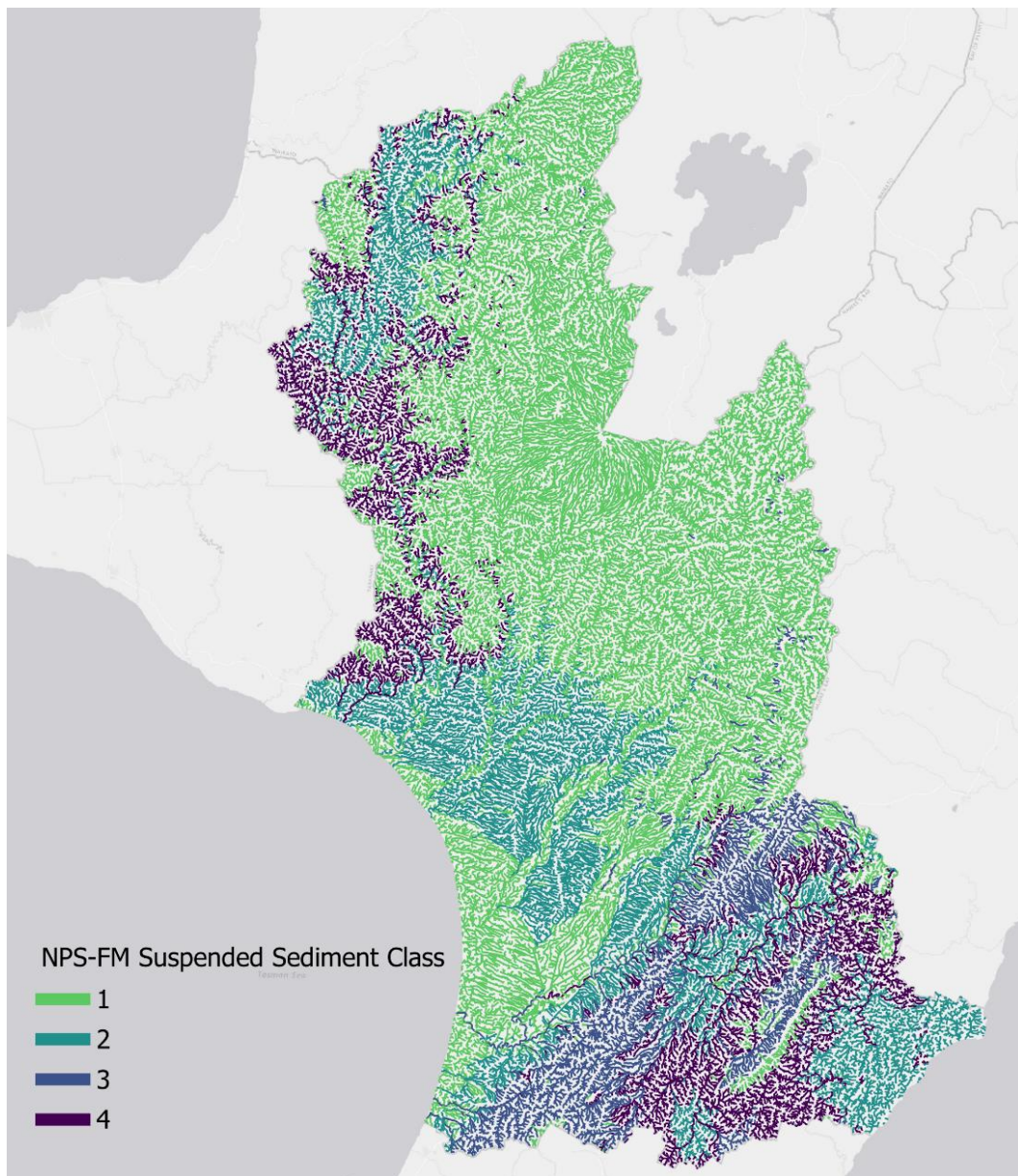


Figure 2. Distribution of NPS-FM suspended sediment classes across the Horizons region. Source: MfE (2020).

The A band represents conditions where suspended sediment has minimal impact on instream biota, while the D band represents high impact, including significant shifts in communities and the potential loss of sensitive fish and macroinvertebrate species.

The One Plan defines two paired targets for visual clarity: a minimum and an allowable percentage change. Three levels are provided, with the most conservative being a minimum clarity of 3 m and an allowable change of up to 20%, the intermediate threshold being a minimum clarity of 2.5 m and an allowable change of up to 30%, and the most permissive threshold being a minimum clarity of 1.6 m and an allowable change of 30%. In the One Plan, visual clarity targets are generally based on geology classes,⁴ although some individual sub-zones have been assigned more stringent values. Threshold values are based on the protection of native fish as well as reference data from the Horizons region, with the degree of allowable change set at a level noticeable by the general public (Ausseil and Clark 2007). Where sub-zones have been assigned more stringent numeric values, it is not clear what additional freshwater values are being protected.

3.3.3. Temporal / flow-linked monitoring requirements

The NPS-FM bases the assessment of visual clarity on monthly monitoring, where sites are visited regularly regardless of flow conditions. In contrast, while the percentage change target in the One Plan applies at all flows, the minimum target applies only at median flows or below. Neither the NPS-FM or the One Plan include any temporal requirements. Horizons already monitor clarity monthly as part of their SoE monitoring programme (Horizons Regional Council 2019), so no change in data collection is required to comply with the monitoring requirements of the NPS-FM.

3.3.4. Data processing and interpretation

A key feature of suspended sediment is that it naturally varies with catchment geology and increased river flows. While both the NPS-FM and One Plan account for geology and increased flows, they do so in different ways that cannot be related to one another. The NPS-FM uses suspended sediment classes to adjust threshold values to match climate, geology and topography, and assesses a median value from all flow conditions (allowing 50% of values to exceed limits). In contrast, the One Plan uses the geological classification of water management sub-zones and considers only values observed at median flows or lower when assessing compliance with minimum clarity targets. These differences in how clarity targets are assessed and how limits are defined mean that both the NPS-FM and One Plan metrics are calculated differently and targets are interpreted differently. A key challenge for interpreting targets is that suspended sediment classes are defined at the scale of river segments

⁴ The One Plan targets are for a visual clarity of > 3 m and an allowable change of 20% for Upland Hard Sedimentary and Upland Volcanic Acidic classes; > 2.5 m and an allowable change of 30% for Hill Mixed, Lowland Mixed, Lowland Sand, Upland Limestone and Upland Volcanic Mixed classes; and > 1.6 m with 30% of allowable change for Hill Soft Sedimentary classes.

rather than water management sub-zones, which could potentially complicate limit setting.

The NPS-FM uses a 5-year dataset to determine attribute bands, meaning a long-term dataset is required for defining current state. Within the NPS-FM, there is also an allowance for using turbidity to estimate visual clarity when the relationship between visual clarity and turbidity is known; however, this goes beyond the scope of this review.

3.3.5. New information since implementation of One Plan that should be considered

Since the One Plan was developed, significant national-scale work has been done to characterise the relationships between fine sediment (both deposited and suspended sediment) and indicators of ecosystem health. These workstreams have derived numeric thresholds to form the basis of fine sediment attributes and sediment classes within the National Objectives Framework that forms part of the NPS-FM. Key reports documenting this work include Depree et al. (2018) and Franklin et al. (2019).

3.3.6. Comparison summary and recommendations

The NPS-FM visual clarity attribute bands do not align with the One Plan targets for visual clarity because metrics are calculated and interpreted differently. Therefore, **we recommend that suspended sediment classes are determined for each sub-zone and clarity metrics are recalculated as 5-year medians following the requirements in the NPS-FM to determine compliance with national bottom lines.** The current targets in the One Plan do not map to NPS-FM bands as the thresholds are based on geology classes rather than protection of freshwater values. Table 6 summarises the One Plan targets and NPS-FM comparative analysis for the compulsory visual clarity attribute.

Table 6. Summary comparison between the visual clarity One Plan targets and compulsory NPS-FM visual clarity attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Green cells denote that the policies align and no change is required, while orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Life Supporting Capacity	Visual clarity data common to both policies	Not comparable due to different (Rowe et al. 2000) flow requirements and threshold definitions	Metric calculation and interpretation different due to consideration of flow and geology	Metrics not comparable	Development of national fine sediment thresholds. See Depree et al. (2018) and Franklin et al. (2019)

3.4. Deposited fine sediment

3.4.1. Metrics / indices used to measure attribute

The NPS-FM includes **% fine sediment cover** as the metric for assessing the compulsory 'deposited fine sediment' attribute. This is the same as the deposited sediment cover measure included within the One Plan. A separate target is also included in the One Plan for the protection of trout spawning, which relates only to specific sites and river segments where trout spawning has been identified as a value.

3.4.2. Current NPS-FM limits and One Plan targets

The deposited fine sediment attribute bands in the NPS-FM are shown in Table 7. Also shown is the (median) national bottom line, which ranges between 21% and 29% depending on deposited sediment class. Deposited sediment class is based on the REC for each individual river segment, determined by climate, topography (source of flow) and geology (table 24 and table 26 in the NPS-FM), and all deposited sediment classes are present in the Horizons region (Figure 3).

Table 7. Deposited fine sediment attribute bands specified within the NPS-FM. Bands are assessed against a 5-year median from monthly monitoring.

Band	% fine sediment cover by deposited sediment class			
	1	2	3	4
A	≤ 7	≤ 10	≤ 9	≤ 13
B	> 7 and ≤ 14	> 10 and ≤ 19	> 9 and ≤ 18	> 13 and ≤ 19
C	> 14 and < 21	> 19 and < 29	> 18 and < 27	> 19 and < 27
<i>National bottom line</i>	21	29	27	27
D	> 21	> 29	> 27	> 27

Within the NPS-FM, A band represents conditions where deposited fine sediment has a minimal impact on instream biota and ecological communities are similar to reference conditions. D band represents conditions where deposited fine sediment has a high impact on instream biota, including the potential loss of sensitive fish and macroinvertebrate species.

The One Plan includes a region-wide target for deposited sediment, with thresholds set at 15%, 20% and 25% fine sediment cover. For the protection of trout spawning values, the One Plan defines further targets for both total deposited sediment cover and an allowable change in deposited sediment cover. At sites and river segments where trout spawning has been identified as a value, the target for total deposited sediment is < 10%. The amount of allowable change is specifically related to resource consents in rivers valued for trout spawning, with the target set at no measurable increase in deposited sediment or POM on the riverbed.

