IMPACT OF THE LIMIT SETTING PROCESS ON STORMWATER DISCHARGES

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ABSTRACT

The paper discusses the implications of the National Policy Statement for Freshwater Management 2014 (NPS-FM) for managers of stormwater assets.

The NPS-FM requires Regional Councils to establish water quality limits for all water bodies in consultation with their community, the "limit setting process". As part of this process, the community decides what level of water quality they think is acceptable in each water body, from pristine, some impact, or just above national bottom line.

The paper identifies the critical impact of the level of water quality selected through the limit setting process in determining the numerical limits for water quality. These limits will become the water quality standards against which discharges, including stormwater, will be assessed and hence will influence the ability to gain Resource Consents for stormwater discharges.

In this paper the numerical limits in the NPS-FM are compared to guidelines commonly used in consent applications to show whether they represent a step change in required compliance. The numerical limits from limit setting processes already completed around the country are also assessed to indicate the numerical limits which could apply at other locations.

The paper then discusses the impact of the narrative (i.e. word based) values in the NPS-FM and their impact upon the assessment of toxicity and nutrient effects and the numerical limits that could result from their implementation.

Stormwater quality data is reviewed from a range of locations in both urban areas and rural townships. This data is used to determine expected level of compliance with potential limits after reasonable mixing for typical areas.

The impact of available management or treatment regimes for stormwater discharges on the affected parameters and whether they will achieve compliance with the potential limits is then discussed.

KEYWORDS

National Policy Statement, Freshwater Management, Limit Setting Process, environmental guidelines, Stormwater Quality, Stormwater Treatment

PRESENTER PROFILE

Sue has worked for MWH for 25 years on a broad range of environmental planning, monitoring and management projects.

She has been involved in a wide variety of projects including stormwater, wastewater, biosolids, contaminated sites, landfills and transfer stations, primarily focused on the assessment and management of any potential environmental effects, in particular impacts on water quality.

Sue has developed an in-depth understanding of the issues involved in environmental planning projects, in particular those involving discharges to the environment.

1 INTRODUCTION

This paper discusses the implications of the National Policy Statement for Freshwater Management 2014 (NPS-FM) for managers of stormwater assets.

The NPS-FM is intended to support improved freshwater management throughout New Zealand. It requires Regional Councils to establish water quality limits for all water bodies in consultation with their community, i.e. the "limit setting process". As part of this process, the community decides what level of water quality they think is acceptable in each water body, from pristine, some impact, or just above national bottom line.

The NPS-FM was first released in 2011 but was revised in 2014 to include, amongst other matters, more definition of the process for limit setting. The 2014 version included two new appendices. Appendix 1 includes narrative descriptions of various values for water bodies, including two compulsory values (ecosystem health and human health for recreation). The narrative values included in ecosystem health of relevance to stormwater include "*management of adverse effects on flora and fauna of contaminants, … excessive nutrients, algal blooms, high sediment loads, …*"

Appendix 2 includes a number of numeric water quality limits for these narrative values. Given the narrative values in Appendix 1, it is interesting to note that nutrient effects are not considered in limits in Appendix 2. Therefore, it can be reasonably expected that the limit setting process could result in lower, more restrictive limits than those in Appendix 2, if nutrient effects are considered. This is considered further in this paper.

The 2014 NPS-FM also changed the required timeframe for implementation of the NPS from that in the 2011 version. Full implementation of the NPS is required by 31 December 2025 (rather than 2030).

Whilst the NPS-FM has no specific obligations on the operation of infrastructure, through the implementation of the NPS-FM:

- Existing long term consents could be reviewed and made more restrictive
- Limits for new consents or renewal of existing consents are likely to become more restrictive
- Limits are likely to be set within 10 years, which is within the Long Term Plan (LTP) timeframe.

2 LIMIT SETTING PROCESS

The NPS-FM requires that Regional Councils establish freshwater objectives and quality limits for all Freshwater Management Units (FMU) in their region. An FMU is a water body, multiple water bodies or any part of a water body at an appropriate spatial scale to set freshwater objectives and limits. The NPS-FM gives minimal guidance on exactly what is an "appropriate spatial scale" and this has been implemented quite differently by those Regional Councils that have already implemented the NPS.

This paper will not discuss the detail of the mechanisms involved with setting the water quality limits. However, it is noted that as part of this process, the community decides what level of water quality they think is acceptable in each water body, from pristine, some impact, or just above national bottom line. It is critical that when the water quality level is selected by the community, consideration is given to its impact on the resultant water quality limits and the ability to obtain consent for discharges.

For each "attribute", which is the term used by the NPS-FM for "a measurable characteristic of fresh water…" such as ammoniacal nitrogen, the required "attribute state" for each FMU must be decided. The available "attribute states" or grades of water quality are A, B, C or D. A equates to being essentially pristine, B to slightly impacted, C to moderately impacted and D equates to there being a high risk of significant impacts from the water quality.

The demarcation between Grade C and D is the National Bottom Line, and the Regional Councils are required to implement measures so that any FMU which would currently be classified as D will improve such that it becomes at least Grade C, and also to ensure that all other FMUs achieve the water quality grade that is selected for them.

There can be a significant difference in the numerical water quality limits associated with each of these grades, with Grade A having much more stringent limits than Grade C. This impact is demonstrated in this paper for ammoniacal nitrogen, nitrate nitrogen and *E.coli*.

These limits will become the water quality standards against which discharges, including stormwater, will be assessed and hence will influence the ability to gain Resource Consents for stormwater discharges.

3 POTENTIAL WATER QUALITY LIMITS

3.1 INTRODUCTION

It is important to remember that the limits in Appendix 2 will apply in the receiving environment after reasonable mixing, rather than as discharge standards. The extent of mixing allowed depends upon each Council's interpretation of what is reasonably allowed for each discharge and hence will vary from site to site, and from region to region.

When undertaking an assessment of effects on the environment, the impact of any discharge is generally assessed with reference to the available dilution coupled with a variety of available guidelines or standards. These are sourced from the relevant Regional Plan and a variety of national guidelines which address impacts, including toxicity, nutrient effects, and human health impacts, amongst others of relevance to the receiving environment.

In the following section, the numerical limits in Appendix 2 of the NPS-FM for ammoniacal nitrogen, nitrate nitrogen and *E.coli* in rivers are compared to guidelines commonly used to show whether they represent a step change in required compliance. The potential for limits for metals is also discussed. The numerical limits from limit setting processes already completed around the country, namely Horizons Regional Council and Otago Regional Council, are also assessed to indicate the numerical limits which could be developed in other locations.

