Integrating policy and science to improve the management of freshwater in New Zealand.

A thesis prepared in partial fulfilment of a

Masters Applied Science

in

Natural Resource Management

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In memory of my Dad

David McArthur

ABSTRACT

Water is an important resource that is degraded in many rivers, including some in New Zealand. The environmental improvements resulting from regulation to improve water quality are frequently not monitored, the effectiveness of water quality policies is typically unknown and there are often no clear measures of success built in to policy development. Two studies were selected to examine these issues in relation to regional planning in the Manawatu-Wanganui region of New Zealand. In the first study, two successive plans that used numerical limits to improve water quality were assessed. The successes and failures of the first planning approach were examined and compared with more recent use of limits in the regional plan. Seven steps to developing robust water quality limits were recommended. In the second study, the monitoring of the effectiveness of freshwater policy was considered and a regional approach to plan development which combined science and policy presented. The approach was built on a catchment-based geographic framework of water management zones, water body values and water quality limits. To measure policy success a ranked matrix method was recommended that combined plan objectives and water quality limits. Integrated and collaborative approaches to policy development, setting of water quality limits and policy effectiveness monitoring were key recommendations from both studies and will be increasingly relevant to future water resource management in New Zealand.

DECLARATION

STUDENT NAME: Kate McArthur

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I declare that:

- This is an original report/thesis and is entirely my own work.
- Where I have made use of the ideas or work of others, I have acknowledged the source in every instance.
- This thesis will not be submitted as assessed work in any other academic course.

STUDENT SIGNATURE:

DATE: 12th September 2011

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List of Abbreviations

ANZECC	Australia and New Zealand Environment and Conservation Council
BOD	Biochemical Oxygen Demand
BPO	Best Practicable Option
DRP	Dissolved Reactive Phosphorus
FARM	Farmer Applied Resource Management strategy
MCI	Macroinvertebrate Community Index
MCWQRP	Manawatu Catchment Water Quality Regional Plan
MfE	Ministry for the Environment (New Zealand)
MoH	Ministry of Health (New Zealand)
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
NPS	National Policy Statement for Freshwater Management (2011)
NRRP	Natural Resources Regional Plan (Environment Canterbury)
OAG	Office of the Auditor General (New Zealand)
OECD	Organisation for Economic Co-operation and Development
PCE	Parliamentary Commissioner for the Environment (New Zealand)
RMA	Resource Management Act (1991) also referred to as "the Act"
RMLA	Resource Management Law Association of New Zealand
SLUI	Sustainable Land Use Initiative
SOS-A	Site of Significance – Aquatic
STP	Sewage Treatment Plant
WMZ	Water Management Zone

CHAPTER 1. INTRODUCTION

Photo 1. Aerial view of the Manawatu River east of Palmerston North City looking upstream towards the Ruahine Ranges. Photo by KJ McArthur, 2005.

Background

Water is one of the most essential resources for the functioning of the biosphere and human society. Clean water is a scarce resource in many parts of the world (Downes et al. 2002) and even New Zealand, with its ‘clean green’ image is not immune to the problems of degraded water quality (Larned et al. 2004; Scarsbrook 2006; Ballantine et al. 2010). New Zealand’s rivers and streams are adversely affected by activities that fall into two main categories: 1) point source discharges (e.g. municipal sewage, industrial or agricultural effluent directly added to waterways), and 2) diffuse discharges (e.g. contaminants from land use which enter water from the landscape via overland run-off or leaching through the soil and groundwater). In recent years, diffuse discharges from urban and agricultural land use have overshadowed point source discharges as the predominant influence on freshwater quality in New Zealand (Richmond et al. 2004; Scarsbrook 2006; Davies-Colley et al. 2010).

Generally, some form of regulatory control is required to manage the effects of activities on water quality, and in New Zealand this responsibility falls to regional councils under the Resource Management Act (1991) or RMA. The sustainable use of natural and physical resources is a principle that underpins the RMA and regional policy making in New Zealand and throughout much of the developed world. The recent release of the National Policy Statement for Freshwater Management (NPS 2011) reflects an understanding at a central government level that the management of freshwater resources is challenging for regional councils. Policy directives in the NPS require councils to set resource limits for water quality and targets for improvement where freshwater objectives are not met, to progress the sustainable management of freshwater. This thesis discusses the setting of numeric resource limits and objectives both past and present for the Manawatu River catchment and describes the development of a monitoring programme to measure the effectiveness of water quality policies.

Problem statement

Measures of environmental policy success are largely ill-defined and despite well-intentioned management principles such as those underpinning the RMA (1991) the effectiveness or success of environmental objectives in providing real-world benefits frequently goes unmonitored (Seasons 2003). The inability to monitor policy success and feed the results of monitoring back into the cycle of policy development can lead to poorly targeted or ineffectual management (Grundy et al. 2001; Gluckman 2011) and, ultimately, on-going water quality decline. To overcome this problem, a collaborative and integrated approach to policy development and monitoring that is informed by sound science is recommended. Objectives and policies that are built on technically robust numerical water quality limits provide clear measures of success that can be monitored in the environment.

Literature overview

The literature reviewed for this thesis spans the themes of freshwater science, ecology, environmental monitoring, planning and policy development. Peer reviewed journal articles and government publications and reports were comprehensively reviewed. The fact that such a large number and broad spectrum of publications reach similar conclusions regarding the lack of, and necessity for, monitoring of environmental policy effectiveness, and the requirement for clear measures of success, supports the recommendations of this thesis to define suitable numeric objectives and limits and to use policy objectives as criteria for developing freshwater monitoring programmes. A number of papers also suggested a collaborative approach to policy development, such as that outlined in the case studies, as an integral step to creating successful policy. However, there were few examples in the literature of methods to monitor policy effectiveness or measure environmental outcomes. Time will tell if the collective wisdom across a wide number of fields will result in a more integrated approach to resource management in the future.

In addition to the points raised by other authors on the topic, this thesis draws on knowledge and experience gained by the author over several years working in a collaborative team in the fields of applied science and ecology, water quality monitoring, freshwater management and policy development for the Manawatu-Wanganui Regional Council. Specific research was also conducted for the purposes of this thesis that examined discharge permits in the Manawatu River (Appendix 1).

Aims

This thesis aims to:

1. examine the past and present use of water quality limits for the Manawatu River catchment;
2. determine steps for defining measureable limits and numeric objectives for water quality;
3. document a method of site selection to measure policy effectiveness through water quality monitoring, and
4. provide recommendations on integrated approaches to setting resource limits and monitoring policy effectiveness through interdisciplinary collaboration between scientists and policy makers.

The combined conclusions and recommendations from chapters two and three of this thesis support a theme of integrated policy development and monitoring. New Zealand's small science and policy communities in relatively close proximity to each other may be advantageous in enabling wider collaboration on these issues. Regional council scientists and planners, given their constant exposure to both science and policy may be well placed to play an important role in facilitating an integrated approach at a national level. This thesis concludes by drawing the recommendations of chapters two and three together with the purpose of encouraging a more collaborative approach to tackling freshwater management and the issues of declining water quality and aquatic ecosystem health in New Zealand.

Study area

The Manawatu-Wanganui region is comprised of a number of river and lake catchments in the lower and central North Island of New Zealand, spanning the east to west coasts (Fig. 1). The total land area of the region is 2.2 million hectares and the predominant land uses are sheep and beef farming (51% of the regional land area), native forest (31%), plantation forestry (8%) and dairy farming (7%) (Clark and Roygard 2008). Palmerston North (population 75,500) and Whanganui (population 42,600) are the two main centres in the region with a number or smaller towns scattered throughout what is predominantly a rural landscape with a total population of 222,500 (census 2006 data).

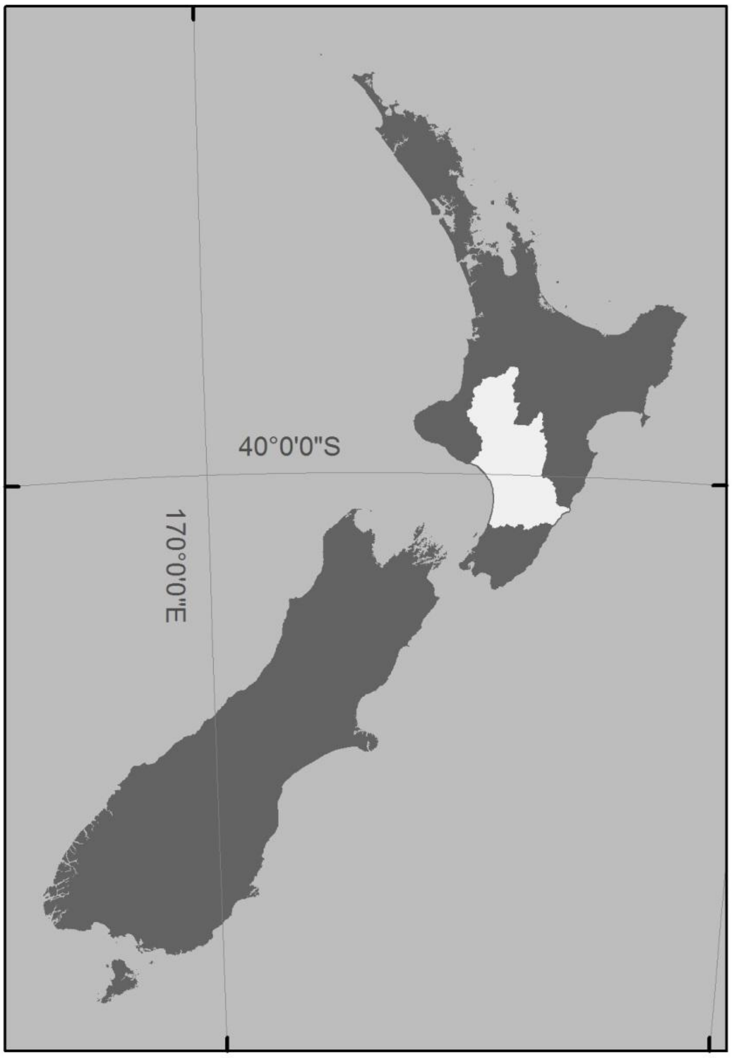

Figure 1. The Manawatu-Wanganui region (highlighted) of New Zealand. Source: Horizons Regional Council.

The Manawatu River is one of the region's four largest rivers, with a catchment comprising 27% of the total regional area. The river flows from east of the main dividing Tararua and Ruahine Ranges, past Palmerston North city mid-way down the catchment, and then to the Tasman Sea on the West Coast. The Manawatu Estuary is a RAMSAR wetland of international significance because of the resident and migratory bird life which inhabits the estuary. However, the estuarine and riverine ecology of the Manawatu River are threatened by poor water quality, which has degraded appreciably over recent decades (Ballantine and Davies-Colley 2009).

Policy initiatives to improve the water quality of the Manawatu catchment are the key emphasis of the second chapter of this thesis and historically, policy and planning initiatives targeted at improving water quality in the region focussed primarily on the Manawatu River (i.e. the Manawatu Catchment Water Quality Regional Plan, 1998). However, recent planning approaches have identified the need to address water quality more widely and have taken a region-wide approach to water quality management. In the third chapter of this thesis the development of a policy effectiveness monitoring programme is discussed at this broader, regional level.

Thesis structure

The main body of this report comprises two chapters, each of which contains a paper that has been submitted for publication. The differences in audience and journal topic are reflected in the style and format of each paper (as outlined in Appendices 2 and 3) which remain largely unchanged from the submitted manuscripts. The first paper is entitled "Setting water quality limits: lessons learned from regional planning in the Manawatu-Wanganui region". This paper was submitted to the Resource Management Theory and Practice Journal of the Resource Management Law Association of New Zealand and has been accepted pending review amendments. The style of this paper is an opinion piece, based on an extensive critique of two consecutive generations of regional plans and policies that addressed the use of water quality limits in the Manawatu catchment. An additional analysis was made of twenty-five point source discharge permits consented over a period of ten years to assess the implementation of the first water quality plan for the Manawatu River (Appendix 1). The audience of this journal are assumed to have considerable prior knowledge of the RMA and the instruments and provisions used for regional planning under the Act in New Zealand. Therefore many of the technical policy and planning terms are given little explanation in the text.