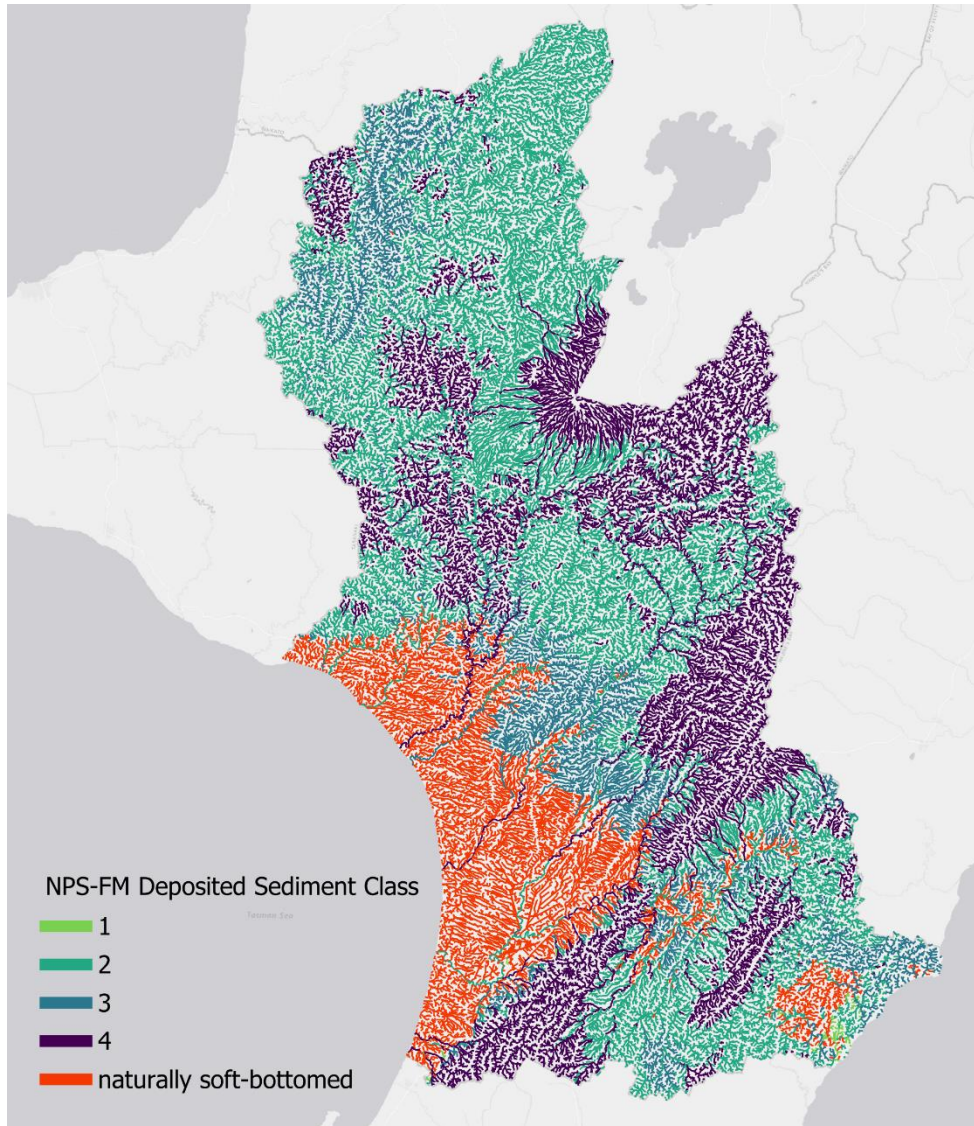


Figure 3. Distribution of NPS-FM deposited sediment classes across the Horizons region. Source: MfE (2020).

3.4.3. Temporal / flow-linked monitoring requirements

The NPS-FM bases the assessment of deposited fine sediment on year-round monthly monitoring, where sites are visited regularly regardless of weather and flow conditions. The One Plan targets for deposited sediment also apply year-round, although targets related to protecting trout spawning apply only between 1 May and 30 September (with no flow requirements). While Horizons currently monitors deposited sediment monthly (Maree Patterson, Horizons, pers. comm., 21 August 2023), changes in data collection procedures may be required to comply with the monitoring requirements of the NPS-FM.

3.4.4. Data processing and interpretation

A key feature of deposited sediment is that it naturally varies with catchment geology. To account for this, the NPS-FM uses deposited sediment classes to adjust threshold values to match climate, geology and topography. In contrast, while the region-wide targets for deposited sediment in One Plan vary with geology class, targets set for the protection of trout spawning (including the locations where targets apply) do not account for catchment geology. This means that while most of the current One Plan targets are more environmentally conservative than the national bottom line for all deposited sediment classes, targets are applied differently than in the NPS-FM. Another key challenge for applying the NPS-FM is that the deposited sediment classes used to apply attribute bands are defined at the scale of river segments rather than water management sub-zones, which will likely complicate setting attribute targets. Due to the spatial mismatch between geological and sub-zone boundaries, it is likely that multiple deposited sediment classes will be present within a sub-zone and so the actual fine sediment cover percentage specified by each attribute band will vary within a sub-zone.

The NPS-FM uses a 5-year dataset to determine attribute bands, meaning a long-term dataset is required for defining current state and for assessing target achievement.

3.4.5. New information since implementation of One Plan that should be considered

Since the One Plan was developed, significant national-scale work has been done to characterise the relationships between fine sediment (both deposited and suspended sediment) and indicators of ecosystem health – see Section 3.3.5.

3.4.6. Comparison summary and recommendations

The region-wide deposited sediment targets included in the One Plan and the targets set in relation to protecting trout spawning do not align with the NPS-FM deposited sediment attribute bands because metrics are interpreted differently. Therefore, **we recommend that deposited sediment classes are determined for all sub-zones as detailed in the NPS-FM.** Table 8 summarises the One Plan targets and NPS-FM comparative analysis for the compulsory deposited sediment attribute.

Table 8. Summary comparison between the deposited fine sediment One Plan targets and compulsory NPS-FM deposited fine sediment attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Green cells denote that the policies align and no is change required, while orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Life Supporting Capacity (also relates to Trout Spawning)	Deposited sediment cover common to both	Not comparable due to protection of different freshwater values	Unclear whether changes in data collection are needed	Metrics comparable, but insufficient spatial coverage	Development of national fine sediment thresholds. See Depree et al. (2018) and Franklin et al. (2019)

3.5. Ammoniacal nitrogen

3.5.1. Metrics / indices used to measure attribute

The NPS-FM includes **milligrams ammoniacal nitrogen per litre** as the metric for assessing the compulsory 'ammonia (toxicity)' attribute. The One Plan also assesses ammonia.

3.5.2. Current NPS-FM limits and One Plan targets

The ammonia attribute bands in the NPS-FM are shown in Table 9. Also shown is the national bottom line of an annual median of 0.24 mg NH₄-N/L and an annual 95th percentile of 0.40 mg NH₄-N/L.

Table 9. Ammonia (toxicity) attribute bands specified within the NPS-FM.

Band	Annual median (mg NH ₄ -N/L)	Annual 95th percentile (mg NH ₄ -N/L)
A	≤ 0.03	≤ 0.05
B	> 0.03 to ≤ 0.24	> 0.05 to ≤ 0.40
<i>National bottom line</i>	<i>0.24</i>	<i>0.40</i>
C	> 0.24 to ≤ 1.30	> 0.40 to ≤ 2.20
D	> 1.30	> 2.20

The A band represents a 99% species protection level where no effects are observed on any species, while the D band represents conditions approaching an acute impact level and risk of death for sensitive species.

The One Plan specifies two targets for ammoniacal nitrogen, including a maximum average value and maximum single value, both matched to geology classes. The most stringent target, a maximum average value of < 0.32 mg/L and maximum single value of < 1.7 mg/L, applies to sub-zones classed as Upland Hard Sedimentary and Upland Volcanic Acidic to protect sensitive macroinvertebrates. For all other geology classes, the target is set at a mean concentration < 0.40 mg/L and a maximum single concentration of 2.1 mg/L. It is important to note that ammoniacal nitrogen is one form of SIN and TN. The advice underlying the One Plan suggested that the ammoniacal nitrogen standard will be superseded by the One Plan targets for SIN 75–95% of the time (Ausseil and Clark 2007), meaning that the realised limit for ammoniacal nitrogen is effectively lower than the specified target.

3.5.3. Temporal / flow-linked monitoring requirements

Both the NPS-FM attribute and the One Plan targets apply year-round and during all flows. The NPS-FM attribute grading does not specify a minimum monitoring period. Horizons already monitor ammoniacal nitrogen as part of their SoE monitoring programme (Horizons Regional Council 2019), so no change in data collection is required to comply with the monitoring requirements of the NPS-FM.

3.5.4. Data processing and interpretation

While following a similar structure of assessing both midpoint and extreme values, the metrics, targets and attribute bands used to assess ammoniacal nitrogen differ between the One Plan and the NPS-FM. In contrast to the mean and maximum values used in the One Plan, the NPS-FM uses median and 95th percentile values. In addition, the numeric values set by the NPS-FM are lower than those in the One Plan.

3.5.5. New information since implementation of One Plan that should be considered

To our knowledge there is no new information for setting ammoniacal nitrogen thresholds that would warrant changing the target numeric values in the One Plan.

3.5.6. Comparison summary and recommendations

Despite the structure of the NPS-FM attribute bands and the One Plan targets being similar, the summary metrics and numeric values specified differ. The key difference preventing assessment of the national bottom line is in the summary metrics used, but alignment should be possible through recalculating summary metrics. It is likely that the NPS-FM attribute bands are lower than the current One Plan targets, so **we recommend calculating the appropriate summary metrics as specified in the NPS-FM and reassessing the current targets**. The current thresholds in the One Plan have two bands above the national bottom line, so the NPS-FM A band and B band could potentially replace the current One Plan numbers for the protection of the Ecosystem Health value, which would align with the species protection levels currently

specified in the One Plan for other toxicants. Table 10 summarises the One Plan targets and NPS-FM comparative analysis for ammoniacal nitrogen attribute.

Table 10. Summary comparison between the ammoniacal nitrogen One Plan targets and compulsory NPS-FM ammoniacal nitrogen attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Green cells denote that the policies align and no is change required, while orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Life Supporting Capacity	Common to both policies (mg NH ₄ -N/L)	NPS-FM likely more stringent but incomparable	Different summary metrics used (median and 95th percentile vs. mean and maximum)	NPS-FM likely more stringent	None

3.6. Nitrate (toxicity)

3.6.1. Metrics / indices used to measure attribute

The NPS-FM includes **milligrams of nitrate-nitrogen per litre** as the metric for assessing the compulsory 'nitrate (toxicity)' attribute. There is no target for nitrate-nitrogen in the One Plan, although there are targets for SIN.