The section also discusses the impact of the narrative (ie word based) values in the NPS-FM on the assessment of toxicity and nutrient effects and the numerical limits that could result from their implementation.

The numerical limits in Appendix 2 for "trophic state" (ie condition of the ecosystem) are similar to the existing guidelines both for lakes (based on total nitrogen, total phosphorus and chlorophyll-a) and rivers (based on periphyton cover and dissolved oxygen). Therefore, the NPS-FM has not significantly changed the basis on which assessments would be performed for these elements and these are not discussed further.

3.2 NITROGEN

Ammoniacal nitrogen and nitrate nitrogen are both toxicants and nutrients. Therefore, dependent upon their concentration, in simplistic terms, they can both kill things (at higher concentrations) and make them grow more and/or faster (at lower concentrations but that are above normal ambient conditions). This can result in some confusion in determining appropriate numeric limits.

Sources of water quality limits reviewed in this paper for these two forms of nitrogen are as follows:

- Appendix 2 of the NPS-FM which is based on prevention of toxicity effects in Rivers. Limits are provided for annual median for both parameters and annual maximum for ammoniacal nitrogen and 95th percentile for nitrate. The limits are based on updates of the ANZECC 2000 Guidelines undertaken for the 2014 NPS-FM to incorporate more recent toxicological data for both forms of nitrogen (2 x Hickey, 2014).

- ANZECC Trigger Values for toxicants (ANZECC, 2000). These nitrogen values are based on various levels of protection from 80%, 90%, 95% to 99%. The levels of protection indicate the percentage of species expected to be protected. The 99% level is typically used for ecosystems with high conservation value and the 95% for slightly to moderately disturbed systems. The lower levels are applied to more impacted ecosystems as considered appropriate. For nitrate, the trigger values have been revised a number of times since 2000. An errata was issued in 2002, which significantly increased the trigger values, and then revisions, resulting in less significant changes, were performed in 2009 for Environment Canterbury (Hickey, 2009) and 2013 for Hawke's Bay Regional Council (Hickey 2013) to incorporate more recent toxicology data. The limits used in this paper are the 2013 trigger values.

- ANZECC trigger value for physical and chemical stressors (ANZECC, 2000) derived to protect against nutrient effects in upland and lowland rivers. The trigger value used in this paper is the sum of the values given for ammoniacal and oxidized nitrogen[1], which equates to the soluble inorganic nitrogen (SIN).

- Receiving water limits in Plan Change 6A of the Regional Plan: Water for Otago. The Plan Change was the Otago Regional Council response to the requirements of the NPS-FM and stipulated water quality limits to apply across the region. Five receiving water groups were established. The ammonia limit was based on the

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[1] Oxidised nitrogen includes nitrate and nitrite nitrogen. Generally nitrite concentrations are low.

removal of effluent from the waterways rather than protection against a specific environmental effect, and the nitrate and nitrite nitrogen limit was based on prevention of nutrient effects.

- Schedule E of Horizons One Plan specifies a number of water quality targets, some of which apply across the whole Region, but others change according to the Water Management Zone, of which there are more than 40 defined in the Plan. Where there is variability in the limits across the region, we have included the lowest and the highest targets in this analysis to indicate the range. Targets specified for ammoniacal nitrogen are an annual average and a maximum value, which have been based on toxicity. A specific toxicity target for nitrate nitrogen is not included but Schedule E states that toxicants not otherwise controlled must comply with the ANZECC 2000 Trigger Values (see above). The Schedule specifically refers to the 2000 version of the Guidelines rather than the errata or subsequent updates as discussed above, and therefore, the original 2000 trigger values have been included in the analysis. A low river flow annual average target is provided for SIN. This SIN target appears to be for prevention of nutrient effects.

Figure 1 presents the water quality limits for ammoniacal nitrogen. The primary distinction between the limits prior to the NPS-FM is that those based on protection against toxicity are significantly higher than those which are based on protection against nutrient effects. The update to the ANZECC trigger values for toxicity that was undertaken in 2014 for the NPS-FM has resulted in the trigger values for the higher levels of protection reducing considerably. This has meant that for Grade B, the limits are similar to the SIN limits for nutrient effects, and Grade A is considerably more stringent.

Also apparent is the significant difference between the limits for Grades A, B and C in the NPS, reflecting the importance of the selected grading of the water body on the resultant water quality limits.