The second paper is entitled "Monitoring the effectiveness of freshwater environmental policy in the Manawatu-Wanganui region, New Zealand." This paper has been submitted to an international journal with a broad, interdisciplinary topic base: *Environmental Management*. Environmental Management covers the use and conservation of natural resources and the protection of habitats and "*aims to improve communication, making ideas and results from any field available to practitioners from other backgrounds*" (Environmental Management website, accessed online 4 August 2011). The style of the second paper is in keeping with the broad topic spectrum and flexible nature of the journal.

CHAPTER 2.

Setting water quality limits: lessons learned from regional planning in the Manawatu-Wanganui region.

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SETTING WATER QUALITY LIMITS: LESSONS LEARNED FROM REGIONAL PLANNING IN THE MANAWATU-WANGANUI REGION.

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INTRODUCTION

The cumulative effects of resource use are degrading the quality of many New Zealand rivers and lakes. Given the current state of freshwater quality it is timely to consider how we can best utilise the planning framework of the Resource Management Act 1991 (RMA) to improve degraded rivers such as the Manawatu River. Narrative descriptions of desirable water quality outcomes were applied in many first generation regional plans. However, broad narrative standards or objectives are difficult to achieve in practice and measuring the delivery of narrative environmental objectives is also problematic.[1] An alternative freshwater management approach is to translate narrative objectives into numeric objectives and to use these to define water quality limits, such as concentration based standards or catchment load limits and to provide a sound basis for measuring policy success over time through environmental monitoring. However, water quality standards have been used in regional planning for the Manawatu River catchment since 1998. So why, more than a decade later, is water quality in the Manawatu River still among the poorest in New Zealand?[2]

The rules of the Manawatu Catchment Water Quality Regional Plan (The Manawatu Plan, 1998) were an early attempt at using numeric limits within the RMA planning framework. A second generation approach is the newly developed combined regional plan and regional and coastal policy statement for the Manawatu-Wanganui region, known as the One Plan. The One Plan contains numeric targets for all of the regions waters (including the Manawatu River) developed from water quality indicators. These targets are neither objectives nor rules but are linked to water body values through the Plan's policies. The One Plan identifies values for all waters and each value is associated with a narrative management objective. Using a spatial framework of catchment-based water management zones, each zone has defined values and specific water quality targets, developed to provide for the values of that zone. [3]

Defining terminology is useful when discussing limits, standards, targets or indicators for water quality. The recently gazetted National Policy Statement for Freshwater Management (NPS, 2011) defines a limit as the maximum amount of resource use available which allows a freshwater objective to be met. In the author's opinion this is consistent with the way water quality targets apply through the One Plan because the targets in the Plan were developed as numeric thresholds (limits) of acceptable water quality, which would provide for the water values sought by the Plan's objectives. However, the NPS defines a water quality target as a limit which must be met at a defined time in the future and which only applies in the context of over-allocation. The One Plan targets (limits) are not time-bound and apply to all waters, not just those that are over-allocated; therefore they do not fit the NPS definition of a target. This paper uses the term limit to refer to the numeric targets linked to values in the One Plan, in place of the term target, to avoid confusion with the definitions of the NPS. The NPS provides no definition of a standard.[i] The definition used here is consistent with standards applied as rules under s 69 of the Act.

For clarity, the terms used in this paper to define water quality are as follows: **numeric objectives** are measurable objectives within a regional plan or policy statement which describe the intended environmental outcomes; **standards** are numeric limits applied as rules in regional plans under s 69 of the Act; and **limits** are numerical levels of water quality associated with resource use which allow objectives, values or outcomes to be met. Water quality **indicators** are the various measurable parameters that are mechanisms for the application of RMA tools such as limits, standards or in some cases numeric objectives depending on the context.

Environment Canterbury's Natural Resources Regional Plan (NRRP Chapter 4), utilises measurable, numeric objectives and rules containing water quality standards that are linked to achieving those objectives in a hierarchical manner.[4] For example, Objective WQL 1.1 contains numeric values for the maximum percentage of nuisance algal cover of the river bed. To support the objective there are standards for dissolved nitrogen and phosphorus that are linked to the desirable level of algal cover defined by the objective.[5] From a science perspective, the hierarchical approach of numeric rules and objectives is a logical system for the application of water quality limits through regional policies and plans. There are also many planning advantages to numeric objectives and linked water quality standards. For instance, objectives have a life beyond the timeframe of the plan, they are overarching goals to guide the consideration of all activities, including those which can affect water quality but may not necessarily be subject to water quality rules (e.g. water allocation, river engineering activities, forestry or vegetation clearance). Numeric objectives provide clarity about the desired state of water bodies for the community and numeric standards provide some

[i] Water quality targets were termed standards in the notified version of the One Plan.

certainty for resource users around the acceptability of activities requiring consent. Numeric objectives linked to values offer good guidance for dealing with non-complying activities that exceed standards, provide a clear basis for monitoring plan performance over time and assist decision makers in dealing with the cumulative effects of resource use on water quality.[6]

The difficulties in setting limits in regional planning

The cumulative effects from agricultural land use are now identified as key concerns for freshwater management in New Zealand.[7] Although some commentators have suggested there are enough tools and mechanisms within the Act to enable councils to deal with cumulative effects,[8] Milne (2008) identified some of the difficulties faced by resource managers in setting limits in plans or through the consent process. Many of these difficulties reflect either a requirement for sufficient information and good science to persuade decision makers to impose limits, or the political difficulties inherent in setting limits on resource use. Despite these difficulties some regional councils have undertaken to set limits to manage cumulative adverse effects on water quality. In addition to the Environment Canterbury example, regional approaches utilising numeric water quality objectives have been included in Environment Waikato's Regional Plan Variation 5 to protect the water quality of Lake Taupo and Environment Bay of Plenty's Regional Water and Land Plan Objective 11 which states a desired trophic level for each of the Rotorua Lakes. All regional councils are now required to set water quality objectives and limits under the Freshwater NPS. A hierarchical system of numeric objectives and rules similar to that now operative in Canterbury, combined with a spatial and values framework such as that underpinning the One Plan for the Manawatu-Wanganui region, provides a robust, defensible method for setting regional water quality limits. This paper concludes by recommending individual steps to develop such a system, informed by an exploration of the advantages and disadvantages of using water quality standards, rules and limits in the Manawatu-Wanganui region.

Considerations for the development of appropriate water quality limits

When comparing systems devised for the development of numerical objectives, standards or limits from water quality indicators there are a number of points for consideration: 1) one size does not fit all (i.e. locally relevant limits are crucial); 2) no system for applying water quality standards and objectives in regional plans will be perfect (i.e. not all the relationships between indicators used for standards and numeric objectives are clear or simple); and 3) not all possible water quality indicators are appropriate for use at the level of Plan objectives. These considerations are explored in more detail below.

A one-size-fits-all approach to setting limits for freshwater management is unlikely to be locally relevant or defensible, potentially jeopardising the success of numeric objectives and linked standards. This is important when considering the future development of National Environmental Standards for water quality to support the Freshwater NPS. A many-to-many relationship of groups of standards and linked numeric objectives which vary according to different community water body values and different physical catchment characteristics is more likely to be accepted and environmentally relevant. Others have identified the importance of a spatial framework in combination with good science to underpin numeric standards and objectives in regional plans and policies.[9]

The relationships between water quality indicators

Sound science is critical to understanding the ecological interactions between the indicators that can be applied as standards, limits or numeric objectives. Ideally, cause and effect relationships would exist between one or more standards (to control causes through rules) and each of the objectives (defined desirable effects). For example, algal growth on the bed of rivers (known as periphyton) is influenced by river flow, substrate size, stability, light availability, temperature, invertebrate grazers and the concentrations of the plant-available nutrients nitrogen and phosphorus. In simple terms, when all other river conditions are suitable, as nutrient concentrations increase periphyton also increases. Nitrogen and phosphorus standards can be applied in order to achieve a numeric objective which states a desired maximum level of periphyton cover of a river bed.

In reality, simple cause and effect relationships between water quality measures are rare. Rivers and the aquatic communities they support are dynamic, complex ecosystems and water quality variables are often interlinked with each other. Not only can water chemistry affect biological communities but the reverse is also true; for instance changes in periphyton can influence the physical and chemical properties of water by reducing dissolved oxygen at night and changing pH, affecting the suitability of habitat for fish and invertebrates. These relationships can all be overridden by the impact of river flow and significant events such as floods or droughts. So any freshwater planning system needs to allow for consideration of biophysical complexity, yet be simple enough to enable effective implementation.

Because freshwater ecosystems are complex and multi-stressor relationships and interactions between water quality variables occur, not all water quality indicators will be suitable as numeric objectives in plans. Listed below are five criteria to test the suitability of indicators as numeric objectives. The criteria are: 1) the objective describes an environmental state which can be readily understood by a non-technical audience, 2) the objective is measurable, 3) the objective is defensible, scientifically tested and generally accepted as fit for purpose, 4) the objective responds in a predictable way to resource use or the presence of contaminants, and 5) the objective is directly linked to the values to be achieved.[10]

This paper contrasts two examples of the use of water quality limits and standards in the Manawatu River and recommends a framework to set limits for water quality that encompasses aspects of three regional approaches and integrates the lessons learned from the

Manawatu examples. In doing this the water quality limits of the One Plan are tested against the five criteria listed above to determine potentially suitable numeric objectives for the Manawatu River.

The need for water quality limits

The effects of activities on freshwater and our understanding of the issues affecting water quality have changed over recent decades. Degraded water quality resulting from poorly treated industrial and municipal waste has been increasingly superseded by degradation caused by diffuse nutrient enrichment from urban and agricultural sources.[11] The issues have changed because 1) the treatment of many point source discharges has improved through better regulation and industry standards; 2) agricultural land use has intensified,[12] and 3) our understanding of the issues has improved through better environmental monitoring and continued research.[ii] Freshwater monitoring and research clearly indicates that any environmental gains from reduced point source pollution in New Zealand are overshadowed by increased diffuse pollution.[13]

At national and regional scales the proportion of pastoral land in a catchment is highly correlated with low water clarity and increasing nitrogen and phosphorus concentrations.[14] Sewage and wastewater discharges are still a significant influence on water quality in some areas,[15] although the cumulative effects of diffuse sources of pollution on streams, rivers and lakes are undeniably the most challenging freshwater management issue in New Zealand today.[16] [17] A number of commentators agree that to deal with the cumulative effects of diffuse pollution, regional councils need to undertake the first three of the four critical steps below:

[ii] River water quality trend analysis and greater collection and availability of national and regional monitoring data have enabled better identification and explanation of these changes over time.

1) Identify the resource,

2) Determine its capacity for use,

3) Establish limits to resource use, [18] and

4) Implement changes in resource use to achieve those limits.

Not only is there an identified environmental need for water quality limits but there is now a statutory requirement for regional councils to give effect to the Freshwater NPS. Policies in the NPS will compel regional councils to undertake the first three steps outlined above by setting water quality objectives, limits and in cases where objectives are not met or resources are over-allocated, to specify targets and implement methods to improve water quality within set timeframes. All of these steps will require continued monitoring effort and good science support. The NPS provisions relating to over-allocation of water quality resources will be particularly applicable in catchments like the Manawatu, where diffuse nutrient enrichment from intensive land use has been identified as the key contributor to degraded water quality.[19] The fourth step noted above is explored in the Manawatu case below which identifies that without effective implementation the integrity of any water quality limits can be undermined and compromised.