3.6.2. Current NPS-FM limits and One Plan targets

The nitrate (toxicity) attribute bands in the NPS-FM are shown in Table 11. Also shown is the (maximum) national bottom line of an annual median of 2.4 mg NO₃-N/L and an annual 95th percentile of 3.5 mg NO₃-N/L.

Table 11. Nitrate (toxicity) attribute bands specified within the NPS-FM.

Band	Annual median (mg NO ₃ -N/L)	Annual 95th percentile (mg NO ₃ -N/L)
A	≤ 1.0	≤ 1.5
B	> 1.0 to ≤ 2.4	> 1.5 to ≤ 3.5
<i>National bottom line</i>	2.4	3.5
C	> 2.4 to ≤ 6.9	> 3.5 to ≤ 9.8
D	> 6.9	> 9.8

The A band represents a nitrate concentration that protects systems of high conservation value where it is unlikely that sensitive species will be affected. The D band represents conditions impacting many species and that are approaching an acute impact level (that is, risk of death) for sensitive species.

3.6.3. Temporal / flow-linked monitoring requirements

The NPS-FM attribute applies year-round and at all flows, although the attribute grading does not specify a minimum monitoring period. Horizons already monitor nitrate as part of their SoE monitoring programme (Horizons Regional Council 2019), so no change in data collection is required to comply with the monitoring requirements of the NPS-FM.

3.6.4. Data processing and interpretation

The attribute bands for nitrate follow the same structure as those for ammoniacal nitrogen of assessing both midpoint and extreme values. These metrics (median and 95th percentile) have already been reported as part of Horizon's SoE monitoring results (Horizons Regional Council 2019). It should be noted that the nitrate (toxicity) attribute measures only the direct toxic effects of nitrate, not the ecological effects of nitrate stimulating periphyton growth. Other attributes measuring trophic state (e.g. periphyton) may be more stringent in limiting nitrate concentrations.

3.6.5. New information since implementation of One Plan that should be considered

Since the One Plan was developed, considerable work has been done to further develop the understanding of nitrate as a toxicant. Updates to overseas guidelines and results from additional chronic toxicity studies are summarised in Hickey (2013), which provides the basis for the numeric values included in the NPS-FM.

3.6.6. Comparison summary and recommendations

While nitrate is monitored by Horizons, there are currently no targets included in the One Plan. Nitrate affects ecosystems in multiple ways, including directly through toxicity effects as well as having indirect ecological effects. **We recommend that targets are at least set for nitrate toxicity (with consideration given to setting nitrate targets to protect linked freshwater values).** The NPS-FM A and B bands align with the species protection levels currently specified in the One Plan for other toxicants. The current One Plan targets for SIN were set based on existing catchment concentrations and for the purpose of managing periphyton growth, so are unlikely to be useful for setting nitrate targets related to toxicity. Table 12 summarises the One Plan targets and NPS-FM comparative analysis for the nitrate attribute, while further discussion regarding setting SIN targets is provided in Section 4.7.

Table 12. Summary comparison between the nitrate One Plan targets and compulsory NPS-FM nitrate attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Green cells denote that the policies align and no change is required, while orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Attribute not included in One Plan	Common to both policies (mg NO ₃ -N/L)	Incomparable as attribute not included in the One Plan	Data collection adequate, presented in SoE reporting as specified in the NPS-FM	Incomparable as attribute not included in the One Plan	Updates to guideline values (Hickey 2013)

3.7. Dissolved reactive phosphorus

3.7.1. Metrics / indices used to measure attribute

The NPS-FM includes **milligrams of dissolved reactive phosphorus per litre** as the metric for assessing the compulsory 'dissolved reactive phosphorus' attribute. The One Plan targets also assess DRP.

3.7.2. Current NPS-FM limits and One Plan targets

The DRP attribute bands in the NPS-FM are shown in Table 13.

Table 13. Dissolved reactive phosphorus attribute bands specified within the NPS-FM. Bands are assessed against a 5-year dataset from monthly monitoring.

Band	Median (mg DRP/L)	95th percentile (mg DRP/L)
A	≤ 0.006	≤ 0.021
B	> 0.006 to ≤ 0.010	> 0.021 to ≤ 0.030
C	> 0.010 to ≤ 0.018	> 0.030 to ≤ 0.054
D	> 0.018	> 0.054

The A band represents ecological communities and processes that are similar to natural reference conditions, with no adverse effects of enrichment attributable to DRP. In contrast, the D band represents conditions where ecological communities are impacted by substantial DRP enrichment, including excessive primary production and the loss of taxa sensitive to hypoxia.

The One Plan specifies three DRP targets, 0.006 mg/L, 0.010 mg/L and 0.015 mg/L. Targets are set for each catchment based on current water quality, the sensitivity of receiving environments and managing periphyton growth.

3.7.3. Temporal / flow-linked monitoring requirements

The NPS-FM attribute applies year-round and at all flows. The One Plan targets apply year-round when river flow is at or below the 20th flow exceedance percentile (i.e. excluding flood flows). Horizons already monitor DRP as part of their SoE monitoring programme (Horizons Regional Council 2019), so no change in data collection is required to comply with the monitoring requirements of the NPS-FM.

3.7.4. Data processing and interpretation

The NPS-FM assesses DRP using 5-year median and 95th percentile summary statistics, rather than the average (assumed to be mean) annual concentration from when river flow is at or below the 20th flow exceedance percentile used in the One Plan. Therefore, while the NPS-FM bands for 5-year medians uses similar thresholds to the One Plan targets, the two are not comparable due to their use of different metrics and flow requirements. Furthermore, the One Plan targets are divided into three thresholds or bands, whereas the NPS-FM includes a four-band system (A–D).

3.7.5. New information since implementation of One Plan that should be considered

Knowledge of the relationships between nutrient concentrations, instream plant abundances and freshwater values have increased since the development of the One Plan (see Matheson et al. 2012; 2016). This research has directly contributed to the numeric DRP values included in the NPS-FM (Matheson et al. 2016).

3.7.6. Comparison summary and recommendations

Despite the threshold values of the NPS-FM attribute bands and the One Plan targets being similar, the metrics and flow requirements differ. The key difference preventing assessment of attribute bands is in the summary metrics used, but alignment should be possible through recalculating summary metrics following the requirements set out by the NPS-FM to calculate 5-year medians using data collected at all flows. This will allow comparison of current One Plan targets and NPS-FM attributes based on current state. Therefore, **we recommend calculating the appropriate summary metrics following the requirements of the NPS-FM and reassessing the current targets**, as switching from an annual mean when flow requirements are met to an annual median at all flows will have implications for achieving targets. The concurrent change in the metric used and flow requirements means that it cannot be determined if the NPS-FM attribute bands are more or less stringent than the current One Plan targets or the current state, creating a minor risk of inadvertently allowing decline from the current state. As a result, care should be taken in defining targets to prevent conflict with the overarching objective of the NPS-FM of allowing no further decline in

freshwater health. In addition, the One Plan specifies only three thresholds for DRP, while four bands are specified in the NPS-FM. Table 14 summarises the One Plan targets and NPS-FM comparative analysis for DRP.

Table 14. Summary comparison between the DRP One Plan Targets and compulsory NPS-FM nitrate attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Green cells denote that the policies align and no change is required, while orange cells signal that changes to the One Plan should be considered. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Life Supporting Capacity	Common to both policies (mg DRP/L)	Incomparable due to different summary metrics and flow requirements, three bands in One Plan vs. four bands in NPS-FM	Data collection adequate, summary metrics calculated differently	Incomparable due to different summary metrics and flow requirements	Research from Matheson et al. (2012, 2016)

3.8. Dissolved oxygen

3.8.1. Metrics / indices used to measure attribute

The NPS-FM includes **milligrams of dissolved oxygen per litre** as the metric for assessing the compulsory 'dissolved oxygen' attribute. This attribute applies below point source discharges as an attribute requiring limits on resource use and across all rivers as an attribute requiring an action plan. The same attribute is included in the One Plan as both a region-wide attribute and an attribute specifically for the protection of trout spawning.

3.8.2. Current NPS-FM limits and One Plan targets

The DO attribute bands in the NPS-FM are shown in Table 15. Also shown is the (maximum) national bottom line of a 7-day mean minimum of 5.0 mg/L and a 1-day minimum of 4.0 mg/L. The same numeric values apply below point sources and across all rivers.

Table 15. Dissolved oxygen attribute bands specified within the NPS-FM. The same values apply below point sources and across all rivers.

Band	Dissolved oxygen (mg/L)	
	7-day mean minimum	1-day minimum
A	≥ 8.0	≥ 7.5
B	≥ 7.0 and < 8.0	≥ 5.0 and < 7.5
C	≥ 5.0 and < 7.0	≥ 4.0 and < 5.0
<i>National bottom line</i>	5.0	4.0
D	< 5.0	< 4.0

The A band represents DO conditions where no organisms (including those found at pristine sites) are subject to any stress from insufficient oxygen, while the D band represents significant, persistent stress on a range of aquatic organisms. At the D band, concentrations are likely to fall below tolerance levels and cause local extinctions of keystone species and a loss of ecological integrity.

The One Plan includes a region-wide target for DO, with thresholds set at a minimum of 60%, 70% and 80% saturation. Target numeric values for each sub-zone are generally matched to different geology classes,⁵ although some individual sub-zones have been assigned more stringent values. Where sub-zones have been assigned more stringent values, it is not clear what additional freshwater values are being protected.

For the protection of trout spawning values, the One Plan defines a further DO target of greater than 80% saturation at sites and river segments where trout spawning has been identified as a freshwater value.

3.8.3. *Temporal / flow-linked monitoring requirements*

The NPS-FM assesses DO using monitoring data collected on at least 7 consecutive days over the summer period (1 November to 30 April), regardless of flow conditions. This differs from the One Plan target, which applies year-round, but also at all flows. While Horizons already collect spot measurement of DO as part of their SoE monitoring programme (Horizons Regional Council 2019) and high temporal-resolution DO measurements (i.e. every 15 mins) at some sites (Young and Kelly 2023), changes will be necessary to meet the monitoring requirements of the NPS-FM across the region.

⁵ The One Plan targets are for a DO saturation of > 80% for Upland Hard Sedimentary and Upland Volcanic Acidic, Upland Volcanic Mixed and Upland Limestone classes; > 70% for Hill Mixed and Hill Soft Sedimentary classes; and > 60% for Lowland Mixed and Lowland Sand classes.