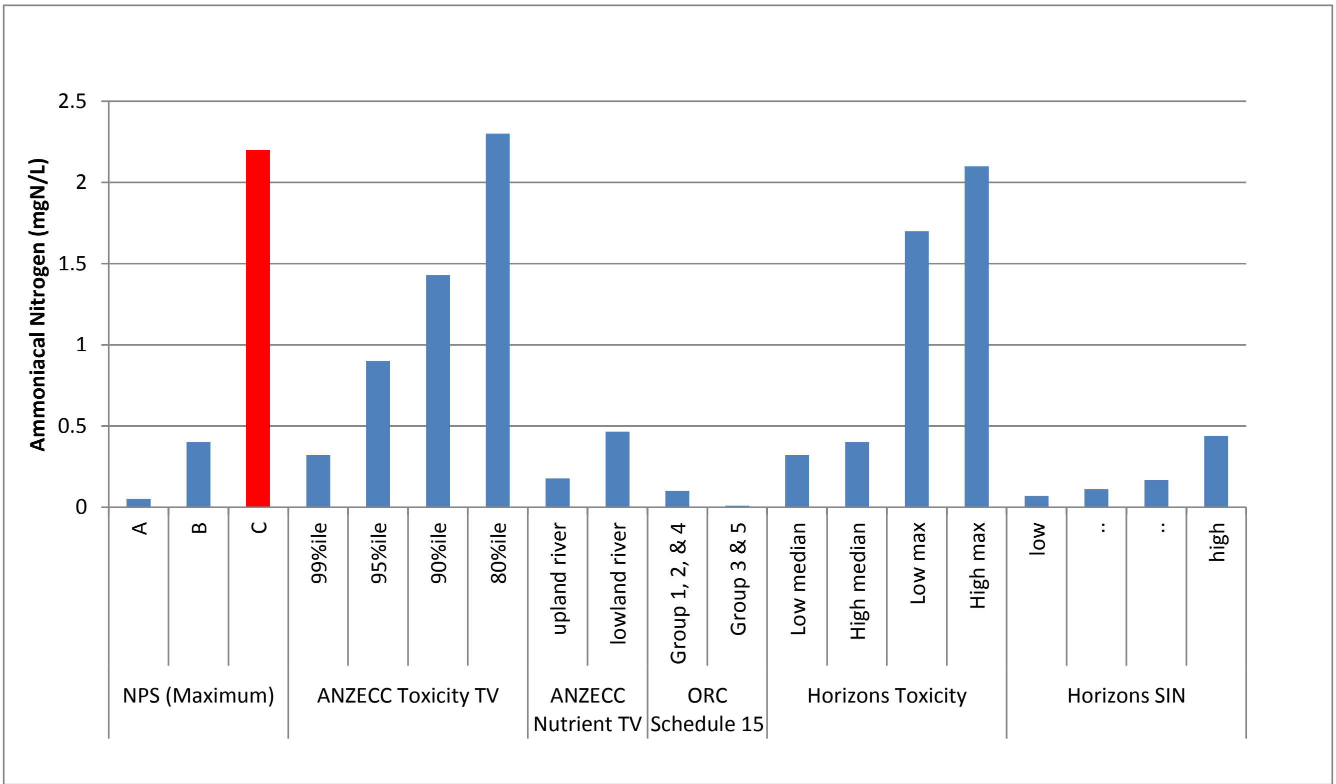

Figure 1: Water Quality Limits for Ammoniacal Nitrogen

Figure 2 presents the limits for nitrate nitrogen. Nitrate is much less toxic than ammonia and hence the limits based on toxicity are higher. This results in a greater difference between the toxicity and nutrient based limits for nitrate compared to ammonia.

Therefore, if nutrient effects are taken into consideration when setting water quality limits, as is required by the narrative description of ecosystem health in Appendix 1, the resultant limits on nitrate nitrogen will be significantly less (ie more stringent) than those in Appendix 2 of the NPS. It is noted that both Otago and Horizons Regional Councils have included nutrient based limits in their Plans.

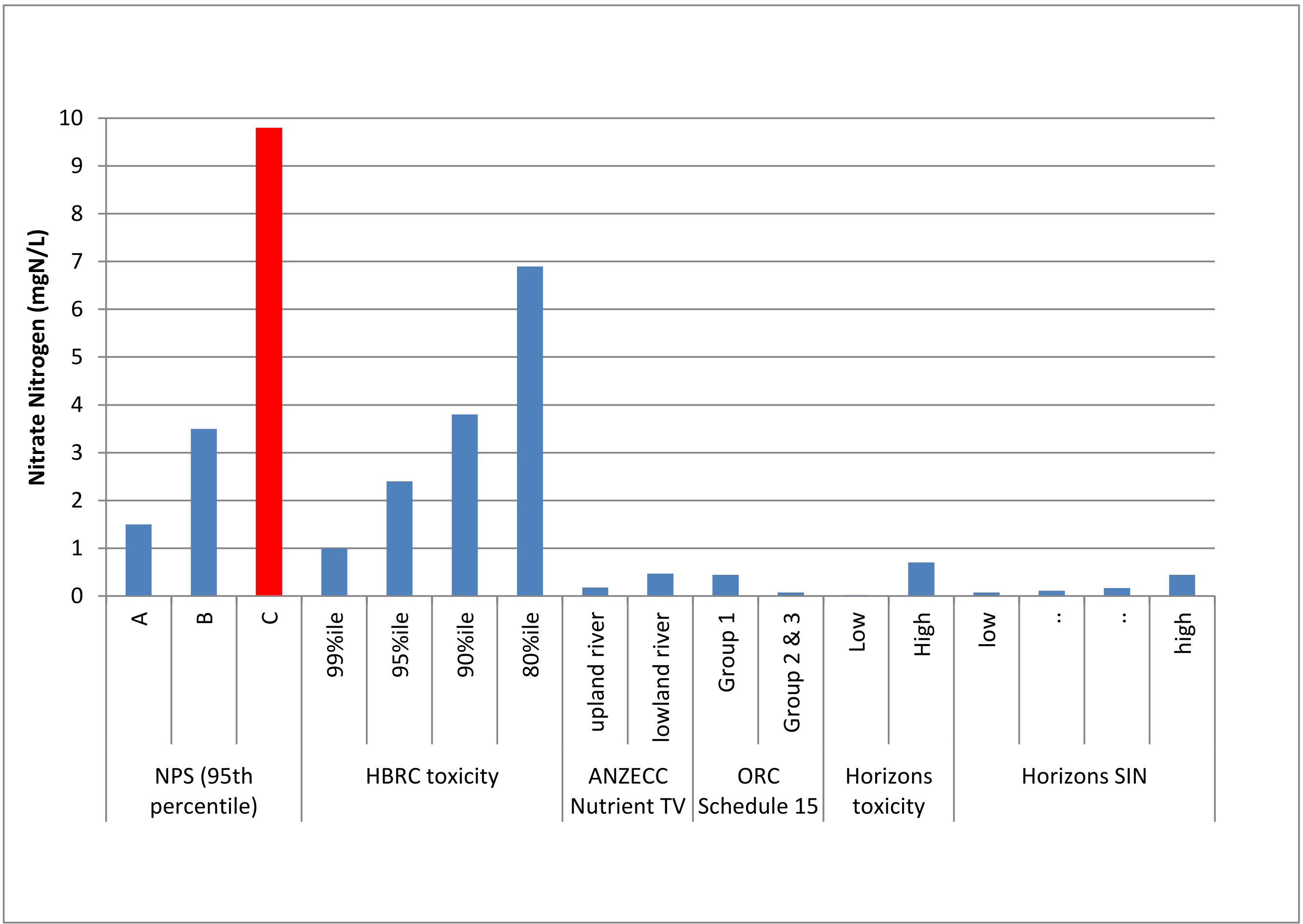

Figure 2: Water Quality Limits for Nitrate Nitrogen

The Horizons toxicity based limit highlights a problem with referring to an external guideline in Regional Plans. The limits in Figure 2 are the 2000 version as specifically referenced in Schedule E of the Plan. These trigger values were corrected in an erratum in 2002 and significantly increased, but this is not referenced in the Plan and hence the original low trigger value applies. While the referencing of specific external documents is required to give certainty in interpreting the Plan, this instance highlights the potential down side of this lack of flexibility.

3.3 *E.COLI*

E.coli is the indicator of the potential for risks to human health resulting from pathogens in the water. People can be exposed to these pathogens when swimming, wading or boating in the water body.

The limits in Appendix 2 of the NPS-FM include numeric limits for an annual median and a 95th percentile. The annual median relates to risks from wading and boating. The 95th

percentile relates to the risk from swimming. For areas where swimming occurs, the limit for Grade B is the minimum acceptable state. However, for non-swimming areas, the limit for Grade C is the national bottom line.