LESSONS LEARNED FROM THE MANAWATU RIVER

Many areas of the Manawatu catchment can be considered over-allocated for nitrogen, phosphorus, sediment and faecal contaminants largely as a result of diffuse agricultural sources, unsustainable hill country land use and in some cases direct discharges of waste.[20] High concentrations of contaminants in the river and its tributaries have reduced the health of aquatic ecosystems, negatively impacting the river's life-supporting capacity.[21] On a national scale soluble nitrogen and phosphorus concentrations in the Manawatu River and some tributaries ranked amongst the highest in New Zealand when compared with guideline values[22] and other national river data.[23] Nutrient trends in the Manawatu were consistent with increasing national trends in nutrient enrichment.[24]

Under suitable environmental conditions, unchecked nutrient enrichment of waterways can lead to nuisance growths of periphyton which adversely affect the ecological, recreational, aesthetic and cultural values of rivers and streams.[25] Nuisance growths change the physicochemical properties of the water, reduce the availability and quality of aquatic habitat and cover the substrate with unsightly algal growth. In severe cases, periphyton induced changes in physicochemistry and habitat can be lethal to aquatic invertebrates and fish.

Management of periphyton and nutrient enrichment in freshwaters to meet the wide-ranging needs of aquatic and human communities has been the subject of national debate.[26] The key mechanism for regional councils to control nuisance plant and algal growth and subsequent deleterious effects on waterway values is to control nutrients entering water from the landscape, particularly nitrogen and phosphorus, through the imposition of water quality limits.[27] The way in which water quality limits are expressed through regional plans can have a significant bearing on how successfully they are implemented to achieve water quality objectives. Having established the issue and the need for a regulatory response we next examine the advantages and disadvantages of two successive generations of plans for the Manawatu River.

Water quality standards: the Manawatu Catchment Plan

In 1998 the Manawatu Catchment Water Quality Regional Plan (the Manawatu Plan) became operative, following a process which began in 1993, identifying degraded water quality and protection of the uses and values of the Manawatu River as key issues. Consultation with environmental and recreational users was focussed on concerns about nuisance growths in the river and the risks posed to public health from bacteriological contamination. The Manawatu Plan's singular objective was to:

Enhance surface water quality in the Manawatu catchment by the year 2009 to a level which meets the needs of all people and communities while safeguarding the life-supporting capacity of the water.

The Plan utilised section 69 of the Act by identifying water classes from Schedule 3 and setting numeric standards within the rules of the Plan.[28] The Plan also conferred a prohibited activity rule (Rule 6) for all consents which could not meet the various standards within the specified timeframes, the last of which were periphyton and phosphorus standards to be complied with by June 2009.[iii]

The use of strict regulatory mechanisms in the Manawatu Plan might have been expected to confer a strong signal to decision makers that further or continued discharge of contaminants was not consistent with the Plan's intentions. Although the numeric standards within the Plan's rules were more stringent than the largely narrative standards in Schedule 3 of the Act, and the impending prohibited activity status was a strong signal of intent, in the author's

[iii] No consents were declined due to the prohibited activity status and the vires of Rule 6 was hotly debated, although no statutory declaration from the court was ever sought on this matter by any party.

opinion the lack of any numeric objectives in the Manawatu Plan was one of the major hurdles to effective implementation of the water quality limits. Evidence to support this is presented in the following sections.

Others have argued the benefits of numerical water quality limits and noted two major disadvantages to plans which contain numeric rules without linked numeric objectives and policies.[29] In such cases no guidance is provided to decision makers on how to deal with non-complying activities as there is no clear, measurable description of the outcome that the plan is seeking. Additionally, quantitative policies and rules alone may not be enough to effectively manage cumulative effects, particularly from land use or other activities that do not sit within the water quality policy or rule framework. The Manawatu Plan had no numeric objectives, only standards within rules and policies. Below I examine the Plan's implementation in light of the potential disadvantages of that approach.

Non-complying activities: the unexceptional exceptional circumstances paradox

Twenty-five consents were granted to renew significant discharges to the Manawatu River since the Manawatu Catchment Water Quality Regional Plan was made operative.[iv] Of those twenty-five consents, fifteen were granted non-complying activity status because they were known to or were likely to exceed the water quality standards, in particular the phosphorus and periphyton standards of Rule 2. These fifteen discharges were all granted consent through the exceptional circumstances provision of Policy 2. Because the development of the Plan was a consultative and political process and the use of water quality standards was new

[iv] The definition of a significant discharge for the purposes of this paper is any discharge of treated human sewage effluent to water, any industrial or food processing discharge or any discharge of more than one contaminant relevant to the standards in Rules 1 or 2 of the Manawatu Plan (e.g. not a gravel washing discharge where sediment is the only contaminant of concern).

and untested, a pragmatic way was sought to deal with situations that were outside the rules. Policy 2 used the same language as the clauses of s 107(2) of the Act to define the allowable exceptions as many of the standards were similar to the effects defined in s 107(1). Misuse of these exceptions was not foreseen by the Plan's developers or decision makers.

Exceptional can be defined as "…out of the ordinary course, unusual, special".[30] Arguably, when taking a catchment-wide view, granting a high proportion of non-complying consents under the definition of exceptional circumstances makes that provision somewhat farcical. The exceptional circumstances noted in the consent decisions ranged from the prohibitive costs of complying with periphyton and phosphorus standards, to upstream water quality which already exceeded the standards (cumulative effects), to uncertainty about the data or uncertainty of the effects of the discharge in relation to the standards. In the author's experience, none of these circumstances were particularly special or unusual within the context of water quality in the Manawatu catchment; in fact most of the circumstances noted in each case were common to a number of consents.

The application of water quality standards in the Manawatu Plan was an attempt to use numeric water quality standards under a relatively young Resource Management Act. However, the common use of the exceptional circumstances provision during the Plan's lifetime undermined the ability of the Plan to improve water quality downstream of point source discharges, an outcome contrary to the Plan's narrative objective. In some cases the utilisation of the exceptional circumstances provision as an out-clause resulted in cumulative adverse effects arising from the re-consenting of multiple non-complying discharges.

The Plan provided no clear guidance on how the objective of water quality enhancement was to be achieved or what level of water quality was required to meet the needs of people, communities or the life-supporting capacity of the water. So there were no measures against which to judge the merit (or otherwise) of applications for non-complying activities. If numeric objectives for the desired maximum level of periphyton growth or microbiological swimming grade for the river were developed alongside the standards, non-complying activities could have been considered directly against their effects on these objectives. Such a scenario would have allowed for an empirical assessment of the effects to inform the evaluative process for non-complying consents.

Addressing cumulative effects in the Manawatu

The narrative objective of the Manawatu Plan made assessing non-complying discharge consents in catchments affected by cumulative degradation difficult. In some cases the cumulative effects of activities upstream of a discharge were regarded as the exceptional circumstances by which a consent was exempted from the water quality standards. This approach seems at odds with the intentions of the Plan which was strongly focussed on addressing the effects of point source discharges. Although diffuse pollution is a pervasive cause of water quality degradation in the Manawatu catchment, the Plan gave little regard to the necessity for controls on land use which affected water quality and without a common, overarching numeric objective; land use could not be assessed against measurable water quality outcomes.

Diffuse contamination from agricultural sources was identified within the Plan as a water quality issue, although the science at the time of the Plan's development was not advanced enough to understand the relative contributions of pollutants from land use versus direct discharges. The Plan attempted to mitigate non-point sourced effects through non-regulatory encouragement of riparian planting and the regulation of discharges to land, plainly stating that non-point sourced contaminants were difficult to regulate, measure or define. Because addressing non-point source pollution was not a priority of the Manawatu Plan, this issue became a key consideration in the development of the second generation One Plan.

Planning success or failure?

There are a number of factors which contributed to the failure of the Manawatu Plan to provide obvious or positive water quality outcomes. These factors can be divided into two categories: poor implementation and inadequacies in the planning framework. There is no doubt that failure to implement the intentions of the Plan on a consent by consent basis was a contributor to the undermining of the Plan's integrity through the Policy 2 exceptional circumstances provision. Two other inadequacies of the Plan's framework included the lack of measurable objectives and lack of spatial resolution. Schedule 3 water classes were applied from the Act to provide some spatial reference for the standards. However the lack of clarity about the desired outcome at any particular point in the catchment meant the values of the receiving environment were often argued on a case by case basis. Subsequently there was no clear path to monitor the Plan's objective over time and the intent of the Plan, although clearly articulated throughout the Plan's narrative, was not adequately carried through into the planning provisions. Additionally, the scientific basis and technical understanding of the issues was hampered by sparse river monitoring data.

With hindsight and a better scientific understanding of the issues it is easy to focus on the negative aspects of the Manawatu Plan and to overlook the Plan's successes which also deserve mention. The reduction in dairy effluent discharges to water over the life of the Plan was an important and successful outcome. At the outset of the Plan in 1998 there were 318 consents for dairy effluent discharge to water in the Manawatu catchment, by 2010 there were just two. Dairy effluent discharges to water were successfully phased out by alerting farmers to the impending change in the acceptability of discharges to water prior to the Plan becoming operative. This approach was backed up by the Plan's preference for discharges to land over water and ultimately the water quality standards in the rules. Generally, as consents for dairy effluent discharge expired farmers were given short term consents to continue discharging to water (usually three years) whilst upgrading to a land irrigation system. The exceptional circumstances provision was not actioned for dairy effluent consents and few, if any, of these consents ended in a hearing.

Removal of dairy effluent discharges from waterways reduced direct phosphorus, nitrogen and faecal pathogen loads to the catchment's rivers and may have contributed to improved nutrient trends in the short term,[31] although this is speculative and any positive effects on overall water quality may have been masked by increased intensification and diffuse nutrient inputs over the same time period.[32] Removing dairy discharges from water does not completely remove adverse effects on water quality; rather, contaminants reach rivers via diffuse mechanisms such as overland runoff or subsurface leaching. Dairy effluent discharges to land would have contributed to diffuse effects on waterways, particularly during wet conditions, in high rainfall areas and on poorer soils. Changes in dairy management were then rolled out across the rest of the region, significantly reducing the number of direct discharges to water region-wide.

Some Territorial Authorities and industries responsible for significant point source discharges in the Manawatu catchment did undertake plant upgrades to achieve some of the Rule 1 and 2 standards. Faecal pathogens were reduced in a number of point source discharges through ultra-violet treatment systems and biochemical oxygen demand (BOD) was reduced throughout most of the catchment. Too much BOD causes growths of what is commonly referred to as sewage fungus. This slimy growth, in conjunction with the BOD itself, reduces dissolved oxygen concentrations at night and was responsible for fish kills in the lower Manawatu in the early 80's.[33] Reduced BOD in point source discharges as a result of a clean-up effort in the 80's was reinforced by the Plan BOD standard and did result in improved BOD concentrations in the lower Manawatu River[34] to levels which no longer caused wide-scale fish kills. Changes to effluent treatment systems that reduced faecal pathogens and BOD were considered more affordable than the upgrades needed to reduce phosphorus as the Plan required by 2009, so compliance with these standards was more easily implemented than for phosphorus.

So how did the approach taken by the Manawatu-Wanganui Regional Council differ for the second generation planning in the One Plan? I explore the similarities and differences below.

The One Plan approach

For the purposes of resource management and monitoring the Manawatu-Wanganui region was split into 44 management units known as water management zones, defined in the Schedules of the One Plan. The water management zones framework provided a basis to ensure that limits for water quality and value judgements for water bodies were spatially relevant; an approach also recommended by other commentators on water quality limits.[35] The One Plan specified water body values and narrative management objectives for each value, supported by the Plan's Objectives and Policies. These values were defined for each water management zone and provided for by the water quality limits for that zone.[36]

Like the Manawatu Plan before it, the One Plan does not contain any numeric objectives. This may mean that the lack of clarity introduced by the broad narrative objective in the former plan is perpetuated in the latter. However, an important advantage the One Plan has over the Manawatu Plan is the detailed specification of water body values for each management zone linked to the objectives in the Plan. Although the objectives are narrative, they are more specific than the broad goals of the Manawatu Plan and this may increase their effective use in the consent process. If an activity is unable to comply with the water quality limits, decision makers can fall back to the objectives to determine whether the activity will have an adverse effect on the values of the receiving environment. Whether measuring activities for their effects on the values of the One Plan will be technically feasible or simple is yet to be thoroughly tested through the consent process. The disadvantages of continuing to rely on narrative objectives are that there is no clarity for resource users about whether consent is likely to be granted and the assessment of an activity against the values could be viewed as subjective. Decision makers will need to refer to the relevant policies, although it could be argued that less guidance is provided there for dealing with activities that do not meet the water quality limits than in the Manawatu Plan.