3.8.4. Data processing and interpretation

The approach used to assess DO in the NPS contrasts with the One Plan. The NPS-FM considers the absolute DO concentration when it is at its lowest (and so causes the most stress on aquatic organisms), while the One Plan assesses dissolved saturation from spot measurements (typically taken during daytime, when DO is high).

The summary metrics used by the NPS-FM are the 7-day mean minimum (the mean value of seven consecutive daily minima) and the 1-day minimum (the lowest daily minimum value recorded over the summer period). The One Plan simply compares measured DO saturation to the target numeric value.

3.8.5. New information since implementation of One Plan that should be considered

Since the development of the One Plan, further work has been done to continue to develop an understanding of the lethal and sub-lethal effects of low DO on aquatic organisms (e.g. Urbina et al. 2011; Franklin 2014). Knowledge of the effect of low DO has been used to develop DO targets that explicitly assess DO when conditions are most stressful for aquatic organisms, with the NPS-FM numeric values derived from Davies-Colley et al. (2013).

3.8.6. Comparison summary and recommendations

The NPS-FM DO attribute does not align with the One Plan targets for DO because metrics assess different types of data. Therefore, **we recommend that the Horizons monitoring programme is modified to commence high temporal-resolution monitoring during the summer period and that targets are set for minimum DO concentrations.** The alignment of the three current target thresholds with the likely degree of impairment in each geology class (Ausseil and Clark 2007) broadly aligns with the degree of protection for freshwater values provided in the NPS-FM by bands A to C, so this may be a useful starting point in setting new DO targets. Table 16 summarises the One Plan targets and NPS-FM comparative analysis for the compulsory visual clarity attribute.

Table 16. Summary comparison between the dissolved oxygen One Plan targets and compulsory NPS-FM dissolved oxygen attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Life Supporting Capacity and Trout Spawning	NPS-FM requires DO data over at least 7 consecutive days	Not comparable due to different metrics and threshold definitions	Different data types and processing methods required than for assessing One Plan	Metrics not comparable	Shift in approach to considering timing of stressful conditions – Davies-Colley et al. (2013)

3.9. E. coli

3.9.1. Metrics / indices used to measure attribute

The NPS-FM includes **number of E. coli per 100 millilitres** as the metric for assessing the compulsory ‘*Escherichia coli* (*E. coli*)’ attribute. This primarily relates to human health (Human Contact value) and is the same measurement used in the One Plan.

3.9.2. Current NPS-FM limits and One Plan targets

The NPS-FM details two sets of attribute bands for *E. coli*, with one applying year-round in all rivers (Table 17) and the other applying to primary contact sites during the bathing season (Table 18). A national bottom line for *E. coli* is specified only for primary contact sites, which is 540 *E. coli* /100 mL as the 95th percentile of observed *E. coli* concentrations.

Table 17. *E. coli* attribute bands specified within the NPS-FM. Bands are assessed against a 5-year period of year-round monthly monitoring.

Band	<i>E. coli</i> (<i>E. coli</i> /100 mL)			
	% exceedances over 540/100 mL	% exceedances over 260/100 mL	Median concentration/100 mL	95th percentile of <i>E. coli</i> /100 mL
A	< 5%	< 20%	≤ 130	≤ 540
B	5–10%	20–30%	≤ 130	≤ 1,000
C	10–20%	20–34%	≤ 130	≤ 1,200
D	20–30%	> 34%	> 130	> 1,200
E	> 30%	> 50%	> 260	> 1,200

Table 18. *E. coli* attribute bands specified within the NPS-FM for primary contact sites. These apply during the bathing season.

Band	<i>E. coli</i> (95th percentile of <i>E. coli</i> /100 mL)
Excellent	≤ 130
Good	> 130 and ≤ 260
Fair	> 260 and ≤ 540
<i>National bottom line</i>	540
Poor	> 540

For both year-round and primary contact site bands, A band or excellent represents a low risk of human infection while swimming, with each subsequent band representing increased infection risk.

The One Plan specifies two region-wide maximum targets for *E. coli*, 260 *E. coli* / 100 mL and 550 *E. coli* /100 mL. The most stringent target is set to protect human health during primary contact (e.g. swimming, bathing), while the lesser target is set to protect human health during secondary contact (e.g. boating, kayaking, fishing) (Ausseil and Clark 2007).

3.9.3. *Temporal / flow-linked monitoring requirements*

Both the NPS-FM attribute bands and One Plan targets relating to primary contact apply during the bathing season (currently defined in the One Plan as 1 November to 1 April inclusive), while the remaining attribute bands and targets apply year-round. The NPS-FM attribute bands apply at all flows. In contrast, the One Plan target relating to primary contact applies at median flows or below, while the target for secondary contact applies when river flow is at or below the 20th flow exceedance percentile (i.e. excluding flood flows). Horizons already monitor *E. coli* as part of their SoE and summer contact recreation monitoring programmes (Horizons Regional Council 2019), so no change in data collection is required to comply with the monitoring requirements of the NPS-FM.

3.9.4. *Data processing and interpretation*

While the data requirements of the NPS-FM attributes and One Plan targets are the same and the thresholds are similar, the summary metrics used and number of bands differ. While the One Plan includes a single statistic for both targets, the year-round *E. coli* attribute in the NPS-FM employs multiple criteria to grade infection risk, with all criteria needing to be satisfied to meet the requirements of an attribute band.

The NPS-FM uses a 5-year dataset to determine attribute bands, meaning a long-term dataset is required for defining current state and assessing achievement of targets.

3.9.5. New information since implementation of One Plan that should be considered

The 2003 ‘Microbiological water quality guidelines for marine and freshwater recreational areas’ (MfE 2003) remains the most recent national guidance for contact recreation in rivers, so there is no new policy guidance to consider since the One Plan was implemented. However, the NPS-FM has updated the *E. coli* threshold for secondary contact from 550/100 mL to 540/100 mL based on an updated quantitative microbial risk assessment of the relationship between *E. coli* concentration and *Campylobacter* infection risk (McBride 2012). While updated target values are slightly more stringent, this is only a minor change in threshold and represents approximately the same risk of infection (MfE 2017).

3.9.6. Comparison summary and recommendations

The division of One Plan targets into setting a more stringent target for primary contact during the bathing season and a more lenient target that applies year-round matches the NPS-FM attributes for *E. coli*. **We recommend that both the primary contact and year-round targets are reassessed using the NPS-FM attribute bands.** It should be noted that the NPS-FM requires an improvement in attribute state for Human Contact values, so the targets for *E. coli* that apply year-round (i.e. in relation to secondary contact in the current One Plan) are required to be set above current state, unless A band has already been achieved. The NPS-FM attribute that applies year-round also uses a greater number of summary metrics to grade infection risk by accounting for both median and extreme values. Table 19 summarises the One Plan targets and NPS-FM comparative analysis for the compulsory *E. coli* attribute.

Table 19. Summary comparison between the *E. coli* One Plan targets and compulsory NPS-FM *E. coli* attributes. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Green cells denote that the policies align and no is change required, while orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Human Contact	Contact Recreation	<i>E. coli</i> data common to both policies	NPS-FM has more bands than current One Plan targets. Need to set targets above current state (unless A band already achieved)	Data collection the same but flow requirements and metric calculation differ	NPS-FM bottom line of 10 <i>E. coli</i> / 100 mL lower than One Plan secondary contact target	Update of secondary contact threshold that applies year-round

3.10. Cyanobacteria (planktonic)

3.10.1. Metrics / indices used to measure attribute

The NPS-FM includes the **biovolume of cyanobacteria** as the metric for assessing the compulsory 'Cyanobacteria (planktonic)' attribute. This primarily relates to human health (Human Contact value) in lakes but also lake-fed rivers (and so is included within this review). This attribute is not in the One Plan.

3.10.2. Current NPS-FM limits and One Plan targets

The cyanobacteria biovolume attribute bands in the NPS-FM are shown in Table 20. Also shown is the (maximum) national bottom line of either a biovolume equivalent of potentially toxic cyanobacteria of 1.8 mm³/L or a total biovolume of all cyanobacteria of 10 mm³/L.

Table 20. Cyanobacteria biovolume attribute bands specified within the NPS-FM for lakes and lake-fed rivers. Bands are assessed against a minimum of 12 samples collected over 3 years.

Band	Biovolume of cyanobacteria (mm ³ /L)
	80th percentile
A	≤ 0.5 mm ³ /L biovolume equivalent for the combined total of all cyanobacteria
B	> 0.5 and ≤ 1.0 mm ³ /L biovolume equivalent for the combined total of all cyanobacteria
C	> 1.0 and ≤ 1.8 mm ³ /L biovolume equivalent of potentially toxic cyanobacteria OR > 1.0 and ≤ 10 mm ³ /L total biovolume of all cyanobacteria
National bottom line	1.8 mm ³ /L biovolume equivalent of potentially toxic cyanobacteria OR 10 mm ³ /L total biovolume of all cyanobacteria
D	> 1.8 mm ³ /L biovolume equivalent of potentially toxic cyanobacteria OR > 10 mm ³ /L total biovolume of all cyanobacteria

The A band indicates that the risk of exposure to cyanobacteria from any contact with fresh water is no different to natural conditions, while the D band indicates that a high health risk exists from exposure to cyanobacteria.

There are no targets for planktonic cyanobacteria in the One Plan.

3.10.3. Temporal / flow-linked monitoring requirements

There are no temporal or flow-linked monitoring requirements specified for the NPS-FM attribute. Horizons do monitor planktonic cyanobacteria in some lakes (Horizons Regional Council 2019), but it is not clear which lake-fed rivers in the region the cyanobacteria (planktonic) attribute applies to and if these are monitored.

3.10.4. Data processing and interpretation

Depending on the Horizons cyanobacteria monitoring programme, changes may be required to ensure suitable data are collected to assess cyanobacteria biovolume in lake-fed rivers. The NPS-FM specifies a minimum of 12 samples collected over 3 years for determining attribute bands but recommends that 30 samples are collected over 3 years.

3.10.5. New information since implementation of One Plan that should be considered

Since no planktonic cyanobacteria attribute is included in the One Plan, there are no targets to update.

3.10.6. Comparison summary and recommendations

Cyanobacteria (planktonic) is not currently included in the One Plan. Therefore, **we recommend that Horizons identify lake-fed rivers that the attribute applies to, review their monitoring of planktonic cyanobacteria and set planktonic cyanobacteria targets** (see Table 21).