The current guidelines to protect human health from swimming are the "Recreational Guidelines" (MfE, 2003). These Guidelines include a structure against which an ongoing monitoring programme can be assessed to determine risk. This includes surveillance, alert and action modes. Where concentrations are less than the alert limit, monitoring should continue as normal. If *E.coli* in a single sample exceeds the alert limit, the Guidelines recommend that sampling frequency is increased, and the source of contamination is to be investigated. If *E.coli* exceeds the action limit, notification and warning signs are recommended, among other actions.

The Guidelines also include a grading system against which a long term data set can be assessed to provide an indication of the overall risk of contamination at the site. These are the Microbiological Assessment Category (MAC), and range from A to D. The limits shown in Figure 3 are to be assessed against the 95th percentile of at least five years of data.

Water Quality Limits for *E.coli* are included in both the Otago and Horizons Plans, as shown in Figure 3.

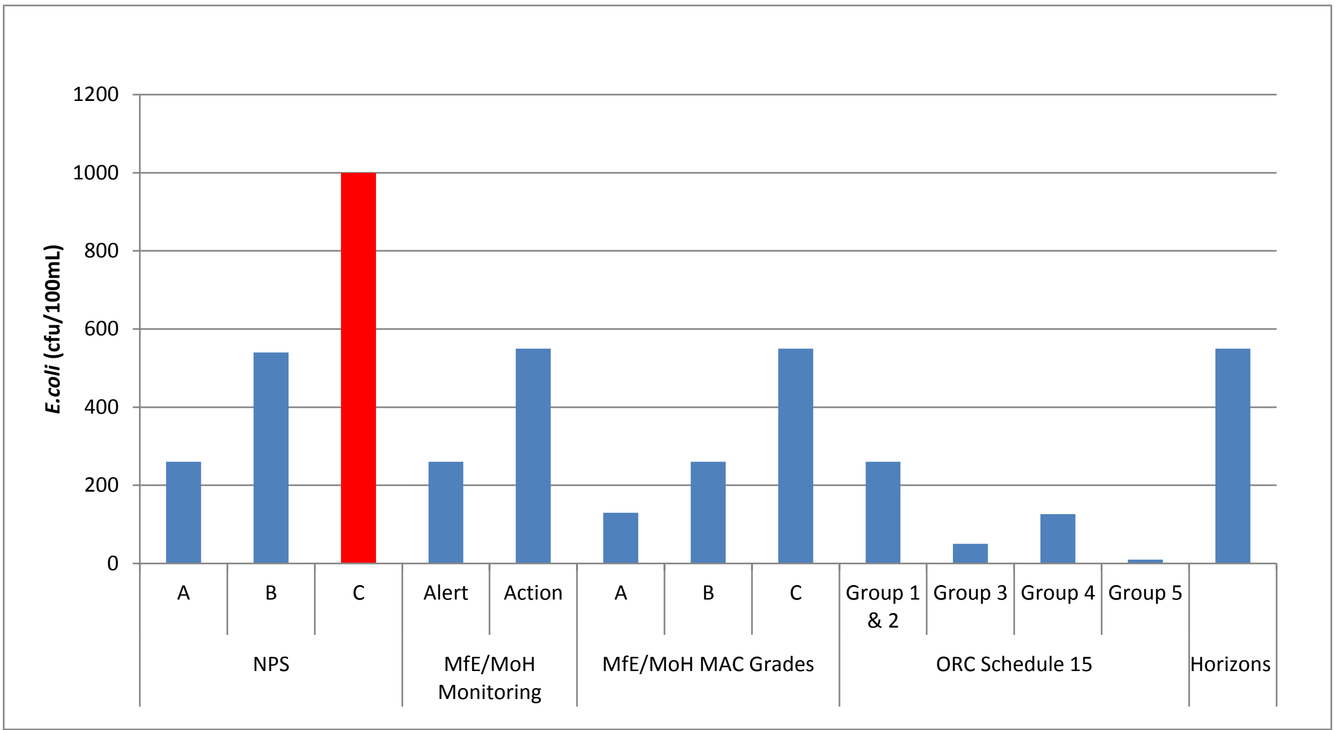

Figure 3: Water Quality Limits for E.coli

The limits in Appendix 2 of the NPS-FM are based on the existing MfE Guidelines and hence do not represent a significant change in the basis for assessments. The difference between the Otago and Horizons limit indicate the differences that can occur between Regions in approaches.

The Otago limit is based on compliance for 80% of the data over a rolling 5 year period. The Horizons limit is a maximum which applies from November to April. Both limits only apply at flows at or below median flow. Therefore, the difference in the numbers may reflect the statistical tests used to determine compliance, as well as reflecting a difference in acceptable risk.

The selection of the statistical test to determine compliance can have a significant impact on the ability to comply with the limit given the considerable variability in bacterial concentrations.

3.4 OTHER PARAMETERS

Whilst Appendix 2 of the NPS-FM includes limits for phosphorus in lakes, it does not include a limit for phosphorus in rivers. Phosphorus can be a limiting nutrient in rivers and hence its control can be important to reduce nutrient effects. Both the Otago and Horizons Plans include nutrient based limits for phosphorus, and hence it is expected that such limits would be introduced throughout the country through the limit setting process.

Sediment is a significant issue for water quality in New Zealand. Whilst the impact of high sediment loads is mentioned in Appendix 1 of the NPS-FM, a numerical limit is not included in Appendix 2. The Otago Plan includes a limit for turbidity based on ensuring the clarity of water. The Horizons Plan includes limits for deposited sediment cover and visual clarity, which both relate to the sediment load entering the water body. Both Regions' limits are based on the resultant effect of sediment load rather than imposing a limit of sediment in the water column itself. It is considered likely that controls on sediment, either direct or indirect will be incorporated into Regional Plans through the limit setting process.

The toxicity of nitrate and ammoniacal nitrogen is specifically addressed in Appendix 2 of the NPS-FM, but the toxicity of other parameters is not addressed, although the adverse effects of contaminants is identified in the "ecosystem health" compulsory value in Appendix 1.

As discussed earlier, there are a number of potential levels of protection for toxicity effects in the ANZECC Trigger Values. The Otago Plan has not provided any further definition of acceptable level of protection. However, Schedule E of the Horizons One Plan stipulates the level of protection for each Water Management Zone, either being 95% or 99%. For metals, the trigger value must be adjusted for hardness and applies to the dissolved fraction. It is possible that other Regions will impose similar requirements.