The One Plan's policies direct the management of activities to maintain water quality where limits are met and enhance water quality where limits are not met. Although an exceptional circumstances provision in the notified version of the One Plan has been removed, the policies do provide a flexible approach in which decision makers on point source discharge consents must have regard to the water quality maintenance and enhancement policies, the water body values, the cumulative effects (both point and non-point source) and a number of other matters including whether best management practises are being used or if the discharger has adopted the best practicable option (BPO). Given the Manawatu catchment (among others) continues to have degraded water quality from point source discharges,[37] the policy framework for these consents could be considered too open to discretion, risking failure at implementation like the Manawatu Plan before it.

With two minor exceptions[v] the water quality limits within the One Plan are not linked to rules or associated with the implementation of standards as rules under s69 of the Act. This is a key difference from the Manawatu Plan, which had a strong rule stream attached to the water quality standards supported by policies and non-complying and prohibited activity status. By contrast, the One Plan has no non-complying activity status for discharges to land or water. In not conferring this status there is a risk of implying that activities which exceed the water quality limits are generally acceptable. A discretionary status for all activities is too open to interpretation on a case by case basis, is unhelpful to decision makers, provides no clarity to resource users on whether a consent is likely to be granted and potentially risks undermining the objectives and policies.[38] Milne cautions that in cases where cumulative effects are approaching sustainable limits (or in the case of water quality in the Manawatu River exceeding sustainable limits) activities should not be left as discretionary for the reasons listed above.[39]

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[v] There are two rules in the One Plan which use the water quality limits as permitted activity thresholds, these rules relate to discharges of water and stormwater and are not within the scope of this analysis.

In this sense the One Plan's approach to water quality limits is inconsistent with its approach to water allocation. For water takes within the core allocation limit the activity is controlled, for those outside the allocation limit the activities are non-complying. In this case the Plan provides clear guidance on which activities are generally acceptable and which are not through the activity status. In the author's opinion the water allocation approach in the One Plan is consistent with the requirement for setting limits in the Freshwater NPS but the water quality policies require strengthening before they will achieve the same level of clarity or consistency.

One leap forward from the Manawatu Plan was the inclusion in the One Plan of rules for the control of intensive land uses such as dairying, irrigated sheep and beef farming, cropping and commercial vegetable growing, to manage the effects of diffuse contaminants. The non-regulatory methods for riparian management in the Manawatu Plan have been ineffectual in arresting water quality degradation from diffuse sources. A tougher regulatory approach was required. The One Plan's shift in focus from point sources (as in the Manawatu Plan) to control of land use to address the cumulative effects on water quality was controversial and untested in river resource management. However, Environment Waikato (through variation 5) and Environment Bay of Plenty (through Rule 11) had led the way in proposing regulation of land use for lake water quality.

The proposed One Plan has been amended by decisions subsequent to hearings which reduced the level of regulatory control of intensive land use. The amended version of the Plan is currently under appeal to the Environment Court and the manner by which water quality limits are applied in the Plan (as standards, targets or limits) and the level of regulatory control of land use are two of the points of appeal to the Court. Changes to the water quality approach may yet occur through the mediation and Court processes.

Numeric objectives from water quality limits in the One Plan

An approach that is unlikely to be within the scope of the One Plan appeals is the potential to elevate some of the water quality limits to the level of numeric objectives. In conjunction with an approach which applies the limits as rules (standards) and a non-complying status for activities which exceed the limits, numeric objectives would provide considerable clarity about what the Plan is trying to achieve in the long term across all activities which affect water quality (including point and non-point sourced contaminants). Numeric objectives also provide a sound basis for monitoring policy effectiveness throughout the Plan's lifetime and beyond.

As discussed earlier, not all water quality indicators are appropriate for use as numeric objectives. For example, the nutrient limits for nitrogen and phosphorus themselves are not important environmental outcomes to manage. It is the effect of nutrient enrichment on periphyton (algae) growth and other river values which are the outcomes these particular limits are intended to manage. The limits were developed to provide for a range of values at different levels depending on the individual water management zone.[40] The limits most closely related to the One Plan's desired outcomes for rivers are *Escherichia coli (E. coli*) limits for faecal indicator bacteria, black disc limits for water clarity, periphyton limits for algal cover and the macroinvertebrate community index (MCI) limits as a measure of the state of aquatic ecosystems.

As explored below, all four of these water quality indicators taken from the One Plan limits meet the suitability tests for consideration as objectives. The first test is that they describe an environmental state that can easily be explained to a non-technical audience. Some translation is required from the raw numeric objectives but essentially *E. coli* under the limit means the river is safe to swim without an increased risk of illness, an alternative approach would be to use a microbiological swimming grade as the objective (i.e. good, fair or poor) with a supporting *E. coli* standard or limit.[41] Horizontal visibility which exceeds a minimum black disc objective means the water is clear enough to see through (for swimmers and fish). Periphyton cover within a maximum limit means there is not a large amount of green slime on the river bed and MCI above the limit means the type of aquatic bugs and insects which are expected for a given environmental state are present. Each of these objectives allows for the setting of a desirable level of environmental state that can be weighed against economic, cultural and social considerations.

The second and third tests are whether the objective is measureable and scientifically defensible. Each of these limits proposed are currently monitored throughout the region's rivers using nationally accepted protocols. All four can be tested statistically for trends over time. The *E. coli*, water clarity and periphyton limits have nationally adopted guidelines on which the objectives can be based.[42] National guidelines for MCI have not been formalised but user guides and protocols for sampling are well documented and the index and its variants are generally accepted as the best currently available measures to determine the state of aquatic macroinvertebrate communities.[43] The fourth test relates to whether the objective responds in a known way to resource use or the presence of contaminants. All four numeric objectives are supported by a body of research literature and their response to the effects of discharges and land use have been widely studied. Elevating these four indicators (*E. coli*, water clarity, periphyton and MCI) to the status of numeric objectives in the One Plan would provide clear, measurable outcomes in relation to contact recreation, life-supporting capacity, trout fishery, and aesthetic values, thereby meeting the fifth and final suitability test.[44]

The adoption of numeric objectives for the Horizons Region would clarify the freshwater outcomes the plan is trying to achieve across all activities and greatly assist Horizons to meet the requirements of the Freshwater NPS. Numeric objectives would also further strengthen existing policy effectiveness monitoring over the long term.

CONCLUSION

A hierarchical system of numeric objectives and rules is a logical, defensible system for the application of water quality limits using the RMA planning framework. The goal of setting water quality objectives is to provide clear, measurable outcomes that are locally relevant, value-based and allow for the cumulative effects of land use and discharges to be considered. Applying water quality indicators as numeric objectives, limits to resource use or rules for resource users, provides a transparent threshold of acceptability and a pathway for dealing with non-complying activities.

The lessons learned from using water quality limits in the Manawatu-Wanganui region lead to the conclusion that, as resource managers, we need to go beyond dealing with cumulative effects using the three steps of identifying the resource, determining its capacity for use, and establishing limits to resource use.[45] Seven integrated steps to assist in the development and application of water quality limits in regional policies and plans are recommended. These steps are:

1. Determine a spatial framework that accounts for environmental variability across and within catchments (e.g. topography, geology, and hydrology). Using this framework, identify the community values for water and develop water quality indicators that are associated with those values.
2. Thoroughly examine the relative contributions of contaminants from all sources to the allocation of water quality resources using sound science.[vi]
3. Choose strong numeric objectives which will give clear guidance for the direction and intent of regional policies and plans. Test the water quality indicators to determine which are appropriate to elevate to numeric objectives using the five suitability criteria detailed above.
4. Set limits to resource use and standards for resource users by using the remaining water quality indicators to develop standards (rules) which support the numeric objectives.
5. Develop an activity status framework that signals the acceptability (or otherwise) of activities that exceed the standards and link all activities that affect water quality to the numeric objectives. Ensure non-complying activities will be captured by the objectives.
6. Be clear and precise in describing any exceptions to the rules. Expect that any exceptions in water quality policies will be challenged.

[vi] Note: the variability of water quality in relation to flow is integral to understanding the effects of activities on river systems.

7. Regularly audit the effectiveness of implementation against the Plan's intentions and objectives to ensure the integrity of the objectives and policies are not undermined.

These considerations will be progressively more relevant to all regional councils grappling with managing the cumulative effects of land use and other activities on freshwater quality in New Zealand and with fulfilling the requirements of the Freshwater NPS.

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CHAPTER 3.

Monitoring the effectiveness of freshwater environmental policy in the Manawatu-Wanganui region, New Zealand.

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Monitoring the effectiveness of freshwater environmental policy in the Manawatu-Wanganui region, New Zealand.

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Abstract

Collaboration between scientists and policy makers, and monitoring of environmental policy, is rare. Traditional approaches to monitoring water quality are designed to answer broad questions on the state of the environment, rather than being targeted to measure policy success. Consideration of the benefits and risks of targeted monitoring, river access and site selection problems, the spatial scale of monitoring and of policy response in the environment, maintaining monitoring over the long term, monitoring multiple impacts and budget constraints are all required for successful monitoring of water quality policy. This paper discusses the considerations for policy monitoring in rivers and uses a case-study to demonstrate how monitoring of water quality policy effectiveness can be achieved. A ranked-matrix approach was used to prioritise sites, combining policy and environmental information collection. The newly proposed policy approach for the region made the development of a monitoring programme to assess policy simple because of a framework of water management zones (geographical management units), water body values and zone specific water quality limits. In particular, the water quality limits provided a baseline condition of river state prior to policy implementation and will in future provide a benchmark against which to measure success. Further strengthening of policies and water quality outcomes could be achieved by adding numeric objectives to the policy framework.

Keywords water quality, policy effectiveness, environmental monitoring, rivers, aquatic ecosystems

Introduction

Environmental policy development and environmental monitoring are traditionally executed separately from one another, so how is the effectiveness of environmental policies measured? At a regional level in New Zealand, staff undertaking each of these functions work within the same organisation, however, collaboration between freshwater scientists and those responsible for policy development is rare. Internationally, policy monitoring is also uncommon and therefore does not inform future policy decisions (Seasons 2003). Generally, policies are not developed with the practicalities of monitoring in mind, nor are environmental monitoring programmes designed to adequately measure the success of policy objectives. Traditional approaches that employ randomised site selection methods to undertake environmental monitoring only make it possible to make broad generalisations about the state of the environment. However, much can be gained by targeted monitoring (i.e. non-random) to measure policy success and provide information for future policy development.

New Zealand's resource management planning cycle is based on the principles of the internationally recognised public policy cycle and its variants (Seasons 2003) and is made up of five steps that: 1) identify issues; 2) set objectives relating to the issues; 3) evaluate methods to achieve the objectives; 4) implement policies and objectives through the chosen methods; and 5) monitor and evaluate the effectiveness of policies, methods and environmental outcomes (Grundy and others 2001; MfE 2003; Richmond and others 2004; MfE 2011). Ideally, collaboration between scientists (across a range of disciplines) and policy makers at each step ensures that science informs policy development which in turn informs the design of monitoring programmes (Downes and others 2002; van Haastrecht and Toonen 2011). The monitoring results are then fed back into the cycle in an iterative process that contributes to the refinement and improvement of environmental policies over time (Grundy and others 2001; Gluckman 2011). Questions that should be asked throughout the environmental policy development process are "how will policy success be monitored and what are the measures of success?"

Environmental legislation in New Zealand requires policy effectiveness monitoring under the Resource Management Act of 1991. Yet, New Zealand has been criticised for failing to measure the outcomes of environmental policy initiatives, particularly those linked to state of the environment monitoring (OAG 2005; OECD 2007; PCE 2010; Gluckman 2011). The problem is not limited to environmental management in New Zealand and although there are some examples of cross-disciplinary policy development internationally (van Haastrecht and Toonen 2011; Gluckman 2011) there are few examples of collaborative measurement of policy effectiveness (Ward and others 1986; Seasons 2003).