Table 21. Summary comparison between the planktonic cyanobacteria One Plan targets and compulsory NPS-FM cyanobacteria (planktonic) attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Human Contact	Attribute not included in One Plan	Incomparable as attribute not included in the One Plan	Incomparable as attribute not included in the One Plan	Incomparable as attribute not included in the One Plan	Incomparable as attribute not included in the One Plan	Addition of cyanobacteria (planktonic) as a compulsory attribute

3.11. Fish Index of Biotic Integrity (F-IBI)

3.11.1. Metrics / indices used to measure attribute

The NPS-FM includes the **Fish Index of Biotic Integrity (F-IBI)** as the metric for assessing the compulsory ‘Fish (Wadeable rivers)’ attribute. No corresponding attribute is included in the One Plan.

3.11.2. Current NPS-FM limits and One Plan targets

The NPS-FM details attribute bands for F-IBI based on annual monitoring carried out between December and April (Table 22), but no national bottom line is specified.

Table 22. F-IBI attribute bands specified within the NPS-FM. Bands are assessed against average scores from annual monitoring.

Band	F-IBI (average)
A	≥ 34
B	< 34 and ≥ 28
C	< 28 and ≥ 18
D	< 18

The A band represents fish communities with high integrity, and with minimal degradation of habitat or migratory access. The D band represents a severe loss of fish community integrity, with a substantial loss of habitat and / or migratory access that is causing a high amount of stress on the fish community.

While targets exist in the One Plan for protecting trout spawning and numeric values are identified for trout fisheries, whitebait spawning and specific native fish habitat (as Sites of Significance – Aquatic), there are no targets for the state of fish communities.

3.11.3. Temporal / flow-linked monitoring requirements

The NPS-FM prescribes that, at a minimum, fish monitoring should be conducted annually between December and April (inclusive). Horizons have previously reported F-IBI across the region, in 2017 (Horizons Regional Council 2019), but fish monitoring conducted by multiple agencies will need to be developed into a cohesive annual monitoring programme following standard national monitoring protocols (Joy et al. 2013).

3.11.4. Data processing and interpretation

Depending on Horizons' current fish sampling programme, changes may be required to ensure suitable data are collected to calculate the F-IBI. The NPS-FM does not specify a minimum time period for determining attribute bands.

3.11.5. New information since implementation of One Plan that should be considered

Since no fish attribute is included in the One Plan, there are no targets to update.

3.11.6. Comparison summary and recommendations

F-IBI is not currently included in the One Plan. Therefore, **we recommend that Horizons implement an annual fish monitoring programme and set F-IBI targets** (see Table 23).

Table 23. Summary comparison between the F-IBI One Plan targets and compulsory NPS-FM fish (rivers) attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Attribute not included in One Plan	Presence/absence fish data	Incomparable as attribute not included in the One Plan	Same for F-IBI, but must be assessed annually	Incomparable as attribute not included in the One Plan	Addition of F-IBI as a compulsory attribute

3.12. Ecosystem metabolism

3.12.1. Metrics / indices used to measure attribute

The NPS-FM includes the **gross primary production** and **ecosystem respiration** in grams of dissolved oxygen per square metre per day as the metrics for assessing the compulsory ‘Ecosystem metabolism’ attribute. Ecosystem metabolism is not included as an attribute in the One Plan.

3.12.2. Current NPS-FM limits and One Plan targets

Currently, there are no limits or attribute bands defined for ecosystem metabolism in the NPS-FM.

3.12.3. Temporal / flow-linked monitoring requirements

The NPS-FM specifies that ecosystem metabolism should be assessed from at least 7 days of continuous DO monitoring, to be collected at least once during the summer period (1 November to 30 April). No flow requirements are specified.

3.12.4. Data processing and interpretation

The NPS-FM specifies that ecosystem metabolism is to be monitored following Young et al. (2016). No guideline numeric values are presented for interpreting data,

although this has been identified as an area requiring further work (Freshwater Science and Technical Advisory Group 2019).

3.12.5. *New information since implementation of One Plan that should be considered*

Since the development of the One Plan, ecosystem metabolism has emerged as an attribute assessing ecosystem function, through describing the rate at which biological processes are occurring (Young and Collier 2009). This provides complementary information to structural measurements of the biota and contaminants present.

However, since no ecosystem metabolism attribute is included in the One Plan, there are no targets to update.

3.12.6. *Comparison summary and recommendations*

Ecosystem metabolism is not currently included in the One Plan and attribute bands are yet to be defined in the NPS-FM. Therefore, it is not possible to compare how the attribute is currently being applied with the NPS-FM requirements or to set targets in line with the NPS-FM (see Table 24). **We recommend that Horizons implement monitoring of dissolved oxygen to calculate ecosystem metabolism in line with the NPS-FM in order to set targets once national attribute bands have been developed.**

Table 24. Summary comparison between the ecosystem metabolism One Plan targets and compulsory NPS-FM ecosystem metabolism attribute. A traffic light system is used to denote the likelihood that the current One Plan adheres to the requirements of the NPS-FM. Orange cells signal that changes to the One Plan should be considered. Cells highlighted in red show where differences occur and action is likely required by Horizons to update their One Plan monitoring and / or reporting framework. A more comprehensive comparison table is presented in Appendix 1.

Compulsory NPS-FM value	Equivalent One Plan value	Data type	Attribute target band thresholds	Data collection / processing methods	Bottom line / minimum target	New information to consider
Ecosystem Health	Attribute not included in One Plan	Incomparable as attribute not included in the One Plan	Incomparable as attribute not included in the One Plan	Incomparable as attribute not included in the One Plan	Incomparable as attribute not included in the One Plan	Development of ecosystem metabolism as a compulsory attribute

4. (NON-COMPULSORY) ADDITIONAL REGIONAL ONE PLAN TARGETS AND ATTRIBUTES

Below we describe the regional attributes proposed by Lennard et al. (2023) and detail potential thresholds that define bands to assess ecosystem state. For the purposes of grading the state of all regional attributes (with the exception of toxicants, biochemical oxygen demand [BOD] and POM), we recommend that a four-band grading system is used to match that of the NPS-FM. Within the four bands, the highest state (A) should represent pristine (or close to reference / pristine) conditions, while the lowest state (D) should represent severely degraded conditions. This ensures consistency with the compulsory attributes, and by doing so provides a common language for engaging communities in freshwater management.

While many regional attributes are linked to multiple freshwater values, only one set of attribute bands is recommended to prevent unnecessary duplication. The connection between attributes and freshwater values, as well as recommendations for setting targets, are detailed in Section 5. Where attributes are already included in the NPS-FM as compulsory attributes for the values of Ecosystem Health or Human Contact, the recommendations for applying the attributes given in Section 3 also apply to other freshwater values. When setting targets, all applicable freshwater values should be considered, with a sufficiently stringent target set to ensure the protection of all values (see Section 5).

4.1. Water temperature

4.1.1. *Linked freshwater values*

Water temperature is recommended by Lennard et al. (2023) as an attribute for assessing Ecosystem Health, Threatened Species, Mahinga Kai and Fishing values.

4.1.2. *Metrics / indices used to measure attribute*

Multiple metrics and indices can be used to assess water temperature, including maximum water temperatures, mean water temperatures, allowable degree of change and indices such as the Cox–Rutherford Index, which accounts for diel temperature fluctuations (Cox and Rutherford 2000).

4.1.3. *Current One Plan targets*

The current One Plan includes targets for both a maximum water temperature and an allowable degree of change. Thresholds for maximum water temperature are 19 °C, 22 °C and 24 °C based on geology class, with a maximum allowable degree of change of 2 °C or 3 °C (specifically related to resource consents). The current targets are set to protect the fish and macroinvertebrate species expected to exist in each

geology class, and so vary between upland and lowland waterways to provide for the requirements of the species present (Ausseil and Clark 2007). No temporal or flow-linked requirements are specified in the One Plan, so the targets apply at all river flows and year-round.

4.1.4. *New information since implementation of One Plan that should be considered*

Both the understanding of the thermal tolerances of aquatic organisms native to Aotearoa New Zealand (Olsen et al. 2012) and potential attribute thresholds (Davies-Colley et al. 2013) have developed since the One Plan was made operative. Davies-Colley et al. (2013) proposed attribute bands for water temperature, which while ultimately not included in the NPS-FM, still offer the most up-to-date starting point for setting targets.

4.1.5. *Recommended bands*

We recommend that the attribute bands proposed for 'Maritime' regions (the appropriate classification for the Horizons region) by Davies-Colley et al. (2013) are adopted for setting water temperature targets (Table 25). Cox–Rutherford Index values are to be averaged from the five hottest days (water temperature) over the summer period, requiring the collection of high temporal resolution (i.e. 'continuous') water temperature data between 1 December and 30 March. The A-band value represents no thermal stress on any aquatic organisms that are present at matched reference (near-pristine) sites. D band, below the suggested bottom line, represents significant stress on a range of aquatic organisms, allowing targets to specify the level of protection sought.

The proposed bands are similar to the current One Plan targets and map to the three existing thresholds for water temperature. While the numeric values for each threshold are slightly lower, the shift to the use of the Cox–Rutherford Index in place of assessing the maximum temperature means that the targets are significantly more stringent for each band as the index is calculated as $(T_{\text{daily max}} + T_{\text{daily mean}}) / 2$. For waterways with naturally high summer maximum temperatures, Davies-Colley et al. (2013) also propose an approach for setting attribute bands using a reference condition approach that can apply on a site-specific basis if needed.

Table 25. Proposed regional attribute bands for water temperature (Davies-Colley et al. 2013). Values are assessed using the Cox–Rutherford Index from the five hottest days (water temperature) over the summer period from 1 December to 30 March, calculated as $(T_{\text{max}} + T_{\text{daily mean}}) / 2$.

Band	Cox–Rutherford Index from five hottest summer days (°C)
A	≤ 18
B	> 18 to ≤ 20
C	> 20 to ≤ 24
<i>Bottom line</i>	24
D	> 24

4.2. Periphyton weighted composite cover

4.2.1. *Linked freshwater values*

Periphyton weighted composite cover (PeriWCC) is recommended by Lennard et al. (2023) as an attribute for assessing the values of:

- Ecosystem Health
- Human Contact / Tauranga Waka and Transport
- Threatened Species
- Mahinga Kai
- Natural Form and Character / Amenity
- Fishing.