4 STORMWATER QUALITY

4.1 INTRODUCTION

The discharges from stormwater networks can include contamination from a number of sources including:

- Stormwater, being surface water runoff from rainfall. This will include contaminants which are picked up by the stormwater as it flows over the surface prior to entry into the network.
- Drainage water from sub-surface drains within the catchment.
- Groundwater, from dewatering works which are discharged to the system and from infiltration into the stormwater network due to "leaky" pipes and elevated groundwater.
- Surface water from adjacent rural catchments which enter the head of the stormwater network.

- Discharges into the stormwater network of wash down water and other sources from residential, commercial and industrial sources.

- Sewage resulting from illegal connections to the stormwater network, cross-contamination between "leaky" sewage and stormwater networks and potentially overflows from the sewerage network during storm events.

Stormwater quality data is available from the Urban Runoff Quality Information System (URQIS). URQIS is a database of urban runoff (stormwater) quality data collected from all over New Zealand compiled by NIWA.

The data has been selected from the web site in aggregated form as box plots which show the range of stormwater quality data for each type of catchment. All of the data for each parameter has been requested from the database, including the full range of flow conditions and treatment options.

This data is used to determine expected level of compliance with the potential limits discussed earlier after reasonable mixing for typical areas.

4.2 NITROGEN

The ranges of ammoniacal nitrogen and nitrate nitrogen concentrations that have been recorded in stormwater are shown in Figures 4 and 5.

The limits for each of the Grades in Appendix 2 of the NPS-FM are shown as:

- Green line is the limit for Grade A

- Yellow line is the limit for Grade B

- Red line is the limit for Grade C, which is the National Bottom Line

Figure 4 indicates that the typical ammoniacal nitrogen concentrations would be less than the National Bottom Line and also the limit for Grade B for most types of land uses. However, for commercial land use, a significant proportion of the data exceeds both limits.

A significant proportion of the recorded concentrations for all land uses exceeds the Grade A limit. Typically these discharges would require at least a ten-fold dilution to achieve this water quality limit, assuming that the water body into which they are discharging contains no ammoniacal nitrogen prior to its discharge. Provided that the discharge is not close to source of ammoniacal nitrogen, concentrations in the water body would generally be low. However, this level of dilution may not be available for networks which constitute a significant proportion of the catchment of the water body to which they discharge.

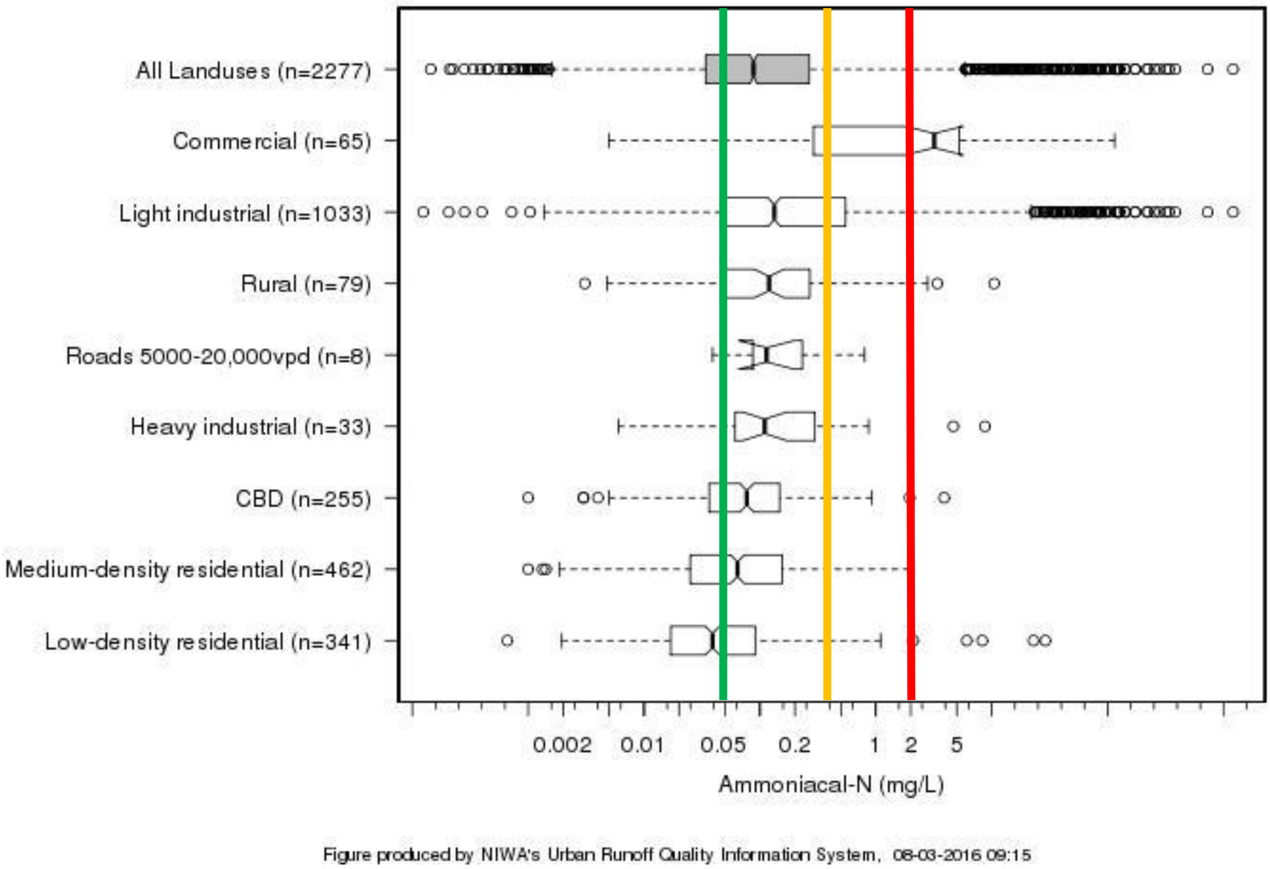

Figure 4: Range of Stormwater Concentrations for Ammoniacal Nitrogen

Figure 5 shows that most of the nitrate concentrations would comply with the limits in the NPS-FM. However, as indicated earlier, these limits are solely based on toxicity. A typical nutrient based limit for nitrate nitrogen is 0.4 mgN/L. Most of the recorded concentrations from all the land use types would not comply with this limit and would require up to ten-fold dilution.

It is important to note however, that many water courses in New Zealand already include significant concentrations of nitrate nitrogen and hence higher dilutions would be required to achieve the water quality limit. For some water bodies, a nutrient based limit may already be exceeded.