In reviewing the literature a number of authors discuss various purposes of environmental monitoring (Ward and others 1986; Grundy and others 2001; Downes and others 2002; PCE 2010; Downes 2010). New Zealand's Parliamentary Commissioner for the Environment (PCE 2010) takes a simplistic approach, identifying the key purposes of monitoring as: 1) understanding the state or health of the environment, 2) identifying causes of environmental change and 3) determining if efforts to manage the environment are working. Numerous studies have also identified other issues for consideration when monitoring freshwater (Ward and others 1986; Smith and others 1996; Hughes and others 2000; Downes and others 2002; Scarsbrook and others 2003; Larned and others 2004; McArthur and Clark 2007; Olsen and Peck 2008; Davies-Colley and others 2011; Roygard and others in press) including balancing the benefits of monitoring environmental state against focussed policy monitoring; site selection and access; matching the spatial scale of monitoring to the scale of policy response; robust monitoring over time; site-specific monitoring of multiple impacts and budgetary constraints to monitoring design. These considerations are discussed in detail in the following section and addressed with reference to the following case study.

The aims of this paper are to review the key considerations for river monitoring to measure policy success and to use these to develop a regional policy effectiveness monitoring programme. In this paper we focus on monitoring to assess the performance of management objectives using water quality limits as measures of success, set within a policy framework for the Manawatu-Wanganui region of New Zealand. We propose a ranked-matrix approach that incorporates policy objectives into the ranking system, along with other considerations specific to the design of river monitoring programmes. The matrix approach was used to rank potential monitoring sites by their value for measuring policy effectiveness over time and the quality of environmental information each site could provide. A method to select the most appropriate site from those available is a useful programme design tool and any method for this purpose needs to be transparent, account for the river-specific considerations raised above, ensure monitoring is locally relevant and able to measure policy outcomes over the long term.

BACKGROUND

This section provides general background on river ecosystems and the national context for freshwater resource management in New Zealand, including a brief description of the Manawatu-Wanganui region, the regional planning framework and specific resource management issues. This background provides a regional setting for the section on monitoring considerations that follows.

River ecosystems

Biological communities in rivers and streams are dependent upon a number of factors, ranging from large scale influences like catchment geology, flood frequency and catchment land use, to smaller scale factors, such as localised physical and chemical conditions or riparian habitat (Allan and others 1997; Death and Joy 2004; Snelder and others 2004; Death 2008). These riverine ecosystems contain communities of fish, macroinvertebrates (including insects, molluscs and worms) and periphyton

(Allan 1995; Allan 2004). Periphyton is the community of organisms which cover the river bed and is made up of algae, fungi, bacteria, diatoms and cyanobacteria (Biggs 1987; Biggs and Kilroy 2004). Periphyton is the primary production base of many river ecosystems and although it is a natural part of the aquatic community, nuisance proliferations can occur in unshaded rivers if low flood frequency and high nutrient conditions prevail (Biggs 2000a). Proliferations have negative impacts on the habitat of fish and macroinvertebrates (Allan 2004) and affect recreational and aesthetic values (Biggs 2000a). Avoiding, remedying or mitigating the adverse impacts of human activities on water, such as unchecked periphyton growth or poor aquatic biodiversity and maintaining the life-supporting capacity of aquatic ecosystems are the underlying legislative principles for freshwater management in New Zealand.

Freshwater management in New Zealand

New Zealand's freshwater resource management is governed by the Resource Management Act (RMA, 1991). The Act outlines the purposes and principles for the sustainable use of the nation's natural and physical resources. Responsibility for the management of freshwater resources in New Zealand was devolved to regional councils under the RMA in 1991 that are responsible for environmental management in one of 16 management regions (Richmond and others 2004). In accordance with the RMA, central government is responsible for drafting national environmental standards and policy statements, the first of which is the National Policy Statement (NPS) for Freshwater Management (2011) that sets out objectives and policies that direct regional government to manage water in "*an integrated and sustainable way, while providing for economic growth within set water quantity and quality limits*". Under the Act regional councils set objectives, policies and rules through regional policy statements and plans. Further, under section 35 of the RMA, there is an obligation for the Manawatu-Wanganui, and all other regional councils to monitor the efficiency and effectiveness of policies, rules or other methods in regional policy statements and plans.

Freshwater management in the regional context

The Manawatu-Wanganui region covers much of the central and southern North Island of New Zealand (Fig. 1) encompassing 2.2 million hectares over four major catchments. A regional plan and policy statement known as the One Plan was developed by the regional council to address the management of soil, air, coast, biodiversity, landscape and water in one document. The Plan focussed on four key issues: degraded water quality, increasing allocation of water, unsustainable hill country land use and declining indigenous biodiversity. Degradation of water quality in many of the region's waterways occurs largely as a result of agricultural land use (Ballantine and Davies-Colley 2009) and discharges of treated waste from municipal and industrial sources (McArthur and Clark 2007). Proposed regulatory control of intensive land use and discharges of waste in the One Plan necessitated a new monitoring framework to measure whether policies for environmental improvement resulted in positive outcomes for water quality and aquatic ecosystem health.

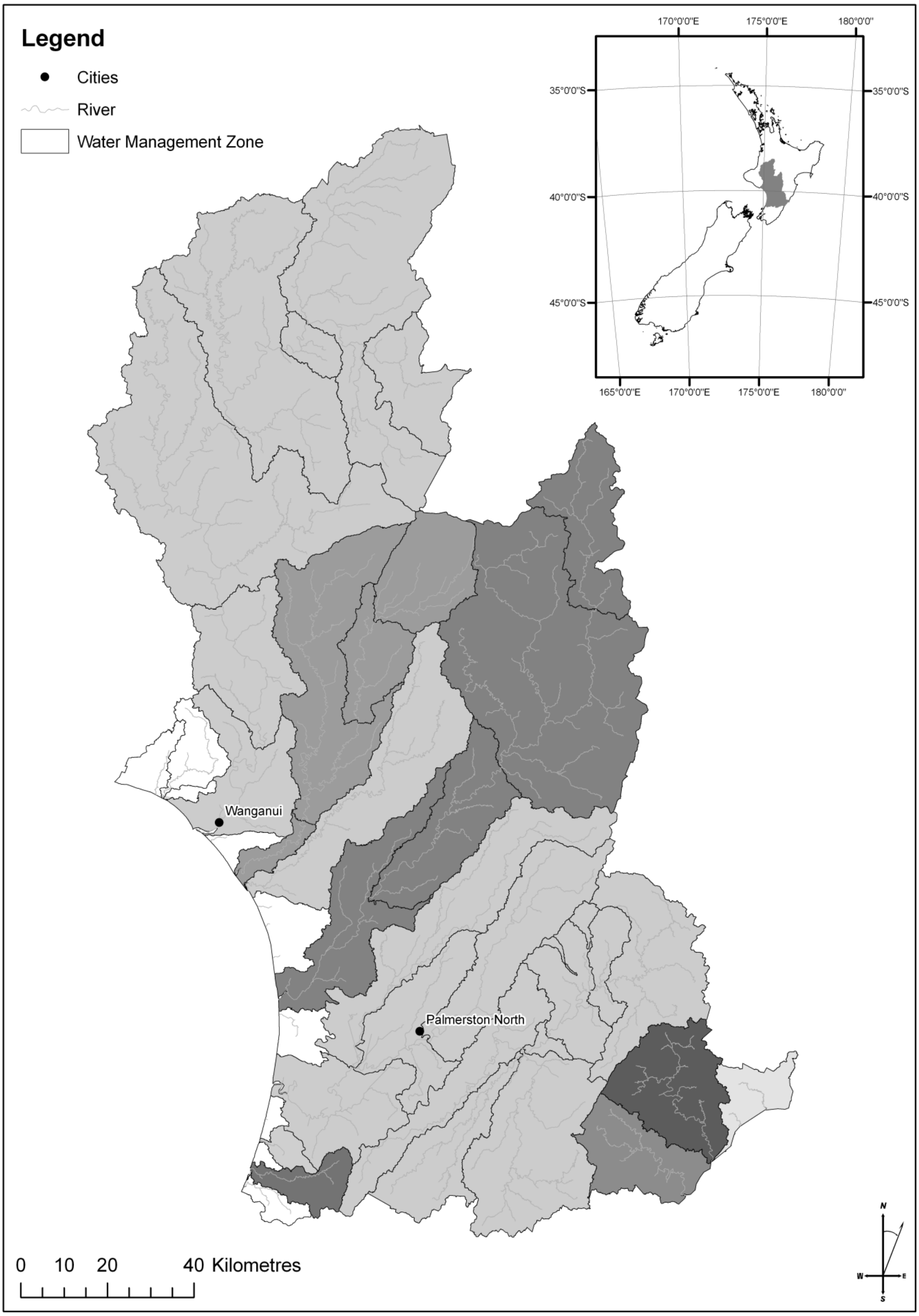

Figure 1. Water Management Zones and major catchments of the Manawatu-Wanganui region, New Zealand. Source: Horizons Regional Council.

MEASURING POLICY OUTCOMES IN RIVERS

In this section we discuss some of the issues raised in the literature on monitoring river environments and relate these issues to the method used to select sites for the water quality policy effectiveness monitoring programme in the region.

Targeted policy monitoring design

Randomised selection of monitoring sites is commonly recommended to allow generalisations about the state of the environment beyond the specific site to answer large scale environmental questions such as "what is the state of water quality and aquatic ecosystem health in the region or nation?" (Hughes and others 2000; Downes and others 2002; Larned and others 2004). Although statistical power is improved by random selection of river monitoring sites, pure randomisation can result in significant problems for site access (both physical site access and entry across private land) and suitability for sampling (i.e. wadeability, flow characteristics and substrate type) (Hughes and others 2000; Downes and others 2002; Olsen and Peck 2008). Yet, if site selection is non-random there are risks of monitoring bias towards particular river types (e.g. large rivers) meaning the condition of less sampled streams may not be picked up (Hughes and others 2000). Such constraints are often overcome using stratification within monitoring designs (Larned and others 2004; Olsen and Peck 2008). Large scale randomised studies are financially costly but there are distinct advantages in knowing that most environmental issues will be captured by the results. Notwithstanding this, the goals of monitoring are not always to answer broad questions and in any programme the objectives and purposes of monitoring should be the foremost considerations when selecting sites and monitoring designs (Ward and others 1986; Olsen and Peck 2008; Davies-Colley and others 2011).

A targeted approach to selecting monitoring sites that accounts for policy objectives may be needed when finances constrain the size of monitoring programmes (Grundy and others 2001; Olsen and Peck 2008) whilst acknowledging that reducing costs is a trade-off against statistical power and may increase the risk of overlooking some impacts (Downes and others 2002). When resources for monitoring are limited integration of policy effectiveness monitoring with other monitoring programmes (i.e. state of the environment) is preferable (Grundy and others 2001). Findings from the case study support the use of targeted site selection if measurement of the success of local environmental policies is the purpose of monitoring, rather than to answer broad questions about water quality state. In this case, a method to select sites for a non-randomised monitoring design was appropriate to answer specific questions. Sites were selected to measure outcomes from multiple policy objectives wherever possible. A framework of catchment management units (water management zones) that are largely homogeneous within zones but cover the regional environmental variability (i.e. hydrological and geological classes) and gradients of resource pressure (e.g. land use), such as that outlined in the case study, alleviates some of the disadvantages of a non-randomised design, but all inferences must still be considered catchment and policy specific.

Linking the scale of policy responses to environmental measurement

To link water quality outcomes with changes in catchment management it is suggested that monitoring of activities (e.g. point source discharges and changes in land management) is undertaken at a scale relevant to the activity (Quinn and Cooper 1997) and the spatial resolution of policies (Ward and others 1986; Downes and others 2002). The number of sites sampled, the spatial sample replication and the frequency of sampling is largely determined by the spatial scale of the application of policies, the estimated scale of the response to changes in resource pressure resulting from those policies, whether the response is biological or physicochemical, and ultimately the budgetary constraints to monitoring (Downes and others 2002). Consideration of which water quality indicators or environmental variables to measure is recommended. Environmental indicators of change in water quality such as the Macroinvertebrate Community Index (MCI) (Stark 1985) in combination with measures of environmental drivers (e.g. physical or chemical properties such as nutrient or sediment concentrations) are ideal for the purposes of answering specific questions about environmental responses to policy actions (Seasons 2003).