4.2.2. *Metrics / indices used to measure attribute*

Periphyton cover is typically assessed as the proportion of the riverbed covered by different forms of periphyton, such as green filamentous algae, or diatoms and mats (Biggs 2000). PeriWCC was developed to combine the proportion of filamentous algae and agal mat cover to recognise that there may be times when both filamentous algae and mat algae growth may be present without exceeding their respective targets but in combination still cover a large portion of the bed (Matheson et al. 2012). Cover is calculated as $\% \text{filamentous cover} + (\% \text{mat cover} / 2)$.

4.2.3. *Current One Plan targets*

The One Plan currently has targets for both filamentous algae cover (must not exceed 30% cover) and diatom or cyanobacterial cover (must not exceed 60% cover) that apply year-round at all flows. No target has been set for PeriWCC as it has been developed since the One Plan was implemented.

4.2.4. *New information since implementation of One Plan that should be considered*

Since the development of the One Plan, the periphyton guidelines have been reviewed and PeriWCC has been developed as a metric of periphyton cover within a

wider work programme of determining appropriate plant abundances and defensible water quality targets to control plant growth (Matheson et al. 2012, 2016).

4.2.5. Recommended bands

As identified by Lennard et al. (2023), the thresholds proposed by Matheson et al. (2012) and Matheson et al. (2016) are the most relevant. We recommend that the suggested bands presented in Table 26 are adopted for setting periphyton cover targets. The thresholds have been proposed for protecting both Ecosystem Health and Fisheries values. Higher thresholds are proposed to apply to fisheries based on the ability to fish for trout (i.e. cast a line) without being impeded, and so the fisheries-linked numeric values are not directly related to fish biology or other elements of ecosystem health. Given that numeric values for fisheries are more stringent than the thresholds related to ecosystem health and that the fisheries value is specific to trout fishing, two sets of attribute bands are proposed, with a further target for amenity values of < 30% PeriWCC from November to April.

Table 26. Proposed regional attribute bands for PeriWCC for ecosystem health (Matheson et al. 2012) and fisheries (Matheson et al. 2016). Fisheries values specifically relate to trout fisheries.

Value	Band	PeriWCC
Ecosystem Health	A	< 20%
	B	≥ 20% to < 40%
	C	≥ 40% to < 55%
	<i>Bottom line</i>	55%
	D	> 55%
Fisheries (92nd percentile of cover)	A	< 10%
	B	≥ 10% to < 35%
	C	≥ 35% to < 75%
	<i>Bottom line</i>	75%
	D	> 75%

4.3. Toxicants

4.3.1. Linked freshwater values

Toxicants are recommended by Lennard et al. (2023) as an attribute for assessing the values of:

- Ecosystem Health
- Threatened Species
- Mahinga Kai
- Fishing
- Stock Drinking Water (referred to as 'Animal Drinking Water' in the NPS-FM)

- Irrigation, cultivation and production of food and beverages
- Commercial and Industrial Use
- Domestic Food Supply.

4.3.2. Metrics / indices used to measure attribute

The common approach for assessing toxicants is to assess the concentration of individual toxicants in either water or riverbed sediments. Commonly, results are compared against the trigger values for toxicants presented in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) default guideline values.

4.3.3. Current One Plan targets

The One Plan targets for toxicants use the Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guideline values (the predecessor to the ANZG 2018 values) and specify a 99% level of species protection for ecosystems with high conservation or ecological value, and a 95% level of protection for slightly to moderately disturbed systems. These targets apply year-round at all flows.

4.3.4. New information since implementation of One Plan that should be considered

Since the One Plan became operative, the ANZECC 2000 guideline values have been superseded by the ANZG 2018 values.

4.3.5. Recommended bands

We recommend that the species protection thresholds defined in the One Plan are retained and are updated to use the ANZG 2018 values. The proposed bands are detailed in Table 27. The A band protects the ecological health of ecosystems with high conservation or ecological value, while the B band protects slightly to moderately disturbed systems. The C band is proposed as a bottom line to protect even more disturbed ecosystems from further degradation. The ANZG guidelines identify only three threshold levels, so no D band is proposed.

Table 27. Proposed regional attribute bands for toxicants. The level of species protection refers to the default guideline values presented by ANZG (2018).

Band	Level of species protection
A	99%
B	95%
C (bottom line)	90%

Lennard et al. (2023) notes that a cross-council collaborative research project is currently underway to advise regional councils on consistent implementation of these guidelines. As such, the development of a regional attribute for toxicants should consider the outcomes of that work.

4.4. Particulate organic matter

4.4.1. *Linked freshwater values*

Particulate organic matter (POM) is recommended by Lennard et al. (2023) as an attribute for assessing Ecosystem Health downstream of point source discharges only.

4.4.2. *Metrics / indices used to measure attribute*

The standardised lab measure for POM is the concentration of POM in a water sample that cannot pass through a filter typically ranging from 0.053 mm to 2 mm.

4.4.3. *Current One Plan targets*

The current One Plan target for POM is a maximum of 5 g/m³ for all sub-zones. This target is set to protect benthic macroinvertebrate communities from the effects of point source discharges (Ausseil and Clark 2007). The target applies year-round when rivers are at or below median flow.

4.4.4. *New information since implementation of One Plan that should be considered*

To our knowledge there is no new information on POM that would warrant changing the target values in the One Plan.

4.4.5. *Recommended bands*

We recommend that the current target of < 5 g/m³ downstream of point source discharges for all sub-zones is retained and applied at all flows.

4.5. Biochemical oxygen demand

4.5.1. *Linked freshwater values*

Biochemical oxygen demand (BOD) is recommended by Lennard et al. (2023) as an attribute for assessing Ecosystem Health downstream of point source discharges only.

4.5.2. Metrics / indices used to measure attribute

Biochemical oxygen demand is a standardised lab measure of microbial oxygen consumption, often associated with discharges due to bacteria decomposing organic material.

4.5.3. Current One Plan targets

The current One Plan targets for the monthly average 5-day BOD are a maximum 1.5 g/m³ for sub-zones where the DO target is set at 80% and 2 g/m³ for all other sub-zones. This target is set to support DO targets through controlling the impact of point source discharges on DO and applies year-round below the 20th flow exceedance percentile (i.e. excludes flood flows).

4.5.4. New information since implementation of One Plan that should be considered

Since the One Plan became operative, no new science has emerged in relation to setting targets for BOD. However, technical advice provided to other councils in Aotearoa New Zealand for the development of regional plans has recommended the same target for BOD of 2 g/m³ (Ausseil 2013; Clapcott and Hay 2014).

4.5.5. Recommended bands

We recommend that the current target of 1.5 g/m³ for sub-zones with the most stringent level of DO targets and 2 g/m³ for all other sub-zones downstream of point source discharges is retained and applied at all flows.

4.6. Cyanobacteria

4.6.1. Linked freshwater values

Cyanobacteria is recommended by Lennard et al. (2023) as an attribute for assessing the values of:

- Human Contact / Tauranga Waka and Transport
- Wai Tapu
- Mahinga Kai
- Drinking Water Supply.

Given cyanobacteria is recommended by Lennard et al. (2023) as an attribute for assessing Mahinga Kai, the same logic ought to apply to Fishing values, particularly where fish are consumed by anglers.

4.6.2. Metrics / indices used to measure attribute

Benthic cyanobacteria in rivers are often assessed based on the percentage of riverbed covered by cyanobacterial mats. Planktonic cyanobacteria are assessed as biovolume and the biovolume of planktonic cyanobacteria is detailed as a compulsory attribute in Section 3.10.

4.6.3. Current One Plan targets

Currently, the One Plan includes a target for a maximum combined diatom and cyanobacteria cover of 60% that applies to all rivers.

4.6.4. New information since implementation of One Plan that should be considered

To our knowledge there is no new information on benthic cyanobacteria attributes that has been published since the One Plan became operative. Work to finalise the interim recreational guidelines for cyanobacteria (MfE and MoH 2009) has not been completed.

4.6.5. Recommended bands

The best available evidence for defining attribute bands are the interim recreational cyanobacteria guidelines (MfE and MoH 2009) and the New Zealand Periphyton Guidelines (Biggs 2000). The key thresholds derived by MfE and MoH (2009) include **20%** and **50%** cover. These thresholds should inform the setting of targets based on the exceedances of each threshold, but work is yet to be done to connect threshold exceedances with human health risk and linked freshwater values such as Tauranga Waka or Mahinga Kai. Therefore, we recommend further development is done to determine appropriate attribute bands for cyanobacteria cover for protecting human health, with the intent of adding it as an attribute once suitably developed. It should be noted that the compulsory attribute for periphyton (see Section 3.1.) includes cyanobacteria. Subsequently, managing rivers for total periphyton biomass will also manage cyanobacteria to some extent.

4.7. Soluble / dissolved inorganic nitrogen

4.7.1. Linked freshwater values

Soluble / dissolved inorganic nitrogen is recommended by Lennard et al. (2023) as an attribute for assessing the values of:

- Ecosystem Health
- Threatened Species
- Fishing.

4.7.2. *Metrics / indices used to measure attribute*

Soluble inorganic nitrogen (SIN) is measured using lab-tested water samples.

4.7.3. *Current One Plan targets*

The One Plan includes a maximum annual average concentration of SIN when river flow is below the 20th flow exceedance percentile (i.e. excluding flood flows). Four thresholds of 0.070 mg/L, 0.110 mg/L, 0.167 mg/L and 0.444 mg/L are specified, with targets set for each catchment based on current water quality, the sensitivity of receiving environments and aspirations for managing periphyton growth.

4.7.4. *New information since implementation of One Plan that should be considered*

Since the One Plan was made operative, the Freshwater Science and Technical Advisory Group (2019) proposed attribute bands and a national bottom line for inclusion within the NPS-FM for the protection of Ecosystem Health. While SIN was not adopted as a compulsory attribute, the advice provided in developing the attribute bands remains relevant for developing regional attributes.

4.7.5. *Recommended bands*

We recommend that the clause 3.13 process of the NPS-FM considering instream loads and receiving environments is used for setting SIN targets. Given that the SIN attribute is intended to protect multiple freshwater values (Ecosystem Health, Threatened Species and Fish), it is important to consider how these values interact. In practice, the most environmentally conservative targets to manage estuaries, fish and periphyton should apply, although the numeric values proposed by the Freshwater Science and Technical Advisory Group (2019) may offer a useful starting point (Table 28).

Table 28. SIN bands proposed by the Freshwater Science and Technical Advisory Group (2019). Bands are assessed against a 5-year dataset from monthly monitoring.