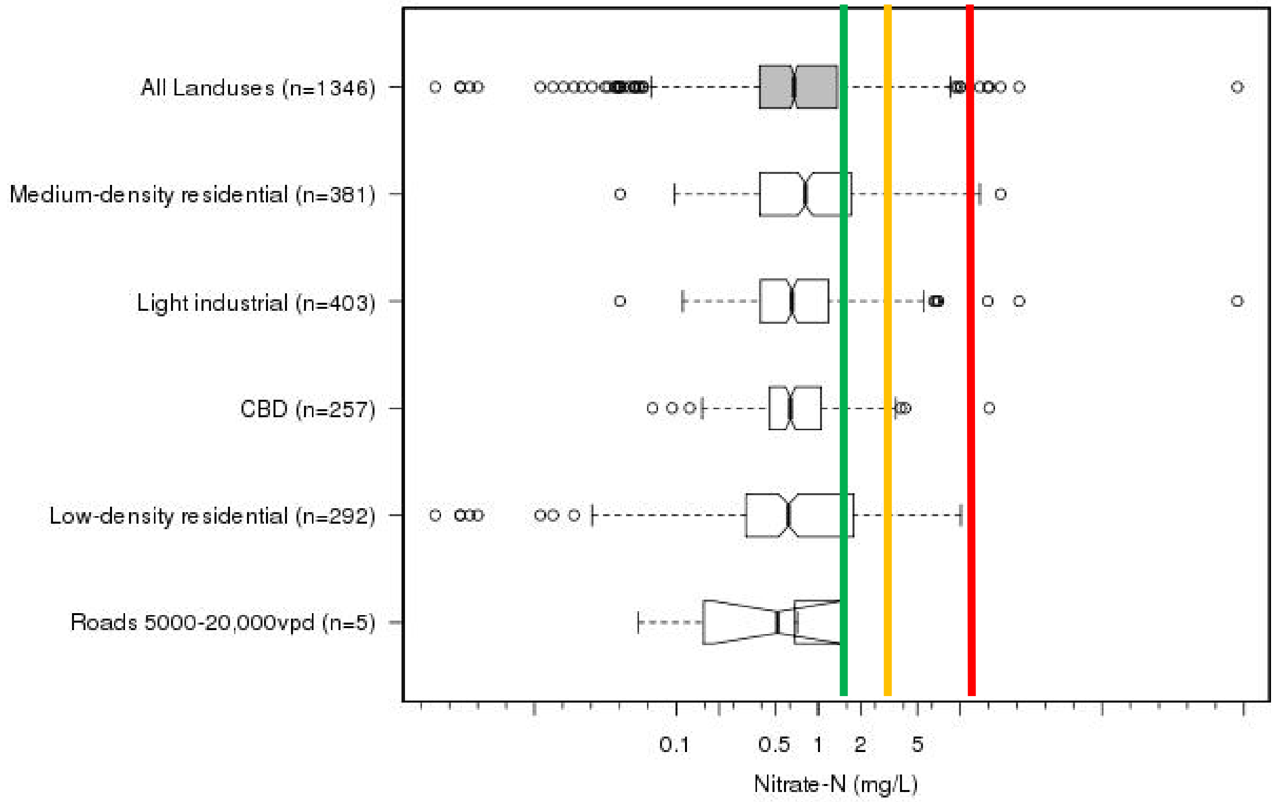

Figure produced by NIWA's Urban Runoff Quality Information System, 08-03-2016 09:17

Figure 5: Range of Stormwater Concentrations for Nitrate Nitrogen

The typical *E.coli* concentrations for all land uses, except medium density housing exceed the National Bottom Line as shown in Figure 6. The stormwater would require at least a ten-fold dilution, if not more, to achieve it, with significantly more dilution required for the more stringent Grades.