Natural or anthropogenic factors outside of policy control can influence water quality, potentially obscuring any response to changes in regulated activities. Concomitant measures of a number of environmental variables (particularly river flow) are made to account for the influences of external sources of variability; the importance of monitoring river flow, water chemistry and biological indicators at the same time, and physical location cannot be understated (Davies-Colley and others 2011). Environmental responses to some changes in resource management occur over long timeframes, therefore the discussion of the requirement for a temporal component in policy monitoring is included below.

Monitoring policy outcomes over time

Determining the success of environmental policies is a long-term process and the benefits of management efforts may take many years to realise. In the case of changes to land use practices, habitat restoration, land retirement or catchment stabilisation, responses may be inter-decadal as vegetation grows and biological organisms recolonise (Quinn and Cooper 1997; Parkyn and others 2003; Quinn and Wright-Stow 2008). In order to effectively measure environmental responses to policy initiatives the following points are suggested:

1. Monitor at regular intervals to increase the reliability of the data (Davies-Colley and others 2011);
2. Accumulate minimum records required for trend analysis, reliability increases with the length of record, depending on the trend strength (Smith and others 1996). It may take five years or more to see a trend from monthly monitoring (i.e. > 50 – 100 samples; Lettenmaier 1976; Ward and others 1986; Davies-Colley and others 2011);
3. Collect flow data to adjust for the effects of climate and hydrological variability on water quality trends. Even with flow adjustment, climate variability (e.g. El Nino Southern Oscillation) may have unforeseen influences on trend results (Scarsbrook 2002; Scarsbrook and others 2003).

Linking the temporal scale of monitoring to the scale at which an activity operates increases the potential for monitoring to pick up responses resulting from environmental policies. The management scale differs between activities, as does the time for a response to policies. Activities which contribute diffuse contaminants into water are usually managed over annual or longer time scales, whereas the management of point source discharges is usually on a shorter timescale (i.e. daily). Policy monitoring considerations with respect to these two different activities are discussed in the following section.

Monitoring different types of impact

Environmental indicators outside those traditionally used for water quality monitoring are employed to link changes in water quality or aquatic ecosystems to changes in land use practises. Examples of indicators used to monitor changes in land management include annual measurement of the proportion of riparian fencing in the catchment, the proportion of stream shading by riparian planting, accounting for catchment nitrogen losses using nutrient modelling and management tools, or determining the annual percentage of farms in the catchment complying with effluent discharge rules (Monaghan and others 2008; Quinn and others 2009). Using a range of alternative indicators decreases the difficulties inherent in measuring the influences of policy on land management and diffuse contaminants. Linking changes in land use to changes in water quality and then linking these responses to changes in policy is more complex than relating changes in point source management to water quality outcomes, although as discussed below, the monitoring of point source discharges is not always straightforward either (Clark 2010).

Ideally, to gauge the impact of point source discharges on water quality, samples are collected from the effluent prior to discharge into water and monitoring sites upstream and downstream of the discharge point, without the influence of any other impacts between the upstream and downstream sites. But, in many cases there are tributary inflows or multiple discharges in close proximity. In these situations contaminant loads calculated from the effluent samples can help explain the effects of multiple impacts within a river (Ward and others 1986; McArthur and Clark 2007). Combining impact monitoring with monitoring of catchment scale policy objectives is also desirable to gauge the degree of contaminant contribution from multiple sources (Ward and others 1986; Roygard and others in press).

Downes and others (2002) note that the number of sites in a monitoring programme is often a trade-off between the funding available for monitoring (including the long-term viability of funding) and the sites required to effectively monitor outcomes, undertake analyses and account for the river-specific considerations listed above (Downes 2010; Davies-Colley and others 2011). If the purpose of monitoring is to determine the effectiveness of environmental policies, it is necessary to have a transparent method to select monitoring sites which accounts for the specific issues of river monitoring over time and also allows the programme designer to make trade-offs. The study below describes a method of site selection employed to measure the success of new policies for water quality improvement in the Manawatu-Wanganui region of New Zealand.

CASE STUDY

This section outlines the regulatory framework introduced in the Manawatu-Wanganui region and the method employed to rank potential monitoring sites by their ability to provide robust water quality and ecological information and their value for measuring environmental responses to the regulatory framework over time.

Measuring values, limits and policy objectives: the Manawatu-Wanganui approach

The freshwater management framework for the Manawatu-Wanganui region was developed using a threefold approach that defined physical management areas known as water management zones; determined water body values (management objectives) for those areas through a process of community consultation and scientific survey; and developed water quality limits from published literature and expert review to protect the values. The framework of water management zones, values and water quality limits (known as targets in the One Plan) eased the development of the policy monitoring programme by providing a set of performance measures (water quality indicators) that could be monitored against the limits at each site, before and after policies were implemented. Scientists and policy makers collaborated on this approach throughout the Plan's development, from defining the water management zones and values to setting measurable limits that could be monitored effectively.

Water Management Zones

To ensure that regulatory initiatives were targeted to the local environment the region was divided into 44 water management zones, which were further split into 124 sub-zones (or sub-catchments), creating a physical framework for the application of locally relevant water quality objectives, policies and limits (Fig. 1). The zones were delineated according to a number of considerations (Fig. 2) including catchment geology, land use, population and resource pressure and existing regulatory frameworks (McArthur and others 2007). Most of the zone boundaries were determined by a multi-disciplinary expert panel of regional council staff, utilising local knowledge.

Other suggested approaches to setting limits and monitoring water quality in New Zealand applied classification methods to rivers or reaches of rivers into groups or types for management (Snelder and others 2004; Norton and Snelder 2009; Norton and others 2010). For this study the water management zones were used as the base unit for monitoring because the physical characteristics of the catchment and resource pressures within the total land drainage area upstream of a particular river site have an overriding influence on the water quality, quantity and ecological values of that site (Quinn and Hickey 1990; Biggs and others 1990; Scarsbrook 2002; McArthur 2004).

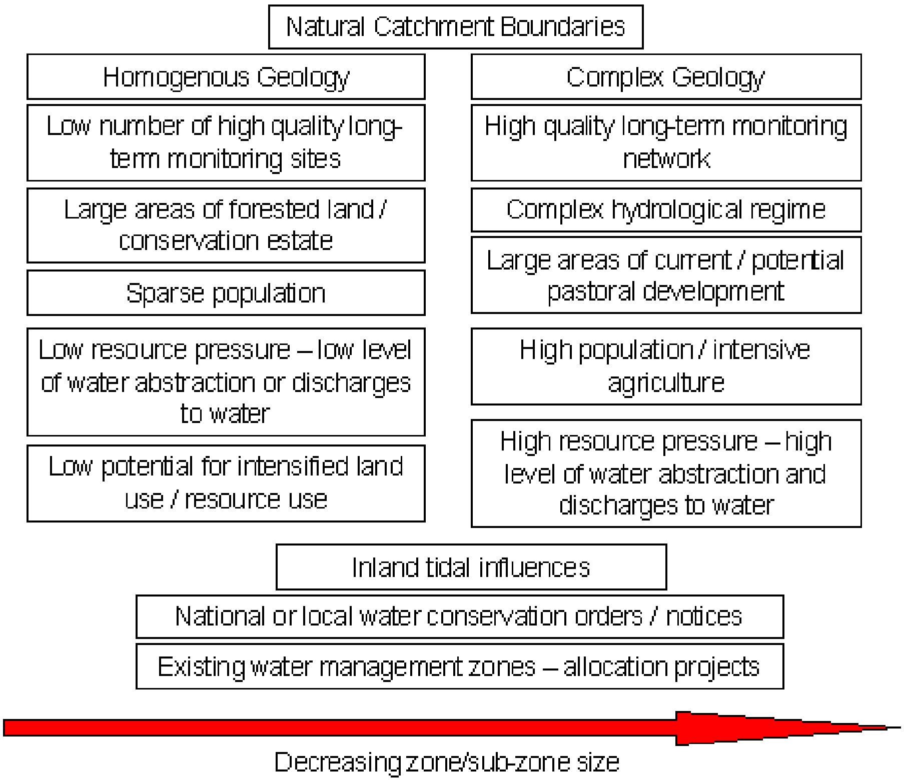

Figure 2. Factors influencing the size of Water Management Zones (spatial catchment management units) in the Manawatu-Wanganui region, New Zealand. Source: McArthur and others (2007).

Waterbody values and water quality limits

Four groups of values were defined for the region: Ecological, Recreational and Cultural, Water Use and Social/Economic (Table 1). Each of the groups contained several individual values that were identified for particular water bodies (Ausseil and Clark 2007a). This paper focuses on the programme developed to monitor water quality indicators against limits associated with the life-supporting capacity, contact recreation, aesthetic, trout fishery and trout spawning values within the Ecological and Cultural and Recreational values groups (Table 1).

Numeric limits to provide for the ecological and recreational values of each water management zone were determined from published literature, expert opinion and assessment of existing monitoring data against established guidelines such as the ANZECC (2000) Guidelines (Ausseil and Clark 2007b) or the New Zealand Periphyton Guidelines (Biggs 2000b). Each of the values had relevant limits applied using a range of water quality indicators. For example, the life-supporting capacity value had limits for periphyton, macroinvertebrate community indices, temperature, pH, biochemical oxygen demand, particulate organic matter, soluble phosphorus and nitrogen, ammonia, toxicants, dissolved oxygen and water clarity, whereas the contact recreation value had associated limits for faecal contaminants, periphyton and water clarity. The practicality and affordability of monitoring each limit was considered at the time the limits and related policies were developed.

Table 1. Surface water value groups and individual values identified in the Proposed One Plan for the Manawatu-Wanganui region, New Zealand. Values highlighted in grey are the focus for protection via specific water quality limits, * inanga are a species of native fish (*Galaxias maculatus*) and +mauri is a term for the life-force of the water that denotes a spiritual connection between the indigenous Māori of New Zealand and the water.

Values Group	Individual Values
Ecosystem Values	Natural State
	Life-Supporting Capacity
	Sites of Significance – Aquatic
	Sites of Significance – Riparian
	Inanga* Spawning
	Whitebait Migration
Recreational and Cultural Values	Contact Recreation
	Mauri+
	Sites of Significance – Cultural
	Trout Fishery
	Trout Spawning
	Aesthetics
Water Use Values	Water Supply
	Industrial Abstraction
	Irrigation
	Stock water
Social/Economic Values	Capacity to Assimilate Pollution
	Flood Control and Drainage
	Existing Infrastructure

The quantitative water quality limits for each water management zone provide an ideal basis for in-river monitoring of the achievement of water quality policy outcomes over time. In some zones where water quality was poor the limits and values functioned more as targets to be worked towards in the future, whereas in other zones where water quality was better and the values were provided for, the limits provided a base-line condition below which water quality must not drop. If long-term monitoring shows water quality is maintained in areas where it is already good and improved towards limits in areas where it is poor, and natural environmental variability is accounted for, this indicates policies have been successful.

Control of land use for water quality

The One Plan proposed regulatory controls on intensive agricultural land use to reduce nitrogen, phosphorus, sediment and faecal loads in water management zones affected by nutrient enrichment and other contamination using what was known as a Farmer Applied Resource Management or FARM strategy. These policy approaches were among the first wave of controversial controls proposed by regional councils in New Zealand to tackle the problem of increasing eutrophication and degradation of rivers from diffuse agricultural sources (Scarsbrook 2006; Ballantine and Davies-Colley 2009; Ballantine and others 2010). The Waikato and Bay of Plenty Regional Councils were the forerunners to the Manawatu-Wanganui approach being the first regional government bodies to tackle the issue of policy regulation of land use to deal with water quality issues in iconic Lake Taupo and the Rotorua Lakes of the North Island of New Zealand. Additionally, policies were proposed to ensure any direct point source discharges to rivers did not degrade water quality beyond the limits set for each zone. Non-regulatory methods were also introduced to reduce the impacts of sediment movement into rivers from highly erodible land through the Sustainable Land Use Initiative or SLUI.