Band	Median (mg SIN/L)	95th percentile (mg SIN/L)
A	≤ 0.24	≤ 0.56
B	> 0.24 to ≤ 0.50	> 0.56 to ≤ 1.10
C	> 0.50 to ≤ 1.00	> 1.10 to ≤ 2.05
<i>Bottom line</i>	1.0	2.05
D	> 1.0	> 2.05

The A band represents ecological communities and processes that are similar to natural reference conditions, with no adverse effects of enrichment attributable to SIN. In contrast, the D band represents conditions where ecological communities are impacted by substantial SIN enrichment, including excessive primary production and

the loss of taxa sensitive to hypoxia and nitrate toxicity. However, given the change in both the attribute metrics assessed and the flow requirements, it is unclear if the recommended bands are more or less stringent than the current One Plan targets.

4.8. Turbidity (lab measure)

4.8.1. *Linked freshwater values*

Turbidity (lab measure) is recommended by Lennard et al. (2023) as an attribute for assessing the values of Fishing and Hydroelectric power generation.

4.8.2. *Metrics / indices used to measure attribute*

Turbidity is one of three related attributes linked to assessing the quantity of suspended sediment in waterways, the other two being suspended sediment concentration and visual clarity (Depree et al. 2018).

4.8.3. *Current One Plan targets*

The One Plan does not include any targets for turbidity, but it does include targets for visual clarity (see Section 3.3.).

4.8.4. *New information since implementation of One Plan that should be considered*

Since the One Plan was developed, significant national-scale work has been done to characterise the relationships between fine sediment (both deposited and suspended sediment) and indicators of ecosystem health (see Section 3.3.5.)

4.8.5. *Recommended bands*

It is unclear why Lennard et al. (2023) have proposed the use of turbidity as a regional attribute for some freshwater values while visual clarity is both a compulsory attribute for Ecosystem Health and a regional attribute for other freshwater values. Given that both turbidity and visual clarity serve as proxies for suspended sediment, we recommend that, for consistency, only visual clarity is retained as an attribute.

If the inclusion of turbidity is for practical reasons (i.e. allowing assessment through using NTU-turbidity meters or lab testing of water samples), we suggest setting a visual clarity target and subsequently translating turbidity values into visual clarity estimates through developing a site-specific relationship between visual clarity and turbidity.

4.9. Indicators of faecal contamination

4.9.1. *Linked freshwater values*

Indicators of faecal contamination are recommended by Lennard et al. (2023) as an attribute for assessing Stock Drinking Water (referred to as 'Animal Drinking Water' in the NPS-FM).

4.9.2. *Metrics / indices used to measure attribute*

Both *E. coli* and faecal coliform concentrations are used to assess faecal contamination (ANZECC 2000; Ausseil and Clark 2007), with faecal coliform concentration being the preferred metric for Stock Drinking Water (Ausseil and Clark 2007). We note that guidelines for primary contact have shifted away from using faecal coliform concentrations to instead using *E. coli* concentrations. However, no such update has occurred for defining standards for Stock Drinking Water.

4.9.3. *Current One Plan targets*

Currently, the only targets related to faecal contamination in the One Plan are the *E. coli* targets related to contact recreation (see Section 3.9.). While targets of a maximum median value of 100 faecal coliforms/100 mL and an 80th percentile of 400/100 mL faecal coliforms were proposed as a parameter related to faecal contamination in the technical guidance for the One Plan (Ausseil and Clark 2007), no targets were included in the One Plan.

4.9.4. *New information since implementation of One Plan that should be considered*

To our knowledge there is no new information on faecal contamination of stock water that has been published since the One Plan became operative. Recent work has investigated the water requirements of stock in terms of water quantity but not in terms of water quality (e.g. Bennett 2022).

4.9.5. *Recommended bands*

In the absence of evidence to define attribute bands or set *E. coli* targets for Stock Drinking Water, we recommend that the targets proposed for the One Plan of a maximum median value of 100 faecal coliforms/100 mL and an 80th percentile of 400/100 mL faecal coliforms are adopted as a bottom line for Stock Drinking Water (Ausseil and Clark 2007). These targets are derived from the 2000 ANZECC guidelines.

4.10. pH

4.10.1. *Linked freshwater values*

While Lennard et al. (2023) recommended removing pH as an attribute, we recommend that it is retained as an attribute for assessing Ecosystem Health.

4.10.2. *Metrics / indices used to measure attribute*

pH is directly measured in the water column, and is assessed as deviation from neutral conditions (pH = 7), as both acidic or alkaline conditions can be stressful for aquatic life (Davies-Colley et al. 2013). Given that pH is known to display diel variation, high-frequency monitoring is required to capture reliable data.

4.10.3. *Current One Plan targets*

The current One Plan includes targets for both an acceptable pH range and an allowable degree of change. Depending on water management sub-zone, the acceptable range for pH is either 7–8.2 or 7–8.5, with an allowable degree of change for all sub-zones of 0.5. The current targets are set to protect fish and aquatic life by maintaining natural pH conditions (Ausseil and Clark 2007). No temporal or flow-linked requirements are specified in the One Plan, so the targets apply at all river flows and year-round.

4.10.4. *New information since implementation of One Plan that should be considered*

The understanding of the pH tolerances of aquatic organisms native to Aotearoa New Zealand remains limited, but potential attribute thresholds have been developed since the One Plan was made operative. Davies-Colley et al. (2013) proposed attribute bands for pH, which while ultimately not included in the NPS-FM, still offer the most up-to-date starting point for setting targets.

4.10.5. *Recommended bands*

We recommend that the attribute bands proposed by Davies-Colley et al. (2013) are adopted for setting pH targets (Table 29). The upper 95th percentile from high-frequency monitoring over the summer period is calculated, requiring the collection of continuous water temperature data between 1 December and 30 March. The A-band value represents no stress caused by acidic or alkaline ambient conditions on any aquatic organisms. D band, below the suggested bottom line, represents significant stress caused by intolerable pH on a range of aquatic organisms, allowing targets to specify the level of protection sought.

While the proposed bands appear more permissive than the current One Plan targets, assessment using high-frequency monitoring means that the proposed attribute bands will incorporate diel variation not currently captured by the assessment of spot pH

measurements. The proposed attribute bands do not apply to waterways with naturally low pH due to humic soils.

Table 29. Proposed regional attribute bands for pH (Davies-Colley et al. 2013). Values are assessed using the upper 95th percentile from continuous summer monitoring.

Band	Cox–Rutherford Index from five hottest summer days (°C)
A	6.5 < pH < 8.0
B	6.5 < pH < 8.5
C	6.0 < pH < 9.0
<i>Bottom line</i>	<i>pH = 6.0 or pH = 9.0</i>
D	pH < 6.0 or pH > 9.0

5. SETTING TARGETS RELATED TO FRESHWATER VALUES

Using the attribute band framework, targets for both compulsory and non-compulsory attributes are determined by the freshwater values underlying each attribute and the degree of protection sought. Further direction for compulsory attributes is provided by the overarching objective of the NPS-FM of allowing no further decline in freshwater health, meaning that targets must be set at or above current state. Within the NPS-FM, national bottom lines are set at numeric values that protect the minimum acceptable level of ecosystem health – i.e. a ‘good’ environmental state is generally some level above the national bottom line, hence the provision of attribute bands.

Targets should generally be set at the sub-zone scale to remain consistent with the scale at which targets have been set in the One Plan, although the NPS-FM requires targets to be set only for Freshwater Management Units (equivalent to zone scale). For certain spatially explicit values, it may be appropriate to set some targets at specific segment scales (e.g. Fisheries, Mahinga Kai, Water use). In setting targets, consideration should be given to the downstream transport of pollutants and toxicants to account for the cumulative effects on receiving environments.

Table 30 aggregates compulsory and non-compulsory attributes for each freshwater value and proposes attribute bands for protecting each of these. For setting targets, the freshwater values applying to a sub-zone (or river segment) must be identified and then the minimum attribute target required to satisfy all applicable values should be identified using Table 30. Where the current state of an attribute, or the degree of protection desired, is higher than the suggested minimum target, a more ambitious target should be set. This is especially true for freshwater values such as Threatened species, where the specific species present in a sub-zone may vary significantly in their attribute requirements. For example, juvenile kākahi (freshwater mussel) are particularly sensitive to ammonia and so require more stringent targets to ensure their protection than other threatened species such as longfin eel (Clearwater et al. 2014). Similarly, cultural (e.g. Mahinga kai) or recreational values are also likely to vary with location depending on the activities undertaken on a site-by-site basis, and therefore some sites will require more stringent targets to protect these values.

Table 30. Compulsory (**bolded**) and non-compulsory attributes grouped by freshwater value. Proposed minimum attribute bands or targets are specified for the **minimum protection of each freshwater value**. Note that suggested minimum attribute band / targets for threatened species and cultural / recreational values will need to be raised to protect different species and / or specific activities that occur within different sub-zones or river segments.

Value group	Sub-value	Attributes	Minimum attribute band / targets to protect value	Source
Ecosystem Health	Ecosystem Health (region wide)	Periphyton (chlorophyll-a)	C	NPS-FM bottom line
		Ammonia (toxicity)	B	NPS-FM bottom line
		Nitrate (toxicity)	B	NPS-FM bottom line
		DO	C	NPS-FM bottom line
		Suspended fine sediment (Visual clarity)	C	NPS-FM bottom line
		F-IBI	C	NPS-FM – set to avoid loss of integrity of fish community
		Macroinvertebrates – MCI	C	NPS-FM bottom line
		Macroinvertebrates – QMCI	C	NPS-FM bottom line
		Macroinvertebrates – ASPM	C	NPS-FM bottom line
		Deposited fine sediment	C	NPS-FM bottom line
		DRP	C	NPS-FM – set to avoid significant change in macroinvertebrate and fish communities
		Ecosystem metabolism	N/A	No bands defined in NPS-FM
		Water temperature	C	Davies-Colley et al. (2013) proposed bottom line
Periphyton weighted composite cover (PeriWCC)	C (using PeriWCC ecosystem health bands)	Matheson et al. (2012) proposed bottom line		

Value group	Sub-value	Attributes	Minimum attribute band / targets to protect value	Source
		Toxicants	B	Aligned with current One Plan target
		SIN	C	Freshwater Science and Technical Advisory Group (2019) proposed bottom line
		pH	C	Davies-Colley et al. (2013) proposed bottom line
	Ecosystem Health (downstream of point source discharges)	DO	C	NPS-FM bottom line
		POM	< 5 g/m ³ (all flows)	Current One Plan target
		BOD	< 1.5 g/m ³ for sub-zones with a DO target of A, < 2 g/m ³ for all other sub-zones (all flows)	Current One Plan target
	Threatened Species	Periphyton (chlorophyll-a)	B	NPS-FM – set to achieve low nutrient enrichment, flow regime modification or habitat modification
		Ammonia (toxicity)	A	NPS-FM – set to 99% species protection level to protect all species and align with One Plan toxicants target
		Nitrate (toxicity)	A	NPS-FM – set to protect high conservation value systems
		DO	B	NPS-FM – set to avoid loss of sensitive organisms
		Suspended fine sediment (visual clarity)	B	NPS-FM – set to avoid loss of sensitive organisms
		Macroinvertebrates – MCI	C	NPS-FM bottom line
		Macroinvertebrates – QMCI	C	NPS-FM bottom line