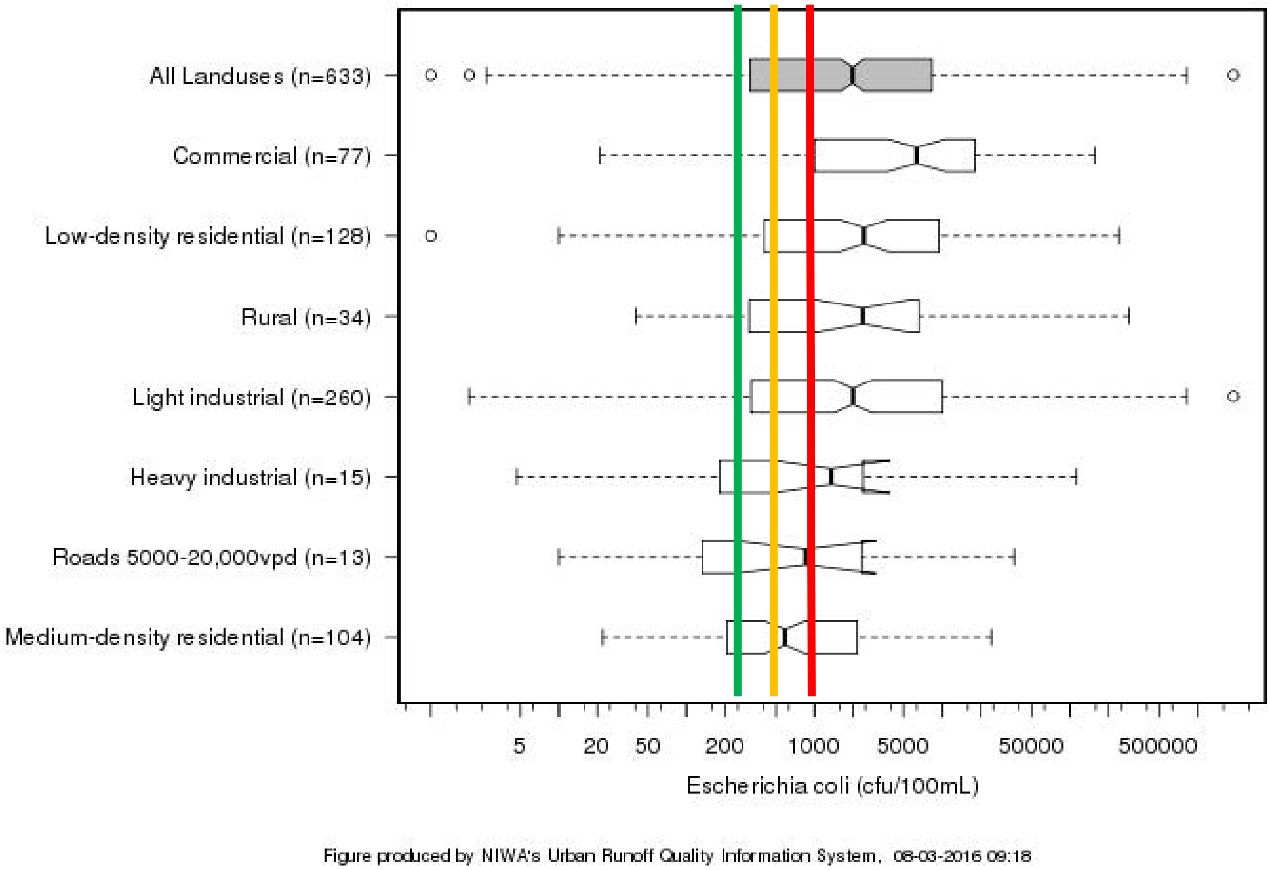

Figure 6: Range of Stormwater Concentrations for E.coli

The primary metals in stormwater discharges are copper and zinc. Figures 7 and 8 present the available data on the dissolved form of these metals from the URQIS database. The dissolved portion more closely represents the bioavailable form of these metals as compared to the total concentrations. Metals in particulate form are generally not as available to exert a toxic effect, as compared to that which is dissolved in the water. The trigger values for toxicity for 99% and 80% protection levels are shown in green and red respectively.

For both metals, the recorded concentrations exceed the 99% protection level, as would be expected. This is also the case for the 80% protection level for copper. This reflects the minimal difference between the trigger values for the different levels of protection for copper. Most of the recorded concentrations would require at least a five-fold dilution to comply with the trigger value for copper.

There is a ten-fold difference between the two trigger values for zinc, and hence for roads and car parks, a large portion of the recorded concentrations achieved the 80% trigger value. However, for the other land uses, the 80% trigger value was exceeded and would require up to ten-fold dilution to achieve the trigger value.