Water quality monitoring: ranking potential monitoring sites

To accurately monitor the state of water quality in each management zone it is desirable to have water quality and flow monitoring sites at reference locations in an upstream reach of the zone, upstream and downstream of any major discharge or change in land use and at the most downstream reach of the zone. As part of the determination of the water management zones, recommendations were made for a number of new monitoring sites to meet these site requirements where information was lacking (McArthur and others 2007).

As resources for monitoring were limited, a method was employed which used a matrix to rank all potential sites according to various attributes (Table 2). The site attributes included the number of years of record, whether it was a core site (currently monitored), the presence of flow or continuous turbidity recorders, whether the FARM strategy policies or SLUI programme applied (policy objectives), whether the site was also monitored under another programme (i.e. contact recreation, biomonitoring or biosecurity surveillance for the invasive diatom 'Didymo'), whether there was a Site of Significance Aquatic (SOS-A) nearby (indicating the presence of rare or threatened native fish and the blue duck *Hymenolaimus malacorhynchos*) or whether the site was recommended for inclusion through the water management zone project. Sites were scored for each attribute using a weighted system.

The attribute most heavily weighted in the site selection scoring system was the number of years of monitoring record for each site. So a site which had previously been monitored for 13 years scored 13 whereas a site with two years of monitoring record only scored a two for this attribute. This heavy weighting of the existing monitoring record reflected the value of the existing record to enable robust trend analysis.

One of the key objectives of monitoring was to measure the success of policies to improve water quality outcomes, so sites in water management zones proposed for regulation of land use to reduce contamination of waterways (FARM strategy priority zones) were also more highly weighted in the matrix scoring process. Sites that were at the lower boundary of priority zones were weighted with a score of two and sites midway through the zone (i.e. between the upper and lower zone boundaries) were scored a one, to ensure the priority zones had adequate monitoring coverage. Sites within water management zones targeted for the non-regulatory SLUI programme were also weighted in the same manner within the matrix.

One hundred and ninety potential monitoring sites were ranked according to the sum of these scores across all attributes in the matrix. This method allowed the monitoring programme designer to choose as many sites with the best attributes as existing budget resources would allow, leaving a comprehensive list of potential monitoring sites should resources improve in the future. Initially, sixty-five sites were identified for monitoring, since that time several sites from the ranked list have been added as monitoring has been made more cost effective, allowing for the addition of new sites to the programme. Of the selected sites, all those that are wadeable are sampled for aquatic invertebrates in the annual biomonitoring programme and all sites suitable for freshwater fish monitoring are sampled on a five-yearly rolling basis. Because of the costs associated with the laboratory analysis of periphyton samples, a programme to monitor periphyton cover and biomass against the Plan's limits was developed for a subset of the 65 sites chosen using the matrix in Table 2.

The One Plan has an expected life of ten years from the time it becomes legally operative. Some of the policies and regulations recommended, which relate to land use controls, have long-term objectives reaching more than twenty years into the future. The monitoring programme described above began in mid-2008 and was reviewed throughout the following year to ensure any start-up issues were ironed out before the Plan became operative. Early monitoring results have been used to establish the baseline condition, against which any changes resulting from the long-term implementation of the Plan can be measured, using the water quality limits as measures of success.

Table 2. Example matrix of the top six sites ranked by attributes for environmental and policy effectiveness monitoring of water quality and aquatic ecosystems in the Manawatu-Wanganui region, New Zealand. Key - FARM: Farmer Applied Resource Management; SLUI: Sustainable Land Use initiative; WMZ: Water Management Zone.

Site name	Years of record	Core site	Flow site	FARM strategy	SLUI	Contact Recreation	Invertebrate Biomonitoring	Didymo	SOS-A	Continuous turbidity	WMZ recommendation	Rank / Sum
Manawatu at Hopelands	12	1	1	2	2	0	1	1	1	0	0	21
Manawatu at Teachers College	12	1	1	2	0	0	0	1	1	0	0	18
Manawatu at Weber	10	1	1	2	2	0	0	1	0	0	0	17
Mangatainoka at SH2	9	1	0	1	2	0	1	1	1	0	0	16
Rangitikei at Pukeokahu	10	1	1	0	1	0	0	1	1	0	0	15
Whanganui at Pipiriki	10	1	1	0	2	0	0	1	1	0	0	16
…..												

CONCLUSION

Policy objectives are an important selection criterion when designing effective monitoring programmes and selecting monitoring sites. New Zealand has a poor record of monitoring the success of public policy and science-informed policy development, particularly in the area of environmental management. Further work is needed to ensure freshwater policies are developed with monitoring requirements and measures of success in mind. Scientists and policy makers must collaborate to ensure policies are able to be monitored (both practically and financially) at the appropriate scale both in space and over time and that the outcomes are fed back into the policy cycle to inform future policy development. Such an approach was developed successfully for the Manawatu-Wanganui region of New Zealand and from a technical perspective the science advice was well-used to inform policy making at most levels of the One Plan's provisions. The physical framework of water management zones allowed for locally relevant, numerical limits to be set and measured over time. Measurable limits associated with policies to improve water quality provided an ideal platform for assessing effectiveness of policies over time and at a relevant spatial scale.

Further work to strengthen the links between water quality indicators and policies is recommended through the adoption of numeric plan objectives to complement the narrative, value-based management objectives of the One Plan. To ensure policy monitoring continues to be practical and affordable, numerical objectives should be collaboratively developed by science and policy staff with the implementation and monitoring of policies in mind. Objectives should contain suitable physicochemical and biological indicators which are measurable, describe an environmental state easily understood by a non-technical audience, be scientifically defensible, respond in a known way to contaminants and be directly linked to the values to be achieved through the Plan (McArthur in press). Indicators, such as faecal indicator bacteria, which determine the risk of pathogenic organisms affecting the safety of river users for contact recreation, may be well suited for monitoring policy objectives over time, enabling clear reporting of results at a level that is easily understood by a non-technical audience (i.e. number of swimmable days per year).

The RMA requires monitoring of environmental policy in New Zealand and the policy cycle relies on feedback from monitoring to identify issues in the first instance and improve the performance of policies and resource management over time. However, policies should not be developed independently of monitoring programmes, nor should monitoring by regional authorities be done in isolation from the policy setting, to ensure that policies are effective and monitoring is practical, sustainable and measures policy success over the long term.

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CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

Photo 2. Cyanobacterial bloom on the bed of the Manawatu River at the Hopelands Road Bridge, downstream view. Photo by KJ McArthur, 2009.

Water quality limits and numeric objectives

A freshwater resource management system that employs numeric objectives and rules developed from water quality limits is an approach that fits logically within New Zealand's RMA planning framework. There are multiple ways of applying water quality limits and numeric objectives in regional plans and four examples have been identified within this thesis.[7] Since the release of the NPS for Freshwater Management in May 2011, all regional councils will need to invest in developing planning approaches which utilise water quality limits to achieve freshwater objectives. Ideally, such approaches will provide clear, measurable outcomes that are locally relevant, value-based and address the cumulative effects of contaminants from various sources, particularly diffuse contaminants. Chapter two of this thesis outlines some suitability criteria to assist in determining the appropriateness of water quality indicators for use as numeric objectives. In assessing the successes and failures of the first Manawatu Plan to apply water quality limits, within the context of more recent planning efforts, this thesis recommends seven steps that can add value to the process of setting limits for freshwater management.

1. Use a spatial framework to give a local focus to the application of appropriate indicators, limits and values;
2. Understand the relative contributions of all key sources of contaminants and their effects on values;
3. Select clear, measurable numeric objectives from the suite of appropriate water quality indicators;
4. Apply numeric rules or standards using indicators which are linked to and support the numeric objectives;
5. Ensure activities that do not meet these rules or standards are captured as 'non-complying' activities;
6. Describe any exceptions to non-complying status clearly within plans; and
7. Audit the effectiveness of policies to achieve environmental outcomes.

[7] Canterbury, Waikato, Bay of Plenty and Manawatu-Wanganui Regional Councils.

Monitoring policy success

A regional plan underpinned by a spatial framework of numeric water quality limits and objectives provides a robust setting for monitoring the effectiveness of policies over time. If policies are applied over a spatial framework, measuring policy success can similarly utilise this framework to select monitoring sites in a targeted manner. Taking into account a number of river-specific monitoring considerations and using a spatial framework allows the monitoring programme designer to match the scale of policy application to the scale of environmental response in space and time. Numeric limits and objectives can also be utilised as measures of success to gauge policy effectiveness through monitoring water quality indicators against these limits. A ranked-matrix method was used to select sites for policy and environmental monitoring in the Manawatu-Wanganui region to provide environmental information and measure environmental responses to policy initiatives. A ranked-matrix method allows for trade-offs between the financial resources available for monitoring and the ability to efficiently gather information on the state of the environment and policy effectiveness in a transparent manner. The development of the planning framework, limits and monitoring programme for the Manawatu-Wanganui Regional Council was a collaborative effort by policy and science practitioners from the regional council.

Interdisciplinary collaboration

The development of informed and successful environmental policy relies on sound science to advise the evaluative process, define defensible and measurable limits, monitor outcomes in the environment and report results into the policy cycle in an iterative manner (Grundy et al. 2001; Norton et al. 2010). Yet, science alone cannot and should not determine environmental policies as there are always considerations outside the realm of the technical which must be weighed in any decision making process (Pielke 2007; Gluckman 2011). The RMA requires policy developers and decision makers to also consider the social, economic and cultural weightings in sustainable environmental management and practitioners from a wide-range of technical fields including social scientists and economists have much to add to the evaluative process of water resource management (van Haastrecht and Toonen 2011).

Notwithstanding this, the role of environmental science in freshwater policy development and in measuring policy success is not a minor one and much can be gained by collaboration between scientists, planners and policy makers. Scientists can inform the policy cycle in an integrated way by:

1. Analysing and communicating the results of environmental data to identify resource management issues;

2. Developing appropriate indicators of water quality and aquatic ecosystem health;

3. Determining appropriate limits to resource use or contaminant inputs;

4. Choosing suitable indicators to use as numeric plan objectives;

5. Designing monitoring programmes using policy objectives as site selection criteria and numeric objectives as measures of policy success;

6. Ensuring environmental policy monitoring is targeted and cost effective; and

7. Reporting results of policy effectiveness monitoring for iterative use in future planning.

Methods for undertaking these steps have been recommended in chapters two and three above and the thinking behind many of the steps was informed by experience with past approaches and the development and implementation of current policy initiatives to improve water quality in the Manawatu-Wanganui region. Undertaking many of these steps is likely to become a routine requirement for local governments as the NPS for Freshwater Management is implemented over the coming years. Further discussion on the integration of science and policy to give effect to the NPS will be needed at a national level and the development of numeric objectives and limits for water quality is likely to become more relevant as stakeholders in the freshwater resource call for National

Environmental Standards to support the NPS. The advantage for a nation the size of New Zealand is that the science and policy communities are relatively small and in close proximity to one another.

Regional council scientists often straddle the science and policy divide through their day to day roles of applying research science to real world problems, within a prescribed policy and legislative framework. Successfully undertaking applied roles such as this requires an ability to clearly communicate technical information to a wide audience and a working knowledge of the policy and planning language and context. Council planners and policy advisors likewise have to understand technical concepts and translate technical advice into policy language. Given the cross-disciplinary nature of these roles, environmental scientists, planners and policy advisors working in many regional councils may be in the best position to facilitate national conversations about integrated freshwater resource management planning between the wider science and policy communities. An integrated approach is urgently needed to find innovative ways of utilising the RMA and regional policy provisions to make improvements in water quality at the coal face.

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APPENDIX 1

Summary of significant point source discharges to the Manawatu River catchment considered under the Manawatu Catchment Water Quality Regional Plan (MCWQRP, 1998) outlining the term of consent, consent status in relation to the Plan and the reason for the decision with regards to Rule 1 and 2 water quality standards. Consents granted under non-complying activity status are shaded grey.