Value group	Sub-value	Attributes	Minimum attribute band / targets to protect value	Source
		Macroinvertebrates – ASPM	C	NPS-FM bottom line
		Deposited fine sediment	B	NPS-FM – set to avoid loss of sensitive organisms
		Ecosystem metabolism	N/A	No bands defined in NPS-FM
		Water temperature	B	Davies-Colley et al. (2013) – set to avoid loss of sensitive organisms
		Toxicants	A	Aligned with current One Plan target
		SIN	B	Freshwater Science and Technical Advisory Group (2019) – set to avoid loss of sensitive taxa
Recreational and cultural values	Human Contact / Tauranga Waka and Transport	<i>E. coli</i>	Above current state unless the A band is already met for year-round targets 'Fair' for primary human contact targets	NPS-FM Clause 3.11(3) and NPS-FM bottom line
		Cyanobacteria (planktonic)	C	NPS-FM bottom line
		Cyanobacteria		Insufficient information to recommend targets
		Suspended fine sediment (visual clarity)	A (when primary contact recreation targets apply)	Ausseil and Clark (2007) – set to allow estimations of depth and identification of sub-surface hazards
		PeriWCC	C (using PeriWCC fishing bands)	Matheson et al. (2016) proposed bottom line
	Wai Tapu	<i>E. coli</i>	'Fair' for primary contact recreation targets	NPS-FM bottom line for Human Contact

Value group	Sub-value	Attributes	Minimum attribute band / targets to protect value	Source
		Suspended fine sediment (visual clarity)	C (site-dependent based on specific activities)	NPS-FM bottom line for Ecosystem Health
		Cyanobacteria		Insufficient information to recommend targets
	Mahinga Kai	Periphyton (chlorophyll-a)	B	NPS-FM – set to limit frequency of blooms
		PeriWCC	C (using PeriWCC fishing bands)	Matheson et al. (2016) proposed bottom line
		Ammonia (toxicity)	B	NPS-FM bottom line for Ecosystem Health
		Nitrate (toxicity)	B	NPS-FM bottom line for Ecosystem Health
		DO	C	NPS-FM bottom line for Ecosystem Health
		Suspended fine sediment (visual clarity)	C (dependent on species being collected and collection method)	NPS-FM bottom line for Ecosystem Health
		Cyanobacteria		Insufficient information to recommend targets
		Deposited fine sediment	C	NPS-FM bottom line for Ecosystem Health
		Water temperature	C	Davies-Colley et al. (2013) proposed bottom line for Ecosystem Health
		Macroinvertebrates – MCI	C	NPS-FM bottom line
		<i>E. coli</i>	Above current state unless the A band is already met for year-round targets 'Fair' for primary contact recreation targets	NPS-FM Clause 3.11(3) and NPS-FM bottom line
		Toxicants	B	Aligned with current One Plan target

Value group	Sub-value	Attributes	Minimum attribute band / targets to protect value	Source
	Natural Form and Character / Amenity	Periphyton (chlorophyll-a)	B	Biggs (2000) – set to avoid nuisance levels of algae
		PeriWCC	< 30% from November to April	Matheson et al. (2012)
		Deposited fine sediment	B	NPS-FM – set to limit effect of deposited fine sediment on instream biota
	Fishing ⁶	DO	A for TF1 and TF2 B for TF3	Ausseil and Clark (2007) – set based on 1-day minimum DO requirements
		Water temperature	A for TF1 and TF2 C for TF3	Ausseil and Clark (2007)
		Suspended fine sediment (visual clarity)	A for TF1 B for TF2 C for TF3	Ausseil and Clark (2007) – set relative to degree of degradation from reference condition
		Macroinvertebrates – MCI	A for TF1 and TF2 B for TF3	Ausseil and Clark (2007)
		Macroinvertebrates – QMCI	A for TF1 and TF2 B for TF3	Ausseil and Clark (2007)
		<i>E. coli</i>	Above current state unless the A band is already met for year-round targets	NPS-FM Clause 3.11(3)
		Periphyton (chlorophyll-a)	B for all fisheries	Ausseil and Clark (2007)

⁶ Three classes of trout fishery are defined in the One Plan: outstanding trout fisheries (TF1), regionally significant trout fisheries (TF2) and other trout fisheries (TF3).

Value group	Sub-value	Attributes	Minimum attribute band / targets to protect value	Source
		Ammonia (toxicity)	A for TF1 B for TF2 and TF3	Ausseil and Clark (2007) – set at 99% and 95% species protection levels
		Nitrate (toxicity)	A for TF1 B for TF2 and TF3	NPS-FM – set to protect high conservation value systems and the national bottom line respectively
		SIN	A for TF1 B for TF2 and TF3	Freshwater Science and Technical Advisory Group 2019 – set to avoid and minimise the effects of enrichment respectively
		DRP	A for TF1 B for TF2 and TF3	Freshwater Science and Technical Advisory Group 2019 – set to avoid and minimise the effects of enrichment respectively
		Deposited fine sediment	A for TF1 B for TF2 and TF3	NPS-FM – set for protection of trout spawning (may be best retained as an individual value)
		Toxicants	A for TF1 B for TF2 and TF3	Ausseil and Clark 2007 – set at 99% and 95% species protection levels
		PeriWCC	A (using PeriWCC fishing bands) for TF1 B for TF2 C for TF3	Matheson et al. 2016
		Turbidity	See Suspended fine sediment target	
Water use values	Drinking Water Supply	Cyanobacteria		Insufficient information to recommend targets, but see Drinking-water Standards for New Zealand

Value group	Sub-value	Attributes	Minimum attribute band / targets to protect value	Source
				2005 (revised 2018; MoH 2018) for maximum allowable values for cyanotoxins
	Stock Drinking Water (Animal Drinking Water in NPS-FM)	Indicators of faecal contamination	Maximum median value of 100/100 mL for faecal coliforms 80th percentile of 400/100 mL for faecal coliforms	Ausseil and Clark (2007)
		Toxicants	B	Aligned with current One Plan target
	Irrigation, Cultivation and Production of Food and Beverages	Periphyton (chlorophyll-a)		Insufficient information to recommend targets. Requirements likely vary and it is anticipated that this value will be provided for by protecting other values (see Ausseil and Clark 2007)
		Ammonia (toxicity)		
		DO		
		Suspended fine sediment (visual clarity)		
		<i>E. coli</i>		
		Toxicants		
	Commercial and Industrial Use	Periphyton (chlorophyll-a)		Insufficient information to recommend targets. Requirements likely vary and it is anticipated that value will be provided for by protecting other values (see Ausseil and Clark 2007)
		Ammonia (toxicity)		
		DO		
		Suspended fine sediment (visual clarity)		
		<i>E. coli</i>		
		Toxicants		

Value group	Sub-value	Attributes	Minimum attribute band / targets to protect value	Source
	Domestic Food Supply	Periphyton (chlorophyll-a)		Insufficient information to recommend targets. Requirements likely vary and it is anticipated that this value will be provided for by protecting other values (see Ausseil and Clark 2007)
		Ammonia (toxicity)		
		DO		
		Suspended fine sediment (Visual clarity)		
		<i>E. coli</i>		
		Toxicants		
	Hydro-electric Power Generation	Turbidity		Insufficient information to recommend targets

6. SUMMARY

While the current One Plan and work done to date mean that Horizons are well placed to incorporate the directives from the NPS-FM into the One Plan, continued work is needed to ensure that the One Plan fully incorporates the requirements of the NPS-FM. Key areas to address are the specific details of setting targets to protect freshwater values, as well as changes in how attributes are assessed. Since the One Plan became operative, knowledge has advanced for some attributes while other proposed attributes still lack sufficient information to set robust targets.

6.1. Compulsory attributes

There is general alignment between the One Plan and equivalent compulsory attributes specified in the NPS-FM. However, further work is required to align data collection, data interpretation and attribute band thresholds. New information has been published for seven attributes, while there are a further three compulsory attributes that are not currently included in the One Plan. In addition, the banding system in the NPS-FM, for some attributes such as visual clarity, explicitly separates the degree of ecosystem protection from natural variation linked to underlying geology. While the NPS-FM retains the approach of excluding the highest flood flows from assessing targets, in many cases the metrics used to assess targets have shifted to include a greater proportion of flows by employing medians and 95th percentile values rather than removing data from flood flows outright. There are fewer differences in the temporal requirements set for targets, but the combined differences in flow and temporal requirements means that like-for-like comparisons of targets are not possible for some key attributes.

6.2. Non-compulsory / regional attributes

For non-compulsory attributes, we have described recently published information, recommended potential band thresholds and proposed minimum bands for setting targets in relation to each freshwater value. In the interests of consistency, only one set of band thresholds was suggested for most attributes, but the development and justification of targets to protect each value has the potential to extend far beyond the scope of this review. Available evidence for supporting the definition of attribute bands varied across attributes, with benthic cyanobacteria in particular lacking supporting information to justify setting targets at this stage. Other recommended targets for recreational and cultural values were based on requirements for ecosystem health and so would benefit from further support to connect band thresholds with the targets set to protect each freshwater value.

Given that many proposed attributes aim to assess multiple freshwater values, consideration should be given to how well a general set of attribute bands can protect all associated values. In some cases, it may be necessary to define attribute bands for each associated freshwater value, although only the most conservative targets for each attribute will apply to a water management zone or sub-zone. Therefore, the key requirement is setting attribute bands that protect all associated freshwater values, including accounting for cumulative effects and downstream effects. To date, the development of attribute bands has focused on ecosystem and human health values, meaning that further development or adaptation of existing attribute bands will be required for other values. Ultimately, the aspirations of the community will decide how targets are set through determining the desired level of protection for each freshwater value.

7. APPENDICES

Appendix 1. Comparison of One Plan targets with NPS-FM compulsory attributes

Information compiled as part of the comparative analysis of the One Plan targets and NPS-FM compulsory attributes are attached separately as a Microsoft Excel file (*OP_NPSFM_comparison.xlsx*).

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