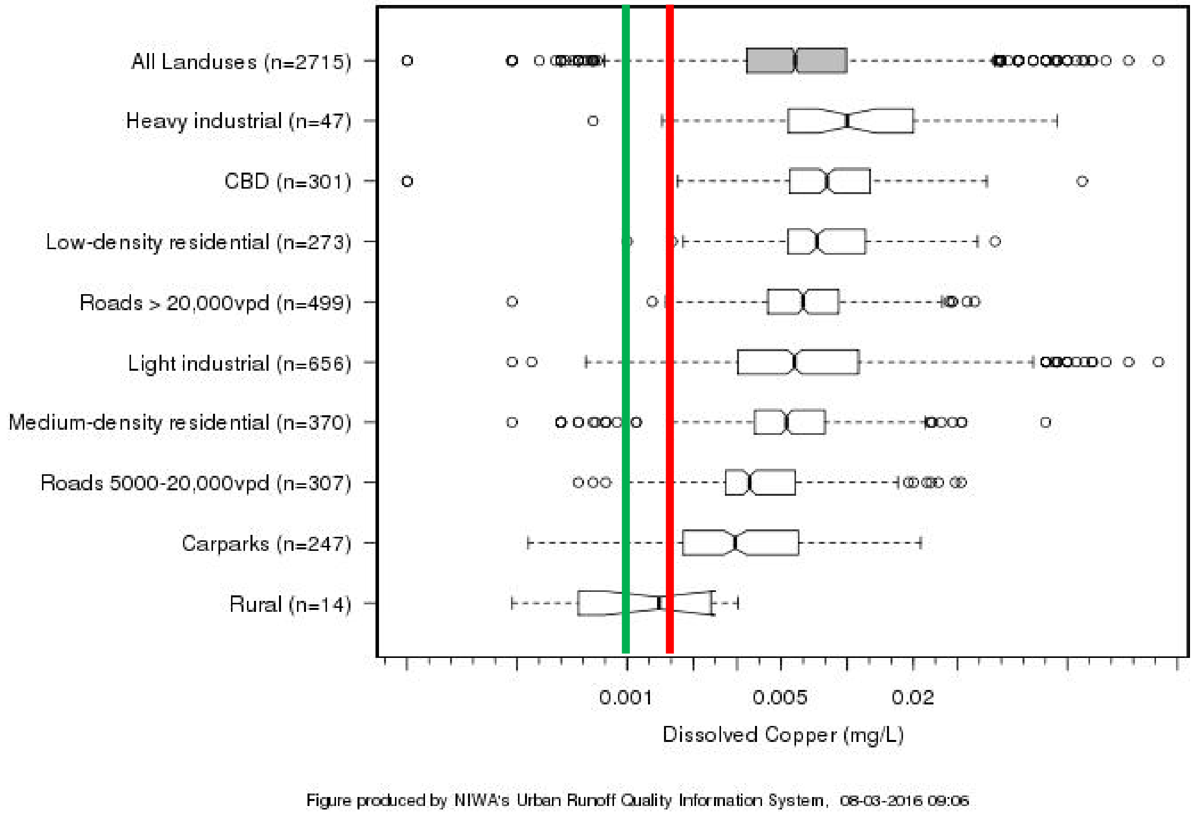

Figure 7: Range of Stormwater Concentrations for Dissolved Copper

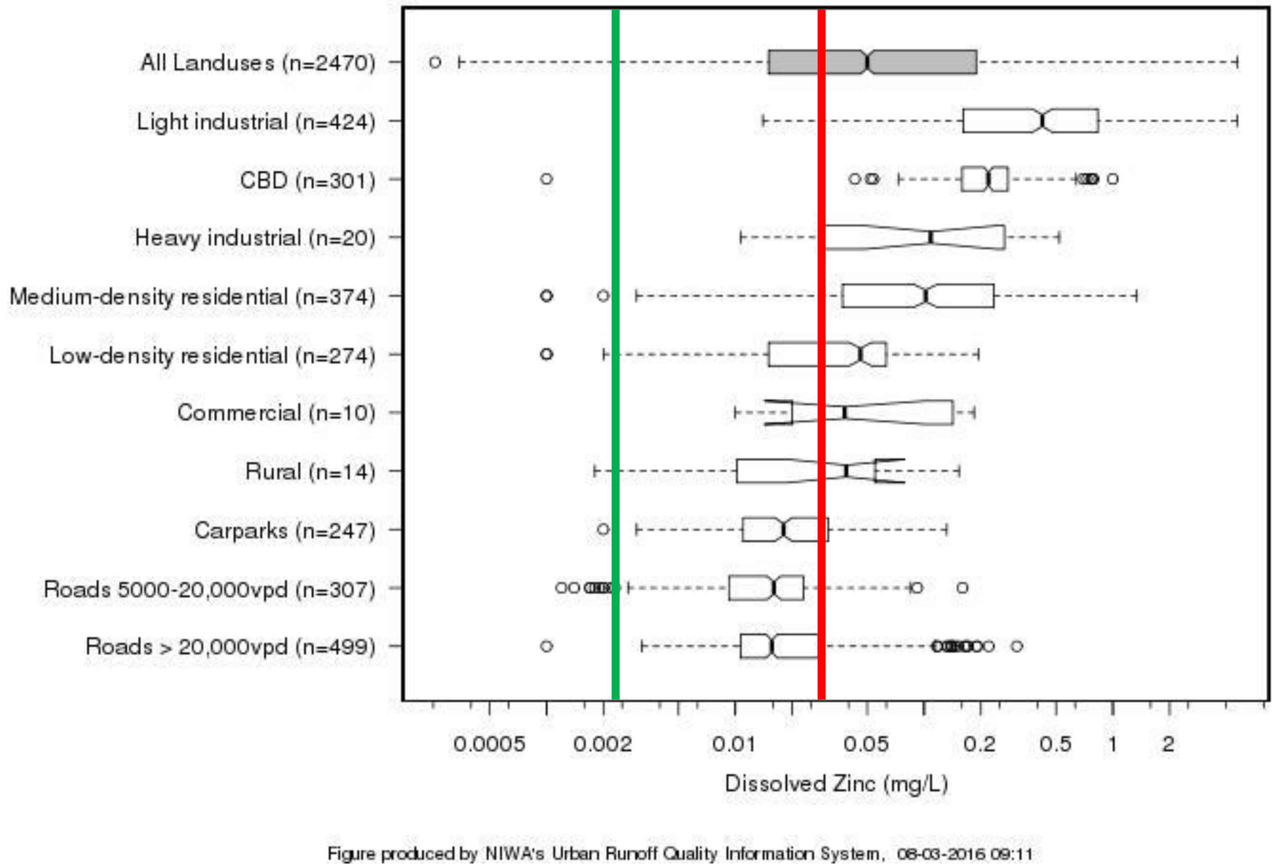

Figure 7: Range of Stormwater Concentrations for Dissolved Zinc

5 TREATMENT METHODS

Based on existing stormwater quality data, the earlier assessment has shown that many stormwater discharges will require dilution to achieve the water quality limits which may be imposed through the limit setting process.

For some parameters, this dilution is significant and may not be available, potentially due to the relative catchment sizes of the stormwater network and the water bodies to which they discharge. The required dilution may not be available as a result of the water quality in the receiving water body having elevated concentrations prior to the discharge of the stormwater, and hence having a reduced assimilative capacity.

Therefore, some improvement in stormwater quality may be required prior to discharge dependent upon the specific catchment and the receiving water body.

The Technical Publication #10, "Stormwater Treatment Devices Design Guideline Manual" (TP10) originally by Auckland Regional Council has been used since October 1992 in response to issues related to stormwater runoff quality. TP10 specifies a range of management responses and treatment approaches and devices that can be used to manage the quality of stormwater discharges.

Generally, treatment devices involve the reduction in the flow of stormwater to reduce scouring and other volume or force based effects, and/or the removal of sediment from the stormwater through settling or filtration of some form.

The parameters which have been assessed in this paper are all in the dissolved phase and hence their concentrations would not be affected by stormwater treatment devices which focus on reduction in particulate contaminants.

Reductions in nutrient concentrations can be achieved through wetlands which provide sufficient retention periods to allow bacterial uptake of nutrients, provided that care is taken to protect the bacterial communities from washing out of the system. These are being developed in the rural environment and considerable space is generally required.

Whilst filtration process can reduce the bacterial concentrations associated with particulates, a large proportion of the bacteria will be in solution and hence will not be removed. The primary mechanism for reducing bacterial concentration is source control to reduce the entry of sewage contamination into the system. This can be through identification and removal of illegal connections or the replacement of "leaky" infrastructure, which can require significant investment and is a longer term solution. Disinfection of stormwater, using a UV facility, has been undertaken internationally, but represents a significant capital and operational expense.

The metal concentrations assessed were the dissolved phase concentrations and hence would not be removed through typical treatment methods.

6 CONCLUSIONS

The review of the available guidelines and comparison with the numerical limits in Appendix 2 of the NPS-FM indicates that the numbers in Appendix 2 probably will not be the actual limits from the limit setting process.

Nutrient effects are required to be considered by the narrative values in Appendix 1 for the compulsory "ecosystem health" value. If this occurs, lower, more stringent limits for nitrogen, and limits for phosphorus, will be imposed.

The "Attribute State" or grade assigned to a water body (ie A, B or C) significantly affects the resultant numeric limit. It is critical that when the "Attribute State" or water quality grade is selected by the community, consideration is given to the impact of the selected grade on the resultant water quality limits and the ability to obtain consent for discharges.

The limit setting process required by the NPS-FM is managed by Regional Councils, and it is important for asset managers to be actively involved in the process, and to understand the implications of any limits on their infrastructure.

The process will occur within this LTP timeframe and can result in:

- Review of existing consents
- More stringent environment for new consents or renewal of existing consents

Dependent upon the catchment land use and the degree of dilution available, some stormwater discharges may not achieve the resultant water quality limits. Typical stormwater treatment methods which rely on removal of particulate contamination will generally not be able to achieve compliance. Source control to reduce the contaminants entering the system is expected to be the most successful method for achieving the limits.

ACKNOWLEDGEMENTS

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REFERENCES

"Derivation of indicative ammoniacal nitrogen guidelines for the National Objectives Framework", Memorandum from Chris Hickey, NIWA, to Vera Power, MfE, March 2014

https://www.niwa.co.nz/freshwater-and-estuaries/freshwater-and-estuaries-update/freshwater-update-60-february-2014/nitrate-toxicity-guidelines-for-the, Hickey, 2014

"Australian and New Zealand Guidelines for Fresh and Marine Water Quality", ANZECC, 2000

"A review of nitrate toxicity to freshwater aquatic species" Report No. R09/57 ISBN 978-1-86937-997-1 Prepared for Environment Canterbury by C.W. Hickey, M.L. Martin, NIWA, June 2009

"Site-specific nitrate guidelines for Hawke's Bay" HAM2012-127, Prepared for Hawke's Bay Regional Council by C.W. Hickey, NIWA, January 2013

"Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas", Ministry for the Environment, 2003

http://urqis.niwa.co.nz/