Consent	Term	Expiry	Consent status	Reason
Affco Feilding	15 years	2011	Discretionary under Rule 7	Rule 2.4g DRP provisions do not come into effect until 2009, discharge to land at low flows mitigates some Rule 1 and 2 effects
DB Breweries	15 years	2009	Discretionary under Rule 7	Rule 2.4g DRP provisions do not come into effect until 2009, consent to expire at this time
Fonterra Longburn	15 years	2022	Non-complying: exceptional circumstances	Upstream water quality exceeds Rule 1.e
Fonterra Pahiatua	15 years	2009	New application in process	Not consented under MCWQRP
Tokomaru STP	15 years	2017	Non-complying: exceptional circumstances	Background water quality and drain environment mean Rule 2.4g is not applicable and effects are considered no more than minor
Foxton STP	6 years	2014	Non-complying: exceptional circumstances	Temporary (6 years) consent before intended removal of discharge from Foxton Loop
Feilding STP	4 years	2009	New application in process	Previous application granted under exceptional circumstances due to temporary nature
Rongotea STP	10 years	2016	Non-complying: exceptional circumstances	Background water quality exceeds Rule 2.4g for DRP
Cheltenham STP	10 years	2016	Non-complying: exceptional circumstances	Discharge is to drain with no flow and ends in land seepage, only reaches the Oroua River very occasionally after major rainfall/flooding events
Kimbolton STP	10 years	2019	Non-complying: exceptional circumstances	Upgrades a significant improvement and cost of further upgrades prohibitive. Receiving waters deemed not suitable for contact recreation or fisheries and therefore effects not applicable. Policy 2 considered *vires* by the Applicant and the Proposed One Plan abandons prohibited activity status

Consent	Term	Expiry	Consent status	Reason
Awahuri STP	20 years	2026	Discretionary	Assessed to comply with Rules 1 and 2
Longburn STP	1 year	2010	Non-complying: exceptional circumstances	Temporary discharge before piping to Palmerston North City STP
NZ Pharmaceuticals	15 years	2023	Non-complying: exceptional circumstances	Background water quality exceeds some Rule 1 and 2 standards
Aokautere STP	10 years	2009	New application in process	Does not need to comply with Rule 2.4 g & f until 2009
PNCC STP	25 years	2028	Non-complying: exceptional circumstances	Background water quality exceeds Rule 2.4g DRP standards, Rule 2.4f periphyton standard only being exceeded on some occasions, costs of further treatment to meet DRP standards prohibitive and evidential link between periphyton and recreational impediment not established.
Ashhurst STP	10 years	2013	Non-complying: exceptional circumstances	Upstream periphyton sometimes exceeds Rule 2.4f standards; Rule 2.4f standard does not require compliance until 2009 and standard for periphyton are considered inappropriate.
PPCS Shannon	10 years	2018	Non-complying: exceptional circumstances	Effects no more than minor as mitigated by consent conditions
Shannon STP	-	-	n/a	Declined by Environment Court
Eketahuna STP	10 years	2005	Non-complying: exceptional circumstances	Costs of complying considered too great (new application in process)
Pahiatua STP	10 years	2005	Not disclosed but likely to be non-complying due to exceptional circumstances	Timeframe allowed for plant upgrades to comply with Plan Rules
Eketahuna Imhoff Tank	10 years	2005	Application in process but likely to be withdrawn	Cannot be granted as considered by Horizons to be a prohibited activity
Dannevirke STP	24 years	2027	Non-complying: exceptional circumstances	Large and costly upgrade undertaken, short length of river affected by Rules exceeded (2-3 km) and periphyton response in Mangatera Stream may not be predictable with respect to DRP.

Consent	Term	Expiry	Consent status	Reason
Woodville STP	3 years	2011	Non-complying: exceptional circumstances	Background water quality exceeds Rule 1 and 2 standards
Norsewood STP	10 years	2002	Application in process	Not consented under MCWQRP
Ormondville STP	25 years	2026	Non-complying: exceptional circumstances	Effects no more than minor as discharge does only reaches Mangarangiora Stream after significant rainfall/flooding

APPENDIX 2

Style guide for paper entitled: Setting water quality limits: lessons learned from regional planning in the Manawatu-Wanganui. Paper accepted (pending review amendments) 18th August 2011: Resource Management Theory and Practice. Resource Management Law Association of New Zealand (submitted 20th July 2011).

GUIDELINES FOR PAPERS

Editorial Committee
Resource Management Law Association of New Zealand Inc.

INTRODUCTION

Resource Management Theory & Practice was established in 2005. The aim of the journal is to provide a vehicle for in-depth analysis of resource management issues relevant to the New Zealand scene.

To promote consistency of layout as well as style, we have written a guide to assist in the preparation of papers. We hope that it will also help with clear communication of ideas.

We are particularly keen to use gender neutral language and the hierarchy of headings shown in this guide, and that papers are fully referenced by the inclusion of appropriate end notes.

We would be very grateful if your paper was fully proof read by the time it reaches us in its final form.

ORGANISATION OF TEXT

Headings

Use no more than three levels of heading. There should be a two line space to the text for all levels of heading.

	TITLE	Bold, centred, 22 point, upper case
Level 1:	**MAIN HEADINGS**	Bold, left justified, 16 point, upper case
Level 2:	**Section headings**	Bold, justified left, 16 point
Level 3:	*Sub-headings*	Italic, justified left, 16 point

Author details

Author details should be centred and appear as follows directly after the paper title, e.g.:

Justice Stuart Morris
President, Victorian Civil and Administrative Tribunal

Or in the case two authors from the same firm or body:

Phil Hughes & Stuart Niven
Victorian Department of Sustainability and Environment

Or in the case of two authors from different firms or bodies:

David Kirkpatrick
Barrister, Park Chambers, Auckland

Kenneth Palmer
Associate Professor of Law, University of Auckland

The author name (only) should be in **bold** text.

Numbering

Please do **not** number paragraphs or headings. Pages (excluding the first page) should be numbered at the bottom of the page, centred.

End notes

In the interests of readability:

- Include **all** references, citations and comment in appropriate end notes;
- Please do not use any other system of referencing;
- In the text, number end notes outside punctuation;
- Number end notes sequentially using Arabic numerals.

Authors should follow the general rules in Parts 2.1, 2.2 and 2.3 of the *New Zealand Law Style Guide* (2009) regarding the use of end notes and the citation of sources. Further guidance on citation of sources is given below.

PROSE

Authors should follow the general rules in Parts 1.1 and 1.2 of the *New Zealand Law Style Guide* (2009) regarding the prose style and format of the main text.

CITATION

Authors should follow the specific rules in Parts 3 to 10 of the *New Zealand Law Style Guide* (2009) regarding the citation of cases, legislation, texts, reports and international materials.

THE TEXT

Generally, papers should **not** include a table of contents, preface or foreword, bibliography, or index.

Acknowledgments

Acknowledgments should appear at the end of the paper, e.g.:

> I acknowledge the valuable contributions and comments of my colleagues at Abbott Tout in the preparation of this paper – particularly, John Cole, Dick Graham, Lesley Finn, and Jeff Reilly.

Appendices

These should appear at the end of your paper as – Appendix 1, Appendix 2, Appendix 3 etc; and require appropriate headings, e.g.:

- Appendix 1 Publications of the AEBC
- Appendix 2 The AEBC

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Font

Use Garamond 16 point unless otherwise specified in these guidelines:

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Full (left and right) unless otherwise specified in these guidelines, e.g. indented quotations.

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Generally, spacing for the text should be single line spacing:

- Spacing between title of paper and author name and details – space of two lines;
- Spacing between author details and first level 1 heading or body of text – space of two lines;
- Spacing before and after level 1 headings – space of two lines before and after the heading;
- Spacing before and after level 2 and 3 headings – space of two lines before and space of one line after such headings;
- Spacing before and after indented quotations – space of one line before and after such quotations;
- Spacing before and after bullet points – space of one line before and after the list of bullet points;
- Spacing between bullet points – single line spacing as for the remainder of the text.

TRANSFER OF THE FINAL PAPER

Your proposal or draft paper should be sent to the Executive Officer for consideration by the Editorial Committee by 31 July. Papers should be within the range of 4,000-8,000 words and should conform with these guidelines. Copies of the final paper should be sent as an email attachment in Microsoft Word by 15 September.

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Facsimile: +64 (0)9 626 6068
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Website: www.rmla.org.nz

Guidelines for Papers: updated 25 May 2010.

APPENDIX 3

Style guide for paper entitled: Monitoring the effectiveness of freshwater environmental policy in the Manawatu-Wanganui region, New Zealand. Paper submitted 16th September 2011: Environmental Management [http://www.springer.com/environment/environmental+management/journal/267]

Instructions for Authors

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Authors should prepare manuscripts in close conformance with the journal's style and the following instructions. If an article is accepted, careful preparation will ensure fewer copy editing changes and possibly a shorter time to its appearance in print. Papers should be written in English and presented in the following order:

- Title of the paper - For each author, full first and last name, affiliation (e.g., department or division, institution, if appropriate) and address (street address or box number if appropriate, city, state or province, postal code and country). If there is more than one author, indicate to whom communications should be sent (please supply an e-mail address).
- An abstract of no more than 250 words, typed double-spaced, that sketches the objectives, results and conclusions of the paper.
- About six key words.
- The text of the paper - Subheadings should be used as appropriate, although the introduction to the paper should not be preceded by a subheading. "Acknowledgments" must include all support of the research reported in the paper. "Acknowledgments" precede the "References" section; "Appendices," if there are any, come after it. Appendices must each have a title. Captions for figures, typed double-spaced on a separate page.
- Tables - prepared on separate sheets and numbered 1, 2, 3, etc.
- Number your pages; the use of line numbers is also encouraged to make reviewers' and editors' comments easier.

Manuscripts should normally not exceed 10,000 words, which is approximately equivalent to 40 pages of double-spaced typed manuscript. A frequent comment in requests for revision is to tighten and shorten the presentation.

References

List only references that are cited in the text. Text citations give the author's name and the date of the work, e.g., Jones (2002) or (Jones 2002). Two authors should be cited as "Jones and Smith (2002)," while more than two should be referred to as "Jones and others (2002)." Journal names should be spelled out in full, not abbreviated. The following list illustrates the journal's style of citation, which should be adhered to:

Klemas VV (2001) Remote sensing of landscape-level coastal environmental indicators. Environmental Management 27:7–57

Reiger HA, Welcomme RL, Steedman RJ, Henderson HF (1989) Rehabilitation of degraded river ecosystems. In: Dodge DP (ed), Proceedings of the International Large River Symposium (LARS). Canadian Special Publication of Fisheries and Aquatic Sciences, Ottawa, Ontario, Canada, pp 86–97

Margoluis R, Salafsky N (1998) Measure of success: designing, managing, and monitoring conservation and development projects. Island Press, Washington, DC, 362 pp

US Fish and Wildlife Service (USFWS) (1990) Instructions for breeding bird survey routes participants. Patuxent Research Laboratory, Patuxent, MD

Please note that references to electronic sites should only occur if there is an expectation that the site will be maintained. Include date accessed and URL.

USDA Forest Service (2001) National visitor use monitoring results: Arapaho-Roosevelt Natioanl Forests. Accessed online May 31, 2005: http:///www.fs.fed.us/recreation /programs/nvnm

Footnotes

These should not be used: information should be integrated into the text.

Metric System

The metric system should be used throughout. If required, equivalent values in other systems may be placed in parentheses immediately after the metric value.

Tables

Should be called out in the text and should have a clear and rational structure. All tables should be numbered (1, 2, 3, etc.). Give enough information in subtitles so that each table is understandable without reference to the text.

Illustrations

These should be referred to in the text as, for example, "Fig. 12." They should be numbered consecutively regardless of whether they are line drawings or photographs, with parts of each figure being referred to by letters (a), (b), (c), etc. - e.g,. "Fig. 12a." The manuscript should include a separate list of figures. Ensure that figures are clear, labeled, and of a size that can be reproduced legibly in the journal. Please see the "Guidelines for Electronically Produced Illustrations for Print" below for more information on figure quality. Poor quality figures are not acceptable. If you are in doubt about the suitability of reproductions of your figures, consult the Editor in Chief.

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No rules narrower than .25 pt. No gray screens paler than 15% or darker than 60%. Screens meant to be differentiated from one another must differ by at least 15%.

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